# Department of Defense
# Fiscal Year (FY) 2012 Budget Estimates

February 2011

## Defense Advanced Research Projects Agency

*Justification Book Volume 1*

***Research, Development, Test & Evaluation, Defense-Wide***

## Fiscal Year (FY) 2012 Budget Estimates

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# Table of Volumes

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Defense-Wide
FY 2012 President's Budget
Exhibit R-1 FY 2012 President's Budget
Total Obligational Authority
(Dollars in Thousands)

01 Feb 2011

| Summary Recap of Budget Activities | FY 2010 (Base & OCO) | FY 2011 Base Request with CR Adj* | FY 2011 OCO Request with CR Adj* | FY 2011 Total Request with CR Adj* | FY 2011 Annualized CR Base** | FY 2011 Annualized CR OCO** | FY 2011 Annualized CR Total** |
|---|---|---|---|---|---|---|---|
| Basic Research | 194,031 | 328,195 | | 328,195 | 327,615 | | 327,615 |
| Applied Research | 1,125,952 | 1,272,679 | | 1,272,679 | 1,270,431 | | 1,270,431 |
| Advanced Technology Development (ATD) | 1,440,932 | 1,425,140 | | 1,425,140 | 1,422,624 | | 1,422,624 |
| RDT&E Management Support | 224,824 | 77,257 | | 77,257 | 77,121 | | 77,121 |
| Total Research, Development, Test & Evaluation | 2,985,739 | 3,103,271 | | 3,103,271 | 3,097,791 | | 3,097,791 |

| Summary Recap of FYDP Programs | FY 2010 (Base & OCO) | FY 2011 Base Request with CR Adj* | FY 2011 OCO Request with CR Adj* | FY 2011 Total Request with CR Adj* | FY 2011 Annualized CR Base** | FY 2011 Annualized CR OCO** | FY 2011 Annualized CR Total** |
|---|---|---|---|---|---|---|---|
| Intelligence and Communications | 49,791 | 10,000 | | 10,000 | 9,982 | | 9,982 |
| Research and Development | 2,935,948 | 3,093,271 | | 3,093,271 | 3,087,809 | | 3,087,809 |
| Total Research, Development, Test & Evaluation | 2,985,739 | 3,103,271 | | 3,103,271 | 3,097,791 | | 3,097,791 |

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| Summary Recap of Budget Activities | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
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| Basic Research | 328,643 | | 328,643 |
| Applied Research | 1,311,073 | | 1,311,073 |
| Advanced Technology Development (ATD) | 1,267,515 | | 1,267,515 |
| RDT&E Management Support | 77,689 | | 77,689 |
| Total Research, Development, Test & Evaluation | 2,984,920 | | 2,984,920 |

| Summary Recap of FYDP Programs | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
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| Intelligence and Communications | 10,000 | | 10,000 |
| Research and Development | 2,974,920 | | 2,974,920 |
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Appropriation: 0400D Research, Development, Test & Eval, DW

| Line No | Program Element Number | Item | Act | FY 2010 (Base & OCO) | FY 2011 Base Request with CR Adj* | FY 2011 OCO Request with CR Adj* | FY 2011 Total Request with CR Adj* | FY 2011 Annualized CR Base** | FY 2011 Annualized CR OCO** | FY 2011 Annualized CR Total** | Sec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0601101E | Defense Research Sciences | 01 | 194,031 | 328,195 | | 328,195 | 327,615 | | 327,615 | U |
| 5 | 0601117E | Basic Operational Medical Research Science | 01 | | | | | | | | U |
| | | Basic Research | | 194,031 | 328,195 | | 328,195 | 327,615 | | 327,615 | |
| 9 | 0602115E | Biomedical Technology | 02 | | | | | | | | U |
| 13 | 0602303E | Information & Communications Technology | 02 | 271,316 | 281,262 | | 281,262 | 280,765 | | 280,765 | U |
| 14 | 0602304E | Cognitive Computing Systems | 02 | 132,630 | 90,143 | | 90,143 | 89,984 | | 89,984 | U |
| 15 | 0602305E | Machine Intelligence | 02 | | 44,682 | | 44,682 | 44,603 | | 44,603 | U |
| 16 | 0602383E | Biological Warfare Defense | 02 | 41,348 | 32,692 | | 32,692 | 32,634 | | 32,634 | U |
| 21 | 0602702E | Tactical Technology | 02 | 240,663 | 224,378 | | 224,378 | 223,982 | | 223,982 | U |
| 22 | 0602715E | Materials and Biological Technology | 02 | 255,807 | 312,586 | | 312,586 | 312,034 | | 312,034 | U |
| 23 | 0602716E | Electronics Technology | 02 | 184,188 | 286,936 | | 286,936 | 286,429 | | 286,429 | U |
| | | Applied Research | | 1,125,952 | 1,272,679 | | 1,272,679 | 1,270,431 | | 1,270,431 | |
| 37 | 0603286E | Advanced Aerospace Systems | 03 | 253,848 | 303,078 | | 303,078 | 302,543 | | 302,543 | U |
| 38 | 0603287E | Space Programs and Technology | 03 | 172,728 | 98,130 | | 98,130 | 97,957 | | 97,957 | U |
| 55 | 0603739E | Advanced Electronics Technologies | 03 | 192,611 | 197,098 | | 197,098 | 196,750 | | 196,750 | U |
| 58 | 0603760E | Command, Control and Communications Systems | 03 | 253,733 | 219,809 | | 219,809 | 219,421 | | 219,421 | U |
| 59 | 0603765E | Classified DARPA Programs | 03 | 162,880 | 167,008 | | 167,008 | 166,713 | | 166,713 | U |
| 60 | 0603766E | Network-Centric Warfare Technology | 03 | 144,609 | 234,985 | | 234,985 | 234,570 | | 234,570 | U |

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(Dollars in Thousands)

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

| Line No | Program Element Number | Item | Act | FY 2012 Base | FY 2012 OCO | FY 2012 Total | Sec |
|---|---|---|---|---|---|---|---|
| 2 | 0601101E | Defense Research Sciences | 01 | 290,773 | | 290,773 | U |
| 5 | 0601117E | Basic Operational Medical Research Science | 01 | 37,870 | | 37,870 | U |
| | | Basic Research | | 328,643 | | 328,643 | |
| 9 | 0602115E | Biomedical Technology | 02 | 110,000 | | 110,000 | U |
| 13 | 0602303E | Information & Communications Technology | 02 | 400,499 | | 400,499 | U |
| 14 | 0602304E | Cognitive Computing Systems | 02 | 49,365 | | 49,365 | U |
| 15 | 0602305E | Machine Intelligence | 02 | 61,351 | | 61,351 | U |
| 16 | 0602383E | Biological Warfare Defense | 02 | 30,421 | | 30,421 | U |
| 21 | 0602702E | Tactical Technology | 02 | 206,422 | | 206,422 | U |
| 22 | 0602715E | Materials and Biological Technology | 02 | 237,837 | | 237,837 | U |
| 23 | 0602716E | Electronics Technology | 02 | 215,178 | | 215,178 | U |
| | | Applied Research | | 1,311,073 | | 1,311,073 | |
| 37 | 0603286E | Advanced Aerospace Systems | 03 | 98,878 | | 98,878 | U |
| 38 | 0603287E | Space Programs and Technology | 03 | 97,541 | | 97,541 | U |
| 55 | 0603739E | Advanced Electronics Technologies | 03 | 160,286 | | 160,286 | U |
| 58 | 0603760E | Command, Control and Communications Systems | 03 | 296,537 | | 296,537 | U |
| 59 | 0603765E | Classified DARPA Programs | 03 | 107,226 | | 107,226 | U |
| 60 | 0603766E | Network-Centric Warfare Technology | 03 | 235,245 | | 235,245 | U |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | 0603767E | Sensor Technology | 03 | 226,953 | 205,032 | | 205,032 | 204,670 | | 204,670 | U |
| 62 | 0603768E | Guidance Technology | 03 | 33,570 | | | | | | | U |
| | | Advanced Technology Development (ATD) | | 1,440,932 | 1,425,140 | | 1,425,140 | 1,422,624 | | 1,422,624 | |
| 158 | 0605502E | Small Business Innovative Research | 06 | 75,379 | | | | | | | U |
| 166 | 0605897E | DARPA Agency Relocation | 06 | 44,812 | 11,000 | | 11,000 | 10,981 | | 10,981 | U |
| 167 | 0605898E | Management HQ - R&D | 06 | 54,842 | 56,257 | | 56,257 | 56,158 | | 56,158 | U |
| 176 | 0305103E | Cyber Security Initiative | 06 | 49,791 | 10,000 | | 10,000 | 9,982 | | 9,982 | U |
| | | RDT&E Management Support | | 224,824 | 77,257 | | 77,257 | 77,121 | | 77,121 | |
| | | Total Research, Development, Test & Eval, DW | | 2,985,739 | 3,103,271 | | 3,103,271 | 3,097,791 | | 3,097,791 | |

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| 61 | 0603767E | Sensor Technology | 03 | 271,802 | | 271,802 | U |
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| | | Advanced Technology Development (ATD) | | 1,267,515 | | 1,267,515 | |
| 158 | 0605502E | Small Business Innovative Research | 06 | | | | U |
| 166 | 0605897E | DARPA Agency Relocation | 06 | 1,000 | | 1,000 | U |
| 167 | 0605898E | Management HQ - R&D | 06 | 66,689 | | 66,689 | U |
| 176 | 0305103E | Cyber Security Initiative | 06 | 10,000 | | 10,000 | U |
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| 166 | 0605897E | DARPA Agency Relocation | 06 | 1,000 | | 1,000 | U |
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Mandatory Legislative Proposal
FY 2012 President's Budget
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|---|---|---|---|---|---|---|---|
| Applied Research | | | | | | | |
| Total Research, Development, Test & Evaluation | | | | | | | |

| Summary Recap of Mandatory Legislative Proposal FYDP Programs | | | | | | | |
|---|---|---|---|---|---|---|---|
| Intelligence and Communications | | | | | | | |
| Total Research, Development, Test & Evaluation | | | | | | | |

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|---|---|---|---|
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| Total Research, Development, Test & Evaluation | 100,000 | | 100,000 |

| Summary Recap of Mandatory Legislative Proposal FYDP Programs | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|
| Intelligence and Communications | 100,000 | | 100,000 |
| Total Research, Development, Test & Evaluation | 100,000 | | 100,000 |

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Mandatory Legislative Proposal
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Exhibit R-1 FY 2012 President's Budget
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|---|---|---|---|---|---|---|---|---|---|---|---|
| 280 | 0302168E | Wireless Innovation Fund | 02 | | | | | | | | U |
| | | Applied Research | | | | | | | | | |
| | | Total Research, Development, Test & Eval, DW | | | | | | | | | |

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Mandatory Legislative Proposal
FY 2012 President's Budget
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01 Feb 2011

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

| Line No | Program Element Number | Item | Act | FY 2012 Base | FY 2012 OCO | FY 2012 Total | Sec |
|---|---|---|---|---|---|---|---|
| 280 | 0302168E | Wireless Innovation Fund | 02 | 100,000 | | 100,000 | U |
| | | Applied Research | | 100,000 | | 100,000 | |
| Total Research, Development, Test & Eval, DW | | | | 100,000 | | 100,000 | |

R-1P: FY 2012 President's Budget (Published Official Position With FY 2011 CR Adjustments), as of February 1, 2011 at 11:20:15

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

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



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

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



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

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

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

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 194.031 | 328.195 | 290.773 | - | 290.773 | 299.049 | 319.167 | 341.688 | 362.021 | Continuing | Continuing |
| BLS-01: *BIO/INFO/MICRO SCIENCES* | 36.528 | 53.739 | 39.686 | - | 39.686 | 64.678 | 76.125 | 73.248 | 77.248 | Continuing | Continuing |
| CCS-02: *MATH AND COMPUTER SCIENCES* | 38.240 | 70.001 | 60.805 | - | 60.805 | 60.670 | 60.942 | 67.512 | 71.512 | Continuing | Continuing |
| CYS-01: *CYBER SCIENCES* | - | - | 16.667 | - | 16.667 | 25.000 | 33.333 | 41.667 | 50.000 | Continuing | Continuing |
| ES-01: *ELECTRONIC SCIENCES* | 49.586 | 73.023 | 46.109 | - | 46.109 | 30.413 | 33.876 | 33.876 | 31.876 | Continuing | Continuing |
| MS-01: *MATERIALS SCIENCES* | 69.677 | 89.854 | 97.506 | - | 97.506 | 78.019 | 75.450 | 76.824 | 78.824 | Continuing | Continuing |
| TRS-01: *TRANSFORMATIVE SCIENCES* | - | 41.578 | 30.000 | - | 30.000 | 40.269 | 39.441 | 48.561 | 52.561 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

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

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

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

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

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

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

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

| B. Program Change Summary ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 205.915 | 328.195 | 268.459 | - | 268.459 |
| Current President's Budget | 194.031 | 328.195 | 290.773 | - | 290.773 |
| Total Adjustments | -11.884 | - | 22.314 | - | 22.314 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | -6.422 | - | | | |
| • SBIR/STTR Transfer | -5.462 | - | | | |
| • TotalOtherAdjustments | - | - | 22.314 | - | 22.314 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2010 | FY 2011 |
|---|---|---|
| **Project:** BLS-01: *BIO/INFO/MICRO SCIENCES* | | |
| Congressional Add: *Countermeasures to Combat Protozoan Parasites* | 1.600 | - |
| Congressional Add Subtotals for Project: BLS-01 | 1.600 | - |

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| **Congressional Add Details ($ in Millions, and Includes General Reductions)** | **FY 2010** | **FY 2011** |
|---|---|---|
| **Project:** CCS-02: *MATH AND COMPUTER SCIENCES* | | |
| Congressional Add: *Science, Technology, Engineering and Mathematics Initiative* | 1.600 | - |
| Congressional Add Subtotals for Project: CCS-02 | 1.600 | - |
| **Project:** ES-01: *ELECTRONIC SCIENCES* | | |
| Congressional Add: *Laboratory for Advanced Photonic Composites Research* | 1.280 | - |
| Congressional Add Subtotals for Project: ES-01 | 1.280 | - |
| **Project:** MS-01: *MATERIALS SCIENCES* | | |
| Congressional Add: *American Museum of Natural History Infectious Disease Research* | 1.200 | - |
| Congressional Add: *Institute for Collaborative Sciences Research* | 2.080 | - |
| Congressional Add: *Advanced Materials Research Institute* | 0.800 | - |
| Congressional Add: *Hydrogen Fuel Cell Research* | 4.000 | - |
| Congressional Add: *Solid Oxide Fuel Technology* | 1.000 | - |
| Congressional Add Subtotals for Project: MS-01 | 9.080 | - |
| Congressional Add Totals for all Projects | 13.560 | - |

**Change Summary Explanation**

FY 2010: Decrease reflects transfer of the "Security Protection using Ballistic Core Technologies" congressional add to the Army Research Lab, SBIR/STTR transfer and internal below threshold reprogrammings.

FY 2012: Increase reflects additional emphasis in basic research for transformative technologies such as social networking, synthetic biology, dialysis-like therapeutics and quantum devices, the establishment of a new project for Cyber Sciences (CYS-01), offset by a reduction for Defense Efficiencies for contractor staff support and studies.

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BLS-01: *BIO/INFO/MICRO SCIENCES* | 36.528 | 53.739 | 39.686 | - | 39.686 | 64.678 | 76.125 | 73.248 | 77.248 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Bio Interfaces<br><br>***Description:*** The Bio Interfaces program supports scientific study and experimentation, emphasizing the interfaces between biology and the physical and mathematical/computer sciences. This unique interaction will develop new mathematical and experimental tools for understanding biology in a way that will allow its application to a myriad of DoD problems. These tools will help exploit the advances in the complex modeling of physical and biological phenomena. It is also expected that understanding the fundamentals of biology will aid in developing tools to understand complex, non-linear networks and force structures. This program will also explore the fundamental nature of time in biology and medicine. This will include mapping basic clock circuitry in biological systems from the molecular level up through unique species level activities with a special emphasis on the applicability to human biology. Operational relevance of this research activity includes improving our understanding of sleep-wake cycles, increasing the scientific understanding of deployment cycle lengths, and enhancing our ability to model the dynamics of disease outbreaks.<br><br>***FY 2010 Accomplishments:***<br>- Tested theoretical mathematical formulations of developmental laws of biology and demonstrated the existence of fundamental biogenesis pathways that operate across plant and animal kingdoms.<br>- Developed novel mathematical tools that decipher complex cardiac signals to detect early warning signs of adverse medical events.<br>- Discovered a novel regulatory mechanism controlling cellular protein expression that expands the understanding of biological control systems and how they have evolved.<br><br>***FY 2011 Plans:*** | 2.000 | 2.000 | 5.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Apply scientific principles of mathematical decoding to elucidate basis temporal-spatial signatures within biological systems, particularly with respect to human biology.<br>- Identify ecology-specific or reagent-specific nucleotide tags in a replicating organism which possess sufficient half-life to last 1000 generations.<br><br>***FY 2012 Plans:***<br>- Demonstrate two genomic indicators of geospatial origin of prokaryotic microorganisms.<br>- Demonstrate the role of phage-bacteria in attack and defense in assigning temporal and geo-localizing data.<br>- Demonstrate four variable determinations of global origin or residence in a simple mammalian system. | | | |
| ***Title:*** Preventing Violent Explosive Neurologic Trauma (PREVENT) - Medical<br><br>***Description:*** The Preventing Violent Explosive Neurologic Trauma (PREVENT) program seeks to understand the causes of blast-induced traumatic brain injury (TBI), an injury that while previously described in the warfighter population, has been referred to as a potential "hidden epidemic" in the current conflict. PREVENT will use a variety of modeling techniques based on in-theater conditions to assess potential TBI caused by blast in the absence of penetrating injury or concussion. Research will create a model that can be directly correlated to the epidemiology and etiology of injury seen in returning warfighters, and attempt to determine the physical and physiological underpinnings and causes of the injury. Mitigation and treatment strategies will be formulated based on our new knowledge of blast-induced brain injury with the eventual goal of reducing injury severity across the forces by over fifty percent, improving recovery time, and preventing future injuries. PREVENT is funded in the newly created Budget Activity 6.1 Medical Program Element 0601117E, beginning in FY 2012.<br><br>***FY 2010 Accomplishments:***<br>- Assessed the effect of commonly available pharmaceuticals in both acute and chronic mitigation of blast brain injury symptoms.<br>- Validated diagnostic criteria for assessment of mild to severe blast brain injury.<br>- Tested and validated fabricated device strategies to ensure that they appropriately mitigate the effects of blast brain injury.<br><br>***FY 2011 Plans:***<br>- Develop and design devices and diagnostic platforms suitable for blast brain injury detection in theater capable of early identification of blast neurotrauma from physiological, neurological, and behavioral changes.<br>- Investigate the long-term effects of multiple exposures to blast on warfighters following return from deployment through comparison to pre-deployment baselining across a battery of psychological, neurological, and behavioral tests and correlation to data collected from in-theater blast events. | 4.500 | 3.207 | - |
| ***Title:*** Biological Adaptation, Assembly and Manufacturing | 7.738 | 9.482 | 8.386 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***Description:*** The Biological Adaptation, Assembly and Manufacturing program will examine the structure, function, and informational basis underlying biological system adaptation, and the factors employed by the organism to assemble and manufacture complex biological subsystems. The unique stability afforded biological systems in their ability to adapt to wide extremes of physical and endurance (e.g., heat, cold, and sleeplessness) parameters will be examined and exploited in order to engineer stability into biological systems required for the military (such as blood, bioengineered tissues or other therapeutics). In addition, the fault tolerance present in biological systems will be exploited in order to assemble and manufacture complex physical and multi-functional systems, both biological and abiotic (such as tissue constructs designed for reconstructive surgery). These systems include novel load-bearing bio-interactive materials and composites for repair of severe hard tissue trauma, including complex bone fractures. A key new antibody technology will develop the ideal antibody master molecule for use in unattended sensors that maintains high temperature stability and controllable affinity for threat agents. Using the Freytag triangle structure, the interplay of narratives or stories may reveal how they tap into an array of mechanisms implicated in memory, reasoning, and strategy behavior. Applications to Defense systems include the development of chemical and biological sensors, tools for strategic military decision-makers involved in public relations and information operations, and improved warfighter battlefield survivability.<br><br>***FY 2010 Accomplishments:***<br>- Developed novel resorbable wet adhesives with the mechanical properties of natural bone, for inclusion into fracture putty formulation.<br>- Demonstrated fracture putty in small animal model of bone fracture.<br>- Initiated large animal studies of fracture putty for bone fracture repair.<br>- Identified fundamental mechanisms for controlling antibody stability and affinity.<br>- Initiated efforts to modify antibody affinity and temperature stability of the MS2 scFv antibody.<br>- Determined the baseline binding parameters of the anti-MS2 scFv and established the methodology for evaluating improvements in antibody performance.<br><br>***FY 2011 Plans:***<br>- Demonstrate fracture putty in large animal model of bone fracture, with independent validation.<br>- Initiate expanded large animal studies of fracture putty in preparation for human clinical trials.<br>- Demonstrate the ability to produce an antibody with thermal stability from room temperature up to 60 degrees Celsius.<br>- Combine identified antibody stability and affinity capabilities into a single "Master Antibody Molecule" that exhibits two target metrics against a single biological threat agent and deliver a minimum of two grams for testing by a government laboratory.<br>- Incorporate the identified "Master Antibody Molecule" into an existing biosensor platform and demonstrate advanced capability in terms of robustness and potential for multiplexing. | | | |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Initiate investigations into the relationship between dopaminergic-driven learning systems, hormones/neurotransmitters such as oxytocin, emotion-cognition interactions, and narrative structures.<br><br>***FY 2012 Plans:***<br>- Further investigate use of fracture putty in fixation and healing of large animal injury.<br>- Revise design of fracture putty compounds as appropriate for safety in human clinical trials.<br>- Explore and refine foundational assumptions on the utility of the Freytag structure ("setup-climax-resolution") for narrative analysis, including determining relationships between decomposed stories and neuropsychological mechanisms, and understanding relationships between narratives and behavior.<br>- Develop decomposition frameworks and initial cluster of neurobiological mechanisms to better understand their relationship.<br>- Develop tools to link analytic frameworks, neural mechanisms, and environmental variables to a particular story. | | | |
| ***Title:*** Human Assisted Neural Devices - Medical<br><br>***Description:*** The Human Assisted Neural Devices program will develop the scientific foundation for understanding the language of the brain for application to a variety of emerging DoD challenges, including improving performance on the battlefield and returning active duty military to their units after injury. This will require an understanding of neuroscience, significant computational efforts, and new material design and implementation. Key advances expected from this research include determining the nature and means through which short-term memory is encoded, and discovering the mechanisms and dynamics underlying neural computation and reorganization. These advances will enable memory restoration through the use of devices programmed to bridge gaps in the injured brain. Further, modeling of the brain progresses to an unprecedented level with this novel approach. The programs funded under the Human Assisted Neural Devices are funded in the newly created Budget Activity 6.1 Medical Program Element 0601117E, in FY 2012.<br><br>***FY 2010 Accomplishments:***<br>- Identified neural processes for encoding short- and long-term memory in primates during a complex motor task.<br>- Built hardware and software to implement pattern extraction and inter-individual verification of homogeneity of patterns between primates.<br>- Created an interface that enables performance of a complex motor/sensory task through an assistive device without using either motor or sensory function.<br>- Determined task performance changes resulting from learning and plasticity through observation of the development of functional networks in the primate and rodent brain over time.<br>- Constructed algorithms and methods capable of more accurately describing and estimating neural signals from limited data.<br><br>***FY 2011 Plans:*** | 15.975 | 18.250 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Assess ability of primate to retain short-term memory encoding following simulated injury through use of neural codes.<br>- Identify homogeneity of neural codes involving long-term memory between primates conducting similar long-term memory tasks.<br>- Map dynamic functional motor and sensory networks and develop methods for characterizing brain-wide sensory/motor tasks.<br>- Determine the role of specific neural pathways in a complex motor/sensory task through perturbation of existing and defined functional networks in primate and rodent experiments.<br>- Investigate stimulation of sensory networks to determine how sensory information is encoded and utilized by the brain.<br>- Improve learning and performance of primates during complex sensorimotor tasks through robust decoding of neural activity.<br>- Develop models of neural behavior that more accurately approximate biological signaling.<br>- Fabricate neural interfaces capable of stimulating and recording multiple channels of neural activity at distributed sites throughout the brain. | | | |
| ***Title:*** Mathematics of the Brain (MoB)<br><br>***Description:*** The Mathematics of the Brain (MoB) program will develop a new mathematical paradigm for understanding how to model reasoning processes for application to a variety of emerging DoD challenges. The program will develop powerful new symbolic computational capabilities for the DoD in a mathematical system that provides the ability to understand complex and evolving tasks without exponentially increasing software and hardware requirements. This includes a comprehensive mathematical theory to exploit information in signals at multiple acquisition levels, which would fundamentally generalize compressive sensing for multi-dimensional sources beyond domains typically used. This program will establish a functional mathematical basis on which to build future advances in cognitive neuroscience, computing capability, and signal processing across the DoD.<br><br>***FY 2010 Accomplishments:***<br>- Hypothesized a new mathematical theory of compressive measurement.<br><br>***FY 2011 Plans:***<br>- Develop a new comprehensive measurement theory to exploit information in signals.<br>- Explore the comprehensive measurement theory's utility in applications such as imaging and radar.<br>- Investigate novel forms of prior knowledge in order to improve sparse signal sampling.<br><br>***FY 2012 Plans:***<br>- Develop detailed mathematical prior-knowledge representations and associated models for imaging and radar applications.<br>- Exploit the new theoretical measurement framework together with novel forms of prior knowledge in order to maximize information gathering from sparse sampling. | 1.872 | 6.000 | 10.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Exploit the new theoretical measurement framework together with novel forms of prior knowledge in order to minimize resource requirements for sparse sampling.<br>- Demonstrate the utility of new comprehensive measurement theory via improvements in imaging and radar applications. | | | |
| ***Title:*** Physics in Biology<br><br>***Description:*** Understanding the fundamental physical phenomena that underlie biological processes and functions will provide new insight and unique opportunities for understanding biological properties and exploiting such phenomena. Physics in biology will explore the role and impact of quantum effects in biological processes and systems. Using quantum theoretical models and mathematical algorithms, new understanding of quantum effects will enable exploitation in new and existing biomimetic applications. This includes exploiting manifestly quantum mechanical effects that exist in biological systems at room temperature to develop a revolutionary new class of robust, compact, high sensitivity and high selectivity sensors. Investigation into quantitative neurophysics will examine new modalities for biological injury which could yield a new class of non-invasive medical imagers. Leveraging neuroscience and physics will lead to new modeling of acoustic signatures based on perceptibility (detection, classification, recognition, identification and localization) involving ear-to-brain mechanisms. These computational models can be used to predict which acoustic signature changes would lead to reduced perceptibility and the brain's ability to learn and adapt to novel acoustic signatures.<br><br>***FY 2011 Plans:***<br>- Develop a detailed theoretical model for manifestly quantum mechanical effects in specific biological systems.<br>- Formulate testable predictions for effects of perturbations on the biological system.<br>- Experimentally verify that the biological system exploits quantum effect(s) at room temperature.<br><br>***FY 2012 Plans:***<br>- Develop theory for sensor utilizing biological quantum effects.<br>- Design synthetic sensor based upon quantum mechanism employed by biological system(s).<br>- Model sensor performance.<br>- Experimentally probe the limits of biological sensors' exploitation of the quantum effects.<br>- Demonstrate initial proof of concept of potential non-electrode based modalities of neural interface.<br>- Identify potential quantitative methods to map structural neuroanatomy and system dynamics for afferent and efferent pathways.<br>- Determine whether auditory percepts can be altered with respect to location of a heard object.<br>- Investigate how auditory patterns are learned and recognized. | - | 8.300 | 14.300 |
| ***Title:*** Scaffold-Free Tissue Engineering | - | 6.500 | 2.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The objective of the Scaffold-Free Tissue Engineering program is the development of tissue and organ construction platforms that utilize non-contact forces such as magnetic fields to achieve desired tissue architectures. The Scaffold-Free Tissue Engineering program is developing platforms that would circumvent current limitations by removing the use of a material scaffold and providing simultaneous control of multiple cell/tissue types for the construction of large, complex tissues in vitro and in vivo. The program will provide a paradigm shift versus current tissue engineering approaches using permanent or resorbable protein scaffolds. Such scaffolds are limited to construct sizes of 2-3 square millimeters due to oxygen and nutrient diffusion limitations, which severely limits the complexity of the tissue(s) constructed to a single cell type. In vivo, scaffold-based tissue engineering has not achieved anticipated widespread application due to the inability to properly control the cellular response to the implanted scaffold and due to difficulties in controlling the scaffold integrity/degradation. The initial Scaffold-Free Tissue Engineering program component is the development of non-contact cell positioning procedures. The fundamental goal is to correctly position target cells in a desired pattern for a sufficient period of time to allow the cells to synthesize their own scaffold. Potential approaches include magnetic field and/or dielectrophoretic positioning. Critical to early programmatic achievement is the capability to position at least two cell types through the identification of cellular magnetic taggants, characterization of cellular dielectric characteristics and determination of application dynamics (e.g., duration, cycles, amplitude) to achieve multicellular tissue construction in vitro. A potential transition to an in situ application would allow wound site reconstruction without the need to implant scaffold material. Construction of a stable implantable skeletal muscle construct (5 cm3) with vascular and neural components will be the final programmatic demonstration.<br><br>***FY 2011 Plans:***<br>- Identify non-contact approaches such as magnetic fields and dielectrophoresis that provide cell positioning in three dimensions without negatively impacting cell viability.<br>- Demonstrate in vitro construction of multicellular tissue using one or more non-contact cell positioning approaches.<br>- Demonstrate survival and functional implantation of a two cubic centimeter multicellular skeletal muscle scaffold-less construct into an appropriate in vivo model.<br><br>***FY 2012 Plans:***<br>- Demonstrate formation of vascular elements from endothelial cells within an existing three-dimensional skeletal muscle construct in vitro.<br>- Demonstrate directed ingrowth of neurons in an existing three-dimensional skeletal muscle construct in vitro. | | | |
| ***Title:*** Nanostructure in Biology<br><br>***Description:*** The Nanostructure in Biology program investigated the nanostructure properties of biological materials to better understand their behavior and accelerate their exploitation for Defense applications. This new information about biomolecules | 2.843 | - | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| and complex cellular systems provided important new leads for the development of threat countermeasures, biomolecular probes and motors, and neuromorphic sensory systems. This program also developed approaches to mathematically predict a priori, the structure of biological materials, especially proteins, based on the desired performance. This enabled 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 also created technology to reliably integrate nanoscale and microsystems payloads on insects that will extract power, control locomotion, and also carry DoD relevant sensors.<br><br>***FY 2010 Accomplishments:***<br>- Discovered methods for precise flight control use in combinations of MEMS techniques originating in the previous fiscal year.<br>- Developed neural interfaces to insect sensors to complement electronic sensors.<br>- Continued development of a protein that preferentially binds to an invariant portion of the influenza virus.<br>- Continued design of de novo inhibitory protein of smallpox. | | | |
| **Accomplishments/Planned Programs Subtotals** | 34.928 | 53.739 | 39.686 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** Countermeasures to Combat Protozoan Parasites<br>***FY 2010 Accomplishments:*** - Initiated research to develop countermeasures to combat protozoan parasites. | 1.600 | - |
| **Congressional Adds Subtotals** | 1.600 | - |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

| | | |
|---|---|---|
| **Exhibit R-2A**, **RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>CCS-02: *MATH AND COMPUTER SCIENCES* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CCS-02: *MATH AND COMPUTER SCIENCES* | 38.240 | 70.001 | 60.805 | - | 60.805 | 60.670 | 60.942 | 67.512 | 71.512 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

## B. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Computer Science Study Group (CSSG) | 6.931 | 10.550 | 11.550 |
| ***Description:*** The Computer Science Study Group (CSSG) program supports emerging ideas from the computer science academic community to address the DoD's need for innovative computer and information science technologies; introduces a generation of junior researchers to the needs and priorities of the DoD; and enables the transition of those ideas and applications by promoting joint university, industry, and government projects. The CSSG project formalizes and focuses this research for efficiency and greater effectiveness.<br><br>***FY 2010 Accomplishments:***<br>- Executed CSSG program plan by selecting twelve 2010 Class Phase 1 performers and nine 2009 Class Phase 2 performers.<br>- Obtained important technical results in several areas including text driven prediction of human behavior, haptic sensing, and deep analysis of computer vulnerabilities.<br>***FY 2011 Plans:***<br>- Select twelve promising faculty computer scientists to form Class of 2011.<br>- Award grants to at least nine Principle Investigators (PIs) from the Class of 2010 in support of groundbreaking research with high payoff potential to DoD.<br>- Award grants to at least three PIs from Class of 2009 who successfully transition their research into partnerships with other sources of funding from government or industry.<br>***FY 2012 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Select Class of 2012 and promote success of Classes 2010-2011. | | | |
| ***Title:*** Young Faculty Award (YFA)<br><br>***Description:*** The goal of the Young Faculty Award (YFA) program is to encourage new faculty members of academic institutions with innovative ideas and concepts to participate in sponsored research programs that will impact capabilities to future defense systems. This program focuses on speculative technologies for greatly enhancing microsystems technologies, transformational convergence technologies, and defense sciences. The long term goal for this program is to develop the next generation of academic scientists, engineers, and mathematicians in key disciplines who will focus a significant portion of their career on DoD and National Security issues. Current activities include revolutionary advances in thirteen topic areas: Quantum Science and Technology; Applied Biology, Biomedical Devices and Bioinformatics; Mathematics; Structural Materials; Functional Materials; Power and Energy; Advanced Electronics; Micro/Nano Electro-Mechanical Systems (MEMS and NEMS); Photonics and Lasers; Manufacturing Science and Technology; Neuroscience; and Computational and Quantitative Social, Decision, and Behavioral Sciences. A key aspect of the YFA program is DARPA-sponsored military visits; all YFA Principal Investigators are expected to participate in one or more military site visit/exercise to help them better understand DoD problems/needs.<br><br>***FY 2010 Accomplishments:***<br>- Continued the thirty-three FY 2009 awards into their 2nd year of research focused on enhancements and new concepts for microsystem technologies, transformational convergence technologies, and defense sciences.<br>- Awarded thirty-three new grants in the following topic areas: Quantum Science and Technology (4); Applied Biology (3) ; Biomedical Devices and Bioinformatics (3); Mathematics (2); Structural Materials (2); Functional Materials (3); Power and Energy (3); Advanced Electronics (3); Micro/Nano Electro-Mechanical Systems (MEMS and NEMS) (1); Photonics and Lasers (4); Manufacturing Science and Technology (1); Neuroscience (2); and Computational and Quantitative Social, Decision, and Behavioral Sciences (2).<br>- Established a mentorship component to the program to educate all of the academic performers on DoD needs and encourage focus of future work in this area.<br><br>***FY 2011 Plans:***<br>- Continue the 2nd year of the FY 2010 grants for research of enhancements and new concepts for microsystem technologies, transformational convergence technologies, and defense sciences.<br>- Award FY 2011 grants for new two-year research efforts among the thirteen established topic areas.<br>- Establish transition approaches for appropriate technologies and research activities to enhance development activities.<br>- Continue education component on DoD needs and encourage focus of future work in this area.<br><br>***FY 2012 Plans:*** | 12.867 | 14.500 | 15.255 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Continue the FY 2011 awards into their 2nd year of research focused on enhancements and new concepts for microsystem technologies, transformational convergence technologies, and defense sciences.<br>- Award FY 2012 grants for new two-year research efforts among the thirteen established topic areas.<br>- Continue education component on DoD needs and encourage focus of future work in this area.<br>- Monitor and facilitate transition of appropriate technologies and research activities. | | | |
| ***Title:*** Strategic Social Interaction Modules (SSIM)<br><br>***Description:*** *Formerly Training for Adaptability<br><br>The Strategic Social Interaction Modules (SSIM) program will take military training beyond traditional tactics, techniques, and procedures/standard operating procedures (TTPs/SOPs) to include cultural awareness and the knowledge, skills, and abilities necessary to develop close collaborative relationships with foreign peoples and leaders and, ultimately, for winning hearts and minds. Counter-insurgency (COIN) missions and stability and support operations (SASO) put U.S. service members in close contact with local populations. Historically, military training has not had to train soldiers on how to skillfully interact with foreign civilians. The current operational environment makes it imperative to develop rapport with local leaders and civilians as their cooperation will be necessary for success in COIN/SASO. SSIM will emphasize the foundational skills necessary to achieve cultural understanding in any social setting and the skills necessary for successful interactions across different social groups. SSIM will develop the requisite training technology including advanced gaming/simulation techniques that incorporate new methods for practicing social agility in cross-cultural encounters, as well as how to discover and learn culturally specific conduct, manners, and practices.<br><br>***FY 2011 Plans:***<br>- Conduct basic studies of interactions, negotiations, and relationships in cross-cultural social encounters.<br>- Develop social interaction engines and expressive intelligence technologies for interpersonal simulations.<br><br>***FY 2012 Plans:***<br>- Create technologies to generate realistic training scenarios and user challenges, automate the evaluation of user responses, and support the expert authoring/editing of scenarios.<br>- Develop tools to identify skillful performance in a training environment and for predicting the efficacy of the training in the intended operational/cultural environment.<br>- Develop techniques for delivering training through a variety of mechanisms including over limited-bandwidth channels to users in theater. | - | 8.364 | 9.500 |
| ***Title:*** Engage | - | 6.600 | 7.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Engage program, previously part of the Training for Adaptability thrust, will develop the means for teaching problem solving in complex real-world settings not amenable to conventional curriculum-based approaches. Traditional modes of education place learning before problem solving, but Engage will take an alternative approach by moving problem solving to the core of the educational experience. This will be accomplished by creating problem-solving games that feature combined human-computer reasoning on complex problems and that provide users with immediate feedback and alternative solutions. Engage will also address the difficult problem of connecting performance in the virtual domain with performance in the real world and then will use this knowledge to drive the creation of more effective game-based training.<br><br>***FY 2011 Plans:***<br>- Explore game and problem-solving-based approaches to learning in complex real-world domains.<br>- Develop approaches for extrapolating performance on computer-based training systems to performance in the real world.<br>***FY 2012 Plans:***<br>- Develop software infrastructure for an educational gaming environment that allows the methods of instruction to be varied in order to determine the best approaches.<br>- Analyze educational methodologies using statistics based on data drawn from a large video game environment. | | | |
| ***Title:*** Mathematics of Sensing, Exploitation and Evaluation (MSEE)<br><br>***Description:*** The Mathematics of Sensing, Exploitation and Evaluation (MSEE) program is an outgrowth of the Focus Areas in Theoretical Mathematics program that seeks to create a comprehensive mathematical theory of information processing, strategy formulation and decision determination. Such a theory would incorporate techniques from diverse mathematical disciplines such as Stochastic Process Theory, Harmonic Analysis, Formal Languages and Theoretical Computer Science to construct a common framework wherein the quantitative value of data acquisition may be assessed relative to dynamically-varying context. In addition, the structure will accommodate the notion that data acquisition and information processing are coupled, requiring some degree of feedback and control, while simultaneously admitting the possibility of different logics, e.g., those that allow for incomplete and time-varying states of knowledge. The result of this effort will produce advances in fundamental domains of mathematics with the potential to reshape current DoD approaches to managing the battlespace.<br><br>***FY 2011 Plans:***<br>- Formalize mathematically the notions of information processing, strategizing and decision determination so that these can be modeled as a computational process. | - | 3.000 | 7.500 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Investigate methods for constructing relevant models of DoD-relevant environments, and develop effective strategies for updating these as new information becomes available.<br><br>***FY 2012 Plans:***<br>- Incorporate statistical/stochastic concepts exploiting stochastic models and statistical reasoning to understand the nature of computations in human minds.<br>- Explore open system concepts capable of demonstrating the ability to process information and determine best available responses, subject to time-varying context.<br>- Begin to quantify notion of effective utility, which measures the relative value of a sensor or sensor system. | | | |
| ***Title:*** Math for Social Networks<br><br>***Description:*** Social networks are recent phenomena whose pervasiveness has become undeniable. Critical information potentially can be extracted by both observing network state at any given instant as well as by monitoring network dynamics. Standard tools for examining network behavior typically target systems of communication or computer nodes, and evaluate context-relevant yet straightforward metrics such as connectivity. When dealing with social networks, the knowledge that can be distilled is potentially more useful, and hence an entirely new set of techniques must be developed. This thrust will develop new mathematical methods to facilitate more complete analysis of social networks while simultaneously constructing mechanisms by which this elevated understanding may be best communicated. This approach could comprise, e.g., i) the application of spatiotemporal signal processing techniques to monitoring network activity, with an emphasis on identifying precursors to undesirable events; and, ii) incorporating fundamentally that the component nodes are humans (or groups of humans), and hence interact in ways subject to psychosocial evaluation. By incorporating sophisticated signal processing while recognizing the defining role of the human agent, this thrust will change how social networks are monitored and analyzed. Hence, we recast social network analysis into a mathematical framework that captures the biological nature of the component nodes intrinsically and exploits this knowledge to produce a unique DoD capability.<br><br>***FY 2012 Plans:***<br>- Create an enhanced network modeling theory that incorporates ability to perform spatiotemporal analysis.<br>- Investigate impact of replacing generic network nodes with human agents whose behavior can be modeled statistically.<br>- Perform small-scale analyses of dynamic networks and demonstrate ability to recognize event precursors. | - | - | 10.000 |
| ***Title:*** Foundational Computer Science<br><br>***Description:*** The Foundational Computer Science program 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 networking, software, hardware, and computational systems in a | 1.896 | 8.276 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| world where computing devices are ubiquitous and heterogeneous. The Foundational Computer Science program is addressing the need for highly reliable and trustworthy mission-critical information systems, including both software and hardware. New programming languages that facilitate parallel programming on multi-core processors, scalable formal methods, clean-slate execution models, co-design approaches for hardware and software, and other techniques will be used to guarantee the security, reliability, performance and robustness of a design while also reducing its complexity and cost. Research efforts in communications and sensor networks will address challenges related to dynamic heterogeneous multi-modal networks. The Foundational Computer Science program will also address problems that are inherently computationally complex and, in many cases, intractable. For example, the game of Go provides an ideal platform for creating the heuristic approaches and tools necessary to solve problems that typically require either enormous computer resources or simplification that sacrifices accuracy. The resulting technologies will be candidates for future command and control decision aids that can assess the consequences of specific actions and strategies to better predict future results in applications such as irregular warfare, cyber-security, supply chain optimization, networking and robotics.<br><br>***FY 2010 Accomplishments:***<br>- Developed improved methods of planning and reasoning to calculate Go best-next-move hypotheses from board positions and to use such hypotheses to develop a highly targeted search strategy.<br>- Developed methods for visualization to determine similarity and differences in positional configurations.<br><br>***FY 2011 Plans:***<br>- Continue development of methods for visualization to determine similarity and differences in positional configurations.<br>- Develop algorithms to introduce intelligence to massive search problems.<br>- Combine algorithmic approaches to Go optimization with heuristic assessment of the value of information to introduce a new area of research in machine learning and planning. | | | |
| ***Title:*** Foundational Machine Intelligence<br><br>***Description:*** The Foundational Machine Intelligence program is supporting research on the foundations of artificial intelligence and machine learning and reasoning. One focus is on techniques that can efficiently process and "understand" massive data streams. Deeply layered machine learning engines will be created that use a single set of methods in multiple layers (at least three internally) to generate progressively more sophisticated representations of patterns, invariants, and correlations from data inputs. These will have far-reaching military implications with potential applications such as anomaly detection, object recognition, language understanding, information retrieval, pattern recognition, robotic task learning and automatic metadata extraction from video streams, sensor data, and multi-media objects. Foundational Machine Intelligence also examines the human aspects of computing, with interest in collaboration, interaction and information exchange; non-symbolic representation/reasoning paradigms | 3.681 | 6.000 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| based upon a universal "cortical" algorithm; and modeling of human language acquisition by associating words with the real-world entities perceived through multiple modes of sensory input.<br><br>***FY 2010 Accomplishments:***<br>- Created machine learning techniques that can assimilate huge amounts of data by creating rich representations of the input data and applying them to multiple applications.<br>- Constructed a single, general-purpose algorithm which started with zero linguistic knowledge of its environment, and then grew to represent the structure latent in that environment.<br>***FY 2011 Plans:***<br>- Create parameter-free methods that learn appropriate representations starting from raw inputs with a single architecture and learning algorithm.<br>- Enable machines to incorporate sensory information in a robust way to improve situational awareness.<br>- Extend sub-symbolic learning algorithms to work with richer, non-linguistic input and knowledge representations. | | | |
| ***Title:*** Information Theory for Wireless Mobile Ad Hoc Networks (ITMANET)<br><br>***Description:*** The Information Theory for Wireless Mobile Ad Hoc Networks (ITMANET) program is creating an information theory for ad hoc mobile wireless networking in the absence of wired infrastructure. Issues being addressed include quantifying network performance in terms of throughput, delay, reliability, and other critical parameters as a function of node mobility, network topology, channel access protocol, bandwidth efficiency, and the overhead incurred through the exchange of channel and network state information. The revolutionary new and powerful information theory developed under ITMANET will enable the next generation of DoD wireless networks and provide insight concerning the acquisition and deployment of nearer-term systems.<br><br>***FY 2010 Accomplishments:***<br>- Predicted performance in terms of throughput-delay-reliability for modest-sized MANETs with and without feedback.<br>- Developed upper-bounding techniques that go beyond the classical bounds and inequalities for MANETs.<br>***FY 2011 Plans:***<br>- Predict performance in terms of throughput-delay-reliability for any MANET realization.<br>- Develop protocols for interference alignment architectures that can approach the end-to-end MANET transmission capacity limit.<br>- Develop a generalized theory of rate distortion and network utilization. | 3.271 | 3.646 | - |
| ***Title:*** Computer Science /Science, Technology, Engineering, and Mathematics Research Outreach | 2.000 | 5.665 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Computer Science, Science, Technology, Engineering, and Mathematics Research Outreach program will develop educational practices and programs that capture the scientific and technical interests of middle and high school students through compelling projects that require computer science, science, technology, engineering, and mathematics.<br><br>***FY 2010 Accomplishments:***<br>- Engaged high school study groups to work on selected ideas.<br>- Initiated programs that capture the scientific and technical interests of middle and high school students through compelling projects that require computer science, science, technology, engineering, and mathematics.<br>***FY 2011 Plans:***<br>- Execute programs that capture the scientific and technical interests of middle and high school students through compelling projects that require computer science, science, technology, engineering, and mathematics. | | | |
| ***Title:*** Focus Areas in Theoretical Mathematics (FAThM)<br><br>***Description:*** The Focus Areas in Theoretical Mathematics (FAThM) program aims to foster major theoretical breakthroughs in pure mathematics whose potential for long-term defense implications is high. By supporting closely integrated and concentrated collaborations among small numbers of leading experts, FAThM will pioneer a new approach for conducting focused research to explore fundamental interconnections between key areas of mathematics where critical insights should lead to both new mathematics and innovative DoD applications.<br><br>***FY 2010 Accomplishments:***<br>- Established and exploited new relations between topology and symmetry groups of fundamental particles.<br>- Established and exploited new relations between the analytic foundations of symmetry and algebraic computation.<br>- Proved an equivalence between using microdifferential operators versus the more general formal microdifferential operators, in microlocal analysis of regular holonomic systems - specific types of differential equations.<br>***FY 2011 Plans:***<br>- Establish and exploit new relations between differential geometry, quantum field theories, and infinite dimensional global analysis.<br>- Establish and exploit new relations between generalized homology theories and partial differential equations. | 1.400 | 1.400 | - |
| ***Title:*** 23 Mathematical Challenges<br><br>***Description:*** This program aims to revolutionize the mathematical tools used by DoD in both theory and applications, discover and generate powerful and innovative new mathematics, tackle long-standing mathematical problems, and create new mathematical disciplines to meet the long-term needs of the DoD across diverse scientific and technological areas. | 1.500 | 2.000 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Exploited novel mathematical techniques in combinatorics (the study of discrete objects) and geometry to build new capabilities in rigidity theory for applications such as robotics.<br>- Developed an algorithm incorporating error that describes evolution of material structures and satisfies the generalized von Neumann relation.<br>- Established new connections between number theory ("finite fields" and "elliptic curves") and geometry ("real structures on abelian varieties"); these connections are the first steps in solving long-standing problems in cryptography.<br>***FY 2011 Plans:***<br>- Extend known links between topology and algebra for continuous manifolds (e.g., de Rahm-Witt complexes and K-groups) to the case of discrete structures. Such an extension will impact cryptographic applications.<br>- Improve understanding of differential equations appearing in number theory, as a tool for passing between number theory and geometry. | | | |
| ***Title:*** Programmable Matter<br>***Description:*** The Programmable Matter program explored a new functional form of matter constructed from mesoscale particles that assemble into complex 3-D objects upon external command. These objects exhibit all of the functionality of their conventional counterparts and ultimately have the ability to reverse back to the original components.<br>***FY 2010 Accomplishments:***<br>- Optimized Programmable Matter properties.<br>- Demonstrated interlocking/adhesion of mesoscale particles to create bulk matter.<br>- Demonstrated reversibility. | 3.094 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 36.640 | 70.001 | 60.805 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** Science, Technology, Engineering and Mathematics Initiative<br>***FY 2010 Accomplishments:*** - Initiated research in the areas of science, technology, and engineering. | 1.600 | - |
| **Congressional Adds Subtotals** | 1.600 | - |

| **Exhibit R-2A, RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>CCS-02: *MATH AND COMPUTER SCIENCES* |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CYS-01: *CYBER SCIENCES* | - | - | 16.667 | - | 16.667 | 25.000 | 33.333 | 41.667 | 50.000 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Crowd-Sourced Cyber<br><br>***Description:*** The Crowd-Sourced Cyber program will develop crowd-sourced approaches for verifying the correctness of software systems. Coding errors are the root cause of many of the most serious security vulnerabilities in software systems. Program verification can reduce coding errors dramatically, but at an unacceptable development cost. Many core problems in code verification are undetectable by computers, so automation in and of itself cannot sufficiently reduce the cost enough to make program verification practical. The Crowd-Sourced Cyber environment will facilitate the mapping from the code/formal specification to the relevant components of the simulation. The Crowd-Sourced Cyber development environment will provide extensible and editable components and user interface items and will facilitate the automated inverse mapping that translates simulation results to code annotations. Crowd-Sourced Cyber is addressing one of the most vexing and long-standing problems in software development, and if successful will greatly increase the quality and security of software systems while reducing the cost.<br><br>***FY 2012 Plans:***<br>- Develop approaches for mapping high-level software specifications and codes into interactive computer simulations.<br>- Develop techniques for inferring specification and coding errors from the results of these simulations and for automatically generating the appropriate annotations.<br>- Develop web-based infrastructure to support large scale program verification workflow. | - | - | 6.500 |
| ***Title:*** Risk-Managed Access Control (RMAC) | - | - | 5.500 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Risk-Managed Access Control (RMAC) program will develop the means to associate risk with access and use this as the basis for more effective identification, authentication, and authorization technologies. Currently, factors for identification and authentication require the user to know something like a password, possess something like a smart card, and/or to exhibit some intrinsic biometric trait like a fingerprint. Once authenticated, the user obtains authorization that defines the user's permissions, for example, what files the user can read. However, none of the current schemes for identification, authentication, and authorization incorporates any mechanism for automatically revisiting previous decisions. RMAC will create techniques and algorithms for quantifying the cumulative risks and benefits associated with a user's actions and incorporate such risk assessments in access control schemes that have additional control loops designed to mitigate the risks associated with large-scale information sharing.<br><br>***FY 2012 Plans:***<br>- Conceptualize methods for assigning a measure of risk to user activities.<br>- Formulate new access control mechanisms that manage the cumulative risk associated with user actions.<br>- Expand RMAC concepts to encompass possible approaches to multi-level security. | | | |
| ***Title:*** Cross-Layer Network Security<br><br>***Description:*** The Cross-Layer Network Security project will develop novel approaches for enhanced network security that involve multiple networked layers. This is in contrast to traditional approaches to network security that operate within a single layer, for example, standard Internet Protocol security is implemented in the network layer. Cross-layer approaches for wireless networks can exploit emerging path diversity technologies to introduce route diversity as a mechanism to counter eavesdroppers/jammers and compromised/malicious network nodes. These approaches have potential benefit for mobile ad-hoc networks and distributed sensor networks in adversarial wireless environments. Cross-layer approaches also hold promise for enhanced security for overlay networks and as the basis for new classes of virtual networks that provide security services. These could enable, for example, the capability to maintain quality of service through distributed denial of service attacks.<br><br>***FY 2012 Plans:***<br>- Conceptualize cross-layer approaches for enhanced security in wireless networks based on information-theoretic results in the areas of secrecy-capacity and secure broadcast channels.<br>- Develop schemes that exploit path and route diversity technologies across the physical, data link, network, and transport layers.<br>- Formulate new types of overlay/virtual networks that provide security-related services such as privacy and robust availability. | - | - | 4.667 |
| **Accomplishments/Planned Programs Subtotals** | - | - | 16.667 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>CYS-01: *CYBER SCIENCES* |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

TBD

**E. Performance Metrics**

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>ES-01: *ELECTRONIC SCIENCES* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ES-01: *ELECTRONIC SCIENCES* | 49.586 | 73.023 | 46.109 | - | 46.109 | 30.413 | 33.876 | 33.876 | 31.876 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Focus Center Research Program (FCRP)*<br><br>***Description:*** *Formerly Semiconductor Technology Focus Centers.<br><br>The Focus Center Research Program (FCRP) is a collaborative effort between the Defense Advanced Research Projects Agency (DARPA) and the semiconductor industry to concentrate research attention and resources to provide radical innovation in semiconductor technology. The program focuses on discovery research to provide solutions to barrier problems in the path of sustaining the historical productivity growth and performance enhancement of semiconductor integrated circuits. The overall goals of this collaborative effort between the DoD and industry is to sustain the unprecedented four decades of uninterrupted performance improvement in information processing power and fundamentally change the design cycle of electronic systems.<br><br>***FY 2010 Accomplishments:***<br>- Discovered new state of matter, the topological insulator, which is simultaneously an insulator and a special type of metal.<br>- Grew first III-V nanolaser monolithically on silicon.<br>- Demonstrated for the first time, nanoelectromechanical relay circuits with zero standby power.<br>- Demonstrated a record setting W-Band amplifier in IBM 45nm Silicon-on-Insulator (SOI) process with 15 db gain and less than 6 db Noise Figure at 85 GHz, at a power consumption of ~25 mW. | 20.400 | 20.400 | 20.400 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Continued to develop innovative approaches to the design and fabrication of scaled devices, circuits, and microsystems within multi-investigator based research consortia.<br>- Initiated a new center in the area of design of information systems across multiple spatial and temporal scales.<br>***FY 2011 Plans:***<br>- Design, synthesize, assemble and integrate materials on the nanoscale to enable extensible information processing systems.<br>- Conceive and explore paths to overcome the limits of Silicon Complementary metal-oxide semiconductor (CMOS) scaling on the continuing evolution of electronics.<br>- Discover and invent new electrical, optical, and thermal interconnect solutions that will meet or exceed International Technology Roadmap for Semiconductors (ITRS) projections and enable hyper-integration of heterogeneous components for future terascale systems.<br>- Invent the circuits that sustain exponential increase in computing performance by exploiting the full capabilities of existing technologies.<br>- Design (hardware and software) and demonstrate utilization (programming and interfacing) of information system platforms for defense applications.<br>- Create a comprehensive and systematic solution to the distributed multi-scale system design challenge.<br>***FY 2012 Plans:***<br>- Continue to leverage industry funding for efforts, maintain formal and informal coupling and industry-based research for development and transition of technologies.<br>- Transition innovative concepts developed with the university program to provide novel capabilities for DoD microelectronics systems. | | | |
| ***Title:*** Quantum Entanglement Science and Technology (QuEST)<br>***Description:*** The Quantum Entanglement Science and Technology (QuEST) program is exploring the research necessary to create new technologies based on quantum information science. Technical challenges include loss of information due to quantum decoherence, limited communication distance due to signal attenuation, protocols, and larger numbers of quantum bits (Qubits) and their entanglement. A key challenge is to integrate improved single and entangled photon and electron sources and detectors into quantum computation and communication networks. Error correction codes, fault tolerant schemes, and longer decoherence times will address the loss of information. Expected impacts include highly secure communications, algorithms for optimization in logistics, highly precise measurements of time and position on the earth and in space, and new image and signal processing methods for target tracking.<br>***FY 2010 Accomplishments:*** | 8.803 | 15.946 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>ES-01: *ELECTRONIC SCIENCES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Continued fundamental research in the area of quantum information.<br>- Developed novel approach to improving decoherence times.<br>- Demonstrated novel quantum algorithms.<br>***FY 2011 Plans:***<br>- Continue fundamental research in the area of quantum information.<br>- Characterize and manipulate entangled quantum systems. | | | |
| ***Title:*** N/MEMS Science and Focus Centers<br>***Description:*** The goal of the N/MEMS Science and Focus Centers program is to support the development of an enhanced fundamental understanding in a number of technical issues considered to be critical to the continuing advance of nanoelectromechanical systems (NEMS) and microelectromechanical systems (MEMS) technologies and their transition into military systems. The basic research being conducted on the program is responsive to recognized challenges in a comprehensive range of technical areas pertinent to future DoD needs. Industrial cost sharing is an important element of the program, with industry matching DARPA resources on a 1:1 basis.<br>***FY 2010 Accomplishments:***<br>- Initiated the second phase of the program, which supports research efforts at seven university centers. Overall, the program supports work at more than 20 participating universities and involves cost-sharing by approximately 40 industry partners.<br>- Completed studies to develop integrated nano/microfluidic components for new medical diagnostic platforms.<br>- Demonstrated GaN optoelectronic nanowires and associated materials properties with silicon complimentary metal-oxide semiconductor (CMOS) substrates demonstrating the potential of heterogeneous integrated opto-electronic-MEMS systems.<br>***FY 2011 Plans:***<br>- Develop and integrate new technologies such as atomic layer deposition (ALD) for realizing full nano/microsystems with sensors, electronic signal processing, energy, and communications on a common chip.<br>- Develop real human sample clean-up and pre-processing strategies for microfluidic diagnostic chips.<br>- Continue studies of materials and interfaces leading to the realization of new, low-cost, and fully integrated infrared sensors and optical signal-processing elements.<br>***FY 2012 Plans:***<br>- Demonstrate an integrated microsystem driver with ALD/Molecular Layer Deposition (MLD)-sealed nanowire/graphene NEMS powered by an embedded battery charged by an embedded solar cell. | 3.741 | 7.035 | 2.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate emerging advanced guided self-assembly processes for integration of 3-D microsystems onto unconventional substrates and their application to an intraocular multi-sensor. | | | |
| ***Title:*** Nanoscaled Architecture for Coherent Hyper-Optic Sources (NACHOS)<br><br>***Description:*** The objective of the Nanoscaled Architecture for Coherent Hyper-Optic Sources (NACHOS) program is to demonstrate sub-wavelength semiconductor lasers by leveraging recent developments in reduced dimensionality and advanced feedback concepts. The specific program goal is to demonstrate Continuous Wave injection lasers operating at room temperature with cavity dimensions smaller than the vacuum wavelength of light they generate, wavelength < 1.5 micrometers. Nanoscale lasers will enable close integration of photonic and electronic devices needed in emerging high-speed processing-intense computing and communication platforms. In addition to reduced size, these lasers are expected to be power-efficient and offer unprecedented modulation bandwidth. New capabilities, such as the ability to place large numbers of lasers on silicon chips, will be enabled by these devices.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated sub-wavelength lasers.<br>- Determined threshold gain under injection.<br><br>***FY 2011 Plans:***<br>- Demonstrate room temperature sub-wavelength laser operating at 1.55 microns in continuous mode.<br><br>***FY 2012 Plans:***<br>- Increase power level to be greater than 1mW. | 1.689 | 5.689 | 2.103 |
| ***Title:*** Tip-Based Nanofabrication (TBN)<br><br>***Description:*** The Tip-Based Nanofabrication (TBN) program will develop the capability to use Atomic Force Microscope (AFM) cantilevers and tips to controllably manufacture nano-scale structures such as nanowires, nanotubes, and quantum dots for selected defense applications. These applications include optical and biological sensors, diode lasers, light emitting diodes, infrared sensors, high density interconnects, and quantum computing.<br><br>***FY 2010 Accomplishments:***<br>- Fabricated multi-tip arrays (5 tips) for parallel manufacturing of locally-controlled nanostructures.<br>- Demonstrated repeatable processes for fabrication of nanowires, quantum dots and other nanostructures with the ability to intentionally fabricate structures with different dimensions or other characteristics side-by-side.<br>- Identified a specific nano-device, a Kane Q-bit, to use as the objective for all future TBN metrics and activities.<br><br>***FY 2011 Plans:*** | 5.895 | 11.618 | 4.606 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>ES-01: *ELECTRONIC SCIENCES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Fabricate a 30-tip array and an associated tool and manufacturing process.<br>- Demonstrate operation of multi-tip arrays over extended periods of time for use in manufacturing complex components.<br>- Demonstrate precision and control of the process and functionality of the resulting devices.<br>- Develop semiconducting nanowires, graphene ribbons, quantum dots, q-bits, carbon nanotubes and other structures for specific device applications.<br>***FY 2012 Plans:***<br>- Use TBN-developed semiconducting nanowires, graphene ribbons, quantum dots, carbon nanotubes and other structures to build devices such as a single-electron transistor or Kane qu-bit. | | | |
| ***Title:*** Optical Radiation Cooling and Heating in Integrated Devices (ORCHID)<br>***Description:*** The objective of the Optical Radiation Cooling and Heating in Integrated Devices (ORCHID) program is to leverage advances in photonics and micro-fabrication to develop integrated chips capable of exploiting quantum optomechanical applications. Although light is usually thought of as carrying energy but relatively little momentum, light confined to a high-finesse cavity can exert significant force on the cavity mirrors. When the mirror is allowed to vibrate by coupling it to a mechanical (spring-like) system, energy can be transferred between coupled optomechanical resonators. Depending on the detuning of the cavity, one can obtain either damping (cooling) or amplification (heating) of the mirror motion. Notable achievements in this field are the demonstration of mirror cooling (damping of the internal degree of motion) to sub-Kelvin (6 mK) temperatures and demonstration of radiation driven high-Q, high-frequency (1 GHz) oscillators. With sufficiently high cavity finesse and Q's of the mechanical system, it is possible to reach a regime in which the mirror motion is no longer thermally limited. Instead, it becomes limited by the quantum mechanical radiation pressure force. Once this limit is reached, it is possible to take advantage of quantum mechanical effects without having to cool the system. It is anticipated this will result in a new generation of mass-sensing devices and ultra high-Q, high-frequency resonators controlled by light. In optical systems, it will be possible to efficiently squeeze light beyond the standard shot-noise limit producing light sources for infrared detection and quantum information applications.<br>***FY 2010 Accomplishments:***<br>- Demonstrated resonant frequency of 10 megahertz (MHz).<br>- Demonstrated Mechanical Q of 1x10^6.<br>***FY 2011 Plans:***<br>- Demonstrate cavity finesse of 1x10^5.<br>- Demonstrate mirror effective mass of 1 nanogram.<br>- Demonstrate resonant frequency of 100 MHz. | 3.411 | 5.263 | 1.500 |

| **Exhibit R-2A, RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>ES-01: *ELECTRONIC SCIENCES* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Demonstrate Mechanical Q of 1x10^7.<br><br>***FY 2012 Plans:***<br>- Demonstrate an opto-mechanical oscillator with frequency > 10 GHz.<br>- Demonstrate an optical switch with switching time < 100 ns.<br>- Demonstrate conditional squeezing between transmitted light and mechanical element.<br>- Demonstrate an opto-mechanical mass sensor with 10 zeptogram sensitivity. | | | |
| ***Title:*** Centers for Integrated Photonics Engineering Research (CIPhER)<br><br>***Description:*** The Centers for Integrated Photonics Engineering Research (CIPhER) program will explore and enhance fundamental understanding in the development and application of integrated photonics, in which an entire photonic system is fabricated on a single chip. Much like integrated electronics, integrated photonics has the potential to enable photonics systems to reach revolutionary new levels of performance and functionality, but with a wider application range than electronics, including such areas as imaging, energy conversion, signal processing, and computing. The rise of integrated photonics as a viable, practical technology, combined with the utility of integrated photonics to many applications, is slated to result in a more rapid transition of basic photonics research to system applications of importance to the DoD. As such, photonics research that is supported by organizations with both fundamental and commercial interests is ideally suited to fostering the growth of the nation's integrated photonics industry. The CIPhER program will therefore use a government/industrial cost-share funding model to foster the next generation of fundamental university-based photonics research. The CIPhER program is directed toward achieving this objective through the establishment of collaborative theme-based focus centers. Focus centers will be comprised of university-led teams, with industrial partners, engaged in long-term basic research of photonic materials, devices, and microsystems.<br><br>***FY 2010 Accomplishments:***<br>- Initiated the development and investigation of new integrated photonics concepts for application to microsystems in: Imaging Science and Technology, Energy Conversion and Manipulation, Chip-scale Signal Processing and Computing, and Chemical/ Biological Sensing and Processing.<br><br>***FY 2011 Plans:***<br>- Exploit scaling and enhanced fabrication techniques to refine and continue development of novel integrated photonics concepts for the range of application domains.<br>- Begin to transfer through direct industrial collaborative interactions those elements that are ready for further development toward applications. | 4.367 | 7.072 | - |
| ***Title:*** Advanced X-Ray Integrated Sources (AXIS) | - | - | 5.500 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The objective of the Advanced X-Ray Integrated Sources (AXIS) program is to greatly reduce the size, weight and power of tunable X-ray sources while dramatically increasing their electrical efficiency through application of microscale engineering technologies such as MEMS and NEMS. Such imaging modalities should speed reverse engineering of integrated circuits to validate trustworthiness as well as contrast-free battlefield imaging of blood vessel injuries in blunt trauma.<br><br>The Basic Research component of this effort will focus on defining the fundamental science necessary for the creation of compact and highly efficient synchrotron X-ray sources. These sources may lead to future developments in the tunable imaging field. This program also has efforts funded in PE 0602716E, Project ELT-01.<br><br>***FY 2012 Plans:***<br>- Define physical limitations for designing compact energy efficient X-ray sources. | | | |
| ***Title:*** Diverse & Accessible Heterogeneous Integration (DAHI) | - | - | 7.000 |
| ***Description:*** Prior DARPA efforts have demonstrated the ability to monolithically integrate inherently different semiconductor types to achieve near-ideal "mix-and-match" capability for DoD circuit designers. Specifically, the Compound Semiconductor Materials On Silicon (COSMOS) program, in which transistors of Indium Phosphide (InP) can be freely mixed with Silicon complementary metal-oxide semiconductor (CMOS) circuits to obtain the benefits of both technologies (very high speed and very high circuit complexity/density, respectively). The Diverse & Accessible Heterogeneous Integration (DAHI) effort will take this capability to the next level, ultimately offering the seamless co-integration of a variety of semiconductor devices (e.g., GaN, InP, GaAs, ABCS), microelectromechanical (MEMS) sensors and actuators, photonic devices (e.g., lasers, photo-detectors) and thermal management structures. This capability will revolutionize our ability to build true "systems on a chip" (SoCs) and allow dramatic size, weight and volume reductions for a wide array of system applications.<br><br>The Basic Research part of this effort will focus on the development of new hetero-integration processes and capabilities that if successful will ultimately be demonstrated in application specific circuits and transferred into the manufacturing flow. This program also has applied research efforts funded in PE 0602716E, Project ELT-01.<br><br>***FY 2012 Plans:***<br>- Explore heterogeneous integration of novel, emerging materials and devices.<br>- Develop new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices. | | | |
| ***Title:*** Microscale Plasma Devices | - | - | 3.000 |

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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>ES-01: *ELECTRONIC SCIENCES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Microscale Plasma Devices program will develop microscale plasma devices for the efficient, high pressure (up to or even including atmospheric pressure) generation of ions, radiofrequency energy, and light sources. Applications for such devices are far reaching, including the construction of complete high-frequency logic circuits, and integrated circuits with superior resistance to radiation and extreme temperatures.<br><br>The Basic Research part of this effort will focus on microelectronic interconnects necessary for operating plasma devices at elevated pressures. This program also has efforts funded in PE 0602716E, Project ELT-01.<br><br>***FY 2012 Plans:***<br>- Identify requirements for maintaining long-term internal atmospheric conditions appropriate for plasma and hard-vacuum devices. | | | |
| **Accomplishments/Planned Programs Subtotals** | 48.306 | 73.023 | 46.109 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** Laboratory for Advanced Photonic Composites Research<br>***FY 2010 Accomplishments:*** - Initiated laboratory research in photonic composites. | 1.280 | - |
| **Congressional Adds Subtotals** | 1.280 | - |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| APPROPRIATION/BUDGET ACTIVITY | R-1 ITEM NOMENCLATURE | PROJECT |
|---|---|---|
| 0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | PE 0601101E: *DEFENSE RESEARCH SCIENCES* | MS-01: *MATERIALS SCIENCES* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MS-01: *MATERIALS SCIENCES* | 69.677 | 89.854 | 97.506 | - | 97.506 | 78.019 | 75.450 | 76.824 | 78.824 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Nanoscale/Bio-inspired and MetaMaterials | 9.255 | 9.567 | 8.000 |
| ***Description:*** The research in this thrust area exploits advances in nanoscale and bio-inspired materials, including computationally based materials science, in order to develop unique microstructures and material properties. This area also includes efforts to develop the underlying physics for the behavior of materials whose properties have been engineered at the nanoscale level (metamaterials) and materials exhibiting a permanent electric charge (charged matter).<br><br>***FY 2010 Accomplishments:***<br>- Developed new material compositions with optical transmission comparable to spinel and doubled mechanical strength, and thermal shock capabilities over single crystal sapphire.<br>- Initiated fabrication of new materials into hemispherical domes with decreased optical scatter, doubled mechanical strength, and doubled thermal shock capabilities over single crystal sapphire.<br>- Characterized the material properties of nano-crystalline dome materials through testing in relevant military environments.<br>- Demonstrated understanding of biophotonic structure/function relationship and design requirements for index/structure actuation.<br>- Demonstrated initial design and fabrication of biophotonic structures.<br>- Initiated development of the capability to compute material properties as a function of the microstructural architectural parameters that govern them, and the extent to which material properties can be modified through the manipulation of these parameters.<br><br>***FY 2011 Plans:***<br>- Identify the strength-limiting flaws in nano-composite optical ceramics through fractographic analysis and relate to processing conditions.<br>- Demonstrate control of fabrication of biophotonic structures.<br>- Demonstrate physical and/or chemical activation of biophotonic structures.<br>- Identify expected physical (and/or chemical) sensitivity in terms of reflectance change noted (percent change in reflectance/Volt, percent change in reflectance/molecule adsorbed). | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>MS-01: *MATERIALS SCIENCES* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Initiate establishment of experimental fabrication methodologies with level of control needed to produce the materials with architectural features necessary to exhibit predicted properties.<br>- Demonstrate by computation that selected properties may be independently manipulated as a function of identified architectural parameters, to a regime currently unachievable.<br>- Demonstrate fabrication methodologies to create the microstructural features with level of control predicted through computation necessary to achieve superior structural/functional properties.<br>***FY 2012 Plans:***<br>- Initiate fabrication of materials with architectural features necessary to exhibit predicted properties.<br>- Experimentally characterize effects of varying architectural features on selected material properties.<br>- Perform sensitivity analyses to develop and validate optimization algorithms for material properties.<br>- Initiate development of multidimensional architecture-to-property design space fabrication of materials with architectural features necessary to exhibit predicted properties. | | | |
| ***Title:*** Fundamentals of Nanoscale and Emergent Effects and Engineered Devices<br>***Description:*** The Fundamentals of Nanoscale and Emergent Effects and Engineered Devices program seeks to understand and exploit physical phenomena for developing more efficient and powerful devices. This includes developing devices and structures to enable controllable photonic devices at multiple wavelengths, engineering palladium microstructures with large deuterium loadings to study absorption thermodynamics and effects, enabling real-time detection as well as analysis of signals and molecules and origin of emergent behavior in correlated electron devices. Arrays of engineered nanoscale devices will result in an order of magnitude (10 to 100 times) reduction in the time required for analysis and identification of known and unknown (engineered) molecules. This program will develop novel nanomaterials for exquisitely precise purification of materials, enabling such diverse applications as oxygen generation and desalination, ultra-high sensitivity magnetic sensors, and correlated electron effects such as superconductivity. This program will compare the phenomenology of various biological, physical and social systems and abstract the common features that are responsible for their properties of self-organization and emergent behavior.<br>***FY 2010 Accomplishments:***<br>- Demonstrated, in a laboratory environment, low power room temperature single magnetic sensors based on atomic vapor cell magnetometry and on multiferroic composites with sensitivities of 100 femtotesla root mean square (rms) per square root hertz (the earth's magnetic field strength varies with location between 30 to 60 microtesla, by comparison).<br>- Demonstrated an array of magnetic sensors with an overall sensitivity of 1 picotesla rms per square root hertz based on multiferroic composites at a frequency of 1 hertz.<br>- Demonstrated an array of magnetic sensors with an overall sensitivity of 1 picotesla rms per square root hertz based on atomic vapor cell magnetometry at a frequency of 1 hertz. | 13.790 | 16.745 | 15.308 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>MS-01: *MATERIALS SCIENCES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|

- Evaluated a broad array of natural phenomena and associated theories addressing the spontaneous creation of structure in the natural world, particularly from fields of thermodynamics, evolution, information, and computation.
- Investigated candidate electronic and chemical systems that are capable of self-organizing when placed in a complex environment; used computer simulation to select/refine/improve the candidate systems for further development.
- Developed initial analytical tools to measure physical intelligence, and show how these tools relate the activities of a physically intelligent entity to the environment in which it exists.
- Quantified the effects of the substrate material composition and microstructure on deposited palladium particle size; and their effects on the capability to generate excess heat collaboratively with Italian Department of Energy.
- Quantified the required dynamic loading and relaxation conditions for high surface area palladium foils required to achieve high levels of deuterium loading that will tolerate the stresses associated with these conditions in collaboration with the Italian Department of Energy.

***FY 2011 Plans:***
- Demonstrate a 50% yield for the fabrication of the magnetic sensors based on multiferroic composites, in a lot size of 10 units which have outputs (volt/tesla values) within a ± 10 percent of the specification.
- Demonstrate a 50% yield for the fabrication of the magnetic sensors based on atomic vapor cells, in a lot size of 10 units which have outputs (volt/tesla values) within a ± 10 percent of the specification.
- Demonstrate a multiferroic magnetic sensor with an optical circuit read-out.
- Create an initial version of a unified theory of physical intelligence and show how it is consistent with the established theories on which it was constructed.
- Using a combination of simulation and real system hardware, conduct a limited demonstration of a physical intelligent electronic or chemical system imbedded in an environment of limited complexity.
- Evaluate the initial physical intelligence theory's ability to describe the candidate electronic and chemical systems.
- Refine analytical tools to measure intelligence and demonstrate them on complex, real world systems and their associated data (e.g., biological networks, internet traffic).
- Develop more complex demonstrations and extend the theoretical and analytical tools to more complex systems.
- Quantify material parameters that control degree of increase in excess heat generation and life expectancy of power cells in collaboration with the Italian Department of Energy.

***FY 2012 Plans:***
- Demonstrate a fieldable magnetic sensor using multiferroic composite structures with a sensitivity of 0.1 femtotesla rms per square root hertz at a frequency of 1 hertz.
- Demonstrate a fieldable magnetic sensor using atomic vapor cells with a sensitivity of 0.1 femtotesla rms per square root hertz at a frequency of 1 hertz.

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601101E: *DEFENSE RESEARCH SCIENCES* | **PROJECT**<br>MS-01: *MATERIALS SCIENCES* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Design a magnetic field gradient imaging array with elements that have sensitivities of 0.1 femtotesla rms per square root hertz for use in imaging low-frequency magnetic anomalies.<br>- Verify the initial unified physical intelligence theory and justify its underlying assumptions in the context of a model system that supports the emergence and evolution of novel structure.<br>- Expand the theoretical effort to address correlated effects such as self-organized criticality renormalization, scaling, and punctuated equilibrium.<br>- In real electro-chemical-physical systems that may include selected human interventions, demonstrate the spontaneous, abiotic evolution in any one of: biopolymers targeted against trace biochemical features in the environment; hydrocarbons from atmosphere, H2O, and sunlight in the environment; electrical networks that route information/energy to solve thermodynamic problems imposed by the structure of the environment; spontaneous information association capability (e.g. holography) in physical or chemical systems near a phase transition or other critical state in the presence of complex spatial/temporal electromagnetic and optical environments; complex spatial and temporal organization of non-equilibrium chemical reactions that are coupled to complex, adaptive electronic systems.<br>- Demonstrate the ability to design an evolving electro-chemical-physical system and direct its evolution toward human-specified objectives.<br>- Quantify the emergent structures that evolve from the demonstrated electro-chemical-physical systems.<br>- Establish scalability and scaling parameters in excess heat generation processes in collaboration with the Italian Department of Energy. | | | |
| ***Title:*** Atomic Scale Materials and Devices<br><br>***Description:*** This thrust examines the fundamental physics of materials at the atomic scale in order to develop new devices and capabilities. A major emphasis of this thrust is to provide the theoretical and experimental underpinnings of a new class of semiconductor electronics based on spin degree of freedom of the electron, in addition to (or in place of) the charge. A new all optical switch capability will also be investigated. It includes a new, non-invasive method to directly hyperpolarize biological tissues, leading to novel quantitative neurodiagnostics. Research on the basic physics and scaling of ionospheric processes utilizing the High Frequency Active Auroral Research Program (HAARP) transmitter will also be explored. New materials and prototype devices will be developed to demonstrate a new class of optoelectronics that operate with ultra-low energy dissipation (~100 atom-Joules (aJ)/operation).<br><br>***FY 2010 Accomplishments:***<br>- Developed spin gradient thermometry and demagnetization cooling techniques in ultracold atoms in an optical lattice.<br>- Demonstrated a quantum gas microscope capable of imaging individual atoms in a 2-D optical lattice. | 13.546 | 15.030 | 6.680 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Emulated a frustrated quantum spin model using ion crystal array in three hours, confirming theoretical calculations to better than 92%.<br>- Demonstrated an initial zeno-based switch using slot waveguides coated or filled with organic nonlinear absorptive materials.<br>- Created a photonic crystal zeno mirror and waveguide with cavity Q > 1000, and loss < 0.1 Decibel (dB).<br>- Generated and focused X-rays with specific state(s) of orbital angular momentum.<br>***FY 2011 Plans:***<br>- Demonstrate production of antiferromagnetically ordered states in 2-D and 3-D optical lattices.<br>- Study and characterize supersolid behavior in multi-spin Bose condensates.<br>- Produce phase diagrams of frustrated 2-D antiferromagnet in less than twelve hours.<br>- Produce phase diagrams of 2-D Fermi-Hubbard model at near half-filling; determine presence or absence of superconducting phase.<br>- Demonstrate all-optical switch (or equivalent device) based on optically-induced absorption.<br>- Demonstrate total energy dissipation for an optical switch (or equivalent device) of less than 1 femtojoules per operation, and signal loss of less than 0.1 dB, excluding waveguide losses before and after device.<br>- Demonstrate hyperpolarization of biologically relevant liquids, using photons with orbital angular momentum and measure the hydrogen and carbon-13 polarization.<br>- Obtain hydrogen and carbon-13 spectra from biologically relevant liquid sample using quantum orbital resonance spectroscopy.<br>***FY 2012 Plans:***<br>- Load polar molecules into optical lattices to study long range character and ordering inside the optical lattice.<br>- Demonstrate all-optical switch (or equivalent device) based on optically-induced absorption for a 25 nm range in input wavelength.<br>- Demonstrate total energy dissipation for an optical switch (or equivalent device) of less than 100 attojoules per operation, and signal loss of less than 0.05 dB, excluding waveguide losses before and after device. | | | |
| ***Title:*** Basic Photon Science<br>***Description:*** Initiated under the fundamentals of nanoscale Devices effort, the Basic Photon Science thrust is examining the fundamental science of photons, from their inherent information carrying capability (both quantum mechanically and classically), to novel modulation techniques using not only amplitude and phase, but also orbital angular momentum. The new capabilities driven by this science will impact DoD through potentially novel approaches to communications and imaging applications, in addition to better understanding the physical limits of such advancement. For example, fully exploiting the computational imaging paradigm and associated emerging technologies to yield ultra-low size, weight, and power persistent/multi-functional intelligence, surveillance, and reconnaissance systems that greatly enhance soldier awareness, capability, security, and survivability. | - | 12.000 | 21.500 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2011 Plans:***<br>- Investigate the theoretical and practical limits to the information content of a single photon via rigorous application of information theory.<br>- Investigate the utility of information theoretic approach for design and improved receivers for high data rate communications.<br>- Investigate the utility of information theoretic approach for improved low-light level imaging.<br>- Develop the basic science required for the exploitation of orbital angular momentum in both the classical and quantum realms.<br>- Identify fundamental limits of computational imaging by quantifying the space of cost and performance.<br>- Develop the mathematical tools required to facilitate the joint optimization of physical and computational degrees of freedom.<br>***FY 2012 Plans:***<br>- Investigate the practical limits to the information content of a single photon via inclusion of various real-world imperfections.<br>- Demonstrate the utility of information theoretic approach via highly photon efficient communications.<br>- Demonstrate the utility of information theoretic approach via improved low-light level imaging.<br>- Demonstrate the benefit of orbital angular momentum for communications applications.<br>- Characterize surfaces of constant performance in the space of camera cost factors including optics, focal planes, and computation.<br>- Study the fundamental limits of wafer scale optical fabrication and the capabilities of in situ 3-D optical metrology.<br>- Investigate novel non-imaging measurements enabled by 3-D design and fabrication.<br>- Develop a collection of candidate computational camera designs that yield high performance and low size, weight and power. | | | |
| ***Title:*** Enabling Quantum Technologies<br>***Description:*** This thrust emphasizes a quantum focus on technology capabilities including significantly improved single photon sources, detectors, and associated devices useful for quantum metrology, communications, and imaging applications. In addition, this thrust will examine other novel classes of materials and phenomena such as plasmons or Bose-Einstein Condensates (BEC) that have the potential to provide novel capabilities in the quantum regime, such as GPS-independent navigation via atom interferometry and communications, and ultrafast laser technologies.<br>***FY 2010 Accomplishments:***<br>- Designed and modeled two hybrid quantum interfaces that use ultracold atoms as magnetic sensors for nuclear spins and strongly-correlated materials.<br>- Designed a mechanical interface to transfer quantum information with high fidelity between optical and microwave photons.<br>***FY 2011 Plans:*** | 4.000 | 6.000 | 14.000 |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Design a physics package for an optical clock including lasers, optomechanics, associated electronics, and environmental isolation and control subsystems.<br>- Determine the mechanical stability of doped-crystal Fabry-Perot optical cavities for use in time and frequency transfer between optical clocks.<br>- Investigate techniques to improve the coherence properties of nitrogen-vacancy (NV) diamond nanocrystals for use in high resolution magnetometry.<br><br>***FY 2012 Plans:***<br>- Trap single atoms near the surface of a metal nanotip. Demonstrate coherent readout and control of atomic state.<br>- Investigate Doppler-free two photon transitions in atomic vapor cells for use as an optical frequency standard.<br>- Demonstrate coherent transfer of classical information between optical and microwave fields via a nanomechanical interface.<br>- Demonstrate an entangled/squeezed quantum sensor that operates below the standard quantum limit.<br>- Demonstrate a magnetometer with sensitivity 0.1 nanotesla/square root hertz with < 2 micron resolution.<br>- Investigate the feasibility of high average power, ultrafast laser architectures suitable for high throughput industrial micromachining.<br>- Explore schemes extending frequency combs from the extreme UV into the medium wavelength infrared (MWIR) and long wavelength infrared (LWIR) spectral regimes for applications of interest to the DoD.<br>- Examine the utility of robust, compact attosecond probes for real-time control of atomic excitations, valence electron dynamics, and transport phenomena in ultra dense matter.<br>- Expand the use of analog quantum simulators to the study of nonlinear optical materials and nuclear systems.<br>- Develop technologies to enable physically separated parties to securely generate identical one-time pad pairs at Gigabit per second (Gb/s) rates.<br>- Develop and demonstrate scalable architecture, capable of extending the range of quantum communications from 100 km to 5000 km. | | | |
| ***Title:*** Fundamentals of Physical Phenomena*<br><br>***Description:*** *Previously included in Fundamentals of Nanoscale and Emergent Effects and Engineered Devices, and Atomic Scale Materials and Devices.<br><br>This thrust will obtain insights into physical aspects of natural phenomena such as magnetospheric sub-storms, fire, lightning, and geo-physical phenomena. A major emphasis of this thrust is to provide predictive models for the interactions between plasmas and electromagnetic waves across a range of energy and length scales, and into new regimes. Specific projects that fall under this heading are foundational studies on: the initiation, propagation, and attachment of lightning, and their associated emissions; | 6.570 | 9.712 | 10.018 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| the critical factors affecting magnetospheric sub-storms; the generation and amplification of extremely low frequency (ELF)/ultra low frequency (ULF)/very low frequency (VLF) radiation in the ionosphere utilizing the High Frequency Active Aural Research Program (HAARP) transmitter; and understanding and quantifying the interaction of electromagnetic and acoustic waves with the plasma in flames.<br><br>***FY 2010 Accomplishments:***<br>- Initiated a series of HAARP experimental campaigns to study ionospheric and trans-ionospheric phenomena, including: optimization of high frequency to very low frequency conversion efficiency, wave-particle interaction, generation and propagation of ultra low frequencies, very low frequencies and artificial ducts, triggering and characterization of specific ionospheric instabilities.<br>- Developed theoretical models for triggered lightning, transient luminous events, lightning-induced electron precipitation and related ionospheric phenomena.<br>- Developed theoretical models for lightning initiation, propagation, and attachment.<br>***FY 2011 Plans:***<br>- Conduct a comprehensive series of ELF/ULF/VLF generation experiments to study the efficiency of density pre-conditioning.<br>- Characterize ionospheric current drive (ICD), artificially stimulated emissions in the ionosphere, and ionospheric turbulence and associated scintillations.<br>- Equip at least two facilities capable of launching rockets every thirty seconds in order to trigger lightning and measure all associated phenomena, including the initiation, propagation, attachment processes as well as all associated emissions such as gamma rays, RF and high power electromagnetic pulse.<br>***FY 2012 Plans:***<br>- Conduct comprehensive HAARP-ULF experiments to study the onset of noise under a variety of space-weather conditions.<br>- Conduct a series of experiments to inject VLF waves into artificial ducts.<br>- Develop, implement and test a continuously-operational, extensive array of instruments which will measure all atmospheric and electromagnetic components of tropospheric lightning and correlate this phenomenon with various ionospheric events.<br>- Deploy balloons into thunderstorms to make in-situ electric field, X-ray and gamma-ray measurements.<br>- Develop and deploy a constellation of receivers to study the radio emissions generated by lightning and associated ionospheric events. | | | |
| ***Title:*** MesoDynamical Architectures (Meso)*<br><br>***Description:*** *Formerly Dynamics-Enabled Frequency Sources (DEFYS). | 8.889 | 20.000 | 22.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| The MesoDynamical Architectures (Meso) program will enable a new generation of sensing, communication, and computation by exploiting quantum collective behaviors. The program will achieve beyond-classical functionality in a number of devices and technologies, including transistors, broadband detectors, and high-efficiency thermal conductors. The majority of devices are expected to involve intrinsic (meso) scales in the nanometer to micrometer range and operate at room temperature. The program will exploit the recently discovered topologically insulating state of matter and use mechanisms in four related thrusts: the strong nonlinearities and fluctuations inherent to the mesoscale, quantum collective behaviors, efficient information transduction between fields and excitations (acoustic, electric, and optical), and coherent feedback control. This program also incorporates recent advances in very small mechanical systems, nonlinear dynamics, and noise management to revolutionize performance of reference oscillators. Since oscillators are a building block of modern electronics any uncertainty in frequency they produce will limit performance of the larger system including: radars, communications, sensors and geo-positioning devices. The exotic and novel devices enabled will provide new opportunities in both the military and commercial sectors.<br><br>***FY 2010 Accomplishments:***<br>- Initiated program with focus on exploiting nonlinear mechanisms to reduce oscillator phase noise.<br>- Completed device designs and simulations.<br>- Completed initial designs for maintaining performance in high acceleration/vibration environments.<br>- Determined approaches for maintaining performance over a large temperature range.<br>- Completed design for an optical coherent feedback controller and began building architecture for single controller demonstration.<br>- Completed designs for two new devices based on collective coherence: Topological Quantum Interference Device and high-density, low power magnetic memory.<br><br>***FY 2011 Plans:***<br>- Demonstrate performance improvements by exploiting nonlinear mechanisms.<br>- Complete designs and simulations for using noise shaping to further reduce phase noise.<br>- Improve acceleration and vibration tolerance.<br>- Improve temperature stability.<br>- Meet device size requirement.<br>- Demonstrate first generation of devices in the nonlinearity and fluctuation thrusts maintain performance despite acceleration/vibrations and temperature variations.<br>- Define spectrum of devices to be produced in collective coherence, information transduction, and control thrusts.<br>- Complete initial designs and simulations of devices in all thrusts.<br><br>***FY 2012 Plans:*** | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Establish background fluctuations that can be tuned to reduce phase noise in high performance frequency sources.<br>- Demonstrate improved vibration insensitivity and temperature stability in 2nd generation of devices of frequency sources.<br>- Provide frequency sources with better than -110 dBc/Hz phase noise, while simultaneously meeting metrics for acceleration and temperature stability.<br>- Determine specific topological insulating devices, simulate architectures, and begin fabrication.<br>- Demonstrate architectures exploiting transduction of signals between light, electricity, and sound.<br>- Realize a quantum controller which provides better than 10 times stability to a coherent state.<br>- Begin to demonstrate the integrability of the prototypes into existing systems. | | | |
| ***Title:*** Surface Enhanced Raman Scattering (SERS) - Science and Technology Fundamentals<br><br>***Description:*** The 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 stand-off 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.<br><br>***FY 2010 Accomplishments:***<br>- Realization of one inch diameter SERS surfaces with enhancement factors of over 10e9.<br>- Understanding of the role of localized radius of curvature on the electromagnetic field enhancement and molecule placement on metal nanoparticles.<br>- Developed the use of non-noble metals to achieve plasmon resonances in the ultraviolet and near-infrared regions.<br>- Used carbon nanotube functionalized Atomic Force Microscopy (AFM) tips to map and spatially correlate "hot spots" on SERS surfaces.<br><br>***FY 2011 Plans:***<br>- Scaling of SERS nanoparticle synthesis approaches compatible with 6 inch active substrates capable of 10e12 enhancements.<br>- Shift laser wavelength (785 nm) to eye-safe near-infrared lasers at 1064 nm and 1530 nm.<br>- Initiate research into micro-fluidic integration of SERS particles for producing sensors capable of sub-part-per-trillion (sub-ppt) explosive vapor detection.<br>- Begin investigation into non-linear optical approaches to increasing enhancement. | 4.547 | 0.800 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Investigate the use of hyper-Raman Scattering and Surface Enhanced Coherent Anti-Stokes Raman for chemical/biological sensor applications. | | | |
| **Accomplishments/Planned Programs Subtotals** | 60.597 | 89.854 | 97.506 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** American Museum of Natural History Infectious Disease Research<br><br>***FY 2010 Accomplishments:*** - Advanced diversity of interaction among different international surveillance and prediction groups to test phylogenetic analysis software program and improve SUPRAMAP system, a web application for integrating genetic, evolutionary, geospatial, and temporal data.<br>- Continued integration of public health and animal surveillance communities to intensify parameters needed for research areas of transition partners.<br>- Advanced integration of proprietary software into programs that are more deeply seated in the global surveillance community. | 1.200 | - |
| ***Congressional Add:*** Institute for Collaborative Sciences Research<br><br>***FY 2010 Accomplishments:*** - Continued investigation of collaborative sciences research. | 2.080 | - |
| ***Congressional Add:*** Advanced Materials Research Institute<br><br>***FY 2010 Accomplishments:*** - Conducted research related to nanoscale engineering of multiferroic materials and tested design of voltage controlled ferromagnetic material for micro- and nano-scale devices.<br>- Investigated chemical synthesis of spinel and perovskite nanostructures with variable architectural complexity.<br>- Developed plans to integrate magnetoelectric composites into functional devices: design, fabrication and testing. | 0.800 | - |
| ***Congressional Add:*** Hydrogen Fuel Cell Research<br><br>***FY 2010 Accomplishments:*** - Initiated innovative research advances into hydrogen fuel cell technology. | 4.000 | - |
| ***Congressional Add:*** Solid Oxide Fuel Technology<br><br>***FY 2010 Accomplishments:*** - Investigated innovative advances into solid oxide fuel technology to reduce the weight and increase the run time of batteries used to power battlefield devices. | 1.000 | - |
| **Congressional Adds Subtotals** | 9.080 | - |

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**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TRS-01: *TRANSFORMATIVE SCIENCES* | - | 41.578 | 30.000 | - | 30.000 | 40.269 | 39.441 | 48.561 | 52.561 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

This project supports scientific research and analysis that leverages converging technological forces and transformational trends in the areas of computing and the computing-reliant subareas of social sciences, life sciences, manufacturing, and commerce in order to improve military adaptation to sudden changes in requirements, threats, and emerging/converging trends, especially trends that have the potential to disrupt military operations. The project has particular interest in custom manufacturing, large-scale, human-centered networks, and cyber-physical systems. Promising research will advance to both technology development and system-level projects.

## B. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Cognitive Cloud* | - | 9.000 | 10.000 |

***Description:*** *Formerly Transformative Sciences

The Cognitive Cloud program develops militarily-relevant basic science as suggested by emerging technological paradigms and societal trends. Two areas in which there is particular interest are "cloud computing" - internet-based, utility computing, and "crowd-sourcing" - large-scale, human-centered networks of web-enabled individuals working towards a unified goal. These will be combined to create solutions for highly complex military problems. Examples of such problems include intelligence, surveillance and reconnaissance of denied areas; modeling foreign societies, governments, and militaries; debugging large, complex software systems; and real-time understanding of activity patterns indicative of imminent cyber-attack. Cognitive Cloud research will combine the strengths of cloud computing (ubiquitous access to information) and crowd-sourcing (the wisdom of the crowd) to enable highly resilient and reactive computing/communication/information systems that respond to and survive attacks. These cloud-based cognitively-enabled cyber defense capabilities will be realized without the imposition of significant bandwidth and/or processing overhead.

***FY 2011 Plans:***
- Explore the use of crowd-sourcing and cloud cognition as the basis for highly sensitive cyber situational awareness and the capability for rapid and massed responses to emergent cyber threats.
- Develop and apply means of using social networking to dramatically improve military situational awareness, not only of the locations of people and installations, but also social maps and leverage points.
- Develop efficient approaches for reactive, adaptable, and survivable wide-area networks and computing systems.

***FY 2012 Plans:***

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate how statistical and quasi-experimental analyses of existing data sets can be used to derive answers to key tactical military questions.<br>- Demonstrate approaches for reactive, adaptable, and agile wide-area networks and computing systems. | | | |
| ***Title:*** Crowd-Sourced Analytics*<br>***Description:*** *Formerly Deep ISR Processing by Crowds<br><br>The Crowd-Sourced Analytics program goes beyond the concept of putting the human in the loop, and instead looks to harness the unique cognitive and creative abilities of large numbers of people to dramatically enhance the knowledge derived from a broad range of sources. This approach is unconventional in that it involves the generation of analysis products based on distributed crowd sourcing across human/machine systems. Novel frameworks will be developed to capture the experience base of users and systems to allow optimum problem partitioning, quantitative confidence assessment, and validation in environments that may be partially compromised by adversaries.<br><br>***FY 2011 Plans:***<br>- Establish analytical framework including problem partitioning and quantitative confidence assessment.<br>- Perform large-scale experimentation and demonstration on sample data sets to quantify performance enhancement.<br>***FY 2012 Plans:***<br>- Develop means for optimum problem partitioning across domains and quantitative confidence assessment under uncertain provenance.<br>- Perform large-scale cross-domain experimentation and demonstration on real data sets to quantify performance enhancement. | - | 7.000 | 8.000 |
| ***Title:*** Production of Knowledge Bases to Bridge Cultural Divides<br>***Description:*** The Production of Knowledge Bases to Bridge Cultural Divides program will develop tools, techniques, and frameworks for the automated interpretation and quantitative analysis of social networks using emerging methods for edge finding and cluster analysis. These systems have important applications in tactical contexts to aid analysts and operators in connecting the dots amid complex, conflicting, and incomplete data sets. They also establish a foundation for cultural intelligence -- understanding the stability, governance, and economic indicators of a region. Beginning in FY 2012 this program is funded under Nexus 7 in PE 0602702E, Project TT-13.<br><br>***FY 2011 Plans:***<br>- Develop mathematical and algorithmic modeling and analysis tools.<br>- Establish baseline performance and demonstration of enhanced analysis using the tools. | - | 9.500 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate automated and semi-automated processes for exploitation of data collected via experimental analyst assistant. | | | |
| ***Title:*** Synthetic Biology<br><br>***Description:*** The Synthetic Biology program will develop and implement a revolutionary approach to the manufacture of bio-based materials that directly support a broad range of military capabilities, such as therapeutics, diagnostics, vaccine development, sensing of chemical/biological agents, production of bio-based fuels and chemicals, remediation of pollutants, and protection of the food supply chain. Synthetic Biology is based on a revolutionary framework for the algorithmic engineering of biological processes, enabling engineered biological systems that are tailored to provide novel solutions and enhancements to military needs and capabilities. Research thrusts include tools for creating synthetic regulatory genetic elements that can be used in mammalian cells, automated process discovery, tool-chain development, bio-foundry development, novel approaches to process measurement and validation, and development of application demonstrations.<br><br>***FY 2011 Plans:***<br>- Design biological host organism concepts.<br>- Design tool-chain framework and workable building blocks for functional outcomes.<br>- Develop synthetic regulatory elements for in vivo biomedical applications to detect threats to health or performance and prevent disease by vaccination.<br>- Initiate development of new materials and synthetic molecular approaches to enable deployable diagnostics.<br><br>***FY 2012 Plans:***<br>- Initiate laboratory development.<br>- Iterate tool-chain framework and building blocks for more efficient functional outcomes. | - | 16.078 | 12.000 |
| **Accomplishments/Planned Programs Subtotals** | - | 41.578 | 30.000 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|

| APPROPRIATION/BUDGET ACTIVITY | R-1 ITEM NOMENCLATURE |
|---|---|
| 0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | - | - | 37.870 | - | 37.870 | 44.676 | 53.500 | 52.500 | 55.500 | Continuing | Continuing |
| MED-01: *BASIC OPERATIONAL MEDICAL SCIENCE* | - | - | 37.870 | - | 37.870 | 44.676 | 53.500 | 52.500 | 55.500 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Program Change Summary ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | - | - | - | - | - |
| Current President's Budget | - | - | 37.870 | - | 37.870 |
| Total Adjustments | - | - | 37.870 | - | 37.870 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | - | - | | | |
| • TotalOtherAdjustments | - | - | 37.870 | - | 37.870 |

**Change Summary Explanation**

FY 2012: Increase reflects establishment of a new PE for basic medical sciences.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Preventing Violent Explosive Neurologic Trauma (PREVENT) | - | - | 2.900 |

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE* |

| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***Description:*** The Preventing Violent Explosive Neurologic Trauma (PREVENT) program seeks to understand the causes of blast-induced traumatic brain injury (TBI), an injury that while previously described in the warfighter population, has been referred to as a potential "hidden epidemic" in the current conflict. PREVENT will use a variety of modeling techniques based on in-theater conditions to assess potential TBI caused by blast in the absence of penetrating injury or concussion. Research will create a model that can be directly correlated to the epidemiology and etiology of injury seen in returning warfighters, and attempt to determine the physical and physiological underpinnings and causes of the injury. Mitigation and treatment strategies will be formulated based on our new knowledge of blast-induced brain injury with the eventual goal of reducing injury severity across the forces by over fifty percent, improving recovery time, and preventing future injuries. This program continues efforts previously funded in PE 0601101E, Project BLS-01.<br><br>***FY 2012 Plans:***<br>- Continue longitudinal study on warfighters pre- and post-deployment in order to relate specific in-theater blast exposure to evidence and rates of blast TBI.<br>- Validate diagnostic devices and criteria in large animal models.<br>- Transition and support studies of therapeutic strategies to military medical community. | | | |
| ***Title:*** Human Assisted Neural Devices*<br><br>***Description:*** *Previously funded in PE 0601101E, Project BLS-01<br><br>The Human Assisted Neural Devices program will develop the scientific foundation for understanding the language of the brain for application to a variety of emerging DoD challenges, including improving performance on the battlefield and returning active duty military to their units after injury. This will require an understanding of neuroscience, significant computational efforts, and new material design and implementation. Key advances expected from this research include determining the nature and means through which short-term memory is encoded, and discovering the mechanisms and dynamics underlying neural computation and reorganization. These advances will enable memory restoration through the use of devices programmed to bridge gaps in the injured brain. Further, modeling of the brain progresses to an unprecedented level with this novel approach.<br><br>***FY 2012 Plans:***<br>- Assess consistency of primate to retain long-term memory encoding following simulated injury through use of neural codes.<br>- Determine potential for improvements in training and skill retention through the use of neural stimulation during task acquisition in primates.<br>- Identify homogeneity of neural codes involving long-term memory between primates conducting differing long-term memory tasks. | - | - | 14.970 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | R-1 ITEM NOMENCLATURE<br>PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Determine whether networks of neurons can be differentially activated through optogenetic stimulation.<br>- Investigate how connectivity effects the rate at which information is transmitted between areas of the brain.<br>- Evaluate the ability of functional Magnetic Resonance Imaging to accurately predict underlying behavior of groups of neurons through hemodynamic modeling.<br>- Study the ability of primates to navigate virtual environments through the use of neural signals.<br>- Determine if primates can evaluate and make use of information provided solely through a neural interface. | | | |
| ***Title:*** Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT)*<br>***Description:*** *Previously funded in Synthetic Biology in PE 0601101E, Project TRS-01<br><br>The overarching goal of the Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) program is to create an ability to rapidly respond to a disease or threat and improve individual readiness and total force health protection. Service members in deployed settings have limited access to health care. The ability to perform continuous monitoring of physiological status to automatically and autonomously report a warning of a detrimental change and enable immediate diagnostic or therapeutic action would expand healthcare capabilities to these service members. Additionally, in vivo production of a vaccine would potentially eliminate the time to manufacture a vaccine ex vivo. This basic research effort will develop in vivo nucleic-acid circuits to control cellular machinery for diagnostic or vaccine applications and include research to: optimize orthogonality and modularity of genetic control elements; identify methods to increase sensitivity and specificity; and demonstrate methods to control cellular machinery in response to changes in physiological status. An additional strategic thrust is to develop methodologies for measuring health-specific biomarkers from a collected biospecimen to enable diagnostics at the point-of-need, in-garrison or deployed. This basic research effort will: develop new molecular methods for isolating and detecting health-associated biomarkers for application at the point-of-need or resource limited clinical facilities (point-of -care); develop new chemical and material methods for optimizing the analytical utility of minimal sample volumes; and, develop capabilities to archive and distribute biospecimens in a stable dried format without tubes, collection vials, or additional reagents. This program also has applied research efforts budgeted in PE 0602115E, Project BT-01.<br><br>***FY 2012 Plans:***<br>- Initiate development of modular and orthogonal nucleic acid-based elements for application within a detect-and-respond circuit.<br>- Demonstrate controlled expression in mammalian cells of synthetic circuit in response to biomarkers associated with health status.<br>- Develop oligonucleotide synthetic construct capable of utilizing cellular control elements to enhance potency, control dosing, and achieve effectiveness. | - | - | 15.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 1: *Basic Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Develop novel materials and molecular approaches to enable deployable diagnostics.<br>- Develop novel materials and approaches for stabilizing reagents and biospecimens at room temperature. | | | |
| ***Title:*** Dialysis-Like Therapeutics<br><br>***Description:*** Sepsis, a bacterial infection of the blood stream, is a significant cause of injury and death among combat-injured soldiers. The key goal of this program is to run the blood volume (approximately five liters) through an external machine (akin to a dialysis system) and literally scrub out harmful bacteria and their toxins. The proposed approach is low-shear/low-resistance fluidic structures to connect cellular and biomolecular purification techniques for blood purification.<br><br>Initial basic research will develop novel low-shear, low-resistance fluidic structures that enable rapid, large volume blood filtration. Additional research will develop novel intrinsic separation techniques that selectively remove bacteria, toxins and host cells from complex fluids, as well as new methods for continuous sensing of these components. Finally, research into predictive control techniques for directing patient health will close the sense, scrub, and control loop. The applied research portion of the program is budgeted in PE 0602115E, Project BT-01.<br><br>***FY 2012 Plans:***<br>- Develop "label-free" intrinsic separation technologies that remove pathogens of different classes, toxins, and activated cells from complex fluids.<br>- Design high flow, low shear microfluidics to transport wound fluid and blood without cellular activation.<br>- Design pathogen sensors for continuous use in complex biological fluids.<br>- Establish mathematical models to classify and predict patient state over relevant time scales. | - | - | 5.000 |
| **Accomplishments/Planned Programs Subtotals** | - | - | 37.870 |

## D. Other Program Funding Summary ($ in Millions)

N/A

## E. Acquisition Strategy

N/A

## F. Performance Metrics

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

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602115E: *BIOMEDICAL TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | - | - | 110.000 | - | 110.000 | 95.400 | 99.400 | 88.000 | 88.000 | Continuing | Continuing |
| BT-01: *BIOMEDICAL TECHNOLOGY* | - | - | 110.000 | - | 110.000 | 95.400 | 99.400 | 88.000 | 88.000 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | - | - | - | - | - |
| Current President's Budget | - | - | 110.000 | - | 110.000 |
| Total Adjustments | - | - | 110.000 | - | 110.000 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | - | - | | | |
| • TotalOtherAdjustments | - | - | 110.000 | - | 110.000 |

### Change Summary Explanation

FY 2012: Increase reflects establishment of a new PE for biomedical applied research.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602115E: *BIOMEDICAL TECHNOLOGY* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Unconventional Therapeutics*<br><br>***Description:*** * Previously funded in PE 0602383E, Project BW-01<br><br>This thrust is developing unique and unconventional approaches to ensure that soldiers are protected against a wide variety of naturally occurring, indigenous or engineered threats. This program will develop approaches to counter any natural or anthropogenic pathogen within one week. This includes development of countermeasures that do not require prior knowledge of the pathogen and are broadly applicable to multiple unrelated bacterial and/or viral infectious agents. The integration of academic research programs with pharmaceutical development efforts will result in reducing the traditional drug development cycle timeframe.<br><br>***FY 2012 Plans:***<br>- Demonstrate various technologies that can increase the median infectious dose (ID50) of a given pathogen by 100-fold in an animal model compared to the untreated control ID50 in order to prevent infection.<br>- Demonstrate a 4-fold increase in survival time after a lethal dose (LD95) challenge of a given pathogen in an animal model due to administered technology.<br>- Demonstrate 95% survival against a first LD95 challenge of a given pathogen in an animal model using a therapy developed within 7 days of receipt of an unknown pathogen.<br>- Demonstrate 95% survival after three LD95 challenges of a given pathogen in an animal model spaced 1 week apart =7 days post countermeasure. | - | - | 9.000 |
| ***Title:*** Pathogen Defeat*<br><br>***Description:*** *Previously funded in PE 0602715E, Project MBT-02<br><br>Pathogens are well known for the high rate of mutation that enables them to escape drug therapies and primary or secondary immune responses. The Pathogen Defeat thrust area will provide capabilities to predict future threats and to deflect pathogen evolution to non-human spaces such as animals, insects, and bacteria. This area will also determine malicious intent by monitoring key technology acquisitions and commercialization of potential dual-use technologies. Pathogen Defeat focuses not on the threats that are already known but rather on the threats of newly emerging agents and mutations in the future, allowing pre-emptive preparation of vaccine and therapy countermeasures.<br><br>***FY 2012 Plans:***<br>- Demonstrate capability of evolutionary pathway of the viral system under multiple selective pressures.<br>- Use demonstrated capability to validate the algorithms' predictions. | - | - | 19.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602115E: *BIOMEDICAL TECHNOLOGY* |

| **C. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Use optimized winner system and algorithm to investigate virus mitigation and frequency globally to predict the timing and geographic location of reassortment events.<br>- Model processes to accurately predict the drift and shift of virus in pre-human animal reservoirs.<br>- Create viral reservoir specific countermeasures that reduce probability that a novel viral pathogen could transfer from animals to humans.<br>- Establish partners for transition of immune-hardening and pathogen anti-evolution technologies. | | | |
| ***Title:*** Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT)* | - | - | 10.000 |
| ***Description:*** *Previously funded in Synthetic Biology in PE 0601101E, Project TRS-01<br><br>The overarching goal of the Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) program is to increase our ability to rapidly respond to a disease or threat and improve individual readiness and total force health protection. Service members in deployed settings have limited access to health care. New methods and devices are needed to address critical conditions on-site, to allow improved care at field hospital, fleet, and air transport settings, and to enable rapid response to emerging threats. This applied research effort will focus on development of devices for integrated diagnostics across multiple echelons of care: 1) Simple to operate diagnostic devices for critical biomarkers at the point of need; 2) highly multiplexed diagnostic devices for broad spectrum diagnostic and response to emerging threats in an automated format; and, 3) the ability to rapidly develop, integrate and distribute new assays for detection of new biomarkers and emerging threats. Research thrusts include: optimization of methodologies for extraction of targeted biomarkers from a biospecimen that has been room-temperature stabilized in a dried format; demonstration of novel molecular detection approaches towards specific biomarkers; optimization of integrated simple-to-operate diagnostic devices (sample in, results out); demonstration of novel molecular approaches for multiplexed analysis over the same or different classes of biomarkers; and, integration of sample preparation and analysis methods. A companion basic research effort is budgeted in PE 0601117E, Project MED-01.<br><br>***FY 2012 Plans:***<br>- Develop new materials and methods for low power diagnostics.<br>- Develop new reagents and reagent storage methods for deployable diagnostics.<br>- Develop processes for clinical sample collection and preparation for deployable diagnostics.<br>- Develop methods and optimization criteria for extraction of targeted biomarker classes for the retrospective analysis of a dried and room-temperature stable biospecimen archive card.<br>- Develop approach for biomarker research from archived biospecimen card, as the first step towards rapid synthesis of deployable diagnostic devices against new threats. | | | |
| ***Title:*** Tactical Biomedical Technologies* | - | - | 17.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602115E: *BIOMEDICAL TECHNOLOGY* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** *Previously funded in PE 0602715E, Project MBT-02<br><br>The Tactical Biomedical Technologies thrust will develop new approaches to deliver life-saving medical care on the battlefield. Uncontrolled blood loss is the leading cause of preventable death for soldiers on the battlefield. While immediate control of hemorrhage is the most effective strategy for treating combat casualties and saving lives, currently no method other than surgical intervention can effectively treat intracavitary bleeding. A focus in this thrust is the co-development of a materials-based agent(s) and delivery mechanism capable of damaged tissue-targeted hemostasis and wound control. This system will effectively treat compressible and non-compressible wounds regardless of geometry or location. Additionally, rapid response to emerging biological threats on the battlefield is impacted by logistical delays of delivering the necessary therapeutics. Creating a "pharmacy on demand" will enable far-forward medical providers to manufacture and produce small molecule drugs and biologics in order to ensure that the therapeutics are available when they need them.<br><br>***FY 2012 Plans:***<br>- Demonstrate hemostatic material compatibility with Food and Drug Administration (FDA)-approved agents that control pain, infection, and inflammation.<br>- Achieve wound treatment system unit specs including coverage of at least 0.20 square meters of tissue area, mass of less than 200 grams, and a volume less than 150 ml.<br>- Demonstrate scale-up for large volume hemostasis agent synthesis.<br>- Demonstrate hemostasis agent stability consistent with operational requirements.<br>- Test and validate the wound stasis system delivery device.<br>- Develop a plan for wound stasis system FDA approval.<br>- Fabricate devices capable of manufacturing six field relevant pharmaceuticals.<br>- Investigate constructing a man-portable device capable of manufacturing four field relevant pharmaceuticals.<br>- Demonstrate limited capability of manufacturing serum, antigen, and vaccine of DoD relevance through directed activity of microbial systems.<br>- Show efficacy and safety of manufactured end products in in-vitro models. | | | |
| ***Title:*** Military Medical Imaging*<br><br>***Description:*** *Previously funded in PE 0602715E, Project MBT-02<br><br>The Military Medical Imaging thrust will develop medical imaging capabilities to support military missions and operations. The emergence of advanced medical imaging includes newly recognized physical properties of biological tissue, or metabolic pathway, or physiological function in order to map it into an image of diagnostic utility and performance. This need is ever increasing as | - | - | 8.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|

| APPROPRIATION/BUDGET ACTIVITY | R-1 ITEM NOMENCLATURE |
|---|---|
| 0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | PE 0602115E: *BIOMEDICAL TECHNOLOGY* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| researchers and scientists seek to better understand anatomical, functional and cellular level interactions. This thrust will also address how to improve the delivery of medical care and medical personnel protection by building a simulated environment for rapid after-action review of field events generated from current military systems. The advanced development of these tools will provide a formidable arsenal of diagnostic tools for warfighter performance and care.<br><br>***FY 2012 Plans:***<br>- Demonstrate ability to automatically detect, track, and analyze similar events and incidents in temporal and physical space.<br>- Qualify system based on theater-relevant demonstrations and replications of scenario exercises.<br>- Implement biologic and agent-based models to project wounds, reactions, and injury cascades following simulation of trauma.<br>- Transition reconstructive scenario system to Service partners for pilot programs in in-theater implementation.<br>- Obtain in vivo hydrogen and carbon-13 spectra from animal brain using quantum orbital resonance spectroscopy (QORS).<br>- Using established animal models for traumatic brain injury (TBI) and using QORS, distinguish healthy animals from those with TBI. | | | |
| ***Title:*** Reliable Neural-Interface Technology (RE-NET)*<br><br>***Description:*** *Previously funded in PE 0602715E, Project MBT-02<br><br>The Reliable Neural-Interface Technology (RE-NET) program will develop the technology needed to reliably extract information from the nervous system, and to do so at a scale and rate necessary to control many degree-of-freedom machines, such as high-performance prosthetic limbs. This program will complement ongoing neural prosthetic activities funded through other DARPA programs. These other activities study cognition and the mechanisms of higher brain function, as well as construction of upper-limb prostheses. RE-NET will develop neural interface technologies to allow the best robotic prosthetic-limb technology, recently developed by DARPA, to be reliably used throughout the life of wounded warriors that have one or more amputated limbs.<br><br>***FY 2012 Plans:***<br>- Refine statistically validated models of neural interface reliability for both central-nervous-system (CNS) and peripheral-system interfaces.<br>- Demonstrate reliable peripheral interface technology to increase the channel count and hence neural information content, while not compromising the already demonstrated reliability.<br>- Develop advanced CNS interface technology to increase operational reliability and functional lifetime, while not compromising the ability to obtain large amounts of neural information. | - | - | 24.500 |
| ***Title:*** Virtual Tricorder | - | - | 9.000 |

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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602115E: *BIOMEDICAL TECHNOLOGY* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Virtual Tricorder program will develop technologies for analyzing and assimilating massive datasets collected on individual test subjects to visualize, understand, and assess health status by modeling and simulating biological systems. The resulting application will enable medical practitioners to visualize and understand complex relationships across patient data in electronic medical record systems. Not only will this technique allow physicians to visualize patients' health status more accurately, but it will also provide tools to predict the systemic impact (positive and negative) of pharmaceutical and other therapeutic interventions on the patient. Achieving this will require modeling the complex, multi-feature, multi-scale interactions in biological systems from the holistic perspective of systems biology rather than the traditional reductionist perspective. Virtual Tricorder will combine multiple physical/biological models to create the capability to realistically simulate numerous simultaneous physical/biological phenomena. Virtual Tricorder technology will have potential applicability in both time-critical medical settings such as a military intensive care unit (ICU) and also long-term recovery settings where patients are being treated for multiple co-morbid conditions with multiple therapeutic approaches.<br><br>***FY 2012 Plans:***<br>- Conceptualize modeling and simulation techniques for biological systems.<br>- Develop techniques for registration and fusion of multi-modal medical imagery (PET/MRI/CAT/sonogram).<br>- Develop techniques for modeling physiological impact of medications and other therapeutic interventions.<br>- Develop approaches for integrating physical and chemical measurements that range from the microscopic (pathology data) to the macroscopic (radiology data).<br>- Initiate development of visualization techniques that scale from the tissue to the organ to the whole-body. | | | |
| ***Title:*** Training for Rapid Acquisition of Critical Knowledge (TRACK)<br><br>***Description:*** The Training for Rapid Acquisition of Critical Knowledge (TRACK) program will create computer simulation-based training tools to rapidly increase the level of competence of all military service members in areas where rapid training is critical. The first area that TRACK will address is military medicine. For traumatic injury, it is often the medical response that is received in the first few minutes after injury that determines survival. TRACK-Medical will create tools that can be used to train all military personnel to a level of medical competence to provide potentially life-saving treatment in the interval before a military medical professional arrives. TRACK-Medical tools will be open and scalable to be used both to teach basic lifesaving skills to all military personnel as well as deliver more advanced training for medics, corpsmen, and nurses. The tools will incorporate intelligent tutoring and will be able to test and evaluate mastery of knowledge. TRACK-Medical tools will also provide the capability to author scenarios to recreate injuries not normally seen in the civilian world and to adapt to changing wound patterns being encountered in combat.<br><br>***FY 2012 Plans:*** | - | - | 8.500 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602115E: *BIOMEDICAL TECHNOLOGY* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Initiate the development of physiologically accurate medical training simulations based on user expertise and provide detailed feedback to the user based on performance.<br>- Explore viability of deploying versions on mobile platforms for maximum distribution. | | | |
| ***Title:*** Dialysis-Like Therapeutics<br><br>***Description:*** This thrust will develop and demonstrate dialysis-like structures that provide very high throughput (> 1.25 liters/hour) for continuous blood sensing and purification. Bench-level techniques for molecular and cellular "scrubbing" of targets such as bacteria, toxins, and select host cells from blood will be demonstrated. At the completion of the program, high throughput removal of circulating bacteria, toxins, and select host cells from blood without collateral activation of the coagulation and immunologic systems will be demonstrated. The basic research part of this program is budgeted in PE 0601117E, Project MED-01.<br><br>***FY 2012 Plans:***<br>- Develop integrated low-shear, high throughput (> 100 milliliters/hour) microfluidics components for complex fluid flow.<br>- Demonstrate bench-level techniques for the sensing and removal of multiple blood targets including bacteria, toxins, and select host cells. | - | - | 5.000 |
| **Accomplishments/Planned Programs Subtotals** | - | - | 110.000 |

## D. Other Program Funding Summary ($ in Millions)

N/A

## E. Acquisition Strategy

N/A

## F. Performance Metrics

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

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| **Exhibit R-2**, **RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 271.316 | 281.262 | 400.499 | - | 400.499 | 368.621 | 378.741 | 397.164 | 411.831 | Continuing | Continuing |
| IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES* | 92.131 | 100.791 | 91.732 | - | 91.732 | 70.633 | 65.400 | 61.092 | 59.092 | Continuing | Continuing |
| IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY* | 109.140 | 126.930 | 208.419 | - | 208.419 | 195.659 | 195.385 | 196.491 | 196.491 | Continuing | Continuing |
| IT-04: *LANGUAGE TRANSLATION* | 70.045 | 53.541 | 67.015 | - | 67.015 | 52.329 | 51.289 | 56.248 | 56.248 | Continuing | Continuing |
| IT-05: *CYBER TECHNOLOGY* | - | - | 33.333 | - | 33.333 | 50.000 | 66.667 | 83.333 | 100.000 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

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

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

The Language Translation project will develop and test powerful new Human Language Technology that will provide critical capabilities for a wide range of national security needs. This technology will enable systems to a) automatically translate and exploit large volumes of speech and text in multiple languages obtained through a variety of means; b) to have two-way (foreign-language-to-English and English-to-foreign-language) translation; c) enable automated transcription and translation of foreign speech and text along with content summarization; and d) enable exploitation of captured, foreign language hard-copy documents.

The Cyber Technology project supports long term national security requirements through the development and demonstration of technology to increase the security of military information systems. This involves networking, people, platforms, weapons sensors, and decision aids to create a whole that is greater than the sum of

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its parts. The results are networked forces that operate with increased speed and synchronization and are capable of achieving massed effects without the physical massing of forces as required in the past.

| B. Program Change Summary ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 272.191 | 281.262 | 279.383 | - | 279.383 |
| Current President's Budget | 271.316 | 281.262 | 400.499 | - | 400.499 |
| Total Adjustments | -0.875 | - | 121.116 | - | 121.116 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | 6.345 | - | | | |
| • SBIR/STTR Transfer | -7.220 | - | | | |
| • TotalOtherAdjustments | - | - | 121.116 | - | 121.116 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2010 | FY 2011 |
|---|---|---|
| **Project:** IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES* | | |
| Congressional Add: *High Speed Optical Interconnects for Next Generation Supercomputing* | 1.200 | - |
| Congressional Add Subtotals for Project: IT-02 | 1.200 | - |
| **Project:** IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY* | | |
| Congressional Add: *Intelligent Remote Sensing for Urban Warfare* | 1.200 | - |
| Congressional Add Subtotals for Project: IT-03 | 1.200 | - |
| Congressional Add Totals for all Projects | 2.400 | - |

**Change Summary Explanation**

FY 2010: Decrease reflects internal below threshold reprogramming offset by SBIR/STTR transfer.

FY 2012: Increase reflects expanded efforts in cyber related research and language translation offset by a reduction for Defense Efficiencies for contractor staff support.

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* | **PROJECT**<br>IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES* | |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES* | 92.131 | 100.791 | 91.732 | - | 91.732 | 70.633 | 65.400 | 61.092 | 59.092 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

The High Productivity, High-Performance Responsive Architectures project is developing high-productivity, high-performance computer hardware and the associated software technology base required to support future critical national security needs for computationally-intensive and data-intensive applications. These technologies will lead to new multi-generation product lines of commercially viable, sustainable computing systems for a broad spectrum of scientific and engineering applications; it will include both supercomputer and embedded computing systems. One of the major challenges currently facing the DoD is the prohibitively high cost, time, and expertise required to build large complex software systems. Powerful new approaches and tools are needed to enable the rapid and efficient production of new software, including software that can be easily changed to address new requirements and can adjust dynamically to platform and environmental perturbations. The project will ensure accessibility and usability to a wide range of application developers, not just computational science experts. This project will also focus on novel design tools for the manufacture of complex ground and aerospace systems.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Architecture Aware Compiler Environment (AACE)<br><br>***Description:*** The Architecture Aware Compiler Environment (AACE) program will develop computationally efficient compilers that incorporate learning and reasoning methods to drive compiler optimizations for a broad spectrum of computing system configurations. AACE compilers will greatly simplify application development by providing the capability to automatically and efficiently generate compiled code that effectively exercises the targeted computer system resources for computer systems that range from a single, multi-core processor system to very large, multi-processor systems. The AACE program will dramatically reduce application development costs and labor; ensure that executable code is optimal, correct, and timely; enable the full capabilities of computing system advances to our warfighters; and provide superior design and performance capabilities across a broad range of military and industrial applications.<br><br>***FY 2010 Accomplishments:***<br>- Developed and demonstrated initial system characterization tools.<br>- Performed compiler Preliminary Design Review (PDR).<br>- Created the initial common development environment and developed supporting technologies.<br>- Successfully met AACE Phase I goals and metrics, for transition into Phase II.<br><br>***FY 2011 Plans:*** | 10.404 | 13.923 | - |

| **Exhibit R-2A, RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* | **PROJECT**<br>IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Complete characterization tools.<br>- Perform research on compiler optimizations that utilize system characterization tools.<br>- Develop runtime learning environment.<br>- Create initial compiler environment and prototype.<br>- Perform compiler Critical Design Review (CDR).<br>- Demonstrate AACE Phase II goals and metrics. | | | |
| ***Title:*** META<br><br>***Description:*** The goal of the META program is to develop novel design flows, tools, and processes to enable a significant improvement in the ability to design complex defense and aerospace systems that are correct-by-construction. The program seeks to develop a design representation of meta-language and a domain-specific component model library from which system designs can quickly be assembled and their correctness verified with a high degree of certainty. Such a "fab-less" design approach is complemented by a foundry-style manufacturing capability, consisting of a factory capable of rapid reconfiguration between a large number of products and product variants through bitstream reprogramability, i.e., with minimal or no resultant learning curve effects. Together, the fab-less design and foundry-style manufacturing capability is anticipated to yield substantial---by a factor of five to ten---compression in the time to develop and field complex defense and aerospace systems.<br><br>The META effort will also explore the initial design of a next generation ground combat vehicle by employing a novel, model-based correct-by-construction design capability, a highly-adaptable foundry-style manufacturing capability, and crowd-sourcing methods to demonstrate 5x-10x compression in the timeline necessary to build an infantry fighting vehicle. Beginning in FY 2012, the specific ground vehicle application work will be funded in PE 0602702E, Project TT-04, Advanced Land Systems.<br><br>***FY 2010 Accomplishments:***<br>- Began development of a new model-based systems engineering process, novel design, integration, and verification flows, and appropriate supporting metrics.<br>- Began development of a meta-language for the representation of models of both software and physical system components.<br><br>***FY 2011 Plans:***<br>- Continue development of supporting tools necessary to implement the model-based design, integration, and verification flows.<br>- Begin development of a foundry configuration toolset to enable the (re)configuration of foundry-style manufacturing capabilities for a given required degree of manufacturing adaptability.<br>- Exercise feedback loop between manufacturability constraints and the system design toolset. | 14.074 | 49.000 | 56.000 |

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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* | PROJECT<br>IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Begin development and testing of crowd-sourced design infrastructure for electromechanical and software systems for a next generation ground combat vehicle.<br><br>***FY 2012 Plans:***<br>- Develop a domain-specific component model library for the military ground vehicle domain through extensive characterization of desirable and spurious interactions, dynamics, and properties of all constituent components down to the numbered part level.<br>- Develop context models to reflect various operational environments.<br>- Develop a domain-specific foundry configuration for military ground vehicles.<br>- Begin the assembly and integration of foundry-style manufacturing capability for military ground vehicles.<br>- Develop and implement an infrastructure for publishing and maintaining detailed component models using the metalanguage construct to expand the design space for subsequent efforts to design and build a military ground vehicle.<br>- Develop a mechanism for the feedback of manufacturability constraints into the design and design tradespace exploration process.<br>- Develop and integrate a library of various fabrication processes and associated manufacturing elements, i.e., machines and techniques employed to produce the various constituent elements of the military ground vehicle. | | | |
| ***Title:*** Ubiquitous High Performance Computing (UHPC)*<br><br>***Description:*** * Formerly Extreme Computing.<br><br>The Ubiquitous High Performance Computing (UHPC) program is creating the technology base necessary for computing systems with performance that exceeds one quintillion operations per second. The UHPC program addresses some of the most challenging areas for embedded and supercomputer systems: power, programming and resiliency to faults/errors. The program is developing the specific technologies necessary for revolutionary improvements relative to scalable performance, productivity, physical size, power, programmability, dependability, data bandwidth, latency, and optimized data placement/storage. Within the context of DoD systems, mechanisms for self-modification and self-optimization will enable extreme computing systems to radically improve performance. This program will develop self-aware trusted computing techniques that will provide autonomous system monitoring.<br><br>***FY 2010 Accomplishments:***<br>- Initiated UHPC collaborative research environments.<br>- Performed initial research on new execution models. | 12.866 | 30.000 | 5.500 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Established preliminary design approaches for the UHPC systems.<br>***FY 2011 Plans:***<br>- Research and develop critical technologies, system methodologies, and architectures to enable general-purpose computing systems to achieve UHPC program goals.<br>- Complete models of five UHPC challenge problems.<br>- Develop initial simulations of critical technologies.<br>***FY 2012 Plans:***<br>- Initiate detailed system design with analyses and simulations including critical technology demonstrations.<br>- Formulate approaches for achieving resiliency to faults and errors in high performance embedded computing systems. | | | |
| ***Title:*** Unconventional Warfighters<br>***Description:*** The Unconventional Warfighters program will create information technologies that enable new classes of participants to contribute to defense missions. One such class includes futurists, inventors, hobbyists, and tinkerers who approach military problems from an unconventional perspective. This latent source of creativity has been successfully tapped in the commercial sector through crowd-sourcing Internet marketplaces that bring human intelligence to bear on tasks for which computers are poorly suited. Information extraction and integration techniques will enable the solutions proposed by individuals to be correlated and fused into meta-solutions for further iterative development. Another class of potential participants is military Veterans, including disabled Veterans, who have deep knowledge of the missions and the operational environment. Machine learning tools will enable individuals with similar interests and complementary capabilities to find each other while advanced collaboration tools will amplify the synergies of diverse dynamic groups. Animals are another class of potential contributors. This is not a new idea, as animals possessing special abilities such as dogs and dolphins have been used before to perform military tasks such as mine detection. The new aspect to be examined under Unconventional Warfighters is the potential for creating new sensor, processing, communication and actuator systems specially adapted to enable animals to execute tasks beyond their natural capabilities.<br>***FY 2012 Plans:***<br>- Conceptualize and develop tools to enable persons with similar interests and complementary capabilities to find each other and collaborate on military problems.<br>- Develop techniques for correlating and fusing solution concepts put forward by diverse proposers to yield "meta-solutions" for complex military problems. | - | - | 25.000 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Design and develop sensor, processing, communication and actuator systems specially adapted to enable animals to execute tasks beyond their natural capabilities. | | | |
| ***Title:*** High-Productivity Computing Systems (HPCS)<br><br>***Description:*** The HPCS program will create a new generation of economically viable, high-productivity computing systems for the national security and industrial user communities. HPCS technologies will enable nuclear stockpile stewardship, weapons design, cryptanalysis, weather prediction, and other large-scale problems that cannot be addressed productively with today's computers. The goal of this 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. Additionally, programming such large systems will be made easier so engineers and scientists can better harness the power of high-performance computers.<br><br>***FY 2010 Accomplishments:***<br>- Incorporated HPCS interconnect technology in a supercomputer product line and delivered to a DoD customer.<br>- Fabricated and tested a terabits-per-second hub chip that will enable the first petascale system with global shared memory.<br>- Successfully demonstrated a high-performance prototype system that can be scaled up to become the world's fastest and most capable supercomputer.<br>***FY 2011 Plans:***<br>- Complete the Phase III prototypes and demonstrate that they meet their goals of world-leading performance and productivity.<br>- Demonstrate Unified Parallel C performance improvements in symmetric multiprocessing, distributed and hybrid modes.<br>- Provide the HPCS stakeholders with access to the prototype systems for a six-month evaluation and experimentation period.<br>***FY 2012 Plans:***<br>- Complete demonstration of prototype systems with stakeholders. | 51.933 | 7.868 | 5.232 |
| ***Title:*** Software Producibility<br><br>***Description:*** A variety of new processor and systems architectures, including multicore and stream processors, large-scale virtualization, and the cloud computing paradigms are becoming the norm for both military and civilian computing infrastructure. Unfortunately, these are highly complex technologies that exceed the capabilities of most of our programmers/application developers, and the result is that the cost of software is skyrocketing. The Software Producibility program addressed this critical issue by creating technologies that reduce the cost, time, and expertise required to build large complex software systems, while ensuring that security and service guarantees are met. | 1.654 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| One promising approach is an intelligent software development system that learns specific implementations of a number of high-level designs, and then uses this knowledge to create initial implementations of novel high-level designs. Automating the development of initial implementations, and then expanding this intelligence to automate debugging will save the software developer considerable time and effort.<br><br>***FY 2010 Accomplishments:***<br>- Conducted load-time field update experiments.<br>- Conducted preliminary design-time security adaptation experiments.<br>- Conducted run-time adaptation and online run-time reconfiguration experiments.<br>- Explored candidate demonstration systems, in addition to those used by the performer that will foster transition to the Services.<br>- Created initial strategies for software frameworks to support multi-core, stream, and cloud computing. | | | |
| **Accomplishments/Planned Programs Subtotals** | 90.931 | 100.791 | 91.732 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** High Speed Optical Interconnects for Next Generation Supercomputing<br><br>***FY 2010 Accomplishments:*** - Initiate research into High Speed Optical Interconnects for Next Generation Supercomputing. | 1.200 | - |
| **Congressional Adds Subtotals** | 1.200 | - |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY* | 109.140 | 126.930 | 208.419 | - | 208.419 | 195.659 | 195.385 | 196.491 | 196.491 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

The Information Assurance and Survivability project is developing the core computing and networking technologies required to protect DoD's information, information infrastructure, and mission-critical information systems. These technologies will enable DoD information systems to operate correctly and continuously even when they are attacked, and will provide cost-effective security and survivability solutions. Technologies developed under this project will benefit other projects within this program element as well as projects in the Command, Control, and Communications program element (PE 0603760E), the Network-Centric Warfare Technology program element (PE 0603764E), the Sensor Technology program element (PE 0603767E), and other projects that require secure, survivable, network-centric information systems.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Cyber Genome | 8.500 | 13.000 | 24.000 |
| ***Description:*** The Cyber Genome program will develop break-through cyber-forensic techniques to characterize, analyze, and identify malicious code. This will allow for the automatic discovery, identification, and characterization of any future variants of previously unknown malicious code in computing systems. Cyber Genome will also develop break-through abilities in visualization, threat identification analysis, and threat mitigation analysis to enable positive identification of malicious code substructures and functionality.<br><br>***FY 2010 Accomplishments:***<br>- Developed automatic techniques to rapidly and interactively reconstruct metadata to assist in the analysis of potentially malicious code.<br>- Refined technologies, ontologies, and algorithms to enable the characterization of future malicious code variants based on analyzed malicious code substructures.<br>- Established teams, instituted community training, and generated test data sets to evaluate the malicious code detection techniques.<br><br>***FY 2011 Plans:***<br>- Expand and refine technologies, ontologies, and algorithms to enable the characterization of future malicious code variants based on analyzed malicious code substructures.<br>- Complete integration of automatic discovery, identification, analysis, and prediction algorithms. | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Refine user signature identification model and correlate with physical security methods.<br>***FY 2012 Plans:***<br>- Continue Cyber Genome prototype experiments.<br>- Create lineage trees for a class of digital artifacts to gain a better understanding of software evolution.<br>- Generate execution trees from submitted malware that include automated analysis of software dependencies.<br>- Identify and/or validate DoD users from their host and/or network behavior.<br>- Commence transition of Cyber Genome prototype to a transition partner. | | | |
| ***Title:*** Integrity Reliability Integrated CircuitS (IRIS)*<br>***Description:*** *Formerly DISCOVER<br><br>The Department of Defense has become increasingly reliant on electronic parts and systems fabricated outside of the United States. In many cases, these parts have also been designed in foreign countries, and there is currently no method available to decipher the full functionality of these circuits that may contain billions of transistors. Even if the part is designed domestically, there is currently no way of verifying that no tampering has occurred during fabrication, especially as processing technology scales to near atomic length scales, that can compromise the warfighter's mission or safety. Integrity Reliability Integrated CircuitS (IRIS) will advance non-destructive reverse engineering of integrated circuits whose functionality is not known a priori. These tools will be compatible with leading edge 32 nanometer complementary metal-oxide semiconductor (CMOS) node size. These tools will ensure that an integrated circuits' full functionality is known and will provide verification that no malicious changes have been introduced.<br><br>***FY 2010 Accomplishments:***<br>- Commenced definition of functional requirements for algorithms that determine circuit functionality without full knowledge of their underlying logic and design.<br>***FY 2011 Plans:***<br>- Complete definition of functional requirements for algorithms that determine circuit functionality without knowledge of their underlying logic and design.<br>- Design tools for non-destructive interrogation of integrated circuit functionality without prior knowledge of the designed functionality.<br>***FY 2012 Plans:***<br>- Demonstrate functional derivation of un-altered digital and mixed-signal circuits at 45 nm integrated circuit (IC) node.<br>- Demonstrate reliability derivation from reduced sample sizes. | 10.000 | 22.878 | 30.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Develop non-destructive techniques for reverse engineering a digital IC. | | | |
| ***Title:*** Trusted Software*<br>***Description:*** * Formerly Total Software Understanding (TSU)<br><br>The Trusted Software program will meet DoD demands for reliable and robust software using technology to diagnose software for inefficiencies, design errors, redundant code, and overall software inconsistencies. Current software projects are massive, dynamic social efforts involving distributed teams of developers, marketers, and users. Without the proper tools, the software engineers create errors and redundancies providing unintended and exploitable security flaws. This program will develop specific techniques to extract information on software products, model the development environment, and integrate the models into low-level software analysis tools to provide a robust diagnostic tool for building and validating trustworthy software.<br><br>***FY 2011 Plans:***<br>- Develop a database of legacy software products that could contain exploitable flaws.<br>- Initiate the design of software development models.<br>***FY 2012 Plans:***<br>- Prototype software development modeling environment.<br>- Compare, for selected software platforms, actual software behavior against intended behavior.<br>- Analyze and determine causes of differences between actual and intended software behavior. | - | 5.000 | 10.000 |
| ***Title:*** Agile Assured Computing *<br>***Description:*** * Previously Confident Computing<br><br>The Agile Assured Computing program will radically change the current paradigm of overly complex, unwieldy, and insecure computing platforms. Current commercial off-the-shelf platforms add layer upon layer of functionality and have become hugely complex and difficult to maintain. The current approach to securing these platforms emphasizes large security applications, such as anti-virus programs, that in themselves are difficult to maintain and vulnerable to attack. The Agile Assured Computing program will create more flexible, responsive methods for securing computing systems that operate in challenging environments. The program will develop automated system technologies to identify and mitigate vulnerabilities in legacy computing platforms. Agile Assured Computing technologies will reduce security risk without requiring lengthy development cycles or time-consuming maintenance by system administrators.<br><br>***FY 2011 Plans:*** | - | 5.349 | 10.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Identify mechanisms to determine outdated and unnecessary system attributes used for attacks.<br>- Initiate development of automated tools for identifying system attributes for attacks.<br>- Identify approaches for modifying those attributes to provide a secure operating pathway.<br>***FY 2012 Plans:***<br>- Demonstrate mechanisms to determine outdated and unnecessary system attributes used for attacks.<br>- Demonstrate automated tools for identifying system attributes for attacks.<br>- Demonstrate approaches for modifying those attributes to provide a secure operating pathway. | | | |
| ***Title:*** Rapid Planning (RP)<br>***Description:*** The Rapid Planning (RP) program will develop rapid planning and replanning tools based on recent mathematical advances such as topological data analysis (TDA). The program will develop tools and techniques for rapid generation and adaptation of robust plans in the presence of uncertainty, imprecision, incomplete, and contradictory data and assumptions. RP will also provide a capability for monitoring plans, providing continuous replanning capability, and plain text explanations for recommended plans. RP will invest in mathematical methods to improve optimization including new branch and bound, mixed integer programming, and sub-modularity methods; techniques for accelerated simulation where accuracy can be traded for speed; design of experiments through manifold learning and identification techniques that build upon previous DARPA programs; and develop a process that is aware of interdependencies in plans and aids planners in resolving these interdependencies.<br>***FY 2011 Plans:***<br>- Create overarching system architecture for rapid replanning incorporating environmental and tactical uncertainty.<br>- Design automated identification of the controlling and nuisance parameters to quickly focus attention.<br>- Implement TDA techniques to predict optimal performance in an evolving non-linear environment.<br>***FY 2012 Plans:***<br>- Develop techniques for rapidly assessing the robustness of plans and create the ability for planners to quickly develop and deploy plan contingencies to address potential failure modes.<br>- Demonstrate and assess the efficacy of the tool to rapidly create and adapt plans more accurately in a military laboratory environment. | - | 5.000 | 9.169 |
| ***Title:*** Clean-slate design of Resilient, Adaptive, Secure Hosts (CRASH)*<br>***Description:*** *Formerly Cyber Immune | - | 15.000 | 29.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* | **PROJECT**<br>IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| The Clean-slate design of Resilient, Adaptive, Secure Hosts (CRASH) program will develop cyber security technologies using the mechanisms of biological systems as inspiration for radically re-thinking basic hardware and system designs. Higher level organisms have two distinct immune systems: the innate system is fast and deadly but is only effective against a fixed set of pathogens; the adaptive system is slower, but can learn to recognize novel pathogens. Similarly, CRASH will develop mechanisms at the hardware and operating system level that eliminate known vulnerabilities exploited by attackers. However, because novel attacks will be developed, CRASH will also develop software techniques that allow it to defend itself, to maintain its capabilities, and even heal itself. Finally, biological systems show that diversity is an effective population defense; CRASH will develop techniques that make each computer system appear unique to the attacker and allows each system to change over time.<br><br>***FY 2011 Plans:***<br>- Develop initial designs of one or more systems, including novel hardware and system features.<br>- Demonstrate through formal methods, simulation, and design walkthroughs that the prototype systems mitigate common technical vulnerabilities.<br>***FY 2012 Plans:***<br>- Integrate and implement one or more CRASH hardware systems capable of supporting the prototype operating system.<br>- Demonstrate the ability to detect and recover from penetrations.<br>- Red-team systems to verify technical vulnerabilities known by the community have been addressed successfully. | | | |
| ***Title:*** Safer Warfighter Computing (SAFER)*<br>***Description:*** *Formerly Securing the Hosts<br><br>The Safer Warfighter Computing (SAFER) program is creating a technology base for assured and trustworthy Internet communications and computation, particularly in untrustworthy and adversarial environments. SAFER creates automated processes and technologies that will enable military users to send and receive content on the Internet, utilizing commercially available hardware and software, in ways that avoid efforts to deny, locate, or corrupt communications. SAFER is also developing technology for performing computations on encrypted data without decrypting it first through fully homomorphic encryption and interactive, secure multi-party computation schemes. This will enable, for example, the capability to encrypt queries and to create an encrypted search result without decrypting the query. This technology will advance the ability to run computationally intensive programs on large datasets on a cluster of untrusted computers, as in a cloud computing environment, while keeping programs, data, and results encrypted and confidential.<br><br>***FY 2011 Plans:***<br>- Develop technical approaches for improving the security of internet-based communications and computation. | - | 13.275 | 20.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate initial security and availability capabilities.<br>- Demonstrate initial encryption algorithms and measurement capabilities.<br>- Demonstrate the feasibility of homomorphic encryption.<br>***FY 2012 Plans:***<br>- Demonstrate robust security and availability capabilities.<br>- Demonstrate robust encryption algorithms and measurement capabilities. | | | |
| ***Title:*** Anomaly Detection at Multiple Scales (ADAMS)*<br>***Description:*** *Formerly part of Security-Aware Systems<br><br>The Anomaly Detection at Multiple Scales (ADAMS) program will develop and apply algorithms for detecting anomalous behaviors over multiple scales of space and time. Spatially, ADAMS technologies will apply to systems, individuals, groups/organizations, and nation-states. Temporally, ADAMS technologies will apply to behaviors that emerge over hours, days, months, and years. ADAMS will develop flexible, scalable and highly interactive approaches to extracting actionable information from information system log files, sensors, and other instrumentation as needed.<br><br>***FY 2011 Plans:***<br>- Conceptualize approaches for finding indicators of anomalous behaviors buried in enormous amounts of observational data.<br>***FY 2012 Plans:***<br>- Create a scalable, distributed architecture to collect, store, access, process, and correlate relevant data from heterogeneous sources over extended periods of time.<br>- Formulate techniques for determining whether a system, individual, group/organization, or nation-state is exhibiting anomalous behavior suggestive of an emerging threat. | - | 4.500 | 18.000 |
| ***Title:*** Cyber Reserve Corps<br>***Description:*** The Cyber Reserve Corps program will develop technologies and tools to enable and educate private citizens to participate in the defense of cyberspace. Private citizens already collaborate on cyber-defense through the numerous blogs and message boards dedicated to issues such as diagnosing problems on home computers/networks and remediating the effects of malware on popular commercial systems. These activities are facilitated through a variety of software tools; additional tools for detecting and diagnosing known exploits and variants of known exploits will be developed. Cyber Reserve Corps will also create technologies for generating shareable host and network log files that are both informative with respect to new exploits yet preserve the privacy of user data, as well as tools for automating the analysis of these log files. Ordinarily this information would | - | - | 20.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| remain widely distributed, but Cyber Reserve Corps will make it possible to bring it all together to reveal subtle patterns of hostile activity that would otherwise go unnoticed.<br><br>***FY 2012 Plans:***<br>- Develop concepts for collaborative cyber-defense encompassing public and private hosts/networks.<br>- Develop technologies that enable confidential sharing of detailed host data and configuration information.<br>- Develop techniques for sensing widely distributed probes/attacks on public/private networks. | | | |
| ***Title:*** Resilient Networks<br><br>***Description:*** The Resilient Networks program will create technologies that enable networks to survive cyber attack. Many vulnerabilities have been identified in the networking protocols used in the routers and switches used in home/small business, enterprise, and wide-area networks. While attackers are able to adapt their attacks in a highly dynamic fashion, the capability to respond to such attacks is limited by the complexity of the networking protocols and their typically proprietary, vendor-specific implementations. Resilient Networks will address this by creating advanced routing/switching software that runs efficiently on commodity processors. Such software-defined routers/switches will enable far greater agility in responding to exploits than is presently possible and provide the basis for highly reactive networked defense capabilities. Resilient Networks will also address embedded computing systems such as vehicle/platform/weapon/industrial control systems, which must operate at a high level of assurance in real-world environments. Resilient Networks will develop new verification and validation techniques for embedded networks that must function reliably in complex adversarial environments. Achieving resilience in enterprise networks is also of interest. This would involve techniques for reconfiguring enterprise networking and computing resources to mitigate the effects of attacks and restore services.<br><br>***FY 2012 Plans:***<br>- Recast datalink and network layer protocols for parallel execution on commercial multicore processors.<br>- Design high-utilization protocol primitives for implementation in widely used development environments while respecting multi-level security requirements.<br>- Perform an in-depth systems engineering analysis to identify changes required to enable simplified provisioning of secure communications and networking services.<br>- Identify algorithmic advances and protocol re-design opportunities/needs to achieve high levels of assurance in internet-based wide-area communications/networking and in embedded networked computing and control systems.<br>- Develop and apply new algorithms and protocols in high-assurance implementations for use in wide-area communications/networking and in embedded networked computing and control systems. | - | - | 20.000 |
| ***Title:*** Assured Mobile Platform (AMP) | - | - | 18.250 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Assured Mobile Platform (AMP) program will develop and demonstrate the technologies required to secure wireless mobile devices. As in the civilian world, the military is making increasing use of wireless devices such as smartphones and personal digital assistants. These devices integrate computational and wireless networking elements that are controlled by a so-called "mobile platform". The mobile platform integrates a computer operating system with software for controlling the wireless component. Because mobile devices have very limited size, weight, and power, the mobile platform must be very efficient and so can devote only a limited share of its computational resources to security. This makes securing mobile wireless devices a challenge. Cross-layer approaches are extremely promising due to the emergence of low-cost electronically-steerable antenna arrays suitable for mobile devices. Another approach is to utilize off-board security resources accessed via the cloud, in effect "security reach-back". AMP will develop, mature, and integrate these technologies to produce a mobile platform that provides a high level of assurance for military users.<br><br>***FY 2012 Plans:***<br>- Explore cross-layer approaches for securing mobile platforms that incorporate an electronically-steerable antenna array.<br>- Formulate "security reach-back" approaches that utilize off-board security resources to secure mobile platforms.<br>- Perform detailed requirements analysis and systems engineering as the basis for a concept of operations and high level design for a mobile platform that provides a high level of assurance for military users. | | | |
| ***Title:*** Next Generation Core Optical Networks (CORONET)<br><br>***Description:*** 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 (WDM) optical channels; 2) creation of a new class of protocols that permit the cross-layer communications needed to support quality-of-service requirements of high-priority national defense applications; and 3) demonstration of novel concepts in applications such as distributed and network-based command and control, intelligence analysis, predictive logistics management, simulation- and scenario-enhanced decision-making support for real-time combat operations, and assured operation of critical U.S. networking functions when faced with severe physical layer attack. These network-based functions will support the real-time, fast-reaction operations of senior leadership, major commands and field units.<br><br>***FY 2010 Accomplishments:***<br>Next-Generation Core Optical Networks (CORONET) | 16.069 | 12.785 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Worked with DISA to ensure that CORONET's next phase incorporates the requirements and technology evolution plan of their DISN-Core network.<br>- Initiated the CORONET next phase development of network control and management software and associated test plan such that the final product will be suitable for transition and implementation in current and future commercial and DoD core optical networks.<br><br>Transmission, Switching and Applications for CORONET<br>- Completed a feasibility study of high-spectral efficiency banded WDM fiber-optic transmission system.<br><br>***FY 2011 Plans:***<br>Next-Generation Core Optical Networks (CORONET)<br>- Continue the CORONET next phase effort to develop the network control and management software, the CORONET network-emulation testbed and the plans for technical testing and demonstrations, and formulate the technology transition plan.<br>- Continue to work with DISA on technical oversight and evaluation of the CORONET software development effort and associated test plan.<br>- Engage Standards Bodies, with the appropriate endorsements of both DISA and the commercial carrier members of the CORONET team, with the goal of amending the existing standards with the developed CORONET technology.<br>- Pursue opportunities for commercial transition as well as future integration into the DISN-Core and other DoD networks. | | | |
| ***Title:*** Intrinsically Assured Mobile Ad-Hoc Networks (IAMANET)<br><br>***Description:*** The Intrinsically Assured Mobile Ad-Hoc Network (IAMANET) program continues a series of successful research programs to design a tactical wireless network that is secure and resilient to a broad range of threats which include cyber attacks, electronic warfare and malicious insiders (or captured/compromised radios). Previous programs included the Dynamic Quarantine of Computer-Based Worms (DQW) and Defense Against Cyber Attacks on Mobile Ad-hoc Network Systems (DCAMANET).<br><br>IAMANET will build upon the successes achieved in both the DQW and the DCMANET programs. IAMANET directly supports the integrity, availability, reliability, confidentiality, and safety of Mobile Ad-hoc Network (MANET) communications and data. In contrast, the dominant Internet paradigm is intrinsically insecure. For example, the Internet does not deny unauthorized traffic by default and therefore violates the principle of least privilege. In addition, there are no provisions for non-repudiation or accountability and therefore adversaries can probe for vulnerabilities with impunity because the likelihood of attributing bad behavior to an adversary is limited. Current protocols are not robust to purposely induced failures and malicious behavior, leaving entire Internet-based systems vulnerable in the case of defensive failure. IAMANET, on the other hand, uses a deny-by-default networking paradigm, allowing only identifiable authorized users to communicate on the network. While the objective transition | 14.543 | 11.912 | - |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| path for IAMANET technologies is to the Services to support mobile tactical operations, the IAMANET systems are interoperable with fixed networks and may also have potential applicability to the broader DoD network architecture.<br><br>***FY 2010 Accomplishments:***<br>- Completed the assessment of technologies developed for possible integration into MANET's.<br>- Transitioned the IAMANET technologies to the Military Networking Protocol (MNP) program for developing robust user authentication and attribution.<br>- Initiated the design, development and integration of a secondary subsystem for the Microsoft Windows XP platform.<br>- Initiated design and proof of concept development of trusted hardware components.<br>- Conducted evaluation in simulated operational networks at the United States Military Academy.<br><br>***FY 2011 Plans:***<br>- Complete the design, development and integration of a secondary subsystem for the Microsoft Windows XP platform.<br>- Complete design and proof of concept development of trusted hardware components.<br>- Integrate technologies into DoD's existing information assurance desktop security application Host Based Security Suite (HBSS) to enable widespread deployment. | | | |
| ***Title:*** Trustworthy Systems<br><br>***Description:*** The goal of the Trustworthy Systems program is to provide new approaches to network-based monitoring that provide maximum coverage of the network (i.e. from the NIPRNET/Internet gateway to service enclaves) with performance independent of the network's size, and with computational costs that either remain constant or decrease as the network's speed or relative size increases. The end deliverable of this program will provide network defense technologies with: (1) high probability of detection (Pd) of malicious traffic per attack launched and, (2) a false alarm rate of not more than one false alarm per day. This technology will provide gateway-and-below network traffic monitoring approaches that scale at rates that are linear (or less) to increases in network size and transmission speeds.<br><br>***FY 2010 Accomplishments:***<br>- Constructed a unique testing environment that supports network speeds in excess of 40 Gbps.<br>- Completed initial asymmetric routing pathway flow and traffic analysis algorithms and initiated integration into Commercial-of-the-Shelf (COTS) high speed switching device.<br>- Completed initial testing of the prototype intrusion detection system at 1 Gbps on an Application Services Gateway hardware system.<br><br>***FY 2011 Plans:***<br>- Develop and integrate test-case scenarios to be used in final product testing. | 13.090 | 7.731 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Complete final asymmetric routing pathway flow and traffic analysis algorithms and initiate integration into COTS high speed switching device to meet 40 Gbps speed thresholds.<br>- Perform network testing of the 10 Gbps and 40 Gbps products. | | | |
| ***Title:*** Security-Aware Systems<br><br>***Description:*** The Security-Aware Systems program developed and advanced a variety of potentially promising technologies to enable the military to field secure, survivable, self-monitoring, self-defending network centric systems. This program evaluated 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 also dynamically adapt to provide desired levels of service while minimizing risk and providing coherent explanations of the relative safety of service level alternatives. The systems bolster the reliability and security of critical software systems by reducing vulnerabilities and logic errors, and providing state-of-the-art software analysis techniques augmented with cognitive decision-making techniques. Research efforts also explored provable protection of information and investigate technologies that enable fundamentally new approaches for detecting insider threats.<br><br>***FY 2010 Accomplishments:***<br>- Investigated the application of Self-Regenerative Systems (SRS) technology to a high value, mission critical, military computing system.<br>- Examined the ability of SRS technology to enable a military computing system to successfully complete a mission in the face of cyber attack or accidental fault. | 5.397 | - | - |
| ***Title:*** Cyber Insider Threat*<br><br>***Description:*** *Formerly part of Security-Aware Systems<br><br>The Cyber Insider Threat (CINDER) program will develop techniques for countering one of the most significant and malicious threats to military networks and systems: the cyber insider threat. Current defenses are based on network and host intrusion detection, and look for "break-ins" and abnormal behavior but do not attempt to characterize a user's mission. The CINDER program will build tools and techniques that characterize user mission in a multi-level security environment. These concepts and technology will continue in PE 0603760E, Project CCC-04 beginning in FY 2012.<br><br>***FY 2010 Accomplishments:***<br>- Obtained realistic exemplars of insider threat activities.<br><br>***FY 2011 Plans:*** | 5.000 | 10.500 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Use machine learning to develop rule-based models of user behavior.<br>- Identify and characterize templates for adversary class, mission and stage of existing compromises for insider threat activities. | | | |
| ***Title:*** Trusted, Uncompromised Semiconductor Technology (TrUST)<br><br>***Description:*** The Trusted, Uncompromised Semiconductor Technology (TrUST) program addressed the fundamental problem of determining whether a microchip manufactured through a process that is inherently "untrusted" (i.e., not under our control) can be "trusted" to perform operations only as specified by the design, and no more. The program consisted of a set of complementary technologies integrated together which developed a product that transitioned to the DoD.<br><br>***FY 2010 Accomplishments:***<br>- Protected Field Programmable Gate Arrays (FPGAs) from unauthorized substitutions to improve and empirically verify the software/firmware framework for using Physically Unclonable Functions.<br>- Integrated a TrUSTed IC solution for Application Specific Integrated Circuits (ASICs) and FPGAs that are ready for transition.<br>- Developed advanced non-destructive IC reverse engineering techniques.<br>- Identified, developed, and quantified performance of innovative destructive and non-destructive evaluation techniques for ICs at the 45 nm node. | 35.341 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 107.940 | 126.930 | 208.419 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** Intelligent Remote Sensing for Urban Warfare<br><br>***FY 2010 Accomplishments:*** - Conducted research in remote sensing for urban warfare operations. | 1.200 | - |
| **Congressional Adds Subtotals** | 1.200 | - |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IT-04: *LANGUAGE TRANSLATION* | 70.045 | 53.541 | 67.015 | - | 67.015 | 52.329 | 51.289 | 56.248 | 56.248 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

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

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Global Autonomous Language Exploitation (GALE) | 38.353 | 22.945 | 11.250 |
| ***Description:*** The Global Autonomous Language Exploitation (GALE) program will create an integrated product enabling automated transcription and translation of foreign speech and text with targeted information retrieval. When applied to foreign language broadcast media and web-posted content, GALE systems will enhance open-source intelligence and local/regional situational awareness by reducing the cost and effort of translation and analysis. GALE will produce a fully-mature architecture and dramatically improve transcription and translation accuracy by broader exploitation of context. GALE will develop timely alerts for commanders and warfighters.<br><br>***FY 2010 Accomplishments:***<br>- Exercised language-independent paradigm for new languages essential for military use - Dari, Pashto and Urdu.<br>- Developed methods for porting targeted information retrieval technology into new languages.<br>- Developed methods for using extraction-empowered machine translation, in which the system extracts the meaningful phrases (e.g., names and descriptions) from foreign language text for highly accurate translation into English. | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Completed the architecture for a summarization system that incorporates adaptive filtering, focused summarization, information extraction, contradiction detection, and user modeling.<br>***FY 2011 Plans:***<br>- Achieve high accuracy translation and distillation using shallow semantics with minimal ancillary information.<br>- Achieve translation accuracy and distillation that exceeds human performance.<br>- Provide technology updates to military and intelligence operations centers.<br>***FY 2012 Plans:***<br>- Incorporate the sophisticated search capabilities developed in the distillation task of GALE into the inserted systems.<br>- Transition to new customers. | | | |
| ***Title:*** Multilingual Automatic Document Classification, Analysis and Translation (MADCAT)<br>***Description:*** The Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) program will develop and integrate technology to enable exploitation of captured, foreign language, hand-written documents. This technology is crucial to the warfighter, as documents including notebooks, letters, ledgers, annotated maps, newspapers, newsletters, leaflets, pictures of graffiti, and document images captured in the field may contain extremely important time-sensitive information. The MADCAT program will address this need by producing devices that will convert such captured documents from Arabic into readable English in the field. MADCAT will substantially improve applicable technologies, in particular document analysis and optical character recognition/optical handwriting recognition. MADCAT will tightly integrate these improved technologies with translation technology and create prototypes for field trials.<br>***FY 2010 Accomplishments:***<br>- Developed algorithms for interpreting different regions within a document; removing noise from contaminated and degraded documents; predicting the syntactic structure and propositional content of text; and extracting information from an address field or the axes of a table.<br>- Integrated these technologies with the translation and summarization components of GALE to yield tightly integrated technology prototypes that convert captured documents into readable and searchable English.<br>***FY 2011 Plans:***<br>- Complete the development of algorithms for interpreting different regions within a document; for predicting the syntactic structure and propositional content of text; and for removing noise from contaminated and degraded documents.<br>- Complete the integration of these improvements with the translation and summarization components of GALE.<br>- Transition tightly integrated technology prototypes that convert captured documents into readable and searchable English to high-impact military systems and intelligence operations centers. | 14.663 | 15.375 | 19.870 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Develop language independent technology extensions to Dari, Pashto and Urdu.<br>- Train and test the technology on data collected in the field.<br>- Develop a system that handles with both handwritten and machine-printed text.<br>***FY 2012 Plans:***<br>- Continue to improve translation accuracy.<br>- Continue development of language independent and script independent technology.<br>- Continue training and testing of field collected data.<br>- Continue training and testing of documents containing printed and hand-written text.<br>- Transition tightly integrated technology prototypes to military and intelligence operations centers. | | | |
| ***Title:*** Robust Automatic Translation of Speech (RATS)<br>***Description:*** The Robust Automatic Translation of Speech (RATS) program will address noisy and hostile conditions where speech signals are degraded by distortion, reverberation, and/or competing conversation. Robust speech processing technologies will enable soldiers to hear or read clear English versions of what is being said in their vicinity, despite a noisy or reverberant environment. RATS technology will isolate and deliver pertinent information to the warfighter by detecting periods of speech activity and discarding silent portions, determining the language spoken, identifying the speaker, and recognizing key words in challenging environments.<br>***FY 2010 Accomplishments:***<br>- Developed noise suppression and speech exploitation approaches based on multi-microphone arrays.<br>- Started refinement of new speech processing techniques for noisy environments, including echo suppression, speech activity detection, language identification, speaker identification and keyword spotting.<br>***FY 2011 Plans:***<br>- Optimize new speech processing techniques for noisy environments, including speech activity detection, language identification, speaker identification and keyword spotting.<br>- Develop bio-inspired algorithms to enable RATS processing.<br>- Develop methods for detecting relevant speech segments.<br>- Adapt present technologies for automatic speech recognition systems to cope with highly degraded signals.<br>- Transition tightly integrated technology prototypes to military and intelligence operations centers.<br>***FY 2012 Plans:***<br>- Continue to improve processing techniques for noisy environments, including speech activity detection, language identification, speaker identification and keyword spotting. | 9.196 | 12.721 | 20.895 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* | **PROJECT**<br>IT-04: *LANGUAGE TRANSLATION* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Train system on field collected data and test system in realistic environments.<br>- Continue to work with transition partners. | | | |
| ***Title:*** Boundless Operational Language Translation (BOLT)<br><br>***Description:*** The Boundless Operational Language Translation (BOLT) program will enable communication regardless of medium (voice or text), and genre (conversation, chat, or messaging) through expansion of language translation capabilities, human-machine multimodal dialogue, and language generation. The BOLT program will enable warfighters and military/government personnel to readily communicate with coalition partners and local populations and will enhance intelligence through better exploitation of all language sources including messaging and conversations. The program will also enable sophisticated search of stored language information and analysis of the information by increasing the capability of machines for deep language comprehension.<br><br>***FY 2012 Plans:***<br>- Formulate approaches for automatically processing informal genres, interpreting poor pronunciation, coping with incorrect/incomplete syntax, resolving references, and correlating co-references.<br>- Conceptualize approaches for comprehension of colloquialisms and idiomatic speech.<br>- Enable machines to carry on multi-modal dialogues with humans and to comprehend concepts and generate responses in multilingual environments. | - | - | 15.000 |
| ***Title:*** Spoken Language Communication and Translation System for Tactical Use (TRANSTAC)<br><br>***Description:*** The Spoken Language Communication and Translation System for Tactical Use (TRANSTAC) program is developing 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 is building upon existing speech translation platforms to create a rapidly deployable language tool that will meet the military's language translation needs. TRANSTAC is currently focusing on key languages of the Middle East region.<br><br>***FY 2010 Accomplishments:***<br>- Tested and refined the Dari prototype.<br>- Developed context management translation techniques.<br>- Demonstrated a hands-free, eyes-free, two-way translator prototype.<br>- Extended translation techniques to develop translation systems emphasizing other key languages such as Pashto.<br><br>***FY 2011 Plans:*** | 7.833 | 2.500 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* | **PROJECT**<br>IT-04: *LANGUAGE TRANSLATION* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Develop simultaneous multi-lingual translation techniques.<br>- Demonstrate a multilingual translation prototype.<br>- Test translation systems emphasizing other key languages. | | | |
| **Accomplishments/Planned Programs Subtotals** | 70.045 | 53.541 | 67.015 |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* | PROJECT<br>IT-05: *CYBER TECHNOLOGY* | |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IT-05: *CYBER TECHNOLOGY* | - | - | 33.333 | - | 33.333 | 50.000 | 66.667 | 83.333 | 100.000 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

The Cyber Technology project supports long term national security requirements through the development and demonstration of technology to increase the security of military information systems. Over the past decade the DoD has embraced net-centric warfare to enable geographically dispersed forces to attain a high level of shared battlespace awareness that is exploited to achieve strategic, operational, and tactical objectives. This involves networking people, platforms, weapons, sensors, and decision aids to create a whole that is greater than the sum of its parts. The results are networked forces that operate with increased speed and synchronization and are capable of achieving massed effects without the physical massing of forces as required in the past. Adversaries seek to limit this "force multiplier" effect through cyber attacks intended to degrade, disrupt, or deny military computing, communications, and networking systems. Due to its importance and the emergence of these threats, cyberspace is now recognized as a critical warfighting domain, equal in importance to the more traditional domains of sea, air, land, and space. Technologies developed under the Cyber Technology project will ensure DoD cyber-capabilities survive adversary cyber attacks. Promising technologies will transition to system-level projects.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Cyber Situational Awareness and Response (CSAR) | - | - | 17.500 |
| ***Description:*** The Cyber Situational Awareness and Response (CSAR) program will develop technologies to enable awareness and understanding of the cyber environment as required for decision making for defensive and/or responsive actions. This includes attack detection, characterization, and assessment, attacker identification, and information/system provenance. Cyber situational awareness is made increasingly difficult by efforts of attackers to elude detection. Approaches to cyber situational awareness will include techniques to exploit data derived from events on hosts and networks that may be quite subtle when examined in isolation but more apparent when correlated in time and space across an enterprise. CSAR will also create new graphical interfaces and Web 2.0 mashups that enable intuitive visualization of anomalous events on hosts and networks suggestive of cyber attack. Toward this end, CSAR will develop, apply and assess pattern detection and analysis and machine learning techniques to create a real-time network forensics capability that can serve as the basis for rapid response capabilities including network reconstitution. This is an area where metrics are difficult to obtain and so CSAR will extend operationally-meaningful measures such as mean-time-to-detect and false-alarm rate to estimate the efficacy of schemes proposed to detect important classes of attacks.<br><br>***FY 2012 Plans:***<br>- Identify events on hosts and networks having the greatest potential to provide indications and warning of cyber attack.<br>- Conceptualize new graphical interfaces that enable intuitive visualization of anomalous events on hosts and networks suggestive of cyber attack. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY* | **PROJECT**<br>IT-05: *CYBER TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Develop canonical classes of cyber attacks and operationally-meaningful metrics to estimate the efficacy of cyber situational awareness and response schemes. | | | |
| ***Title:*** Cyber Camouflage, Concealment, and Deception (C3D)<br><br>***Description:*** The Cyber Camouflage, Concealment, and Deception (C3D) project will develop novel approaches for protecting cyber systems that mimic camouflage concealment, and deception in the physical world. C3D will enable the creation, deployment, management, and control of synthetic entities, objects, resources, and identities that create uncertainties for attackers and make their task significantly more difficult, perhaps even intractable. With C3D, infrastructure and other enterprise resources such as switches, servers, and storage could be virtually replicated to confound enemy targeting. Multiple C3D copies of file systems, only one of which holds correct information, will require attackers (including insiders) to either exfiltrate many times the data they would normally (and then work to identify which data is correct ) or to guess which file system contains operationally meaningful data, thereby greatly decreasing their odds for success. Ultimately, C3D will produce intelligent artificial users that can defeat phishing attacks. C3D will make attackers work harder and take more risks to achieve their goals and will enhance the effectiveness of conventional cyber defenses.<br><br>***FY 2012 Plans:***<br>- Develop a framework for the creation, deployment, management, and control of synthetic entities, objects, resources, and identities on enterprise information systems.<br>- Develop approaches for creating multiple plausible versions of file systems and data where provenance will be uncertain for the attacker.<br>- Explore techniques capable of deceiving an attacker into believing they have executed a successful phishing attack when in fact they have been deceived by an intelligent synthetic user. | - | - | 15.833 |
| **Accomplishments/Planned Programs Subtotals** | - | - | 33.333 |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

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| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 132.630 | 90.143 | 49.365 | - | 49.365 | 46.424 | 34.405 | 34.832 | 34.927 | Continuing | Continuing |
| COG-02: *COGNITIVE COMPUTING* | 84.601 | 42.143 | 11.674 | - | 11.674 | 13.542 | 12.578 | 12.840 | 12.840 | Continuing | Continuing |
| COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES* | 48.029 | 48.000 | 37.691 | - | 37.691 | 32.882 | 21.827 | 21.992 | 22.087 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

The Cognitive Computing Systems program element is budgeted in the Applied Research budget activity because it is developing the next revolution in computing and information processing technology that will enable computational systems to have reasoning and learning capabilities and levels of autonomy far beyond those of today's systems. The ability to reason, learn and adapt will raise computing to new levels of capability and powerful new applications.

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

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

| **B. Program Change Summary ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012 Base** | **FY 2012 OCO** | **FY 2012 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 144.236 | 90.143 | 88.462 | - | 88.462 |
| Current President's Budget | 132.630 | 90.143 | 49.365 | - | 49.365 |
| Total Adjustments | -11.606 | - | -39.097 | - | -39.097 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | -7.780 | - | | | |
| • SBIR/STTR Transfer | -3.826 | - | | | |
| • TotalOtherAdjustments | - | - | -39.097 | - | -39.097 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* |

**Congressional Add Details ($ in Millions, and Includes General Reductions)**

| | FY 2010 | FY 2011 |
|---|---|---|
| **Project:** COG-02: *COGNITIVE COMPUTING* | | |
| Congressional Add: *BioButanol Production Research* | 2.000 | - |
| Congressional Add Subtotals for Project: COG-02 | 2.000 | - |
| Congressional Add Totals for all Projects | 2.000 | - |

**Change Summary Explanation**

FY 2010: Decrease reflects internal below threshold reprogrammings and SBIR/STTR transfer.
FY 2012: Decrease reflects transition of robotics efforts and completion of the Personalized Assistant that Learns (PAL) program and Defense Efficiencies for contractor staff support and studies.

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* | PROJECT<br>COG-02: *COGNITIVE COMPUTING* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COG-02: *COGNITIVE COMPUTING* | 84.601 | 42.143 | 11.674 | - | 11.674 | 13.542 | 12.578 | 12.840 | 12.840 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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, and the capacity to reconfigure themselves and survive with reduced programmer intervention. These capabilities will make the difference between mission success and mission degradation or failure, even in the event of cyber-attack or component attrition resulting from kinetic warfare or accidental faults and errors. Systems that learn and reason will reduce the requirement for skilled system administrators and dramatically reduce the overall cost of system maintenance.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Autonomous Robotic Manipulation (ARM)*<br>***Description:*** *Formerly Robust Robotics<br><br>The Autonomous Robotic Manipulation (ARM) program is developing advanced robotic technologies that will enable autonomous (unmanned) mobile platforms to manipulate objects without human control or intervention. A key objective is intelligent control of mobile manipulators to independently perform subtasks over a broad range of domains of interest to the warfighter, thereby reducing operator workload, time on target, training time, bandwidth, and hardware complexity. Current mobile manipulation systems have many limitations. For example, while they perform well in certain mission environments, they have yet to demonstrate proficiency and flexibility across multiple mission environments; they require burdensome human interaction and the full attention of the operator; and the time required to complete tasks generally exceeds military users' desires. ARM will create mobile manipulators with a high degree of autonomy capable of serving multiple military purposes across a wide variety of application domains, including but not limited to counter-improvised explosive device, countermine, search and rescue, weapons support, checkpoint and access control, explosive ordnance disposal, and combat casualty care (including battlefield extraction). ARM will enable autonomous mobile manipulation systems to surpass the performance level of remote manipulation systems that are controlled directly by a human operator.<br><br>***FY 2010 Accomplishments:***<br>- Developed a manipulator platform--a base with arm and sensor heads, each with a multi-fingered hand--to serve as a common development platform. | 16.490 | 20.500 | 11.674 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Developed control algorithms that simultaneously manage the degrees of freedom in the arms and hands based on inputs from perception sensors.<br><br>***FY 2011 Plans:***<br>- Develop bi-manual manipulation primitives for handling deformable materials, such as opening a satchel with one hand holding a handle and the other zipping a zipper or opening a clasp.<br>- Develop kinesthetic search techniques based on tactile and haptic sensing.<br><br>***FY 2012 Plans:***<br>- Develop a mobile manipulator platform--add a mobile base to existing manipulator system that can handle outdoor environments.<br>- Develop algorithms to accomplish challenge tasks with mobile platform. | | | |
| ***Title:*** Personalized Assistant that Learns (PAL)<br><br>***Description:*** The Personalized Assistant that Learns (PAL) program enables intelligence in information processing systems so critical DoD systems can better support the warfighter. PAL 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 PAL system to improve over time. Cognitive systems technologies developed in this program will be applied and demonstrated in ongoing and future Command and Control Systems programs.<br><br>***FY 2010 Accomplishments:***<br>- Fine tuned all algorithms for scale-up, response time and throughput.<br>- Finalized human-computer interface and completed the debugging of all PAL software.<br>- Extended the capability of PAL software to learn semantic representations from end users.<br>- Assessed the military impact of enabling users to rapidly integrate and manipulate data, software services and web content.<br><br>***FY 2011 Plans:***<br>- Develop the ability for an integrated cognitive system such as PAL to model its own behavior.<br>- Create the ability for cognitive systems to exchange locally-learned knowledge. | 17.355 | 10.825 | - |
| ***Title:*** Foundational Learning Technology<br><br>***Description:*** The Foundational Learning Technology program develops advanced machine learning techniques that enable cognitive systems to continuously learn, adapt and respond to new situations by drawing inferences from past experience and existing information stores. The techniques developed under Foundational Learning Technology address diverse machine | 8.300 | 6.818 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| learning challenges in processing of sensory inputs, language acquisition, combinatorial algorithms, strategic analysis, planning, reasoning, and reflection. One very promising approach involves transfer learning techniques that transfer knowledge and skills learned for specific situations to novel, unanticipated situations and thereby enable learning systems to perform appropriately and effectively the first time a novel situation is encountered. This is essential because most military operations occur in ever-changing environments; U.S. forces and systems must be able to act appropriately and effectively the first time each novel situation is encountered.<br><br>***FY 2010 Accomplishments:***<br>- Formulated learning approaches applicable to processing of sensory inputs.<br>- Developed techniques to enable generalization of knowledge across application areas such as language acquisition, strategic analysis, planning, reasoning, and reflection.<br>***FY 2011 Plans:***<br>- Implement and test machine learning approaches on selected problems in processing of sensory inputs, language acquisition, strategic analysis, planning, reasoning, and reflection.<br>- Develop a platform for visual and tactile input to ground concepts such as objects and actions for language learning. | | | |
| ***Title:*** Biomimetic Computing<br><br>***Description:*** Biomimetic Computing's goal is to develop the critical technologies necessary for the realization of a cognitive artifact comprised of biologically derived simulations of the brain embodied in a mechanical (robotic) system, which is further embedded in a physical environment. These devices will be a new generation of autonomous flexible machines that are capable of pattern recognition and adaptive behavior and that demonstrate a level of learning and cognition. Key enabling technologies include simulation of brain-inspired neural systems and special purpose digital processing systems designed for this purpose.<br><br>***FY 2010 Accomplishments:***<br>- Developed the capability to simulate a system of one million thalamocortical neurons with spike time dependent plasticity connected to an ape-inspired robot.<br>- Demonstrated the ability of the robot and simulated neural system to organize its visual system and associate sensory inputs and motor output.<br>- Improved and extended neural system models to include capabilities to integrate visual cortex, motor cortex, thalamus, basal ganglion and neuromodulatory systems.<br>***FY 2011 Plans:*** | 5.300 | 4.000 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate an autonomous robot with a simulated neural system capable of mentally rotating images in order to grasp complex three dimensional objects. | | | |
| ***Title:*** Integrated Learning<br><br>***Description:*** The Integrated Learning program created a new computer learning paradigm in which systems learn complex workflows from warfighters while the warfighters perform their regular duties. The effort focused on military planning tasks such as air operations center 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 expensive and error prone hand-encoded knowledge. 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. Such a cognitive system will ultimately need the capability to build and update its own internal model of the world and the objects in it without human input.<br><br>***FY 2010 Accomplishments:***<br>- Expanded the scope of the problems being learned so the systems learn multi-user task models.<br>- Modified the integrated learning systems to be able to abstract the details of the process it is learning and learn general process or meta process knowledge.<br>- Extended capabilities of the integrated learning systems so they can share information (low-level data, mid-level hypothesis, and high-level conclusions) with other learners.<br>- Evaluated systems by having them compete against expert humans. | 5.102 | - | - |
| ***Title:*** Bootstrapped Learning<br><br>***Description:*** The Bootstrapped Learning program provided computers with the capability to learn complex concepts the same way people do: from a customized curriculum designed to teach a hierarchy of concepts at increasing levels of complexity. Learning each new level depends on having successfully mastered the previous level's learning. In addition, the learning program will be "reprogrammable" in the field using the same modes of natural instruction used to train people without the need for software developers to modify the software code. 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. This will enable rapid learning of complex high-level concepts, a capability which is essential for autonomous military systems that 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.<br><br>***FY 2010 Accomplishments:*** | 7.650 | - | - |

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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* | PROJECT<br>COG-02: *COGNITIVE COMPUTING* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Established system generality by demonstrating learning performance in a "surprise" domain that was completely unknown to the learning system developers.<br>- Enhanced system capabilities to include instructible situational awareness.<br>- Demonstrated end-to-end autonomous bootstrapped learning. | | | |
| ***Title:*** Machine Reading and Reasoning Technology<br><br>***Description:*** The Machine Reading and Reasoning Technology program is developing enabling technologies to acquire, integrate, and use high performance reasoning strategies in knowledge-rich domains. Such technologies will provide DoD decision makers with rapid, relevant knowledge from a broad spectrum of sources that may be dynamic and/or inconsistent. To address the significant challenges of context, temporal information, complex belief structures, and uncertainty, new capabilities are needed to extract key information and metadata, and to exploit these via context-capable search and inference (both deductive and inductive). Machine reading addresses the prohibitive cost of handcrafting information by replacing the expert, and associated knowledge engineer, with un-supervised or self-supervised learning systems that "read" natural text and insert it into AI knowledge bases especially encoded to support subsequent machine reasoning. Machine reading requires the integration of multiple technologies: natural language processing must be used to transform the text into candidate internal representations, and knowledge representation and reasoning techniques must be used to test this new information to determine how it is to be integrated into the system's evolving models so that it can be used for effective problem solving. These concepts and technology development efforts will continue in PE 0602305E, Project MCN-01 beginning in FY 2011.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated the ability of a system to acquire and organize factual information directly from unstructured narrative text in multiple domains.<br>- Developed knowledge representation and reasoning capabilities to support simple temporal reasoning using ordered relationships in text.<br>- Demonstrated the ability of machine reading systems to extract knowledge from texts that employ varied writing styles and require contextualization for proper interpretation.<br>- Demonstrated human-level performance by machines at categorizing text quality preparatory to automatic knowledge extraction. | 17.404 | - | - |
| ***Title:*** Mind's Eye<br><br>***Description:*** The Mind's Eye program, previously part of the Machine Reading and Reasoning thrust, is developing in machines, a capability that currently exists only in animals: "visual intelligence." Machines enhanced by Mind's Eye technology will have the capability to learn generally applicable and generative representations of action between objects in a scene, directly from visual inputs, and be able to reason over those learned representations. While current research in machine vision has been | 5.000 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| successful in developing techniques recognizing objects and their properties, Mind's Eye will add the perceptual and cognitive underpinnings for reasoning about the action in scenes, enabling the creation of a more complete narrative for the visual field. The technologies developed under Mind's Eye will have broad applicability in robotics and surveillance. These concepts and technology will continue in PE 0602305E, Project MCN-01 beginning in FY 2011.<br><br>***FY 2010 Accomplishments:***<br>- Developed enduring research corpus and library of thousands of video vignettes to support technical development and evaluation as well as future research.<br>- Developed high-level system integration concept to support implementation of visual intelligence algorithms on smart camera platforms.<br>- Developed first-generation visual intelligence algorithms for domain-independent event recognition, prediction, interpolation, and visualization. | | | |
| **Accomplishments/Planned Programs Subtotals** | 82.601 | 42.143 | 11.674 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** BioButanol Production Research<br><br>***FY 2010 Accomplishments:*** - Continue to investigate bio-butanol production capabilities. | 2.000 | - |
| **Congressional Adds Subtotals** | 2.000 | - |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* | **PROJECT**<br>COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES* | 48.029 | 48.000 | 37.691 | - | 37.691 | 32.882 | 21.827 | 21.992 | 22.087 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

The Collective Cognitive Systems and Interfaces project will dramatically improve warfighter and commander effectiveness and productivity using advanced cognitive approaches that enable faster, better informed, and more highly coordinated actions than those of our enemies. This will be accomplished by developing revolutionary methods that increase our information processing capabilities, enhance our situational awareness, and enable more cohesive group action by our forces. Critical technical areas addressed in this project include automated decision support, information sharing, ensured communications, and advanced informatics. Cognitive decision support tools reason about tasks, timings, and interactions so that when plans change or the enemy does not respond as anticipated, U.S. forces can quickly adapt. The quality of such decisions and the effectiveness of our actions depend critically on our ability to take full advantage of all available information in a rapid and flexible manner. This requires the capability to share information and to automatically integrate distributed information bases for broad tactical battlespace awareness. Team cohesion requires effective and reliable communication in difficult environments such as urban settings 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 what parameters each radio will use. Finally, the use of advanced informatics will help guide user's to information most relevant to them, assist caregivers with treatment, destigmatize the psychological health process, and help alert DoD to emerging psychological health trends and crises. The suite of programs under this project will significantly advance the military's ability to successfully deal with complex situations in operational environments.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Transformative Apps<br><br>***Description:*** The goal of the Transformative Apps effort is to put mobile, tactical applications (apps) in the hands of warfighters and to create a new military apps marketplace with a vibrant apps development community. The effort will demonstrate a broad array of apps supporting command and control, situational awareness, collaboration, geo-spatial visualization, training, and language translation. Many of these applications will require ongoing network connectivity; others will require occasional data synchronization. While commercial networks benefit from robust cellular networks and the presence of large data centers, tactical networks are notorious for their limited bandwidth, frequent outages, and high-latency links. Specialized backend architecture and middleware will be developed to enable apps to run while providing engaging user experience and without over-burdening the network. Of particular importance is development of a new data synchronization architecture between the handhelds and the backend computing/storage nodes. Additionally, appropriate middleware services and libraries will be developed to facilitate shared capabilities such as map viewing, apps management, and collection of logs, usage statistics and user feedback. Apps, together with handhelds and networks, will be tested in different training environments as well as in deployed environments. Performance and usage will be carefully tracked and user feedback collected to guide rapid enhancement of apps. The effort | 9.400 | 15.500 | 16.502 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* | **PROJECT**<br>COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| will create a military apps development community by reaching out to non-traditional performers and will explore new models for software acquisitions based on end-user empowerment. The effort will leverage the resources, experience, and lessons-learned derived from the Tactical Ground Reporting System (TIGR).<br><br>***FY 2010 Accomplishments:***<br>- Launched a series of user conferences.<br>- Established innovation and collaboration tools.<br>- Created application programming interfaces (APIs) and a development framework that will enable efficient creation of specialized military apps later in the program.<br><br>***FY 2011 Plans:***<br>- Develop initial set of middleware services and tools.<br>- Develop initial apps suite available on BETA repository.<br>- Perform operational evaluation testing with military and commercial networks.<br><br>***FY 2012 Plans:***<br>- Conduct evaluations with security infrastructure.<br>- Enhance middleware and services for apps.<br>- Develop tools for non-experts to create apps on smartphone platforms.<br>- Test interoperability with Wireless Network After Next (WNAN) or other military tactical networks. | | | |
| ***Title:*** Healing Heroes - Medical<br><br>***Description:*** The Healing Heroes program will develop automated information systems that identify group and individual trends indicative of post-traumatic stress disorder (PTSD) and traumatic brain injury (TBI), anomaly detection algorithms to identify emerging physical and psychological crises, and provide guided access to information and educational materials. This will complement commercial on-line resources, interactive media, and social networks that supplement traditional healthcare options but have not focused on issues specific to the Warfighter. Healing Heroes will integrate social networking and medical informatics technologies in a secure web-based platform that provides both functionality and privacy to the user. The program will also provide tools for spouses, caregivers, and children, and will leverage related DoD family outreach efforts. Healing Heroes recognizes that security and privacy are critical to user acceptance and Health Insurance Portability and Accountability Act (HIPAA) compliance and so will incorporate strong authentication and other security mechanisms as needed to protect patient data. The program will also develop partnerships with key DoD organizations working in this area, including the Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury, the Defense Medical Research and Development Program | 6.000 | 14.948 | 9.079 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* | PROJECT<br>COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| (DMRDP), the Army Telemedicine & Advanced Technologies Research Center (TATRC), and the National Center for TeleHealth and Technology.<br><br>***FY 2010 Accomplishments:***<br>- Developed Healing Heroes system concept of operations and preliminary privacy framework.<br>- Developed system security requirements and performed initial system engineering.<br>***FY 2011 Plans:***<br>- Develop the Healing Heroes functional and security services.<br>- Implement and release initial prototype version of Healing Heroes on a DoD network.<br>- Perform alpha test/user trial of the system.<br>***FY 2012 Plans:***<br>- Complete final modifications to the system based on the results of the alpha test/user trial.<br>- Perform beta test/user trial of the system.<br>- Operationalize system software and documentation, harden the system, and obtain certification and accreditation. | | | |
| ***Title:*** Graph Understanding and Analysis for Rapid Detection - Deployed On the Ground (GUARD DOG)*<br>***Description:*** *Previously in Advanced Soldier Sensor Information System and Technology.<br><br>The Graph Understanding and Analysis for Rapid Detection - Deployed On the Ground (GUARD DOG) program will develop an integrated system to provide real-time data collection and analysis of patrol-based civilian interviews and field observations to facilitate understanding of the local and regional political, social, economic, and infrastructure situation in which U.S. forces are deployed. GUARD DOG will consist of two segments: a handheld/portable digital assistant to support dismounted soldiers patrolling neighborhoods and villages; and a laptop/desktop computer system that integrates data from multiple patrols and supports battalion/brigade-level analysts. GUARD DOG will provide automated support for the Collect-Update-Analyze-Prioritize process by supporting data collection and advanced analytics to evaluate the current local/regional situation, identify gaps in the knowledge base, and generate information requirements.<br><br>***FY 2011 Plans:***<br>- Develop fast, graph-based, information analysis algorithms that can handle large, complex data sets.<br>- Develop new technologies and system architecture to support real-time data collection and analysis.<br>- Develop simulation test bed to evaluate selected graph-based algorithms. | - | 10.000 | 12.110 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* | **PROJECT**<br>COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Design, conduct and analyze field experiments using test bed and National Training Center at Ft. Irwin.<br>***FY 2012 Plans:***<br>- Optimize algorithms to run on handheld devices in the field.<br>- Enhance algorithms to address uncertain and dynamic data.<br>- Expand architecture to support multiple, distributed users.<br>- Design, conduct and analyze field experiments using test bed and National Training Center at Ft. Irwin and/or Joint Readiness Training Center at Ft. Polk, LA. | | | |
| ***Title:*** Cognitive Networking<br>***Description:*** The Cognitive Networking program will develop technologies that provide information systems and communication networks with the ability to maintain and self-optimize 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. Cognitive information processing will be used to optimize networked communications based on current conditions, past experience and high-level user guidance. The Cognitive Networking program is also addressing the warfighter's need for actionable situational awareness in complex radio frequency (RF) environments. This work leverages advances in software-defined radio technology to achieve specific military goals. Cognitive Networking funds three programs: SAPIENT, LANDroids, and BOSS.<br><br>The Situation-Aware Protocols in Edge Network Technologies (SAPIENT) effort 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 SAPIENT 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. SAPIENT technology enables the automatic adaptation of protocols to the operational environment to dramatically reduce the effect of network impairments on applications while demonstrating a positive trend in capability as new situations are encountered and learned.<br><br>The Local Area Network droids (LANdroids) effort will give warfighters reliable communications in urban settings. LANdroids will accomplish this by creating robotic radio relay nodes that move autonomously to configure and maintain a communications mesh by reasoning about their positions relative to one another and relative to the warfighters. LANdroids will move as the warfighters move with the goal of maintaining warfighter connectivity throughout their operations. LANdroids will be pocket-sized so warfighters can carry several and drop or deploy them as they move through an area. The effort is creating both the intelligent | 16.459 | 5.552 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| radio control software and the small radio platform on which it runs. The technologies will be tested in a physical setting and at an operationally relevant scale.<br><br>The Brood of Spectrum Supremacy (BOSS) effort 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 to generate breakthrough capabilities in the warfighter knowledge of their surroundings, with a particular focus on RF-rich urban operations. Ultimately this effort will develop Software Communications Architecture (SCA)-compliant waveforms suitable for implementation on a tactical software radio system.<br><br>***FY 2010 Accomplishments:***<br>Situation-Aware Protocols in Edge Network Technologies (SAPIENT)<br>- Demonstrated an adaptive cognitive prototype for a tactical environment using mobile, airborne, and stationary nodes.<br><br>Local Area Network droids (LANdroids)<br>- Evaluated tethering, power management and load-balancing algorithms using a 15-node LANdroids network that spans two indoor floors of a building.<br>- Developed control algorithms for LANdroids that enable them to tether the network to warfighters so the network moves as the warfighters move.<br>- Developed intelligent power management algorithms for LANdroids so they make intelligent decisions about whether or not to move based on current conditions and expected power expenditures and savings.<br>- Developed network load-balancing protocols for LANdroids that dovetail with the power management algorithms to enable the network to last as long as possible.<br><br>Brood of Spectrum Supremacy (BOSS)<br>- Collected RF data with Wireless Network after Next (WNaN) radio to evaluate BOSS algorithms with these radios.<br>- Performed minor modifications on the WNaN radio to extend the frequency range for BOSS applications and enable BOSS to be used with a wider range of signals of interest.<br>- Optimized BOSS software as necessary for use with WNaN radios.<br>- Began embedding the BOSS algorithms into radios for real-time testing and evaluation.<br>- Evaluated network understanding algorithms with collected RF data.<br><br>***FY 2011 Plans:***<br>Brood of Spectrum Supremacy (BOSS) | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* | **PROJECT**<br>COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Complete implementation of BOSS capabilities utilizing WNaN radios with BOSS frequencies.<br>- Test and evaluate BOSS in "real-world" scenarios including test and evaluation of real-time RF geolocation and network understanding performance. | | | |
| ***Title:*** Advanced Soldier Sensor Information System and Technology (ASSIST)<br><br>***Description:*** The Advanced Soldier Sensor Information System and Technology (ASSIST) effort 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. This includes an integrated system using advanced technologies for processing, digitizing and analyzing information captured and collected by soldier-worn sensors. ASSIST draws heavily on the experiences and lessons learned from previous Operation Iraqi Freedom (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.<br><br>***FY 2010 Accomplishments:***<br>- Developed the means for efficient transfer of ASSIST information across Army tactical networks.<br>- Integrated with Army battlefield command systems by addressing system latencies and data exchange formats and modalities.<br>- Demonstrated an accelerated capability for recognizing new classes of events, objects and activities.<br>- Integrated biometric feature extraction and comparison capabilities into Tactical Ground Reporting System (TIGR).<br><br>***FY 2011 Plans:***<br>- Automate the extraction of relevant portions of feeds for indexing into the TIGR database.<br>- Integrate multiple, real-time sensor feeds including high-bandwidth sensor feeds such as video streams.<br>- Implement robust operation over wireless networks of very limited bandwidth.<br>- Develop real-time collaboration tools for dismounted soldiers. | 9.450 | 2.000 | - |
| ***Title:*** Cloud Computing<br><br>***Description:*** Cloud Computing explored techniques to enable information, applications, services, storage, and other resources that reside on military networks to be used by web-based clients to perform critical mission functions. The Cloud Computing program created architectures to automatically integrate distributed information bases for broad tactical battlespace awareness and produced the infrastructure and application technologies needed to automate the integration of multiple media (text, video, and digital photographs) as well as its analysis, indexing, and storage. | 6.720 | - | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602304E: *COGNITIVE COMPUTING SYSTEMS* | **PROJECT**<br>COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| The Digital Object Storage and Retrieval (DOSR) effort pursued a network-based approach to information storage and management that will enable a network-based repository to hold all digital information. DOSR technology enables and facilitates controlled access to information by approved and authenticated users across administrative domains, and in this fashion it will enable transparent sharing of information across the enterprise.<br><br>The Data Integration and Exploitation SystEm that Learns (DIESEL) effort addressed a significant problem facing the warfighter: the lack of interoperability of stovepiped information systems. DIESEL created a new suite of intelligent information integration tools that automatically understand heterogeneous information systems and integrate them into the existing information environment. The result is more complete and reliable information for better decision-making by warfighters.<br><br>***FY 2010 Accomplishments:***<br>Digital Object Storage and Retrieval (DOSR)<br>- Completed final assessment of architectural approaches to secure controlled access.<br><br>Data Integration and Exploitation SystEm that Learns (DIESEL)<br>- Completed study to identify and understand user models based on the task to be performed (aided by the Army's Tactics, Techniques, and Procedures manuals), which will provide semantic context to refine search results.<br>- Prototyped techniques to integrate with existing automated visualization services to provide 'at a glance' understanding of relevant content, customized to the user and task.<br>- Designed an automated data integration technology through tests with realistic military information systems and a variety of new data sources of increasing complexity. | | | |
| **Accomplishments/Planned Programs Subtotals** | 48.029 | 48.000 | 37.691 |

## C. Other Program Funding Summary ($ in Millions)
N/A

## D. Acquisition Strategy
N/A

## E. Performance Metrics
Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602305E: *MACHINE INTELLIGENCE* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | - | 44.682 | 61.351 | - | 61.351 | 52.276 | 51.752 | 51.484 | 51.484 | Continuing | Continuing |
| MCN-01: *MACHINE INTELLIGENCE* | - | 44.682 | 61.351 | - | 61.351 | 52.276 | 51.752 | 51.484 | 51.484 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

The Machine Intelligence project is budgeted in the Applied Research Budget Activity because it is developing technologies that will enable computing systems to extract and encode information from dynamic and stored data, observations, and experience, and to derive new knowledge, answer questions, reach conclusions, and propose explanations. Enabling computing systems with machine intelligence in this manner is now of critical importance because sensor, information, and communication systems continuously generate and deliver data at rates beyond which humans can assimilate, understand, and act. Since its creation over 50 years ago, artificial intelligence (AI) has gone through several phases. Initially, AI emphasized rule-based and symbolic approaches. These were eventually reconceived using a human-intelligence paradigm ("cognitive computing"). Recently, a more powerful approach has emerged, with rule-based, symbolic and human-oriented approaches combined with large-scale statistical approaches that make explicit use of massive distributed data and information bases. These data/information bases are curated (e.g., machine-filtered or human-selected) and raw (e.g., as originally obtained and perhaps of unknown provenance); structured (e.g., tabular or relational) and unstructured (e.g., text documents, multi-media files); static (e.g., historical, unchanging) and dynamic (e.g., real-time sensor data). This explosion in available data/information, combined with the ready availability of inexpensive mass storage and ubiquitous, inexpensive, computation-on-demand, provide the foundation for entirely new machine intelligence capabilities. The technologies developed in the Machine Intelligence project will result in revolutionary capabilities in military command and control, intelligence, decision-making, and situational awareness/indications and warning for a complex, global environment where traditional (e.g., nation-states) and non-traditional (e.g., trans-national) actors and new classes of cyber-physical-human threats have become the status quo.

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | - | 44.682 | 68.972 | - | 68.972 |
| Current President's Budget | - | 44.682 | 61.351 | - | 61.351 |
| Total Adjustments | - | - | -7.621 | - | -7.621 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | - | - | | | |
| • TotalOtherAdjustments | - | - | -7.621 | - | -7.621 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602305E: *MACHINE INTELLIGENCE* |

**Change Summary Explanation**

FY 2012: Decrease reflects minor repricing of on-going programs and Defense Efficiencies for contractor staff support.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Machine Reading and Reasoning Technology* | - | 23.896 | 29.859 |

***Description:*** *Previously funded in PE 0602304E, Project COG-02.

The Machine Reading and Reasoning Technology program will develop enabling technologies to acquire, integrate, and use high performance reasoning strategies in knowledge-rich domains. Such technologies will provide DoD decision makers with rapid, relevant knowledge from a broad spectrum of sources that may be dynamic and/or inconsistent. To address the significant challenges of context, temporal information, complex belief structures, and uncertainty, new capabilities are needed to extract key information and metadata, and to exploit these via context-capable search and inference. Cognitive inference has traditionally emphasized deduction via theorem-proving and induction via statistical techniques, but abduction - also known as "inference to the best explanation"- is also likely to play a large role. Machine Reading addresses the prohibitive cost of handcrafting information by replacing the expert, and associated knowledge engineer, with un-supervised or self-supervised learning systems, systems that "read" natural text and insert it into artificial intelligence knowledge bases, i.e. data stores especially encoded to support subsequent machine reasoning. Machine Reading requires the integration of multiple technologies: natural language processing must be used to transform the text into candidate internal representations, and knowledge representation and reasoning techniques must be used to test this new information to determine how it is to be integrated into the system's evolving models so that it can be used for effective problem solving.

***FY 2011 Plans:***
- Extend knowledge extraction capabilities of machine reading systems to acquire simple relationship information in addition to factual data.
- Force generality of machine reading systems through introduction of multiple, hidden domains.
- Develop knowledge extraction, representation, and reasoning capabilities to support spatial, complex temporal, and event reasoning.

***FY 2012 Plans:***
- Develop capability to automatically learn reading patterns by addressing ambiguity resolution and discovering inference patterns.
- Demonstrate temporal reasoning over facts and events extracted from text.
- Begin developing military transition with DoD organization focused on semantic understanding of heterogeneous knowledge sources in a targeted domain.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602305E: *MACHINE INTELLIGENCE* | |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Develop techniques for inferring potentially classified information from unclassified text. | | | |
| ***Title:*** Mind's Eye*<br><br>***Description:*** * Previously funded in PE 0602304E, Project COG-02.<br><br>The Mind's Eye program is developing a machine-based capability that currently exists only in animals: "visual intelligence," the capability to learn generally applicable and generative representations of action between objects in a scene, directly from visual inputs, and then to reason over those learned representations. Mind's Eye will add the perceptual and cognitive underpinnings for reasoning about the action in scenes, enabling the creation of a more complete narrative for the visual field. The technologies developed under Mind's Eye will have broad applicability in robotics and surveillance.<br><br>***FY 2011 Plans:***<br>- Develop initial visual intelligence implementation and evaluate on relevant dataset(s).<br>- Identify systems integration opportunities and perform initial systems engineering analysis.<br><br>***FY 2012 Plans:***<br>- Develop improved visual intelligence capabilities based on initial assessment(s) and evaluate on additional relevant dataset(s).<br>- Integrate visual intelligence into a prototype smart camera and perform concept demonstration. | - | 10.000 | 16.000 |
| ***Title:*** Web-Scale Information Integration<br><br>***Description:*** The Web-Scale Information Integration program will create technologies to automatically integrate distributed information bases for broad strategic and tactical battlespace awareness, including technologies to automate the integration of multiple media (text, video, and digital photographs) as well as analyze, index, and store that media, so that it can be easily queried and retrieved by users across the DoD enterprise. A key enabler is the development of advanced document/content/information-object services including indexing, metadata creation, search, versioning, records management, schema alignment, and information visualization. Program interest extends to semantic web technologies whereby the semantics of information and services are made explicit, enabling machines to understand and satisfy the information requests of users (people and machines). This includes the technologies needed to automatically create and maintain, in real-time, encyclopedic knowledge of critical military, scientific, economic and social-cultural information in formats that are both human readable and machine processable. Such encyclopedic knowledge of the world will provide fundamental context to counter-insurgency, global strike and (near-) peer conflict including strategy, rules of engagement, planning and execution, while semantically-enabled search and processing will automate information discovery and manipulation to enable better decision-making for warfighters.<br><br>***FY 2011 Plans:*** | - | 10.786 | 15.492 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602305E: *MACHINE INTELLIGENCE* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Integrate dialogue system with semantically-enabled search capabilities to enable intelligent, user-defined Web search routines.<br>- Link dialogue semantics with learning-by-demonstration techniques to produce reusable and composable Web search and content manipulation services.<br>- Conceptualize approaches for authoring, maintaining, querying, and visualizing global knowledge capable of scaling to tens of millions of articles, inference over uncertain/inconsistent data, socially reconciling semantic inconsistencies, and additional social challenges (contrasting point of view, non-logical semantics, etc.).<br>***FY 2012 Plans:***<br>- Extend dialogue capability to enable user-defined extensions to descriptions of Web semantics.<br>- Develop and demonstrate cognitive agents that greatly reduce the time it takes users to find and process information on the World Wide Web.<br>- Develop approaches for extracting and representing facts and implications from crowd-sourced information streams as well as tracking provenance and detecting inconsistent data.<br>- Identify operational scenarios (use cases), needs, and constraints. | | | |
| **Accomplishments/Planned Programs Subtotals** | - | 44.682 | 61.351 |

## D. Other Program Funding Summary ($ in Millions)

N/A

## E. Acquisition Strategy

N/A

## F. Performance Metrics

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

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602383E: *BIOLOGICAL WARFARE DEFENSE* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 41.348 | 32.692 | 30.421 | - | 30.421 | 62.736 | 94.008 | 67.076 | 58.425 | Continuing | Continuing |
| BW-01: *BIOLOGICAL WARFARE DEFENSE* | 41.348 | 32.692 | 30.421 | - | 30.421 | 62.736 | 94.008 | 67.076 | 58.425 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

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

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 40.418 | 32.692 | 30.250 | - | 30.250 |
| Current President's Budget | 41.348 | 32.692 | 30.421 | - | 30.421 |
| Total Adjustments | 0.930 | - | 0.171 | - | 0.171 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | 2.002 | - | | | |
| • SBIR/STTR Transfer | -1.072 | - | | | |
| • TotalOtherAdjustments | - | - | 0.171 | - | 0.171 |

**Change Summary Explanation**

FY 2010: Decrease reflects internal below threshold reprogramming and SBIR/STTR transfer.

FY 2012: Increase reflects minor repricing.

## C. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Unconventional Therapeutics - Medical | 20.062 | 13.000 | - |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602383E: *BIOLOGICAL WARFARE DEFENSE* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** This thrust is developing unique and unconventional approaches to ensure that soldiers are protected against a wide variety of naturally occurring, indigenous or engineered threats. Past successes in this effort have come from developing therapeutics that are designed to work against broad classes of pathogens. Work in this area has also uncovered new approaches to therapeutics that, rather than attacking specific pathogens, enhance innate human immune mechanisms against broad classes of pathogens. Integral to these efforts is the development of methods that rapidly identify a broad spectrum of pathogens. Not only will these approaches be more effective against known pathogens, they also promise to offer substantial protection against unknown pathogens including engineered and emerging pathogens from third-world environments.<br><br>A current emphasis is on the discovery and development of technologies that will allow a rapid response (within weeks) to unanticipated threats, whether they are naturally encountered emerging diseases or agents from intentional attack. This thrust has a goal of radically transforming the protein design process by researching and developing new mathematical and biochemical approaches to the in silico design of proteins with specific functions. This significantly decreases the time needed and increases the probability of success for biological warfare vaccine development. An additional focus is the development of entirely new technologies that will allow the rapid, cost-effective manufacture of complex therapeutic proteins such as monoclonal antibodies and vaccine antigens; these technologies will reduce the time for biologics manufacture from years (or even decades) to only weeks. The Unconventional Therapeutics efforts will be funded in the newly created Budget Activity 2 Program Element 0602115E, beginning in FY 2012.<br><br>***FY 2010 Accomplishments:***<br>- Tested human H1N1 subunit vaccine produced by Blue Angel/Accelerated Manufacture of Pharmaceuticals for inflammatory mediations.<br>- Demonstrated dose efficacy for non non-egg-based vaccines using animal models and DARPA's Rapid Vaccine Assessment, an in vitro artificial immune system.<br>- Documented vaccine contaminants, system development, and quality control to facilitate pre-investigational new drug meetings with the Food and Drug Administration (FDA).<br>- Began developing innovative approaches to counter any known, unknown, naturally occurring or engineered pathogen.<br>- Initiated identification of means to prevent initial infection and secondary transmission of any contagious agent from primary to secondary contact.<br>- Began developing approaches for slowing disease progression and sustain survival from highly lethal infections until either immunity is achieved or treatment is administered.<br>- Began developing techniques to provide temporary protection against a pathogen in which the host has no immunity against.<br>- Began developing strategies that accelerate acquisition of effective persistent immunity before death from a lethal pathogen.<br>***FY 2011 Plans:*** | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602383E: *BIOLOGICAL WARFARE DEFENSE* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Ascertain minimal dose of vaccine necessary for antibody protection.<br>- Further develop innovative approaches to counter any known, unknown, naturally occurring or engineered pathogen.<br>- Demonstrate various technologies that increase the median infectious dose (ID50) of a given pathogen by 10-fold compared to the untreated control ID50 in an animal model.<br>- Demonstrate a 2-fold increase in survival time in an animal model after a lethal dose (LD95) challenge of a given pathogen.<br>- Demonstrate 95% survival against a first medium lethal dose (LD50) challenge of a given pathogen in an animal model using a therapy developed within 14 days of receipt of an unknown pathogen.<br>- Demonstrate 95% survival after three LD50 challenges of a given pathogen in an animal model spaced 1 week apart = 14 days post countermeasure. | | | |
| ***Title:*** Medical Countermeasures - Medical<br><br>***Description:*** To further develop an expedited medical countermeasure capability, emerging technologies will be integrated to address the safety considerations in the risk/benefit package required for Emergency Use Authorization (EUA) issuance to counter naturally emerging or engineered biological warfare threats. These technologies will also be focused on new safety standards to reduce the time, risk, and cost associated with licensing a new therapeutic which might be considered under an EUA.<br><br>***FY 2011 Plans:***<br>- Assess the capability for rapid manufacture of medical countermeasures based on new expression platforms such as plant and fungi.<br>- Identify relevant genetic events resulting in changes in virus phenotypes in the presence of selective environmental pressures.<br><br>***FY 2012 Plans:***<br>- Investigate targets for high yield medical countermeasures synthesis that do not require access to the pathogen.<br>- Review the current Emergency Use Authorization (EUA) process from end to end and identify opportunities where an integrated countermeasure pipeline could exploit technological advances created at DARPA to rapidly create a safe and potent therapy for which the Food and Drug Administration (FDA) can confidently issue an EUA.<br>- Initiate development of predictive preclinical bioterrorism agent disease models including in silico surrogates to increase the quality and quantity of data in the risk-benefit package available for new bioterrorism countermeasures.<br>- Begin library development for preclinical safety and efficacy biomarkers based on physiochemical and in vitro data as technologies to support new standards of safety, thereby reducing the time, risk, and cost associated with licensing a new therapeutic.<br>- Initiate development of physiological-based pharmacokinetic/pharmacodynamic modeling and simulation for prediction of therapeutic activity in man based on preclinical library. | - | 1.000 | 15.919 |
| ***Title:*** Chemical Reconnaissance* | 21.286 | 18.692 | 14.502 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602383E: *BIOLOGICAL WARFARE DEFENSE* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** *Formerly Hyperadsorptive Atmospheric Sampling Technology (HAST).<br><br>The Chemical Reconnaissance program will enable exhaustive, accurate, and economical collection of atmospheric trace constituents to support chemical mapping of urban and military environments. The system will demonstrate materials, packaging, and extraction technologies that sample atmospheric impurities with concentrations ranging from 10 parts per trillion to 100 parts per million by volume, from 100 liter-atmospheres of gas, in less than five minutes. New systems to provide rapid, comprehensive, and quantitative trace gas analysis without preconceived lists or libraries of target chemicals will also be developed. The analysis systems will integrate sophisticated separation and spectroscopic techniques with advanced quantum chemistry algorithms to enable library-free identification and ranking (by concentration) of all components present in complex gas mixtures. This capability will revolutionize our understanding of the environment through chemical mapping and reconnaissance. Reproducible analysis of atmospheric samples using sophisticated analytical technology will yield maps of baseline conditions, natural variability, and permit detections of nefarious anomalies involving production, movement, and storage of weapons, even under shifting backgrounds driven by meteorological and seasonal events.<br><br>***FY 2010 Accomplishments:***<br>- Tested prototype architecture using calibrated gas mixtures.<br>- Demonstrated prototype sampling and extraction architecture using calibrated gas mixtures.<br>- Demonstrated sampling retention and return of analytes with accuracy and fidelity.<br>- Demonstrated ability to seal sampled trace gases before readout.<br>- Developed advanced mass spectrometry and infrared spectroscopy instrumentation.<br>- Demonstrated analysis of samples fidelity and accuracy in prototype analytical system.<br>***FY 2011 Plans:***<br>- Engineer portable prototype systems for autonomous collection on mobile and stationary platforms.<br>- Integrate sample labeling with meteorological data, time, and geographic coordinates.<br>- Extend accuracy and fidelity of sampling capsules.<br>- Deliver and field test functional sampling technology prototypes for autonomous vehicle-borne operation.<br>- Demonstrate adsorbent manufacturing technology and economical collection.<br>***FY 2012 Plans:***<br>- Demonstrate prototype analytical system analysis of samples with high fidelity and accuracy.<br>- Design and validate a system to analyze a large number of samples at low cost that fits in a standard shipping container.<br>- Integrate sampling technologies with laboratory analytical systems. | | | |

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602383E: *BIOLOGICAL WARFARE DEFENSE* |

| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Demonstrate chemical source attribution, using virtual analysis output. | | | |
| **Accomplishments/Planned Programs Subtotals** | 41.348 | 32.692 | 30.421 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**E. Acquisition Strategy**

N/A

**F. Performance Metrics**

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

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| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 240.663 | 224.378 | 206.422 | - | 206.422 | 217.032 | 198.916 | 211.247 | 225.047 | Continuing | Continuing |
| TT-03: *NAVAL WARFARE TECHNOLOGY* | 42.217 | 45.328 | 35.855 | - | 35.855 | 53.486 | 45.371 | 39.392 | 39.392 | Continuing | Continuing |
| TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY* | 30.899 | 18.911 | 34.896 | - | 34.896 | 50.308 | 51.551 | 50.609 | 50.609 | Continuing | Continuing |
| TT-06: *ADVANCED TACTICAL TECHNOLOGY* | 74.728 | 67.308 | 63.719 | - | 63.719 | 41.184 | 29.642 | 34.716 | 52.516 | Continuing | Continuing |
| TT-07: *AERONAUTICS TECHNOLOGY* | 26.915 | 34.692 | 23.042 | - | 23.042 | 27.773 | 28.655 | 42.806 | 42.806 | Continuing | Continuing |
| TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY* | 65.904 | 58.139 | 48.910 | - | 48.910 | 44.281 | 43.697 | 43.724 | 39.724 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

The Naval Warfare Technology project develops advanced enabling technologies for a broad range of naval requirements. Technologies under development will increase survivability and operational effectiveness of small and medium surface vessels in rough seas and demonstrate advanced technologies for hypersonic flight. New areas to be investigated include ship self defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations and unmanned sea vehicles for anti-submarine warfare.

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

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

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* |

The Aeronautics Technology project explores technologies to reduce costs associated with advanced aeronautical systems and provide revolutionary new capabilities for current and projected military mission requirements. This project funds development of a hybrid ground/air vehicle, an advanced helicopter rotor capable of being optimized for each mission, and robust study efforts.

The Network Centric Enabling Technology project funds sensor, signal processing, detection, tracking and target identification technology development required for true network-centric tactical operations. Technologies developed in this project will enable localized, distributed and cross-platform collaborative processing so that networks of sensors can rapidly adapt to changing force mixes, predictive modeling tools to evaluate failing nation states and identify potential hot spots, and social networking approaches to identify and track potential terrorist cells.

| **B. Program Change Summary ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012 Base** | **FY 2012 OCO** | **FY 2012 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 248.683 | 224.378 | 260.518 | - | 260.518 |
| Current President's Budget | 240.663 | 224.378 | 206.422 | - | 206.422 |
| Total Adjustments | -8.020 | - | -54.096 | - | -54.096 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | -1.424 | - | | | |
| • SBIR/STTR Transfer | -6.596 | - | | | |
| • TotalOtherAdjustments | - | - | -54.096 | - | -54.096 |

| **Congressional Add Details ($ in Millions, and Includes General Reductions)** | **FY 2010** | **FY 2011** |
|---|---|---|
| **Project:** TT-03: *NAVAL WARFARE TECHNOLOGY* | | |
| Congressional Add: *Center of Excellence for Research in Ocean Sciences (CEROS)* | 8.000 | - |
| Congressional Add: *SeaCatcher Unmanned Aircraft Launch and Recovery System* | 1.600 | - |
| Congressional Add Subtotals for Project: TT-03 | 9.600 | - |
| Congressional Add Totals for all Projects | 9.600 | - |

**Change Summary Explanation**

FY 2010: Decrease reflects internal below threshold reprogrammings and the SBIR/STTR transfer.
FY 2012: Decrease reflects the end of programs such as EXACTO and Formation Flight in order to emphasize new directed energy efforts, social networking analysis and manufacturing efforts. In addition, the decrease also includes Defense Efficiencies for contractor staff support.

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-03: *NAVAL WARFARE TECHNOLOGY* | |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TT-03: *NAVAL WARFARE TECHNOLOGY* | 42.217 | 45.328 | 35.855 | - | 35.855 | 53.486 | 45.371 | 39.392 | 39.392 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling and novel technologies include concepts for expanding the envelope of operational naval capabilities such as drag reduction, ship stability, hypersonic missiles, logistically friendly distributed lighting systems, ship self defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations, high speed underwater vessels, improved techniques for underwater object detection and discrimination, long endurance unmanned surface vehicles, and high bandwidth communications.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV)<br><br>***Description:*** The Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV) program has three primary goals: (1) to build and demonstrate an X-Ship with beyond state-of-the-art platform performance based on clean sheet design for unmanned operation, (2) demonstrate the technical viability of operating autonomous unmanned ships at theater or global ranges under a sparse remote supervisory control model, and (3) leverage unique ACTUV characteristics to transition a game changing ASW capability to the Navy. By establishing the premise that a human is never intended to step on board at any point in the operational cycle, ACTUV concepts can take advantage of an unexplored design space that eliminates or modifies conventional ship design constraints such as internal arrangement, reserve buoyancy, and dynamic stability in order to achieve disproportionate speed, endurance, and payload fraction. The resulting unmanned naval vessels must possess sufficient situational awareness and autonomous behavior capability to operate in full compliance with the rules of the road and maritime law to support safe navigation for operational deployments spanning thousands of miles and months of time. When coupled with innovative sensor technologies, the ACTUV system provides a low cost unmanned system with a fundamentally different operational risk calculus that enables game changing capability to detect and track even the quietest diesel electric submarine threats. Key technical areas include unmanned naval vessel design methodologies, ship system reliability, high fidelity sensor fusion to provide an accurate world model for autonomous operation, novel application of sensors for ASW tracking, and holistic system integration due to unique optimization opportunities of the ACTUV system.<br><br>This effort will also explore a Tactically Expandable Maritime Platform (TEMP) concept to develop and demonstrate macroscopic integrated systems built up from International Organization for Standardization (ISO) modular technologies that can be operated from unmodified commercial container ships and deliver credible naval capability for high priority missions. TEMP will develop critical enabling modular technologies and evaluate the feasible range of naval missions that can be serviced from this highly flexible and cost effective unconventional force structure model. An initial mission to be explored will be the modular sea depot | 9.900 | 18.000 | 19.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-03: *NAVAL WARFARE TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| concept to enable a remote unmonitored refueling capability for small craft; enabling independent operation from host ships. TEMP will also evaluate a Humanitarian Assistance and Disaster Relief (HA/DR) mission, engineering a modular first responder capability that allows the rapid force closure capability of TEMP to deliver immediate life saving operations in the hours and days following a disaster event, prior to the time that conventional platforms and organizations are able to respond.<br><br>***FY 2010 Accomplishments:***<br>- Conducted mission-focused integrated system concept development for ACTUV.<br>- Made ACTUV critical enabling technology assessments.<br>- Conducted ACTUV producibility and manufacturing sourcing analysis.<br>- Initiated ACTUV program concept design and risk reduction development activity.<br>- Completed exploratory studies validating operational, legal, and economic viability of the TEMP concept.<br><br>***FY 2011 Plans:***<br>- Execute multiple comprehensive integrated system concept design activities for ACTUV including supporting technology surveys, concept of operations development, preliminary operational performance assessments, and fabrication planning.<br>- Complete sensor and autonomy risk reduction and proof of principle testing for ACTUV.<br>- Develop ACTUV system concept of operations and conduct preliminary operational performance assessments.<br>- Complete ACTUV user assessment of strategic and operational value.<br>- Integrate preliminary system performance specifications from competing system concepts into ACTUV best-of-breed system performance specification for the demonstration activity.<br>- Initiate ACTUV integrated prototype detailed design, fabrication, and demonstration activity.<br>- Initiate TEMP HA/DR system preliminary design activity.<br>- Conduct stakeholder coordination and system requirements definition for the TEMP HA/DR system.<br>- Complete TEMP Modular Sea Depot detailed design, prototype fabrication, and developmental testing.<br>- Fabricate and test TEMP Modular Sea Depot prototype.<br><br>***FY 2012 Plans:***<br>- Complete ACTUV system preliminary design and conduct preliminary design review.<br>- Demonstrate critical enabling technologies for ACTUV.<br>- Develop ACTUV surrogate hardware-in-the-loop system.<br>- Complete ACTUV concept of operations and preliminary operational performance assessments.<br>- Commence ACTUV system detailed design.<br>- Complete TEMP HA/DR critical technology risk reduction demonstrations.<br>- Complete TEMP HA/DR preliminary design activity and conduct a preliminary design review. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-03: *NAVAL WARFARE TECHNOLOGY* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Conduct TEMP Modular Sea Depot prototype operational demonstration. | | | |
| ***Title:*** Sea Change<br><br>***Description:*** Sea Change is a portfolio of disruptive approaches to critical operational challenges in the maritime domain. The goal of the Sea Change program is to develop integrated system technologies that offer fundamentally new capabilities to address long-standing operational limitations of naval forces. Sea Change focus areas include platform concepts to overcome naval force structure challenges to increase operational capability and efficiency of maritime systems and development of standoff technologies for rapid defeat of anti-access mines through a hydroacoustic anti-mine array. The hydroacoustic anti-mine array effort will explore the technical feasibility of a novel mine clearance approach using coordinated high energy density acoustic sources to deliver standoff clearance of mines throughout the water column and on the ocean bottom. By eliminating all explosive neutralizers and maintaining effectiveness with uncertain mine identification and location, the hydroacoustic anti-mine array concept has the potential to achieve dramatic reductions in area mine clearance timelines.<br><br>***FY 2012 Plans:***<br>- Complete concept studies and operational assessments of novel maritime propulsion approaches.<br>- Complete proof of principle testing for hydroacoustic anti-mine array source technology.<br>- Conduct design activity for novel propulsion system proof of principle demonstration.<br>- Initiate hydroacoustic anti-mine array preliminary design activity and conduct developmental risk reduction testing. | - | - | 10.000 |
| ***Title:*** Caiman<br><br>***Description:*** The Caiman program will develop a prototype amphibious robotic vehicle which will navigate tropical rivers autonomously for long range/long duration missions (~100 kilometers and ~7+ days) while gathering intelligence. Navigating tropical rivers requires traversing long stretches of sandbars, very shallow water and avoiding small to large obstacles. It also demands new advances in perception, autonomy and locomotion to enable the system to make progress in cluttered, shallow waters, including occasionally exiting the water, traversing ground such as sandbars, and then reentering. The Caiman mission is targeted for the interface between water and land, which will result in the vehicle being able to access riverine and swamp areas which are currently inaccessible.<br><br>***FY 2011 Plans:***<br>- Develop, analyze, and assess preliminary designs to achieve a system capable of a hundred kilometers of travel over a 7 day mission.<br>- Simulate water to land to water transitions to validate design. | - | 6.000 | 6.855 |

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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-03: *NAVAL WARFARE TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Build subsystems that prove design validity.<br><br>***FY 2012 Plans:***<br>- Complete critical design review and integration plan.<br>- Initiate demonstration system fabrication.<br>- Conduct final pre-assembly bench testing. | | | |
| ***Title:*** Very High Speed Vessel (VHSV)<br><br>***Description:*** The Very High Speed Vessel (VHSV) program will explore the development of a small tactical surface vessel capable of protecting high value naval vessels in contested littoral environments. The program will evaluate tactical mobility, mission endurance, lethality, and survivability that is well beyond that of any current or proposed littoral warfare platform. The vessel will be designed to operate as an unmanned naval combat system with an integrated control system and weapons suite which will be optimized to defend against irregular naval warfare threats such as fast inshore attack crafts, high speed swarming combatant boats, and conventional diesel submarines operating in shallow coastal waters. The VHSV system will leverage emerging developments in reconfigurable hull forms, fluid drag reduction, hybrid naval propulsion design, and dynamic control in fully cavitated flow to develop a vessel with significantly superior maximum speed, endurance, and seakeeping in elevated sea states.<br><br>***FY 2011 Plans:***<br>- Conduct military and tactical utility studies and establish seaframe and weapons development metrics.<br>- Perform advanced hullform technology studies and establish vessel performance limits. | - | 4.207 | - |
| ***Title:*** Super-Fast Submerged Transport (Underwater Express)<br><br>***Description:*** The Super-Fast Submerged Transport (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 undetected, no radar or visible signature, and avoidance of rough sea conditions that may limit or deny mission execution. Supercavitation places the vehicle inside a cavity where vapor replaces the water, and drag due to fluid viscosity is reduced by orders of magnitude, thus reducing the power requirement dramatically. This program will use modeling, simulation, 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. The program will culminate in an at-sea demonstration of a submerged unmanned vehicle capable of supercavitating operations and autonomous maneuvering.<br><br>***FY 2010 Accomplishments:*** | 13.230 | 7.241 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-03: *NAVAL WARFARE TECHNOLOGY* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Completed design, fabrication and component testing of a scaled vehicle.<br>- Analyzed vehicle performance for speed, power and stability.<br>- Completed development of vehicle control system.<br>- Modified vehicle systems for at-sea testing series based on testing results.<br>***FY 2011 Plans:***<br>- Complete at-sea testing of a scaled vehicle.<br>- Analyze vehicle performance for speed, power and stability. | | | |
| ***Title:*** Submersible Aircraft<br>***Description:*** This program will combine the speed and range of an airborne platform with the stealth of an underwater vehicle by developing a vessel that can both fly and submerge. The program will exploit lightweight materials, unique dynamic structures and advanced propulsion systems to overcome the technical barriers to achieving this capability. If successful, the program will enable insertion and extraction of special operations and expeditionary forces at greater ranges, and higher speeds in locations not previously accessible with minimal direct support from additional military assets. The program goals are to demonstrate a vessel capable of multimodal operations (airborne, surface, and submerged) and that can easily transition between these modes.<br>***FY 2010 Accomplishments:***<br>- Initiated concept design studies and feasibility analysis in order to quantify extent of possible operational envelope.<br>- Began to identify key technology limitations and performance objectives that need to be overcome in order to achieve concept design.<br>***FY 2011 Plans:***<br>- Complete developmental activities including modeling and experiments, demonstrating technologies, and approaches that can overcome the identified performance objectives.<br>- Complete objective system design based on the results of developmental activities, providing an accurate projection of the systems operational envelope. | 4.518 | 4.000 | - |
| ***Title:*** Non-traditional Active Sonar<br>***Description:*** The goal of the Non-traditional Active Sonar program is to develop alternative solutions for anti-submarine warfare active sonar. Given the trend of submarine quieting, passive sonar is of diminishing value to the Navy. The existing alternatives are high-power active sonar systems that are overt and difficult to use in peace time, especially in far forward or congested littoral areas. The program will investigate new approaches which exploit special acoustic phenomena and techniques, through | 4.969 | 5.880 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| advanced active sonar signal processing to achieve advanced active sonar. Emphasis is on data-driven algorithm development applicable across existing Navy hydrophone sensor arrays.<br><br>***FY 2010 Accomplishments:***<br>- Developed initial processing algorithms for use with the initial data set.<br>- Exercised the algorithms with surrogate and simulated data.<br>- Conducted controlled data collection with surrogate sources and targets.<br>- Developed and assessed algorithms using collected data.<br>***FY 2011 Plans:***<br>- Iterate on algorithm designs to assess detection capability (e.g., range) and extrapolate performance to other environments and concepts of operations.<br>- Conduct at-sea data collection with real targets, and identify existing data to support assessment of processing algorithm performance under realistic conditions.<br>- Demonstrate processing feasibility for relevant system designs. | | | |
| **Accomplishments/Planned Programs Subtotals** | 32.617 | 45.328 | 35.855 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** Center of Excellence for Research in Ocean Sciences (CEROS)<br><br>***FY 2010 Accomplishments:*** - Selected projects and monitored progress of ocean related technologies of high interest to the DoD. | 8.000 | - |
| ***Congressional Add:*** SeaCatcher Unmanned Aircraft Launch and Recovery System<br><br>***FY 2010 Accomplishments:*** - Continued to explore launch and recovery system concepts. | 1.600 | - |
| **Congressional Adds Subtotals** | 9.600 | - |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

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## E. Performance Metrics

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY* | 30.899 | 18.911 | 34.896 | - | 34.896 | 50.308 | 51.551 | 50.609 | 50.609 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

This project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire. This project will also explore novel design technologies for the manufacture of ground vehicles and new tools for systems assessments of emerging DARPA technologies.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** C-Sniper<br><br>***Description:*** Based on promising results obtained under the Crosshairs program, the C-Sniper effort will develop the capability to detect and neutralize enemy snipers before they can engage U.S. Forces. The program will deliver a field testable prototype suitable for experimentation on a compatible vehicle such as the Stryker. The C-Sniper system will identify threats before they can fire. Enemy snipers may be operating both with and without telescopic sights and other optical systems in highly cluttered urban environments. The C-Sniper system will operate day and night from a static or mobile military vehicle and will provide the operator with sufficient information to make a timely engagement decision. Once a decision is made, the C-Sniper will provide data and control to point and track the on-board weapon to the selected target. The final decision to fire the weapon will be left to the operator.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated system capability to correctly detect optical systems in a highly cluttered urban environment.<br>- Conducted trade studies on camera systems and laser systems to optimize design.<br><br>***FY 2011 Plans:***<br>- Develop, deliver and demonstrate the operation of C-Sniper on moving vehicles.<br>- Integrate C-Sniper on a test vehicle and demonstrate full system capability.<br><br>***FY 2012 Plans:***<br>- Complete demonstration of fully integrated system capabilities. | 9.955 | 8.401 | 0.896 |
| ***Title:*** Fast, Adaptable, Next Generation Ground Combat Vehicle (FANG)<br><br>***Description:*** The goals of the Fast, Adaptable, Next-Generation Ground Combat Vehicle (FANG) program are to employ a novel, model-based correct-by-construction design capability, a highly-adaptable foundry-style manufacturing capability, and design | - | - | 20.000 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| crowd-sourcing methods to demonstrate 5X-10X compression in the timeline necessary to build an infantry fighting vehicle.<br>The program seeks to develop an open-source development infrastructure for the aggregation of designer inputs applicable to complex electromechanical systems as well as software, and to exercise this infrastructure with a series of design challenges, leading to prize awards and builds of winning designs in a foundry-style, rapidly configurable manufacturing facility. The design challenges will culminate in a complete build of a next generation infantry fighting vehicle to a requirements set loosely analogous to the Army's Ground Combat Vehicle-but executed on a roughly one-year timescale. Additionally, the program will pursue an explicit outreach activity to high school-age students to teach the principles of model-based design and distributed foundry-style manufacturing to build a next-generation cadre of manufacturing innovators. Initial ground vehicle design work is funded under the META program in PE 0602303E, Project IT-02.<br><br>***FY 2012 Plans:***<br>- Complete the development and begin operational testing of the crowd-sourced vehicle design environment.<br>- Perform experimental subsystem designs and subsequent design builds using the vehicle design environment as well as the iFAB foundry.<br>- Promulgate component model libraries, foundry capabilities, and objective design criteria for a mobility and drivetrain challenge.<br>- Conduct a competitive, crowd-sourced design challenge for the mobility and drivetrain subsystem of an infantry fighting vehicle.<br>- Continue high school outreach effort for the procurement, deployment, and utilization of a distributed additive manufacturing capability. | | | |
| ***Title:*** Adaptive System Assessment (ASA)<br><br>***Description:*** The Adaptive System Assessment (ASA) program seeks to develop new tools, technologies, and techniques that enable efficient, rigorous, and informative readiness assessments of emerging and mature DARPA technology. ASA will create rapid, composed, quantitative and qualitative simulations for systems and systems of systems, methods for reliably extrapolating the evaluation results from subsystem components to assess overall system potential performance, and methods for integrating virtual and live experimentation in realistic operational scenarios. This program will create formal or empirical methods and tools for (semi-) automatically rating the maturity of systems according to Technology Readiness Level (TRL) or alternative measures, as well as extensions, enhancements, and alternatives to the TRL rating system.<br><br>***FY 2012 Plans:***<br>- Investigate the use of dynamic, reconfigurable, agile, virtual environment framework for the assessment of technologies in DoD systems.<br>- Initiate development of scalable simulation environment for adaptive assessment.<br>- Define simulation module format and interfaces for assessment simulation components. | - | - | 14.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Develop initial virtual environments for assessment in two domains and produce prototype simulation based on a reconfigurable framework. | | | |
| ***Title:*** Magneto Hydrodynamic Explosive Munition (MAHEM)<br><br>***Description:*** The Magneto Hydrodynamic Explosive Munition (MAHEM) program will demonstrate compressed magnetic flux generator (CMFG)-driven magneto hydrodynamically formed metal jets and self-forging penetrators (SFP) with significantly improved performance over explosively formed jets (EFJ) and fragments. EFJ and 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 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 (multimodal warhead) with a much higher EFJ velocity, hence increased lethality precision, than conventional EFJ/SFP. MAHEM could be packaged into a missile, projectile or other platform, and delivered close to target for final engagement. 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.<br><br>***FY 2010 Accomplishments:***<br>- Using theoretical models, began design of flux compression generator (FCG) components in preparation for fabrication and testing of the armature and stator configuration with static and dynamic loads.<br>- Designed and modeled shaped charge liners and magnetically formed penetrators (MFPs) that will provide maximum penetration against hardened targets of interest.<br><br>***FY 2011 Plans:***<br>- Design, fabricate and test a first-of-its-kind ring initiator to be used for the multimodal warhead configuration.<br>- Begin fabrication of armature for the multimodal warhead configuration.<br>- Complete fabrication of FCG components, shaped charge liners, and MFPs.<br>- Perform testing of FCG components.<br>- Test shaped charge liners and MFPs. | 1.759 | 1.210 | - |
| ***Title:*** Crosshairs<br><br>***Description:*** The Crosshairs program seeks to develop a vehicle mounted threat detection and countermeasure system that will detect, locate, and engage enemy shooters against a variety of threats to include bullets, Rocket Propelled Grenades (RPGs), | 7.929 | 3.900 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| Anti-Tank Guided Missiles, 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 initial development and testing of the Crosshairs sensor system. Phase IA culminated with a static live fire test to determine the most effective candidate sensor system. During Phase IB, enhancements were made to the sensor system for on the move performance, and on the move testing against multiple threats was conducted. DARPA and the U.S. Army Rapid Equipping Force (REF) entered into an MOA for Phase IIA. Phase IIA consisted of a moving demonstration of the hardened, packaged, and enhanced Phase I sensor system on two networked HMMWVs, integration with candidate response systems, and testing and evaluation of the complete systems in relevant environments. The program is currently in Phase IIB. During this phase, the Crosshairs sensor system is being integrated with the Iron Curtain Active Protection System (IC-APS) on four up-armored vehicles. At the end of Phase IIB, the Crosshairs systems will be ready for field testing.<br><br>DARPA is working with the Army REF and the Project Manager Mine Resistant Ambush Protected Vehicles to validate the capabilities and initiate transition to combat forces in the 2010/2011 time frame.<br><br>***FY 2010 Accomplishments:***<br>- Completed integration of the IC-APS and CrossCue system.<br>- Validated system performance and field-worthiness through testing by the Army Test and Evaluation Command.<br>***FY 2011 Plans:***<br>- Demonstrate final integrated system capability, including active protection, in live fire tests.<br>- Transition Crosshairs technology to the military. | | | |
| ***Title:*** Rocket Propelled Grenade (RPG) Nets<br><br>***Description:*** The goal of the Rocket Propelled Grenade (RPG) Nets program is to develop a near-term counter RPG net system that has performance at least equivalent to bar or slat armor, but that is lighter and easier to deploy; and a mid-term net-based system with active elements that has greatly improved performance. Development of these systems will be supported by modeling to enhance understanding of the net interactions and with extensive live fire testing against RPGs. Successful candidates have been installed on vehicles for evaluation in an operational context. DARPA is working with the Marine Program Manager for Motor Transport to develop, test and transition this capability to combat forces.<br><br>***FY 2010 Accomplishments:***<br>- Installed near-term net systems on military vehicles and performed initial user evaluation.<br>- Commenced evaluation of near-term net system and initiated transition.<br>***FY 2011 Plans:*** | 3.306 | 0.900 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Complete evaluation of near-term net system and initiate transition. | | | |
| ***Title:*** Helicopter ALert and Threat Termination (HALTT)<br><br>***Description:*** The Helicopter ALert and Threat Termination (HALTT) program will provide Army and Navy/Marine helicopters with a way to detect small arms and provide shooter location to improve their ability to respond. System effectiveness with emphasis on low false alarm rates is critical. The program goal is to successfully demonstrate protection of helicopters by automatic threat detection of small arms with an "o'clock" accuracy in azimuth as well as elevation and range to shooter.<br><br>***FY 2010 Accomplishments:***<br>- Installed prototype HALTT systems on platforms for CONOPS evaluations.<br>- Demonstrated the HALTT prototype system in operational evaluation scenarios.<br>- Enhanced sensor design and platform interface.<br>- Integrated the acoustic sensors on unmanned aircraft to determine true system accuracy.<br><br>***FY 2011 Plans:***<br>- Integrate and demonstrate acoustic system on multiple platforms.<br>- Demonstrate a fully integrated HALTT system in operational scenarios. | 3.950 | 2.500 | - |
| ***Title:*** Lightweight Ceramic Armor (LCA)<br><br>***Description:*** The Lightweight Ceramic Armor (LCA) program is leveraging recent breakthroughs in novel ceramic fabrication processes developed in the Materials Processing Technology project to drive a dramatic performance shift in the trade-off between weight and ballistic projectile protection of body armor. Currently fielded body armor is heavy and its weight and bulk limit a soldier's agility and mobility. Utilizing recent breakthroughs in unconventional ceramics processing technology, the LCA program has demonstrated greater than ten percent reduction in weight for equal ballistic protection.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated an initial ten percent reduction in weight for equal performance compared to currently fielded body armor systems.<br>- Investigated the potential for significantly improved ballistic characteristics of meta-structured ceramic systems by incorporating multiple materials layers in a monolithic plate and combining it with high performance energy absorbing backing materials.<br>- Evaluated the capability of various ceramic materials and layering configurations to defeat armor piercing projectiles, and demonstrated threat defeat with multiple system configurations.<br>- Demonstrated key manufacturing steps at pilot scale throughput with consistent and reliable yielded ceramic part performance.<br><br>***FY 2011 Plans:*** | 2.000 | 2.000 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Scale the unconventional ceramic consolidation process to consistently produce curved ceramic plates up to specified size.<br>- Develop the procedure (including preparation, consolidation, and cooling) to manufacture side ballistic inserts consistent with U.S. Army specifications.<br>- Evaluate the ballistic performance of the scaled, uniquely layered armor system against multiple armor piercing threats.<br>- Validate the capability to produce a full-size side ballistic armor insert at greater than ten percent reduction in weight as compared to current state-of-the-art solutions.<br>- Demonstrate the capability to produce at least 10,000 ceramic plates per year. | | | |
| ***Title:*** Recognize Improvised Explosive Devices and Report (RIEDAR)<br>***Description:*** The goal of the Recognize Improvised Explosive Devices and Report (RIEDAR) program was to develop and demonstrate a capability for stand-off detection of various devices.<br>***FY 2010 Accomplishments:***<br>- Investigated designs for sub-system consisting of optical detector and compact laser for detection of explosives. | 1.000 | - | - |
| ***Title:*** Rocket Propelled Grenade (RPG) Pre-launch Detection and Cueing<br>***Description:*** The Rocket Propelled Grenade (RPG) Pre-launch Detection and Cueing program explored the development of an omni directional, visual, vehicle mounted surveillance system for threat detection using cognitive swarm recognition technology to rapidly detect and identify the locations of attackers with RPGs before they are launched.<br>***FY 2010 Accomplishments:***<br>- Analyzed and documented promising methods for detection and classification algorithms. | 1.000 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 30.899 | 18.911 | 34.896 |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TT-06: *ADVANCED TACTICAL TECHNOLOGY* | 74.728 | 67.308 | 63.719 | - | 63.719 | 41.184 | 29.642 | 34.716 | 52.516 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** High Energy Liquid Laser Area Defense System (HELLADS) | 18.989 | 20.894 | 29.453 |
| ***Description:*** The goal of the High Energy Liquid Laser Area Defense System (HELLADS) program is to develop a high-energy laser weapon system (150 kW) with an order of magnitude reduction in weight compared to existing laser systems. With a weight goal of <5 kg/kW, HELLADS will enable high energy lasers (HELs) to be integrated onto tactical aircraft, and will significantly increase engagement ranges compared to ground-based systems, enabling high precision, low collateral damage, and rapid engagement of fleeting targets for both offensive and defensive missions. The HELLADS program has completed the design and demonstration of a revolutionary prototype unit cell laser module. That unit cell demonstrated power output and is demonstrating optical wavefront performance that supports the goal of a lightweight and compact 150 kW high energy tactical laser weapon system. Two unit cell module designs with integrated power and thermal management systems were fabricated and tested; they demonstrated an output power exceeding 34 kW. Based on the results of the unit cell demonstration, additional laser modules will be replicated and connected to produce a 150 kW laser that will be demonstrated in a laboratory environment. The 150 kW laser will then be integrated with beam control, prime power, thermal management, safety, and command and control subsystems all based upon existing technologies to produce a ground-based laser weapon system field demonstrator. The capability to shoot down tactical targets such as surface-to-air missiles and rockets and the capability to perform ultra-precise offensive engagements will be demonstrated in a realistic ground test environment. Additional funding for this integration effort will be provided for HELLADS testing in Project NET-01, PE 0603766E starting in FY 2011. The HELLADS laser will then be transitioned to the Air Force for modification and aircraft integration and flight testing.<br><br>***FY 2010 Accomplishments:***<br>- Completed a unit cell laser module with integrated power and thermal management subsystems and demonstrated required performance relative to power, run-time, weight, and volume.<br>- Completed the detailed design of a ground-based 150kW laser weapons system demonstrator. | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Initiated fabrication of the ground-based demonstrator laser weapon system.<br>- Initiated ground-based demonstrator laser weapon system component and subsystem testing.<br>- Started aircraft integration studies and design.<br><br>***FY 2011 Plans:***<br>- Complete unit cell performance optimization to obtain beam quality to support full system performance.<br>- Develop advanced diagnostic tools to assess high energy laser beam quality.<br>- Prescribe and build the active optical component to provide remaining correction of static and dynamic optical disturbances in the high energy laser.<br>- Continue subsystem testing of the ground-based demonstrator laser weapon system.<br>- Complete the detailed design of the 150 kW laser.<br>- Initiate the fabrication and laboratory testing of the 150kW laser.<br><br>***FY 2012 Plans:***<br>- Complete the fabrication of the 150 kW laser.<br>- Complete planning and preparations to integrate the 150 kW laser with the ground-based demonstrator laser weapon system.<br>- Complete subsystem testing of the ground-based demonstrator laser weapon system. | | | |
| ***Title:*** Aero-Adaptive/Aero-Optic Beam Control (ABC)<br><br>***Description:*** The goal of the Aero-Adaptive/Aero-Optic Beam Control (ABC) program is to improve the performance of high-energy lasers on tactical aircraft, against targets in the aft field-of-regard. In order to achieve a large field-of-regard, current optical turret designs protrude into the flow. This causes severe optical distortions in the aft field-of-regard due to turbulence in the wake and the unsteady shock movement over the aperture. These distortions decrease the power flux on target (the measure of lethality for a directed energy system) and consequently limit the utility of directed energy systems to targets in the forward field-of-regard. This program will optimize flow control strategies for pointing angles in the aft field-of-regard. The program will also explore the ability to synchronize the flow control system with adaptive optics. This effort will initially focus on wind tunnel testing to prove the feasibility of steady and periodic flow control techniques to reduce or regularize the large scale turbulent structures surrounding an optical turret. These tests will culminate in a hardware-in-the-loop demonstration utilizing flow control with an adaptive optics system in a full-scale wind tunnel test for the turret. Following successful wind tunnel demonstrations, a preliminary design of a flight test turret incorporating flow control will be undertaken.<br><br>***FY 2010 Accomplishments:***<br>- Developed methods, designed and fabricated optics, electronics, and mechanics for full-scale wind tunnel test of turret.<br>- Conducted wind tunnel tests of selected turret to characterize the uncontrolled flow in preparation for flow control entries. | 4.446 | 5.100 | 5.084 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Designed and implemented ABC flow control actuators for full-scale wind tunnel test.<br>- Performed bench-level evaluation of system functionality.<br>***FY 2011 Plans:***<br>- Perform initial testing of full-scale flow control in open-loop wind tunnel testing of ABC turret.<br>- Demonstrate and validate ABC concept with closed-loop adaptive optic system and flow control in a full-scale wind tunnel test.<br>***FY 2012 Plans:***<br>- Identify new mission capabilities enabled by aero-effects control technology.<br>- Commence preliminary design of a flight test turret incorporating flow control and optical compensation. | | | |
| ***Title:*** Excalibur*<br>***Description:*** *Excalibur aggregates the following programs: High Power Efficient and Reliable Laser Bars (HiPER), Revolution in Fiber Lasers (RIFL), and Coherently Combined High-Power Single-Mode Emitters (COCHISE)<br><br>The Excalibur program will develop high-power electronically-steerable optical arrays, with each array element powered by a fiber laser amplifier. These fiber-laser arrays will be sufficiently lightweight, compact, and electrically efficient to be fielded on a variety of platforms with minimal impact to the platform's original mission capabilities. Each array element will possess an adaptive-optic capability to minimize beam divergence in the presence of atmospheric turbulence, together with wide-field-of-view beam steering for target tracking. With each Excalibur array element powered by high power fiber laser amplifiers (at up to 3 kilowatts per amplifier), high power air-to-air and air-to-ground engagements will be enabled that were previously infeasible because of laser system size and weight. In addition, this program will also develop kilowatt-class arrays of diode lasers that will provide the higher spatial and temporal bandwidths needed to correct for the increased air turbulence effects encountered in ground-to-ground engagements. Excalibur arrays will be conformal to aircraft surfaces and scalable in size and power by adding elements to the array. By defending airborne platforms such as unmanned aerial vehicles against proliferated, deployed, and next-generation man-portable air-defense systems (MANPADS), Excalibur will enable these reconnaissance platforms to fly at lower altitude and obtain truly persistent, all-weather ground reconnaissance despite low-lying cloud cover. Further capabilities include multichannel laser communications, target identification, tracking, designation, precision defeat with minimal collateral effects as well as other applications.<br><br>The Excalibur Budget Activity 2 program will develop the core set of laser components for efficiently driving elements of high-power electronically steerable optical arrays, namely, high-power coherently- and spectrally-combinable fiber laser amplifiers, high-brightness laser diodes for efficiently pumping the fiber laser amplifiers, and kW-class single-mode laser diode arrays. These | 18.423 | 17.294 | 21.325 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-06: *ADVANCED TACTICAL TECHNOLOGY* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| components will be designed to work in tandem with the high-power laser amplifier arrays developed under the Budget Activity 3 Excalibur program in PE 0603739E, Project MT-15.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated a coherently combinable fiber laser amplifier with an output of 1 kW, electrical efficiency of 30.6%, and near-perfect, diffraction-limited beam divergence.<br>***FY 2011 Plans:***<br>- Develop 3-kW coherently combinable fiber laser amplifiers at electrical efficiencies exceeding 30% and with near-perfect beam divergence (better than 1.4x diffraction-limited).<br>- Demonstrate compact 100-W coherent array of single-mode laser diodes.<br>- Demonstrate a single laser diode bar (1 cm x 5 mm) with an output power of 500 W and a lifetime of 100 hours on a compact low thermal-resistance (<60mK/W) heat sink.<br>***FY 2012 Plans:***<br>- Demonstrate compact 500-W coherent array of single-mode laser diodes.<br>- Demonstrate a single wavelength-stabilized laser diode bar coupled to an optical fiber (100-µm core, 0.22NA) with 200 W exiting from the fiber. | | | |
| ***Title:*** Polarizing Keyless Cryptography (POLKA)<br><br>***Description:*** Cryptographic security of the Department of Defense's point-to-point data links is fundamentally important and faces an emerging threat as encryption devices are rapidly out-paced by the increasing data rates of links. Building upon concepts developed under the Integrated Sensing and Processing program, the POLKA program will demonstrate a compelling all-optical encryption system that has the potential to meet the Department's needs. Traditional encryption techniques rely on mathematical algorithms implemented on electronic devices; POLKA will develop a physics-based, all-optical technique for encryption. Along with its transition partner, DARPA will analyze the theoretical and practical vulnerabilities of the POLKA system and demonstrate experimental verification of its efficacy.<br><br>***FY 2012 Plans:***<br>- Integrate optical encryption with Information Theoretic Security Code for secure high speed data transfer.<br>- Complete prototype development and testing of all-optical encryption system.<br>- Begin experimental verification of vulnerabilities. | - | - | 7.857 |
| ***Title:*** Integrated Sensing and Processing | 6.400 | 6.370 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602702E: *TACTICAL TECHNOLOGY* | PROJECT<br>TT-06: *ADVANCED TACTICAL TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** 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, encryption 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, and novel approaches to multiplexed hyper-spectral chemical/biochemical sensing systems.<br><br>***FY 2010 Accomplishments:***<br>- Extended graph topology to simplex methods to develop novel algorithms.<br>- Generated algorithms to provide flexible, movable, reactive border generation for dynamics and unpredictable events.<br>- Developed multi-body algorithms to enable formation flight and interaction of sensors in zero-gravity environments.<br>- Investigated technologies to enable novel, physics-based, high-speed network encryption approaches.<br><br>***FY 2011 Plans:***<br>- Develop stochastic topological theory of non-parametric statistics and apply to automatic target recognition problems.<br>- Develop clock-free strongly open-loop controls and information state estimation and comparison for minimal-sensing in localization and navigation problems.<br>- Test multi-body algorithms to enable formation flight and interaction of sensors in zero-gravity environments.<br>- Develop novel optical encryption design and initiate component development. | | | |
| ***Title:*** High Performance Algorithm Development<br><br>***Description:*** The High Performance Algorithm Development programs identify, develop and demonstrate new mathematical paradigms enabling maximum performance at minimum cost in a variety of DoD systems applications. The programs look for opportunities to aggressively leverage the power of mathematical representations in order to effectively exploit large-scale computational resources as they apply to specific problems of interest. They also 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. | 5.000 | 5.000 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-06: *ADVANCED TACTICAL TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Implemented geometric theory of higher dimensional clustering for novel data analysis to produce user-friendly fast algorithms.<br>- Developed multi-parameter and multi-dimensional topological persistence algorithms to extract high dimensional, dynamic, hidden features in massive data sets across DoD applications; including communications, biology, neuroscience as well as classically important radar and other digitally represented applications.<br>- Developed taxonomy of systems representing different system dependencies, down times and recovery rates to be analyzed for survivability.<br>- Began investigating a new family of non-increasing stochastic processes that enables the replacement of propensity by probability in uncertainty modeling.<br>***FY 2011 Plans:***<br>- Develop an Ito-style stochastic calculus to build theoretical models to improve uncertainty prediction.<br>- Develop and use novel topological tools to analyze non-linear dynamical systems. | | | |
| ***Title:*** Training Superiority<br>***Description:*** The Training Superiority program will provide a new capability for military training by developing new approaches to increase technical competence. This includes elements of human-tutor interactions integrated with emotional involvement of computer games coupled with the fidelity and feedback of Combat Training Center learning. In addition, this thrust will scale-up new digital tutor methodologies capable of training at a high proficiency level in reduced time and deliver these to a large cohort of warfighters.<br>***FY 2010 Accomplishments:***<br>- Developed the underlying engine and the hardware/software architecture necessary to create a large scale Digital Tutor system, with focus on scaling, capacity and performance.<br>- Elaborated intrinsic, instrumental and extrinsic motivation models in order to maintain student motivation over two months of instruction demonstrated over one week.<br>- Ported two months of Navy IT-School content from a human-tutored course to the Digital Tutor.<br>- Created an automatic capability to identify students requiring remediation.<br>- Developed methodology for establishing correspondence between Digital Tutor content/training and existing Navy curriculum, to facilitate transition of Digital Tutor to Navy Schoolhouse.<br>***FY 2011 Plans:***<br>- Extend Natural Language Understanding to encompass the full range of the IT domain. | 8.900 | 8.400 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602702E: *TACTICAL TECHNOLOGY* | PROJECT<br>TT-06: *ADVANCED TACTICAL TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Create a semantic model, abstractions, and Application Program Interface (API) that allows Socratic dialogs capable of handling large number of semantic responses rather than a predefined set of answers.<br>- Complete full sixteen weeks of content in the Digital Tutor and integrate results of theoretical work.<br>- Demonstrate deployment to pier-side and harden the system (full course).<br>- Establish effectiveness of Digital Tutor system in creating Mastery-level students by conducting second IWARs competition between Digital Tutor trained students and Navy-selected Fleet experts. | | | |
| ***Title:*** RealWorld<br><br>***Description:*** The RealWorld program exploits technical innovation and integration to provide any U.S. warfighter with the ability to open a laptop computer and rehearse a specific mission in the relevant geo-specific terrain, with realistic physics. Because the system will be scalable and distributed, a warfighter can practice by himself, in a small group, or with as many other warfighters as needed for the mission over a local or distributed network, and across all relevant platforms (dismounts, vehicles, helicopters, and fast movers). Most important is the understanding that RealWorld is not a static simulation; it is a simulation builder with applications across the spectrum of modern kinetic and non-kinetic warfare. The program is building tools that allow warfighters to rapidly and easily build their own missions though the introduction of new methodology for building simulation software. This methodology and adherence to a highly modular approach will cause a fundamental paradigm shift in the acquisition, as well as the construction, of DoD modeling and simulation products.<br><br>***FY 2010 Accomplishments:***<br>- Scaled to 1000 warfighter entities.<br>- Integrated meteorological capability so real-time weather can be imported into training and rehearsal scenarios.<br>- Demonstrated integration of data from Google Earth.<br>- Transformed pictures taken by a cell phone camera into a 3-D model capable of being ingested by a real-time 3-D engine.<br><br>***FY 2011 Plans:***<br>- Demonstrate ability to support joint air/land/sea operations.<br>- Integrate RealWorld with a mission planning/C2 system (e.g., in the Special Operations Mission Planning Environment (SOMPE)) and demonstrate two-way data flow.<br>- Add voice capability to avatar system.<br>- Create an application programming interface that will allow external artificial intelligence systems to be easily integrated into RealWorld. | 6.250 | 4.250 | - |
| ***Title:*** Fiber Laser Pulse Source (FLIPS) | 3.160 | - | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-06: *ADVANCED TACTICAL TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Fiber Laser Pulse Source (FLIPS) program evaluated concepts for a compact fiber-based laser system that generates short high-energy pulses, at a high average-power level, (pushing past fundamental limits of existing fiber-based laser amplifiers.) Such a system could enable applications such as remote detection of biological and chemical agents, free space communications, advanced photolithography as well as long-range high-resolution laser-radar systems.<br><br>***FY 2010 Accomplishments:***<br>- Developed concepts for power scaling of pulsed fiber lasers beyond the fundamental nonlinear limitations of individual amplifiers. | | | |
| ***Title:*** Efficient Mid-Wave Infrared Lasers (EMIL)<br><br>***Description:*** The Efficient Mid-Wave Infrared Lasers (EMIL) program evaluated efficient solid-state coherent sources that can cover the atmospheric transmission bands in the mid-wave infrared (MWIR; 3-5 micrometers). Infrared countermeasure (IRCM) systems in particular depend on intense sources at these bands. The current generation IRCM systems utilize diode-pumped Thulium (Tm) lasers used to pump optical parametric oscillators, most commonly based on zinc germanium phosphide.<br><br>The lasers developed in this program operate across the three relevant bands within the MWIR at 10 W power with wall plug efficiencies of at least 10 percent. By virtue of the enormous volumetric reduction (100-1000 times), power reduction (ten times), and superior pulse format (cw-operation), such sources are enabling 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 and other threats but for which current IRCM systems are prohibitive or are inadequate (e.g., unable to defeat staring sensors).<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated epitaxial growth and preliminary characterization of final structures. | 3.160 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 74.728 | 67.308 | 63.719 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
|---|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-07: *AERONAUTICS TECHNOLOGY* | |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TT-07: *AERONAUTICS TECHNOLOGY* | 26.915 | 34.692 | 23.042 | - | 23.042 | 27.773 | 28.655 | 42.806 | 42.806 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

## B. Accomplishments/Planned Programs ($ in Millions)

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Transformer (TX) Vehicle | 6.000 | 12.200 | 16.000 |
| ***Description:*** The Transformer (TX) Vehicle program will examine the feasibility and approaches for developing a vertical take-off and landing (VTOL), road-worthy vehicle that can carry a 1,000 lb payload at a range of 250nm on a single tank of fuel. With a flyable/roadable vehicle, the warfighter has the ability to avoid road obstructions as well as improvised explosive devices and ambush threats, providing flexibility for tactical military and personnel transport missions. The primary focus of this program is to demonstrate the ability to build a ground vehicle that is capable of configuring into a VTOL air vehicle that provides sufficient flight performance and range, while carrying a payload that is representative of four troops with gear. The enabling technologies of interest include hybrid electric drive, advanced batteries, stowable wing structures, ducted fan propulsion, lightweight materials, and advanced sensors and flight controls for stable transition from vertical to horizontal flight. TX vehicles could be dispatched for downed airman recovery, for evacuating injured personnel from difficult-to-access locations, or to resupply isolated small units. TX will also be suitable for enhanced company operations concepts which would provide the warfighter/team increased situational awareness for operations in an urban environment.<br><br>***FY 2010 Accomplishments:***<br>- Initiated trade studies of vehicle designs, propulsion systems, flight dynamics and control, ground mobility, energy conversion and storage, vehicle architecture, and stowable wing structures.<br>- Initiated conceptual design of the operational vehicle and the system requirements of a demonstration prototype vehicle.<br><br>***FY 2011 Plans:***<br>- Continue detailed trade studies to develop a vehicle design in areas including propulsion, adaptable wing structures, lightweight materials, advanced flight control system, air/ground configuration designs, and energy storage and distribution.<br>- Develop a detailed technology maturation plan that provides an integrated risk reduction strategy and achieves the ground and flight test goals of the demonstration prototype vehicle. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-07: *AERONAUTICS TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Continue development of a conceptual design of the operational vehicle and the system requirements of a demonstration prototype vehicle.<br>- Conduct technology interchange meetings to develop integration plan for vehicle critical enabling technologies.<br>***FY 2012 Plans:***<br>- Conduct preliminary design review of TX prototype vehicle concepts to examine the prototype vehicle solutions in higher detail and the detailed program plans and cost for the remaining phases.<br>- Integrate critical enabling technology development efforts into overall vehicle development.<br>- Conduct component testing to show feasibility and function of key technology components.<br>- Initiate risk reduction experiments and modeling to validate design performance. | | | |
| ***Title:*** Mission Adaptive Rotor (MAR)<br>***Description:*** The goal of the Mission Adaptive Rotor (MAR) program is to develop and demonstrate the capability to achieve dramatic improvements in rotor performance, survivability, and availability through the use of technologies that enable adaptation of the rotor throughout military missions and/or mission segments. Recent research indicates that significant performance benefits could be achieved by actively morphing the shape or properties of the rotor system; additionally, active rotors with on-blade control could eliminate the need for a rotor swashplate. MAR capability will result in dramatic improvements in system performance, operational availability, sustainability, and survivability, including reduction in acoustic susceptibility and rotor vibration while increasing useful payload fraction and range.<br><br>The MAR program will mature active rotor technologies that enable the effective operation of military rotorcraft in performance-limited environments of high-altitude mountainous terrain and deserts. The MAR program will also focus on development of advanced technologies for application to future helicopter, tiltrotor, and other rotorcraft platforms, with demonstration on a fielded system to enable application to new systems as well as facilitate upgrade of current multi-service rotorcraft systems.<br>***FY 2010 Accomplishments:***<br>- Initiated conceptual designs of the MAR demonstration system.<br>- Conducted evaluations of adaptive rotor technologies.<br>***FY 2011 Plans:***<br>- Define quantitative results of design trade studies and risk mitigation assessments.<br>- Initiate preliminary design of the MAR demonstration rotor system.<br>- Conduct principal investigators meeting for joint-Service and industry collaboration to identify critical enablers (tools, test facilities, specification revisions, etc) for successful adaptive rotor development and deployment. | 8.596 | 12.792 | 5.042 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-07: *AERONAUTICS TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Define a rotor system design for technology demonstration.<br>- Complete objective system application development.<br>- Complete technology maturation plan for the MAR rotor system.<br>- Complete systems requirement review for the MAR demonstration rotor system.<br><br>***FY 2012 Plans:***<br>- Conduct preliminary design review of the MAR demonstration rotor system.<br>- Conduct major component tests and demonstrations to mature active rotor technologies.<br>- Initiate planning for ground testing of MAR demonstration rotor system. | | | |
| ***Title:*** Advanced Aeronautic Technologies<br><br>***Description:*** The Advanced Aeronautics Technologies program will examine and evaluate aeronautic technologies and concepts through applied research. These may include feasibility studies of novel or emergent materials, devices and tactics for air vehicle applications, as well as manufacturing and implementation approaches. The areas of interest range from propulsion to control techniques to solutions for aeronautic mission requirements. The result of these studies may lead to the design, development and improvement of prototypes.<br><br>***FY 2011 Plans:***<br>- Conduct feasibility and trade studies of candidate technologies and architectures.<br>- Perform military utility analyses of proposed tactics and concepts of operation.<br><br>***FY 2012 Plans:***<br>- Perform modeling of concepts and architectures.<br>- Conduct enabling technology and sub-system feasibility experiments. | - | 2.000 | 2.000 |
| ***Title:*** Formation Flight<br><br>***Description:*** The Formation Flight program is exploring the development of drag reduction technologies for aircraft. Drag reduction allows aircraft to fly at increased ranges, reduces fuel consumption, and may allow increased payload capacity. Formation flight is used in nature by geese and other migratory birds to reduce drag, but requires the development of an autonomous system to maintain the optimum position for drag reduction to be practical for long duration aircraft flights. Safety of flight considerations require aircraft separation distances of up to one mile, necessitating automated sensing and tracking algorithms to track the lead aircraft wake. Flight testing a formation flight configuration will allow structural excitation and vehicle dynamic response to be addressed in proximity to the lead aircraft wake.<br><br>***FY 2010 Accomplishments:*** | 8.000 | 7.700 | - |

| | | |
|---|---|---|
| **Exhibit R-2A**, **RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-07: *AERONAUTICS TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Began detailed flight test planning for assessment of autopilot faults, alarms, and structural response of the aircraft wing in proximity to the aircraft wake.<br>- Started detailed stability and control law assessments for aircraft-wake interactions and trim effects.<br>- Initiated evaluation of existing database of wake crossings to determine impacts on flight control systems.<br><br>***FY 2011 Plans:***<br>- Complete detailed flight test planning for assessment of autopilot faults, alarms, and structural response of the aircraft wing in proximity to the aircraft wake.<br>- Complete detailed stability and control law assessments for aircraft-wake interactions and trim effects.<br>- Complete evaluation of existing database of wake crossings to determine impacts on flight control systems. | | | |
| ***Title:*** Helicopter Quieting<br><br>***Description:*** The goal of the Helicopter Quieting program was to advance the capability for analytical development of advanced rotor technologies to dramatically enhance the survivability of military rotor systems while enabling improvements to performance, affordability, availability and suitability. A critical element toward this goal was the creation and demonstration of a physics-based toolset to enable analytical design of novel rotor systems and rotorcraft for reduced acoustic susceptibility (detection and recognition) by human and electro-acoustic threats. Novel and creative concepts and ideas were employed in this program for accurate aerodynamic analysis of helicopter rotor airloading, flowfield, and wakes using high-end computational fluid dynamics techniques. The program developed tools capable of accurately predicting noise signature of advanced rotor concepts that exhibit a significant reduction in low-frequency in-plane signatures.<br><br>***FY 2010 Accomplishments:***<br>- Identified acoustic design criteria for new rotor system designs based on operational scenarios.<br>- Transitioned tools to Services, industry, and academia. | 1.819 | - | - |
| ***Title:*** Nano Air Vehicle (NAV)<br><br>***Description:*** The goal of the Nano Air Vehicle (NAV) program was to develop a hummingbird-inspired flapping air vehicle technology with less than a five inch wingspan and gross take-off weight of fifteen 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. Examples of such missions include intelligence, surveillance and reconnaissance (ISR) in buildings, underground facilities, caves, tunnels, and confined urban environments. Key enabling technologies included: flapping wing aerodynamics, kinematics and flight dynamics, lightweight aero-elastically tailored wing structures, miniature navigation systems, micro-propulsion systems, small payloads, and the ability to perch like a bird. | 2.500 | - | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-07: *AERONAUTICS TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Demonstrated mission-relevant flight times of >5 minutes hovering and >10 minute forward flight.<br>- Developed preliminary user controller and onboard vehicle navigation system to permit robust remote-controlled flight.<br>- Demonstrated prototype vehicle outfitted with video cameras in mock missions relaying video to the vehicle operator. | | | |
| **Accomplishments/Planned Programs Subtotals** | 26.915 | 34.692 | 23.042 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
|---|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY* | |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY* | 65.904 | 58.139 | 48.910 | - | 48.910 | 44.281 | 43.697 | 43.724 | 39.724 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

The Network Centric Enabling Technology project provides technology to build mission applications explicitly tailored to exploit the promise 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.

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 while enabling 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.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Video and Image Retrieval and Analysis Tool (VIRAT)<br><br>***Description:*** The Video and Image Retrieval and Analysis Tool (VIRAT) program will develop and demonstrate a system for video data exploitation that enables an analyst to rapidly find video content of interest from archives and provides alerts to the analyst of events of interest during live operations. The ability to quickly search large volumes of existing video data and monitor real-time video data for specific activities or events will provide a new capability to the U.S. military and intelligence agencies. Currently, video analysis is very labor intensive, limited to metadata queries, manual annotations, and "fast-forward" examination of clips. The software tools developed under VIRAT will radically improve the analysis of huge volumes of video data by: 1) alerting operators when specific events or activities occur at specific locations or over a range of locations and; 2) enabling fast, content-based searches of existing video archives. The final product of the VIRAT program is a system that can be transitioned to and integrated within an operational military system, such as the Distributed Common Ground System (DCGS).<br><br>***FY 2010 Accomplishments:*** | 15.159 | 13.716 | 13.021 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Developed technologies for efficient indexing and interactive retrieval against multiple activities.<br>- Designed an interactive retrieval process to incorporate improved algorithms and enhanced human factors.<br>- Ensured activity descriptor extraction technologies exhibit acceptable performance across multiple airborne video sources.<br>***FY 2011 Plans:***<br>- Develop technologies to accommodate stationary, ground-mounted video sources.<br>- Add geo-registration capability to support operational use of the data.<br>- Continue developing efficient indexing and interactive retrieval against a larger set of activities.<br>***FY 2012 Plans:***<br>- Complete development and optimization of technologies to accommodate larger datasets.<br>- Integrate final prototype system in accordance with the architecture of the program of record transition target.<br>- Test and evaluate performance of the system against an experienced analyst's performance. | | | |
| ***Title:*** Integrated Crisis Early Warning System (ICEWS)<br>***Description:*** The Integrated Crisis Early Warning System (ICEWS) program develops and integrates a set of data analysis tools into a unified information system to support Theater Security Cooperation (TSC). The ICEWS system monitors, assesses and forecasts leading indicators of events that make countries vulnerable to crises. ICEWS technologies include quantitative and computational social science modeling and simulation, scenario generation, ontological modeling of security problems, advanced interactive visualization techniques, and agent-based programming. ICEWS will also develop a collaborative, open-source testbed that will facilitate the integration and evaluation of alternative, operationally relevant social theories. Natural language processing is required to identify and extract information that is predictive from text and speech-based media and to distill that information into a form that is actionable by civilian and military leadership. ICEWS will develop a large body of test cases (source data and outcomes) against which the social science theories can be evaluated. When integrated, these tools will allow combatant commanders and their staff to understand and anticipate conditions that precipitate instability and conflict while there is still time to influence them. ICEWS will also help commanders anticipate unintended consequences of actions taken to influence or remediate situations, consequences that may be delayed by months or years.<br>***FY 2010 Accomplishments:***<br>- Applied the ICEWS data extraction and analysis methodologies in PACOM Terminal Fury exercise.<br>- Began generating and evaluating monthly forecasts of events of interest in the PACOM Area of Responsibility (AOR) and transitioned system components to PACOM.<br>- Developed a prototype system to explore how changes in leading indicators of events of interest can enable mitigating crises in the AOR. | 10.195 | 8.705 | 5.284 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Developed and applied initial social network models as a means for understanding groups of individuals connected through shared interests and collaborative activities.<br>***FY 2011 Plans:***<br>- Test the ICEWS forecasting algorithms against intelligence analysts' judgment at PACOM and deploy additional ICEWS components to PACOM for test and evaluation.<br>- Extend the ICEWS data extraction and analysis methodologies to additional combatant commands.<br>- Integrate new unclassified data feeds from the Open Source Center into ICEWS.<br>- Experiment with different methodologies to extract more accurate real time event data and other indices important for crisis forecasting.<br>- Develop and apply methods to detect, characterize, and predict the dynamics of social networks from complex, conflicting, and incomplete data sets.<br>***FY 2012 Plans:***<br>- Implement a testbed and develop associated datasets as a platform for integrating and evaluating social science theories.<br>- Extend testbed platform to address operationally-relevant questions from multiple problem classes and demonstrate the capability to formalize and integrate theories proposed by others.<br>- Test and evaluate social science theories across a rich set of retrospective and prospective testbed data and quantify the anticipated strengths and weaknesses of alternative approaches.<br>- Integrate classified data feeds into ICEWS.<br>- Test, evaluate, and transition ICEWS components to combatant commands as they mature. | | | |
| ***Title:*** Nexus 7*<br>***Description:*** *Previously funded in Production of Knowledge Bases to Bridge Cultural Divides in PE 0601101E, Project TRS-01<br><br>The Nexus 7 program is applying the forecasting, data extraction, and analysis methodologies developed in ICEWS to develop tools, techniques, and frameworks for the automated interpretation, quantitative analysis, and visualization of social networks. Social network theory has emerged in recent years as a promising approach for understanding groups of individuals connected through a variety of shared interests and collaborative activities. For the military, social networks provide a promising model for terrorist cells, insurgent groups, and other stateless actors whose connectedness is established not on the basis of shared geography but rather through the correlation of their participation in coordinated activities such as planning meetings, training/ mission rehearsal sessions, sharing of materiel/funds transfers, etc. The Nexus 7 program will develop and apply emerging methods for edge finding and cluster analysis to detect, characterize, and predict the dynamics of social networks. The resulting capabilities have important application in tactical contexts to aid analysts and operators in connecting the dots amid | - | - | 30.605 |

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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602702E: *TACTICAL TECHNOLOGY* | **PROJECT**<br>TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| complex, conflicting, and incomplete data sets. They also establish a foundation for cultural intelligence - understanding the stability, governance, and economic indicators of a region - and the capability to better focus stability, security, transition, and reconstruction operations on high-payoff initiatives.<br><br>***FY 2012 Plans:***<br>- Develop techniques for simulation, visualization, inference, and prediction of social network dynamics.<br>- Develop techniques for modeling the interactions between and within cooperating/competing/conflicting social networks, sub-networks, and super-networks and for predicting the merging and splitting of social networks.<br>- Evaluate tools and techniques on real-world social-cultural-network data. | | | |
| ***Title:*** Extreme Accuracy Tasked Ordnance (EXACTO)<br><br>***Description:*** The objective of the Extreme Accuracy Tasked Ordnance (EXACTO) program is to revolutionize the Service sniper's ability to engage targets at long range, regardless of target motion or crosswinds, with previously unachievable accuracy. The EXACTO system is comprised of an advanced targeting optic, the first ever guided small caliber bullet, innovative guidance and control software, and a conventional sniper rifle. The EXACTO 50-caliber bullet and optical sighting technology will greatly extend the day and night ranges over current state-of-the-art sniper systems allowing sniper teams to engage tactically important moving (or accelerating) targets in high crosswind conditions such as those commonly found in Afghanistan. Current technology is extremely limited in its ability to compensate for high crosswinds, significant target motion, or target acceleration. EXACTO will not only dramatically improve sniper effectiveness, but also enhance troop safety by allowing greater shooter standoff range and reduce target engagement timelines. The EXACTO system combines a command guided bullet with a guidance control system capable of compensating for adverse environmental conditions and tracking mobile targets in real-time. The technology development plan includes risk reduction and system integration of all system components and will culminate in live fire testing of a prototype EXACTO system at a full spectrum of ranges, day/night, and environmental conditions, to fully validate system performance.<br><br>***FY 2010 Accomplishments:***<br>- Performed component testing, performance modeling, and explored system integration opportunities for all subsystems.<br>- Validated critical sub-system component performance including optical link, electronics packaging, bearings survivability, and turbulence mitigation for target optic.<br>- Successfully demonstrated potential system performance of two competing EXACTO designs through detailed simulation based on established component and subsystem performance data, featuring integrated hardware components, and a comprehensive Monte Carlo simulation executed at numerous simulated ranges and environmental and target conditions. | 16.889 | 22.218 | - |

| **Exhibit R-2A, RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Developed program plans and a preliminary design for prototype EXACTO system live fire demonstration.<br><br>***FY 2011 Plans:***<br>- Revise component, software, and prototype system design as necessary to optimize performance.<br>- Continue risk reduction simulation and testing of EXACTO system, component hardware and software.<br>- Perform initial bullet packaging demonstration.<br>- Develop detailed design and begin fabrication of EXACTO prototype system and bullets.<br>- Validate critical integrated sub-systems and performance models with software-in-the-loop simulations.<br>- Complete fabrication of EXACTO prototype system and bullets.<br>- Validate EXACTO system performance by incrementally demonstrating key system functionality.<br>- Conduct live fire performance demonstration of prototype system over full scope of target ranges, velocities, and environmental conditions. | | | |
| ***Title:*** PERsistent Stare Exploitation and Analysis System (PerSEAS)<br><br>***Description:*** The PERsistent Stare Exploitation and Analysis System (PerSEAS) program will develop and demonstrate a tool to automatically and interactively identify activity-based events of interest from persistent, wide area, motion imagery data with support from signals intelligence and other sources. Persistent, wide area surveillance imagery is an ever increasing source of operational data, but exploitation of this data at present is mostly manual and requires hours to days to produce results. Tools are needed to automatically detect potentially significant adversary activities and to discriminate these from nominal background activity. These tools would be supported by libraries of activity patterns, logic to generate hypotheses about which activities are being observed, and mechanisms to quantitatively score the consistency of the data with each activity hypothesis. Such capabilities are necessary to detect and defeat threats in real-time. The major thrust of the program is the hierarchical processing of extracted features (such as context and tracks) to yield events of interest, which in turn would be linked to form activities and then integrated to discover and infer potential threat patterns. The discovery and identification of the potential threat patterns would then produce alerts and cues for analysts to interactively adjudicate and validate. PerSEAS technologies and system are planned for transition to the Distributed Common Ground System and other intelligence applications.<br><br>***FY 2010 Accomplishments:***<br>- Formulated approaches to network discovery based on normalcy estimates, improved tracking algorithms using pattern analysis, and contextual analysis for anomaly detection.<br><br>***FY 2011 Plans:***<br>- Implement and evaluate techniques on wide area motion imagery data.<br>- Develop a system prototype. | 7.500 | 9.000 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Refine and improve modeling techniques for normalcy modeling and anomaly detection.<br>- Refine and improve inferencing algorithms to recognize complex chains of activities and events.<br>- Incrementally transition algorithms or subcomponents. | | | |
| ***Title:*** Home Field<br><br>***Description:*** The Home Field program develops networked video and Laser Detection and Ranging (LADAR) processing technology to rapidly and reliably update a 3-D model of an urban area. It provides 3-D 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.<br><br>Drawing upon technologies developed in the Home Field program, the Urban Photonic Sandtable Display (UPSD) program has developed revolutionary interactive holographic displays for complex volumetric 3-D data to replace current 3-D visualization technologies that are either static or have limited effective field-of-view. Current technologies include traditional holography, computer graphics on 2-D screens, slice stacking, parallax autostereo, and goggles/glasses. These techniques not only give a poor image quality and poor movement, they also are not created quickly and do not allow for collaborative viewer interaction. The desire to improve these components launched the development of the UPSD. Applying the design fundamentals of the monochrome active grouping of pixels for a light modulator element into a single 3-D holographic pixel (hogel-based proof-of-concept) display and further developed module, a scalable and tileable laboratory prototype has been validated by transforming computer data to optical data, making sophisticated integration possible to optimize image quality. The UPSD program developed an affordable 3-D display that operates at full video rate, displays red-green-blue (RGB) color, increases viewing angle, and increases display size. The result will be the world's first full-motion, full aspect 3-D imaging technology system. The emissive micro displays effort will develop technologies to support the fabrication of Low-cost High pixel density Power efficient Direct emission Microdisplays (LHPDM). Current microdisplay systems use light modulation systems (liquid crystal displays, digital micromirror devices,) and by using LHPDM, it will enable the transmission of larger fractions of light from the illumination source.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated assembled monochrome and RGB 9-title hogel displays. | 16.161 | 4.500 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Completed development of UPSD hogel display titles.<br>- Developed and demonstrated techniques for layer doping of heterostructure materials.<br>- Evaluated and selected approaches for the development of affordable emissive microdisplays.<br>- Demonstrated 32K pixel IR micro-emitter array.<br>- Selected fabrication technologies with five times cost reduction potential.<br>- Commenced demonstration of fabrication technologies that support the fabrication of affordable emissive microdisplays.<br>- Transitioned the UPSD technology to the Air Force and Army.<br>***FY 2011 Plans:***<br>- Complete demonstration of fabrication technologies that support affordable emissive microdisplays.<br>- Demonstrate red-green-blue capability for emissive micro displays.<br>- Demonstrate UV micro-emitter array.<br>- Complete development and fabrication of all emissive micro display modules. | | | |
| **Accomplishments/Planned Programs Subtotals** | 65.904 | 58.139 | 48.910 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 255.807 | 312.586 | 237.837 | - | 237.837 | 253.396 | 290.881 | 312.941 | 299.092 | Continuing | Continuing |
| MBT-01: *MATERIALS PROCESSING TECHNOLOGY* | 148.728 | 184.614 | 104.538 | - | 104.538 | 108.573 | 114.347 | 122.543 | 118.243 | Continuing | Continuing |
| MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES* | 107.079 | 127.972 | 35.499 | - | 35.499 | 46.023 | 40.534 | 58.122 | 62.849 | Continuing | Continuing |
| MBT-03: *TACTICAL AND STRATEGIC ENERGY TECHNOLOGY* | - | - | 97.800 | - | 97.800 | 98.800 | 136.000 | 132.276 | 118.000 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

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

The Biologically Based Materials and Devices project acknowledges the growing and pervasive influence of the biological sciences on the development of new materials, devices and processes, as well as the commensurate influence of materials, physics and chemistry on new approaches to biology and biochemistry. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the development of biochemical materials to maintain performance, the use of biology's unique fabrication capabilities to produce structures that cannot be made any other way, and the development of manufacturing tools that use biological components and processes for material synthesis. It also supports a major thrust that will revolutionize the development of prosthetics for the wounded soldier.

The Tactical and Strategic Energy Technology project is focused on the unique challenges facing the DoD in developing and demonstrating advanced power generation and energy storage technologies. It will address critical military needs for improved energy efficiency and availability to support a range of military missions that include individual warfighter and small unit operations, large platform operations, and sustainment of forward operating bases. At the individual warfighter and small unit operations level, efforts are addressing the need for mission extending power generation and energy storage technologies with particular emphasis on portability and robustness challenges that are unique to the DoD. At the large platform and forward operations scale, efforts are addressing needs for deployable energy storage and more efficient power generation and distribution technologies. As electronic systems are common to all scales of power generation and energy storage and management, this project also investigates improved board-level power conversion and regulation strategies to more efficiently convert and distribute high voltages to locally required low voltages for powering integrated circuits and sensors.

| B. Program Change Summary ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 270.207 | 312.586 | 254.218 | - | 254.218 |
| Current President's Budget | 255.807 | 312.586 | 237.837 | - | 237.837 |
| Total Adjustments | -14.400 | - | -16.381 | - | -16.381 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | -7.233 | - | | | |
| • SBIR/STTR Transfer | -7.167 | - | | | |
| • TotalOtherAdjustments | - | - | -16.381 | - | -16.381 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2010 | FY 2011 |
|---|---|---|
| **Project:** MBT-01: *MATERIALS PROCESSING TECHNOLOGY* | | |
| Congressional Add: *Strategic Materials* | 5.000 | - |
| Congressional Add: *Photovoltaic Ribbon Solar Cell Technology Project* | 2.880 | - |
| Congressional Add Subtotals for Project: MBT-01 | 7.880 | - |
| Congressional Add Totals for all Projects | 7.880 | - |

**Change Summary Explanation**

FY 2010: Decrease reflects the transfer of "Center for Non-Proliferation Studies" congressional add to the Defense Threat Reduction Agency, SBIR/STTR transfer and internal below threshold reprogrammings.

FY 2012: Decrease reflects shift of on-going medical programs in Project MBT-02 to the new Biomedical Technology PE 0602115E and Defense Efficiencies for contractor staff support, partially offset by increases for power programs and transfer of the Vulcan effort from PE 0603286E, Advanced Aerospace Systems.

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

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MBT-01: *MATERIALS PROCESSING TECHNOLOGY* | 148.728 | 184.614 | 104.538 | - | 104.538 | 108.573 | 114.347 | 122.543 | 118.243 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Materials Processing and Manufacturing | 16.300 | 14.034 | 11.000 |
| ***Description:*** 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 to fabricate DoD systems. It will also develop approaches that yield new materials and materials capabilities that cannot be made through conventional processing approaches as well as address efficient, low-volume manufacturing. Included are disruptive manufacturing approaches for raw materials and components, advanced carbon fiber material, and manufacturable gradient index optics.<br><br>***FY 2010 Accomplishments:***<br>- Synthesized new high molecular weight carbon fiber polymer precursor materials dispersed with additives to enhance fiber strength and stiffness in downstream processing.<br>- Demonstrated ability to characterize flaws in carbon fiber at all scales relevant to strength and stiffness performance (i.e., nano-, micro-, and macro-sized defects).<br>- Demonstrated ability to control defect type, size, and concentration to optimize carbon fiber properties.<br>- Transitioned non-autoclave tooling and materials/processes to large-scale polymer matrix composite (PMC) fabricators.<br>- Produced functional, integrally cored molds suitable for turbine foil casting trials at commercial foundry.<br>- Demonstrated out-of-the-autoclave PMC curing capability to fabricate large complex parts such as co-cured rib/spar structures and multi-pocketed sandwich structures for a high-altitude, long-endurance vertical tail aircraft.<br>- Initiated development of optical design tools with incorporated material properties and fabrication parameters.<br>- Exploited new capabilities in design and fabrication to spatially control the index of refraction in materials, resulting in the demonstration of a prototype short wave infrared (SWIR) lens made with gradient index (GRIN) materials.<br><br>***FY 2011 Plans:*** | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Initiate carbon nanotube templating as a means of alleviating nano-scale defects and enhancing carbon fiber tensile strength and modulus.<br>- Enhance carbon fiber properties via cross-planar bonding.<br>- Start evaluation and testing by Air Force Composites Testing Lab to establish first generation advanced carbon fiber insertion points within Air Force systems.<br>- Demonstrate successful casting of superalloy turbine blades using ceramic molds made or produced via direct digital manufacturing.<br>- Demonstrate fabrication of large composite wing (at the 50 ft x 10 ft scale) and a complex polymer composite structure using the out-of-the-autoclave process for High Altitude Long Endurance (HALE) prototype aircraft.<br>- Demonstrate GRIN lenses in imaging and non-imaging applications such as a high-resolution imager for micro-UAV and solid state-tracking solar concentrator, and demonstrate the manufacture of custom lenses in single- and high-volume lots.<br>- Demonstrate expanded range and rate of refractive index gradient through new materials development or processes.<br>- Develop and test new metrology for GRIN materials and optics.<br>- Produce scale to manufacturing plan including cost model and risk management plan.<br><br>***FY 2012 Plans:***<br>- Demonstrate microstructure/property/process relationship needed for overcoming critical defect limitations in carbon fiber performance for structural applications.<br>- Demonstrate carbon fiber with 100 percent improvement in strength and 50 percent improvement in stiffness over today's state-of-the-art high-performance structural carbon fibers.<br>- Demonstrate scalability of fiber production process for structural carbon fiber in suitable quantities for small-lot manufacturing.<br>- Demonstrate proof of concept for disruptive manufacturing of ceramic matrix composites.<br>- Significantly accelerate the speed and accuracy of modeling and simulation tools in the design of electromechanical systems. | | | |
| ***Title:*** Structural Materials and Coatings<br><br>***Description:*** The Structural Materials and Coatings thrust is exploring and developing new materials that will provide enhanced structural and/or surface properties for DoD applications. Included are approaches that avoid corrosion, provide superior strength at greatly reduced material density, provide the basis for a new generation of structural composite and submarine propeller materials, and enable prolonged lifetimes for DoD systems and components.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated commercially pure titanium from oxide at a production rate of 500 pounds per day.<br>- Quantified structural amorphous metal performance and specific fuel consumption attributes for both military and commercial engines. | 16.751 | 13.000 | 10.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated coatings of structural hybrid amorphous metal fan blades that successfully meet galling and environmental requirements.<br>- Planned and launched structural amorphous composite hybrid test panels for space applications.<br>- Identified candidate material systems, manufacturing methods, and quality control procedures to fabricate a high-quality, thick-section, multi-material tapered beam extensible to a doubly-curved, full-scale, multi-material rotor blade fabrication.<br>- Began design for the thick-section multi-material tapered beam (70 percent of the weight, equivalent stiffness, and 2x performance of a nickel aluminum bronze (NAB) alloy 95800 tapered beam).<br>- Initiated the development of multi-physics Coupling Software Environment (CSE) architecture providing a clear articulation of the domain code coupling (i.e., coupling of Computational Fluid Dynamics (CFD), Computational Structural Mechanics (CSM), and other performance prediction tools).<br>- Initiated government team testing and evaluation of vendor-proposed hybrid multi-materials and manufacturing concepts.<br>- Completed 12" diameter water tunnel (WT) flexible hydrofoil design for test and evaluation in support of benchmark problem to be performed in the 48" diameter WT during FY 2011.<br><br>***FY 2011 Plans:***<br>- Demonstrate meltless titanium consolidation.<br>- Monitor structural amorphous composite hybrid test panels in space.<br>- Fabricate and test constant cross-section multi-material beam manufacturing demonstration articles (70 percent of the weight with equivalent stiffness of a nickel aluminum bronze (NAB) beam).<br>- Fabricate multi-material panel manufacturing demonstration articles for experimental modal analysis (2x NAB panel performance).<br>- Conduct modal analysis.<br>- Develop and initiate demonstration of non-destruction evaluation techniques and associated calibration standards to detect all defects greater than 2 inches in diameter in the hybrid multi-material.<br>- Fabricate and test thick-section multi-material tapered beam (70 percent of the weight, equivalent stiffness, and 2x performance of a NAB tapered beam).<br>- Continue development of the CSE including the hybrid multi-material rotor (HMMR) model/domain code coupling.<br>- Perform a small-scale diagnostic flexible hydrofoil experiment in the 12" diameter WT and use the measurement techniques developed to perform the steady flow Phase 1 rigid and flexible hydrofoil benchmark 48" diameter WT tests.<br>- Perform verification of the CSE against the 48" diameter WT benchmark test results.<br><br>***FY 2012 Plans:***<br>- Demonstrate that meltless titanium alloy exhibits properties equivalent to the same conventionally-processed alloy. | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Fabricate and test thick-section multi-material tapered beam (50 percent of the weight, 1.5x stiffness, and 5x performance of a NAB tapered beam).<br>- Fabricate small-scale multi-material rotors for benchmark 48" diameter WT testing.<br>- Continue development and initiate verification of the CSE to enable strong coupling of the HMMR domain codes required for time-accurate performance predictions of multi-material rotors.<br>- Perform unsteady flow Phase 2 multi-material hydrofoil benchmark 48" diameter WT tests and verification simulations.<br>- Conduct Phase 2 small-scale single-material and multi-material rotor testing in the 48" diameter WT and use the data for CSE verification simulations. | | | |
| ***Title:*** Multifunctional Materials and Structures<br><br>***Description:*** The Multifunctional Materials and Structures thrust is developing materials and structures that are explicitly tailored for multiple functions and/or unique mechanical properties. This thrust also explores novel materials and surfaces that are designed to adapt structural or functional properties to environmental and/or tactical threat conditions. Included in this thrust are efforts that will lower the weight and increase the performance of aircraft, enhance the efficiency of turbines, improve the survivability of space structures, increase dampening of structural loads, and improve the performance of surface dominated properties (friction and wear, membrane permeability, etc.).<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated the ability to fabricate carbon nanotube (CNT) triode cold cathode microstructures for high current density electron emission at low voltages.<br>- Designed scalable radial array of CNT cold cathode microchips for integration with space propulsion systems.<br>- Increased efficiency of flexible Cadmium Telluride (CdTe) solar cells by improving device design.<br>- Demonstrated new membranes and technologies for particle separation to reduce the clogging and fouling of desalination systems.<br>- Evaluated novel membranes and technologies for their abilities to remove dissolved salts and contaminants from seawater.<br>- Demonstrated critical risk reduction for development of a hybrid energy storage system designed to maximize run time of DoD portable electronics through more efficient extraction of electrical energy from portable energy storage systems (batteries, fuel cells, etc.).<br>- Investigated the development of negative stiffness structural elements that can be incorporated at different levels in the structural frame of aircraft and high-speed maritime platforms in order to provide the optimum mechanical response to a given dynamic load.<br><br>***FY 2011 Plans:***<br>- Demonstrate repeatable fabrication of uniform CNT cold cathodes with high current densities and long lifetimes. | 17.092 | 23.488 | 9.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate operation of CNT cold cathodes with a Hall Effect Thruster (HET) in relevant space environment.<br>- Design for the ability to produce flexible CdTe solar cells with 10 percent efficiency.<br>- Finalize the design of CNT triode microstructures.<br>- Design and test new membranes with high flux transport properties that are robust enough to double the lifetime over current membranes.<br>- Design novel membranes and technologies that will desalinate seawater at 75 gallons per hour (gph) with twice the lifetime of existing desalination systems.<br>- Demonstrate a portable seawater desalination system that provides 30 gph potable output from seawater while requiring significantly less energy and maintenance than current military systems.<br>- Design a lightweight (20 lbs.) desalination system with an overall power consumption of less than or equal to 5 W/gph.<br>- Complete developmental activities, including finite element modeling and shake table experiments, to validate the predicted performance of the negative stiffness structural elements for application to aircraft and high-speed maritime platforms.<br>- Initiate the design of an adaptive structural sub-assembly incorporating mechanical programs of tiered negative stiffness structural elements; activities include preliminary design and finite element modeling of the sub-assembly being used in the demonstration.<br><br>***FY 2012 Plans:***<br>- Begin to transition carbon nanotube (CNT) cold cathode technology to Air Force.<br>- Demonstrate thrust vectoring in Hall Effect Thrusters using distributed CNT emitter arrays.<br>- Demonstrate that propellant-less CNT cold cathodes reduce propellant budgets on satellites.<br>- Increase manufacturability of photovoltaic (PV) arrays, and demonstrate high-efficiency PV array pilot production capability.<br>- Finalize the design and test adaptive structural sub-assemblies incorporating tiered negative stiffness structural elements; activities include final design construction and testing of adaptive structural systems.<br>- Initiate the design, development, and construction of a platform with an adaptive structural frame that incorporates mechanical programs of tiered negative stiffness structural elements. | | | |
| ***Title:*** Materials for Force Protection<br><br>***Description:*** The Materials for Force Protection thrust is developing novel materials and materials systems that will greatly enhance protection against ballistic, blast, and explosively formed projectile (EFP) threats across the full spectrum of warfighter environments. Included in this thrust are novel topological concepts as well as entirely new structural designs that will afford enhanced protection and functionality, at reduced weight and/or cost.<br><br>***FY 2010 Accomplishments:*** | 15.200 | 22.966 | 14.850 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Developed glass/transparent ceramic formulation and processing technologies to enable multi-hit performance of transparent armor equivalent to that of opaque armor.<br>- Developed and demonstrated opaque armor configuration that achieved multi-hit performance at a 25 percent weight reduction over current opaque armors.<br>- Developed and demonstrated armor configuration that achieved EFP defeat at a 30 percent weight reduction over current armor.<br>- Evaluated the effectiveness of stiffness, shock isolation, blast venting, and energy absorption and integrated these features into an underbody armor design.<br>- Established greater than 30 percent reduction in acceleration loads to underbody blasts in half scale tests.<br>- Continued the initiative to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and military vehicles.<br>- Characterized the effects of novel compositions of new armor materials and processing methods on the improvement in ballistic performance against various levels of threats.<br>- Began passive, multi-material armor design and testing for warhead defeat in maritime application geometries.<br>- Developed a surrogate threat to represent a high performance warhead in stand-off configurations that would otherwise be challenging and expensive to repeatedly test; this surrogate will be used for future program validation testing.<br><br>***FY 2011 Plans:***<br>- Demonstrate transparent armor based on high purity glass and ceramic formulations capable of achieving multi-hit performance at weights equivalent to that of opaque armor.<br>- Demonstrate multi-hit performance of transparent armor equivalent to that of opaque armor.<br>- Continue the initiative to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and military vehicles.<br>- Develop candidate concepts to capture kinetic energy from ballistic threats and convert it quickly enough into a form that can be applied to counteract the same threat.<br>- Characterize the fundamental mechanisms and properties that control threat energy propagation and material response under dynamic loads across applicable regimes.<br>- Initiate development of physics-based models to explicitly compute dynamic behavior of armor materials to include load paths, critical energy spreading/dissipation/conversion mechanisms, and failure modes.<br>- Begin development of mechanisms that can be incorporated into candidate armor material systems to manipulate ballistic energy to maximize rate of degradation without degrading material strength and at a minimum weight.<br>- Initiate development of mechanisms that can be incorporated into candidate armor material systems that can maximize absorption, diversion, or reflection of blast energy at a minimum weight. | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Develop and validate new passive armor solutions that exploit unique high-strength/polymer composite/ceramic/glass hybrid configurations.<br>- Begin to develop multifunctional passive and active hybrid systems concepts with efficient structural load support capabilities and protection within critical size, weight, and power constraints.<br>- Develop corrugated and lattice truss core structures that can be flexed into desired complex geometries.<br><br>***FY 2012 Plans:***<br>- Continue the initiative to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and military vehicles.<br>- Apply developed high performance armor technologies to maritime platforms and exploit them in applications where traditional materials would not be appropriate for the operational environment.<br>- Demonstrate synergistic passive and active armor systems for warhead defeat in multi-material configurations within critical size, weight, power, space, and cost constraints.<br>- Conduct experimental characterization of candidate energy management integrated into armor materials across stress levels, strain rates, and impulsive loading regimes characteristic of ballistic and blast threat regimes.<br>- Continue development and initiate validation of physics-based models to explicitly compute dynamic behavior of armor materials that incorporate essential materials properties, critical response characteristics, and relevant energy management mechanisms.<br>- Continue development of ballistic and blast energy management mechanisms and initiate integration with material properties into candidate armor material systems for optimization against specific threats.<br>- Develop survivability concepts and correlate protection system performance with physics-based models and testing to assess capability for maritime vehicles.<br>- Begin to exploit multi-functional materials and systems to enhance the protection and survivability of maritime platforms and initiate evaluations for material performance in littoral and undersea environments with respect to corrosion, water-tightness, and other critical factors. | | | |
| ***Title:*** Prognosis<br><br>***Description:*** The Prognosis thrust will demonstrate revolutionary new concepts, physics-based models, and advanced interrogation tools to assess damage evolution and predict future performance of the structural materials in defense platforms/ systems. Included are demonstrations on Navy and Air Force aircraft structures and engines for advanced jet aircraft and helicopters. Also included are sensor and model development required to support the damage prediction.<br><br>***FY 2010 Accomplishments:***<br>- Developed data mining tools for extracting key parameters from actual flight data and installed acoustic sensors and feed into structural integrity prognosis system (SIPS) damage models. | 3.000 | 5.000 | 5.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Evaluated P3 flight data and tested Prognosis systems versus legacy method.<br>- Demonstrated the capability to predict the performance, life, and reliability of the full P3 weapons system.<br>- Engaged F-22 program office and initiated study for full implementation of engine system program (ESP) and SIPS into F-22.<br>***FY 2011 Plans:***<br>- Harden and miniaturize acoustic sensors to make them suitable for fighter aircraft such as the F-22.<br>- Exploit developments in acoustic emission sensor technology for rogue flaw detection in multiple P3 aircraft critical wing zones, and demonstrate the capability to identify crack location within 1 percent of the wing zonal area.<br>- Perform probabilistic predictions of the current and future state of the P3 aircraft wing zones using adapted fatigue models and incorporated sensor characterization; conduct model analysis based on inspection feedback.<br>- Identify fatigue initiation and crack growth mechanisms in titanium and begin development of physics-based models to characterize its microstructure and damage progression properties.<br>- Assess F-22 aircraft areas of interest related to structural integrity including geometry, loads, and material properties.<br>***FY 2012 Plans:***<br>- Demonstrate the capability to extend aircraft maintenance and inspection intervals using probabilistic models for the P3 aircraft materials and structures.<br>- Develop a methodology for P3 fleet-wide deployment of the structural integrity prognosis and usage-based capabilities to include hardware, software, and life-cycle supportability.<br>- Adapt developing physics-based fatigue models for F-22 structural materials to a probabilistic framework to predict the onset of crack growth, and validate the models through fatigue predictions and testing.<br>- Improve the Prognosis 'plug and play' software architecture to incorporate new physics-based F-22 material models and integrate with sensor characterization data for current and future performance predictions of an F-22 aircraft structure. | | | |
| ***Title:*** Materials for Initiation and Actuation<br>***Description:*** The Materials for Initiation and Actuation thrust explores and develops materials for initiation and propagation of mechanical and/or chemical effects. Included efforts are structures for meso-scale electrically initiated combustion, cyclic chemical reactions for communication, and high-power, low-volume actuators required for high-efficiency mobile platforms.<br>***FY 2010 Accomplishments:***<br>- Developed initial theory using electric and acoustic fields as a "material" for suppressing fire and verified it experimentally using laboratory scale flames.<br>- Demonstrated the ability to achieve high density, high enthalpic energy, and high strength in the same material composite. | 6.915 | 6.230 | 2.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated the ability to control particle size upon initiation and decomposition of reactive material to achieve micron-sized particles.<br>- Demonstrated the ability to ignite and combust reactive particles upon initiation and dispersion.<br>***FY 2011 Plans:***<br>- Use numerical simulation to obtain scaling behavior and determine best approaches for suppressing larger fires.<br>- Conduct fire suppression demonstration using electric and acoustic fields on a class A/B fire approximately 1 square meter in size.<br>- Demonstrate both structural and energetic function in a single material composite and the ability to produce multiple samples with specified properties in sizes greater that one half pound.<br>- Demonstrate ability to initiate energy release in a material composite that has the density of steel and a moderate (50 ksi tensile) strength.<br>- Demonstrate blast performance from an explosive filled reactive case of at least twice that achievable with a similar explosive charge in an inert case.<br>***FY 2012 Plans:***<br>- Demonstrate small-scale combustion enhancement based on prior suppression development. | | | |
| ***Title:*** Reconfigurable Structures<br>***Description:*** In the Reconfigurable Structures thrust, new combinations of advanced materials, devices, and structural architectures are being developed to allow military platforms to move, morph, or change shape for optimal adaptation to changing mission requirements and unpredictable environments.  This includes the demonstration of new materials and devices that will enable the military to function more effectively in the urban theater of operations.  For example, a key focus is to formulate a more principled, scientific basis for robotic ground mobility and manipulation, and to develop and demonstrate from that basis innovative robot design tools, fabrication methods, and control methodologies.<br>***FY 2010 Accomplishments:***<br>- Performed laboratory testing of engineered soft material robot operations and optimized design.<br>- Performed laboratory demonstrations of robot function.<br>- Developed engineering model for soft robots, and designed prototype robots for selected applications.<br>- Demonstrated a fully loaded soldier (300 lb) wearing reattachable pads (magnets and microspines) scaling a series of 25-foot walls built from mission-relevant materials using Z-MAN technology. | 7.126 | 20.046 | 21.188 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated an unloaded soldier (150 lb) using reattachable pads (gecko nanoadhesives) to scale a series of 25-foot walls built from mission-relevant materials.<br>***FY 2011 Plans:***<br>- Perform laboratory demonstration of prototype soft material robots and refine designs.<br>- Perform simulated field testing of prototype robots.<br>- Finalize robot designs for field use.<br>- Demonstrate a fully loaded soldier (300 lb) using reattachable pads (gecko nanoadhesives) to scale a series of 25-foot walls built from mission-relevant materials.<br>- Transition Z-MAN prototype technologies (magnets and microspines) to the Services.<br>- Demonstrate components of new design tools for accelerating high quality design of robots by non-experts.<br>- Demonstrate proof of concept prototypes of new fabrication methods for producing robots at low cost.<br>- Demonstrate components of new control algorithms able to improve the mobility and manipulation performance of robots.<br>- Demonstrate in simulation proof of concept robots with higher mobility and manipulation performance than currently available.<br>- Demonstrate proof of concept components for increasing robot mobility and manipulation performance.<br>***FY 2012 Plans:***<br>- Perform field testing of prototype robots for transition to end user.<br>- Refine final robot designs based on field test results.<br>- Identify potential end users and transition to end users.<br>- Integrate and demonstrate components of new design tools for accelerating high quality design of robots by non-experts.<br>- Brass board new fabrication methods for producing robots at low cost.<br>- Demonstrate new control algorithms able to significantly improve mobility performance.<br>- Demonstrate new control algorithms able to significantly improve manipulation performance.<br>- Demonstrate of proof of concept robot prototypes with higher mobility.<br>- Integrate and demonstrate proof of concept robot prototypes with higher manipulation performance. | | | |
| ***Title:*** Alternate Power Sources<br>***Description:*** The Alternate Power Sources thrust aims to develop materials and technologies to utilize alternative power sources with the potential to provide significant strategic and tactical advantages to the DoD. A consistent DoD need continues to be greater efficiency in a portable form factor. Portable photovoltaic technologies will strive to meet this need and at low cost manufacturing. Very small volume (less than one cubic millimeter) rechargeable micro-batteries with maintained energy density comparable to conventional lithium ion batteries are being developed. | 7.500 | 6.500 | 5.500 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Achieved an energy density of 250 Wh/L for a 1 cubic millimeter battery and demonstrated progress towards reliable sealing approach for the all metal-ceramic packaging.<br>- Explored the light acquisition, energy capture, and carrier extraction aspects of portable photovoltaic (PV) devices to identify the most advantageous breakthroughs to exploit these devices.<br>- Explored the robust and durable portability and flexibility aspects of portable PV devices to identify most advantageous breakthroughs to exploit these devices.<br>***FY 2011 Plans:***<br>- Create new portable PV technologies that function at greater than or equal to 16 percent power conversion efficiency (under AM1.5 illumination at one sun) in a form factor amenable to flexible substrates.<br>- Develop new portable PV technologies that allow for low-cost manufacturing at $3.75 per Watt.<br>- Develop new portable PV technologies that allow for backpack portable PV devices.<br>***FY 2012 Plans:***<br>- Design portable PV devices that function at greater than or equal to 20 percent power conversion efficiency (under AM1.5 illumination at one sun) and have a minimum radius of curvature of 3 cm.<br>- Design PV devices that are lightweight and man-portable, defined as a density less than or equal to 1500 grams per square meter.<br>- Design portable PV devices that produce at least 80 percent of their specified electrical output after one year duration and after exposure to environmental hazards such as punctures, humidity, temperature extremes, rain, and dust. | | | |
| ***Title:*** Functional Materials and Devices<br>***Description:*** The Functional Materials and Devices thrust will address problems with high performance functional materials development. Functional materials deployed for applications are most often bulk structures and performance is limited to those properties found in nature. Improved materials require deliberate control at the scale of the relevant phenomena (electron transport, phonon transport, etc.). This thrust will leverage the advanced fabrication capabilities currently available, coupled with design of material and structure, to drive functional materials to high performance for DoD applications by design. Thermoelectric materials for cooling and power generation, and IR emissive materials are examples of near-term materials in which design of structure at the scale of the critical phenomena can have significant impact on their performance. To eliminate the ISR capability gap that currently exists at the soldier-scale, capability will be developed to provide high space/time resolution (mm/ms) throughout the soldier-scale 4 sphere of influence (km/min) by developing task-specific functionality (e.g. hands-free zoom, automated brightness adjustment, threat detection, targeting assistance, change detection, supplementary data overlay, etc.). | 3.500 | 8.000 | 7.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| This thrust will also explore newly emerging areas where structure may play an important role, but has not been fully exploited yet, such as hybrid nanocomposite materials, plasmonics, phononics, and superconductors.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated structural control methodology application to superconducting materials.<br>- Investigated nonlinear optical properties of organic nanocomposites.<br>***FY 2011 Plans:***<br>- Demonstrate significant improvements in thermoelectric materials' figure of merit at cryogenic temperature ranges (below 200 degrees Kelvin) for solid state refrigeration.<br>- Demonstrate significant improvements in thermoelectric materials' figure of merit at high temperature ranges (above 100 degrees Kelvin) for power generation.<br>- Demonstrate improved efficiency of infrared emitting materials.<br>- Demonstrate modeling capabilities to predict material performance.<br>- Design novel contact lens binocular telescope providing hands-free 10x all-optical zoom on demand.<br>- Design low profile contact lens based heads-up display with field of view and resolution comparable to the unaided eye.<br>***FY 2012 Plans:***<br>- Fabricate and test contact lens binocular telescope providing hands-free 10x all-optical zoom on demand.<br>- Fabricate and test low profile heads-up display with field of view and resolution comparable to the unaided eye.<br>- Demonstrate algorithms for computer enhanced vision in conjunction with low size, weight and power (SWaP) micro-cameras. | | | |
| ***Title:*** Universal Batteries<br><br>***Description:*** The goal of this program is to develop adaptable and highly efficient primary batteries with a path toward future rechargeable versions. The basic concept is to include control electronics within the battery housing that will allow the voltage to be set to suit particular needs and to provide external physical adapters to allow batteries to be fit into end-use systems. Another key development area is sufficiently miniaturized power management circuitry that could be integrated into compact battery packages such as the common AA, C, and D cells, providing access to the "leftover" charge capacity in these cells which is normally discarded due to voltage droop.<br><br>***FY 2011 Plans:***<br>- Analyze key primary battery needs, design appropriate power management circuitry, and fabricate prototype battery units. | - | 10.000 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Create and demonstrate development path, including compact switch-mode energy storage elements, for miniaturized, mass-production capable power conversion/management modules that could be integrated into compact battery formats. | | | |
| ***Title:*** Manufacturable Gradient Index Optics (M-GRIN)<br><br>***Description:*** Based upon technology development from the Materials Processing and Manufacturing thrust, the Manufacturable Gradient Index Optics (M-GRIN) program seeks to advance the development of GRIN lenses from a Technology Readiness Level (TRL) 3 to a Manufacturing Readiness Level (MRL) 8. The program will expand the application of gradient index optics (GRIN) by providing compact, lightweight, and cost-effective lenses with controlled dispersion and aberrations that will replace large assemblies of conventional lenses. The ability to create entirely new optical materials and surfaces creates the potential for new or significantly improved military optical applications, such as solar concentrators, portable designators, highly efficient fiber optics, and imaging systems. A key component of the program is to develop new design tools that enable optics designers to incorporate dynamic material properties, fabrication methods, and manufacturing tolerances. The integration of new materials, design tools, and manufacturing processes will enable previously unattainable 3-D optical designs to be manufactured. This new manufacturing paradigm will enable flexible production of GRIN optics in quantities of one to thousands.<br><br>***FY 2012 Plans:***<br>- Develop new materials with variable index of refraction (lens tunability).<br>- Establish GRIN exchange to expand materials development and share design tools.<br>- Improve materials and designs to further reduce size and weight of optical assemblies for solar concentrator and high resolution telephoto lens. | - | - | 9.000 |
| ***Title:*** Propulsion Science<br><br>***Description:*** The introduction of small military platforms such as Unmanned Air Vehicles (UAVs), Unmanned Underwater Vehicles (UUVs), micro/nanosatellites, and robots has placed a new demand on small-scale, high-performance propulsion systems (less than 10 horsepower). Current small military platforms are being powered by scaled-down versions of larger military propulsion systems, which are not optimized for smaller power demands or for significantly different mission requirements. Furthermore, these small platforms have the same limitations as their larger counterparts being dependent on a single energy source (most are fossil fuel based), suboptimal efficiency, large acoustic signature, and reliability problems. The Propulsion Science thrust will develop new small-scale propulsion systems (less than 10 horsepower) with increased fuel efficiency, reduced signature, and capable of running on multiple energy sources that are robust, adaptable, and scalable. Adaptability and scalability will allow for smart propulsion systems than can run on multi-energy sources, adjust their performance based on operational demands, and have the ability to self-diagnose problems before they impact operational readiness. For example, biomimetic | - | - | 10.000 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| propulsion approaches could allow for low-signature, high-efficiency propulsion for both UUVs and UAVs at a reduced size and weight.<br><br>***FY 2012 Plans:***<br>- Design prototype microelectromechanical systems (MEMS) electric propulsion architecture that electrostatically accelerates nanoparticles to produce thrust.<br>- Integrate nanoparticle enabled space propulsion technology and Z-MAN adhesion technologies for operationally relevant space applications such as orbital debris cleanup, and intelligence, surveillance, and reconnaissance (ISR).<br>- Initiate development of propulsion mechanisms using similarities to muscle responses directed towards low-power, self-regulated applications. Actuation methods, control authority, and power will be varied and may include electric, non-organic chemical, organic-chemical, hydraulic, air, or a combination of sources.<br>- Initiate development of potential solution sets and proposed control authority to enable low-power, highly-adaptive propulsion, pumps, and actuation mechanisms which may include self-diagnoses and performance-based feedback.<br>- Perform laboratory-scale testing of static evaporative cooling concepts to validate computational predictions. | | | |
| ***Title:*** Power Components<br><br>***Description:*** This thrust explores and develops novel components for use in diverse power systems that will dramatically increase overall energy efficiency, typically with a substantial savings of weight/volume as well as cost. Included in this thrust are high energy density capacitors as well as new permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors and generators. Radically new thermoelectric architectures that allow for high efficiency in converting heat to electricity will be developed. Hybrid superconducting/cryogenic components will provide a new paradigm for power electronics for the "all electric" platforms of the future. Novel energy systems focused on immediate DoD needs such as long endurance small unmanned aerial systems, and far future technologies to exceed the efficiency limits imposed by combustion of hydrocarbons will be developed. Materials technology is also being developed to enhance power conditioning for large power applications such as Navy ships. Promising technologies within this thrust will fall under Tactical and Strategic Energy (Project MBT-03) in FY 2012.<br><br>***FY 2010 Accomplishments:***<br>- Integrated nanostructured thermoelectric materials into effective structures for highly efficient devices for military use.<br>- Continued improving nanostructured magnetic materials with high energy product for integration into military motors.<br>- Integrated nanostructured electrochemical materials with high energy and power densities into prototype test batteries for use in the battlefield. | 13.576 | 20.807 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY* | **PROJECT**<br>MBT-01: *MATERIALS PROCESSING TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated lab-scale capacitor with ten times better energy density than currently available and very small energy losses for military operations.<br>- Demonstrated nanogap thermo-tunneling device with an efficiency greater than 8 percent at a temperature difference of 200 degrees Celsius.<br>- Initiated design and fabrication of ruggedized fuel cell for a long-endurance small unmanned aerial system (SUAS).<br>- Initiated modification of fuselage and flight controls of SUAS platform for long endurance capability.<br><br>***FY 2011 Plans:***<br>- Demonstrate new nanocomposite magnetic materials with increased energy products for use in motors to better power both air and ground military vehicles.<br>- Demonstrate innovative thermoelectric nanomaterials with improved power conversion efficiency to enable on-board powering of auxiliary electronics for aircraft and unmanned vehicles.<br>- Improve processing methods for nanocomposite thermoelectric and magnetic materials to enhance power generation and motor efficiency.<br>- Create new capacitors with sensing capabilities and fault tolerances to provide reliable high-power capacitors with four times the energy density than currently available in pulse power weapon military application systems.<br>- Begin to transition high energy dense capacitor technology to Air Force for improved weapons capabilities and Army for advanced vehicle armor.<br>- Demonstrate nanogap thermo-tunneling device with efficiency greater than 16 percent at a temperature difference of 350 degrees Celsius.<br>- Complete flight tests of fuel-cell-enabled, long-endurance small unmanned aerial system (SUAS)-including multiple flights and landings on a single system-as threshold for transition to user community.<br>- Demonstrate commercially viable packaging of one cubic millimeter Li-ion battery and transition one cubic millimeter battery to user community.<br>- Demonstrate viability of novel energy storage systems and select most promising technologies for increasing energy storage capacity of DoD BA-5590 battery pack form factor.<br>- Investigate new approaches for electrochemical conversion of stored energy in carbon-based fuels to exceed the efficiency limits imposed by combustion. | | | |
| ***Title:*** Very High Efficiency Solar Cell (VHESC)<br><br>***Description:*** The Very High Efficiency Solar Cell (VHESC) program seeks to raise the system power efficiency of a new class of solar modules to forty percent and deliver engineering prototype modules that are producible. The modules use a novel optical system that splits light from the Sun into at least two different paths corresponding to the color of the light, and concentrates the | 4.755 | 2.000 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| light onto photovoltaic (PV) cells that cover different segments of the solar spectrum. System power efficiency includes all factors that impact the system (module) power efficiency, such as the transmission of light through the optics as well as the individual efficiencies of the PV cells. Analysis predicts that fifty percent efficiency at the PV cell level yields a system power efficiency of at least forty percent. DARPA is developing the VHESC solar module technology for compact renewable energy to power both permanent and mobile bases, as well as reducing the considerable logistical burden of supplying energy (e.g., batteries and fuel) to the warfighter in the field.<br><br>The program addresses all aspects of the high-efficiency photovoltaic problem including the development and analysis of high efficiency design concepts, the development of new and innovative components, materials, and processes necessary to achieve these concepts, and the development of scalable fabrication processes that are extensible to industrial manufacturing of an affordable product. Breakthrough results achieved in previous program phases including lateral architectures and non-imaging optical systems, high performance multi-band PV conversion, and ultra-low-cost PV materials fabrication processes have strongly narrowed the focus of the effort going forward. VHESC development is addressing: 1) system-integrated design optimization of the lateral optics subsystem and corresponding PV devices, and 2) development of high-volume cost-effective manufacturing engineering designs and processes for transition to affordable production.<br><br>***FY 2010 Accomplishments:***<br>- Delivered an initial integrated prototype.<br>- Conducted demonstration necessary for the effective implementation of the VHESC technology to an affordable product.<br><br>***FY 2011 Plans:***<br>- Investigate effects on PV materials in high altitudes and high solar concentration environments.<br>- Evaluate further development and improvements in solar cell technology for future DoD applications. | | | |
| ***Title:*** Biofuels<br><br>***Description:*** The Biofuels program is exploring longer term, higher risk approaches to obtaining and using energy. A pathway to affordable self-sustainable agriculture-sourced production of an alternative to petroleum-derived JP-8, that meets all DoD needs, will be investigated. Initial efforts are focused on the conversion of crop oil triglycerides to JP-8. Additional efforts will expand the spectrum of convertible feedstocks to cellulosic, algal, and other similar materials, enabling a diversified feedstock portfolio that can meet the entire DoD need within a sustainable commercial framework. An important variant of this latter category is the development of man- and vehicle-portable technologies that produce substantial quantities of JP-8 and other useful liquid fuels from indigenously available or harvestable resources near desired locations worldwide.<br><br>***FY 2010 Accomplishments:*** | 25.441 | 32.543 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Developed a qualification plan that specifies the path to support full DoD qualification of the developed BioFuel as an acceptable alternative to JP-8.<br>- Developed a commercialization plan incorporating sensitivity to geographic and economic conditions that serves to assist in transition of technology to the commercial sector.<br>- Developed and demonstrated technology to enable low-cost triglyceride oil from algae with a competitive projected cost of production of JP-8 at initial commercial scale implementation (50Mgal/yr).<br>- Demonstrated technology for efficient conversion of various cellulosic materials to JP-8.<br>- Performed fleet-test of Biodiesel 25 with twenty-five percent hydrocarbon base to demonstrate possibilities of 100 percent biological jet fuel with hydrocarbon base.<br>- Designed business models to analyze costs of biofuel production incorporating combinations of feedstock, geographic, and economic characteristics.<br><br>***FY 2011 Plans:***<br>- Demonstrate system scale-up and validate cost goal.<br>- Demonstrate technology to enable very low cost triglyceride oil from algae with competitive projected costs of production of JP-8 at initial commercial scale implementation (50Mgal/yr).<br>- Demonstrate technologies to enable increasing conversion efficiency of cellulosic materials with competitive projected costs of production of JP-8 at initial commercial scale implementation (50Mgal/yr).<br>- Evaluate sensitivity of biofuel cost of production in multiple locations by developing business models that take advantage of the economies of scale and shows that the technology will meet or exceed the cost goals for oil and JP-8 when extrapolated to a production scale (less than or equal to 50Mgal/yr).<br>- Establish commercialization path to include production, co-product application, and transition to industry and DoD. | | | |
| ***Title:*** Novel Power Sources<br><br>***Description:*** The Novel Power Sources thrust explored new materials solutions that enable power to be efficiently generated and controlled. The primary focus was new catalytic materials and processes for alternative energy sources that are compatible with military logistic fuels. These include catalysts that affect JP-8, sunlight, and cellulose biomass.<br><br>***FY 2010 Accomplishments:***<br>- Identified and characterized new catalysts for highly efficient alternative energy systems including fuel cells, biomass conversion systems, and solar fuel systems.<br>- Continued catalyst development and showed initial success using sunlight for reducing carbon dioxide and water into syngas (carbon monoxide and hydrogen). | 3.692 | - | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Demonstrated the ability to use JP-8 jet fuel as a source to generate electricity in fuel cells through the use of new catalysts and new fuel cell architectures.<br>- Continued catalyst development and demonstrated a 60 percent carbon yield for converting cellulosic biomass into synthetic fuel components with eight carbons or more. | | | |
| **Accomplishments/Planned Programs Subtotals** | 140.848 | 184.614 | 104.538 |

| | **FY 2010** | **FY 2011** |
|---|---|---|
| ***Congressional Add:*** Strategic Materials<br>***FY 2010 Accomplishments:*** - Developed a state-of-the-art production process for silicon carbide parts for satellite, high-energy laser, and nuclear applications.<br>- Produced a laser mirror that has very low distortion characteristics to enable precision navigation devices.<br>- Identified transition opportunities with the Missile Defense Agency. | 5.000 | - |
| ***Congressional Add:*** Photovoltaic Ribbon Solar Cell Technology Project<br>***FY 2010 Accomplishments:*** - Conducted research into photovoltaic ribbon solar cell technology. | 2.880 | - |
| **Congressional Adds Subtotals** | 7.880 | - |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES* | 107.079 | 127.972 | 35.499 | - | 35.499 | 46.023 | 40.534 | 58.122 | 62.849 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Bioinspired Robotics and Mechanics*<br><br>***Description:*** *Formerly BioRobotics and BioMechanics.<br><br>The Bioinspired Robotics and Mechanics thrust explored approaches to capture biological systems' ability to move and sense, and emulate them in man-made robotic or sensor systems. The effort included providing robotics with the mobility required to provide support to soldiers in all terrains, including climbing, through a significantly improved scientific framework for understanding robot mobility and manipulation in natural environments and demonstration of proof of concept technologies. The framework includes better design tools, fabrication methods, and control algorithms.<br><br>***FY 2010 Accomplishments:***<br>- Initiated proof of concept studies on improving the mobility of the Packbot, Talon, and RHex.<br>- Initiated proof of concept study on a high speed legged platform. | 1.618 | - | - |
| ***Title:*** Maintaining Combat Performance - Medical<br><br>***Description:*** The Maintaining Combat Performance thrust utilizes breakthroughs in biology and physiology to sustain the peak physical and cognitive performance of warfighters operating in extreme conditions. Today, warfighters must accomplish their missions despite extraordinary physiologic stress. Examples of these stressors include temperature extremes (-20 degrees F to 125 degrees F), oxygen deficiency in mountains, personal loads in excess of 100 lbs, dehydration, psychological stress, | 6.144 | 15.000 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| and even performance of life-sustaining maneuvers following combat injury. Not only must troops maintain optimum physical performance, but also peak cognitive performance, which includes the entire spectrum from personal navigation and target recognition, to complex command and control decisions, and intelligence synthesis. The Maintaining Combat Performance thrust leverages breakthroughs in diverse scientific fields in order to mitigate the effects of harsh combat environments. For example, understanding the natural mechanisms for core body temperature regulation in hibernating mammals has led to a novel, practical approach for soldier cooling, which is now being evaluated by the Services. Other examples include fundamental research elucidating the biological mechanisms of adaptation to extreme altitude, the molecular correlates of muscle fatigue and psychological stress and pre-symptomatic biomarkers of infection, performance degradation and stress.<br><br>***FY 2010 Accomplishments:***<br>- Investigated mechanisms to speed natural acclimatization at high altitudes.<br>- Developed strategies based on identified mechanisms to accelerate natural altitude acclimatization from 4 weeks to 48 hrs.<br>- Determined pharmacological markers to alleviate high altitude illness.<br>- Developed algorithm to rank therapeutics based on: (1) expected / measured efficacy within a category, (2) favorable duration of activity (must match mission length), and (3) toxicity data or Food and Drug Administration (FDA) safety record and select the five top compounds in each category.<br>***FY 2011 Plans:***<br>- Determine range of effective dose for each compound to use as basis for dosing in combinational drug model.<br>- Develop field-deployable therapeutic that includes minimal training requirements and minimal demands on supporting infrastructure for optimal battlefield use.<br>- Analyze efficiency, toxicity, and pharmacokinetic information from in vivo swine testing.<br>- Prepare Investigational New Drug (IND) application for use in an FDA Phase I clinical trial.<br>- Enroll a limited FDA Phase I clinical trial for pharmacokinetics, surrogate-efficiency markers, and tolerance in healthy adults ages 18-24 (n=20 minimum) to determine drug safety. | | | |
| ***Title:*** Cognitive Technology Threat Warning System (CT2WS)<br><br>***Description:*** Recent advances in computational and neural sciences indicate it is possible to push the visual threat detection envelope to enable more response choices for our soldiers than ever before. The objective of the Cognitive Technology Threat Warning System (CT2WS) program is to drive a breakthrough in soldier-portable visual threat warning devices by leveraging discoveries in the disparate technology areas of flat-field, wide-angle optics, large pixel-count digital imagers, visual processing pathways, neurally based target detection signatures and ultra-low power analog-digital hybrid signal processing electronics. This program will lead to the development of prototype soldier-portable digital imaging threat queuing systems capable of effective | 9.811 | 12.000 | 1.750 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| detection ranges of 1-10 km against dismounts and vehicles. Simultaneously, the system will survey a 120-degree or greater field of view, enabling the warfighter to detect, decide and act on the most advantageous timeline in complex operational environments.<br><br>***FY 2010 Accomplishments:***<br>- Developed integrated brassboard designs consistent with desired threat cueing performance.<br>- Increased field of view to 120 degrees by 20 degrees while maintaining size, weight and power constraints.<br>- Demonstrated visual/cognitive algorithm performance for threat detection on operationally significant image streams with probability of detection (greater than .98) and false alarm rates (less than ten) in less than thirty seconds of scan time.<br>- Completed critical design review of bench-integrated prototype system evaluations that demonstrate the capability of the design to meet the objective system program performance.<br>- Evaluated device packaging approaches with the knowledge of ruggedization and robustness required for soldier-portable tactical electronic devices.<br>- Completed final optimization of the brassboard components and subsystems.<br><br>***FY 2011 Plans:***<br>- Conduct mid-phase Test Readiness Review (TRR) to validate both the maintenance of the performance efficacy previously demonstrated and suitable device ruggedization to support extended field testing.<br>- Conduct extended field testing over a six-month period. The in-the-field performance of the devices shall be analyzed for efficacy and potential improvements.<br>- Integrate and package three or more fully functional prototype systems for subsequent extended field testing in a range of real environments including desert and tropical conditions.<br>- Improve operator interface design to allow operator to monitor and enhance real-time detection and classification performance.<br>- Initiate a Memorandum of Agreement with Service transition partner(s) for test and evaluation.<br><br>***FY 2012 Plans:***<br>- Perform extended field testing and evaluation in a range of real environments. | | | |
| ***Title:*** Neovision2<br><br>***Description:*** Biological vision systems have the exquisite ability to recognize, categorize, and learn new objects in fractions of a second. While animals and humans accomplish this seemingly effortlessly and constantly, computational vision systems have, to date, been unable to replicate this feat of biology. The Neovision2 program is pursuing an integrated approach to developing an advanced object recognition capability based on the visual pathways in the mammalian brain. Specifically, this program will develop a cognitive sensor technology with limited size, weight, and power that transforms data from an imaging sensor suite into communicable knowledge for mobile, autonomous surveillance systems. To achieve the vision, the program will utilize advanced | 15.620 | 11.524 | 1.461 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| device design, signal processing and mathematical techniques across multiple brain regions to revolutionize the field and create an electronic neuro-biological (neuromorphic) vision system.<br><br>***FY 2010 Accomplishments:***<br>- Began design of next generation neuromorphic vision system capable of emulating entire mammalian visual pathway, through object recognition.<br>- Began fabrication of breadboard neuromorphic object recognition system(s) with enhanced visual function capabilities beyond state of the art.<br>- Began testing of new neuromorphic object recognition system(s) against desired visual pathway performance.<br>- Began evaluation of device packaging approaches with the knowledge of ruggedization and robustness required for robotic and airborne unmanned systems.<br>- Combined existing neomorphic models in an integrated system.<br>- Developed and coded a standardized neomorphic software building block system that will support implementation of an advanced neomorphic system in commercial off-the-shelf hardware.<br>***FY 2011 Plans:***<br>- Complete design of next generation neuromorphic vision system capable of emulating entire mammalian visual pathway, through object recognition.<br>- Complete fabrication of breadboard neuromorphic object recognition system(s) with enhanced visual function capabilities beyond state of the art.<br>- Complete testing of new neuromorphic object recognition system(s) against desired visual pathway performance.<br>- Complete evaluation of device packaging approaches with the knowledge of ruggedization and robustness required for robotic and airborne unmanned systems.<br>- Begin development of brassboard neuromorphic vision system(s) inclusive of retinal input to subsequent output.<br>- Begin fabrication of brassboard neuromorphic object recognition system(s) with size, weight, and power cognizant of constraints for unmanned systems.<br>- Demonstrate saccade, foveation, and object recognition with visual inputs, neuromorphic processing, and outputs.<br>- Begin extensive testing for object recognition performance; evaluate as compared to standard target recognition systems currently in use.<br>***FY 2012 Plans:***<br>- Complete fabrication and testing of breadboard neuromorphic object recognition system(s) with enhanced visual function capabilities beyond state of the art non-neuromorphic systems. | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Complete development of brassboard neuromorphic vision systems(s) inclusive of retinal input to subsequent output. | | | |
| ***Title:*** Tactical Biomedical Technologies - Medical<br><br>***Description:*** The Tactical Biomedical Technologies thrust will develop new approaches to deliver life-saving medical care on the battlefield, as well as novel technologies for reconstruction and rehabilitation of severely injured warfighters. Implicit in this thrust is the fact that there are unique, warfighter-specific challenges in acute and chronic treatment that are not addressed by civilian research and development. Today, more than half of American battlefield fatalities are due to hemorrhage, particularly due to improvised explosive devices (IEDs). To prevent these deaths, there is an urgent need for technologies that enable relatively unskilled personnel (battlefield medics) to diagnose and treat injuries, including the ability to locate and coagulate non-compressible deep bleeders in the thorax or abdomen. 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, such as an active battlefield. 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. The results of this program will greatly enhance our ability to save lives on the battlefield and provide restoration of normal function to survivors. This effort continues in FY 2012 in PE 0602115E, Project BT-01.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated that bone elongation following injury in a neonatal mouse model is achieved through the proper timing, concentration, and placement of bone morphogenic protein 2 (BMP-2) at the injury site.<br>- Demonstrated regeneration of complex tissue structures in a neonatal mouse model treated with a synthetic BMP-2 agonist at an injury site.<br>- Initiated selection and screening of candidate hemostatic agents.<br>- Initiated selection and screening of wound-specific targets and target homing agents.<br>- Demonstrated in vivo efficacy of feedback component of the drug delivery system.<br>- Optimized automated algorithms for bleeder detection, localization, coagulation, and cuff control in in vivo and in vitro models.<br><br>***FY 2011 Plans:***<br>- Develop a material that can be delivered to a closed, intracavity space and binds specifically to damaged tissue as demonstrated in situ by immunohistology.<br>- Identify signaling pathways that are critical to joint formation in an adult animal and explore the timing of manipulation for restoration of functional multi-tissue type structures following injury.<br>- Demonstrate that hemostatic material does not induce intracavity scar formation within 28 days when left at the wound site.<br>- Demonstrate hemostasis in less than four minutes on a high-pressure non-compressible injury model. | 12.816 | 12.600 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Maintain hemostasis in high pressure model for three hours.<br>- Demonstrate capability to manufacture a set of commonly-used organic pharmaceuticals in a small form-factor device while maintaining comparable mass efficiency to shelf-stable products.<br>- Investigate potential for chemical modification of pharmaceuticals and therapeutics in order to stabilize compounds that are otherwise unstable at room temperature. | | | |
| ***Title:*** Neuroscience Technologies<br><br>***Description:*** The Neuroscience Technologies thrust leverages recent advances in neurophysiology, neuro-imaging, cognitive science and molecular biology to sustain and protect the cognitive functioning of the warfighter faced with challenging operational conditions. Warfighters experience a wide variety of operational stressors, both mental and physical, that degrade critical cognitive functions such as memory, learning, and decision making. These stressors also degrade the war fighter's ability to multitask, leading to decreased ability to respond quickly and effectively. Currently, the long-term impact of these stressors on the brain is unknown, both at the molecular and behavioral level. This thrust area will utilize modern neuroscientific techniques, in conjunction with emerging solutions in neurally enabled human-machine interface technologies, to develop quantitative models of this impact and explore mechanisms to protect, maintain, complement, or restore cognitive functioning during and after exposure to operational stressors. In addition, new approaches for using neural signals to make human-machine systems more time efficient and less workload intense will be identified, developed, and evaluated. This project will also investigate the integration of recently-characterized properties of human brain function and real-time signal processing to enable rapid triage of target-containing imagery. This thrust area will have far-reaching implications for both current and future military operations, with the potential to protect cognitive performance at the individual and group level both prior to and during deployment.<br><br>***FY 2010 Accomplishments:***<br>- Leveraged recent advances in molecular neurobiology, neuro-imaging and molecular pathway modeling to understand animal models of acute and chronic stress.<br>- Began to identify and characterize the genetic and molecular targets behind the adaptive vs. dysfunctional response to stress, exploring a minimum of four stressors (e.g., cognitive, physical, social sleep deprivation, illness, etc).<br>- Identified multiple electroencephalography (EEG)-based predictors of expertise and skill acquisition in individuals training for rifle marksmanship.<br>- Identified EEG-based synchronization patterns of mental workload and engagement associated with collaborative teamwork in a submarine control room simulation environment.<br>- Developed brain imaging technology improvements capable of mapping 250k+ source to destination fibers in the brain allowing for physiological measurement of cortical network growth through learning. | 13.473 | 14.272 | 14.493 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated significant increase in imagery throughput and analytic product generation on specific operational tasks in the authentic imagery analysis environment.<br>- Developed prototype systems that utilize neural signatures to speed analysis and improve quality and accuracy of imagery exploitation.<br><br>***FY 2011 Plans:***<br>- Prepare and integrate brain imaging, cognitive monitoring and stimulation technologies for optimization of individual and group learning in existing military training paradigms.<br>- Establish a fast, functionally relevant, brain-based measurement of the current state of the stress response system that captures the basic features of physiological responses associated with changes in acute and chronic stress state.<br>- Utilize predictive modeling to determine which genetic and molecular targets are optimal for adaptive versus dysfunctional responses to stress.<br>- Establish an in vivo anatomical and molecular pathway that causes stress related dysfunction in an animal model and identify targets for modulation.<br>- Demonstrate that modulation of the identified and validated targets/pathways improves stress-induced cognitive dysfunction in a minimum of 75 percent of animals as measured by molecular markers and resulting behavior.<br>- Design pharmacological, behavioral or other interventions for prevention of stress-induced cognitive dysfunction based on observations.<br>- Validate and improve optogenetic techniques as they apply to animal models of chronic stress.<br><br>***FY 2012 Plans:***<br>- Identify genes and gene networks that are linked to specific stressors and stress response systems through the use of integrated genetics involving quantitative model building, bioinformatics, and computational biology approaches.<br>- Continue modeling and verification of causal factors and relationships between variables in the complex systems and networks involved in the response to stress and the ability to resist stress.<br>- Validate genes and pathways mediating acute and chronic stress-induced dysfunction in circuits for reward, fear and habit learning.<br>- Develop and implement interventions for prevention of stress-induced cognitive dysfunction in animal models of acute and chronic stress.<br>- Determine the effects of prophylactic treatments for the prevention of stress-induced decrements in the brain and on behavior in animal models.<br>- Identify multiple permutations of successful unit dynamics given particular environment/resource/capabilities profiles and explore the differences and similarities among the various dynamical states of unit performance. | | | |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Survey global successful military (and some non-military) units cataloging the nature of their successes under the rubric of the triad of threat (challenge), resources, and organic capabilities.<br>- Begin developing dynamical mathematical models of robust systems built upon known characteristics seen in biology (e.g., human-to-human, human within complex hierarchical and non-hierarchical systems) using advanced computer applications. | | | |
| ***Title:*** Military Medical Imaging - Medical<br><br>***Description:*** The Military Medical Imaging thrust will develop medical imaging capabilities to support military missions and operations. Examples include novel technologies to miniaturize and enhance the capabilities and speed of computerized axial tomography (CAT) scanners and to develop non-invasive imaging modalities for use by medics. The emergence of advanced medical imaging includes newly recognized physical properties of biological tissue, or metabolic pathway, or physiological function in order to map it into an image of diagnostic utility and performance. This need is ever increasing as researchers and scientists seek to better understand anatomical, functional and cellular level interactions. This thrust will also address how to improve the delivery of medical care and medical personnel protection by building a simulated environment for rapid after-action review of field events generated from current military systems. The advanced development of these tools will provide a formidable arsenal of diagnostic tools for warfighter performance and care. This effort continues in FY 2012 in PE 0602115E, Project BT-01.<br><br>***FY 2010 Accomplishments:***<br>- Incorporated rapid mission rehearsal thrust technologies with computer-aided forensic methods into after-action review to aid in reconstructing incidents from existing data.<br>- Utilized reconstructed scenarios for assessment of "lessons learned" and to gain immediate and relevant tactical battlefield knowledge.<br>- Simulated elements of data collected from battlefield through existing RealWorld simulation platform to investigate how this software's unique capabilities can be fully exploited for an after-action simulated environment.<br><br>***FY 2011 Plans:***<br>- Demonstrate that an incident can be fully reverted to initial conditions using only injury and vehicle data.<br>- Attempt to determine directionality, cause, and type of non-lethal injuries to individuals and insults to vehicles from in-theater data, improving responsiveness to threats on the battlefield as new threats emerge.<br>- Demonstrate geographic tracking of disparate events in physical and temporal space.<br>- Integrate all databases with data fusion engine appended onto RealWorld simulation platform.<br>- Focus X-rays with orbital angular momentum through a model of skin and bone.<br>- Develop X-ray optics for scanning. | 8.000 | 9.175 | - |
| ***Title:*** Revolutionizing Prosthetics - Medical | 15.000 | 10.000 | 7.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY* | **PROJECT**<br>MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The goal of this thrust is to radically improve the state of the art for upper limb prosthetics, moving them from crude devices with minimal capabilities to fully integrated and functional limb replacements. Current prosthetic technology generally provides only gross motor functions, with very crude approaches to control. This makes it difficult for wounded soldiers to re-acquire full functionality and return to military service if so desired. The advances required to provide fully functional limb replacements will be achieved by an aggressive, milestone driven program combining the talents of scientists from diverse areas including: medicine, neuroscience, orthopedics, engineering, materials science, control and information theory, mathematics, power, manufacturing, rehabilitation, psychology and training. The results of this program will radically improve the ability of combat amputees to return to normal function.<br><br>***FY 2010 Accomplishments:***<br>- Developed clinical protocol for testing of four-year prosthetic devices at military medical centers.<br>- Initiated manufacture plan consistent with Good Manufacturing Practices (GMP).<br>- Completed clinical and take-home trials supporting Food and Drug Administration (FDA) submission criteria.<br>- Supported experiments to determine potential level of direct neural control for upper-extremity prosthetic.<br>- Finalized mechanical arm design and ensured readiness for wide-scale manufacture and production.<br><br>***FY 2011 Plans:***<br>- Complete qualification testing and demonstrations of central and peripheral multimodal neural interfaces suitable for submission to FDA.<br>- Continue trials to determine level of sensory stimulation that can be delivered to patients through neural interface.<br>- Design and fabricate new neural interfaces to enable complex stimulation and control.<br>- Ensure that mechanical arm capabilities meet and exceed patient expectations.<br><br>***FY 2012 Plans:***<br>- Complete demonstration of neural control of arms in multiple patients.<br>- Demonstrate safety and stability of neural interfaces over multiple month periods.<br>- Finalize and submit complete FDA package to obtain approval for commercial production of arms and sockets.<br>- Support transition efforts of final limb, components, and refinements required by the FDA. | | | |
| ***Title:*** Blood Pharming - Medical<br><br>***Description:*** The Blood Pharming program objective is to develop an automated culture and packaging system that yields transfusable levels of universal donor red blood cells (RBCs) from progenitor cell sources. The goal is to produce 100 units of universal donor (Type O negative) RBCs per week for eight weeks in an automated closed culture system using a renewing progenitor population, and to demonstrate a two hundred million-fold expansion of progenitor cell populations to mature RBCs. | 11.379 | 5.669 | 4.295 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| The program will capitalize advances in cell differentiation, expansion, and bioreactor technology developed early in the program. Successful completion of the Blood Pharming effort will provide a safe donorless blood supply that is the functional equivalent of fresh donor cells, satisfying a large battlefield demand and reducing the logistical burden of donated blood in theater.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated continuous production of universal donor RBCs for 5 cycles in both a 2mL and 8mL bioreactor batch production system using a non-renewing progenitor cell population.<br>- Developed a strategy for cost-effective continuous production of RBCs at larger scales.<br>- Demonstrated a 12 million-fold expansion from progenitor source to mature RBCs.<br>- Demonstrated magnetic isolation of mature enucleated RBCs at a rate greater than one million cells per second.<br>***FY 2011 Plans:***<br>- Demonstrate a 2-fold increase in cell density in the bioreactor perfusion system.<br>- Increase magnetic sorting rate efficiency to match bioreactor output.<br>- Increase the output of mature red blood cells coming out of the bioreactor.<br>***FY 2012 Plans:***<br>- Demonstrate continuous production of universal donor RBCs in a large scale bioreactor perfusion system.<br>- Demonstrate a multi-fold reduction in cost per unit of RBCs. | | | |
| ***Title:*** Reliable Neural-Interface Technology (RE-NET) - Medical<br><br>***Description:*** The goal of the Reliable Neural-Interface Technology (RE-NET) program is to develop technology needed to reliably extract information from the nervous system, and to do so at a scale and rate necessary to control many degree-of-freedom (DOF) machines, such as high-performance prosthetic limbs. This program will complement ongoing DARPA neural prosthetic activities funded through other DARPA programs. These activities study cognition and the mechanisms of higher brain function, as well as upper-limb prostheses and motor-decoding algorithms. RE-NET will develop the neural interface technologies to allow the best robotic prosthetic-limb technology, recently developed by DARPA, to be reliably used throughout the life of wounded warriors that have one or more amputated limbs. This effort continues in FY 2012 in PE 0602115E, Project BT-01.<br><br>***FY 2010 Accomplishments:***<br>- Developed plans to obtain statistically validated models of electrode channel loss as well as improved historical methods to gain more information about tissue response and channel failure.<br>- Formulated plans to achieve far shorter interface development and evaluation cycles through the use of new methods of predicting long-term interface failure and accelerating long-term interface failure. | 6.000 | 20.000 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Established relationship with the Food and Drug Administration (FDA), which will perform independent verification and testing of new neural-interface development and assessment technologies.<br><br>***FY 2011 Plans:***<br>- Obtain statistically validated models of tissue foreign-body response (FBR) and electrode channel loss for both central nervous System (CNS) and peripheral nervous system (PNS) interfaces using existing and new historical methods.<br>- Demonstrate new methods of predicting long-term interface failure and accelerating long-term interface failure.<br>- Develop advanced PNS interface technology to increase the channel count and hence neural information content, while not compromising their existing long-term reliability capability. | | | |
| ***Title:*** BioDesign<br><br>***Description:*** BioDesign is a new intellectual approach to biological functionality. The intrinsic concept is that by using gained knowledge of biological processes in combination with biotechnology and synthetic chemical technology, humans can employ system engineering methods to originate novel beneficial processes. BioDesign eliminates the randomness of natural evolutionary advancement primarily by advanced genetic engineering and molecular biology technologies to produce the intended biological effect. This thrust area includes designed molecular responses that increase resistance to cellular death signals and improved computational methods for prediction of function based solely on sequence and structure of proteins produced by synthetic biological systems. Development of technologies to genetically tag and/or lock synthesized molecules would provide methods for prevention of manipulation ("tamper proof" synthetic biological).<br><br>***FY 2011 Plans:***<br>- Identify mechanisms to protect unauthorized use of research virus.<br>- Develop genetically encoded ID tag.<br><br>***FY 2012 Plans:***<br>- Develop genetically encoded locks to create "tamper proof" DNA.<br>- Develop strategies to create a synthetic organism "self-destruct" option to be implemented upon nefarious removal of organism.<br>- Permanently append a synthetic organism's genome and prevent foul play by tracking organism use and history, similar to a traceable serial number. | - | 3.000 | 6.500 |
| ***Title:*** Pathogen Defeat - Medical<br><br>***Description:*** Pathogens are well known for the high rate of mutation that enables them to escape drug therapies and primary or secondary immune responses. The Pathogen Defeat thrust area will provide revolutionary capabilities to predict future threats and to deflect pathogen evolution to non-human spaces such as animals, insects, and bacteria. This area will also determine | - | 12.000 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| malicious intent by monitoring key technology acquisitions and commercialization of potential dual-use technologies. Pathogen Defeat focuses not on the threats that are already known but rather on the threats of newly emerging agents and mutations in the future, allowing pre-emptive preparation of vaccine and therapy countermeasures. This program continues in FY 2012 in PE 0602115E, Project BT-01.<br><br>***FY 2011 Plans:***<br>- Develop an iterative system that accurately predicts viral evolution.<br>- Strategize methods to induce and monitor evolutionary change through the application of individual selective pressures (variable growth conditions, host switching, resistance to host cell antiviral strategies such as interferons, etc).<br>- Demonstrate the effect of a vaccine at directing the outcome of viral evolution.<br>- Develop in vivo and in vitro evolution platforms for generating datasets used to build and validate algorithms predictive of viral evolution.<br>- Initiate concept test for predictive algorithm, biological validation system, and metrics demonstrating successful prediction of evolution.<br>- Enhance or develop a complex predictive algorithm and biological validation system that utilizes multiple selective pressures. | | | |
| ***Title:*** Bioinspired Sensors<br><br>***Description:*** The Bioinspired Sensors thrust explores the application of biomimetic principles to materials and devices of interest to the DoD. Specifically, the unique characteristics of biologically derived material and devices will be exploited through understanding, control and emulation of the structure and chemistry of the interface between man-made and biotic materials. This includes an effort to understand the mammalian olfactory system and develop a system that performs equal to or better than a canine in distance and level of chemical detection. Biological hearing systems also provide localization accuracy much better than predicted by simple array theory. Development of implantable optical neural interface devices will enable "repair" of disrupted neural pathways due to catastrophic spinal or nerve damage.<br><br>***FY 2010 Accomplishments:***<br>- Developed breadboard olfactory system(s) accurately mimicking odorant intake and distribution of odorants to detection system.<br>- Identified properties of odorant binding proteins challenging inconsistent output of detection systems.<br><br>***FY 2011 Plans:***<br>- Design modifications in odorant binding proteins to increase stability and reduce variability.<br>- Demonstrate capacity to recognize odorants using stabilized binding proteins.<br>- Develop system with stabilized odorant binding proteins.<br>- Demonstrate detection and identification of odorants at a probability of detection greater than or equal to ninety percent. | 3.218 | 1.732 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate the system's ability to detect twenty-five individual odorants/chemicals, with a portion contained in a chemical mixture. | | | |
| ***Title:*** Biological Interfaces<br><br>***Description:*** This thrust area explores and develops biological interfaces between biotic and abiotic materials. Examples include infection prevention/sterilization at the interface between skin and a battlefield medical device (such as a central intravenous catheter) as well as enhancing the rehabilitation/recovery effectiveness of interfaces between bone and orthopedic stabilization devices.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated reduction in pathogenic population in in vitro and in vivo studies of plasma discharge sterilization method for multiple micro-organisms.<br><br>***FY 2011 Plans:***<br>- Design fieldable plasma based sterilization device and clinical methodology. | 2.000 | 1.000 | - |
| ***Title:*** Bioderived Materials<br><br>***Description:*** The Bioderived Materials thrust explored the use of biological and bioinspired materials to support diverse Defense missions and/or technologies that enhance the capabilities of U.S. military systems. Areas of interest included designing and developing biomolecular materials that have unique electrical and mechanical properties; new bioinspired processing routes for dynamic self-assembly of complex functional structures, including biomanufacturing; and adapting the ability of biological systems to manipulate light and texture.<br><br>***FY 2010 Accomplishments:***<br>- Investigated the existence of novel biomaterials that may be used as model systems to develop high performance sensors and devices with new and unique capabilities.<br>- Studied structures found in biological systems that could enable new multifunctional materials. | 2.000 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 107.079 | 127.972 | 35.499 |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

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**E. Performance Metrics**

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MBT-03: *TACTICAL AND STRATEGIC ENERGY TECHNOLOGY* | - | - | 97.800 | - | 97.800 | 98.800 | 136.000 | 132.276 | 118.000 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

This project is focused on the unique challenges facing the DoD in developing and demonstrating advanced power generation and energy storage technologies. It will address critical military needs for improved energy efficiency and availability to support a range of military missions that include the individual warfighter and small unit operations, large platform operations, and sustainment of forward operating bases (FOBs). At the individual warfighter and small unit operations level, efforts are addressing the need for mission extending power generation and energy storage technologies with particular emphasis on portability and robustness challenges that are unique to the DoD. At the large platform and forward operations scale, efforts are addressing needs for deployable energy storage and more efficient power generation and distribution technologies. As electronic systems are common to all scales of power generation and energy storage and management, this project also investigates improved board-level power conversion and regulation strategies to more efficiently convert and distribute high voltages to locally required low voltages for powering integrated circuits and sensors.

Included in this project are efforts to improve the utilization of larger generators at FOBs and on large platforms, by improving efficiency and developing multi-fuel capability that will allow for greater use of indigenous sources. Smart energy distribution at the FOB level will allow for more effective energy management, improved overall distribution efficiency, and the effective integration of host country resources. Efforts exploring power generation for FOB operations from ruggedized nuclear-fueled reactors, and ultra-high-efficiency gas turbine engines for power generation on large platforms including Navy cruisers and destroyers, will also be investigated. At the small-scale tactical-level, a new generation of robust fuel cells, batteries, and supercapacitors will be developed to handle the demanding loads found on portable electronics carried by the individual warfighter and many small military platforms. New storage technologies beyond batteries will be explored that are exploiting novel approaches to electrochemical conversion of carbon-based fuels. Also included in this project are scalable power management systems from integrated circuits that exploit novel magnetic materials through large power controls for efficient grid power management and distribution, novel regenerative or electrochemical storage technologies allowing for the recovery of excess energy produced during low peak periods, and environmentally robust energy sources that can meet the energy requirements for military operations in extreme environments.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Energy Distribution<br><br>***Description:*** The current paradigm of distributed generation for meeting the electrical needs of forward operating bases involves deploying numerous tactical generators of varying size and capacity in ways that often do not match capacity with demand. This mismatch between load and capacity reduces overall generator efficiency significantly and results in considerable waste in terms of fuel and logistics support. The Energy Distribution thrust will explore how emerging concepts in smart grid and energy management technologies combined with renewable energy sources, deployable energy storage technologies, and novel | - | - | 10.000 |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| technologies for resource distribution can be developed for use in military forward operations. These efforts will contribute to improved overall energy efficiency and reduced logistics demands associated with fuel transport to forward operating bases. This thrust will investigate technologies that reduce the dependence on traditional fuel sources and delivery methods, and increase fuel-efficiency to provide more flexibility to military assets in the field. Energy management modeling and design will be utilized to assess host-country resources (e.g. heating fuels, locally-grown biomass, unrefined fuels, waste, and other hydrocarbon rich materials), and advanced power generation technologies (e.g. fuel cells, renewable solar, wind, biofuels, etc.).<br><br>***FY 2012 Plans:***<br>- Using data collected from current operations worldwide, construct a baseline modeling tool that depicts how energy is currently generated and distributed in existing military forward operating bases.<br>- Identify emerging smart grid and other energy management tools that may be adapted to a military forward operating environment.<br>- Identify key technology gaps currently precluding the deployment of energy distribution and management systems that can optimally match load with capacity while increasing overall energy efficiency of a forward operating base.<br>- Identify emerging electrochemical and/or electrothermal storage technologies that may facilitate the efficient redistribution of energy resources, including renewable sources such as wind and solar, in a military forward operating environment.<br>- Identify opportunities to leverage host country resources provide feedstocks for on-site generation of fuel and power.<br>- Further develop the energy management modeling tool to incorporate knowledge of indigenous resources, advances in power generation (including renewable - solar, wind, geothermal, etc.), and advances in energy distribution technologies. | | | |
| ***Title:*** Extreme Environment Energy Program (EEE)<br><br>***Description:*** Advanced DoD platforms and missions increasingly demand energy generation, storage, and conversion technologies that can function reliably in extreme environments. Adverse conditions to be managed include, for example, optical and ionizing radiation, extremes of temperature, chemical damage, and harsh mechanical loading. Also of interest are energy generation in anaerobic environments, and the development of materials that enable high temperature power generation processes. In addition, environmentally robust energy sources such as existing primary (disposable) batteries can be improved to considerably improve efficiency and make them adaptable to a wide variety of target systems. Another aspect of this program is to adapt advanced wavelength-splitting photovoltaic cells to high altitude and space environments. The overall focus of this program is on developing technologies that significantly improve robustness and adaptability of energy sources for a variety of mission locations and durations.<br><br>***FY 2012 Plans:*** | - | - | 5.000 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Design components for photovoltaic devices, advanced materials, power converters, and storage devices capable of operating at extreme temperatures and high radiation environments.<br>- Design power system for resistance to UV and chemical damage simultaneously with extreme temperatures.<br>- Design intelligent disposable batteries with internal electronics to adapt them to a wide variety of target systems and to optimally extract energy from the internal storage cells.<br>- Assess the potential to improve power generation in anaerobic environments. | | | |
| ***Title:*** Small Rugged Reactor Technologies<br><br>***Description:*** True self-sufficiency at forward operating bases (FOBs) requires the development of deployable power plant concepts that can operate without need for refueling or logistics resupply. Such a power plant needs to provide base electricity requirements and produce additional electrical, and/or thermal energy, to drive processes for hydrocarbon fuel and potable water production in sufficient quantities to sustain the base. This will significantly reduce the need for delivery of these items via dangerous and difficult routes. The only known technology that has potential to address the power needs of the envisioned self-sufficient FOB is a nuclear-fuel reactor. The need for an integrated, deployable system that produces electricity, fuel, and water presents technical challenges that are unlikely to be addressed by existing commercial or Government funded advanced reactor concept development efforts. For example, integrating hydrocarbon fuel production with electricity production will require either advanced reactor designs that provide thermal energy at the temperatures required for known hydrocarbon production processes, or the development of novel fuel production processes that are compatible with temperatures achievable with existing reactor concepts. The scale of a reactor needed for a FOB (well below the scale of the smallest reactors that are being developed for domestic energy production) poses unique challenges with materials and reactor design. In addition, non-proliferable fuels (i.e., fuels other than enriched uranium or plutonium) and reactor designs that are fundamentally safe will be required of reactors that may be deployed to regions where hostile acts may compromise operations. This will require development of novel fuels and approaches to effectively shut down reactor operations in a way that leaves any remaining fissile material safely contained and useless for weapons applications. The Small Rugged Reactor Technologies thrust will explore these unique challenges while collaborating with DoE to ensure that existing advanced reactor development activities are being exploited and/or accelerated as appropriate, based on the military's needs.<br><br>***FY 2012 Plans:***<br>- Assess and quantify the anticipated total energy, fuel, and water needs of future military FOBs, as they may be deployed in isolated, harsh environments.<br>- Conduct preliminary study of achievable energy density and temperature parameters for existing and emerging reactor technologies.<br>- Identify preliminary, non-proliferable reactor designs that have the potential for being compact, safe, and deployable to FOBs. | - | - | 10.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Identify hydrocarbon fuel production processes that may be compatible in terms of process temperature and energy requirements for integrations with a small deployable reactor.<br>- Identify technology gaps, in terms of materials and fuels, for the development of small reactor technologies that can meet the electricity, fuel, and water production needs of military FOBs. | | | |
| ***Title:*** Tactical Advanced Power (TAP)*<br>***Description:*** *Previously funded under Power Components in project MBT-01<br><br>The Tactical Advanced Power (TAP) program is solving high-risk, mission-critical portable power and energy challenges (approximately 1 kilowatt and below) that are unique to DoD. TAP provides near-term solutions while simultaneously working towards meeting far-term DoD energy needs through an integrated approach that leverages available technologies, further develops existing science, and establishes new methods of energy generation, extraction, conversion, and storage. TAP is deploying fuel cell-enabled small (hand-held) unmanned aerial vehicles for long endurance missions (greater than 5 hours) and micro-batteries (less than one cubic millimeter) for ultra-small sensors. TAP is also developing novel power and energy systems to decrease the dismounted soldier's battery load by up to 50 percent. This program will establish new scientific pathways for the electrochemical conversion of stored energy in carbon-based fuels, which can exceed the efficiency limits imposed by combustion (approximately 40 percent) and approach the electrochemical conversion efficiency limit (approximately 98 percent).<br><br>***FY 2012 Plans:***<br>- Deploy and transition long-endurance small unmanned aerial system (SUAS) to user community.<br>- Demonstrate novel energy storage system(s) with greater than 2X increase in energy density and equal power response over currently deployed DoD BA-5590 battery packs.<br>- Demonstrate integration of new catalyst with conducting surfaces for efficient energy extraction from carbon-based fuels.<br>- Demonstrate pathways to electrochemical conversion of stored energy in carbon-based fuels capable of exceeding the efficiency limits imposed by combustion (approximately 40 percent) and approaching the electrochemical conversion efficiency limit (approximately 98 percent). | - | - | 7.800 |
| ***Title:*** Vulcan<br>***Description:*** Previously funded in PE 0603286E, Project AIR-01, Advanced Aerospace Systems<br><br>The goal of the Vulcan turbine engine demonstration program is to design, build, and ground test a pressure gain combustion (PGC) technology system that demonstrates a 20% reduction in fuel consumption for a power generation turbine system. PGC technology has been under development for more than a decade and considerable progress has been made in key enabling | - | - | 50.000 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| technology areas. The technology is believed mature enough to permit a dramatic new system capability. PGC, when combined with turbine engines, offers the ability to design a new class of hybrid turbine power generation engines and Mach 4+ air breathing engines. The Vulcan system will consist of a full scale PGC, a compressor, and a turbine. The Vulcan program PGC technology would have direct application to ship power generation & propulsion turbine engines, aviation turbine engines, high-mach air breathing engines, as well as commercial turbine engines of the same variety.<br><br>***FY 2012 Plans:***<br>- Continue risk reduction testing and demonstrations of key PGC component technologies and subsystems.<br>- Continue to mature and validate critical PGC enabling technologies and analytical tools.<br>- Final assembly and instrumentation of an integrated PGC module with a turbine test rig.<br>- Conduct a demonstration of full-scale PGC module for a 4-5 MW class turbine engine on a test rig.<br>- Complete preliminary design of a full scale 4-5 MW marine gas turbine engine with an integrated PGC module. | | | |
| ***Title:*** Microscale Power Conversion<br><br>***Description:*** Current DoD electronic systems rely on centralized or board-level power conversion and regulation circuitry to convert from efficiently distributed high voltages to locally required low voltages for powering integrated circuits and sensors. A new approach, and the goal of this work, is to increase the granularity of power management to the module or component level by developing integrated capacitive and inductive energy storage and switching elements. This would provide intelligent and adaptive buck (drop voltage) or boost (raise voltage) power conversion throughout complex systems, increasing reliability and power efficiency, while decreasing size and weight.<br><br>***FY 2012 Plans:***<br>- Develop integrated-circuit-compatible fabrication processes for high-performance and low-loss energy-storage and conversion circuit elements and switches.<br>- Design new chip-scale power-conversion circuits to exploit and drive integrated high-performance energy-storage and conversion circuit elements and switches.<br>- Design integrated passive element and packaging approaches compatible with implementations of chip-scale power conditioning with microwave monolithic integrated circuits.<br>- Develop power amplifier circuit architectures and initial demonstrations for high efficiency applications involving point-of-load integrated power converters. | - | - | 15.000 |
| **Accomplishments/Planned Programs Subtotals** | - | - | 97.800 |

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**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 184.188 | 286.936 | 215.178 | - | 215.178 | 204.416 | 194.518 | 197.900 | 212.900 | Continuing | Continuing |
| ELT-01: *ELECTRONICS TECHNOLOGY* | 184.188 | 286.936 | 215.178 | - | 215.178 | 204.416 | 194.518 | 197.900 | 212.900 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

This program element is budgeted in the Applied Research budget activity because its objective is to develop electronics that make a wide range of military applications possible.

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

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

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

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| **B. Program Change Summary ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012 Base** | **FY 2012 OCO** | **FY 2012 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 179.402 | 286.936 | 348.377 | - | 348.377 |
| Current President's Budget | 184.188 | 286.936 | 215.178 | - | 215.178 |
| Total Adjustments | 4.786 | - | -133.199 | - | -133.199 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | 9.545 | - | | | |
| • SBIR/STTR Transfer | -4.759 | - | | | |
| • TotalOtherAdjustments | - | - | -133.199 | - | -133.199 |

**Congressional Add Details ($ in Millions, and Includes General Reductions)**

| | FY 2010 | FY 2011 |
|---|---|---|
| **Project:** ELT-01: *ELECTRONICS TECHNOLOGY* | | |
| Congressional Add: *3-D Technology for Advanced Sensor Systems* | 2.000 | - |
| Congressional Add Subtotals for Project: ELT-01 | 2.000 | - |
| Congressional Add Totals for all Projects | 2.000 | - |

**Change Summary Explanation**

FY 2010: Increase reflects internal below threshold reprogramming offset by SBIR/STTR transfer.
FY 2012: Decrease reflects repricing of on-going electronics efforts following program aggregations and transition of energy-related electronics to the new tactical and strategic energy project (MBT-03) in PE 0602715E and Defense Efficiencies for contractor staff support.

| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***Title:*** Quantum Information Science (QIS) | 3.416 | 10.641 | 4.700 |
| ***Description:*** The Quantum Information Science (QIS) program will explore all facets of the research necessary to create new technologies based on quantum information science. Research in this area has the ultimate goal of demonstrating the potentially significant advantages of quantum mechanical effects in communication and computing. Expected applications include: new improved forms of highly secure communication; faster algorithms for optimization in logistics and wargaming; highly precise measurements of time and position on the earth and in space; and new image and signal processing methods for target tracking. Technical challenges include: loss of information due to quantum decoherence; limited communication distance due to signal | | | |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| 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.<br><br>***FY 2010 Accomplishments:***<br>- Measured single electron spin lifetime and demonstrated controlled gate operations in gated quantum dots (QD) in silicon (Si).<br>- Conducted theoretical analysis of improvement in decoherence time resulting from dynamical decoupling schemes.<br>- Explored novel materials, noise characteristics and decoherence mitigation strategies for superconducting qubits.<br>***FY 2011 Plans:***<br>- Measure single electron spin decoherence time in gated QD in Si.<br>- Demonstrate entanglement swapping protocol in three QD quantum devices in Si.<br>- Perform state tomography and dispersive readout for one and two superconducting qubits.<br>- Fabricate high quality superconducting tunnel junctions through material improvement.<br>***FY 2012 Plans:***<br>- Demonstrate interconversion of quantum information from one type to another.<br>- Demonstrate transport of quantum information over microscopic scales. | | | |
| ***Title:*** Terahertz Electronics<br><br>***Description:*** Terahertz Electronics will develop the critical semiconductor device and integration technologies necessary to realize compact, high-performance microelectronic devices and circuits that operate at center frequencies exceeding 1 Terahertz (THz). There are numerous benefits to operating in the THz regime and multiple new applications in imaging, radar, communications, and spectroscopy, all enabled by electronics that operate in the THz frequency regime. The Terahertz Electronics program is divided into two major technical activities: Terahertz Transistor Electronics that includes the development and demonstration of materials and processing technologies for transistors and integrated circuits for receivers and exciters that operate at THz frequencies; and Terahertz High Power Amplifier Modules that includes the development and demonstration of device and processing technologies for high power amplification of THz signals in compact modules.<br><br>***FY 2010 Accomplishments:***<br>- Developed devices and circuits for candidate applications with demonstration of operation at a frequency of at least 0.67 THz. | 15.251 | 18.053 | 16.330 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated 14dBm power amplification at 0.67 THz.<br>***FY 2011 Plans:***<br>- Achieve key device and integration technologies to realize compact, high performance electronic circuits operating beyond 0.85 THz.<br>***FY 2012 Plans:***<br>- Achieve key device and integration technologies to realize compact, high performance electronic circuits operating beyond 1.03 THz. | | | |
| ***Title:*** High Frequency Integrated Vacuum Electronic (HiFIVE)<br>***Description:*** The objective of the High Frequency Integrated Vacuum Electronic (HiFIVE) program is to develop and demonstrate new high-performance and low-cost technologies for implementing high-power millimeter-wave sources and components. This program is developing new semiconductor and micro-fabrication technologies to produce vacuum electronic high-power amplifiers for use in high-bandwidth, high-power transmitters. Innovations in design and fabrication are being pursued to enable precision etching, deposition, and pattern transfer techniques to produce resonant cavities, electrodes, and magnetics, and electron emitting cathodes for compact high-performance millimeter wave devices. These new technologies will eliminate the limitations associated with the conventional methods for assembly of high-power sources in this frequency range.<br>***FY 2010 Accomplishments:***<br>- Validated the design of a high-power amplifier through experiments and computational simulation.<br>- Completed development of the high-performance cathode prototype and demonstrated its ability to operate without degradation for at least 1,000 hours.<br>***FY 2011 Plans:***<br>- Complete advanced cathode development activities.<br>- Complete fabrication and initial testing of a high-power amplifier prototype device incorporating HiFIVE micro-fabrication technologies into a compact module form factor.<br>- Initiate efforts to perform laboratory measurements of performance.<br>***FY 2012 Plans:***<br>- Demonstrate integrated and compact amplifier technology at G-band in a tube form factor.<br>- Complete laboratory measurements of performance of miniaturized tube amplifier at 220GHz. | 11.080 | 11.500 | 3.540 |
| ***Title:*** Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) | 17.025 | 27.608 | 31.000 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The vision of the Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) program is the development of biological-scale neuromorphic electronic systems for autonomous, unmanned, robotic systems where humans are currently the only viable option. The successful development of this technology will revolutionize warfare by providing intelligent terrestrial, underwater, and airborne systems that remove humans from dangerous environments and remove the limitations associated with today's remote-controlled robotic systems. Applications for neuromorphic electronics include not only robotic systems, but also natural human-machine interfaces and diverse sensory and information integration applications in the defense and civilian sectors. If successful, the program will also reinvigorate the maturing microelectronics industry by enabling a plethora of computer and consumer electronics applications.<br><br>***FY 2010 Accomplishments:***<br>- Developed a brain-inspired neuromorphic architectural design and specification capability.<br>- Developed software tools to translate neuromorphic designs into electronic implementations using hybrid Complementary Metal-Oxide Semiconductor (CMOS) and high-density electronic synapse components.<br>- Developed capability to simulate the performance of neuromorphic electronics systems using very large scale computation.<br>- Developed virtual reality environments intended for training and evaluating electronic neuromorphic systems and their corresponding computer simulations.<br>- Developed standard testing protocols for assessing the performance of large neuromorphic electronic systems.<br><br>***FY 2011 Plans:***<br>- Demonstrate all core microcircuit functions in hybrid CMOS electronic synapse hardware.<br>- Demonstrate a dynamic neural system simulation of approximately one million neurons that shows plasticity, self-organization, and network stability in response to sensory stimulus and system level reinforcement.<br>- Develop tools to design electronic neuromorphic systems of 100 billion neurons with mammalian connectivity.<br>- Demonstrate virtual environments with a selectable range of complexity across the cognitive capabilities of small to medium sized mammals.<br>- Specify a chip fabrication process supporting 1 million neurons per square centimeter and ten billion synapses per square centimeter.<br><br>***FY 2012 Plans:***<br>- Design and simulate in software a complete neural system of ~10 billion synapses and ~1 million neurons performing cognitive tasks in a virtual environment comparable to those routinely tested in mice.<br>- Design and verify a hardware neural system of ~10 billion synapses and ~1 million neurons.<br>- Demonstrate a chip fabrication process and development plan supporting ~10 billion synapses per square centimeter and ~1 million neurons per square centimeter. | | | |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Refine design tools and techniques by codifying design rules and component properties and matching them to fabrication and simulation capabilities.<br>- Demonstrate a virtual environment supporting visual perception, decision and planning, and navigation environments fully integrated with software or hardware neural systems enabling the testing, training, and evaluation of these neural systems.<br>- Expand the feature set of the virtual environment to include auditory perception and proprioception.<br>- Introduce modalities of competition within the virtual environment to further tailor the evolution of the neural systems. | | | |
| ***Title:*** Short-range Wide-field-of-regard Extremely-agile Electronically-steered Photonic Emitter and Receiver (SWEEPER)<br><br>***Description:*** The objective of the Short-range Wide-field-of-regard Extremely-agile Electronically-steered Photonic Emitter and Receiver (SWEEPER) program is to develop chip-scale dense waveguide modular technology to achieve true embedded phase array control for beams equivalent to 10W average power, less than 0.1 degree instantaneous field of view (IFOV), greater than 45 degree total field of view (TFOV), and frame rates of greater than 100 Hertz (Hz) in packages that are "chip-scale." Such performance will represent a three order of magnitude increase in speed, while also achieving a greater than two orders of magnitude reduction in size. Additionally, the integrated phase control will provide the unprecedented ability to rapidly change the number of simultaneous beams, beam profile, and power-per-beam, thus opening a whole new direction in operational capability. Key technical challenges include the ability to achieve the needed facet density (facet pitch should be on the order of a wavelength or two), control the relative phase across all facets equivalent to 9-bits, and efficiently couple and distribute coherent light to facets from a master laser oscillator with an integrated waveguide structure. Related projects and studies have pointed to the significant system-level pay-offs of the new proposed technology.<br><br>***FY 2010 Accomplishments:***<br>- Evaluated transmit and receive photonic phased array technologies.<br><br>***FY 2011 Plans:***<br>- Demonstrate chip scale beam-forming capability in laboratory.<br>- Demonstrate integrated photonic phased array transceiver concept.<br><br>***FY 2012 Plans:***<br>- Demonstrate 8x8 integrated photonic chip scale array beam forming with path towards 32x32 array.<br>- Demonstrate 10°x10° beam steering with <20dB sidelobes. | 2.800 | 8.800 | 6.000 |
| ***Title:*** Electric Field Detector (E-FED)<br><br>***Description:*** The goal of the Electric Field Detector (E-FED) program is to develop a small room temperature electric field sensor/ sensor array based on new optical electric field sensor architectures. Electric fields are ubiquitous in the warfighter environment. | 3.807 | 4.295 | 2.304 |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| It is expected that these compact sensor arrays will be useful for the monitoring of brain activity and muscle action without the need to apply electrodes directly in or on the surface of the skin. The arrays would also be useful for the remote sensing of electronics, motors, and communications devices enabling the sensing of these devices at greater distances with a more unobtrusive and portable system.<br><br>***FY 2010 Accomplishments:***<br>- Designed and modeled miniature electric field sensors with high sensitivity to alternating electric fields.<br>***FY 2011 Plans:***<br>- Demonstrate sensors sensitive to an alternating electric field of 1 millivolt (mV)/meter root Hertz from 1-10,000 Hertz (Hz).<br>- Develop techniques to increase the frequency range, dynamic range and sensitivity of the electric field sensors while reducing their size.<br>- Explore manufacturing techniques in order to produce electric field sensor arrays with high reproducibility.<br>***FY 2012 Plans:***<br>- Demonstrate a sensor array with at least 25 elements with high sensitivity to an alternating electric field.<br>- Demonstrate sensors sensitive to an alternating electric field of 1 microvolt (μV)/meter root Hertz from 0.5-1,000,000 Hertz (Hz). | | | |
| ***Title:*** Self-HEALing mixed-signal Integrated Circuits (HEALICs)<br><br>***Description:*** The goal of the Self-HEALing mixed-signal Integrated Circuits (HEALICs) program is to develop technologies to autonomously maximize the number of fully operational mixed-signal systems-on-a-chip (SoC) per wafer that meet all performance goals in the presence of extreme process technology variations, environmental conditions, and aging. Virtually all DoD systems employ mixed-signal circuits for functions such as communications, radar, navigation, sensing, high-speed image and video processing. A self-healing integrated circuit is defined as a design that is able to sense undesired circuit/system behaviors and correct them automatically. As semiconductor process technologies are being scaled to even smaller transistor dimensions, there is a dramatic increase in intra-wafer and inter-die process variations, which have a direct impact on realized circuit performance, as well as significantly increased sensitivity to temperature and ageing effects.<br><br>The core goal of the HEALICs program is to regain this lost performance and stabilize operation over system lifetimes. Consequently, the long-term reliability of DoD electronic systems is expected to be significantly enhanced.<br><br>***FY 2010 Accomplishments:***<br>- Continued development of self-healing mixed-signal cores. | 13.819 | 15.540 | 12.111 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated increase in performance yield of mixed-signal cores to greater than seventy-five percent with minimal power and die area overhead.<br>***FY 2011 Plans:***<br>- Integrate previously demonstrated mixed-signal cores into a full microsystem/SoC.<br>- Develop global self-healing control at the microsystem/SoC level.<br>- Demonstrate simulated increase in performance yield of mixed-signal SoCs to greater than ninety-five percent with minimal power and die area overhead.<br>- Continue development of self-healing IP core library for DoD user access.<br>***FY 2012 Plans:***<br>- Demonstrate increase in performance yield of fabricated mixed-signal SoCs to greater than ninety-five percent with minimal power and die area overhead.<br>- Develop a full self-healing IP core library for DoD user access. | | | |
| ***Title:*** Efficient Linearized All-Silicon Transmitter ICs (ELASTx)<br>***Description:*** The goal of the Efficient Linearized All-Silicon Transmitter ICs (ELASTx) program is the development of revolutionary high-power/high-efficiency/high-linearity single-chip millimeter (mm)-wave transmitter integrated circuits (ICs) in leading edge silicon technologies. The high levels of integration possible in silicon technologies enable on-chip linearization, complex waveform synthesis, and digital calibration and correction. Military applications include ultra-miniaturized transceivers for satellite communications-on-the-move, collision avoidance radars for micro-/nano-air vehicles, and ultra-miniature seekers for small munitions. The technology developed under this program could also be leveraged to improve the performance of high-power amplifiers based-on other nonsilicon technologies through heterogeneous integration strategies. Significant technical obstacles to be overcome include the development of highly efficient circuits for increasing achievable output power of silicon devices (e.g., device stacking, power combining) at mm-waves; scaling high-efficiency amplifier classes to the mm-wave regime; integrated linearization architectures for complex modulated waveforms; and robust RF/mixed-signal isolation strategies.<br>***FY 2010 Accomplishments:***<br>- Initiated development of Watt-level, high power added efficiency (PAE) silicon-based power amplifier (PA) circuits at Q-band frequencies.<br>- Initiated development of linearized transmitter circuits based on high PAE PAs at Q-band frequencies.<br>- Initiated development of measurement techniques for mm-wave linearized transmitter circuits with complex modulated waveforms.<br>***FY 2011 Plans:*** | 7.436 | 9.491 | 6.306 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate Watt-level, high PAE silicon-based PA circuits at Q-band frequencies.<br>- Demonstrate linearized transmitter circuits based on high PAE PAs at Q-band frequencies with complex modulated waveforms.<br>***FY 2012 Plans:***<br>- Initiate development of Watt-level, high PAE silicon-based PA circuits at W-band frequencies.<br>- Initiate development of linearized transmitter circuits based on high PAE PAs at W-band frequencies. | | | |
| ***Title:*** Compact Mid-Ultraviolet Technology<br>***Description:*** The goal of the Compact Mid-Ultraviolet Technology program is to develop compact high-brightness Middle Ultraviolet source and detector technologies based on wide band gap diode structures. This program will address a critical technology shortfall preventing mid-UV capability in portable chem-bio defense systems for aerosol detection (enhanced capability for small particulates), chem-bio identification (Raman scattering and spectroscopy), and chemical decontamination/water purification applications. The technologies will also address solar-blind detectors for missile plume identification.<br>***FY 2010 Accomplishments:***<br>- Initiated developments for large non-absorbing (UV transparent) low-defect-density substrate materials on which to grow devices.<br>- Initiated high-quality, highly-strained epitaxy developments to confine carriers and provide the required energy band offsets.<br>- Initiated highly efficient electric injection of carriers to improve quantum efficiency.<br>- Initiated low-resistance non-absorbing contacts.<br>***FY 2011 Plans:***<br>- Demonstrate diode operation at proposed mid-UV wavelength.<br>- Create high-quality aluminum nitride substrates and ternary templates to enable development of optimized devices.<br>- Design and develop epitaxial structures for mid-UV light-emitting diode (LED) sources and detectors.<br>***FY 2012 Plans:***<br>- Demonstrate high wall plug efficiency, high brightness LED operating between 250-270nm.<br>- Demonstrate 5mW semiconductor lasers operating below 250nm in wavelength. | 7.798 | 15.400 | 15.000 |
| ***Title:*** Adaptive Radio Frequency Technology (ART)<br>***Description:*** There is a critical ongoing military need for flexible, affordable, hand-held cognitive military communications systems. The Adaptive Radio Frequency Technology (ART) program will provide the warfighter with a new, fully adaptive radio platform capable of sensing the electromagnetic and waveform environment in which it operates, making decisions on how to best communicate in that environment, and rapidly adapting its hardware to meet ever-changing requirements, while simultaneously | 6.763 | 17.619 | 16.918 |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| significantly reducing the size, weight and power (SWAP) of such radio nodes. ART will also equip each warfighter, as well as small-scale unmanned platforms, with a compact and efficient signal identification capabilities for next-generation cognitive communications, sensing and electronic warfare applications. ART technology will also enable rapid radio platform deployment for new waveforms and changing operational requirements. ART aggregates the Feedback Linearized Microwave Amplifiers program, the Analog Spectral Processing program, and Chip Scale Spectrum Analyzers (CSSA) program, and initiates new thrusts in Cognitive Low-energy Signal Analysis and Sensing Integrated Circuits (CLASIC) and RF Field-Programmable Arrays (RF-FPGA).<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated feedback-linearized InP HBT monolithic low-noise amplifiers with improved third-order-intercept point and noise figure.<br>- Demonstrated feedback linearized InP HEMT monolithic low-noise amplifiers.<br>- Demonstrated miniaturized, low-loss, tunable and reconfigurable RF and IF sensor filter banks.<br>***FY 2011 Plans:***<br>- Extend feedback linearized amplifier approaches to analog/RF applications such as active impedance matching of electrically small antennas, and initiate transition activities to signal intelligence and electronic warfare platforms.<br>- Initiate development of novel signal recognition sensor integrated circuits that can achieve >400 times reduction in signal recognition energy as compared to state of the art sensor systems.<br>- Initiate development of reconfigurable RF circuit (RF FPGA) technologies.<br>***FY 2012 Plans:***<br>- Continue development of novel signal recognition sensor integrated circuits.<br>- Continue development of reconfigurable RF circuit (RF FPGA) technologies. | | | |
| ***Title:*** Nitride Electronic NeXt-Generation Technology (NEXT)<br><br>***Description:*** The objective of the Nitride Electronic NeXt-Generation Technology (NEXT) program is to develop a revolutionary nitride transistor technology that simultaneously provides extremely high-speed and high-voltage swing [Johnson Figure of Merit (JFoM) larger than 5 THz-V] in a process consistent with large scale integration in enhancement /depletion (E/D) mode logic circuits of 1000 or more transistors. In addition, this fabrication processes will be manufacturable, high-yield, high-uniformity, and highly reliable. The accomplishment of this goal will be validated through the demonstration of specific Program Process Control Monitor (PCM) Test Circuits such as 5, 51, and 501-stage of ring oscillators in each program phase. The NEXT program was previously included in the High Frequency Wide Band Gap Semiconductor program.<br><br>***FY 2010 Accomplishments:*** | 7.221 | 12.717 | 16.130 |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Developed self-aligned structure with short gate length, novel barrier layers and reduced parasitics.<br>- Demonstrated technologies to achieve circuits of significant complexity (1,000 transistor devices or more).<br>- Developed transistor models.<br>***FY 2011 Plans:***<br>- Develop high-performance Gallium Nitride Field Effect Transistors (FETs).<br>- Achieve yield to enable modest integration levels.<br>- Demonstrate superior thermal management and packaging strategies.<br>- Demonstrate self-aligned structure with short gate length, novel barrier layers and reduced parasitics.<br>- Optimize transistor performance to include ultra-fast power switching capability.<br>- Develop an optimized enhancement mode power switch process to complement high frequency FET process.<br>- Design an integrated process for power switching and MMIC capability using advanced wide band gap devices.<br>***FY 2012 Plans:***<br>- Develop complex analog and digital monolithically integrated circuits based on next generation gallium nitride transistors and integration processes. | | | |
| ***Title:*** Non-Volatile Logic<br>***Description:*** The objective of the Non-Volatile Logic program is to develop the theory, design, and fabrication methodology, and demonstrate example circuits that utilize new computational state variables. The program will fabricate and demonstrate circuits that dissipate lower power, per logic operation, while having equal or better computational throughput as equivalent charge-based circuits. Non-Volatile Logic is an outgrowth of the Spin Torque Transfer Random Access Memory program.<br>***FY 2010 Accomplishments:***<br>- Initiated design and development of non-volatile logic gates and computational circuits to exploit new nano-magnet and electron spin state variables.<br>- Demonstrated zero off-state power and reconfigurable majority logic gates with significantly reduced energy consumption relative to state-of-the-art Complementary Metal-Oxide Semiconductor (CMOS) logic gates.<br>***FY 2011 Plans:***<br>- Develop circuits capable of performing logic functions based on the nano-magnetic re-orientation information and not on the movement of electrical charge.<br>- Develop fabrication techniques to make nano-magnetic based logic devices.<br>***FY 2012 Plans:*** | 4.750 | 7.911 | 5.839 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate a simple computational circuit based on magnetic orientation information that can switch in 10 nanoseconds and that utilizes less than 100 attojoules per switch.<br>- Demonstrate the non-volatility of information in the fabricated circuit. | | | |
| ***Title:*** Photonically Optimized Embedded Microprocessor (POEM)<br><br>***Description:*** Current trends in scaling microprocessor performance are projected to saturate and fall far short of future military needs. Microprocessor performance is saturating and leading to reduced computational efficiency because of the limitations of electrical communications. The Photonically Optimized Embedded Microprocessor (POEM) program will demonstrate chip-scale, silicon-photonic technologies that can be integrated within embedded microprocessors for seamless, energy-efficient, high-capacity communications within and between the microprocessor and Dynamic random access memory (DRAM). This technology will propel microprocessors onto a higher performance trajectory by overcoming the "memory wall", and thus satisfy projected microprocessor performance needs for memory intensive applications. This program aggregated Advanced CAD, Non-Silicon Electronics and Terahertz Photonics plus Advanced Photonic Switch (APS), Photonic Integrated Circuits on Silicon (EPIC), Ultradense Nanophotonic Intra chip Communications (UNIC) previously reported in PE 0603739E, Project MT-15.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated the world's lowest power photonic transmitter, comprised of Complementary Metal-Oxide semiconductor (CMOS)-compatible Si photonic devices and electronic drivers, and operating at 5 gigabits/second (Gb/s), with an efficiency of 400 fJ/bit (energy scatter) (unit time).<br>- Demonstrated the world's lowest power digital, optical receiver, comprised of a CMOS-compatible, Ge-on-Si-based photodetector with associated circuitry, and operating at 5 Gb/s, with an efficiency of 690 fJ/bit.<br>- Demonstrated a low power, thermally tolerant, 2x2 port, switch device with 110 nano meter (nm) switching bandwidth and 160 Gb/s throughput.<br><br>***FY 2011 Plans:***<br>- Develop CMOS-compatible modulator, multiplexor, coupler, and photodetector devices for low-power, high capacity photonic links.<br>- Develop DRAM-compatible modulator, multiplexor, coupler, and photodetector devices for low-power, high capacity photonic links.<br>- Develop CMOS-compatible, waveguide coupled, high-gain-bandwidth avalanche photodiodes for high speed operation.<br>- Develop low power, thermally tolerant, switch devices with >30 nm switching bandwidth.<br><br>***FY 2012 Plans:***<br>- Demonstrate a CMOS-compatible 300 fJ/bit photonic link with 120 Gb/s capacity. | 13.333 | 21.965 | 28.000 |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Demonstrate a DRAM-compatible 1500 fJ/bit photonic link with 80 Gb/s capacity.<br>- Demonstrate CMOS-compatible, waveguide coupled, high-gain-bandwidth avalanche photodiodes which operate at 40 Gb/s.<br>- Demonstrate a low power, thermally tolerant, 8x8 port, switch device with >30 nm switching bandwidth and 800 Gb/s throughput. | | | |
| ***Title:*** Compound Semiconductor Materials On Silicon (COSMOS)<br><br>***Description:*** Conventional integrated circuit processing is limited to one type of semiconductor material but many DoD systems have circuits based on multiple types of semiconductor devices. Consequently, these diverse devices and circuits are assembled together on printed circuit boards or in multi-chip modules. This conventional approach suffers from degraded performance at high-speed/RF frequencies due to parasitic and signal path delays, and increased costs due to packaging and module assembly steps. The objective of the Compound Semiconductor Materials On Silicon (COSMOS) program is to develop robust, high-yield semiconductor fabrication technologies and manufacturing processes for the intimate heterogeneous integration of multiple types of devices and semiconductor materials, specifically III-V compound semiconductor (CS) devices into high-density silicon Complementary Metal-Oxide Semiconductor (CMOS) platforms. This capability enables designers to leverage the high-speed and high-breakdown voltage of CS devices where most appropriate, while exploiting the complexity of advanced silicon CMOS for in situ calibration, linearization and signal processing - i.e. the principle of "best junction for the function". Based on this approach, the COSMOS program is specifically developing high-speed, high-linearity mixed-signal designs such as digital-to-analog converters and analog-to-digital converters with revolutionary performance for future military communications, sensing and electronic warfare systems.<br><br>***FY 2010 Accomplishments:***<br>- Increased the density of heterogeneous interconnections between compound semiconductor and silicon devices.<br>- Implemented process enhancements to improve the yield of the heterogeneous integration process.<br>- Initiated design and fabrication of an advanced mixed-signal circuit demonstrator, a heterogeneously-integrated wideband, ultra-high-linearity digital-to-analog converter with in situ silicon enabled calibration and linearization.<br><br>***FY 2011 Plans:***<br>- Complete and test an advanced mixed-signal circuit demonstrator, a heterogeneously-integrated wideband, ultra-high-linearity digital-to-analog converter with in situ silicon enabled calibration and linearization.<br>- Initiate design of a higher complexity mixed signal circuit demonstrator, a heterogeneously-integrated wideband, ultra-high-linearity analog-to-digital converter with in situ silicon enabled calibration and linearization. | 6.700 | 15.900 | 8.000 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Optimize the COSMOS process to demonstrate that fine-scale heterogeneous integration can be realized on a large-scale circuit with high manufacturing and performance yield.<br><br>***FY 2012 Plans:***<br>- Continue design, fabrication and test of a higher complexity mixed signal circuit demonstrator, a heterogeneously-integrated wideband, ultra-high-linearity analog-to-digital converter with in situ silicon enabled calibration and linearization.<br>- Continue COSMOS process yield and robustness enhancement. | | | |
| ***Title:*** Analog-to-Information (A-to-I) Receiver Development<br><br>***Description:*** The Analog-to-Information (A-to-I) Receiver Development program will fundamentally improve the operational bandwidth, linearity, and efficiency of electronic systems where the objective is to receive and transmit information using electromagnetic (radio) waves under extreme size/weight/power and environmental conditions required for DoD applications. The A-to-I Look-Through program will develop ultra-wideband digital radio frequency (RF) receivers based on Analog-to-Information Converter (AIC) technology. Compared to conventional RF receivers, AIC-based designs will increase receiver dynamic range and frequency band of regard while reducing data glut, power consumption and size. Likewise, limitations of current art power amplifier technology in simultaneously achieving high operational bandwidth, linearity, efficiency and power has resulted in well documented instances of electronic fratricide. This program will overcome these limitations by converting digital signals directly to high power RF analog signals, thus eliminating the traditional high power amplifiers that are limited by the above-mentioned tradeoffs. Transition is anticipated into airborne SIGINT and electronic warfare systems, as well as ground-based special operations forces systems.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated effectiveness of 2x to 20x Nyquist sub-sampling and addressed critical issues regarding noise.<br>- Developed and demonstrated novel mathematical algorithms to rapidly process sub-Nyquist data, improving execution time for signal detection, identification, and reconstruction.<br>- Completed prototypes of critical receiver hardware components for A-to-I receivers.<br><br>***FY 2011 Plans:***<br>- Develop complete brassboard A-to-I receivers and demonstrate against realistic and challenging RF environments in simulator, chamber, and/or flight tests.<br>- Compare bandwidth, resolution, dynamic range, and power-consumption of prototype A-to-I receivers against state-of-the-art conventional receivers performing similar functions. | 13.110 | 14.429 | 14.500 |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Initiate design of direct-digital to high-power RF transmitter modules with high linearity, wide bandwidth and efficiency, focusing on reduction of electronic fratricide.<br>***FY 2012 Plans:***<br>- Develop and demonstrate through analysis, simulation and measurement feasible Look-Through transmitter architectures.<br>- Design, tape out and characterize suitable Look-Through transmitter cells and signal combining structures. | | | |
| ***Title:*** Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) | - | 12.000 | 10.000 |
| ***Description:*** The Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) program primarily addresses the passive imaging needs for multi-band, wide field of view (FOV) and high-resolution imaging for ground and near ground platforms. The AWARE program aims to solve the technological barriers that will enable FOV, high resolution and multi-band camera architectures by focusing on four major tasks: high space-bandwidth product (SBP) camera architecture; small pitch pixel focal plane array architecture; broadband focal plane array architecture; and multi-band focal plane array architecture.<br><br>The AWARE program demonstrates technologies such as detectors, focal plane arrays, read-out integrated circuitry, and computational imaging that enable wide FOV and high space bandwidth, novel optical designs, high resolution and multiple wavelength band imagers. These technologies will be integrated into subsystem demonstrations under the related MT-15 project in PE 0603739E. This program also includes technologies previously addressed in the MultiScale Optical Sensor Array Imaging (MOSAIC) program.<br><br>***FY 2011 Plans:***<br>- Develop components to construct baseline visible wavelength camera and simulate data acquisition.<br>- Design and fabricate visible wavelength optical system.<br>- Complete broadband detector array test chips.<br>- Demonstrate 10x10 LWIR 5 micron pixel pitch and complete 256x256 array design with small pitch ROIC.<br>- Demonstrate and test hybridization schemes.<br>***FY 2012 Plans:***<br>- Demonstrate optical, electronic and software components for integrated macrocameras.<br>- Finalize design, fabrication process and assembly of hardware for camera.<br>- Demonstrate various operating modes with highly developed interface. | | | |
| ***Title:*** Advanced X-Ray Integrated Sources (AXIS) | - | - | 4.500 |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***Description:*** The objective of the Advanced X-Ray Integrated Sources (AXIS) program is to greatly reduce the size, weight and power of X-ray sources while dramatically increasing their electrical efficiency through application of microscale engineering technologies such as MEMS and NEMS. Such imaging modalities should speed reverse engineering of integrated circuits to validate trustworthiness as well as contrast-free battlefield imaging of blood vessel injuries in blunt trauma.<br><br>The Advanced Research component of this effort will focus on applying basic research discoveries to the development of compact, pulsed X-ray sources. Such sources are a necessary component to enable future technologies with high-speed motion imaging capabilities and the reverse engineering of integrated circuits. This program has basic research efforts funded in PE 0601101E, Project ES-01.<br><br>***FY 2012 Plans:***<br>- Investigate designs for compact and energy efficient X-ray sources that are spectrally tunable with narrow energy width. | | | |
| ***Title:*** Diverse & Accessible Heterogeneous Integration (DAHI)<br><br>***Description:*** Prior DARPA efforts have demonstrated the ability to monolithically integrate inherently different semiconductor types to achieve near-ideal "mix-and-match" capability for DoD circuit designers. Specifically, the Compound Semiconductor Materials On Silicon (COSMOS) program, in which transistors of Indium Phosphide (InP) can be freely mixed with Silicon Complementary Metal-Oxide Semiconductor (CMOS) circuits to obtain the benefits of both technologies (very high speed and very high circuit complexity/density, respectively). The Diverse & Accessible Heterogeneous Integration (DAHI) effort will take this capability to the next level, ultimately offering the seamless co-integration of a variety of semiconductor devices (for example, GaN, InP, GaAs, ABCS), microelectromechanical (MEMS) sensors and actuators, photonic devices (e.g., lasers, photo-detectors) and thermal management structures. This capability will revolutionize our ability to build true "systems on a chip" (SoCs) and allow dramatic size, weight and volume reductions for a wide array of system applications.<br><br>In the Applied Research part of this effort, High performance RF/optoelectronic/mixed-signal SoCs for specific DoD transition applications will be developed as a demonstration of the DAHI technology. In addition, in order to provide maximum benefit to the DoD, as these processes are developed, they will be transferred to a manufacturing flow and made available (with appropriate computer aided design support) to a wide variety of DoD laboratory, FFRDC, academic and industrial designers. Manufacturing yield and reliability of the DAHI technologies will be characterized and enhanced. This program has basic research efforts funded in PE 0601101E, Project ES-01.<br><br>***FY 2012 Plans:*** | - | - | 10.000 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Optimize CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices, including interconnect and thermal management approaches.<br>- Design high complexity heterogeneously integrated RF/optoelectronic/mixed signal and circuits, such as wide band, high-resolution analog-to-digital converters and transmitters, and optoelectronic RF signal sources.<br>- Initiate manufacturing, yield and reliability enhancement, and multi-user foundry capability. | | | |
| ***Title:*** Microscale Plasma Devices<br><br>***Description:*** The objective of the Microscale Plasma Devices is to develop microscale plasma devices for the efficient, high pressure (up to or even including atmospheric pressure) generation of ions, radiofrequency energy, and light sources. Applications for such devices are far reaching, including the construction of complete high frequency logic circuits, and integrated circuits with superior resistance to radiation and extreme temperatures.<br><br>This effort addresses the Applied Research part of the overall program, translating the basic science advances to complex circuit designs that may be integrated with commercial electronic devices. This program has basic research efforts funded in PE 0601101E, Project ES-01.<br><br>***FY 2012 Plans:***<br>- Demonstrate durable plasma and vacuum microelectrode structures.<br>- Identify approaches for integration of supporting devices (e.g., thin-film photoconductors, diodes, triode vacuum devices, etc.) for complete circuit functions. | - | - | 4.000 |
| ***Title:*** Microscale Power Conversion*<br><br>***Description:*** *Formerly COmpact Power Processing Electronics Research<br><br>The Microscale Power Conversion (MPC) program will address the fundamental limitations of power conversion by enabling a new technology and approach that exploits advances in basic power devices that can operate at very high frequencies with low losses. A key benefit of these new devices is that they can be integrated into very compact circuits and assemblies that will provide dramatic advances to the power bus of a platform. Specifically, this program will develop the technology to enable DC to DC power conversion for military applications at the scale of an integrated circuit so it can be embedded within the electronics subsystem and a new distributed power architecture can be realized. The focus of this program is on attaining 100MHz internal operation frequencies of power circuits since the size of the passive elements (inductors and capacitors) in a power converter scales as the fourth power of the internal operating frequency. In FY 2012 MPC moves to PE 0602715, Project MBT-03, which consolidates all of the DARPA energy programs into one project. | - | 10.000 | - |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2011 Plans:***<br>- Develop design and initial fabrication of critical sub-circuits and perform measurements in laboratory.<br>- Develop theoretical design and analyses for understanding of the high-frequency trade-off space of relevant circuit designs and topologies.<br>- Optimize transistor performance to include ultra-fast power switching capability.<br>- Develop new fabrication techniques for incorporating high frequency transistors and devices compatible with integrated power amplifier topologies.<br>- Document measurements of converter efficiency and losses. | | | |
| ***Title:*** Carbon Electronics for RF Applications (CERA)<br><br>***Description:*** The Carbon Electronics for RF Applications (CERA) program will develop a wafer-scale graphene (2-D carbon monolayer) synthesis process resulting in films with excellent mobility, uniformity and layer control (down to single monolayer films). These carbon films will then be used to develop ultra-low power, high-speed field effect transistors optimized for RF-applications (RF-FET). The program will conclude with a demonstration of a low power, low noise amplifier (LNA) using graphene-field effect transistors (FETs) as the channel material.<br><br>***FY 2010 Accomplishments:***<br>- Optimized synthesis process for wafer-scale graphene thin films.<br>- Optimized RF-FETs based on graphene channels.<br><br>***FY 2011 Plans:***<br>- Increase area of graphene synthesis to wafer-scale dimensions.<br>- Demonstrate film thickness control down to single monolayer.<br>- Demonstrate low power, high performance RF-FETs with graphene.<br>- Demonstrate initial wide-band LNA using graphene channel based RF-FETs. | 8.764 | 6.958 | - |
| ***Title:*** Leading Edge Access Program (LEAP)<br><br>***Description:*** The focus of the Leading Edge Access Program (LEAP) is to enable university, industry, and government lab access to on-shore state of the art Complementary Metal-Oxide Semiconductor (CMOS) technology for the purpose of performing advanced integrated circuit (IC) research of benefit to the DoD. Specifically, LEAP intends to offer foundry access at a substantially reduced cost for CMOS technology nodes of 45 nanometers (nm) and below. Currently much of the IC design work performed using advanced technology nodes, including that done for the DoD, uses off-shore facilities in Asia and Europe. This results in substantial intellectual property (IP) development outside the U.S. and creates a number of difficulties for technology transition of DoD-critical applications. This program will stimulate U.S.-based advanced design research, providing top | 2.928 | 3.210 | - |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| researchers early and partially subsidized access to validate and test innovative ideas and facilitate a more natural transition of pioneering ideas.<br><br>***FY 2010 Accomplishments:***<br>- Initiated transition of 45 nm Si On Insulator (SOI) to 32 nm bulk CMOS.<br><br>***FY 2011 Plans:***<br>- Transition to 32 nm SOI, 22 nm bulk CMOS, and 22 nm SOI. | | | |
| ***Title:*** Quantum Sensors<br><br>***Description:*** The Quantum Sensors program exploits non-classical effects to improve the resolution and range of military sensors. The objective of the program is to enhance sensitivity, resolution, and effectiveness of electromagnetic sensors beyond what is classically possible. In the initial effort, the types of sensors that propagate entangled light out to and back from a target were proven to be ineffective when realistic scattering and absorption occur between the source and the target. Sensors that propagate classical light to the target but use non-classical effects only in the receiver were shown to provide qualitative advantages over their classical counterparts. These include compensation for soft aperture losses using squeezed vacuum injection and compensation for detectors' quantum inefficiency using noiseless amplification.<br><br>***FY 2010 Accomplishments:***<br>- Designed laser radar with combined squeezed vacuum injection and noiseless amplification.<br><br>***FY 2011 Plans:***<br>- Test and demonstrate system performance.<br>- Make technology available to the Services for further development. | 5.089 | 7.639 | - |
| ***Title:*** Spin Torque Transfer-Random Access Memory (STT-RAM)<br><br>***Description:*** The Spin Torque Transfer-Random Access Memory (STT-RAM) program will develop materials and processes to fully exploit the spin-torque transfer (STT) phenomenon for creating "universal" memory elements. This program will develop the core technology for exploiting spin-torque transfer and related phenomena for producing large-scale memories. Compatibility and stability with expected mainstream processes for semiconductor electronics and patterned media is an important attribute that should enable significant leverage for these new technologies in delivering early demonstrations and in gaining wider acceptance.<br><br>***FY 2010 Accomplishments:***<br>- Developed magnetic materials and architectures that allow for fast, low power switching in a STT architecture. | 8.277 | 6.065 | - |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Demonstrated fast low power STT memory cell that has size and endurance similar to current non-volatile electronic memories.<br>***FY 2011 Plans:***<br>- Develop improved magnetic materials that allow for faster and lower power switching in the STT architecture.<br>- Develop processes and circuit designs to manufacture operational memory arrays in high yield. | | | |
| ***Title:*** Radio Frequency Photonics Technology (RPT)<br>***Description:*** The Radio Frequency Photonics Technology (RPT) program is developing components and microsystems to revolutionize deployed signal intelligence (SIGINT) gathering capabilities. The radio frequency (RF) spectrum contains innumerable friendly and adversarial signals of interest including: voice and data communications, electronic signatures, and navigation information. Conventional electronic systems are challenged in detecting weak signals in the presence of strong ones (low-linearity) across a broad range of frequencies (narrow-band). The RPT program aims to efficiently capture all RF signals of interest by developing broad-band (>10 gigahertz) high-linearity (>70 decibels dynamic-range) optical components and microsystems. RPT enables linear broadband microsystems such as remote links, channelizers, and analog-to-digital converters (ADCs). The RPT program will reduce susceptibility to electronic attack, increase the probability-of-intercepting (POI) adversaries on their first-pulse transmission, and increase information awareness 1000-fold.<br><br>The Applied Research portion of this program will develop linear broadband optical components such as modulators, photodetectors, lasers, delay elements, and low-noise oscillators in support of linear broadband microsystems. These components will be integrated into subsystem demonstrations in the related RPT, PE 0603739E, Project MT-15. This program includes technologies previously addressed in the Remoted Analog-to-Digital Converter with De-serialization and Reconstruction (RADER) and Integrated Photonic Delays (iPhoD) programs.<br><br>***FY 2010 Accomplishments:***<br>- Refined waveguide materials, fabrication and coupling approaches.<br>- Demonstrated a precise and low loss fiber input/output coupling technology.<br>- Developed an analog to digital converter performance multiplier architecture.<br>***FY 2011 Plans:***<br>- Develop high-linearity photodetectors and modulators.<br>- Demonstrate low-loss integrated optical delay lines (<0.1 decibels per meter).<br>- Improve waveguide materials, processes, and devices to the performance levels needed for successful demonstration of an array processor. | 5.300 | 18.129 | - |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Fabricate an array processor with 500 ns of on-chip optical delay for the longest path. | | | |
| ***Title:*** Ultrabeam<br><br>***Description:*** The goal of the Ultrabeam program was to demonstrate the world's first gamma-ray laser using laboratory equipment. Compact gamma ray lasers can enable the development of new and more effective radiation therapies and radiation diagnostic tools for medical and materials/device inspection applications. This unique X-ray laser technology could also eventually enable the development of compact, laboratory-scale high-brightness coherent sources for 3-D molecular scale imaging of living cells and debris-free advanced lithography.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated 50 micro joule, 60 as X-ray laser.<br>- Modeled gamma-ray gain of 100 per cm.<br><br>***FY 2011 Plans:***<br>- Demonstrate gamma-ray excitation and coherent gamma-ray amplification in solids. | 1.000 | 2.656 | - |
| ***Title:*** Chip-to-Chip Optical Interconnects (C2OI)<br><br>***Description:*** The performance of electronic interconnect technologies, particularly for implementing high-speed communications channels on printed circuit boards and back planes, is currently being outpaced by the ever-advancing needs of Complimentary Metal-Oxide Semiconductor (CMOS) microprocessor chips. This performance gap in the on-chip and between chip interconnection technology will create substantial data throughput bottlenecks, deleteriously affecting future military-critical sensor signal processing systems. To address this pressing issue, the Chip-to-Chip Optical Interconnects (C2OI) program is developing optical technology for implementing chip-to-chip interconnects at the board and backplane level.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated a chip-scale opt-electronic transceiver circuit based on C2OI operating at 1 Terabit per second (consisting of twenty four bidirectional channels each operating at 20 Gigabits/second).<br><br>***FY 2011 Plans:***<br>- Demonstrate a full system-scale demonstration of C2OI technology through the optical interconnect of two high performance computer servers using embedded C2OI technology integrated with commercial circuit boards. | 2.000 | 2.321 | - |
| ***Title:*** Near-Junction Transport (NJT)<br><br>***Description:*** The Near-Junction Transport (NJT) program explores heat conduction and mitigation through materials layers near a high-power device junction. This program will develop and verify accurate quantitative models for heat generation and transport in | - | 6.089 | - |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| and near device junctions to include development of novel high spatial and temporal resolution metrology techniques, fabrication of device-compatible materials and interfaces expected to offer unique thermal characteristics resulting in the development of models, tools, and materials for near-junction thermal management in a broad class of electronic device materials. The second stage will concentrate on development of specific materials to enhance the local heat-spreading in the region of the semiconductor chip. Industry leaders with the expertise in developing high-power semiconductor devices will be expected to demonstrate significantly enhanced heat density and the use of enhanced heat spreading technologies within an existing fabrication process. Additionally, the program will address developing novel device-scale structures to enable highly conductive thermal paths to remove unwanted heat from electronic devices. The impressive improvements obtained through miniaturization and integration in electronics have led to a thermal bottleneck where dense logic circuits, mixed-signal analog and digital circuits, and RF electronics are all limited by energy dissipation in small volumes. This program is a companion program to the Thermal Management Technologies (TMT) program in PE 0603739E, Project MT-12.<br><br>***FY 2011 Plans:***<br>- Develop specific materials to enhance the local heat-spreading in the region.<br>- Preliminary design of thermally enhanced semiconductor device.<br>- Demonstrate the use of enhanced heat spreading technologies within an existing fabrication process.<br>- Demonstrate significantly enhanced heat density utilizing high-power semiconductor devices.<br>- Identify nanostructured material designs for revolutionary thermal pathways compatible with electronic devices.<br>- Explore the potential improvement possible by the use of phonon engineering.<br>- Transit resulting advancements to TMT research in MT-12. | | | |
| ***Title:*** Advanced Microsystems Technology<br><br>***Description:*** The Advanced Microsystems Technology program explored a range of advanced microsystem concepts well beyond existing current technologies. The program focus was on technologies that exploit 3-D structures, new materials for Geiger-mode detectors, advance patterning, and extreme scaling in silicon devices. Insights derived in these areas will be exploited in future program initiatives.<br><br>***FY 2010 Accomplishments:***<br>- Developed and demonstrated a process of controllable release and handling of fiber-like silicon-on-insulator flexible electronics.<br>- Designed and fabricated slab-coupled optical waveguide (SCOW) photodiode packages with fiber-pigtail input and microwave output.<br>- Demonstrated successful actuation of polydimethylsiloxane (PDMS) valves for use in electowetted microfluidic devices. | 5.000 | - | - |
| ***Title:*** High Frequency Wide Band Gap Semiconductor | 4.646 | - | - |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | R-1 ITEM NOMENCLATURE<br>PE 0602716E: *ELECTRONICS TECHNOLOGY* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The High Frequency Wide Band Gap Semiconductor program fully exploited the properties of wide bandgap semiconductors (WBGS) to enhance the capabilities of microwave and millimeter-wave (MMW) monolithic integrated circuits (MMICs) and in turn, enable future RF sensor, communication, and multifunction military capabilities. Wide bandgap semiconductors have the ability to deliver very high power and other very favorable high frequency characteristics. Prior efforts have focused on improvements to the basic semiconductor while current efforts are focused on realizing devices and circuits. These technologies will lead to affordable, high performance, reliable, wide bandgap devices and MMICs with characteristics suitable for enabling new DoD systems and greatly improved performance for fielded platforms.<br><br>This effort addressed the Applied Research portion of the program. In this effort, the electronic devices with long lifetimes were developed. The effort develops models to predict device electronic performance and reliability characteristics, to ensure reproducible behavior and to enable integration of these devices into integrated circuits. This program also has efforts funded in PE 0603739E, project MT-15.<br><br>***FY 2010 Accomplishments:***<br>- Developed and utilized physics-based models that accurately predict device performance.<br>- Demonstrated reproducible WBGS device and MMICs fabrication processes.<br>- Demonstrated WBGS devices and MMICs that, while maintaining high levels of producibility and reliability, achieved substantially higher levels of performance compared to GaAs-based microwave and MMW devices and MMICs. | | | |
| ***Title:*** Parametric Optical Processes and Systems (POPS)<br><br>***Description:*** The Parametric Optical Processes and Systems (POPS) program has demonstrated all optical signal processing based on Four Wave Mixing in optical fibers and using silicon waveguides to achieve data rates of 100 Gigabits per second (Gb/s) to 1 Terabit per second (Tb/s). This program developed components such as wavelength-shifting wideband amplifiers, tunable optical delays, and parametric sampling for this application. These components will be used in higher level sub-systems such as serializers, de-serializers, and wavelength grooming devices at high data rates of 100 Gb/s - 1Tb/s. These demonstrations of functionality also included quantitative bit error rate measurements. POPS components and subsystems will enable optical communications at data rates ten times higher than currently possible with conventional approaches. POPS technology will allow all optical manipulation of high rate data streams with a precision and flexibility not currently possible.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated enhanced serializer component with data rate of 640 Gb/s.<br>- Demonstrated enhanced deserializer component with granularity of 10 Gb/s. | 3.577 | - | - |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Demonstrated 3000 nano second continuous parametric delay technology. | | | |
| ***Title:*** Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF)<br><br>***Description:*** The Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF) program increased the tuning speed of high-temperature semiconducting (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 relied upon semiconductor tuning, properly mated with the superconducting filter materials; the fundamental challenge - that normal electrical conductivity and superconductivity cannot coexist in the same circuit - has been overcome. In addition to interference-rejection at microsecond speeds, these filters make it possible to perform wide spectral searches with unprecedented frequency resolution, enabling detection of very weak emissions (signatures) characteristic of threat systems. Such a capability within a small add-on box to the RF receiver revolutionized the performance of all types of receivers, with applications ranging from communications to signals intelligence, and enabled operation in the densest of interference environments.<br><br>***FY 2010 Accomplishments:***<br>- Developed a concept for a front-end pre-selector filter bank, consisting of both tunable notch and bandpass filters, which demonstrated the capability of removing local interference, particular those agile signals such as JTIDS.<br>- Constructed a pre-selector module, incorporating HTS filters and supporting circuitry, and demonstrated the capability of eliminating interference in the first stage of the receiver. | 1.298 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 182.188 | 286.936 | 215.178 |

| | **FY 2010** | **FY 2011** |
|---|---|---|
| ***Congressional Add:*** 3-D Technology for Advanced Sensor Systems<br><br>***FY 2010 Accomplishments:*** - Continued 3-D device development. | 2.000 | - |
| **Congressional Adds Subtotals** | 2.000 | - |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**E. Acquisition Strategy**

N/A

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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0602716E: *ELECTRONICS TECHNOLOGY* |

**F. Performance Metrics**

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

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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | **R-1 ITEM NOMENCLATURE**<br>PE 0302168E: *WIRELESS INNOVATION FUND* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | - | - | 100.000 | - | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | Continuing | Continuing |
| WIF-01: *WIRELESS INNOVATION FUND* | - | - | 100.000 | - | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

The goal of this effort is to carry out research within the Defense Advanced Research Projects Agency to allow selected spectrum reallocation and conversion of DoD's wireless communications systems and those of other users, coordinating activities as part of the Wireless Innovation (WIN) Fund. This project will develop technologies to create breakthroughs that can solve core security, analytic, sharing, and reliability challenges while increasing data transmission speeds to enable the next generation of wireless networks.

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | - | - | - | - | - |
| Current President's Budget | - | - | 100.000 | - | 100.000 |
| Total Adjustments | - | - | 100.000 | - | 100.000 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | - | - | | | |
| • TotalOtherAdjustments | - | - | 100.000 | - | 100.000 |

### Change Summary Explanation

FY 2012: Funds are requested as part of the Wireless Innovation Fund.

## C. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Wireless Innovation Fund<br><br>***Description:*** Building upon DARPA's legacy in developing information and communications technology and command, control and communications systems, DARPA will seek to develop technologies to create breakthroughs that can solve core security, analytic, sharing, and reliability challenges while increasing data transmission speeds to enable the next generation of wireless networks. As part of this program, DARPA will investigate novel spectrum sharing and interference mitigation techniques to | - | - | 100.000 |

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| APPROPRIATION/BUDGET ACTIVITY | R-1 ITEM NOMENCLATURE |
|---|---|
| 0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 2: *Applied Research* | PE 0302168E: *WIRELESS INNOVATION FUND* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| enable more efficient uses of the wireless spectrum. Ultimately, this program will test and demonstrate the technologies to provide a more secure, reliable and robust wireless network that will have broad impacts that span both DoD and commercial applications.<br><br>***FY 2012 Plans:***<br>- Identify and develop technologies for security, reliability, and scalability of next generation wireless networks.<br>- Investigate new techniques that increase spectrum efficiency in order to gain more capacity in congested spectrum.<br>- Conduct experiments to assess scalability of spectrum sharing technologies and technologies that reduce spectrum requirements.<br>- Perform in collaboration with interested Government organizations such as National Telecommunications and Information Administration, National Institute of Standards and Technology, and others. | | | |
| **Accomplishments/Planned Programs Subtotals** | - | - | 100.000 |

## D. Other Program Funding Summary ($ in Millions)

N/A

## E. Acquisition Strategy

N/A

## F. Performance Metrics

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

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603286E: *ADVANCED AEROSPACE SYSTEMS* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 253.848 | 303.078 | 98.878 | - | 98.878 | 116.716 | 106.930 | 112.474 | 112.474 | Continuing | Continuing |
| AIR-01: *ADVANCED AEROSPACE SYSTEMS* | 253.848 | 303.078 | 98.878 | - | 98.878 | 116.716 | 106.930 | 112.474 | 112.474 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 258.278 | 303.078 | 189.075 | - | 189.075 |
| Current President's Budget | 253.848 | 303.078 | 98.878 | - | 98.878 |
| Total Adjustments | -4.430 | - | -90.197 | - | -90.197 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | 2.421 | - | | | |
| • SBIR/STTR Transfer | -6.851 | - | | | |
| • TotalOtherAdjustments | - | - | -90.197 | - | -90.197 |

**Change Summary Explanation**

FY 2010: Decrease reflects and SBIR/STTR transfer offset by internal below threshold reprogramming.

FY 2012: Decrease reflects the termination of the ArcLight program, drawdown of Vulture and ISIS, transfer of the Vulcan program to the new tactical and strategic energy project (MBT-03) in PE 0602715E, and reductions for Defense Efficiencies for contractor staff support.

## C. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Vulture<br><br>***Description:*** The objective of the Vulture program is to develop and demonstrate the technology to enable an airborne payload to remain persistently on-station, uninterrupted and unreplenished, for over five years performing strategic and tactical | 35.450 | 60.000 | 4.000 |

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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | R-1 ITEM NOMENCLATURE<br>PE 0603286E: *ADVANCED AEROSPACE SYSTEMS* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| communications, position/navigation/timing (PNT) and intelligence, surveillance, and reconnaissance missions over an area of interest. Vulture technology enables a re-taskable, persistent pseudo-satellite capability, in an aircraft package. The technology combines the key benefits of an aircraft (flexibility & responsiveness, sensor resolution, reduced transmit/receive power, affordability) with the benefits of space assets (on-station persistence, no logistics tail, energy independence, fleet size, absence of in-country footprint). The system has potential in numerous roles: operation as a single platform, as a formation of multiple aircraft, or as a constellation providing infrastructure augmentation or recovery. The technology challenges include structural integrity of very lightly-loaded airframe structure, efficient and reliable energy collection, storage/retrieval and management, and reliability technologies capable of allowing the aircraft to operate continuously for five years. The Vulture program will conduct subscale and full-scale technology maturation and demonstration activities to prove out critical technologies. The anticipated transition partner is the Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Conducted initial risk reduction analyses, testing, experiments, and demonstrations.<br>- Initiated demonstration of component performance and reliability including energy storage, propulsion, and flight management/control systems.<br>***FY 2011 Plans:***<br>- Conduct system requirements review.<br>- Initiate preliminary design of the flight demonstrator aircraft.<br>- Demonstrate component performance and reliability including energy storage, propulsion, and flight management/control systems.<br>- Perform cantilever wing, 2-D and 3-D wind tunnel test.<br>- Continue subsystem and risk reduction testing.<br>- Fabricate and structurally test critical wing sections.<br>- Initiate energy collection system fabrication and testing.<br>- Initiate 1 KW energy storage system fabrication and pressure test.<br>***FY 2012 Plans:***<br>- Conduct system critical design review.<br>- Initiate fabrication, assembly, ground test and check out flight demonstrator in preparation for long endurance demonstration flight. | | | |
| ***Title:*** Triple Target Terminator (T3) | 11.146 | 16.908 | 30.820 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Triple Target Terminator (T3) program will develop a high speed, long-range missile that can engage air, cruise missile, and air defense targets. T3 would be carried internally on stealth aircraft or externally on fighters, bombers, and UAVs. The enabling technologies are: propulsion, data links, and digital guidance and control. T3 would allow any aircraft to rapidly switch between air-to-air and air-to-surface capabilities. T3's speed, maneuverability, and network-centric capabilities would significantly improve U.S. aircraft survivability and increase the number and variety of targets that could be destroyed on each sortie. The program is jointly funded with, and will transition to the Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Conducted studies to define T3 trade space and concepts of operation.<br>- Initiated preliminary design studies.<br>- Conducted risk reduction experiments and modeling to validate designs.<br>***FY 2011 Plans:***<br>- Conduct preliminary design review of T3 concepts.<br>- Initiate T3 critical design activities.<br>***FY 2012 Plans:***<br>- Conduct hardware-in-the-loop integrated subsystem testing.<br>- Conduct propulsion system ground testing.<br>- Fabricate and ground test demonstration vehicles. | | | |
| ***Title:*** Integrated Sensor is Structure (ISIS)<br><br>***Description:*** The joint DARPA/Air Force Integrated Sensor is Structure (ISIS) program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship that will address the nation's need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly integrated lightweight multi-purpose airship structure - completely erasing the distinction between payload and platform. The ISIS concept includes ninety-nine percent on-station 24/7/365 availability for simultaneous Airborne Moving Target Indicator (AMTI) (600 kilometers) and Ground-Based Moving Target Indicator (GMTI) (300 kilometers) operation; ten years of autonomous, unmanned flight; hundreds of wideband in-theater concealed communications links; responsive reconstitution of failed space assets; plus CONUS-based sensor analysis and operation. An MOA has been signed by DARPA and the Air Force to pursue the program objectives through to transition. The ISIS technology demonstration system transitions to the Air Force in 2013.<br><br>***FY 2010 Accomplishments:*** | 72.650 | 43.400 | 5.000 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Conducted preliminary design review of demonstration system.<br>- Conducted radar system operational modeling and simulation.<br>- Developed and demonstrated flight dynamic controls in a lab environment.<br>- Demonstrated large-scale manufacturing of prototypes and initial integration.<br>- Conducted radar and power system critical design reviews.<br>***FY 2011 Plans:***<br>- Conduct critical design review of demonstration system.<br>- Conduct simulations to validate subsystem detailed designs.<br>- Conduct risk reduction testing and demonstrations of integrated subsystems.<br>- Manufacture airship envelope.<br>- Manufacture and chamber test of dual-band RF apertures.<br>***FY 2012 Plans:***<br>- Assemble radar panels to pill structure and perform radar/aperture testing.<br>- Integrate airship hull and radar aperture structures.<br>- Install and pre-flight test power, propulsion, and ballast systems.<br>- Manufacture and demonstrate launch on station, demonstration hardware.<br>- Complete Ground Station development.<br>- Complete Flight Test Readiness Review.<br>- Launch and transit to on station, demonstration area. | | | |
| ***Title:*** Long Range Anti-Ship Missile Demonstration (LRASM)<br>***Description:*** In response to emerging threats, DARPA is building on recent technology advances to develop and demonstrate standoff anti-ship strike technologies to reverse the significant and growing U.S. naval surface strike capability deficit. The Long Range Anti-Ship Missile (LRASM) program is investing in advanced component and integrated system technologies capable of providing a dramatic leap ahead in U.S. surface warfare capability focusing on organic wide area target discrimination in a network denied environment, innovative terminal survivability in the face of advanced defensive systems, and high assurance target lethality approaches. Specific technology development areas will include: robust precision guidance, navigation and control with GPS denial, multi-modal sensors for high probability target identification in dense shipping environments, and precision aimpoint targeting for maximum lethality. Component technologies are being developed, demonstrated, and integrated into a complete weapon system. The program will result in a high fidelity demonstration to support military utility assessment. LRASM is a joint DARPA/Navy effort, with the Navy providing 50% of funds. | 54.950 | 67.560 | 24.490 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Completed integrated system preliminary designs and held preliminary design reviews.<br>- Conducted high fidelity independent government performance assessment of preliminary designs against key performance criteria, validating LRASM performance potential.<br>- Performed risk reduction testing of critical components, including propulsion direct-connect testing.<br>- Generated supporting documentation including concepts of operation, flight test and safety plans, system engineering master plans, test and evaluation master plans, lifecycle cost estimates, and transition plans.<br>***FY 2011 Plans:***<br>- Initiate system detailed design activity.<br>- Develop high fidelity simulation tools and initiate system performance studies.<br>- Complete subsystem designs and developmental testing including wind tunnel tests and propulsion direct connect tests.<br>- Develop integrated hardware-in-the-loop platforms and conduct system developmental tests.<br>- Initiate long-lead procurements.<br>- Commence range planning activities.<br>***FY 2012 Plans:***<br>- Complete propulsion system transition testing.<br>- Complete missile seeker captive carry testing against surrogate targets.<br>- Complete integrated system detail designs and hold critical design reviews.<br>- Conduct high fidelity independent government performance assessment of detailed designs against key performance criteria.<br>- Update supporting documentation including concepts of operations, flight test and safety plans, lifecycle cost estimates, and transition plans.<br>- Commence fabrication, assembly, integration, and checkout of flight test vehicles for initial incremental test events.<br>- Complete canister expulsion and ballistic flight testing.<br>- Complete controlled test vehicle flights. | | | |
| ***Title:*** Persistent Close Air Support (PCAS)<br>***Description:*** The Persistent Close Air Support (PCAS) program will significantly increase close air support (CAS) capabilities by developing a system to allow continuous CAS availability and lethality to the supported ground commander. The enabling technologies are: manned/unmanned attack platforms, next generation graphical user interfaces (GUI), data links, digital guidance and control, and advanced munitions. PCAS will demonstrate the ability to digitally task a CAS platform from the ground to attack multiple/simultaneous targets. PCAS will allow the Joint Tactical Air Controller (JTAC) the ability to rapidly engage multiple moving targets simultaneously within the area of operation. PCAS's ability to digitally task a CAS platform to attack multiple/ | 9.000 | 18.000 | 21.000 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| simultaneous targets would improve U.S. ground forces operations and speed of attack. The system will be designed to reduce collateral damage and potential fratricide to friendly forces. The anticipated transition partner is the Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Conducted studies to define PCAS trade space and concepts of operation.<br>- Established unmanned A-10 demonstration aircraft requirements for the live-fire demonstration.<br>- Established JTAC kit demonstration requirements for the live-fire demonstration.<br>***FY 2011 Plans:***<br>- Conduct trade studies for an integrated PCAS system.<br>- Conduct conceptual design and system requirements reviews of the unmanned A-10 demonstration aircraft and JTAC kit.<br>- Complete a technology maturation plan and program risk reduction activities to ensure a successful live-fire demonstration of the PCAS system.<br>- Initiate subcomponent developer critical enabling technology designs that will complement the system integrator A-10 and JTAC Kit designs.<br>***FY 2012 Plans:***<br>- Integrate subcomponent developer critical enabling technology components into system integrator A-10 and JTAC kit designs.<br>- Perform initial modifications to unmanned A-10 demonstration aircraft and conduct software and hardware ground testing.<br>- Complete initial designs of next generation JTAC kit and perform hardware and software breadboard testing.<br>- Continue modifications to the unmanned A-10 demonstration aircraft based on software and hardware ground testing results. | | | |
| ***Title:*** Advanced Aerospace System Concepts<br><br>***Description:*** Studies conducted under this program examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact/improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future programs or refocus ongoing work. Topics of consideration include: methods of defeating enemy anti-aircraft attacks; munition technologies to increase precision, range, endurance, and lethality of weapons for a variety of mission sets; novel launch systems; air vehicle control, power, propulsion, materials, and architectures; and payload and cargo handling systems.<br><br>***FY 2010 Accomplishments:***<br>- Analyzed materials, designs and techniques for air systems weight reduction and structural efficiency, including complex fittings associated with propulsion and drive system housings and gearbox cases. | 2.500 | 3.000 | 3.000 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Conducted enabling technology and sub-system feasibility experiments.<br>***FY 2011 Plans:***<br>- Perform studies of candidate technologies and develop system concepts.<br>- Conduct proof-of-concept demonstrations to verify technologies developed.<br>***FY 2012 Plans:***<br>- Conduct modeling and simulation of system architectures and scenarios.<br>- Perform feasibility experiments of candidate technologies and system concepts. | | | |
| ***Title:*** Autonomous High Altitude Long Endurance (HALE) Refueling (AHR)*<br>***Description:*** * Formerly Autonomous Aerial Refueling<br><br>The Autonomous High Altitude Long Endurance (HALE) Refueling (AHR) program will demonstrate high altitude refueling between unmanned aircraft in an operational environment. The program will leverage existing RQ-4 Global Hawk unmanned aircraft to evaluate the opportunity to develop superior next generation, high-altitude, long-endurance aircraft built around the advantages of air refueling that have proven so vital to manned aviation. Specific challenges include achieving a repeatable probability of success with limited flight performance aircraft under high-altitude conditions, redundant safe separation, and unmanned flight operations. The program will also promote the application of autonomy for better effectiveness, efficiency, and safety in challenging environments and also offers the potential for direct transition to the Global Hawk fleet.<br><br>***FY 2010 Accomplishments:***<br>- Performed initial requirements allocation and system design.<br>- Conducted modeling and simulation of high-altitude refueling.<br>***FY 2011 Plans:***<br>- Validate drogue performance at altitude (single-ship).<br>- Accomplish aircraft modifications.<br>- Initiate flight tests to achieve repeatable refueling performance.<br>***FY 2012 Plans:***<br>- Complete flight test and achieve repeatable refueling performance.<br>- Conduct operationally stressing refueling demonstration.<br>- Complete demonstration and document feasibility of fully autonomous aerial refueling in challenging conditions. | 17.000 | 18.000 | 10.568 |
| ***Title:*** ArcLight | 2.000 | 5.000 | - |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The goal of the ArcLight program is to design and evaluate in simulation a tactical, long range, time critical, boost/glide vehicle capable of carrying a payload of 100-200 lbs over 2,000 nm in less than 30 minutes. The boost/glide vehicle would be launched from a Mark 41 vertical launch system (VLS) capable booster stack. The development of the ArcLight vehicle could enable tactical, long range strike weapons capable of engaging time critical targets. Transition partners include the Navy and Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Conducted feasibility testing of novel material technology.<br><br>***FY 2011 Plans:***<br>- Conduct trade studies of vehicle shape, size, critical systems, trajectory, and range estimations.<br>- Develop initial concept of operations and military utility analyses.<br>- Develop initial critical technology development plan.<br>- Assessment and testing of critical system elements, including wing materials and leading edges. | | | |
| ***Title:*** Vulcan<br><br>***Description:*** The goal of the Vulcan turbine engine demonstration program is to design, build, and ground test a pressure gain combustion (PGC) technology system that demonstrates a 20% reduction in fuel consumption for a power generation turbine system. PGC technology has been under development for more than a decade and considerable progress has been made in key enabling technology areas. The technology is believed mature enough to permit a dramatic new system capability. PGC, when combined with turbine engines, offers the ability to design a new class of hybrid turbine power generation engines and Mach 4+ air breathing engines. The Vulcan system will consist of a full scale PGC, a compressor, and a turbine. The Vulcan program PGC technology would have direct application to ship power generation & propulsion turbine engines, aviation turbine engines, high-mach air breathing engines, as well as commercial turbine engines of the same variety. Beginning in FY 2012, this program is funded from PE 0602715E, Project MBT-03, Tactical and Strategic Energy Technology. Anticipated Service users include the Air Force and Navy.<br><br>***FY 2010 Accomplishments:***<br>- Completed designs and simulations of critical components.<br>- Conducted risk reduction demonstrations of the combustor rig, fuel system, valve rig, initiator, seals, and thermal management system rig components.<br>- Completed Constant Volume Combustion (CVC) engine preliminary design review.<br>- Initiated detailed design of subsystems. | 35.000 | 45.000 | - |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Completed systems requirements review.<br><br>***FY 2011 Plans:***<br>- Conduct simulations to validate subsystem detailed designs.<br>- Conduct risk reduction testing and demonstrations of key PGC component technologies and subsystems.<br>- Begin CVC engine compressor.<br>- Mature and validate critical PGC enabling technologies and analytical tools.<br>- Design, procure and begin assembly and instrumentation of a PGC module test rig. | | | |
| ***Title:*** DiscRotor Compound Helicopter<br><br>***Description:*** The goal of the DiscRotor program is to design and demonstrate the enabling technologies required to develop a new type of compound helicopter capable of high-efficiency hover and high-efficiency, high-speed flight, with stable, continuous and reversible transition between these flight states. The aircraft concept features a mid-fuselage disc with extendable rotor blades, and an aft swept wing. With the rotor blades extended and the disc rotating, the aircraft can operate like a helicopter with vertical take-off, efficient hover, controllable low speed flight and vertical landing. With the blades retracted, the aircraft is capable of efficient wing-borne cruise at speeds exceeding any existing rotorcraft, 2-3 times that of a conventional helicopter. Transition from helicopter mode to fixed-wing flight is achieved by fully retracting the blades within the disc. An aircraft capable of long range (400 nm), high speed (350-400 kts) and vertical take-off and landing /hover will provide new capabilities to the warfighter, bridging the gap between helicopter and fixed-wing aircraft by providing improved survivability, mobility, and responsiveness for troop and cargo insertion, combat search and rescue, armed escort, and other critical missions. The DiscRotor enabling technologies are: extendable/retractable telescoping rotor blades, counter torque control, high-efficiency ducted propellers, and an integrated propulsion system. Specific objectives of the DiscRotor program include: demonstrating the feasibility of safely and repeatedly retracting/extending the blades into the disc in forward flight, characterizing the flowfield environment created by a disc-rotor, demonstrating disc-rotor enabling technologies, and designing and wind tunnel testing a retractable rotor demonstrator. Potential transition partners include the Army, Navy, Marines, Air Force, Coast Guard, and SOCOM.<br><br>***FY 2010 Accomplishments:***<br>- Conducted testing of a subscale rotor in a hover test rig.<br>- Completed preliminary design of 12 foot diameter large-scale extendable/retractable rotor model.<br>- Conducted forward flight wind tunnel testing of small-scale (5%) air vehicle and hover testing of small scale (non-retractable) rotor model.<br>- Continued analysis and refinement of operational air vehicle configuration. | 4.819 | 2.210 | - |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Continued refinement of computational fluid dynamics analyses and predictions.<br><br>***FY 2011 Plans:***<br>- Conduct testing of a subscale rotor and fuselage in a hover test rig.<br>- Continue refinement of operational air vehicle configuration.<br>- Complete critical design of 12 foot diameter large-scale extendable/retractable rotor model.<br>- Complete fabrication and check-out of 12 foot diameter large-scale extendable/retractable rotor model.<br>- Test extensions and retractions of the 12 foot diameter large-scale rotor model in a wind-tunnel under simulated conversion conditions.<br>- Validate DiscRotor conceptual approach, risk assessment, and definition of demonstrator requirements. | | | |
| ***Title:*** Mode Transition (MoTr) Demonstration<br><br>***Description:*** The Mode Transition (MoTr) Demonstration program seeks to ground test a turbine-based combined-cycle (TBCC) engine using hydrocarbon fuel. The MoTr program will demonstrate transition from turbojet to ramjet/scramjet cycle and is the critical experiment required to enable reusable, air-breathing, hypersonic flight. MoTr leverages previous and on-going advances in air-breathing propulsion technology, including the Falcon Combined-cycle Engine Technology (FaCET) and the Air Force/ DARPA High Speed Turbine Engine Technology Demonstration (HiSTED) program. The anticipated transition partner is the Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Completed preliminary design of a TBCC engine model.<br>- Completed preliminary design of primary testing modifications.<br><br>***FY 2011 Plans:***<br>- Complete critical design of a TBCC engine model.<br>- Complete critical design of primary testing modifications.<br>- Initiate demonstration hardware fabrication.<br>- Complete primary test rig modifications and checkouts. | 5.055 | 24.000 | - |
| ***Title:*** Shrike<br><br>***Description:*** The goal of the Shrike program was to develop a new generation of perch-and-stare micro air vehicles based on the Wasp platform which would be capable of: 1) vertical launch, 2) forward flight to a target, 3) transition from forward flight to vertical landing at the target site, 4) secure, stable attachment to its perch, 5) sustained perch-and-stare missions, to include | 4.278 | - | - |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| data collection, and 6) re-launch from the perch and fly home. Anticipated Service users include the Army, Marines, and Special Forces.<br><br>***FY 2010 Accomplishments:***<br>- Refined and improved prototype designs based on field testing.<br>- Developed auto-pilot for semi autonomous landing.<br>- Developed and demonstrated schemes for exploitation of digital communications.<br>- Developed reduced operator footprint design.<br>- Fabricated second increment Shrike prototypes. | | | |
| **Accomplishments/Planned Programs Subtotals** | 253.848 | 303.078 | 98.878 |

## D. Other Program Funding Summary ($ in Millions)

| Line Item | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| • Integrated Sensor is Structure: *Air Force PE 0305205F Project 675372F* | 48.533 | 0.000 | 53.000 | 0.000 | 53.000 | 21.000 | 8.000 | 0.000 | 0.000 | Continuing | Continuing |
| • Integrated Sensor is Structure-: *Air Force PE 0603203F Project 665A* | 0.200 | 2.100 | 2.800 | 0.000 | 2.800 | 9.400 | 1.000 | 0.000 | 0.000 | Continuing | Continuing |
| • LRASM: *Navy* | 35.100 | 67.560 | 24.510 | 0.000 | 24.510 | 0.000 | 0.000 | 0.000 | 0.000 | Continuing | Continuing |
| • Triple Target Terminator (T3): *Air Force* | 4.690 | 8.930 | 27.050 | 0.000 | 27.050 | 41.730 | 0.000 | 0.000 | 0.000 | Continuing | Continuing |

## E. Acquisition Strategy

N/A

## F. Performance Metrics

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 172.728 | 98.130 | 97.541 | - | 97.541 | 138.704 | 213.546 | 211.308 | 211.308 | Continuing | Continuing |
| SPC-01: *SPACE PROGRAMS AND TECHNOLOGY* | 172.728 | 98.130 | 97.541 | - | 97.541 | 138.704 | 213.546 | 211.308 | 211.308 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

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

Systems development is also required to increase the interactivity of space systems, space-derived information and services with terrestrial users. Studies under this project include technologies and systems that will enable satellites and microsatellites to operate more effectively by increasing maneuverability, survivability, and situational awareness; enabling concepts include solar thermal propulsion, novel ion-thruster applications, payload isolation and pointing systems.

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 183.477 | 98.130 | 97.395 | - | 97.395 |
| Current President's Budget | 172.728 | 98.130 | 97.541 | - | 97.541 |
| Total Adjustments | -10.749 | - | 0.146 | - | 0.146 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | -5.882 | - | | | |
| • SBIR/STTR Transfer | -4.867 | - | | | |
| • TotalOtherAdjustments | - | - | 0.146 | - | 0.146 |

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**Congressional Add Details ($ in Millions, and Includes General Reductions)**

| | FY 2010 | FY 2011 |
|---|---|---|
| **Project:** SPC-01: *SPACE PROGRAMS AND TECHNOLOGY* | | |
| Congressional Add: *Mosaic Camera Technology Transition* | 1.600 | - |
| Congressional Add Subtotals for Project: SPC-01 | 1.600 | - |
| Congressional Add Totals for all Projects | 1.600 | - |

**Change Summary Explanation**

FY 2010: Decrease reflects internal below threshold reprogramming and SBIR/STTR transfer offset by the new start authorization.
FY 2012: Increase reflects minor repricing offset by a reduction for Defense Efficiencies for contractor staff support.

| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***Title:*** System F6 | 65.000 | 40.000 | 40.000 |
| ***Description:*** The objective of the System F6 program is to demonstrate the feasibility and benefits of a satellite architecture wherein the functionality of a traditional "monolithic" spacecraft is replaced by a cluster of wirelessly-interconnected spacecraft modules. Each such "fractionated" module would contribute a unique capability, e.g., computation and data handling, communications relay, guidance and navigation, payload sensing, etc., or it can replicate the capability of another module. The fractionated modules would fly in a loose, proximate cluster orbit capable of semi-autonomous reconfiguration or a rapid defensive scatter/re-gather maneuver. Critical to this architecture is a robust, system-level approach to ensuring security, integrity, and availability, while implementing authentication and non-repudiation. While delivering a comparable mission capability to a monolithic spacecraft, System F6 significantly enhances architectural and programmatic adaptability and robustness-reducing risk through the mission life and spacecraft development cycle, enabling incremental deployment of the system, and enhancing survivability. The System F6 architecture provides valuable options to decision makers throughout the life cycle development of future space systems that are absent in present-day monolithic architectures.<br><br>The System F6 program will culminate in an on-orbit demonstration of a multi-module space system incorporating the F6 Technology Package-a suite of technologies, components, and algorithms which enables semi-autonomous multi-body cluster flight and secure, distributed, real-time sharing of various spacecraft resources at the cluster level. Multiple version of the F6 Technology Package will be developed on the basis of open-source interface standards, software, and reference designs. The on-orbit demonstration will be capable of accommodating one or more spacecraft payload modules supplied by a third-party mission partner. Residual capability to support future payloads with the existing on-orbit infrastructure will also remain, and the infrastructure can be upgraded for a perpetual on-orbit resource capability. The utility of the F6 architecture in low earth orbit (LEO) is significantly enabled by persistent broadband connectivity to the ground which allows resource sharing between space- | | | |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| based modules and terrestrial network nodes. A solution to enable high-availability, low-latency, persistent, high-bandwidth communications with LEO spacecraft will be developed in the course of the F6 program. The anticipated transition partner is the Air Force, though the architecture will have the ability to simultaneously accommodate payloads from multiple other partners including the Army and Navy, the resultant architecture is expected to significantly lower the barrier to entry and enhance competiveness of the national security space industrial base.<br><br>***FY 2010 Accomplishments:***<br>- Began development of a persistent broadband terrestrial connectivity solution for low-earth-orbit fractionated clusters.<br>- Commenced development of an information assurance architecture for the F6 space data network.<br>- Developed a preliminary draft of the F6 Developer's Kit (FDK).<br>- Restructured program to focus on architecture, open standards, interfaces, and F6 Technology Packages (F6TP).<br>***FY 2011 Plans:***<br>- Continue development of open-source interface standards, software, and reference hardware models for the F6 Developer's Kit (FDK).<br>- Conduct preliminary design review for the persistent broadband terrestrial connectivity solution for LEO fractionated clusters.<br>- Conduct critical design review for the persistent broadband terrestrial connectivity solution for LEO fractionated clusters.<br>***FY 2012 Plans:***<br>- Complete development and beta release of the FDK.<br>- Continue FDK software testing and verification.<br>- Begin build of one or more F6TP based on FDK specification.<br>- Perform end-to-end hardware-in-the-loop testing of the persistent broadband terrestrial connectivity solution for LEO fractionated clusters. | | | |
| ***Title:*** Space Domain Awareness (SDA)*<br>***Description:*** *Formerly Space Situational Awareness (SSA) & Counterspace Operations Response Environment (SCORE)<br><br>The goal of the Space Domain Awareness (SDA) program is to develop and demonstrate an operational framework and responsive defense application to enhance the availability of vulnerable space-based communications resources. SDA will investigate revolutionary technologies in two areas: 1) advanced space surveillance sensors to better detect, track, and characterize space objects, with an emphasis on deep space objects, and 2) space surveillance data processing/data fusion to provide automated data synergy, to increase space domain awareness, overall space safety of flight, and ultimately to allow space operators to make informed, timely decisions. Current space surveillance sensors cannot detect, track, or determine the future | 2.052 | 9.000 | 20.000 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|

location and threat potential of small advanced technology spacecraft in deep space orbits, where a majority of DoD spacecraft are located. Additionally, manned servicing missions to geosynchronous (GEO) orbits will require exquisite situational awareness, from ultra high-accuracy debris tracking for safety of flight at GEO orbits to high resolution imaging of GEO spacecraft for service mission planning. The SDA program will leverage data fusion and advanced algorithms developed under the SST program, as well as seek to exploit new ground-breaking technologies across the electromagnetic spectrum and utilize already existing sensor technology in non-traditional or exotic ways, to bring advanced capabilities to the space domain. SDA will correlate a wide range of operational support and space system user data to rapidly identify threat activities, propose mitigating countermeasures, and verify the effectiveness of selected responses. Critical technologies include accessing disparate sources of relevant data, model-based situational awareness, and candidate response generation and evaluation. Particular emphasis will be placed on the ability to continuously adapt to changes in defended system components and usage patterns as well as validation of system integrity. The potential transition customer is the Air Force.

***FY 2010 Accomplishments:***
- Developed algorithms and software required to integrate disparate information into a single framework.
- Integrated software environment into a suite of visualization products that provide situational awareness and decision making tools.
- Conducted operational scenario testing of system, and refined algorithms and software.

***FY 2011 Plans:***
- Survey existing systems and identify critical technology gaps.
- Initiate data fusion modeling effort to determine limitations of currently developed algorithms.
- Begin investigating the applicability of using a dynamic track graph algorithmic approach to achieve timely cataloging of breakups and collisions.
- Evaluate high resolution passive imaging of GEO satellites using incoherent intensity correlation imaging.
- Investigate using remote ultra-low light imaging technology to significantly enhance incoherent intensity correlation for GEO-imaging.

***FY 2012 Plans:***
- Develop prototype next-generation collaborative space information fusion center to provide a revolutionary approach to integrating, collaborating and visualizing complex space system and environmental data, enabling operators to make informed decisions to protect critical space capabilities; concepts to be explored include intuitive applications and adaptive understanding.
- Develop architecture for low cost space situational awareness (SSA) data sources, initial sensors will focus on small, ultra wide field of view optical systems.
- Develop additional SSA data integration algorithms to incorporate cyber initiatives into the space information fusion center.

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Expand the concept of dynamically tasked sensors so that the entire SSA network is continuously optimized and capable of responding to any highlighted space threat. | | | |
| ***Title:*** XTIM<br><br>***Description:*** XTIM is an autonomous system of determining timing and positioning of space assets using X-ray pulsars and then broadcasting this information for navigation and time uses independent of, and supplemental to, GPS. XTIM autonomously calculates its position and absolute time from celestial sources. XTIM then broadcasts this information to users either on the ground or in space as a method to enhance their navigation solutions. In addition, XTIM reference data can be used to update the GPS constellation ephemerides and timing with limited or no ground support. XTIM also provides an alternative timing source that can be used as a checksum for GPS receivers to insure detection of spoofing or sophisticated jamming attacks. XTIM leverages previous work by DARPA which analytically demonstrated that X-ray pulsars could be used for navigation of space assets. XTIM will create a truly autonomous and universal time reference for military navigation and communication needs. The anticipated transition partner is the Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Designed an architecture utilizing XTIM to seamlessly integrate into the current pointing, navigation and timing systems allowing them to utilize the strengths of the autonomous nature of XTIM to defeat current vulnerabilities.<br>***FY 2011 Plans:***<br>- Design a geosynchronous orbit demonstration mission to be launched aboard an evolved expendable medium class launch vehicle and proceed through preliminary design review.<br>- Perform an X-ray beam line test of the brass board design to demonstrate feasibility of X-ray detection and timing.<br>- Perform an electron background rejection measurement of the brass board design to demonstrate feasibility of the geosynchronous background mitigation concept.<br>- Conduct preliminary design review.<br>***FY 2012 Plans:***<br>- Conduct critical design review.<br>- Begin construction of a space qualified XTIM payload in support of a launch. | 6.000 | 7.000 | 8.041 |
| ***Title:*** Membrane Optic Imager Real-Time Exploitation (MOIRE)*<br><br>***Description:*** *Formerly Big Eye | 5.000 | 5.000 | 10.000 |

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| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| Leveraging advanced membrane optics demonstrating photon sieve optics, the Membrane Optic Imager Real-Time Exploitation (MOIRE) program will enable the technology for very large aperture optics for space platforms. MOIRE utilizes the fact that photon sieve optics can achieve diffraction limited images for very large structures where flatness is the primary concern. MOIRE will demonstrate the manufacturability of large membranes (up to 20 meters), large structures to hold the optics tight and flat, and also demonstrate the secondary optical elements needed to turn a diffraction based optic (such as photon sieve) into a wide bandwidth imaging device. MOIRE will end with a technology demonstration that significantly reduces the risk of using these types of optics for flight development. The anticipated transition partner is the Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Began system engineering to identify the system requirements which a large (20 m) optic would need to satisfy to obtain near diffraction limited images at geo-synchronous orbit.<br>***FY 2011 Plans:***<br>- Complete system engineering to identify the system requirements which a large (20 m) optic would need to satisfy to obtain near diffraction limited images at geo-synchronous orbit.<br>- Design, construct, and test an optic at least 1 m in diameter which shows how the material qualities needed for orbit could be obtained.<br>- Conduct payload preliminary design review for a 10 m demonstration system.<br>- Conduct system concept design review for a 10 m demonstration at geo-synchronous orbit.<br>***FY 2012 Plans:***<br>- Design, construct and test an optic at least 5 m in diameter which shows how the material qualities needed for orbit could be obtained.<br>- Conduct a system preliminary design review for a 10 m demonstration at geo-synchronous orbit. | | | |
| ***Title:*** Manned Geostationary Earth Orbit (GEO) Servicing<br><br>***Description:*** The Manned Geostationary Earth Orbit (GEO) Servicing program, an outgrowth of the FREND program, will investigate the feasibility, risks, and technologies necessary for human and robotic servicing of spacecraft in GEO. To date, servicing operations have not been conducted on spacecraft beyond LEO. A large number of national security and commercial space systems operate at GEO altitudes, furthermore, many end-of-life or failed spacecraft drift without control through portions of the GEO belt, creating a growing hazard to operational spacecraft. DARPA has previously pursued technologies for servicing of spacecraft with the expectation such servicing would involve a mix of highly autonomous and remotely (i.e., ground-based) teleoperated robotic systems. The Manned GEO Servicing program will build upon this DARPA legacy, tackling the more complex GEO environment, and developing technologies to allow for both human and robotic servicing. Key challenges include | - | 4.000 | 8.500 |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| transportation and orbital maneuvering, life support, radiation protection, robotic systems and integration, and extravehicular tool requirements. The anticipated transition partners are NASA and the Air Force.<br><br>***FY 2011 Plans:***<br>- Identify and evaluate flight/ground servicing experience, satellite failures, and candidate servicing missions.<br>- Define preliminary mission architecture and technology trade space to enable human and robotic GEO servicing missions.<br>- Investigate technologies for key requirements of manned servicing, for both intravehicular and extravehicular activity.<br>***FY 2012 Plans:***<br>- Perform conceptual mission design and feasibility studies.<br>- Perform conceptual design of selected demonstration mission, focusing on system architecture and key technology gaps. | | | |
| ***Title:*** Single Wafer Integrated Femto Satellites (SWIFT)*<br>***Description:*** *Formerly Advanced Nano/Micro-Satellite Technology for Tactical Applications<br><br>The goal of the Single Wafer Integrated Femto Satellites (SWIFT) program is to demonstrate critically needed technologies enabling a very small (nano- and micro-) satellite constellation for persistent tactical military applications. SWIFT will develop, fabricate, and demonstrate fully functional "femtosat" spacecraft (less than 100 grams) which can enable new missions not currently possible with singular monolithic satellites by means of an adaptable hardware architecture and microfabrication technologies. Swarms of femtosats are ideally suited for distributed missions, such as sparse aperture arrays for remote sensing or fly-around inspectors for larger spacecraft. The U.S. Army, U.S. Air Force, intelligence community, and other potential users have identified such small satellites as a potential technical approach for delivering affordable support to the tactical warfighter. By deploying large numbers of very low cost nano-satellites in distributed constellations a persistent effect can be provided to terrestrial forces. Today's technology limits the ability to do this and advances in key areas are needed to make this vision a reality. Specifically, nanosatellites lack sufficient power, communications, propulsion and imaging capacity to address many tactical needs. Key technologies include: deployable communications antennas, crosslink communications, interferometric technologies, small imaging systems, attitude control subsystems, efficient solar electric arrays, efficient maneuver capability, efficient upper stages, and revolutionary manufacturing techniques. The anticipated transition partner is the Air Force.<br><br>***FY 2011 Plans:***<br>- Conduct trade study of available technologies and investment opportunities.<br>- Initiate concept design.<br>***FY 2012 Plans:***<br>- Perform military utility analysis and develop concepts of operation. | - | 2.400 | 3.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | R-1 ITEM NOMENCLATURE<br>PE 0603287E: *SPACE PROGRAMS AND TECHNOLOGY* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Conduct fabrication test run to validate novel fabrication technologies.<br>- Perform detailed femtosat design and analysis. | | | |
| ***Title:*** Horizontal Launch*<br>***Description:*** *Formerly Responsive, Reliable Access to Space Program (R2A2 Space)<br><br>The goal of the Horizontal Launch program is to mature and demonstrate technologies for low cost, routine, reliable, horizontal access to low earth orbit (LEO). The program will explore launch to LEO concepts for payload classes between 5,000 and 20,000 lbs, and will consider overall launch architectures to include ground processing flows, ground handling and associated infrastructure, methods for reducing turnaround time, and flexible basing. Combinations of reusable or expendable upper stages and hydrocarbon versus hydrogen fuels will be examined. Enabling technologies include composite or light weight structures, integral load bearing propellant tanks, thermal management systems, high energy density propulsion systems, advanced guidance and controls, rocket back maneuvering for a reusable first stage, and advanced upper stages. The program will validate critical technologies on the ground and, where practical, demonstrate them in flight. Where feasible, flight testing will leverage the substantial ongoing entrepreneurial private sector investments. The anticipated transition partner is the Air Force.<br><br>***FY 2011 Plans:***<br>- Conduct market/business case analysis for horizontal launch concepts.<br>- Analyze alternative infrastructure options including cost considerations.<br>***FY 2012 Plans:***<br>- Perform conceptual design of selected architecture focusing on key technology gaps.<br>- Initiate preliminary design. | - | 5.000 | 8.000 |
| ***Title:*** Fast Access Spacecraft Testbed (FAST)<br>***Description:*** The goal of the Fast Access Spacecraft Testbed (FAST) program is to demonstrate a suite of critical technologies including high efficiency solar cells, sunlight concentrating arrays, large deployable structures, and ultra light weight solar arrays. These technologies enable light-weight, high efficiency, and high-power satellites of 20kW scalable to 80kW or more. The specific power goal is 130 W/Kg yielding an ultra light-weight power system of approximately 230 Kg for a 30 kW array. Combined with electric propulsion, FAST enables fast-transfer roaming satellites with nearly five times the fuel efficiency of conventional chemical propulsion. For example, FAST will permit on-demand access to any point on the geosynchronous ring or within the high-altitude, super synchronous "graveyard" (where derelict systems are regularly repositioned in order to free up orbital slots within the ring), greatly improving our ability to rapidly deploy and reposition satellites, as well as monitor the geosynchronous environment. Alternatively, FAST will permit responsive launch capabilities including deployment of small geosynchronous | 9.347 | 3.290 | - |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| satellites on small launch vehicles. Scaled up systems will nearly double the effective satellite mass launched to high altitude orbits today, significantly downsizing the need for large launch vehicles. The anticipated transition partner is the Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Conducted 30-day ground test of a FAST solar wing segment (10%) in thermal vacuum chamber to characterize key performance metrics including heat rejection capability, optical performance, and power generation capability.<br>- Demonstrated full-scale mechanical deployment of FAST solar concentrator wing under 1g conditions.<br>***FY 2011 Plans:***<br>- Conduct system level testing of FAST technology to support future orbital demonstrations.<br>- Conclude data analysis from test campaign and finalize test report. | | | |
| ***Title:*** Space Surveillance Telescope (SST)<br><br>***Description:*** The Space Surveillance Telescope (SST) program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. A major goal of the SST program is to develop the technology for large curved focal surface array sensors to enable an innovative telescope design combining high detection sensitivity, short focal length, wide field of view, and rapid step-and-settle to provide orders of magnitude improvements in space surveillance. This capability will enable ground-based detection of un-cued objects in deep space for purposes such as asteroid detection and space defense missions. The Air Force will participate in the DARPA funded developmental testing of SST and then take over operation of SST as a sensor in the Air Force Space Surveillance Network. An MOA has been established with Air Force Space Command (AFSPC) for transition.<br><br>In addition, the program will investigate data fusion and advanced algorithms for correlation of unknown objects. SST is expected to generate a large number of uncorrelated targets (UCTs), and new methods will need to be employed to rapidly characterize and attribute the new objects. Furthermore, the program will investigate methods which combine observations from disparate sensors (such as optical and radar installations) to more rapidly, accurately, and completely provide knowledge about UCTs, as compared to the existing system where no data fusion is employed. Where appropriate, SST will investigate new concepts which would provide complementary or further advances in ground-based deep space object detection and characterization.<br><br>***FY 2010 Accomplishments:***<br>- Assembled rapid slewing telescope mount on site.<br>- Completed integration and testing of high-speed shutter and mosaic, curved focal plane array.<br>- Completed fabrication of primary and secondary telescope mirrors.<br>- Initiated integration of telescope elements (optics, gimbal mount) on site. | 14.960 | 10.840 | - |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Completed a survey of multi-aperture optical survey technologies.<br>- Performed parametric trades to define candidate architectures.<br>- Initiated development of algorithms for complex field reconstruction from sensor data.<br>- Conducted experiments to determine image resolution capabilities of system prototype for near-horizontal 149km propagation.<br><br>***FY 2011 Plans:***<br>- Finish optics integration on site.<br>- Integrate camera and data processing subsystems at site.<br>- Complete initial alignment of full SST system ("First Light").<br>- Perform final focus and alignment.<br>- Evaluate demonstration activities and SST mission functionality.<br>- Validate SST system performance and demonstrate surveillance operations.<br>- Investigate data processing algorithms to enhance contribution of SST data to SSA.<br>- Investigate data fusion capabilities to enhance SSA through use of multiple optical sensors (multi-static observations, track handoffs).<br>- Complete demonstration and transition system to AFSPC.<br>- Complete targeted multi-aperture alternative trade studies and more detailed concept evaluations.<br>- Initiate multi-aperture alternative proof of concept technology demonstrations.<br>- Develop compensation and timing algorithms for maximum resolution improvement and near-real-time processing.<br>- Develop capability for dynamic sensor tasking, resident space object signature analysis threat binning, and positive object identification. | | | |
| ***Title:*** Multi-Aperture Geosynchronous (GEO) Imager (MAGI)<br><br>***Description:*** The goal of the Multi-Aperture Geosynchronous (GEO) Imager (MAGI) program is to demonstrate a segment of a world-wide millimeter wave (MMW) surveillance capability by combining radar and radio astronomy technologies and techniques. By merging interferometric receiving and correlation techniques, used by radio astronomers for decades, with high power narrow-band radar transmitter technologies, MAGI hopes to prove the capability to obtain an order of magnitude improvement in imaging resolution of GEO and near-GEO satellites. A low cost demonstration using the NASA Goldstone X-Band radar and existing radio astronomy assets (the National Radio Astronomy Organization's Very Long Baseline Array) will be conducted to prove the concept at X-band. Based on resolution requirements, the follow-on prototype demonstration will be at MMW (~90GHz) and, to the greatest extent practicable, will utilize COTS MMW antennas and high power narrow-band transmitters. The anticipated transition partner is the Air Force.<br><br>***FY 2010 Accomplishments:*** | 4.749 | 2.600 | - |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Conducted second measurement campaign on candidate deep space objects.<br>- Refined algorithms.<br>- Began development of requirements and system concept for a prototype MAGI system.<br><br>***FY 2011 Plans:***<br>- Conduct additional measurement campaigns.<br>- Survey current state of the art and developmental MMW technologies to provide a development plan for high power sources that could be used for the prototype demonstration.<br>- Investigate co-operative use of the bistatic radar and very long baseline interferometry data to improve satellite state vector information.<br>- Perform MMW radar measurements of satellite mock-ups in the lab to simulate the MAGI experiment to more accurately predict and understand the results of the imaging campaigns. | | | |
| ***Title:*** Front-end Robotics Enabling Near-term Demonstration (FREND)<br><br>***Description:*** The goal of the Front-end Robotics Enabling Near-term Demonstration (FREND) program is to develop, demonstrate, and fly robotic manipulator technologies designed to allow interaction with geosynchronous orbit (GEO)-based military and commercial spacecraft, extending their service lives and permitting satellite refueling, repair, refurbishment, repositioning or retirement. Existing GEO spacecraft are outfitted with sufficient propellant to provide for needed station keeping, repositioning, and retirement maneuvers, which in many cases defines their useful mission durations. Once the propellant is expended, the vehicle is retired and, in many cases, replaced. FREND technologies can enable significant service extension to these spacecraft through re-boosting near end-of-life. FREND technologies may also be applied to crewed servicing vehicles to provide robotic assistance to manned GEO servicing missions.<br><br>Recent events have significantly increased the number of objects/debris in low earth orbit (LEO), particularly in orbital planes of most interest to DoD users, causing an increased threat to safe space operations. FREND combines detailed photogrammetric and laser imaging with robotic multi-degree-of-freedom manipulators to autonomously grapple space objects not outfitted with custom interfaces. A FREND-based servicing spacecraft offers the potential for spacecraft salvage, repair, rescue, reposition, de-orbit and retirement, and debris removal. The program will examine possible solutions for all classes of LEO debris to determine the most economical technical solution set to mitigating the problem. In addition, FREND will investigate neurorobotics as a potential replacement for the baseline suite of algorithms (e.g., arm trajectory planning, vehicle pose estimation, grapple feature identification, or compliance control) required to dock multiple robotic arms with a client spacecraft. The anticipated transition partner is the Air Force.<br><br>***FY 2010 Accomplishments:*** | 12.000 | 9.000 | - |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated application of neurorobotic technology to FREND payload in "earth's gravity" environment.<br>- Investigated the application of FREND technologies to support human GEO servicing spacecraft.<br><br>***FY 2011 Plans:***<br>- Conduct technology and utility trade studies to model the LEO debris problem, identify significant risks to operational assets, and determine possible technological solutions.<br>- Develop debris remediation conceptual designs. | | | |
| ***Title:*** Falcon<br><br>***Description:*** The Falcon program objectives are to develop and demonstrate hypersonic technologies that will enable prompt global reach missions. The technologies include high lift-to-drag techniques, high temperature materials, precision navigation, guidance and control, communications through plasma, and an autonomous flight safety system. Falcon addresses the implications of long range hypersonic flight using the Hypersonic Technology Vehicle (HTV-2). The HTV-2 program will demonstrate enabling hypersonic technologies for future operational systems through rocket-boosted hypersonic flights with sufficient cross-range and downrange performance to evaluate thermal protection systems, aerodynamic shapes, maneuverability, and long-range communication for hypersonic cruise and re-entry vehicle applications. 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 the HTV-2 program in May 2003 and with NASA in October 2004. Since 2008, the effort has been jointly funded with the Office of Secretary of Defense Global Strike program office. Falcon capabilities are planned for transition to the Air Force with data enabling further Conventional Prompt Global Strike (CPGS) developments in support of OSD efforts in this area.<br><br>***FY 2010 Accomplishments:***<br>- Completed assembly, integration and testing (AI&T) of first HTV-2 vehicle.<br>- Completed second flight vehicle aeroshell.<br>- Completed first Minotaur IV Lite Launch Vehicle.<br>- Completed integration and stacking of HTV-2 vehicle to Minotaur IV Lite Launch Vehicle.<br>- Successfully executed largest ever stationary and mobile (land, sea, air, and space) test asset deployment for hypersonic flight test in support of 100% real-time telemetry collection.<br>- Completed first successful flight of Minotaur IV Lite Launch Vehicle.<br>- Conducted flight test of first HTV-2 vehicle incorporating next generation hypersonic technologies.<br>- Performed post-flight data reduction and analysis assessing technology performance in flight regime.<br>- Complete AI&T of second HTV-2 vehicle.<br>- Complete second Minotaur IV Lite Launch Vehicle.<br>- Execute flight test of second HTV-2 vehicle. | 24.170 | - | - |

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| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Perform post-flight data reduction to assess hypersonic flight performance of the Minotaur IV and HTV-2 flight vehicle.<br>- Transition technology development products to continue further maturation of OSD funded CPGS programs. | | | |
| ***Title:*** Integrated Sensor is Structure (ISIS)<br><br>***Description:*** The joint DARPA/Air Force Integrated Sensor is Structure (ISIS) program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship that will address the nation's need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly integrated lightweight multi-purpose airship structure - completely erasing the distinction between payload and platform. The ISIS concept includes ninety-nine percent on-station 24/7/365 availability for simultaneous airborne moving target indicator (600 kilometers) and ground-based moving target indicator (300 kilometers) operation; ten years of autonomous, unmanned flight; hundreds of wideband in-theater covert communications links; responsive reconstitution of failed space assets; plus CONUS-based sensor analysis and operation. An MOA has been signed by DARPA and the Air Force to pursue the program objectives through to transition. Starting in FY 2010, this program has also been budgeted in PE 0603286E, Project AIR-01. The ISIS technology demonstration system transitions to the Air Force in 2013.<br><br>***FY 2010 Accomplishments:***<br>- Conducted preliminary design review of demonstration system.<br>- Conducted radar system operational modeling and simulation.<br>- Developed and demonstrated flight dynamic controls in a lab environment.<br>- Demonstrated large-scale manufacturing of prototypes and initial integration.<br>- Conducted radar and power system critical design reviews. | 27.850 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 171.128 | 98.130 | 97.541 |

| | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** Mosaic Camera Technology Transition<br><br>***FY 2010 Accomplishments:*** - Continue research into the transition of mosaic camera technology. | 1.600 | - |
| **Congressional Adds Subtotals** | 1.600 | - |

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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## D. Other Program Funding Summary ($ in Millions)

| Line Item | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| • Falcon: *OSD* | 44.016 | 38.631 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | Continuing | Continuing |

## E. Acquisition Strategy

N/A

## F. Performance Metrics

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

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 192.611 | 197.098 | 160.286 | - | 160.286 | 111.499 | 114.843 | 124.903 | 123.003 | Continuing | Continuing |
| MT-07: *CENTERS OF EXCELLENCE* | 7.000 | - | - | - | - | - | - | - | - | Continuing | Continuing |
| MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY* | 72.301 | 85.835 | 70.053 | - | 70.053 | 44.466 | 44.355 | 46.642 | 46.642 | Continuing | Continuing |
| MT-15: *MIXED TECHNOLOGY INTEGRATION* | 113.310 | 111.263 | 90.233 | - | 90.233 | 67.033 | 70.488 | 78.261 | 76.361 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

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

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

The Centers of Excellence project provided funding to finance the demonstration, training and deployment of advanced manufacturing technology at Marshall University.

| **Exhibit R-2**, **RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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| **B. Program Change Summary ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012 Base** | **FY 2012 OCO** | **FY 2012 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 194.094 | 197.098 | 151.274 | - | 151.274 |
| Current President's Budget | 192.611 | 197.098 | 160.286 | - | 160.286 |
| Total Adjustments | -1.483 | - | 9.012 | - | 9.012 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | 3.665 | - | | | |
| • SBIR/STTR Transfer | -5.148 | - | | | |
| • TotalOtherAdjustments | - | - | 9.012 | - | 9.012 |

**Congressional Add Details ($ in Millions, and Includes General Reductions)**

| | **FY 2010** | **FY 2011** |
|---|---|---|
| **Project:** MT-07: *CENTERS OF EXCELLENCE* | | |
| Congressional Add: *Advanced Flexible Manufacturing* | 7.000 | - |
| Congressional Add Subtotals for Project: MT-07 | 7.000 | - |
| Congressional Add Totals for all Projects | 7.000 | - |

**Change Summary Explanation**

FY 2010: Decrease reflects internal below threshold reprogrammings and the SBIR/STTR transfer.
FY 2012: Increase reflects repricing, offset by a reduction for Defense Efficiencies for contractor staff support.

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MT-07: *CENTERS OF EXCELLENCE* | 7.000 | - | - | - | - | - | - | - | - | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 |
|---|---|---|
| ***Congressional Add:*** Advanced Flexible Manufacturing<br><br>***FY 2010 Accomplishments:*** - Modernized and increased the availability of shared manufacturing equipment at the four RCBI (Robert C. Byrd Institute) facilities, with selection of equipment based on focus group discussions and studies of manufacturers in the serviced region.<br>- Expanded the electronic procurement and bidding network, the RCBI 21st Century Manufacturing Network, to include procurement counseling assistance.<br>- Provided technical training to 600 people that represent 110 companies, including group and individual training formats.<br>- Continued semi-annual publication of the manufacturing report 'Capacity.' | 7.000 | - |
| **Congressional Adds Subtotals** | 7.000 | - |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

| **Exhibit R-2A, RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES* | **PROJECT**<br>MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY* | 72.301 | 85.835 | 70.053 | - | 70.053 | 44.466 | 44.355 | 46.642 | 46.642 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Chip-Scale Technology*<br>***Description:*** *Previously Chip-Scale Micro-Gas Analyzers.<br><br>The goal of the Chip-Scale Technology effort is to enhance Microsystems performance. The current focus of the program is to develop an efficient fluid distribution capability for on-chip vacuum pumps that meet the stress application requirements. Additionally, this program will refine microresonator capabilities to accept very narrow radio spectrum channels while canceling out or eliminating others. The Chip-Scale Technologies have the potential to improve the critical performance of Microsystems such as micro mass spectrometers, nanoscale detectors, RF resonators, and vacuum microelectronic components. There is a pressing need to significantly improve chip-scale micropump performance (capable of operating at ~10^-6 Torr in a volume smaller than 1 CM^3) and this program will develop a high-performance integrated low-power microscale pumping capability. Additionally, the microresonator effort has the potential to provide a universal communications receiver that is able to reconfigure and operate | 7.759 | 9.776 | 3.199 |

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

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| under any communication standard, anywhere from an urban setting to an outer space environment. The program will transition via industrial performers.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated a deep reactive ion-etched silicon turbo-molecular vacuum micropump with rotational frequency greater than 70 KHz.<br>- Demonstrated micromechanical vacuum on a chip operating at pressures less than 1 Torr.<br>- Demonstrated micromechanical resonator structures with quality factor Q > 100,000; separate demonstration of operating frequency greater than 3 GHz.<br>- Developed a new micromechanical resonator concept combining both capacitive and piezoelectric structural approaches to simultaneously achieve for high Q and low impedance.<br><br>***FY 2011 Plans:***<br>- Develop MEMS-based component capability with multiple stages to achieve vacuum pressures less than 1 mTorr.<br>- Continue to develop resonators with simultaneous high quality factor (>100,000), high frequency (> 3 GHz), and low impedance (< 50 Ohms).<br><br>***FY 2012 Plans:***<br>- Demonstrate the concept of a micromechanical signal processor directly coupled to a receive antenna. | | | |
| ***Title:*** Nano-Electro-Mechanical Computers (NEMS)<br><br>***Description:*** The goal of the Nano-Electro-Mechanical Computers (NEMS) 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 magnetoresistance, 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. Mechanical power supplies and mechanical vibrating clocks could facilitate production of electronics that are less susceptible to electromagnetic pulse attacks. Integrating nanomechanical elements in direct bandgap materials will circumvent problems of gate oxide stability, allowing fast logic with optics functionality. This program will transition into DoD systems via industrial program performers.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated NEMS devices and technologies for microcontroller building blocks - adders, counters, | 3.653 | 7.170 | 2.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| memories that can operate at very high temperatures.<br>***FY 2011 Plans:***<br>- Demonstrate capability to produce mixed signal mechanical components such as operational amplifiers, analog to digital converts and digital to analog converters.<br>***FY 2012 Plans:***<br>- Demonstrate capability to produce microcontrollers consisting of analog and digital building blocks based on NEMS devices. | | | |
| ***Title:*** Thermal Management Technologies (TMT)<br>***Description:*** The goal of the Thermal Management Technologies (TMT) program is to explore and optimize new nanostructured materials and other recent advances for use in thermal management systems. Innovative research is underway to go beyond evolutionary thermal management systems. Modern, high-performance heat spreaders, which use two-phase cooling, are being developed to replace the copper alloy spreaders in conventional systems. Enhancing air-cooled exchangers by reducing the thermal resistance through the heat sink to the ambient, increasing convection through the system, improving heat sink fin thermal conductivity, optimizing and/or redesigning the complimentary heat sink blower, and increasing the overall system (heat sink and blower) coefficient of performance is another thrust of this program. Another element of this effort is focused on novel materials and structures that can provide significant reductions in the thermal resistance of the thermal interface layer between the backside of an electronic device and the next layer of the package, which might be a spreader or a heat sink. The TMT program is an aggregation of: Thermal Ground Plane (TGP), Microtechnologies for Air-Cooled Exchangers (MACE), Nano Thermal Interfaces (NTI) and Active Cooling Modules (ACM) technology research. Technology will be inserted through DoD industrial firms into future DoD systems.<br>***FY 2010 Accomplishments:***<br>- Investigated active cooling of electronic devices using techniques such as thermoelectric coolers, sterling engines, etc.<br>- Demonstrated a full-performance high-thermal conductivity substrate with enhanced thermal conductivity, hermeticity, and lifetime in a scaled-up 3 cm x 3 cm < 2mm sample.<br>- Scaled up prototype air-cooled exchangers to a large, full-format heat sink.<br>- Developed prototype reworkable nanostructured thermal interfaces that exhibit better thermal conduction than conventional epoxy-based materials.<br>***FY 2011 Plans:***<br>- Deliver sample high thermal conductivity substrates to DoD labs (ARL, NSWC, AFRL) for testing against DoD application needs.<br>- Design customized substrates for customer-selected insertion opportunities.<br>- Design and build prototype active cooling module elements that demonstrate active cooler benefits. | 35.866 | 29.951 | 20.737 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Initiate efforts to reduce thermal resistance within the first 10 micrometers near a high-power electronic junction.<br>- Deliver enhanced heat exchangers for insertion demonstrations on mobile platforms.<br>- Demonstrate reliable, reworkable nanostructured thermal interface materials based on nanotubes, nanoplates and nanosprings with reduced thermal resistance.<br><br>***FY 2012 Plans:***<br>- Insert TGP substrates to demonstrate improvements in GaN Power amplifiers, High-Power T/R modules, high-density electronic systems, composite projectile casings, airborne radar modules, and other opportunities enabled by lightweight, flexible, highly-conductive heat spreaders.<br>- Complete insertion demonstrations for enhanced heat exchangers, and initiate transitions to platforms.<br>- Demonstrate 10x improvements over state of the art (SOA) for reworkable thermal interface materials.<br>- Demonstrate high active cooling modules for efficient operation of cooled electronic devices.<br>- Fabricate and demonstrate significant reductions in near-junction thermal resistance for manufacturable GaN power devices.<br>- Overall goal of TMT program: Insert breakthrough materials and structures at all layers of DoD systems, and enable higher power densities, increased performance, and improved efficiency. | | | |
| ***Title:*** Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)<br><br>***Description:*** The Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T) program is developing technology for self-contained chip-scale inertial navigation and precision guidance. This technology promises to effectively mitigate dependence on Global Positioning System (GPS) or any other external signals, and enable uncompromised navigation and guidance capabilities. The program will enable positioning, navigation and timing functions without the need for external information updates by employing on-chip calibration, thereby overcoming vulnerabilities which arise in environments where external updates are not available such as caves, tunnels, or dense urban locations. The technologies developed will enable small, low-power, micro-gyroscopes capable of operating in both moderate and challenging dynamic environments; chip-scale primary atomic clock standards; and on-chip calibration systems for error correction. Advance micro-fabrication techniques allow a single package containing all the necessary devices (clocks, accelerometers, gyroscopes and calibration) to be incorporated into a volume the size of a sugar cube. The small size, weight and power of these technologies and their integration into a single package responds to the needs of guided munitions, unmanned aerial vehicles and individual soldiers. The Micro PN&T program is an aggregation of Integrated Primary Atomic Clock, Information Tethered Microscale Autonomous Rotary Stages, Microsystem Integrated Navigation and Precision Navigation and Positioning Technologies. The technology is expected to transition through industry.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated navigation grade low-power gyroscope (20mW) in a small package (10 cubic centimeters). | 20.911 | 37.838 | 44.117 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Independently tested MEMS gyros and experimentally verified low bias drift of the angular rate response 0.05 degrees/hour and Angle Random Walk 0.01 [o/vhr].<br>- Demonstrated cold atom micro-primary standard physics package of 16 cubic centimeters.<br>- Demonstrated 10m @ 0.5hrs navigation accuracy during walking.<br>- Developed and demonstrated micro-fabrication technologies for creating new classes of MEMS navigation instruments that can be used for achieving high accuracy, GPS free navigation using zero-velocity updating.<br>- Initiated technology development efforts for demonstrating a complete physics package for an advanced miniaturizable atomic clock that can interrogate gaseous atoms and does not suffer from light shifts and buffer gas shifts that usually limit the use of hyperfine transition frequencies for applications to clocks.<br><br>***FY 2011 Plans:***<br>- Develop design architecture for low-cost, small size rate integrating gyroscopes to provide direct measurement of orientation and angular velocity.<br>- Demonstrate three-dimensional microfabrication techniques for rate integrating gyroscopes that are compatible with large scale manufacturing.<br>- Identify fabrication method to co-fabricate clocks and inertial sensors into a single low power package for navigation microsystems.<br>- Identify self-calibration techniques to compensate for long-term drift.<br><br>***FY 2012 Plans:***<br>- Demonstrate a microsystem rate integrating gyroscope to provide directly measured orientation and angular velocity.<br>- Demonstrate a microsystem that combines a functional timing and inertial measurement unit.<br>- Demonstrate the co-fabrication of an inertial sensor and a calibration stage to enable integration of error correction technologies on the same stage. | | | |
| ***Title:*** MEMS Exchange<br><br>***Description:*** The MEMS Exchange 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 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. | 1.459 | 1.100 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Implemented new state-of-the-art technical unit process capabilities to achieve greater effectiveness for creating MEMS devices, including electron-beam lithography, mixed transistor and MEMS process modules, and general purpose MEMS hermetic packaging.<br>- Initiated new quality control efforts to achieve higher reliability in manufacturing.<br>***FY 2011 Plans:***<br>- Optimize process cost efficiencies by increased marketing of MEMS Exchange capability.<br>- Improve self-sufficiency by providing a higher value to program users by improved yield and lower manufacturing costs. | | | |
| ***Title:*** Harsh Environment Robust Micromechanical Technology (HERMIT)<br>***Description:*** The Harsh Environment Robust Micromechanical Technology (HERMIT) program developed micromechanical devices that operate under harsh conditions (e.g., under large temperature excursions, large power throughputs, high g-forces, corrosive substances) while maintaining unprecedented performance, stability, and lifetime. Micromechanical RF switches were 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 were also addressed. Among the HERMIT implementation approaches pursued were: 1) wafer-level encapsulation or packaging strategies based on MicroElectroMechanical systems (MEMS) technology that isolates a micromechanical device from its surroundings while maintaining a desired environment via passive or active control; and 2) material and design engineering strategies that render a micromechanical device impervious to its environment with or without a package (if possible). The technology transitioned through Industry.<br>***FY 2010 Accomplishments:***<br>- Demonstrated hermetic packaging technology for advanced MEMS inertial gyroscopes and accelerometers. | 0.525 | - | - |
| ***Title:*** Low Power Micro Cryogenic Coolers (MCC)<br>***Description:*** The Low Power Micro Cryogenic Coolers (MCC) program achieved 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 was to selectively cool. Such an approach benefits 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. The technology transitioned through industry. | 2.128 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Demonstrated fully integrated Joule-Thompson micro-cooler capable of cooling from room temperature to 145 K.<br>- Combined hybrid integration of an integrated micro cryogenic cooler with a 3-5 micron HgCdTe infrared focal plane detector array.<br>- Designed a new low cost infrared focal plane detector architecture exploiting the full power of silicon microfabrication and direct MEMS materials integration. | | | |
| **Accomplishments/Planned Programs Subtotals** | 72.301 | 85.835 | 70.053 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MT-15: *MIXED TECHNOLOGY INTEGRATION* | 113.310 | 111.263 | 90.233 | - | 90.233 | 67.033 | 70.488 | 78.261 | 76.361 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

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

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** COmpact Ultra-stable Gyro for Absolute Reference (COUGAR)<br><br>***Description:*** The COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) program goal is to realize the fundamental performance potential of the resonant fiber optic gyro in combination with bandgap optical fiber (BGOF), ultra-stable compact lasers, phase conjugate elements, and silicon optical benches: a compact ultra-stable gyro for absolute reference applications. | 7.256 | 17.601 | 8.987 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| The COUGAR gyro will have a practical and typical size (~ 4 inch diameter) featuring bias stability and sensitivity (or angle random walk), which is more than 100 times better than state-of-the-art gyroscopes. This program will transition via industry.<br><br>***FY 2010 Accomplishments:***<br>- Initiated development of optical bench interface technology for the air-to-bandgap fiber to then be exploited for a gyroscope with reasonable bias performance levels and consistent with military needs.<br>***FY 2011 Plans:***<br>- Reduce loss in BGOF to 0.5dB/km.<br>- Integrated laser noise suppression electronics with laser devices.<br>- Demonstrate full gyroscope with integrated electronics and performance exceeding 10 micro-degrees/hr drift.<br>***FY 2012 Plans:***<br>- Demonstrate full gyro with performance of 1 micro-degree/hr bias drift in integrated 4" diameter package. | | | |
| ***Title:*** Gratings of Regular Arrays and Trim Exposures (GRATE)<br><br>***Description:*** The Gratings of Regular Arrays and Trim Exposures (GRATE) program will develop revolutionary circuit design methodologies combined with hybrid lithography tools to enable cost-effective low volume nanofabrication for DoD applications. Moore's law has driven the silicon industry for several decades with the minimum feature size on an integrated circuit (IC) reduced to 45 nm for today's commercial products. Due to challenging patterning requirements and complex circuit designs, costs of lithography tools and masks have become unaffordable for low-volume manufacture, i.e., military electronics or application specific integrated circuit (ASICs). Similarly, the circuit design, verification, and testing costs have also grown exponentially further preventing military electronics from using advanced silicon technology nodes. Military electronics capabilities are currently limited by the high cost of nanofabrication. To solve this important problem, DARPA has invested in a variety of maskless patterning technologies including parallel e-beam arrays, parallel scanning probe arrays, and an innovative e-beam lithography tool. This program will develop revolutionary circuit design methodologies coupled with innovative hybrid maskless patterning tools to realize cost-effective nanofabrication for low-volume defense or commercial ASICs. Such an approach can also address the nanofabrication requirements of other low-volume DoD technologies such as photonics and micro-electro-mechanical systems. This program will transition via industry.<br><br>***FY 2010 Accomplishments:***<br>- Initiated development of 1-D fabrication demonstrations.<br>- Began development of 1-D standard cell library for digital designs at < 32 nm node. 1-D computer aided design tool development.<br>- Commenced 1-D fabrication demos including various circuit elements making use of 1-D specific process extensions. | 6.522 | 10.995 | 11.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Began development of 1-D circuit patterns using trimmed interference lithography.<br>***FY 2011 Plans:***<br>- Demonstrate grating-based design and fabrication, including experimental verification of desired patterns. The demonstration vehicles will be logic/memory "standard cells" and high speed RF devices in state-of-the-art Complimentary Metal-Oxide Semiconductor (CMOS) technologies.<br>- Develop re-usable grating and trim masks, design methodology, process design kits, and software for layout conversion from standard (2-D) to grating-based (1-D) layout styles.<br>- Demonstrate wafer-scale patterning of gratings, and the customization of these gratings by the "trim/stitch" processes.<br>***FY 2012 Plans:***<br>- Fabricate 1-D digital design at 22 nm node.<br>- Demonstrate > 300 GHz performance for 1-D SiGe transistor circuit. | | | |
| ***Title:*** Maskless Direct-Write Nanolithography for Defense Applications<br>***Description:*** The Maskless Direct-Write Nanolithography for Defense Applications program will develop a maskless, direct-write lithography tool that will address both the DoD's need for affordable, high performance, 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 nanophotonics initiatives within the DoD. Transition will be achieved by maskless lithography tools, installed in the Trusted Foundry and in commercial foundries, which will enable incorporation of state-of-the-art semiconductor devices in new military systems, and allow for the cost-effective upgrade of legacy military systems.<br>***FY 2010 Accomplishments:***<br>- Demonstrated system level lithography performance on a linear stage demonstrator system.<br>- Designed, built, and tested a rotary stage.<br>- Integrated electron beam column and rotary stage demonstrator platform.<br>- Designed, built, and characterized an enhanced electron beam column for system alpha prototype experiments.<br>***FY 2011 Plans:***<br>- Fabricate and test digital pattern generator (DPG) with lenslet structure.<br>- Design, build, and test wafer metrology system.<br>- Design, build, and test DPG, data preparation system, and data path.<br>- Develop and demonstrate a sensitive photoresist with acceptable performance for the 32 nanometer node.<br>***FY 2012 Plans:*** | 32.045 | 25.560 | 16.275 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Integrate electron optics and new pattern generator onto column prototype.<br>- Demonstrate system level lithography performance on a column prototype. | | | |
| ***Title:*** Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) | 26.454 | 27.347 | 18.001 |
| ***Description:*** The Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) program primarily addresses the passive imaging needs for multi-band, wide field of view (FOV) and high-resolution imaging for ground and near ground platforms. The AWARE program aims to solve the technological barriers that will enable wide FOV, high resolution and multi-band camera architectures by focusing on four major tasks: High space-bandwidth product (SBP) camera architecture; Small pitch pixel focal plane array architecture; Broadband focal plane array architecture; and Multi-band focal plane array architecture.<br><br>The AWARE program will advance integration of technologies that enable wide field of view and high resolution and multi-band cameras, including the technologies demonstrated in the related AWARE program in PE 0602716E, Project ELT-01. AWARE aggregates the following programs: Nyquist-Limited Infrared Detectors (NIRD), Photon Trap Structures for Quantum Advanced Detectors (P-SQUAD), Dual-Mode Detector Ensemble (DUDE), and Multiscale Optical Array Imaging (MOSAIC). The integration of the technologies will demonstrate subsystems such as focal plane arrays and cameras.<br><br>***FY 2010 Accomplishments:***<br>- Established initial focal plane array (FPA) performance models and projections, iterating flow down analysis that includes material and device specifications for small pixels.<br>- Demonstrated very low (18 microamps/cm2) dark current for 5 µm pitch photodiodes with 0.8 µm via diameter, surpassing requirements.<br>- Completed dual-band read out integrated circuit (ROIC ) design.<br>- Demonstrated Low Wave Infrared (LWIR) microbolometer fabrication with low temperature process.<br>- Developed Visible-Near Short Wave Infrared test chip for InGaAs performance evaluation.<br>- Fabricated pillar nBBn device structures in the photonic structures with dark currents below current nBn devices. Completed p/n junctions in photonics structures.<br>- Fabricated 64x64 arrays with broadband response and tested arrays.<br>- Demonstrated a 640 x 480 array that is fully integrated with readout processor.<br>- Designed and validated broadband integrated detector array.<br>- Demonstrated LWIR detectors, with a size of 5 micrometers, operating at 80K with dark current less than 0.5ma/cm^2.<br>- Achieved 10 x 10 LWIR array with 5 micrometer pixels interconnected to silicon read-out with interconnect resistance less than 5 ohm.<br><br>***FY 2011 Plans:*** | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate and fabricate photonic structure in each detector unit cell for broadband response with 80% quantum efficiency across full band.<br>- Develop low cost materials for focal plane arrays and associated optics.<br>- Demonstrate the feasibility of achieving wide angle, near diffraction-limited instantaneous Field of View (iFOV) data capture in moderate size (~10's cm aperture diameter) imaging systems.<br>***FY 2012 Plans:***<br>- Demonstrate 5µmx5µm LWIR photodetector unit cell design with detector ROIC and capacitor 3-D interconnects.<br>- Complete hybrid integration of 1024x1024 FPA with ROIC with < or equal to 30 µm pitch for broadband.<br>- Demonstrate integrated Visible-Near Short Wave Infrared and Long Wave Infrared detectors with noise equivalent temperature difference of 30 milli-Kelvin @ F/1. | | | |
| ***Title:*** Excalibur*<br>***Description:*** * Formerly Adaptive Photonic Phased Locked Elements (APPLE).<br><br>The Excalibur program will develop high-power electronically-steerable optical arrays, with each array element powered by a fiber laser amplifier. These fiber-laser arrays will be sufficiently lightweight, compact, and electrically efficient to be fielded on a variety of platforms with minimal impact on the platform's original mission capabilities. Each array element will possess an adaptive-optic capability to minimize beam divergence in the presence of atmospheric turbulence, together with wide-field-of-view beam steering for target tracking. With each Excalibur array element powered by a high power fiber laser amplifier (at up to 3 kilowatts per amplifier), high power air-to-air and air-to-ground engagements will be enabled that were previously infeasible because of laser system size and weight. In addition, this program will also develop kilowatt-class arrays of diode lasers that will provide the higher spatial and temporal bandwidths needed to correct for the increased air turbulence effects encountered in ground-to-ground engagements. Excalibur arrays will be conformal to aircraft surfaces and scalable in size and power by adding additional elements to the array. By defending airborne platforms such as unmanned aerial vehicles against proliferated, deployed and next-generation man-portable air-defense systems (MANPADS), Excalibur will enable these reconnaissance platforms to fly at lower altitude and obtain truly persistent, all-weather ground reconnaissance despite low-lying cloud cover. Further capabilities include multi-channel laser communications, target identification, tracking, designation, precision defeat with minimal collateral effects as well as other applications. This technology will transition via industry.<br><br>In the Excalibur program, efficient high-power laser amplifier arrays based on coherent or spectral beam-combining will be developed. The potential of these arrays to scale to tactical power levels (100 kW class) will be investigated as well as near-term | 12.942 | 17.000 | 15.970 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| options for low-altitude self defense against MANPADS. These laser amplifier arrays will be designed to work in tandem with the core laser components developed under the Excalibur program in PE 0602702E, Project TT-06.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated atmospheric compensation of laboratory-generated turbulence and turbulence on a 2-km range using a 7-element optical phased array at 1 watt power levels.<br>- Demonstrated high-power stand-off tracking of moving ball bearing using a coherent 7-element, electronically-steerable, fiber laser amplifier array with a conformal beam director.<br>- Demonstrated coherent combination of a 150-W fiber laser amplifier array.<br>***FY 2011 Plans:***<br>- Complete laser lethality testing.<br>- Develop system requirements for low-altitude MANPADS self-defense using fiber-laser arrays.<br>- Demonstrate a phased array of seven 500-W fiber laser amplifiers.<br>***FY 2012 Plans:***<br>- Complete the design, fabricate and procure the components for a coherently or spectrally combinable array of 21 array elements, each fed by a 1 kW fiber laser amplifier.<br>- Demonstrate 7 kW 7-element fiber-amplifier laser array using coherent-combining and spectral-combining technologies. | | | |
| ***Title:*** Low Cost Thermal Imager (LCTI-M)*<br>***Description:*** *Formerly Advanced Imaging Program.<br><br>The Low Cost Thermal Imager (LCTI-M) effort will develop a pocket-sized, manufacturable, and practical thermal imager at a price point allowing them to be provided to large numbers of warfighters. The resulting devices will allow a soldier to have practical thermal imaging capability for locating warm objects (e.g., enemy combatants) in darkness. The small Size, weight and Power (SWaP) thermal camera will be integrated with a handheld device such as a cell phone with network capability for tactical ISR. In order to achieve this goal, breakthroughs will be required in low-cost thermal imagers manufactured using wafer scale integration, vacuum packaging, low cost optics and low-power signal processing. By the end of the program, the imager chips will be fully integrated with a low-cost processor and optics. The camera will have wireless connectivity to integrate video display with cell phones or PDAs.<br><br>***FY 2012 Plans:***<br>- Develop wafer-scale vacuum packaging with infrared-transparent windows.<br>- Develop low cost infrared optics. | - | - | 20.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate integrated bolometer-based thermal imager chips with integral packaging.<br>- Initial demonstration of connectivity and display on a handheld device. | | | |
| ***Title:*** Hemispherical Array Detector for Imaging (HARDI)<br><br>***Description:*** The objective of the Hemispherical Array Detector for Imaging (HARDI) program 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 DoD systems through a demonstration of an array prototype developed by industrial contractors.<br><br>***FY 2010 Accomplishments:***<br>- Developed novel photodetector materials for the spectral range 400-1900 nanometers (nm).<br>- Demonstrated a 16,000 pixel array on a 2.5 cm radius hemispherical substrate.<br>- Explored manufacturing techniques amenable to producing hemispherical array detectors with high reproducibility.<br><br>***FY 2011 Plans:***<br>- Demonstrate a prototype 1 megapixel, 1 cm radius hemispherical focal plane array for the spectral range of 400-1900 nm.<br>- Demonstrate a prototype f/1.4 camera with a 120 degree field of view with high reliability. | 3.152 | 3.754 | - |
| ***Title:*** Radio Frequency Photonic Technology (RPT)<br><br>***Description:*** The Radio Frequency Photonics Technology (RPT) program is developing components and microsystems to revolutionize deployed signal intelligence (SIGINT) gathering capabilities. The radio frequency (RF) spectrum contains innumerable friendly and adversarial signals of interest including: voice and data communications, electronic signatures, and navigation information. Conventional electronic systems are challenged in detecting weak signals in the presence of strong ones (low-linearity) across a broad range of frequencies (narrow-band). The RPT program aims to efficiently capture all RF signals of interest by developing broad-band (>10 gigahertz) high-linearity (>70 decibels dynamic-range) optical components and microsystems. The RPT program will reduce susceptibility to electronic attack, increase the probability-of-intercepting (POI) adversaries on their first-pulse transmission, and increase information awareness 1000-fold.<br><br>RPT program integrates optical components such as modulators, photodetectors, lasers, delay elements, and low-noise oscillators with microwave electronics to demonstrate microsystems such as remote links, channelizers, and analog-to-digital converters (ADCs). Components developed under the RPT program in PE 0602716E, Project ELT-01 will be integrated into | 7.969 | 9.006 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| subsystem demonstration under this program. This program also incorporates photonic components previously addressed in the Photonic-enabled Simultaneous Transmit and Receive (P-STAR) program, Electromagnetic Pulse Tolerant Microwave Receiver Front End (EMPIRE), Integrated Photonic Displays (iPHoD) in ELT-01, Remoted Analog-to-Digital Converter with De-serialization and Reconstruction (RADER) in ELT-01, and the Transmit and Receive Optimized Photonics (TROPHY) program. This technology will transition via industry.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated 10 GHz, 44 decibel (dB) dynamic-range photonic ADC.<br>- Demonstrated 500 MHz receiver with 61 dB dynamic-range.<br>- Developed and demonstrated low loss lithium niobate optical modulators, which exhibit low switching voltages and incorporate a long effective length for achieving high Transmit/Receive (T/R) isolation.<br>- Developed and demonstrated a power amplifier that when connected to the electro-optic modulator and incorporated into the T/R module package, enables the transmit power goal over a multi-octave frequency range.<br>- Enhanced third-order intercept point of the Transmit link to +65 decibels (dB) relative to a milliwatt of power (dBm).<br>- Enhanced gain of the Receive link to 35 dB.<br><br>***FY 2011 Plans:***<br>- Develop 10-channel channelizer that extends 10 GHz ADC to 100 GHz bandwidth.<br>- Demonstrate >4 GHz antenna remote link with >30 dB dynamic-range.<br>- Demonstrate 10 GHz, 50 dB dynamic-range remoted ADC. | | | |
| ***Title:*** Visible/Short Wave IR - Photon Counting Arrays<br><br>***Description:*** The Visible/Short Wave IR - Photon Counting Arrays program developed 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. The program leveraged recent innovations in solid state imaging devices, including parallel processing at the pixel level and novel read read-out technology, to develop a new class of sensors, that create images 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 has provided access to a suite of signal processing, image enhancement and communications techniques not available with current low light level imaging devices. This program transitioned via industry for ultraviolet to infrared imaging applications.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated real-time processor and interface with an existing photon counting camera. | 2.007 | - | - |
| ***Title:*** Advanced Photonic Switch (APS) | 1.468 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Advanced Photonic Switch (APS) program developed a technology for creating on-chip, photonic switching devices that can be fabricated in a silicon-compatible process. Most high performance photonic switching devices are fabricated with compound semiconductors, but silicon manufacturing technologies now offer potential advantages due to the great precision being driven by commercial mainstream markets for microelectronics. This program pursued advanced technologies that take full advantage of those commercial capabilities to produce photonic devices that maximize switching speed, minimize device power dissipation and transmission losses, small area, and decreased sensitivity to ambient temperature variations. This technology transitioned via industry.<br><br>***FY 2010 Accomplishments:***<br>- Enhanced APS fabrication technologies and design approaches to improve devices and integrated assemblies. | | | |
| ***Title:*** Compound Semiconductor Materials on Silicon (COSMOS) Multi-Project Wafer (MPW)<br><br>***Description:*** The Compound Semiconductor Materials on Silicon (COSMOS) Multi-Project Wafer (MPW) program has pioneered the intimate integration of high-performance compound semiconductor devices (specifically Indium Phosphide Heterojunction Bipolar Transistors) with advanced, high-density silicon Complementary Metal Oxide Semiconductor devices to realize mixed-signal circuits that exploit the principle of "best junction for the function". The COSMOS MPW program established a foundry capability in order to provide broad access to the DoD and commercial RF/mixed-signal design community. This program introduced early access multiproject wafer effort and will support 4 MPW runs of increasing sophistication. This program is a companion effort to the COSMOS program in PE 0602716E, Project ELT-01, and is budgeted in Budget Activity 3 to initiate foundry activities and prepare for transition. This technology transitioned to industry.<br><br>***FY 2010 Accomplishments:***<br>- Initiated development of a COSMOS foundry technology design kit.<br>- Initiated mask aggregation and support functions for eventual transition to the Trusted Access Program Office (TAPO) or MOSIS (a production service for chip fabrication) to facilitate future regular offerings of the technology following the early access program. | 10.445 | - | - |
| ***Title:*** High Frequency Wide Band Gap Semiconductor<br><br>***Description:*** The High Frequency Wide Band Gap Semiconductor program fully exploited the properties of wide bandgap semiconductors (WBGS) to enhance the capabilities of microwave and millimeter-wave (MMW) monolithic integrated circuits (MMICs) and enable future RF sensor, communication, and multifunction military capabilities. Wide bandgap semiconductors have the ability to deliver very high power and other very favorable high frequency characteristics. Prior efforts have focused on improvements to the basic semiconductor while current efforts are focused on realizing devices and circuits. These technologies led to affordable, high performance, reliable, wide bandgap devices and MMICs with characteristics suitable for enabling new DoD | 3.050 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| systems and greatly improved performance for fielded platforms. This program was a companion to the effort in PE 0602716E, Project ELT-01.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated superior thermal management and packaging strategies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 113.310 | 111.263 | 90.233 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 253.733 | 219.809 | 296.537 | - | 296.537 | 266.783 | 270.941 | 282.805 | 287.746 | Continuing | Continuing |
| CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS* | 69.491 | 69.310 | 76.800 | - | 76.800 | 53.487 | 39.237 | 42.632 | 42.632 | Continuing | Continuing |
| CCC-02: *INFORMATION INTEGRATION SYSTEMS* | 104.874 | 68.876 | 88.519 | - | 88.519 | 84.669 | 86.083 | 85.291 | 85.291 | Continuing | Continuing |
| CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS* | - | - | 15.000 | - | 15.000 | 23.000 | 40.000 | 40.000 | 45.000 | Continuing | Continuing |
| CCC-CLS: *CLASSIFIED* | 79.368 | 81.623 | 116.218 | - | 116.218 | 105.627 | 105.621 | 114.882 | 114.823 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

The Command, Control and Communications Systems program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

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

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

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

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| B. Program Change Summary ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 269.198 | 219.809 | 202.240 | - | 202.240 |
| Current President's Budget | 253.733 | 219.809 | 296.537 | - | 296.537 |
| Total Adjustments | -15.465 | - | 94.297 | - | 94.297 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | -8.324 | - | | | |
| • SBIR/STTR Transfer | -7.141 | - | | | |
| • TotalOtherAdjustments | - | - | 94.297 | - | 94.297 |

**Change Summary Explanation**

FY 2010: Decrease reflects internal below threshold reprogrammings and SBIR/STTR transfer.
FY 2012: Increase reflects establishment of a new project (CCC-04, Secure Information and Network Systems) for 6.3 cyber security efforts and increases for advanced communications programs, EW/Counter EW technologies, and classified programs offset by reductions for Defense Efficiencies for contractor staff support and classified programs.

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS* | 69.491 | 69.310 | 76.800 | - | 76.800 | 53.487 | 39.237 | 42.632 | 42.632 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

Military operations since the end of the Cold War show 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 peacekeeping in urban centers to heavy battle actions in remote areas. Current capabilities do not provide the commander with real-time, secure, situational awareness or the ability to orchestrate high-tempo planning, rehearsal, and execution. The programs in this project are developing and testing innovative, secure architectures and tools to enhance information processing, dissemination, and presentation capabilities. These will provide the commander with insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making, and execution, secure multimedia information interfaces, and software assurance to the warfighter "on the move." Integration of collection management, planning, and battlefield awareness are essential elements for achieving battlefield dominance through assured information systems.

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** ZETA<br><br>***Description:*** The ZETA program is exploring the unclassified aspects of novel physical devices, concepts, and techniques that leverage quantum physics for information technology. Research in this area has the ultimate goal of demonstrating information technology components with radical improvements in power efficiency and/or computational power relevant to military applications and opportunities. The program will transition via industrial performers.<br><br>***FY 2010 Accomplishments:***<br>- Continued validation of key physical device assumptions.<br><br>***FY 2011 Plans:***<br>- Continue validation of key physical device assumptions.<br>- Initial planning for small-scale demonstration of key physical devices.<br><br>***FY 2012 Plans:***<br>- Perform preliminary small-scale demonstration of key physical devices. | 25.586 | 29.000 | 32.000 |
| ***Title:*** Resilient Command and Control (RC2)*<br><br>***Description:*** *Previously part of Advanced Tactical Battle Manager. | 10.800 | 17.760 | 23.600 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| The Resilient Command and Control (RC2) program is developing a general framework and set of critical mission assurance capabilities to enable Commanders and their staffs to manage the array of C2 systems and architectures (sensor, communications, and information processing) used to conduct operations. These adaptive, resilient C2 resource planning and re-planning capabilities will ensure mission success in the face of C2 system outages. Specific technologies being developed under RC2 include advanced analysis, visualization, and planning tools to provide Commanders and their staffs with a dashboard that enables the following operational and corresponding analytical capabilities: (1) attain and maintain situation awareness of the C2 architectures; (2) understand mission impact of outages; and (3) dynamically realign the C2 systems to ensure the Commander's intent. The tools and technologies that result from RC2 will enable operators to detect anomalous behavior via intuitive information displays; assess business function impact, including 2nd and 3rd-order effects; and dynamically re-plan how the system can be used to achieve organizational goals and priorities. Transition is planned to U.S. Pacific Fleet (USPACFLT).<br><br>***FY 2010 Accomplishments:***<br>- Defined program concept and developed performance metrics.<br>- Conceptualized visualizations that support enhanced C2 situation awareness and understanding.<br>- Participated in USPACFLT Terminal Fury exercise.<br>***FY 2011 Plans:***<br>- Provide predictive and diagnostic estimation of C2 system health and status in terms of the ability of those systems to support operational missions.<br>- Prosecute anomalies in context of operational mission priorities.<br>- Conduct experiments with users at USPACFLT.<br>- Conduct an operational demonstration at a single node in the context of a major military exercise.<br>***FY 2012 Plans:***<br>- Automatically determine the impact of multiple correlated anomalies on operational activities.<br>- Develop dynamic approaches to allocating critical C2 functions, relations, and information flows over space and time.<br>- Adapt C2 plan to support mission needs.<br>- Develop active visualizations to support C2 system situation awareness and understanding.<br>- Conduct experiments with users at USPACFLT and Commander 7th Fleet.<br>- Conduct an operational demonstration at two nodes in the context of a major military exercise. | | | |
| ***Title:*** Deep Green<br><br>***Description:*** Deep Green is a next-generation, battle command and decision support technology that combines anticipatory planning with adaptive execution to help the commander think ahead, identify when a plan is going awry, and prepare options | 15.776 | 13.727 | 4.200 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| before they are needed. Deep Green will radically reduce the time needed to plan and execute military operations and will reduce the number of staff officers needed in an operations center. Through rapid mission planning and execution and reduced staff overhead, Deep Green's goal is to save lives and reduce costs. Deep Green will automatically infer the commander's intent and output a plan from the commander's hand-drawn sketches to facilitate rapid option creation. Deep Green generates a broad set of possible futures from those options for all sides in an operation and predicts the likelihood of each future. It supports anticipatory planning by using information about the ongoing operation to nominate future states that are no longer feasible and probable future states upon which the commander should focus additional planning efforts. By anticipating decision points early and allowing the commander to explore the future option space, Deep Green supports commander's visualization and adaptive execution, enabling correct, timely decisions by the commander. Deep Green technology will transition to the U.S. Army.<br><br>***FY 2010 Accomplishments:***<br>- Extended technologies to monitor an ongoing operation and update the likelihoods that the possible future states being generated by Deep Green will actually occur.<br>- Integrated major components to produce an initial prototype Deep Green system that enables proactive (vice reactive) battle management.<br>- Extended the Deep Green system to support additional battlefield functional areas, such as air defense, intelligence, and military engineering.<br>- Conducted system evaluation exercises in military simulation environments with military operators.<br>***FY 2011 Plans:***<br>- Extend Deep Green to support multi-echelon operations, including Deep Green systems at brigade and battalion levels coordinating among themselves.<br>- Demonstrate fully-functional, multi-echelon, full-spectrum battle command technology.<br>- Extend the Deep Green system to support both mid-intensity conflict and counter-insurgency operations.<br>- Conduct virtual and live field exercises with Deep Green at military training facilities.<br>***FY 2012 Plans:***<br>- Integrate Deep Green technology into fielded battle command systems.<br>- Demonstrate functional battle command technology in force-on-force exercises against a live, intelligent enemy.<br>- Transition Deep Green technology to U.S. Army. | | | |
| ***Title:*** Adaptive Collaborative Environment (ACE)<br><br>***Description:*** The Adaptive Collaborative Environment (ACE) is a comprehensive set of technologies designed to establish information flow through the Joint, Intergovernmental, Interagency, and Multinational (JIIM) communities as they respond to | - | - | 17.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| operations in infrastructure denied environments. These denied environments may be caused by massive natural disasters, such as massive earthquakes or tsunamis, or in areas where our communications are actively being denied or subverted by an adversary. The goal of this program is to create an architecture that will allow full, meaningful collaboration to begin across the JIIM community in 48-96 hours after an event.<br><br>***FY 2012 Plans:***<br>- Collect and synthesize information pertaining to prior disasters and relief missions, and challenges to effective mission collaboration.<br>- Develop a framework for translating mission needs into technology and architecture needs.<br>- Develop tools and techniques for rapid data discovery and integration of ad-hoc information systems.<br>- Create a prototype collaborative decision support interface.<br>- Develop and test initial ACE technologies set. | | | |
| ***Title:*** Heterogeneous Airborne Reconnaissance Team (HART)<br><br>***Description:*** The Heterogeneous Airborne Reconnaissance Team (HART) program develops integrated tactical planning and sensor management systems for heterogeneous collections of manned and unmanned platforms operating in urban environments. HART 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. HART 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 4-D airspace and groundspace deconfliction tools, route planners, and task/platform assignment algorithms. The technology presents mission status and future courses of action to commanders for collaborative adjudication. HART enables augmentation of low-footprint, rapidly deployable, easily sustainable human command structures with teams of machines operating together. There is a Memorandum of Agreement in place with the U.S. Army for technology transition.<br><br>***FY 2010 Accomplishments:***<br>- Tested and demonstrated cooperative interaction with Tactical Airspace Integration System to achieve permissive airspace management for manned and unmanned platforms and indirect fires.<br>- Supported operational evaluation and certification of capabilities and limitations.<br>- Collaborated with Program Manager, Unmanned Aircraft Systems and Army G-2 Intelligence, Surveillance, Reconnaissance Task Force lead to integrate and transition selected capabilities to the U.S. Army.<br>- Ruggedized and miniaturized hardware suite. | 7.290 | 2.000 | - |

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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | **PROJECT**<br>CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Ensured scalability appropriate to anticipated areas of employment.<br>- Supported operational transition of technology to Program Executive Office Aviation Programs of Record.<br>***FY 2011 Plans:***<br>- Formulate and assess geo-registration algorithms suitable for highly variable terrain.<br>- Develop new collection management methods that account for terrain-induced routing constraints, ground field of view mapping, and sensor visibility constraints. | | | |
| ***Title:*** Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis)<br>***Description:*** The Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis) program is developing an integrated, soldier-worn situational awareness system that allows the small unit leader to display iconic representations of blue force locations, tactically relevant targets, and coordinated actions and effects The icons are geo-registered on the battlefield and viewed from each warfighter's perspective using a see-through, head-mounted display. The system will enable the small unit leader to conduct non-line-of-sight combat operations using hands-free, iconic command and control while on the move. Information management protocols will support the dissemination of tactical information to allow the squad leader to direct weapons platforms for real-time collaboration without overload. ULTRA-Vis technologies will allow small unit leaders and members to selectively receive and visualize critical combat information using existing, low-bandwidth soldier voice and data radios. ULTRA-Vis empowers the small unit leader with a clear tactical advantage through inter/intra-squad collaboration, heightened situational awareness and the ability to take decisive action while on-the-move. The ULTRA-Vis prototype units are planned for transition to the U.S. Army, Air Force Special Operations Command (AFSOC), and U.S. Marine Corps.<br>***FY 2010 Accomplishments:***<br>- Developed the capability to recognize standard hand and arm signals used by small unit leaders in close range combat operations.<br>- Developed the capability to create geo-registered icons and affix the icons with high placement accuracy to the shared urban landscape for display from each warfighter's perspective.<br>- Developed a non-occluding, head-mounted see-through optic for viewing iconic overlay on the battlespace.<br>***FY 2011 Plans:***<br>- Create Cursor on Target (CoT) XML formatted data displays and information management for inter-squad collaboration.<br>- Continue refinement and improvements in function and performance of all sub-components.<br>- Integrate multi-mode testbeds to evaluate system functionality and capabilities. | 8.033 | 6.823 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Conduct service relevant simulated operational exercises and demonstrations using ULTRA-Vis in current Concept of Operations (CONOPS). | | | |
| ***Title:*** Increased Command and Control Effectiveness (ICE)<br><br>***Description:*** The Increased Command and Control Effectiveness (ICE) program developed and integrated cognitive systems technology into operational Command, Control, and Intelligence (C2I) systems. 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 automatically, during deployment and in real time, to the changing conditions that military commanders confront. It enables commanders to more rapidly adapt to evolving situations and priorities, and accelerates the incorporation of new personnel into command operations. This program funded portions of the technologies developed in PE 0602304E, Project COG-02 that were ready for application to command and control and situational awareness systems.<br><br>***FY 2010 Accomplishments:***<br>- Extended Personalized Assistant that Learns (PAL) analyst support capabilities based on test and evaluation in exercises along with end-user feedback.<br>- Integrated PAL-based prototypes with an operational Army C2 system and participated in an Army military readiness exercise at the National Training Center in Fort Irwin.<br>- Evolved and improved the PAL Learning Services Framework based on developer feedback and released for general use. | 2.006 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 69.491 | 69.310 | 76.800 |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CCC-02: *INFORMATION INTEGRATION SYSTEMS* | 104.874 | 68.876 | 88.519 | - | 88.519 | 84.669 | 86.083 | 85.291 | 85.291 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Optical & RF Combined Link Experiment (ORCLE) | 31.496 | 19.070 | 3.951 |
| ***Description:*** The Optical & RF Combined Link Experiment (ORCLE) program seeks to develop combined radio frequency (RF) and free space optical (FSO) communications as well as networking technologies that exploit the benefits of complementary path diversity. This effort encompasses the extension of research into the FSO/RF Internet Protocol-based Network system, called Optical RF Communications Adjunct (ORCA). Using optical and RF communication techniques, ORCLE will demonstrate improved battlespace communications using a hybrid RF and FSO link in air-to-air-to-ground environments. The central challenge is to enable optical communications bandwidth without giving up RF reliability, regardless of the weather. ORCLE will develop RF and FSO propagation channel analysis, coding techniques, and modeling to include weather, atmospherics, and aero-optics to provide the joint force commander assured high-data rate communications. The technical objective is to prototype and flight demonstrate hybrid FSO/RF air-to-air-to-ground links that combine the best attributes of both technologies and simulate hybrid network performance. The ORCLE technology is planned for transition to the Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Executed design reviews that provided information to build prototype system.<br>- Integrated improved adaptive optics, e.g., lighter deformable mirror, and faster steering mirrors, into an airborne optical link system that will be incorporated into future systems to provide gigabits of data over long ranges with high reliability and quality.<br>- Completed design and build of a router for integration into future prototypes.<br>- Validated adaptive optics approaches and control methods during ground checkout.<br><br>***FY 2011 Plans:*** | | | |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Test airborne and ground-based FSO communications terminals that use adaptive optics (AO) to increase the coupling efficiency of received laser light, while reducing overall received power variations.<br>- Develop and test an optical modem and forward error correction (FEC) system that, combined with the Optical Automatic Gain Control (OAGC), demonstrate greatly improved receiver sensitivities.<br>- Incorporate a multifunction hybrid router capable of providing node discovery, Mobile Ad Hoc Network (MANET) formation, differentiation of services, and retransmission of lost packets.<br>- Assemble prototype nodes and install on a minimum of three aircraft networked to ground terminals for data distribution as well as battlefield command and control experiments.<br>***FY 2012 Plans:***<br>- Execute final testing of a 4 node network (3 air nodes and one ground node) to demonstrate hybrid high data rate FSO/RF and advanced network capabilities that provide information rates sufficient for current military needs and mission requirements.<br>- Validate the ability to provide the warfighter low latency information for command and control as well as Intelligence, Surveillance and Reconnaissance (ISR) requirements.<br>- Demonstrate network instantiation and user interfaces to command and control at multiple levels.<br>- Complete transition of the technology. | | | |
| ***Title:*** Military Networking Protocol (MNP)<br>***Description:*** The Military Networking Protocol (MNP) program will create architectures, protocols and network controllers to enhance security and operation of military networks. MNP technologies will enforce military user authentication, manage military network traffic and automatically configure military networks. By enforcing military user authentication, military network protocols will provide full attribution of every military device and track each device's network flows to provide full attribution down to the individual source of bad/erroneous data or malicious activity. MNP prioritization schemes will be controlled by the military commanders at various echelons to address changing mission requirements. MNP technologies will transition to DISA and/or the military Services.<br>***FY 2010 Accomplishments:***<br>- Developed and initiated formal testing of military networking architectures, protocols and network controllers.<br>- Developed and tested a 200-node military networking testbed.<br>***FY 2011 Plans:***<br>- Complete initial testing and down-select to a single MNP architecture, protocol and network controller design set.<br>- Coordinate with DISA and the Services to foster program participation and to develop a transition plan for MNP technologies. | 13.385 | 9.750 | 21.268 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Initiate the continued design of the selected MNP architecture and protocols and build prototype network controllers.<br><br>***FY 2012 Plans:***<br>- Conduct interim system test and verification of the MNP architecture and protocols.<br>- Continue the refinement and design of the selected MNP architecture, protocols and network controllers.<br>- Increase the scale of the MNP test-bed for the final test and demonstration.<br>- Coordinate with DISA and the Services to continue program participation and to finalize a transition plan and/or memorandum of agreement for MNP technology. | | | |
| ***Title:*** Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS)<br><br>***Description:*** The Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS) program goals are to develop and demonstrate technologies and system concepts that will enable densely deployed radio networks to compensate for limitations of the physical layer of a low-cost wireless node. WNaN/AWNS networks will manage node configurations and the topology of the network to reduce the demands on the physical and link layers of the network. The technology created by the WNaN/AWNS effort will provide reliable and available battlefield communications at low system cost. This program will also improve the hardware, firmware, and software to allow the integration of the Joint Tactical Radio System (JTRS) Soldier Radio Waveform (SRW) for backward interoperability to legacy communication systems. An ancillary initiative is investigating the integration of Multi-User Detection (MUD) and Multiple-Input Multiple Output (MIMO) technology into the WNaN radio platform. The objective of this effort is to perform MUD and MIMO algorithm development and system trade studies analysis that position these technologies for transition into the WNaN radio node. In addition, this effort will investigate Wireless Distributive Computing (WDC), Content Base Access (CBA), and smart antenna technology to enhance the network and node ability to understand the operating environment, mission concept of operations, and node responsibilities to assist in data processing, information dissemination, and accomplishment of the military objectives.<br><br>In addition, this program will develop a low-cost handheld/body wearable wireless node that can be used to form high-density ad-hoc networks and gateways to the Global Information Grid. This program will also develop robust networking architecture(s) and network technologies/processes that will exploit high-density node configurations. Coordination between DARPA and the Army will culminate in network demonstrations using the multichannel nodes to establish viability for the Army to transition to programs of record and procure WNaN/AWNS devices and technology. Transition to the Army is planned to begin in 2011 and complete in 2013 following culmination of experiments and demonstrations.<br><br>***FY 2010 Accomplishments:***<br>- Conducted field experiments and demonstrations of prototypes of more than 100 radio nodes operating in a mobile ad hoc network. | 18.602 | 10.923 | 18.300 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrated enhanced networking technology to include Disruption Tolerant Networking (DTN) and Dynamic Spectrum Access (DSA) capability with the spectrum policy reasoning engine.<br>- Simulated mobile ad-hoc wireless network performance for networks of >250 nodes.<br>- Demonstrated a communication system where the network layers can mitigate shortfalls in the radio physical layer.<br>- Initiated development/implementation of Type 2 security architecture within the WNaN radio/network.<br>- Conducted demonstrations of pre-production radios in field tests that form a highly adaptive, dynamic, self-forming, self-healing WNaN military tactical network.<br>***FY 2011 Plans:***<br>- Demonstrate spectrum efficiency and utilization in experimentation and simulation.<br>- Complete and integrate initial installation of Type 2 security architecture.<br>- Complete simulations of mobile ad hoc wireless network performance in networks of 1,000 nodes.<br>- Integrate Mobile Networked MIMO (MNM), Multi-User Detection (MUD) and Soldier Radio Waveform (SRW) within radio nodes.<br>- Integrate smart antenna capabilities into radio nodes.<br>- Integrate Wireless Distributed Computing (WDC), Content Based Access (CBA) and any required networking functions to support transformative application functionality.<br>- Initiate transition to U.S. Army.<br>- Explore ability of radio node to perform multi-purpose applications and alternative platform applications.<br>***FY 2012 Plans:***<br>- Identify functions, perform implementation, and integrate WDC and CBA into the WNaN system.<br>- Integrate MUD and MIMO into the system so all waveform types are available for various communication conditions to improve network performance.<br>- Perform experiments utilizing transformational applications within the WNaN node. | | | |
| ***Title:*** Communications Under Extreme RF Spectrum Conditions (CommEx)*<br>***Description:*** *Formerly Next Generation Communications<br><br>The Communications Under Extreme RF Spectrum Conditions (CommEx) program will develop signal detection and reasoning technology that will allow radios to recognize jamming attacks and then adapt to maintain communications, even in the presence of cognitive jammer attacks and dynamic interference of multiple cognitive network interactions. The program will develop models of adversary, commercial, and friendly cognitive radios and implement those models in a "reasoner" that assesses, in real time, the current and future dynamics of the communications network. Core technologies for operation in highly dynamic and/or high jamming to signal environments will be developed to include: automated jamming waveform forensics; RF Environment | - | 6.500 | 25.000 |

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| assessment (time, space, frequency, polarization); technologies for addressing known attack strategies and interference properties; and antenna, RF, signal processing, modulation, and network optimization technology. Based on predictions of the level of communication success compared to mission communication requirements, the "reasoner" within the cognitive radio will choose waveform selections/configurations that best achieve mission objectives. The "reasoner" will include the capability to analyze and select optimum waveform configurations during all aspects of a mission, to include initial alert, ingress, mission, and infiltration. The design effort will lead to new radio communication architectures, more robust radio communication networking, and better understanding of selection amongst interference avoidance and interference suppression strategies.<br><br>This program also seeks to enable communication between dispersed and distributed emitters and receivers to provide a multiplier in capacity for both locating emitters and assessing effectiveness of an electronic attack. In addition to protecting communications from jamming, an analysis of methods to prevent geolocation of communication signals is also planned. The CommEx technology is planned for transition to the U.S. Army.<br><br>***FY 2011 Plans:***<br>- Develop and demonstrate algorithms to measure cognitive radio jammers and communication network behaviors that sufficiently characterize state space and behavior.<br>- Establish baseline sensor performance requirements.<br>- Develop efficient model structures of communication links, interference networks, essential metrics, and transforms.<br>- Define what resources are available to handheld, vehicular, airborne, or shipboard communication platforms to determine what level of performance would be able to be achieved for each platform.<br>- Develop efficient distributed algorithms and implement hardware prototypes for carrier frequency offset and frame synchronization.<br>- Develop efficient algorithms for channel estimation, computation and distribution of network information; design the associated protocols.<br>***FY 2012 Plans:***<br>- Integrate live hardware into the detailed experiments to assure that dynamic range, realistic multipath and clutter, and implementation specific simulations are analyzed with sufficient rigor to assure performance in live hardware.<br>- Perform experiments and simulations that model legacy waveforms and interference sources not previously seen by the system.<br>- Develop hardware, firmware and software using CommEx technologies, and corresponding application programming interfaces and drivers in the radio to understand and control system performance.<br>- Investigate counter geolocation techniques. | | | |
| ***Title:*** Cloud to the Edge | - | - | 10.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The goal of this program is to provide tactical warfighters operating at the edge with interactive, on-demand access to relevant information and a greater ability for real-time sharing of new operational content. This content can include images, video, maps, and database access along with tools for visualization of information, and reach back search capabilities. Ubiquitous access to relevant situational awareness and command and control information throughout the battle space is a key objective. Advances in key enabling technologies in Optical RF Communications Adjunct (ORCA), MAINGATE, and WNaN (all budgeted in this PE), and programs in PE 0602716E, Project ELT-01, are enabling high-capacity communications to the edge. However, the current centralized or regional storage and dissemination of information presents security, reliability, and capacity challenges in identifying and getting relevant information to users at the edge. Commercial industry has developed approaches to the autonomous dissemination of high demand information by using distributed servers and advanced networking and information database technologies, combined with highly-reliable fixed networking infrastructure with embedded complex information exploitation tools. This program will leverage commercial capabilities to develop and demonstrate the technologies and prototype systems in networking, servers, and information dissemination techniques to enable efficient, robust information dissemination using dynamic, mobile, ad hoc military networks. These technologies and system concepts will autonomously seek out relevant information and move it to where it is needed in a timely and assured manner. Capabilities from this effort will transition to the DoD.<br><br>***FY 2012 Plans:***<br>- Conduct studies and analyses for information flow patterns through the regional and localized networks.<br>- Develop software architectures for distributed data dissemination and technologies for dynamic networks.<br>- Begin development of key enabling technologies. | | | |
| ***Title:*** Mobile Hot Spots<br><br>***Description:*** Military users operating at the edge are facing huge challenges with regard to reporting a whole host of tactical activities to include voice reports, accurate and timely position location information (PLI), texting options for unique missions, and imagery and video requirements for high value targets and site exploitation. This large increase in responsibilities at the Battalion, Company, Platoon, Squad, Team, and Special Operations levels requires improved communications capabilities. All requirements grow exponentially due to the proliferation of high-data rate sensors (video, etc), UAVs, and the emergence of the Soldier/Marine as both an operator and a sensor. Thus, the development of tactical tools exploiting these data sources demands new ways of providing this level and sophistication of high bandwidth communications support. This data growth has created a 100-1000x mismatch of data needs and available network capacity. Mobile Hot Spots will provide an analog to the commercial wired solution to exploding high bandwidth requirements that relies on a hierarchical approach using core networks, regional/neighborhood distribution networks, and finally distributed access points. This program will develop the high data rate mobile communications technologies that are required to close the bandwidth gap and create high-capacity and secure wireless | - | - | 10.000 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| technologies by exploiting advances in high-frequency and new security paradigms using RF, millimeter wave (MMW) and/or optical transmission. This work will leverage advances in critical system technologies in Optical, MMW, RF Combined Link Experiment (ORCLE), and SMART (both budgeted in this PE), and programs in PE 0602716E, Project ELT-01. This effort will also leverage commercial off the shelf short range, high speed communications access portals and scalable high data rate networking technologies. Trade-offs between scaling capacity, high data rate, communications overhead, system overhead (size, weight, and power), and mobility will be addressed. The Mobile Hot Spots program is targeted to transition to the Army, Marine Corps Expeditionary Forces.<br><br>***FY 2012 Plans:***<br>- Develop hardware and networking architectures for regional and local reliable, high capacity / high speed networks.<br>- Develop possible physical layer, data layer, and network layer security solutions.<br>- Initiate baseline technologies for short range, high data rate networks.<br>- Explore hardware, software, and waveform options to include unmanned aerial systems, soldiers, and mobile platforms connected into network topologies.<br>- Develop methods to support high density spectrum / high capacity activity in the communication networks.<br>- Develop Hot Spot service interfaces to high demand applications subsystems.<br>- Initiate security solution technology development. | | | |
| ***Title:*** Network Enabled by WDM-Highly Integrated Photonics (NEW-HIP)<br><br>***Description:*** The Network Enabled by WDM-Highly Integrated Photonics (NEW-HIP) program will facilitate building or upgrading military aircraft and other aerospace platforms with a wavelength division multiplexed (WDM) single-mode fiber-optic networking infrastructure. This will have many capabilities that are well beyond those of currently used copper- and multi-mode-fiber-based technologies. Originally, the program focused on specific technologies for application on the Navy's EA-6B Prowler aircraft; however, the program has been broadened to focus on technologies that will provide advanced capabilities to a multitude of military aircraft. The NEW-HIP technologies and associated architecture will provide: scalability in the bandwidth and the 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 single-mode fiber-optic WDM technology and leveraging optoelectronic and photonic integration techniques developed in DARPA photonics components program. To reduce the size, weight, and power and to increase the reliability and the flexibility of interconnecting arbitrarily placed client devices with various signal formats, the NEW-HIP program will use passive, transparent, and 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 | 6.100 | 3.500 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| transition to the Services for eventual incorporation into military aircraft, including tactical aircraft, UAVs, wide-bodied aircraft and rotorcraft.<br><br>***FY 2010 Accomplishments:***<br>- Developed the final architectures of the avionics optical network that satisfies the requirements for networking digital signals and developed preliminary architectures for analog signals.<br>- Developed the final performance specification for NEW-HIP circuits to satisfy the performance and environmental requirements of military aircraft.<br>- Continued the development and prototyping of the digital optoelectronic components.<br>- Began development of analog optoelectronic components.<br>- Conducted performance analysis of the digital links using prototype network component performance data.<br>- Began investigation of the application of NEW-HIP technology to military rotary aircraft.<br><br>***FY 2011 Plans:***<br>- Continue development of the key optoelectronic digital and analog networking components with respect to performance, size, weight, power and environmental requirements.<br>- Conduct packaging and environmental testing of the key optoelectronic digital networking components. | | | |
| ***Title:*** Analog Logic<br><br>***Description:*** The Analog Logic program will develop and demonstrate architectures, designs, and development tools for implementing probability computational functions in analog circuitry to overcome performance limitations inherent in digital designs. This program will apply the technologies to signal processing functions typically performed in digital form, which experience design complexity, high power consumption, thermal loads, limits to computational speeds, loss in dynamic range, and susceptibility to manufacturing variances. The Analog Logic program will build and demonstrate an analog-only signal processing capability with no local oscillator, down conversion, or analog-to-digital conversion. The Analog Logic program will also develop the algorithm libraries and automated development tools needed for developing algorithms in a low-cost fashion similar to Very-High-Speed Integrated Circuit (VHSIC) Hardware Description Language (VHDL).<br><br>The Analog Logic program has the potential to reduce complexity and power requirements for signal processing functions while improving performance relative to digital implementations in field programmable gate arrays (FPGA), digital signal processors (DSP), and general purpose processors (GPP). The result is a significant reduction in system cost, increase in battery life, and higher system reliability and performance for critical wireless military communications system components. As a consequence of this effort, there will be a great saving in cost, power, and volume to many modern military systems implementing wideband | 6.486 | 7.650 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | **PROJECT**<br>CCC-02: *INFORMATION INTEGRATION SYSTEMS* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| signal spreading, spectrum utilization, multiple input multiple output channels and radar applications. This program is planned for transition to the Army.<br><br>***FY 2010 Accomplishments:***<br>- Completed design for 1024 Point fast fourier transform (FFT) engine with 8 bits equivalent dynamic range, and with 10 times reduction in gate count.<br>- Demonstrated software implementation of FFT-based convolution engine with programmable coefficients.<br>- Completed designs for linear and short-term memory devices cell designs.<br>- Developed description programming language for both analog logic algorithms and constraint sets.<br>- Completed design study of microprocessors based on analog logic archetypes.<br>- Initiated fabrication of analog logic FFT engine with programmable weights using silicon complimentary metal-oxide-semiconductor (CMOS) technology.<br><br>***FY 2011 Plans:***<br>- Complete fabrication of analog logic 1024 Point FFT engine with 8 bits equivalent dynamic range, and with 10 times reduction in gate count.<br>- Demonstrate automated circuit design synthesis from factor graph description.<br>- Demonstrate direct RF processing for a sub-3 GHz receiver (decoded signal, with no (U) conventional local oscillator, down-conversion, or analog-to-digital conversion).<br>- Demonstrate automated generation of the analog logic cells and synthesis of the constraint sets.<br>- Demonstrate proof-of-concept analog logic processor.<br>- Complete technology transition planning of the analog logic capability for DoD applications. | | | |
| ***Title:*** Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM)<br><br>***Description:*** The Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) program will pursue MIMO communication systems, which have the potential to increase data rates by 10-20 times above current systems. MIMO will use multipath to create parallel channels in the same frequency band thereby increasing spectral efficiency. This effort will demonstrate the MNM capability under dynamic urban Non-Line-of-Sight multipath channel conditions where conventional techniques are degraded. This effort will undertake advanced MIMO technology development and perform field demonstrations of mobile ad hoc networks (MANETs). This effort will culminate in the development of a wideband form-factor system for use in tactical edge devices including troops, vehicles, and robotics. The MNM technology is planned for transition to the Army.<br><br>***FY 2010 Accomplishments:***<br>- Designed nodes to be employed in various devices, including robotics, mobile, and/or advantaged devices. | 4.000 | 4.483 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | **PROJECT**<br>CCC-02: *INFORMATION INTEGRATION SYSTEMS* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Showed the ability to scale to a large number of network nodes while providing an order of magnitude improvement in reliability over related single-input/single-output systems.<br>- Demonstrated a communication system where the network layer can mitigate shortfalls in the physical layer in a live multi-node demonstration.<br><br>***FY 2011 Plans:***<br>- Design, build, test, and demonstrate MIMO capabilities into a handheld/body wearable multi-channel radio that utilizes high volume, low cost commercial off the shelf RF circuits, narrowband tuning filters and dual-core digital signal processing baseband processing.<br>- Perform a demonstration in an operational environment. | | | |
| ***Title:*** Mobile Ad Hoc Interoperability Networking GATEway (MAINGATE)<br><br>***Description:*** Building upon gateway technology developed under the WNaN and Future Combat Systems (FCS) Communications program, the Mobile Ad hoc Interoperability Networking GATEway (MAINGATE) program seeks to develop the next generation Network Centric Radio System (NCRS) with additional capabilities. MAINGATE will enable heterogeneous groups of radios to be integrated into a heterogeneous network tolerant to high latency and packet loss. The technologies developed for the program will permit affordable, tactical, real-time, high-fidelity video, data, and voice services for deployment in a networked environment, to support tactical operations in maneuvering or dismounted operations for line-of-sight (LOS) and beyond-line-of-sight (BLOS) communications, on the move (OTM) and at the halt (ATH). Two critical technologies for achieving these goals: 1) a backbone radio architecture that enables a versatile internet protocol Mobile Ad hoc Network (MANET) and 2) a radio gateway that enables legacy analog and digital communications systems to be interconnected through a network. The MAINGATE program will use an iterative build-test-build approach that will culminate with limited user testing by U.S. and Allied Experimental Forces evaluating the affect of MAINGATE on new tactics, techniques, and procedures designed for the networked maneuver and dismounted forces. The resulting MAINGATE system and capability is planned for transition to the U.S. Army.<br><br>***FY 2010 Accomplishments:***<br>- Developed and demonstrated Engineering Design Model 2 (EDM2) MAINGATE system units which include a gateway capability for interoperability between all targeted legacy networks and a wireless MANET capability, to create an adaptive internet protocol backbone network among gateways, and for connection to the Global Information Grid (GIG).<br>- Continued integration of Dynamic Spectrum Access (DSA) and Disruption Tolerant Networking (DTN) technologies into the MAINGATE system. | 10.000 | 7.000 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | **PROJECT**<br>CCC-02: *INFORMATION INTEGRATION SYSTEMS* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Provided the network backbone and radio interoperability for the U.S. Army Training and Doctrine Command (TRADOC), Advanced Expeditionary Warrior Experiment (AEWE), at the Spiral F large scale premier testing.<br><br>***FY 2011 Plans:***<br>- Enhance the MAINGATE system units by expanding RF spectrum coverage, and increasing aggregate data rate.<br>- Conduct in-theater field evaluation of 40 units performing Intelligence, Surveillance and Reconnaissance / Command and Control (ISR/C2) networking radio interoperability. | | | |
| ***Title:*** Disruption Tolerant Networking (DTN)<br><br>***Description:*** The Disruption Tolerant Networking (DTN) program developed 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, Unmanned Aerial Vehicle (UAV) over-flights, orbital mechanics, or links that experience fading or interference, etc. The program developed a single model for bundling information and ensuring its delivery, through a series of episodic communications links, from generator to user and explored a new security model which protects information held in portable devices. Protocols were implemented in the Software Interoperability Environment (SIE) situational awareness (SA) tool to verify both the performance of the protocol and to validate the utility. DTN technology is transitioning to the U.S Army and U.S. Marine Corps.<br><br>***FY 2010 Accomplishments:***<br>- Tested DTN on USMC operational networks.<br>- Coordinated DTN transition opportunities with U.S. Army and U.S. Marine Corps. | 1.000 | - | - |
| ***Title:*** Retro-directive Ultra-Fast Acquisition Sensor (RUFAS)<br><br>***Description:*** The Retro-directive Ultra-Fast Acquisition Sensor (RUFAS) effort designed, constructed, and demonstrated an X-band noise correlating radar with a retro-directive antenna. This effort researched and developed 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 reradiation of the correlated noise. Combining and tailoring noise correlating interferometry and retro-directive antenna arrays into a retro-directive noise-correlating (RNC) radar allows the radar to operate in omni-directional search mode. The result of this project is technology supporting a new type of search-mode radar having promising performance in terms of short acquisition time and low probability-of-intercept.<br><br>***FY 2010 Accomplishments:***<br>- Assessed design alternatives to improve performance. | 1.265 | - | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | **PROJECT**<br>CCC-02: *INFORMATION INTEGRATION SYSTEMS* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Researched feasibility of using RUFAS algorithms to detect Measurements and Signature Intelligence signatures to support Electronic Warfare (EW).<br>- Completed technology maturation and development that will reduce risk for insertion into follow-on efforts. | | | |
| ***Title:*** Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART)<br><br>***Description:*** The Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART) program developed a new technology for producing very thin millimeterwave array apertures and transceivers. The technology development culminated in the demonstration of a large-sized coherent, active electronically steerable array (AESA) with an output power density of 5W per square cm and a total layer thickness of less than 1cm. The SMART technology approach resulted in a breakthrough in performance over conventional millimeterwave approaches. The 3-D multi-layer assembles developed will greatly reduce AESA packaging complexity and enable very compact, low-cost, millimeterwave, and radio frequency circuit "building blocks" to combine to form arbitrarily large arrays. New capabilities, such as the ability to construct reconfigurable and/or multi-band AESAs and other MMW circuits, will be enabled by this architectural approach. This program is transitioning through industrial producers of MMW radar systems for DoD applications.<br><br>***FY 2010 Accomplishments:***<br>- Completed initial testing of integrated components at high frequencies.<br>- Initiated a large-size integrated transceiver array of 400 active elements with high output power, low losses, and low noise.<br>- Initiated final demonstrations of transceiver technology. | 10.540 | - | - |
| ***Title:*** Networked Bionic Sensors for Threat Detection<br><br>***Description:*** The Networked Bionic Sensors for Threat Detection program developed and demonstrated low power micro-sensor devices and networks for multiple missions including, language/speech detection and recognition processing, and shooter localization. The system used ultra-low power signal conditioning/processing front-end processors with advanced algorithms for distributed sensor network applications. This program provided 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 will be enhanced with this technology by allowing detection and tracking of high-value targets with hand emplaced or air deployed sensor networks. The technology developed is transitioning to the U.S. Marine Corps.<br><br>***FY 2010 Accomplishments:***<br>- Evaluated bionic sensor technology in a field experiment conducted at the National Training Center at Fort Irwin. | 2.000 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 104.874 | 68.876 | 88.519 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | **PROJECT**<br>CCC-02: *INFORMATION INTEGRATION SYSTEMS* |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | **PROJECT**<br>CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS* | - | - | 15.000 | - | 15.000 | 23.000 | 40.000 | 40.000 | 45.000 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

Computer, networking, and communication technologies have rapidly matured in the last decade and have had a profound effect on DoD weapons systems. In many instances the combination of those technologies has become either the integral piece of many of the emerging traditional land, air, and sea based weapon platforms or have become a stand alone, non-platform based virtual weapon system. In recognition of this fact, the Secure Information and Network Systems project will develop and test emerging computer, communications, and network systems where the impact of the systems and the vulnerabilities of the systems are not kinetically based. The project will identify, further develop and integrate, and test prototypes of promising network security technologies generated in projects such as, but not limited to, those developed in DARPA's Information & Communications program element (PE 0602303E), Cognitive Computing Systems program element (PE 0602304E), and Machine Intelligence program element (PE 0602305E).

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Cyber Insider Threat (CINDER)*<br><br>***Description:*** *Previously funded in PE 0602303E, Project IT-03<br><br>The Cyber Insider Threat (CINDER) program will develop techniques for countering one of the most significant and malicious threats to military networks and systems: the cyber insider threat. Current defenses are based on network and host intrusion detection, and look for "break-ins" and abnormal behavior but do not attempt to characterize a user's mission. The CINDER program will build tools and techniques that characterize user mission in a multi-level security environment.<br><br>***FY 2012 Plans:***<br>- Identify constraints for each class/mission and develop constraint detection concepts.<br>- Quantify probability of detection and probability of false alarms as a function of adversary class and mission for each system.<br>- Design and build scalable prototype systems. | - | - | 12.000 |
| ***Title:*** Secure Information and Network Systems Experimentation (SINSE)<br><br>***Description:*** Protecting the integrity of DoD networks and systems is vitally important, given the constant barrage of attempted intrusions. The Secure Information and Network Systems Experimentation (SINSE) program will leverage promising technologies generated in Project IT-03 (PE 0602303E), Project CCC-02 (PE 0603760E) and other network-based weapons technology projects to build an agile and robust defense for DoD networks and systems. Rapidly changing approaches to malicious attacks on DoD networks cannot be neutralized with one approach. Integrating, testing, and expanding approaches developed across | - | - | 3.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | **PROJECT**<br>CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| many initiatives gives SINSE a diverse knowledge base to further explore techniques and strategies. Viable technologies will be assessed, tested, and quickly transitioned to DoD networks. SINSE offers the opportunity to integrate multiple technologies to augment and reinforce existing network and system defenses.<br><br>***FY 2012 Plans:***<br>- Identify promising technologies for further study, experimentation, prototyping, and development.<br>- Conduct experiments using DoD network assets to validate technology defense capabilities. | | | |
| **Accomplishments/Planned Programs Subtotals** | - | - | 15.000 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
|---|---|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | R-1 ITEM NOMENCLATURE<br>PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS* | PROJECT<br>CCC-CLS: *CLASSIFIED* | |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CCC-CLS: *CLASSIFIED* | 79.368 | 81.623 | 116.218 | - | 116.218 | 105.627 | 105.621 | 114.882 | 114.823 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Classified DARPA Program<br>***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified.<br>***FY 2010 Accomplishments:***<br>Details will be provided under separate cover.<br>***FY 2011 Plans:***<br>Details will be provided under separate cover.<br>***FY 2012 Plans:***<br>Details will be provided under separate cover. | 79.368 | 81.623 | 116.218 |
| **Accomplishments/Planned Programs Subtotals** | 79.368 | 81.623 | 116.218 |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

Details will be provided under separate cover.

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603765E: *CLASSIFIED DARPA PROGRAMS* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 162.880 | 167.008 | 107.226 | - | 107.226 | 107.483 | 108.669 | 109.742 | 109.603 | Continuing | Continuing |
| CLP-01: *CLASSIFIED DARPA PROGRAMS* | 162.880 | 167.008 | 107.226 | - | 107.226 | 107.483 | 108.669 | 109.742 | 109.603 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

**B. Program Change Summary ($ in Millions)**

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 177.582 | 167.008 | 314.719 | - | 314.719 |
| Current President's Budget | 162.880 | 167.008 | 107.226 | - | 107.226 |
| Total Adjustments | -14.702 | - | -207.493 | - | -207.493 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | -9.992 | - | | | |
| • SBIR/STTR Transfer | -4.710 | - | | | |
| • TotalOtherAdjustments | - | - | -207.493 | - | -207.493 |

**Change Summary Explanation**

FY 2010: Decrease reflects internal below threshold reprogrammings and SBIR/STTR transfer.

FY 2012: Decrease reflects reduced emphasis and restructuring of classified programs, Defense Efficiencies for contractor staff support, and classified programs.

**C. Accomplishments/Planned Programs ($ in Millions)**

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Classified DARPA Programs<br><br>***Description:*** Classified DARPA Programs<br><br>***FY 2010 Accomplishments:***<br>Details will be provided under separate cover.<br><br>***FY 2011 Plans:*** | 162.880 | 167.008 | 107.226 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603765E: *CLASSIFIED DARPA PROGRAMS* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| Details will be provided under separate cover.<br>***FY 2012 Plans:***<br>Details will be provided under separate cover. | | | |
| **Accomplishments/Planned Programs Subtotals** | 162.880 | 167.008 | 107.226 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**E. Acquisition Strategy**

N/A

**F. Performance Metrics**

Details will be provided under separate cover.

| **Exhibit R-2**, **RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 144.609 | 234.985 | 235.245 | - | 235.245 | 226.485 | 191.645 | 191.733 | 201.698 | Continuing | Continuing |
| NET-01: *JOINT WARFARE SYSTEMS* | 53.378 | 71.175 | 81.404 | - | 81.404 | 69.662 | 53.793 | 68.873 | 78.873 | Continuing | Continuing |
| NET-02: *MARITIME SYSTEMS* | 30.727 | 46.903 | 56.245 | - | 56.245 | 60.881 | 39.011 | 39.096 | 39.096 | Continuing | Continuing |
| NET-CLS: *CLASSIFIED* | 60.504 | 116.907 | 97.596 | - | 97.596 | 95.942 | 98.841 | 83.764 | 83.729 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

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

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

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY* |

| **B. Program Change Summary ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012 Base** | **FY 2012 OCO** | **FY 2012 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 138.361 | 234.985 | 220.099 | - | 220.099 |
| Current President's Budget | 144.609 | 234.985 | 235.245 | - | 235.245 |
| Total Adjustments | 6.248 | - | 15.146 | - | 15.146 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | 9.918 | - | | | |
| • SBIR/STTR Transfer | -3.670 | - | | | |
| • TotalOtherAdjustments | - | - | 15.146 | - | 15.146 |

**Change Summary Explanation**

FY 2010: Increase reflects internal below threshold reprogrammings offset by the SBIR/STTR transfer.

FY 2012: Increase reflects minor repricing of joint warfare and maritime programs, offset by reductions for Defense Efficiencies for contractor staff support and classified programs.

| **Exhibit R-2A, RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY* | **PROJECT**<br>NET-01: *JOINT WARFARE SYSTEMS* |

| **COST ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012 Base** | **FY 2012 OCO** | **FY 2012 Total** | **FY 2013** | **FY 2014** | **FY 2015** | **FY 2016** | **Cost To Complete** | **Total Cost** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NET-01: *JOINT WARFARE SYSTEMS* | 53.378 | 71.175 | 81.404 | - | 81.404 | 69.662 | 53.793 | 68.873 | 78.873 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***Title:*** Geospatial Exploitation (GEO)<br><br>***Description:*** The Geospatial Exploitation (GEO) thrust will provide a new set of geospatial intelligence (GEOINT) products, continuously updated and maintained in a form that ensures their consistency across both product elements (digital elevation models, traditional maps, 3-D structure models, census summaries, and directories) and spatial nodes (coarse resolution country data for economic analysis to fine resolution building data for platoon-level combat operations). Techniques of interest include 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 human-made structures. These algorithms will be scaled to operate on data streams including full-motion video, Laser Identification Detection and Ranging (LIDAR), multi- and hyper-spectral, synthetic aperture radar (SAR), and Geographic Information Systems (GIS) in addition to conventional electro-optical (EO) geospatial imagery. GEO algorithm architectures will be explored to achieve scalability through spatial, temporal and ontological partitioning. GEO technologies are planned for transition to the National Geospatial-Intelligence Agency (NGA). Activities funded within the GEO research space include:<br><br>The Urban Reasoning and Geospatial Exploitation Technology (URGENT) program is developing a 3-D urban object recognition and exploitation system that enables advanced mission planning and situation analysis capabilities for the warfighter operating in | 4.127 | 7.516 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|

urban environments. URGENT will create techniques for the rapid exploitation of EO and LIDAR sensor data at the city scale to recognize urban objects down to the soldier scale. URGENT will apply image processing technology to geospatially registered 2-D/3-D data collected from airborne and terrestrial sources, yielding precise annotations for the objects in an urban area. URGENT will also develop a 3-D reasoning engine to query object shapes, locations, and classifications for advanced geospatial exploitation capabilities.

The Geospatial Representation Integrated Dataspace (GRID) program is investigating an automated geospatial data fusion, modeling, and dissemination technology for the tactical warfighter. Geospatial registration algorithms have demonstrated success in automatically fusing geospatial data from multiple ISR sources (e.g., electro-optical, full motion video, hyperspectral, and LIDAR) and encoding the fused data as a temporally indexed volumetric model that can potentially reduce geospatial theater ISR sensor data storage requirements while enhancing image quality for exploitation. In addition, converting sensor data enables efficient delivery of geospatial information to the warfighter even with the bandwidth constraints of tactical networks. Based on the success of previous investigations, GRID is investigating a comprehensive 3-D representation of high-resolution data for a broad range of sensor data, including ISR sources as well as medical imaging and scans, common in the manufacturing process. The establishment of the GRID format as an open standard will enable revolutionary efficiencies in the storage, application, and exchange of 3-D information across myriad industries.

***FY 2010 Accomplishments:***
Urban Reasoning and Geospatial Exploitation Technology (URGENT)
- Developed capability for rapid retraining on one or more new geospatial areas and object classes.
- Developed interactive user environment for military geospatial exploitation.
- Began the process of transition of selected object recognition technology to a military geospatial analysis environment.

Geospatial Representation Integrated Dataspace (GRID)
- Investigated multiple implicit and explicit geometric modeling techniques and their applications in the defense, manufacturing, medical imaging, and simulation domains.

***FY 2011 Plans:***
Urban Reasoning and Geospatial Exploitation Technology (URGENT)
- Implement a reasoning capability that exploits knowledge from Geographic Information System (GIS) documents.
- Complete the process of transition of selected object recognition technology to a military geospatial analysis environment.

Geospatial Representation Integrated Dataspace (GRID)
- Define framework for the GRID format standard.

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate the volumetric encoding of electro-optical data from tactical sensors. | | | |
| ***Title:*** Network Targeting<br><br>***Description:*** The Network Targeting program will develop advanced capabilities for a specified emitter density, operating environment, radio frequency (RF) signal location accuracy, probability of correct RF signal identification and probability of false alarm. Each phase will progressively mature the design and technologies required to achieve system performance goals and move incrementally toward an operational system. The technology is planned to transition to the Services in FY 2013.<br><br>***FY 2010 Accomplishments:***<br>- Developed components and software for a system.<br>- Conducted performance validation via laboratory demonstrations in a controlled operational environment.<br>***FY 2011 Plans:***<br>- Demonstrate real-time processing on brassboard hardware.<br>- Conduct performance validation via demonstrations in a complex operational environment.<br>***FY 2012 Plans:***<br>- Optimize and integrate algorithms with modified software radio platform.<br>- Demonstrate networked real-time processing on a software radio platform. | 12.260 | 12.310 | 7.220 |
| ***Title:*** Legged Squad Support System (LS3)<br><br>***Description:*** The Legged Squad Support System (LS3) program will explore the development of a mission-relevant quadruped platform scaled to unburden the infantry squad and hence unburden the soldier. In current operations, soldiers carry upwards of 50lbs of equipment, in some cases over 100lbs, over long distances in terrain not always accessible by wheeled platforms that support infantry. As a result, the soldier's combat effectiveness can be compromised. The LS3 program will design and develop prototypes capable of carrying 400lbs of payload for 20 miles in 24 hours, negotiating terrain at endurance levels expected of typical squad maneuvers. LS3 will leverage technical breakthroughs of prior biologically inspired legged platform development efforts. It will develop system designs to the scale and performance adequate for infantry squad mission applications, focusing on platform, control, and human-machine interaction capabilities, as well as secondary design considerations, such as acoustic signature. Anticipated service users include the Army, Marines and Special Forces.<br><br>***FY 2010 Accomplishments:***<br>- Completed trade studies and initial powering, endurance, and load design estimates to narrow design options.<br>- Began building/integrating preliminary subsystem and components for testing to prove design validity.<br>- Modeled foot placement, stability against disturbances, self-righting, and advanced gaits. | 8.776 | 16.083 | 15.452 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Completed a preliminary perception sensing head for obstacle avoidance and leader tracking; performed early data collections.<br>- Successfully completed preliminary design review.<br>***FY 2011 Plans:***<br>- Complete critical design review and prototype build plan.<br>- Final subsystem test stand development, testing, and analysis of results to support design estimates.<br>- Complete initial integration of controls to demonstrate walk and trot.<br>- Integrate perception hardware.<br>***FY 2012 Plans:***<br>- Complete build phase of prototype system.<br>- Conduct walkout and acceptance testing of system. | | | |
| ***Title:*** Chemical Analysis Sans Machinery (CASM)<br>***Description:*** The Chemical Analysis Sans Machinery (CASM) program will develop novel materials and fabrication methods to produce high throughput, autonomous, low cost, chemical analysis devices. This program will transition to the Services.<br>***FY 2010 Accomplishments:***<br>- Developed novel materials and technologies with unique chemical analysis properties.<br>- Fabricated materials with high throughput for chemical analysis.<br>- Fabricated materials for chemical analysis, amenable to low cost manufacturing.<br>***FY 2011 Plans:***<br>- Fabricate materials with more rapid response time for chemical analysis.<br>- Fabricate materials that are more reliable and sensitive for chemical analysis.<br>- Integrate novel materials and technologies into chemical analysis devices.<br>***FY 2012 Plans:***<br>- Test chemical analysis devices against representative levels of appropriate chemicals.<br>- Demonstrate the utility of these devices under conditions expected during deployment.<br>- Improve manufacturing processes to demonstrate clear path to low cost production.<br>- Improve durability and robustness of device for increased shelf-life.<br>- Compare effectiveness of chemical analysis devices to state-of-art technological alternatives. | 9.817 | 8.026 | 13.880 |
| ***Title:*** High Energy Liquid Laser Area Defense System (HELLADS) | - | 24.000 | 25.630 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** Building upon the achievements of the High Energy Liquid Laser Area Defense System (HELLADS) development program budgeted in DARPA PE 0602702E, Project TT-06, the goal of the HELLADS program is to develop a high-energy laser weapon system with an order of magnitude reduction in weight compared to existing laser systems. HELLADS will enable high-energy lasers (HELs) to be integrated onto tactical aircraft and will significantly increase engagement ranges compared to ground-based systems, enable high precision/low collateral damage, and rapid engagement of fleeting targets for both offensive and defensive missions. With the assistance of the U.S. Air Force, the HELLADS program will pursue the necessary analysis, coordination, and design activity for a prototype laser weapon system incorporating the HELLADS laser system into a test aircraft. DARPA will explore reductions in beam control and other subsystems that are required for the practical integration of a laser weapon into existing tactical platforms.<br><br>***FY 2011 Plans:***<br>- Initiate Laser Weapon System Module (LWSM) preliminary design to integrate laser, beam control, power, thermal management, and battle management systems in a flight qualifiable module.<br>- Design suitable physical and functional aircraft interfaces for the modularize weapon system.<br>- Initiate investigation of alternative approaches to beam control and laser integration to enable reduced size, weight, and power (SWaP) and reduced platform performance impacts.<br>***FY 2012 Plans:***<br>- Complete LWSM preliminary design.<br>- Conduct necessary modeling and simulation for system performance and target interactions.<br>- Coordinate other activities necessary for safe and effective operation of the prototype system on the test aircraft.<br>- Complete critical design and initiate fabrication of LWSM subsystems including integrating structure, aircraft interfaces, beam control, and battle management subsystems to facilitate early low power demonstration of in-flight performance.<br>- Design and assess the performance of alternative beam control approaches that reduce SWaP and enable integration with reduced platform performance penalties. | | | |
| ***Title:*** Robotic Activators and Physical Performance Improvements in Dynamic Environments (RAPPIDE)<br><br>***Description:*** Advancements are being made in land-capable, high degree-of-freedom unmanned platforms to enable mobility over very complex terrain. Many current prototypes are inspired by biological systems and while proof-of-principle systems have or are demonstrating unprecedented mobility, limitations have emerged. Concurrently, soldier physical limitations are resulting in lower physical strength when operating at load in dismounted terrain and lower redeployment rates due to injury. The goals of the Robotic Activators and Physical Performance Improvements in Dynamic Environments (RAPPIDE) program will be to develop robust and efficient hardware components, physical performance models, and integrated prototypes for improved soldier | - | - | 19.222 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| performance in dynamic and complex environments. These are critical enablers for performing mission-relevant tasks in austere and remote terrain environments. Solving these technical challenges will result in high-degree-of-freedom manned/symbiotic systems that are high performance, provide longer range/endurance for soldiers, operational in multiple terrain environments, and improve the physical availability of soldiers due to mitigation of injury. This program will transition to the Army, Marines, and Special Forces.<br><br>***FY 2012 Plans:***<br>- Complete and review initial selection of novel hardware components.<br>- Begin development of a physical performance model.<br>- Investigate initial integrated concepts. | | | |
| ***Title:*** Seismic/Acoustic Vibration Imaging (SAVI)<br><br>***Description:*** The Seismic/Acoustic Vibration Imaging (SAVI) program developed the capability to locate both buried landmines and near-surface tunnels using active acoustic and seismic sources coupled with a multi-pixel laser vibrometer. These systems employed well characterized acoustic and seismic sources to stimulate the targets of interest from a remote platform. Focused acoustic sources to remotely stimulate plastic or metal antipersonnel and antitank mines and a laser vibrometer system then detects the stimulated resonant characteristic of the mines to discriminate against natural sources of clutter. The capabilities are transitioning to the Army and Marine ground forces for development and employment of operational systems.<br><br>***FY 2010 Accomplishments:***<br>- Completed scalable system integration for mobile buried landmine and static near surface tunnel detection.<br>- Completed scalable system outdoor demonstration of acoustic landmine hunting and limited seismic tunnel testing.<br>- Initiated scaled system development to improve coverage rate and standoff distance.<br><br>***FY 2011 Plans:***<br>- Demonstrate final scaled system for active acoustic landmine and active seismic tunnel detection with laser vibrometer. | 8.733 | 1.000 | - |
| ***Title:*** Multipath Exploitation Radar (MER)<br><br>***Description:*** The Multipath Exploitation Radar (MER) program will address radar deficiencies in urban operations: limited line of sight due to urban structures and excessive confusers due to multipath reflections. This program will exploit multipath bounces to detect and track moving targets beyond line-of-sight (LOS), and extend the area coverage rate of airborne sensors by a factor of six or more over physical line-of-sight limits. The urban coverage improvement will make it cost effective for airborne surveillance of an area the size of a large metropolitan area with a handful of airborne sensors. This capability will facilitate both manned and unmanned airborne Intelligence, Surveillance and Reconnaissance (ISR) and is planned to transition to the Air Force and Army. | 4.000 | 2.240 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Developed and validated urban target and clutter signature models accounting for non-line-of-sight (NLOS) propagation.<br>- Developed urban tracking algorithms that predict, detect, and incorporate multipath radar returns using knowledge of the urban terrain.<br>- Documented modeling and algorithm performance against urban collected field data.<br>***FY 2011 Plans:***<br>- Determine upper bounds on track accuracy, persistence, and target density that can be achieved using NLOS returns.<br>- Develop system concept for persistent wide-area surveillance over large metropolitan areas using multiple platforms.<br>- Quantify the radar hardware and processing requirements to implement MER and identify potential transition platforms.<br>- Validate urban clutter model and tracking algorithms on urban radar data set.<br>- Transition Multipath Exploitation Radar system to the Services. | | | |
| ***Title:*** Network Command<br>***Description:*** The Network Command program leveraged recent advances in network computing, simulation, and visualization to improve collaboration among physically separate command posts and lower echelons. Network Command enables warfighters to share situation information from the area of responsibility, develop coordinated battle plans, generate and compare alternate courses of action, and assess likely outcomes, without conventional group briefings. Network Command also enables warfighters to prepare for joint missions using high-fidelity, mixed-reality combat simulation and visualization technologies. The Joint Mission Rehearsal program integrated high-fidelity, mixed-reality combat simulations with situation assessment and planning tools to allow rehearsal of joint missions, prior to actual engagements. Technologies transitioned to the Army Simulation, Training & Instrumentation Command, Special Operations Command (SOCOM), and the Marine Corps Combat Development Command (MCCDC).<br>***FY 2010 Accomplishments:***<br>- Designed a game-based mission rehearsal environment that supports real-time learning assessment.<br>- Demonstrated learning in a simulated urban training environment suitable for mission rehearsal. | 2.665 | - | - |
| ***Title:*** Mobile Intelligent Sensors (MIS)<br>***Description:*** There has been continuing interest in exploiting new legged, wheeled, and tracked robots to create "robot-enabled sensors" that are capable of sensing, moving, and self-organizing into a viable network for reliable data exfiltration. The Mobile Intelligent Sensors (MIS) program and the Remote Detection of Suspicious Vehicles (RDSV) program developed such advanced sensor, exploitation, networking, and battle management capabilities for joint dismounted forces. These nodes have a sufficient level of embedded intelligence so that they can identify, learn, adapt, and traverse through or under small openings and | 1.000 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| circumnavigate barriers larger than themselves, yet are capable of carrying an operationally-meaningful day/night sensor payload. Technologies transitioned to the Army, Special Operations Command, and the Marine Corps.<br><br>***FY 2010 Accomplishments:***<br>Mobile Intelligent Sensors (MIS)<br>- Developed miniaturized sensor concepts meeting size, weight and power constraints and explored signal processing approaches.<br><br>Remote Detection of Suspicious Vehicles (RDSV)<br>- Conducted multiple field Army test and evaluation experiments to validate system performance, concept of operations, and reliability.<br>- Transitioned RDSV to the Army and Marine Corps. | | | |
| ***Title:*** Human-carried Explosive Detection Stand-off System (HEDSS)<br><br>***Description:*** 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 was to develop a system that rapidly and automatically identifies human-carried explosives (HCEs) at stand-off ranges. While alternative technologies exist for HCE detection, they necessitate close-in sensing, are expensive and require extended processing times. Successful development of a HEDSS could 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 transitioned to the Army, Air Force and Marines.<br><br>***FY 2010 Accomplishments:***<br>- Completed development of processing software, and performed system integration. | 2.000 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 53.378 | 71.175 | 81.404 |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NET-02: *MARITIME SYSTEMS* | 30.727 | 46.903 | 56.245 | - | 56.245 | 60.881 | 39.011 | 39.096 | 39.096 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

## B. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Blue Laser for Submarine Laser Communications (SLC) | 10.025 | 23.550 | 12.100 |

***Description:*** The Blue Laser for Submarine Laser Communications (SLC) program will develop the critical laser technology necessary to support the requirements for Non-Acoustic Anti-Submarine Warfare (NAASW), mine detection, and SLC. This program will develop the world's first wall-plug efficient laser that operates at an optimal water transmission band of open ocean water and at the wavelength of a Cesium Atomic Line Filter and will enable duplex communications for the submarine at speeds and depths. A Memorandum of Agreement (MOA) was signed among DARPA; Commander, Submarine Forces (COMSUBFOR); Deputy Chief of Naval Operations for Integration of Capabilities and Resources (N8); and Program Executive Officer, Command, Control, Communications, Computers and Intelligence (PEO C4I). The MOA establishes a joint program to conduct a demonstration of SLC technology during a recognized fleet exercise in FY 2012. Additionally, there is a pressing need for improved ASW capabilities in the current operating environment, particularly in shallow water and littoral areas of operations. This program will demonstrate significant improvements to Lidar hull detection depths during daylight conditions that meet Navy requirements. The Blue Laser technology is planned for transition to the Navy.

***FY 2010 Accomplishments:***
- Completed design, built, and tested the breadboard blue solid state laser.
- Demonstrated laser/filter compatibility in a laboratory environment.
- Successfully built and tested a blue solid-state laser and atomic line filter for the breadboard modules.

***FY 2011 Plans:***
- Initiate developments of the laser brassboard modules and Cesium Atomic Line Filter receivers.
- Test airborne and submarine based brassboard transmitters for wavelength, energy per pulse, repetition rate, and beam quality.
- Integrate the second gimbal and laser anamorphic zoom; test with the receiver subsystem in the lab.

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Develop the data recording and field calibration systems and the Low Probability of Intercept (LPI) receiver.<br>- Complete demonstration of High Pulse Repetition Rate Blue Laser for Non-Acoustic Anti-Submarine Warfare laser identification detection and ranging applications.<br>- Develop and pressure test the submarine transmitter canisters, test receiver canisters and develop fairings and electrical cabling.<br>- Develop the aircraft installation, fabrications, and install aircraft modifications.<br>- Conduct test planning and laser safety planning and reviews.<br>***FY 2012 Plans:***<br>- Install aircraft and submarine transceiver systems, and flight and water test, respectively.<br>- Fly end-to-end system test and conduct engineering testing on demonstration system.<br>- Investigate submarine hull detection using blue laser technology. | | | |
| ***Title:*** Distributed Agile Submarine Hunting (DASH)<br>***Description:*** *Formerly Deep Sea Operations (DSOP)<br><br>The Distributed Agile Submarine Hunting (DASH) program goal is to counter the asymmetric diesel-electric submarine threat through the development of advanced standoff sensing from unmanned systems. Through a scalable number of collaborative sensor platforms that use multiple sensing modalities, the program will demonstrate system solutions to detect and localize submarines over large areas in both shallow and deep water environments. Initial efforts will focus on identifying the best detection methods leveraged from state-of-the-art sensors and new physical and operational insights. From this work, a prototype system will evolve through at-sea testing and sensor integration. The program will achieve breakthrough technology for long-range detection and classification, communications, energy management, sensor and platform integration, and robust semi-autonomous processing and control for distributed sensing platforms. This program will transition to the Navy.<br>***FY 2010 Accomplishments:***<br>- Conducted simulation and trade space analysis of various system architectures.<br>- Conducted at-sea data collection supporting processing development and technology feasibility assessment.<br>- Initiated design of deep ocean sub-system architectures.<br>***FY 2011 Plans:***<br>- Initiate designs of multiple configurable systems.<br>- Initiate development of key deep ocean subsystems and conduct any necessary in water testing.<br>- Collect additional signature and environmental data needed to support technology designs. | 6.000 | 12.387 | 35.145 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Conduct capability-based assessment to finalize requirements and assess cost-effectiveness.<br>- Conduct trade studies to investigate feasibility of incorporating other sensing modalities employed by UAVs.<br><br>***FY 2012 Plans:***<br>- Complete development of key deep ocean sensing subsystem components.<br>- Complete in-water testing of key deep ocean sensing subsystem components.<br>- Begin integration of deep ocean sensing system for initial capability demonstration.<br>- Explore various sensing modalities and sensors to determine the system architecture to incorporate shallow-water sensing capabilities.<br>- Complete overall system design and test sensors in realistic ocean environments. | | | |
| ***Title:*** Unmanned/Minimally-manned Underwater Vehicle (UMUV)<br><br>***Description:*** Increasing requirements for missions in shallow littoral waters have created a need for a survivable and cost-effective capability to perform intelligence surveillance and reconnaissance, antisubmarine warfare, special operations forces, and other missions in the littorals. Today we risk manned submarines in waters that are shallower than the length of our hulls and we pit these high value assets against diesel electric submarines that in some cases pose an overmatching threat against our systems in these shallow waters. The Unmanned/Minimally-manned Underwater Vehicle (UMUV) program will develop a vehicle specifically designed to operate in the littoral battlespace with the capability of performing littoral missions that span a wide range of complexity and can be performed with a small manned crew or autonomously (ie, unmanned) depending upon mission requirements. The UMUV will have the autonomy, range and endurance to drive to the fight from a safe basing location, will be capable of carrying the full range of payloads that are needed to support operational needs in littoral waters, and will provide the capability to perform missions where risk to personnel limits our willingness to execute these missions. The program will explore low-cost derivatives of commercial underwater vehicles, the integration of advanced communication and sensor technologies, and the teaming of the UMUV with manned systems. The UMUV program will transition to the Navy.<br><br>***FY 2012 Plans:***<br>- Perform technology trades to address key vehicle capabilities.<br>- Develop concept of operations.<br>- Initiate development of enabling technologies.<br>- Initiate system conceptual design. | - | - | 9.000 |
| ***Title:*** Tango Bravo<br><br>***Description:*** 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. | 5.804 | 1.000 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY* | **PROJECT**<br>NET-02: *MARITIME SYSTEMS* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| 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 and infrastructure cost. DARPA and the Navy 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. A Memorandum of Agreement (MOA) establishing joint DARPA/Navy funding for the Tango Bravo program was executed in September 2004.<br><br>Anticipating success of shaftless propulsion technologies demonstrated in the Tango Bravo program, DARPA and the U.S. Navy collaborated in 2008 with the goal of designing, building, and testing a large scale Submarine Shaftless Stern Demonstrator (S3D) to characterize and mitigate risks associated with ship integration into a next generation submarine propulsion option. The S3D program focused on full-ship concept studies supported by Tango Bravo Shaftless Propulsion technical risk reduction activities. Elements of the Tango Bravo program began transition to the Navy in FY 2009.<br><br>***FY 2010 Accomplishments:***<br>- Completed Shaftless Propulsion demonstrator assembly.<br>- Completed Shaftless Propulsion technical risk reduction integration tasks on S3D.<br>- Completed cyclic testing of the X-Planes electrical actuator and concluded the Electric Actuation project (Radical Ship Infrastructure Reduction).<br>***FY 2011 Plans:***<br>- Complete Shaftless Propulsion integrated system testing (in-air, full load motor testing).<br>- Complete Shaftless Propulsion in-water acoustic and endurance testing.<br>- Complete Shaftless Propulsion demonstrator test results analysis and modeling validation/updates. | | | |
| ***Title:*** Thermal Management System for Ship Decks (TMD)<br><br>***Description:*** It is anticipated that the high engine exhaust temperatures from the next generation of Vertical Take Off and Landing (VTOL) aircraft deployed on Navy ships will dramatically reduce the life of both the deck structure and the non-skid surfaces. The Thermal Management System for Ship Decks (TMD) will address this problem by demonstrating a heat distribution system with an integrated thermally stable non-skid coating. Upon satisfactory completion of the development and certification of the design, the TMD will be transitioned to the Navy for integration into amphibious assault ships.<br><br>***FY 2010 Accomplishments:*** | 3.500 | 4.000 | - |

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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY* | **PROJECT**<br>NET-02: *MARITIME SYSTEMS* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Initiated the design and development of scaled modular passively cooled thermal management system.<br>***FY 2011 Plans:***<br>- Conduct assessment of thermo physical properties of non-skid coatings and develop thermally resistant non-skid coating.<br>- Complete development, construction and evaluation of a small-scale, non-skid, coated, passively cooled thermal management system. | | | |
| ***Title:*** Persistent Ocean Surveillance (POS)<br>***Description:*** The Persistent Ocean Surveillance (POS) program combines geolocation techniques such as global positioning systems, with station keeping and intra-sensor communication technologies, to provide long-term ocean environment sensing buoys. Application of these technologies with state-of-the-art undersea warfare sensors will result in a floating field of smart sensors capable of observing the undersea environment in an area, including the presence of submarines and other undersea vehicles. A range of technologies were 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. The Renewable At-Sea Power program focuses on efficient energy capture from the environment in order to achieve capability for fully renewable power at sea. Technology from this program will be available for transition to the Navy.<br>***FY 2010 Accomplishments:***<br>- Completed numerical model of system performance and conducted trade studies to evaluate several design alternatives.<br>- Built instrumented platform to test improved endurance and survivability in high sea conditions.<br>- Conducted at-sea testing to validate performance of technologies and system models.<br>***FY 2011 Plans:***<br>- Complete design, fabrication and assembly of instrumented prototype platform.<br>- Integrate power take-off device with instrumented prototype platform.<br>- Conduct at-sea testing of instrumented platform.<br>- Perform modeling and analyses of near-surface vehicle docking concepts. | 1.850 | 1.500 | - |
| ***Title:*** River Eye<br>***Description:*** 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 determining objective assault engagement/disengagement strategies. For uncharted and/or denied areas, present methods are inadequate for obtaining this necessary information. Reliable remote | 3.025 | 4.466 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| sensing methods that produce bathymetry and current water data in waters that are sediment laden (bottom not visible) and/or sheltered (swell and significant wind waves are not likely) do not exist. The River Eye effort provided a new capability to predict or assess, in real time, river and estuary conditions that enable special operations mission planning and execution. New techniques were developed to indirectly determine current speed and direction by remotely sensing advection of scene features. Using advanced modeling techniques, indirectly sensed current data provided bathymetry data. Forward circulation models used the bathymetry data to predict future currents and water heights in a mission planning decision support tool. An initial set of algorithms and processes transitioned to the Navy and National Geospatial-Intelligence Agency in FY 2010; in FY 2011 the algorithms will be extended to enable night-time capability, and will transition to the Navy and National Geospatial-Intelligence Agency.<br><br>***FY 2010 Accomplishments:***<br>- Improved the automation of the current extraction algorithms to handle clouds and moving objects in the time series data.<br>- Developed a variable grid size to improve current resolution.<br>- Developed capability to identify shoals.<br>- Applied inverse model to new physical environments and improved the efficiency of the model.<br>- Demonstrated the inverse model's capability to estimate bathymetry for a new location having an unknown environment.<br>- Transitioned River Eye current and bathymetry algorithms to the Navy and National Geospatial-Intelligence Agency.<br><br>***FY 2011 Plans:***<br>- Develop current and bathymetry algorithms for use with infrared (IR) image data, leading to a day / night capability.<br>- Collect IR data on rivers and estuaries for testing and evaluation of the algorithms.<br>- Develop IR sensor payload prototype for a small tactical unmanned air vehicle (TUAV). | | | |
| ***Title:*** Maritime Persistent Surveillance and Awareness (MPSA)<br><br>***Description:*** The Maritime Persistent Surveillance and Awareness (MPSA) program developed an extensible battle management automation capability to provide persistent surveillance and situational awareness to protect naval forces against overwhelming threats. MPSA used layered and distributed sensing, and added data from all sources for the non-traditional areas of infrastructure, socio-political developments and economic indicators. These systems enable timely and coordinated decision-making and vastly improved situational awareness under uncertainty for naval commanders. MPSA enables intelligent deployment of sensors and network infrastructures to protect sea-based assets through effective cross-platform and multi-mission fusion and resource management with focus on stand-off and elusive threats. MPSA departed from previous approaches in assessing the operational environment in that it will not rely solely upon military indicators, but also expanded understanding | 0.523 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| to include national infrastructure, socio-political, and economic indicators to better assess trends and threat development. The program is transitioning to the Navy.<br><br>***FY 2010 Accomplishments:***<br>- Analyzed maritime and littoral sensor systems and developed an architectural approach to combining them into an effective Intelligence, Surveillance and Reconnaissance/Reconnaissance, Surveillance and Target Acquisition ISR/RSTA system. | | | |
| **Accomplishments/Planned Programs Subtotals** | 30.727 | 46.903 | 56.245 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

| **Exhibit R-2A, RDT&E Project Justification:** PB 2012 Defense Advanced Research Projects Agency | | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY* | **PROJECT**<br>NET-CLS: *CLASSIFIED* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NET-CLS: *CLASSIFIED* | 60.504 | 116.907 | 97.596 | - | 97.596 | 95.942 | 98.841 | 83.764 | 83.729 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Classified DARPA Program<br>***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified.<br>***FY 2010 Accomplishments:***<br>Details will be provided under separate cover.<br>***FY 2011 Plans:***<br>Details will be provided under separate cover.<br>***FY 2012 Plans:***<br>Details will be provided under separate cover. | 60.504 | 116.907 | 97.596 |
| **Accomplishments/Planned Programs Subtotals** | 60.504 | 116.907 | 97.596 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

Details will be provided under separate cover.

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603767E: *SENSOR TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 226.953 | 205.032 | 271.802 | - | 271.802 | 237.238 | 246.905 | 255.322 | 265.481 | Continuing | Continuing |
| SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY* | 33.951 | 37.053 | 40.212 | - | 40.212 | 47.897 | 60.564 | 62.965 | 77.965 | Continuing | Continuing |
| SEN-02: *SENSORS AND PROCESSING SYSTEMS* | 117.041 | 77.903 | 77.669 | - | 77.669 | 73.717 | 77.913 | 78.971 | 78.971 | Continuing | Continuing |
| SEN-03: *EXPLOITATION SYSTEMS* | 24.582 | 63.420 | 88.674 | - | 88.674 | 69.407 | 62.407 | 62.013 | 72.013 | Continuing | Continuing |
| SEN-CLS: *CLASSIFIED* | 51.379 | 26.656 | 65.247 | - | 65.247 | 46.217 | 46.021 | 51.373 | 36.532 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

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

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

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

| | |
|---|---|
| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
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| **B. Program Change Summary ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012 Base** | **FY 2012 OCO** | **FY 2012 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 222.866 | 205.032 | 251.805 | - | 251.805 |
| Current President's Budget | 226.953 | 205.032 | 271.802 | - | 271.802 |
| Total Adjustments | 4.087 | - | 19.997 | - | 19.997 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | 9.999 | - | | | |
| • SBIR/STTR Transfer | -5.912 | - | | | |
| • TotalOtherAdjustments | - | - | 19.997 | - | 19.997 |

**Change Summary Explanation**

FY 2010: Increase reflects internal below threshold reprogramming offset by SBIR/STTR transfer.

FY 2012: Increase reflects repricing of sensor data exploitation technologies and the classified programs, offset by reductions for Defense Efficiencies for contractor staff support and classified programs.

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603767E: *SENSOR TECHNOLOGY* | **PROJECT**<br>SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY* | 33.951 | 37.053 | 40.212 | - | 40.212 | 47.897 | 60.564 | 62.965 | 77.965 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Combat Laser Infrared Countermeasure (IRCM) Preemptive Survivability System (CLIPSS) | 2.000 | 4.995 | 6.000 |
| ***Description:*** The Combat Laser Infrared Countermeasure (IRCM) Preemptive Survivability System (CLIPSS) will enable air dominance at low altitude and at night against infrared missile threats. Man portable air defense (MANPAD) systems, guided air defense missile systems, and advanced search and track systems, will be addressed with the development of advanced infrared countermeasures. CLIPPS will leverage the systems and focal plane array (FPA) technologies developed in the near and mid-wave infrared (NMIR), and potentially the long-wave infrared (LWIR) bands of the optical spectrum and the directed infrared countermeasures capabilities currently in the field. CLIPSS will provide a near-term demonstration and transition of the advanced capabilities and serve as a pathfinder for the transition to the Services. The primary technical obstacles are the continued development and integration of high sensitivity infrared Focal Plane Array (FPA) and multi-frequency laser technologies into compact, efficient packages for demanding IRCM environments. The real-time processing of the data over wide-fields-of view to rapidly cue countermeasures poses significant systems integration challenges and will be addressed by this demonstration. CLIPSS technology is planned to transition to the Services.<br><br>***FY 2010 Accomplishments:***<br>- Completed laboratory and outdoor testing of small-format 128x128 NMIR FPA in a compact camera/cryo-cooler package.<br>- Completed first fabrication run of large format 256x256 NMIR FPAs.<br>***FY 2011 Plans:***<br>- Complete testing of 256x256 NMIR FPAs to guide the final design/ fabrication phase. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
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| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603767E: *SENSOR TECHNOLOGY* | **PROJECT**<br>SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Complete design and initiate fabrication of airborne NMIR breadboard data collection system based on these large-format arrays.<br>- Initiate design and modeling of CLIPSS integrated IRCM pod-based demonstration system.<br>- Initiate key optical technology development to support detailed design objectives.<br>- Complete testing of small-format LWIR FPAs and initiate design and fabrication of lower power dissipation, large-format LWIR coherent arrays.<br>***FY 2012 Plans:***<br>- Complete fabrication of NMIR breadboard flight system and initiate flight test - results to guide the detailed design of the integrated CLIPSS pod.<br>- Complete critical design of the CLIPSS pod using breadboard results and key component performance measurements and then initiate subsystem fabrication.<br>- Complete testing of first large-format LWIR arrays and initiate bench testing. | | | |
| ***Title:*** Adaptable Navigation Systems (ANS)*<br>***Description:*** * Formerly Robust Surface Navigation.<br><br>The Adaptable Navigation Systems (ANS) program (previously funded under PE 0603768E, Project GT-01) will provide the U.S. warfighter with the ability to navigate effectively in all environments, including when Global Positioning System (GPS) is unavailable due to hostile action (e.g. jamming) or blockage by structures and foliage. The ANS approach relies on two major technology innovations. The first is the use of Signals of Opportunity (SoOp) from a variety of ground, air, and space-based sources. These will be received on the Services' forthcoming software-defined radios and use specially tailored algorithms to determine position. The second technology innovation allows SoOp-based position information to be combined with inertial and other sensors to enable flexible navigation systems that can be reconfigured in the field to support any platform or environment. While component technology for positioning, navigation, and timing is advancing rapidly (in the form of MEMS devices, clocks, and new aiding sensors), real-time integration and reconfiguration of these components is not possible given today's navigation filters and centralized processing architectures, which are inherently fragile to change. Recent advances in mathematics, data abstraction, and network architectures could enable "plug-and-play" integration of both existing and future navigation components to allow real-time integration and reconfiguration of navigation systems. If successful, major improvements in navigation accuracy and system cost could also be realized. Early transition partners would include all Services, with emphasis on platforms and users that must operate in multiple environments.<br><br>***FY 2011 Plans:***<br>- Develop non-form-fit prototype ANS system. | - | 10.000 | 17.512 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Demonstrate ANS prototype system in urban canyons and inside buildings.<br>- Conduct field tests and demonstrate the functional ANS prototype in user-selected environments such as forested, jungle and open environments, and for airborne platforms.<br>- Validate performance prediction models from previous phases for use in mission planning tools.<br>- Identify candidate filter, sensor, and architecture designs to enable plug-and-play all environment precision navigation and timing.<br>- Quantify the required performance including accuracy and reconfiguration robustness to enable plug-and-play all environment precision navigation and timing.<br>***FY 2012 Plans:***<br>- Evaluate candidate filter, sensor, and architecture design for plug-and-play system.<br>- Conduct tests to compare plug-and-play navigation system performance with existing state-of-the-art.<br>- Develop system specification for platform-specific form factor of ANS reference stations.<br>- Demonstrate SoOp-based ranging and navigation.<br>- Develop and demonstrate through-the-earth communications for navigation (surface-to-subsurface communications). | | | |
| ***Title:*** Strategically Hardened Facility Defeat<br>***Description:*** Building upon the success of technology developed under the Counter Underground Facilities program, the Strategically Hardened Facility Defeat program leveraged recent advances in earth-penetrating technologies for full defeat of strategically hardened targets at depths inaccessible to traditional earth penetrating weapons. Technology developed under this program is available for transition to the Defense Threat Reduction Agency (DTRA).<br>***FY 2010 Accomplishments:***<br>- Designed and initiated development of deployable system with advanced penetration and navigation capabilities.<br>- Demonstrated several subsystems and technologies for autonomous earth penetrating system. | 1.000 | - | - |
| ***Title:*** Airborne Tomography using Active Electromagnetics (ATAEM)<br>***Description:*** The Airborne Tomography using Active Electromagnetics (ATAEM) program investigated approaches to develop an active electromagnetic (EM) system for airborne imaging of subsurface structures, such as underground facilities (UGFs) or perimeter-breaching tunnels. The ATAEM system goal was to illuminate the ground with electromagnetic energy and interpret resulting distortions of the electric and magnetic fields to detect and characterize surreptitious structures. The ATAEM program investigated the component technologies, including EM illumination sources, noise-isolated sensor payloads and signal processing. Results of the ATAEM program are available for transition to the U.S. Army, U.S. Marine Corps, and U.S. Special Operations Command. | 1.000 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Completed independent analysis of Phase I data collected by Fort Hood. | | | |
| ***Title:*** Adaptable, Low Cost Sensors<br><br>***Description:*** The objective of the Adaptable, Low Cost Sensor program is to leverage commercial technology and commercial manufacturing techniques with antenna technologies developed in PE 0602716E, Project ELT-01 to significantly reduce the cost of sensors and sensor systems. Military sensors are currently developed as unique designs that fully integrate mission-specific hardware required for sensing, with all of the other non-mission specific capabilities, including sensors (e.g., GPS), processing, memory storage and communications into a single device. Not only does this approach significantly increase the cost of the device, it makes changing requirements extremely difficult and the upgrading of any specific component impossible. However, significant advances have been made in the capabilities of commercial equipment for almost all of those non-mission capabilities, mostly driven by the smart phone industry. This makes it possible to create a mission-independent, designed-to-cost "commercial smart core" that can be combined with an applique of mission-specific hardware to provide the overall sensing capability. Because the core can be upgraded independently of any particular mission, sensors can make use of the advances and decreasing cost that is inherent in commercial technology. Because commercial technology can be used in the core, commercial development and manufacturing techniques can also be leveraged, further improving the cost and development time of sensor systems. In addition, this program will enable effective distributed sensor systems that were previously infeasible due to high cost of individual sensors. This program will transition to the Services.<br><br>***FY 2012 Plans:***<br>- Manufacture initial version of commercial smart core.<br>- Identify candidate sensors for ground and airborne demonstrations and quantify the required performance, including adaptability.<br>- Define objectives for distributed sensor systems (ground and UAV) and quantify performance against traditional, non-distributed systems.<br>- Develop a distributed ground sensor system using smart core.<br>- Develop smart core re-usable software and ground mission software.<br>- Define objectives for ground system field test and plan field test activities. | - | - | 16.700 |
| ***Title:*** Rescue Transponder (RT)<br><br>***Description:*** Building upon technologies developed in other sensor programs, the Rescue Transponder (RT) program investigated the use of a unique localization and tracking technology to provide a very low probability of detection (LPD) call for help signal. The system used a wideband radio frequency signal with low power and extremely low duty cycle. The program | 2.150 | 1.000 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| developed a small, rugged transponder that provides a call for help to friendly forces. The RT system operates over ranges that enable rescue forces or surveillance systems to receive its signals. It supports accurate localization by rescue forces, and permits transmission of identifying, authenticating, and status information. The RT technology is transitioning to the U.S. Marine Corps.<br><br>***FY 2010 Accomplishments:***<br>- Developed advanced prototypes with self-calibration and non-synchronization tag capabilities to simplify operations.<br>- Developed design for a miniaturized light-weight receive prototype to support expeditionary operations.<br>- Initiated effort to miniaturize receiver, extend tag battery life, and execute field experiments to validate performance.<br>***FY 2011 Plans:***<br>- Complete development and deliver miniaturized receivers and extended-life tags to U.S. Marine Corps.<br>- Complete transition to U.S. Marine Corps. | | | |
| ***Title:*** Visibuilding<br><br>***Description:*** The Visibuilding program is developing technologies and systems for new building surveillance capabilities to detect personnel within buildings, determine building layouts, and locate weapons caches within buildings. This program is developing techniques to inject and recover probing radar waveforms and unravel the complicated multipath in the return signals to enable the mapping and characterization of building interiors. Radar signals 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 allow mapping of building pathways and stairways by monitoring traffic through buildings. 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. Other sensing modalities and component technologies are concurrently being investigated that offer the possibility of providing complementary information about the layout of large buildings as well as their associated underground areas. Component pieces will transition to the Army's Program Executive Office (PEO) Intelligence, Electronic Warfare & Sensors (IEWS) and U.S. Special Operations Command.<br><br>***FY 2010 Accomplishments:***<br>- Developed system design for a radar-based system to meet metric for determining floor plan and insurgent tracks within 30 minutes.<br>- Developed radar design and processing techniques to mitigate radar clutter experienced in realistic urban environments (e.g. from furniture).<br>- Developed and modeled performance of multiple alternative sensing approaches.<br>***FY 2011 Plans:*** | 16.572 | 10.184 | - |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Complete demonstrations of low-latency, radar-based prototype system and quantify ability to determine building layout and track insurgents within furnished multi-story buildings.<br>- Identify validated alternative sensing modalities for continued development.<br>- Transition radar-based system to U.S. Army and U.S. Special Operations Command. | | | |
| ***Title:*** Low-Altitude Airborne Sensor System (LAASS)<br><br>***Description:*** The Low-Altitude Airborne Sensor System (LAASS) program is developing an airborne sensor system to find and characterize underground facilities (UGFs) used to shield and protect strategic and tactical activities. This includes command and control, weapons storage, manufacture of weapons of mass destruction (WMD) and tunnel networks that breach secure borders and perimeters. By passively capturing emissions associated with underground facility presence and operations, and doing so using airborne sensors (acoustic, electromagnetic, gravity gradiometry), LAASS can significantly increase our ability to seek out underground facilities and map out their vulnerabilities and backbone structure. LAASS technologies are planned to transition to Northern Command, Southern Command, Strategic Command, or Defense Threat Reduction Agency.<br><br>***FY 2010 Accomplishments:***<br>- Developed algorithm concepts and operational Concept of Operations (CONOPS) for the confident detection of tunnels in the presence of geologic structures that can degrade false alarm performance.<br>- Developed integrated system architecture and model to conduct system and subsystem performance predictions.<br>- Completed design of gravity gradiometry sensor suite and performed major technology design trades.<br>- Explored the performance gains achievable by fusing additional technologies to mitigate false alarms.<br><br>***FY 2011 Plans:***<br>- Validate, through modeling and laboratory tests, that the system design, component gravity gradiometry sensor technologies, and supporting subsystems successfully meet system requirements and detection performance.<br>- Document expected performance of system concept (sensor, installation, processing, CONOPS).<br>- Develop high-risk, critical-path components (e.g. sensor and sensor isolation).<br>- Validate that high-risk components can be fabricated and meet required system specifications for detection performance.<br>- Generate system design (preliminary and critical) for capability on tactical platform.<br>- Conduct multi-modal fusion study to validate clutter rejection and tunnel detection improvement. | 2.973 | 4.331 | - |
| ***Title:*** Sferic-Based Underground Geo-positioning (S-BUG)<br><br>***Description:*** The Lightning Based (Sferic) Underground Geo-positioning program will address the challenges presented when navigating and tracking within underground structures, both manmade and natural, by exploiting the abundance and long propagation range of naturally occurring global lightning events. As conceived, surface receivers at known locations will | 8.256 | 6.543 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| compare time difference of arrival of very low frequency (VLF) sferic events and employ super-resolution correlation techniques to accurately determine the VLF source locations. Any subsurface receiver will also detect the sferics, and real time or post-mission correlation with the surface data will enable geo-location of the subsurface receiver. Exploitation of naturally-occurring, nondeniable signals has the potential to significantly reduce logistical requirements and increase operational standoff by orders of magnitude (1000+ km). Transition to U.S. Special Operations Command (SOCOM) and the U.S. Army is anticipated.<br><br>***FY 2010 Accomplishments:***<br>- Validated S-BUG system concept by demonstrating non-real time geolocation of an above-ground user in the field.<br>- Demonstrated through-the-earth (TTE) correlation of sferic signals.<br>- Initiated design of prototype hardware for subsurface receivers and processors and TTE communications.<br><br>***FY 2011 Plans:***<br>- Complete design of prototype hardware for subsurface receivers and processors and TTE communications.<br>- Build and test prototype hardware (receiver and processors) for sferic-based geopositioning and navigation.<br>- Demonstrate above ground to below ground TTE communications for navigation (surface-to-subsurface communications) and scenarios. | | | |
| **Accomplishments/Planned Programs Subtotals** | 33.951 | 37.053 | 40.212 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SEN-02: *SENSORS AND PROCESSING SYSTEMS* | 117.041 | 77.903 | 77.669 | - | 77.669 | 73.717 | 77.913 | 78.971 | 78.971 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Wide Area Video Surveillance<br><br>***Description:*** The Wide Area Video Surveillance program is developing advanced electro-optical and infrared sensor technologies to enable persistent, wide-area, day-night video surveillance. Specific examples of these technologies includes: gigapixel focal plane arrays; advanced digital signal processors for giga-pixel image formation; advanced image processing algorithms for real-time detection, identification, and tracking of elusive and deceptive military targets; and advanced optics, telescopes and gimbals for high-resolution image capture. The Wide Area Video Surveillance program integrates these technologies in proof-of-concept prototypes for demonstration on military platforms including large and small, manned and unmanned aerial vehicles. Wide Area Video Surveillance technologies are planned for transition to the U.S. Air Force. Efforts in this program include:<br><br>- The Autonomous Real-time Ground Ubiquitous Surveillance - Imaging System (ARGUS-IS) program is developing an airborne sensor system that provides persistent, real-time, high-resolution, wide-area video surveillance. ARGUS-IS will provide the warfighter with a minimum of 65 "Predator like" video windows across the field of view. Each video window is electronically steerable and independent of the others. ARGUS-IS can also provide a global moving target indicator for vehicle size objects across the entire field of view. ARGUS-IS is comprised of three major subsystems: (1) a Gigapixel Sensor Subsystem (GSS) which consists of a set of four telescopes and is mounted in a 3-axis stabilized gimbal; (2) an Airborne Processing Subsystem (APS) which takes raw pixels from the GSS and performs all required processing; and (3) a ground processing subsystem which | 25.000 | 16.000 | 16.850 |

**B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012**

provides the interface to the user and records down-linked imagery. A Memorandum of Agreement (MOA) for the transition of ARGUS-IS from DARPA to the U.S. Air Force has been executed, and technologies are transitioning to the U.S. Air Force and U.S. Army.

- The Autonomous Real-time Ground Ubiquitous Surveillance - Infrared (ARGUS-IR) program is developing an airborne sensor system that provides a persistent, real-time, high-resolution, wide-area night video surveillance capability. ARGUS-IR uses an advanced infrared (IR) focal plane array (FPA) sensor. The nighttime persistent capability provided by ARGUS-IR combined with the daytime capability provided by ARGUS-IS enables 24-hour day/night surveillance. ARGUS-IR's wide-area, high-update-rate, high-resolution imaging capability will enable detection and tracking of dismounts as well as vehicles. ARGUS-IR will utilize the signal/image processor developed as part of ARGUS-IS, enabling ARGUS-IS and ARGUS-IR to be combined into a common pod. ARGUS-IR must overcome a number of demanding technical challenges related to the IR FPA and size, weight, and power constraints for the IR sensor. A transition plan is being developed with the U.S. Air Force.

***FY 2010 Accomplishments:***
Autonomous Real-time Ground Ubiquitous Surveillance - Imaging System (ARGUS-IS)
- Completed the build and delivery of sensor and airborne processing systems for the U.S. Air Force.
- Integrated the sensor and airborne processing systems into a compatible pod.
- Integrated the ARGUS-IS pod with the target platform.
- Conducted flight tests to validate the video windows and video tracking functionality.

Autonomous Real-time Ground Ubiquitous Surveillance - Infrared (ARGUS-IR)
- Performed initial design studies for the IR sensor and airborne processing system.
- Performed analysis for the pod/fairing and gimbal layout.
- Initiated data link software design and development efforts.

***FY 2011 Plans:***
Autonomous Real-time Ground Ubiquitous Surveillance - Infrared (ARGUS-IR)
- Build the IR FPAs.
- Complete the development and build of the optics for the IR sensor.
- Complete software and firmware development.
- Complete development of the airborne processing system hardware.

***FY 2012 Plans:***
Autonomous Real-time Ground Ubiquitous Surveillance - Infrared (ARGUS-IR)

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Integrate the IR sensor into the gimbal.<br>- Integrate the IR sensor and airborne processing system into a pod.<br>- Conduct IR sensor system and airborne processing system qualification and air worthiness testing.<br>- Conduct initial flight testing on a manned platform. | | | |
| ***Title:*** Military Imaging and Surveillance Technology (MIST)*<br><br>***Description:*** *Formerly Super-Resolution Vision System (SRVS)<br><br>The Military Imaging and Surveillance Technology (MIST) program will develop a fundamentally new optical ISR capability that can provide high-resolution 3-D images that will be sufficient to locate and identify a target at much longer ranges than is possible with existing optical systems. Several prototype optical surveillance and observation systems will be developed that will: (1) demonstrate probabilities of recognition and identification at distances sufficient to allow stand-off engagement; (2) overcome atmospheric turbulence, which now limits the ability of high-resolution optics; and (3) increase target identification confidence to reduce fratricide and/or collateral damage. The program will develop and integrate the necessary component technologies including high-energy pulsed lasers, receiver telescopes that have a field of view and depth of field that obviates the need for steering or focusing the optical system, computational imaging algorithms to improve system resolution, and data exploitation and analysis tools.<br><br>Advances in laser systems, digital imagers, and novel image processing algorithms will be leveraged to result in the reduction of the overall size, weight and power of imaging systems to allow for soldier portable and UAV platform integration.<br><br>MIST will also continue to integrate technologies developed under the Crosswind Sensor System for Snipers (C-WINS) and the Dynamic Image Gunsight Optics (DInGO) efforts. MIST will develop an optical rifle scope that enables a soldier, with minimal training, to shoot a firearm with marksman accuracy at range while also enhancing the capability for close quarters combat. The MIST program will transition the developed rifle-scope to the Army, Marines, and Special Operations Forces. The optical ISR technology will transition to the Air Force and SOCOM.<br><br>***FY 2010 Accomplishments:***<br>- Conducted field testing of initial SRVS spotting-scope prototype.<br>- Completed Preliminary Design Review level designs for the DiNGO rifle-scope that allow for a hands-free variable zoom and ballistic correction capabilities.<br>- Identified system designs for several compact, high-resolution 3-D imaging ISR systems that enable 3-D optical images to be taken at long range. | 8.894 | 11.540 | 35.819 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Completed the initial designs for a compact, high-energy, pulsed laser system.<br>- Began prototype development of a high-energy, pulsed fiber laser.<br><br>***FY 2011 Plans:***<br>- Begin prototype development of the DiNGO rifle-scope that will allow for retrofit upgrade.<br>- Conduct laboratory demonstration of a high-energy pulsed fiber laser subsystem that is phase-locked to an external reference.<br>- Demonstrate a high-energy pulsed fiber laser, with output power that can be scaled well above fundamental limitations of existing fiber laser systems.<br>- Complete the Preliminary Design Review level design for MIST 3-D imaging systems.<br>- Commence integration of subsystems for laboratory demonstration of MIST 3-D imaging systems to assess new imaging techniques and image processing algorithms.<br>- Complete real-time hardware implementation of advanced image processing algorithms and system integration.<br><br>***FY 2012 Plans:***<br>- Complete development and packaging of a high-power pulsed fiber laser system with a SWaP that is suitable for integration on a small or persistent airborne platform.<br>- Complete development of the DiNGO rifle-scope prototype.<br>- Complete field testing of the prototype scopes in conjunction with the transition partner.<br>- Complete a Critical Design Review level design for the MIST 3-D imaging system.<br>- Complete a laboratory demonstration of a breadboard system capable of achieving the final program MIST 3-D imaging performance goals for a single target range.<br>- Begin integrating the high peak power pulsed laser technology to increase the operating distance of the MIST 3-D imaging effort. | | | |
| ***Title:*** Multifunction RF*<br><br>***Description:*** *Formerly Sandblaster<br><br>The Multifunction RF program developed a helicopter pilot performance enhancement system for landing in degraded visual environments (DVE) such as dust clouds. This program addressed this important operational challenge in a Blackhawk platform environment, in four distinct areas: (1) Advanced flight controls which enable the helicopter to auto-land at a pilot-selected landing point; (2) See-through sensing based on a forward-looking 3-D W-band radar, which enables the pilot to see through the dust and select a safe landing point; (3) A powerful fusion engine which combines map and obstacle database knowledge with real-time radar data to construct a full current assessment of landing zone hazards; and (4) An enhanced, synthetic vision display | 1.000 | 2.500 | 6.500 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| to present real-time landing zone information to the pilot in the most useful manner, combined with all necessary aircraft-state symbology needed to complete a safe landing.<br><br>Beyond landing aids in DVE, RF-based sensors can also be used for additional situational awareness, such as near ground obstacle avoidance, air-to-air collision avoidance, targeting/fire control, as well as many other combat support activities. Building on advancements made with RF sensors under this program, the Multifunction RF program will seek to eliminate many redundant RF elements of current independently-developed systems for landing in DVEs, terrain avoidance, obstacle avoidance, and targeting/fire control. This will reduce the overall weight, power usage, cost, and profusion of exterior antennas on military aircraft, thus enabling greater mission capability with reduced vehicle system integration burden. Transition is planned to the Services.<br><br>***FY 2010 Accomplishments:***<br>- Commenced design of lighter-weight-tailored systems to enable landing in DVEs, for use on Department of Defense (DoD) operational helicopters.<br>***FY 2011 Plans:***<br>- Continue design and development of lighter weight DVE systems.<br>- Begin design and development of advanced high frequency multifunction radar.<br>- Commence planning for the integration of a multifunction RF system on helicopter platforms.<br>***FY 2012 Plans:***<br>- Complete testing and transition of lighter weight DVE systems for use on DoD operational helicopters.<br>- Complete development and laboratory testing of key subsystem technologies for multifunction RF waveforms and arrays.<br>- Prototype and initiate testing of multifunction RF sensor capabilities. | | | |
| ***Title:*** Advanced Airborne Optical Sensing<br><br>***Description:*** The Advanced Airborne Optical Sensing program develops electro-optical and infrared sensors and processing technologies for aerial platforms. Significant challenges arise as the result of two warfighting trends. First, the ever-changing mix of airborne platforms now includes a greater number of smaller UAVs. Second, the target set is increasingly challenging and now includes vehicles and individual dismounts that operate under foliage and in urban canyons, using camouflage, obscurants, and other means of concealment. In response to these challenges, the Advanced Airborne Optical Sensing program brings recent advances in optical, electro-optical, photonic and other technologies to airborne optical sensing systems. Specific examples of these technologies include: embedded image processors tailored to real-time detection, identification, and tracking of military targets; advanced laser radar technologies; hyper-spectral sensing technologies; flash detection and underwater object detection; advanced digital signal processing to support onboard image reconstruction, atmospheric correction, and system calibration; and | 23.131 | 12.618 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| adaptive optics techniques, such as deformable mirrors and liquid crystal spatial light modulators. The program extends these technologies and makes them practical for airborne surveillance systems. Efforts in this program include:<br><br>- The Standoff Precision ID in 3-D (SPI 3-D) program is developing an affordable sensor package capable of high-resolution 3-D imaging for confirmatory target ID at long ranges, as well as full field of view (FOV) ranging to support precise geolocation of targets. The program includes a series of ground-based and airborne demonstrations of SPI 3-D capabilities including: (1) high range resolution 3-D imaging; (2) full FOV range to pixel determination; (3) multiple frame-to-frame registration of imagery; and (4) GPS-based cueing from search systems. A demonstration will be performed to illustrate SPI 3-D compatibility with operational ISR systems such as the joint-service LITENING pod or Multi-spectral Targeting System (MTS) turrets and to support transition to the USAF in FY 2012. The program will also produce high speed, ultra sensitive photodetectors for systems requiring operation at very low photon counts. This will support long range sensors that can detect highly obscured targets under canopy/camouflage as well as very wide-area searches for submerged targets including sea mines and semi-submerged mobile vessels.<br><br>- The HALOE (High Altitude Lidar Operations Experiment) program will demonstrate, in an operational environment, the full capability of a 3-D imaging system. The HALOE system will provide support for current and emerging warfighter needs by delivering high-resolution, wide-area 3-D lidar imagery data in the OCONUS environment. This system provides the unprecedented capability to collect accurate, high resolution 3-D data over wide areas, to support a wide range of high-value applications, including detailed mission planning, vertical obstruction detection, helicopter landing zone analysis, and imagery geolocation. The pathway to accomplish this goal includes improving the robustness and reliability of the sensor, conducting demonstrations, and training with CONUS flight tests leading to OCONUS operational experimentation in partnership with the Army.<br><br>HALOE successfully completed the CONUS flight testing phase and has deployed OCONUS to address current and emerging needs of U.S. forces under the direction of commanders in theater. The HALOE system is planned to transition to the Army upon completion of the DARPA operations experiment.<br><br>- The Spatially Processed Image Detection and Ranging (SPIDAR) program will demonstrate coherent imaging methods that will form a large, effective optical aperture from a set of smaller, lighter telescopes providing for very high-resolution 3-D and 2-D ladar imagery of distant targets with a compact system configuration. This capability is very well suited for long-range engagements from airborne or space-based platforms and could significantly enhance the current synthetic aperture imaging approaches by providing the desired cross-range resolution along the axis perpendicular to the direction of travel. This capability is also applicable on a small scale to provide very-high resolution imagery in a compact configuration for long-range target ID beyond the | | | |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|

range of conventional imaging methods limited by diameter of the primary receiver aperture. The gain in size, weight, and power over more conventional lidar implementations will be assessed and demonstrated. Additionally, suitable missions and platforms for the technology will be identified. SPIDAR technologies will be transitioned to the U.S. Air Force.

- The Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND) program will develop and demonstrate a system for collecting and processing IR data operating as a framing sensor. The system will accept long wave infrared and color camera images permitting day/night reconnaissance for real-time target detection and tracking. The resulting sensor and processing system will decrease the time required to focus the sensor operator's attention on relevant targets. The TAILWIND system is planned for transition to the U.S. Army.

***FY 2010 Accomplishments:***
Standoff Precision ID in 3-D (SPI 3-D)
- Initiated fabrication of miniaturized components and initiated integration into the demonstration system.
- Performed initial design studies for a Geiger-mode Avalanche Photodiode (GmADP) array-based sensor that provides robust under-canopy, high-resolution real-time 3-D video and imagery using selective range gate processing.

High Altitude Lidar Operations Experiment (HALOE)
- Completed the refurbishment of the 3-D imager and verified system functionality with a series of CONUS flight tests.
- Completed deployment preparation for OCONUS flight operations, to include performance assessment and verification, team training, and flight planning.

Spatially Processed Image Detection and Ranging (SPIDAR)
- Developed plan to support ground-based demonstration of spatially synthesized apertures to support models of long-range system performance.
- Initiated design of the ground-based demonstration system.

Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND)
- Completed preliminary design of infrared and color sensor package.
- Developed parallel processing, compression, and image exploitation algorithms.
- Developed passive infrared exploitation technologies.

***FY 2011 Plans:***
Standoff Precision ID in 3-D (SPI 3-D)
- Complete integration of miniaturized components into the demonstration system.

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Conduct airborne demonstration of the metric sensing and 3-D imaging on a manned aircraft supporting transition to U.S. Air Force.<br>- Design and implement target detection, identification, and tracking algorithms in high-performance signal processing hardware architectures.<br>- Develop promising technologies identified for use for air platform to air target identification and location.<br><br>High Altitude Lidar Operations Experiment (HALOE)<br>- Deploy OCONUS and conduct flight operations.<br>- Transition HALOE system upon the completion of the DARPA flight series.<br>- Initiate the design and development of a compact configuration of HALOE that could be integrated with military unmanned and manned platforms.<br>- Explore additional applications for the high performance LIDAR components embedded within the HALOE system.<br><br>Spatially Processed Image Detection and Ranging (SPIDAR)<br>- Initiate development of mountain-to-ground multi-aperture system outdoor demonstration to validate system modeling.<br><br>Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND)<br>- Complete final design of infrared and color sensor package.<br>- Provide custom image products to multiple soldiers via adaptive processing and dissemination techniques.<br>- Construct a 3-D model of the scene on the fly from the optical imagery. | | | |
| ***Title:*** NetTrack<br><br>***Description:*** The NetTrack Program is developing feature-aided tracking technologies to enable airborne surveillance radars to maintain track on moving high value targets (HVTs) in traffic and cluttered environments. Ground moving target indicator (GMTI) radars provide excellent potential for tracking HVTs because they operate in all weather and at long ranges. However, maintaining target tracks is very challenging because obscuration and close target spacing make it difficult to associate radar kinematic measurements over time. To address this challenge, NetTrack is developing feature aided tracking technology that automatically collects and exploits target high range resolution (HRR) radar measurements. Specific NetTrack technologies include signal processing to generate HRR measurements from raw radar returns, feature extraction and matching to exploit HRR measurements, multiple hypothesis tracking to associate measurements to tracks and estimate target location and velocity, and sensor resource management to automatically select optimum radar mode parameters and timing sequences. A Memorandum of Agreement (MOA) has been established for transition of NetTrack to the Navy Advanced Airborne Sensor which is a follow-on to the Navy Littoral Surveillance Radar System. | 7.890 | 2.000 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***FY 2010 Accomplishments:***<br>- Demonstrated NetTrack capabilities in real-time on an operational radar platform.<br>- Initiated plans for Operational Utility Assessment.<br>***FY 2011 Plans:***<br>- Complete demonstration of NetTrack capabilities.<br>- Study extensions of the NetTrack capabilities to the maritime environment.<br>- Complete the Operational Utility Assessment.<br>- Transition to the Navy Advanced Airborne Sensor program. | | | |
| ***Title:*** Large Area Coverage Search-while-Track and Engage (LACOSTE)<br>***Description:*** The Large Area Coverage Search-while-Track and Engage (LACOSTE) program enables persistent, tactical-grade ground-moving target indicator (GMTI) capability in dense urban areas. Wide-area continuous tracking of moving vehicles requires very small coverage gaps, small resolution cells, and target separation and identification features. The ideal sensor has the area coverage rates of GMTI radar and the resolution/identification capabilities of an electro-optical infrared system. The LACOSTE program will provide wide area surveillance, simultaneous tracking, and target engagement with electro-optical and infrared sensors for tactical GMTI operations. The program is developing a sensor with a very wide field of regard, and a wide instantaneous field of view (FOV) that is rapidly scanned in a search-while-track mode, tracking up to thousands of targets in an urban area. Additionally, the LACOSTE sensor will provide next-generation precision tracking to enable engagement on a large number of targets in dense urban areas within that same field of regard with minimal penalty on the search-mode area coverage rate. The program 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 U.S. Air Force and the U.S. Army at the conclusion of the program.<br>***FY 2010 Accomplishments:***<br>- Manufactured and tested full-scale components.<br>- Performed system integration and laboratory testing.<br>- Demonstrated performance (sensitivity, resolution, and tracking) via tower testing.<br>***FY 2011 Plans:***<br>- Conduct demonstration of sensitivity, resolution, and tracking. | 12.460 | 2.110 | - |
| ***Title:*** Crosswind Sensor System for Snipers (C-WINS) and Dynamic Image Gunsight Optics (DInGO) | 6.000 | 5.000 | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Description:*** The Crosswind Sensor System for Snipers (C-WINS) program provided optical techniques to correct for crosswinds on ballistic objects. The C-WINS program developed a novel weapon mounted optical correction sighting system for various rifles and machine guns. An eye-safe laser and a high speed camera record motion of eddies in the atmosphere to measure the wind profile that will be used to provide ballistic correction. The system provides offset corrections to the shooter for compensating the aim point affected by the crosswind. Key parameters of interest are: a) bullet hit points 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 provide elevation correction; 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; increased ID range during day and night; and shimmer compensation. Smaller size, weight, and power (SWAP) and increased engagement range are additional objectives for FY 2010. This program will transition to the U.S. Army and Marines.<br><br>Leveraging technologies developed under the Crosswind Sensor System for Snipers (C-WINS) program, the Dynamic Image Gunsight Optics (DInGO) program will develop an optical scope that enables a soldier, with minimal training, to shoot a firearm with marksman accuracy. The ability to engage targets at range with a conventional firearm is currently limited by user training rather than the accuracy of the weapon. The technology developed under this program line will enhance a soldier's ability to observe and engage targets at range as well as enhance the capability for close quarters combat. Technical achievements under other programs in this PE/Project provide the basis for radically new approaches to optical scopes, dynamic imaging systems, and low-power video analytics. By extending the capability of combat optics, DInGO enables a soldier to operate at the limit of the system performance with reduced training requirements. DInGO technology will integrate with the Military Imaging and Surveillance Technology (MIST) program (in this PE/Project). Transition to the Army is anticipated.<br><br>***FY 2010 Accomplishments:***<br>Crosswind Sensor System for Snipers (C-WINS)<br>- Reduced size, weight and power and increased effective engagement range.<br>- Completed transition to Marine Corps, Rapid Equipment Force (REF), Night Vision Lab (NVL) and PEO Soldier/Army.<br><br>Dynamic Image Gunsight Optics (DInGO)<br>- Performed major system design trades.<br>- Developed a system design for a combat-rifle scope that can be used for close quarters combat as well as to engage targets at distance.<br>- Validated key technology components.<br><br>***FY 2011 Plans:***<br>Dynamic Image Gunsight Optics (DInGO) | | | |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Fabricate a fieldable prototype system for user testing. | | | |
| ***Title:*** Advanced Electronic Warfare*<br><br>***Description:*** *Formerly Precision Electronic Warfare (PreEW)<br><br>The Advanced Electronic Warfare program will develop a system that enables highly precise communications jamming. This program will develop and demonstrate robust, low cost, small size, weight, and power (SWAP) distributed electronic warfare (EW) platforms to allow the warfighter to disrupt and impede an adversary's communication network. The program uses an array of nodes that have synchronized clocks to enable the signal from each node to be aligned so that the carrier and phase are focused on the desired location. The effect will be to place the desired energy on the specific target area while not affecting the non-target area. The node is planned to contain localization, network, synchronization, and jamming processing and communication in a low-cost, easily deployable package. Key technology challenges include oscillator synchronization, accurate pointing, and energy focusing to impact quality of service of intended target. The program is planned for transition to the Services.<br><br>***FY 2010 Accomplishments:***<br>- Initiated design and developed precision clock synchronization techniques for evaluation and selection for static scenarios.<br>- Developed beamforming and inter-mode communication architecture.<br>- Validated design to demonstrate ability for small SWAP.<br>- Performed simulations to validate clock synchronization, precision pointing, and precision jamming capabilities.<br><br>***FY 2011 Plans:***<br>- Conduct initial field experiments using multiple pole-mounted payloads to validate the ability to synchronize and direct energy to an area of interest and extract measurements of performance.<br>- Conduct advanced experiments with improvements in distributed precision clock synchronization and initial multi-node over the air demonstrations with fixed nodes. | 13.000 | 10.000 | - |
| ***Title:*** Behavioral Learning for Adaptive Electronic Warfare (BLADE)*<br><br>***Description:*** *Previously part of Advanced Electronic Warfare<br><br>The Behavioral Learning for Adaptive Electronic Warfare (BLADE) program will develop the capability to jam adaptive and rapidly evolving radio frequency (RF) threats in tactical environments and at tactically-relevant timescales. This will change the paradigm for responding to evolving threats from lab-based manual development to an adaptive in-the-field systems approach. When an unknown or advanced RF threat appears, BLADE networked nodes will dynamically characterize the emitter, synthesize an effective countering technique, and evaluate jamming effectiveness by iteratively probing, learning, and adapting to the threat. An | - | 14.000 | 18.500 |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| optimization process will tailor near-real-time responses to specific threats, producing a countermeasure waveform that maximizes jam effectiveness while minimizing the required jamming resources. Thus BLADE will enable the rapid defeat of new RF threats and provide the warfighter with real-time feedback on jam effectiveness. The program is planned for transition to the Services.<br><br>***FY 2011 Plans:***<br>- Develop and evaluate techniques for the detection and characterization of known and unknown threats using adaptive threshold detection and open-set signal classification.<br>- Create techniques for jam waveform generation via learning and active probing techniques.<br>- Develop approaches for battle damage assessment to determine jam effectiveness through observation of changes in threat behavior.<br>***FY 2012 Plans:***<br>- Conduct non-real time testing in a laboratory environment demonstrating detection and proper characterization of known and unknown signals with sufficient fidelity to validate the program concept.<br>- In non-real time, generate and optimize jamming waveforms using detection and characterization with probing and learning techniques.<br>- Conduct non-real time battle damage assessment performance validation via laboratory testing.<br>- Begin end-to-end system development for real-time open-air operational-like demonstrations. | | | |
| ***Title:*** Precision Inertial Navigation Systems High Dynamic Range Atom Sensors and Systems (PINS HiDRA)<br><br>***Description:*** Precision Inertial Navigation Systems High Dynamic Range Atom Sensors and Systems (PINS HiDRA) will develop an integrated cold atom-based inertial measurement unit (IMU) suitable for use on a wide range of military platforms. The program will build on the work of the Precision Inertial Navigation Systems (PINS) program (funded in PE 0603768E, Project GT-01) to dramatically increase the dynamic range of the sensors, thereby enabling operation on aircraft and missiles. Extensive system integration and miniaturization will reduce system size, weight, and power, while increasing navigation performance as measured against currently fielded aircraft inertial navigation systems. Key technology challenges include high-brightness atom sources, innovative atom interferometer measurement schemes that function in high-dynamic environments, and high g-tolerant laser stabilization schemes. The PINS HiDRA program will focus on transition to the Services.<br><br>***FY 2011 Plans:***<br>- Design system microcontroller and compact laser and optomechanics frame.<br>- Develop computer models for atom sensor operation under high dynamic input and predict navigation performance under relevant sensor configuration. | - | 2.135 | - |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Validate sub-system technology selections and incorporate into full six degree-of-freedom inertial sensor design. | | | |
| ***Title:*** Network Centric Sensing and Engagement<br><br>***Description:*** The Network Centric Sensing and Engagement program developed technology and tools to support small unit 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. The program uses organic reconnaissance, surveillance and target acquisition data to update tactical users and planners over multiple echelons with critical environmental and operational information. 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. Technologies will transition to small tactical units in irregular operations.<br><br>***FY 2010 Accomplishments:***<br>- Evaluated the effect of combining multiple semi-autonomous organic sensor updates and novel display technologies on situation assessment for rapid military riverine operations. | 3.426 | - | - |
| ***Title:*** Advanced Radar Sensor Technology<br><br>***Description:*** The Advanced Radar Sensor Technology thrust developed radar systems technology to provide significant improvements in our ability to detect, identify, and track surface targets. Program efforts focused on exploiting emergent and novel RF sensing technology and phenomenology. Key elements were advancements in ultra-wide band, bistatics, UHF/VHF, emitter location and direction-finding, polarimetric change detection, tomographic imaging, space-time adaptive processing and other advanced signal processing, advanced Ground Moving Target Indicator (GMTI) techniques, and foliage, building, and ground-penetrating radar phenomenology. Technologies were developed for use on Navy, Army, and Air Force current and emerging platforms, including small and micro UAVs, with emphasis on the most stressing military radar sensor challenges. Programs in this thrust include:<br><br>- The Next Generation RF Antenna System program developed and demonstrated a light-weight wide-band RF antenna that enables high gain over a broad frequency range and signal detection at extended ranges.<br><br>- The Airborne Passive Direction Finding with a Tactical Vector Sensor (ATVS) program developed and demonstrated a compact, lightweight, airborne, real-time, tactical emitter detection and location system suitable for tactical UAVs. | 6.396 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - The Efficient Digitization of Element Signals program exploited new and emerging techniques in signal coding and compressive sensing to allow large, element-count, radio frequency (RF) arrays to be digitally sampled using small numbers of receivers.<br><br>***FY 2010 Accomplishments:***<br>Next Generation RF Antenna System<br>- Designed a novel antenna element with superior gain and bandwidth.<br>- Validated design using electromagnetic modeling.<br><br>Airborne Passive Direction Finding with a Tactical Vector Sensor (ATVS)<br>- Developed prototype ATVS antenna, installed on a Shadow UAV, and measured RF performance characteristics in an outdoor range.<br><br>Efficient Digitization of Element Signals<br>- Demonstrated the potential to reduce data imaging requirements without significant performance degradation for synthetic aperture arrays.<br>- Demonstrated that random sensor array performance and compressive sensing theory are related and that it is possible to quantify certain parameters of anticipated array performance. | | | |
| ***Title:*** Sensor Tape<br><br>***Description:*** The Sensor Tape program developed and demonstrated a low-cost, one-time-use, low-power, band-aid size, adhesive-applied blast dosimeter that records accumulative blast effects for integration into combat medical care. Significant technical obstacles that were overcome include achieving adequate switching frequencies, packaging, print-on ink technologies and production costs. Sensor Tape is transitioning to the Air Force and Army.<br><br>***FY 2010 Accomplishments:***<br>- Demonstrated web-printing process for sensors, printed electronics and memory components.<br>- Fabricated prototype sensor tapes.<br>- Demonstrated sensor tape performance in field test. | 2.282 | - | - |
| ***Title:*** Short Wave Infrared through Fog and Clouds (SWIF)<br><br>***Description:*** The Short Wave Infrared through Fog and Clouds (SWIF) program developed and demonstrated advanced signal processing and optical imaging technology to allow detection of collision and grounding threats in fog and clouds at useful ranges (day or night), which substantially degrade performance in precision handling operations. Humans are able to operate | 7.562 | - | - |

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| successfully with sensor assistance, but situational awareness significantly degrades. Successful development of this technology has restored this situational awareness to tactically relevant distance and time scales. Significant technical obstacles that needed to be overcome included development of an ultra-short pulse laser with sufficient bandwidth and fast enough pulse rise time to create transient-like propagation characteristics in an aerosol cloud, distributed active sources, and advanced filtering techniques. Technologies are transitioning to the U.S. military.<br><br>***FY 2010 Accomplishments:***<br>- Manufactured test articles.<br>- Distributed obscurant chamber testing and performed system validation. | | | |
| **Accomplishments/Planned Programs Subtotals** | 117.041 | 77.903 | 77.669 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

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| APPROPRIATION/BUDGET ACTIVITY | R-1 ITEM NOMENCLATURE | PROJECT |
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| 0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | PE 0603767E: *SENSOR TECHNOLOGY* | SEN-03: *EXPLOITATION SYSTEMS* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SEN-03: *EXPLOITATION SYSTEMS* | 24.582 | 63.420 | 88.674 | - | 88.674 | 69.407 | 62.407 | 62.013 | 72.013 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

## B. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Wide Area Network Detection (WAND)* | 8.000 | 10.000 | 20.874 |

***Description:*** *Formerly Target Identification.

The Wide Area Network Detection (WAND) program is developing methods to detect, characterize, and identify targets from both imaging and other sensors, including national, theater, and organic sensors. Critical performance metrics are timeliness, accuracy, error rates, and interpretation workload. The program addresses the challenges of target identification, acquisition, tracking and denial in difficult environments. The technologies will apply advanced signal processing, sensor fusion, and platform control to leverage advances in sensor capabilities. Transition is planned to the Air Force and Army.

***FY 2010 Accomplishments:***
- Designed and analyzed performance of new sensing approaches for target detection and performed limited field testing.
- Developed concepts of employment and an overall system architecture, and validated with potential transition customers.

***FY 2011 Plans:***
- Develop sensor processing, mount on surrogate platforms, and collect data in realistic operating environments.
- Validate concepts of employment, and test overall system via modeling and simulation.

***FY 2012 Plans:***
- Perform initial field tests of system in realistic operating environment.

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| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Verify performance under extended operating conditions via simulation. | | | |
| ***Title:*** Multi-Sensor Exploitation<br><br>***Description:*** The Multi-Sensor Exploitation program provides multi-sensor exploitation capabilities enabling missions such as overwatch, border surveillance, high value target tracking, and threat network detection using mixes of imaging, radar, signals, human intelligence, and other sources. Key challenges in the first two missions include real-time and wide area dismount and vehicle target detection, discrimination, tracking, and pattern of life analysis. Key challenges in the third mission include tracking through periods of obscuration and confusion in environments in which existing sensors and methods are not able to provide high quality signature data. Key challenges in the fourth mission include discriminating threats from large volumes of civilian clutter and determining the behavior patterns of and relationships between those threats. The Multi-sensor Exploitation program will develop new target tracking methods for wide area motion imaging sensors enabling long duration tracking of vehicles and dismounts through the development of new target dynamic modeling methods, new processing methods tailored to dismounts, and new methods for signature aided tracking. Scalable stochastic modeling and inference techniques will yield improved situation awareness and assessment for wide-area EO/IR motion imaging, radar, and multi-sensor exploitation applications in settings where large numbers of interacting entities engaged in complex activities are observed over long periods of time. Techniques intended for use in riverine and maritime environments, where extremist and criminal groups threaten political stability, trade routes, and free commerce, must quickly map navigable tributary systems, rapidly detect and identify threats, and monitor their activity. The program will develop new methods for automatically correlating different sources of information to identify threats, estimate threat networks, and analyze behavioral patterns. The program will include a focus on integrated human and machine processing to better take advantage of the strengths of each. Potential transition partners include the U.S. Navy, Air Force, and Army as well as USAFRICOM, USSOUTHCOM, USSOCOM and Intelligence agencies.<br><br>***FY 2010 Accomplishments:***<br>- Created new methods for tracking targets in urban environments leveraging dynamic models motivated by traffic flow theory.<br>- Executed multisensor data collections for high value target tracking, overwatch, road and border monitoring, and other scenarios.<br><br>***FY 2011 Plans:***<br>- Evaluate and optimize techniques and software for tracking targets in dense target environments.<br>- Continue execution of multisensor data collections against a broader mission set.<br><br>***FY 2012 Plans:***<br>- Demonstrate flow-based tracker improvements using instrumented data and in-theater data. | 8.000 | 6.900 | 10.595 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| - Develop stochastic models that capture complex spatial, temporal, and relational structures, while enabling efficient computations for learning, inference, and prediction.<br>- Formulate and evaluate approaches for ISR information fusion across air, river banks, water surface, water column, and river bottom.<br>- Develop techniques for dealing with riverine and maritime challenges such as turbidity, multi-path reflection, sea clutter, and high clutter density. | | | |
| ***Title:*** Foliage Penetrating Radar Planning and Exploitation | 5.500 | 7.500 | 7.000 |
| ***Description:*** The Foliage Penetrating Radar Planning and Exploitation program will complete final Forester FOPEN radar demonstrations and provide further exploitation capabilities to find dismounted targets in densely forested terrain. Current foliage penetrating radar systems provide an important capability for detecting dismount targets under foliage, but the systems also detect animals, moving water, blowing trees, and other scene clutter moving under or in the foliage that makes situation assessment manpower and radar resource intensive. Further, Doppler signature data that experiments indicate may enable improved automated discrimination of dismount targets from other detections is not currently exploited. Finally, no planning tools are available for optimizing and dynamically replanning collection assets to improve imaging geometries and detectability. This program will provide capabilities to address these issues by exploiting Doppler signature data, automating temporal processing approaches currently used, and automating terrain, weather, and on-line exploitation data to enable planning and dynamic replanning. The result will be significantly improved capability for finding and localizing targets under foliage. The program will transition to USSOUTHCOM and USSOCOM.<br><br>***FY 2010 Accomplishments:***<br>- Developed overall processing architecture for integration of exploitation modules.<br>***FY 2011 Plans:***<br>- Formulate, evaluate, and optimize algorithms for mitigating detections in radar systems due to non-living objects in motion and confusion between humans and animals.<br>- Formulate, evaluate, and optimize algorithms for assessment of group-state activity level sufficient to assist an operator in assessment of the group's intent.<br>***FY 2012 Plans:***<br>- Refine algorithms for mitigating false detections and assessing group state and activity.<br>- Optimize and transition algorithms to operational FOPEN systems. | | | |
| ***Title:*** Insight* | - | 37.195 | 50.205 |

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| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***Description:*** *Previously part of Multi-Sensor Exploitation.<br><br>The Insight program builds on the successes of a number of programs, including POSSE, HART, and TTNT, which demonstrated the value and importance of multi-INT sensor fusion when prosecuting time-critical targets in challenging environments. Insight will develop new capabilities for automated exploitation and collection management. Insight will emphasize several areas, including model-based correlation, adversary behavior modeling, and threat network analysis tools to automatically combine data across sources and manage uncertainty; collection management tools to identify collection opportunities and enable efficient use of multi-INT sensors and platforms across missions; and tools to integrate human and machine processing, including visualization, hypothesis manipulation, and distributed social intelligence. Insight development activities will leverage virtual and physical testbed environments. The virtual testbed will enable testing against extended operating conditions and evaluation of alternative concepts of operation, and the physical testbed will enable live-fly testing with current and next generation sensing and processing systems. Insight technologies will transition to the Air Force and Army.<br><br>***FY 2011 Plans:***<br>- Design and begin development of multi-INT correlation, behavior modeling, and threat network analysis tools.<br>- Perform initial testing on collected datasets.<br>- Develop concepts of operation to realize the benefits of multi-INT fusion.<br>- Begin design of collection management tools and design metrics for evaluating collection management efficiency.<br>- Develop initial implementation of virtual testbed integrating Insight-collected data with existing Government data sources.<br><br>***FY 2012 Plans:***<br>- Baseline exploitation, collection management, and user interaction techniques against user validated scenarios.<br>- Demonstrate virtual environment for baseline testing of system scalability and alternative concept of operations analysis.<br>- Populate development database with collected data to support rapid prototyping of innovative exploitation, collection management, and other analytic tools.<br>- Evaluate fusion and control techniques in the virtual testbed.<br>- Perform a limited field test with operational users. | | | |
| ***Title:*** Persistent Operations Surface Surveillance and Engagement (POSSE)<br><br>***Description:*** The Persistent Operations Surface Surveillance and Engagement (POSSE) program is developing the capability to integrate sensor input from multiple modalities to find indications of insurgent activities. Combined with dynamically updated information from soldiers on the ground, POSSE will enable near-real-time generation of the evidence necessary for further investigation or interdiction. POSSE experiments are conducted at the National Training Center (NTC) with realistic role players | 3.082 | 1.825 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603767E: *SENSOR TECHNOLOGY* | **PROJECT**<br>SEN-03: *EXPLOITATION SYSTEMS* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| emulating typical residential, commercial and light industrial activity. Within this environment, insurgent activity is simulated by qualified experts using the latest and most complete intelligence available. Measurements include precision collections of insurgent activities, as well as the realistic surrounding background clutter of typical civilian activity. Results will inform future experiments, lead to specifications for future sensor design, and provide insights into how to integrate other narrow and wide area sensors into an integrated approach to countering insurgencies. Transition is planned for U.S. Army Intelligence and Security Command.<br><br>***FY 2010 Accomplishments:***<br>- Concluded the Chemical Detection Experiment series and analyzed results.<br>- Examined the feasibility of new sensor designs based on experimental results.<br>***FY 2011 Plans:***<br>- Refine sensors specific to close-in insurgent activity detection.<br>- Demonstrate new insurgent activity detection techniques in field exercises at the National Training Center. | | | |
| **Accomplishments/Planned Programs Subtotals** | 24.582 | 63.420 | 88.674 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603767E: *SENSOR TECHNOLOGY* | **PROJECT**<br>SEN-CLS: *CLASSIFIED* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SEN-CLS: *CLASSIFIED* | 51.379 | 26.656 | 65.247 | - | 65.247 | 46.217 | 46.021 | 51.373 | 36.532 | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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

## B. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Classified DARPA Program<br>***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified.<br>***FY 2010 Accomplishments:***<br>Details will be provided under separate cover.<br>***FY 2011 Plans:***<br>Details will be provided under separate cover.<br>***FY 2012 Plans:***<br>Details will be provided under separate cover. | 51.379 | 26.656 | 65.247 |
| **Accomplishments/Planned Programs Subtotals** | 51.379 | 26.656 | 65.247 |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

Details will be provided under separate cover.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603768E: *GUIDANCE TECHNOLOGY* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 33.570 | - | - | - | - | - | - | - | - | Continuing | Continuing |
| GT-01: *GUIDANCE TECHNOLOGY* | 21.152 | - | - | - | - | - | - | - | - | Continuing | Continuing |
| GT-CLS: *CLASSIFIED* | 12.418 | - | - | - | - | - | - | - | - | Continuing | Continuing |

## A. Mission Description and Budget Item Justification

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. Consequently, this program element is merging with the Sensors Technology program element in FY 2011. Many of the guidance programs have ended eliminating the need for such a specifically focused program element.

The Guidance Technology project increases 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.

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 36.886 | - | - | - | - |
| Current President's Budget | 33.570 | - | - | - | - |
| Total Adjustments | -3.316 | - | - | - | - |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | -2.338 | - | | | |
| • SBIR/STTR Transfer | -0.978 | - | | | |

### Change Summary Explanation

FY 2010: Decrease reflects internal below threshold reprogramming and SBIR/STTR transfer.

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | | DATE: February 2011 |
|---|---|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | R-1 ITEM NOMENCLATURE<br>PE 0603768E: *GUIDANCE TECHNOLOGY* | PROJECT<br>GT-01: *GUIDANCE TECHNOLOGY* | |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GT-01: *GUIDANCE TECHNOLOGY* | 21.152 | - | - | - | - | - | - | - | - | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

Fire-and-forget stand-off 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.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Multifunctional Electro-Optics for Defense of U.S. Aircraft (MEDUSA)<br><br>***Description:*** The Multifunction Electro-Optics for Defense of U.S. Aircraft (MEDUSA) program developed the technologies and systems to give the U.S. air dominance at low altitude and at night. This program developed 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 in the Near Infrared (NIR), Mid-wave Infrared (MWIR) and Long-wave Infrared (LWIR) regimes. MEDUSA 1) conducted phenomenological measurements and developed countermeasures and target classification/identification techniques; 2) developed critical component technologies such as high-power IR laser sources, advanced IR detectors, and fibers for high-power IR transmission; and 3) developed and demonstrated an end-to-end MEDUSA system. The MEDUSA technology is available for transition to the Air Force and Army.<br><br>***FY 2010 Accomplishments:***<br>- Completed design and fabrication of large format 256x256 Near/Mid-Wave Infrared (NMIR) detector and Readout Integrated Circuits (ROICs) supporting proactive Infrared Counter Measure (IRCM) and other applications.<br>- Completed laboratory and outdoor testing of hybridized 128x128 NMIR detector arrays and ROICs.<br>- Performed analysis of measured-range precision demonstrated by the 128x128 focal plane arrays. | 7.460 | - | - |
| ***Title:*** Robust Surface Navigation (RSN)<br><br>***Description:*** The Robust Surface Navigation (RSN) 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 | 5.239 | - | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603768E: *GUIDANCE TECHNOLOGY* | **PROJECT**<br>GT-01: *GUIDANCE TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| foliage. The RSN program will use Signals of Opportunity (SoOP) from a variety of ground, air, and space-based sources, augmented by judiciously placed RF beacons. These will be received on the warfighter's forthcoming software defined radios and use specially tailored algorithms to determine position. The greater strength and diversity of these signals will provide coverage when GPS is denied due to environmental conditions or hostile activity. This is a two-part program: (1) cataloging and assessing potential exploitable signals followed by analysis and performance modeling and hardware-based concept validation, and; (2) designing, testing, and demonstrating a (non-form-fit) prototype receiver(s) and algorithms for geolocation using the SoOP. Beginning in FY 2011, this program is budgeted in PE 0603767E, Project SEN-01. The RSN technology is planned for transition to the U.S. Special Operations Command (SOCOM) and the U.S. Army with specific elements of the program transitioning to the U.S. Navy and U.S. Air Force.<br><br>***FY 2010 Accomplishments:***<br>- Initiated development of RSN prototype system and planning for field tests and demonstrations in dense urban environments, including within large buildings and urban canyons.<br>- Developed test plan for total system readiness demonstration.<br>- Conducted Critical Design Review in preparation for development of non-form-fit prototype system. | | | |
| ***Title:*** Sub-Surface Navigation (SsN)<br><br>***Description:*** Building on technologies developed under the RSN program, the Sub-Surface Navigation (SsN) program provided the U.S. warfighter with the ability to navigate effectively underground, where the Global Positioning System (GPS) is unavailable. SsN also enables long endurance or covert underground missions where alternative navigation aids like inertial measurement units (IMUs) or inertial navigation units (INUs) are unsuitable. The SsN program uses specialized low frequency RF beacons and specially tailored algorithms to provide 3-dimensional navigation of personnel and mobile platforms underground. The greater strength and diversity of these signals provide coverage when GPS is denied due to lack of penetration through the earth. The SsN technology is available for transition to the U.S. Special Operations Command (SOCOM).<br><br>***FY 2010 Accomplishments:***<br>- Completed experimental measurements to support design and development of next generation, small form-factor beacon antenna design.<br>- Demonstrated underground navigation using beacon-based system. | 1.812 | - | - |
| ***Title:*** Precision Inertial Navigation Systems (PINS)<br><br>***Description:*** The Precision Inertial Navigation Systems (PINS) program developed 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 | 6.641 | - | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603768E: *GUIDANCE TECHNOLOGY* | **PROJECT**<br>GT-01: *GUIDANCE TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| atomic analogue of an optical interferometer to provide unprecedented sensitivity to accelerations and rotations. The atomic sensors measure the local gravitational field gradient to ensure that instrument alignment is properly maintained throughout vehicle maneuver, thus mitigating gravity-induced navigation errors. While originally planned for transition to the Navy at the conclusion of Phase III, program developments indicate opportunities for insertion in multiple Service applications and plans are being revised accordingly.<br><br>***FY 2010 Accomplishments:***<br>- Completed study of technical hurdles preventing 200 hour continuous sensor system operation and designed system changes to address key items identified.<br>- Devised transition plan for technology insertion consistent with Department of Defense Positioning, Navigation, and Timing roadmap. | | | |
| **Accomplishments/Planned Programs Subtotals** | 21.152 | - | - |

## C. Other Program Funding Summary ($ in Millions)

N/A

## D. Acquisition Strategy

N/A

## E. Performance Metrics

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

| Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency | | DATE: February 2011 |
|---|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 3: *Advanced Technology Development (ATD)* | **R-1 ITEM NOMENCLATURE**<br>PE 0603768E: *GUIDANCE TECHNOLOGY* | **PROJECT**<br>GT-CLS: *CLASSIFIED* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GT-CLS: *CLASSIFIED* | 12.418 | - | - | - | - | - | - | - | - | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Classified DARPA Program<br>***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified.<br>***FY 2010 Accomplishments:***<br>Details will be provided under separate cover. | 12.418 | - | - |
| **Accomplishments/Planned Programs Subtotals** | 12.418 | - | - |

**C. Other Program Funding Summary ($ in Millions)**

N/A

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

Details will be provided under separate cover.

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| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|

| **APPROPRIATION/BUDGET ACTIVITY** | **R-1 ITEM NOMENCLATURE** |
|---|---|
| 0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 6: *RDT&E Management Support* | PE 0605502E: *SMALL BUSINESS INNOVATIVE RESEARCH* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 75.379 | - | - | - | - | - | - | - | - | Continuing | Continuing |
| SB-01: *SMALL BUSINESS INNOVATIVE RESEARCH* | 75.379 | - | - | - | - | - | - | - | - | Continuing | Continuing |
| Quantity of RDT&E Articles | | | | | | | | | | | |

## A. Mission Description and Budget Item Justification

In accordance with Public Law No: 111-251 (Small Business Reauthorization Act) and Small Business Technology Transfer Program Reauthorization Act, the DARPA Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to enable fundamental discoveries and technological breakthroughs that provide new military capabilities.

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | - | - | - | - | - |
| Current President's Budget | 75.379 | - | - | - | - |
| Total Adjustments | 75.379 | - | - | - | - |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | 75.379 | - | | | |

### Change Summary Explanation

FY 2010: Increase reflects the SBIR/STTR transfer.

## C. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** SB-01: SMALL BUSINESS INNOVATIVE RESEARCH<br><br>***Description:*** In accordance with Public Law No: 111-251, the DARPA Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; | 75.379 | - | - |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 6: *RDT&E Management Support* | **R-1 ITEM NOMENCLATURE**<br>PE 0605502E: *SMALL BUSINESS INNOVATIVE RESEARCH* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities.<br><br>***FY 2010 Accomplishments:***<br>The DARPA SBIR and STTR programs were executed within OSD guidelines. | | | |
| **Accomplishments/Planned Programs Subtotals** | 75.379 | - | - |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**E. Acquisition Strategy**

N/A

**F. Performance Metrics**

Not applicable.

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 6: *RDT&E Management Support* | **R-1 ITEM NOMENCLATURE**<br>PE 0605897E: *DARPA AGENCY RELOCATION* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 44.812 | 11.000 | 1.000 | - | 1.000 | - | - | - | - | Continuing | Continuing |
| AR-02: *DARPA AGENCY RELOCATION* | 44.812 | 11.000 | 1.000 | - | 1.000 | - | - | - | - | Continuing | Continuing |
| Quantity of RDT&E Articles | | | | | | | | | | | |

## A. Mission Description and Budget Item Justification

This Program Element is budgeted in the Management Support Budget Activity because it is funding the building relocation support cost requirements for the Defense Advanced Research Projects Agency (DARPA). The move to a new facility is in response to the Department of Defense Unified Facilities Criteria (UFC) and Anti-terrorism/Force Protection Requirements Regulation (UFC 4-010-01 dtd 8 Oct 2003, as amended 22 Jan 2007). The regulation is mandatory for facilities leased for DoD use and applies to all new leases executed on or after 1 Oct 2005 and to renewal or extension of any existing lease on or after 1 Oct 2009. DARPA's existing leased facility does not meet the UFC standards and the lease extends beyond October 2009. This Program Element will fund all expenses associated with planning and movement of the Agency to its new location. Initial costs will include design and trade studies, costs associated with implementing force protection standards, floor plan layout and planning activities leading up to the move. Further, it will fund outfitting of the selected property with the force protection standards, infrastructure, equipment, and furniture required for the DARPA staff and completion of the move in 2012.

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 44.812 | 11.000 | - | - | - |
| Current President's Budget | 44.812 | 11.000 | 1.000 | - | 1.000 |
| Total Adjustments | - | - | 1.000 | - | 1.000 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | - | - | | | |
| • TotalOtherAdjustments | - | - | 1.000 | - | 1.000 |

**Change Summary Explanation**

FY 2012: Increase reflects additional funding to complete the building move and restore the current facility in accordance with lease requirements.

## C. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** DARPA Agency Relocation | 44.812 | 11.000 | 1.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 6: *RDT&E Management Support* | **R-1 ITEM NOMENCLATURE**<br>PE 0605897E: *DARPA AGENCY RELOCATION* |

| **C. Accomplishments/Planned Programs ($ in Millions)** | **FY 2010** | **FY 2011** | **FY 2012** |
|---|---|---|---|
| ***Description:*** DARPA Agency Relocation<br><br>***FY 2010 Accomplishments:***<br>- Completed design of tenant build out.<br>- Initiated construction of base build out.<br>***FY 2011 Plans:***<br>- Initiate tenant build out to include: unclassified office space, Sensitive Compartmented Information Facilities (SCIFs), conference center, wiring closets, building security system, unclassified and classified cabling, and all associated activities to prepare the building for occupancy.<br>- Outfit offices, conference rooms, and conference center with IT equipment.<br>***FY 2012 Plans:***<br>- Complete move and restoration of current facility in accordance with lease requirements. | | | |
| **Accomplishments/Planned Programs Subtotals** | 44.812 | 11.000 | 1.000 |

## D. Other Program Funding Summary ($ in Millions)
N/A

## E. Acquisition Strategy
N/A

## F. Performance Metrics
Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 6: *RDT&E Management Support* | **R-1 ITEM NOMENCLATURE**<br>PE 0605898E: *MANAGEMENT HQ - R&D* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 54.842 | 56.257 | 66.689 | - | 66.689 | 70.090 | 72.046 | 74.051 | 74.216 | Continuing | Continuing |
| MH-01: *MANAGEMENT HQ - R&D* | 54.842 | 56.257 | 66.689 | - | 66.689 | 70.090 | 72.046 | 74.051 | 74.216 | Continuing | Continuing |
| Quantity of RDT&E Articles | | | | | | | | | | | |

## A. Mission Description and Budget Item Justification

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

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 54.842 | 56.257 | 57.848 | - | 57.848 |
| Current President's Budget | 54.842 | 56.257 | 66.689 | - | 66.689 |
| Total Adjustments | - | - | 8.841 | - | 8.841 |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | - | - | | | |
| • TotalOtherAdjustments | - | - | 8.841 | - | 8.841 |

### Change Summary Explanation

FY 2012: Increase reflects additional resources required for the building move. Rent is required for both buildings until the move and refurbishments are complete.

## C. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Management Headquarters<br>***Description:*** Management Headquarters<br>***FY 2010 Accomplishments:*** | 54.842 | 56.257 | 66.689 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 6: *RDT&E Management Support* | **R-1 ITEM NOMENCLATURE**<br>PE 0605898E: *MANAGEMENT HQ - R&D* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| - Funded civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.<br>- Funded travel, rent and other infrastructure support costs.<br>- Funded security costs to continue access controls, uniformed guards, and building security requirements.<br>- Funded CFO Act compliance costs.<br>- Funded DARPA share of DoD Acquisition Workforce Fund.<br>***FY 2011 Plans:***<br>- Fund civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.<br>- Fund travel, rent and other infrastructure support costs.<br>- Fund security costs to continue access controls, uniformed guards, and building security requirements.<br>- Fund CFO Act compliance costs.<br>- Fund DARPA share of DoD Acquisition Workforce Fund.<br>***FY 2012 Plans:***<br>- Fund civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.<br>- Fund travel, and other infrastructure support costs.<br>- Fund security costs to continue access controls, uniformed guards, and building security requirements.<br>- Fund CFO Act compliance costs.<br>- Fund DARPA share of DoD Acquisition Workforce Fund.<br>- Fund rent on existing building (full year to allow phased move to new building).<br>- Fund rent on new building on a pro-rata basis. | | | |
| **Accomplishments/Planned Programs Subtotals** | 54.842 | 56.257 | 66.689 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**E. Acquisition Strategy**

N/A

**F. Performance Metrics**

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

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Defense Advanced Research Projects Agency | **DATE:** February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 6: *RDT&E Management Support* | **R-1 ITEM NOMENCLATURE**<br>PE 0305103E: *CYBER SECURITY INITIATIVE* |

| COST ($ in Millions) | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total | FY 2013 | FY 2014 | FY 2015 | FY 2016 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | 49.791 | 10.000 | 10.000 | - | 10.000 | 10.000 | - | - | - | Continuing | Continuing |
| CYB-01: *CYBER SECURITY INITIATIVE* | 49.791 | 10.000 | 10.000 | - | 10.000 | 10.000 | - | - | - | Continuing | Continuing |
| Quantity of RDT&E Articles | | | | | | | | | | | |

## A. Mission Description and Budget Item Justification

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

## B. Program Change Summary ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 Base | FY 2012 OCO | FY 2012 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 49.791 | 10.000 | 10.000 | - | 10.000 |
| Current President's Budget | 49.791 | 10.000 | 10.000 | - | 10.000 |
| Total Adjustments | - | - | - | - | - |
| • Congressional General Reductions | | - | | | |
| • Congressional Directed Reductions | | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | | - | | | |
| • Congressional Directed Transfers | | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | - | - | | | |

### Change Summary Explanation

Not applicable.

## C. Accomplishments/Planned Programs ($ in Millions)

| | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| ***Title:*** Cyber Security Initiative<br><br>***Description:*** The goal of the Cyber Security Initiative is to revolutionize the Nation's ability to conduct cyber operations by developing a persistent and cost-effective cyber testing environment. The National Cyber Range (NCR) program will develop a network testbed that will allow for research experimentation on diverse hardware and software topologies to produce qualitative and quantitative assessments of cyber security research and development programs through a safe, instrumented experimentation environment. The range will replicate complex, heterogeneous networks. It will revolutionize cyber testing to | 49.791 | 10.000 | 10.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency | DATE: February 2011 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide*<br>BA 6: *RDT&E Management Support* | **R-1 ITEM NOMENCLATURE**<br>PE 0305103E: *CYBER SECURITY INITIATIVE* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2010 | FY 2011 | FY 2012 |
|---|---|---|---|
| enable efficient cyber experimentation and facilitate realistic testing of tools and techniques to enable high fidelity assessments of cyber tools and techniques and the rapid transition of research programs to operations. This program will transition to a DoD agency in FY 2012 and will be available for leverage or use by all Federal Government organizations.<br><br>***FY 2010 Accomplishments:***<br>- Continued development of the prototype range and demonstration technologies.<br>- Continued development of key technologies relevant to cyber testing.<br>- Transitioned range automation software tools to the Air Force and SOCOM.<br>***FY 2011 Plans:***<br>- Complete NCR prototype development.<br>- Commence NCR prototype cyber experiments.<br>- Initiate the development of a business model to operate the NCR prototypes.<br>***FY 2012 Plans:***<br>- Continue to develop and test relevant technologies to improve the functionality of the NCR.<br>- Develop plans to scale the NCR.<br>- Complete transition of the National Cyber Range to a DoD customer and the transition of NCR technologies to government customers. | | | |
| **Accomplishments/Planned Programs Subtotals** | 49.791 | 10.000 | 10.000 |

## D. Other Program Funding Summary ($ in Millions)

N/A

## E. Acquisition Strategy

N/A

## F. Performance Metrics

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