Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	158.175	166.654	160.389	-	160.389	200.725	219.944	236.197	257.703	-	-
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	122.658	125.144	81.413	-	81.413	101.018	110.634	124.077	127.453	-	-
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	35.517	41.510	78.976	-	78.976	99.707	109.310	112.120	130.250	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*

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

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

Change Summary Explanation

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	Project (Number/Name) MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	122.658	125.144	81.413	-	81.413	101.018	110.634	124.077	127.453	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

FY 2013 Accomplishments:

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

FY 2014 Plans:

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Reduce non-diamond carbon content to improve film quality and properties by adjusting process component parameters/ integration strategy.			
Title: Materials for Force Protection	25.573	26.159	22.649
Description: The Materials for Force Protection thrust is developing novel materials and materials systems that will greatly enhance performance against ballistic and blast threats including explosively formed projectiles (EFP) and shaped charges across the full spectrum of warfighter environments. Included in this thrust are novel topological concepts as well as entirely new structural designs that will afford enhanced protection and functionality, at reduced weight and/or cost. ***FY 2013 Accomplishments:*** - Scaled up transparent armor solution with multi-hit performance capability at weights equivalent to that of opaque armor. - Demonstrated the ability to produce transparent armor in military relevant sizes while maintaining optical and ballistic performance characteristics. - Initiated development of capability to accurately account for and track load paths during an underbody blast event and provide material properties and energy management mechanisms to meet survivability objectives. - Continued to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and vehicles. - Performed validation testing of optimized advanced armor solutions that exploit the high-performance characteristics of low-cost materials using unique combinations of material composition and topology. - Developed and demonstrated the high-risk manufacturing methods to transition the advanced armor technologies from laboratory scale into large-scale manufacturing and quality control processes that provide a marinized armor solution. - Initiated effort to identify critical parameters that will permit scaling of subscale ballistic modeling and testing into the regime of military relevance. - Established and used mechanics-based models and simulations to guide the design, development, and fabrication of ballistic armor. - Continued integration of ballistic and blast energy management mechanisms into material systems and incorporated into candidate armor material systems for optimization against specific threats. ***FY 2014 Plans:*** - Integrate material properties and energy management mechanisms into ballistic armor materials optimized for single threat defeat in each regime (bullet, frag, EFP) to meet survivability objectives. - Demonstrate at least 50% enhancement in opaque vehicle ballistic armor performance in each regime (bullet, frag, EFP) for single threats over state-of-the-art fielded designs. - Conduct study, based on single threat results, to establish feasibility of achieving 2x enhancement in opaque vehicle ballistic armor performance for multiple threats.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

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

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	35.517	41.510	78.976	-	78.976	99.707	109.310	112.120	130.250	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

FY 2013 Accomplishments:

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

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

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

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

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiate development of high-throughput arrayed microbiome-based technologies to identify novel secondary-metabolite antibiotics against pathogenic bacteria that have evolved multi-drug resistance.			
Title: Living Foundries	10.310	18.155	28.122
Description: The goal of the Living Foundries program is to create a revolutionary, biologically-based manufacturing platform to provide new materials, capabilities, and manufacturing paradigms for the DoD and the Nation. With its ability to perform complex chemistries, be flexibly programmed through DNA code, scale, adapt to changing environments and self-repair, biology represents one of the most powerful manufacturing platforms known. However, the DoD's ability to harness this platform is rudimentary. Living Foundries seeks to develop the foundational technological infrastructure to transform biology into an engineering practice, speeding the biological design-build-test-learn cycle and expanding the complexity of systems that can be engineered. The program will enable the rapid and scalable development of previously unattainable technologies and products (i.e., those that cannot be accessed using known, synthetic mechanisms), leveraging biology to solve challenges associated with production of new materials (e.g., fluoropolymers, enzymes, lubricants, coatings and materials for harsh environments), novel functions (e.g., self-repairing and self-regenerating systems), biological reporting systems, and therapeutics to enable new solutions and enhancements to military needs and capabilities. Ultimately, Living Foundries aims to provide game-changing manufacturing paradigms for the DoD, enabling distributed, adaptable, on-demand production of critical and high-value materials, devices, and capabilities in the field or on base. Such a capability will decrease the DoD's dependence on tenuous material supply chains vulnerable to political change, targeted attack, or environmental accident. Research thrusts will focus on the development and demonstration of open technology platforms, or bioproduction pipelines, that integrate the tools and capabilities developed in PE 0601101E, TRS-01 to prove out capabilities for rapid (months vs. years) design and construction of new bio-production systems for novel materials. The result will be an integrated, modular infrastructure across the areas of design, fabrication, debugging, analysis, optimization, and validation -- spanning the entire development life-cycle and enabling the ability to rapidly assess and improve designs. Integrated processes developed in this program will translate into significant performance improvements and cost savings for the production of advanced materials, biological reporting systems, and therapeutics. These technologies will ultimately result in on-demand, customizable, and distributed production of strategic materials and systems. Key to success will be tight coupling of computational design, fabrication of systems, debugging using multiple characterization data types, analysis, and further development such that iterative design and experimentation will be accurate, efficient and controlled. Demonstration platforms will be challenged to build a variety of DoD-relevant, novel molecules and chemical building blocks with complex functionalities, such as synthesis of advanced, functional chemicals, materials precursors, and polymers (e.g., those tolerant of harsh environments). ***FY 2013 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated integration of fundamental tools and capabilities developed in PE 0601101E, TRS-01 to speed the design, build, and test loop of biological manufacturing, and start bio-foundries development. - Demonstrated ability to speed the design, engineering and production of multiple new bioproducts by >7.5X (from years to months). - Began development and refinement of tools and capabilities to translate designs across multiple platforms and biological systems; demonstrated ability to port a refactored gene cluster across multiple organisms while retaining function. - Began to standardize fabrication, characterization, and test processes on a common infrastructure to enable modularity and flexibility for design and construction of new systems. - Began development of new computational algorithms to perform quality control and evaluate screening data to automatically inform the redesign and optimization of novel biological production systems. - Began initial demonstrations of ability to design, build and test materials production pathways that are difficult or impossible to synthesize using known mechanisms. - Validated the concept of computational design and construction for a novel bio-synthetic pathway for acetaminophen, which was not previously obtainable through biosynthesis.			
FY 2014 Plans: - Continue standardization, integration, and automation of the fundamental tools and capabilities developed in PE 0601101E, TRS-01 into a readily adoptable and adaptable biomanufacturing platform. - Begin to integrate data streams (using previously developed computation algorithms and software) from fabrication, quality control and characterization tools to provide a comprehensive debugging capability and to enable forward design. - Begin to demonstrate, test, and evaluate the extent of design-build-test cycle compression using integrated platforms to engineer new bioproduction systems. - Initiate development of rapid design and prototyping infrastructure pipelines, including initial system integration and process optimization. - Begin testing the ability of integrated infrastructure pipelines to demonstrate rapid, improved prototyping of DoD-relevant molecules.			
FY 2015 Plans: - Demonstrate the ability of each infrastructure pipeline to rapidly generate DoD-relevant molecules. - Expand the capabilities of the rapid design and prototyping infrastructure to target molecules and chemical building blocks that are currently inaccessible using traditional synthesis mechanisms. - Complete proof-of-concept demonstrations of component technologies developed under PE 0601101E, TRS-01 that accelerate the design-build-test cycle. - Expand access and experimental scale to promote the production capabilities of rapid design and prototyping facilities infrastructure.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Begin establishing the efficacy of the integrated design-build-test-debug feedback cycle for forward design and rapid optimization of novel, currently inaccessible molecules via the prototyping facility's established processes.			
Title: SAEBR (Surprise Avoidance in Engineering Biology Research) ***Description:*** There is a national security need to assess and address the capabilities enabled by enhanced engineering biology technologies, and to protect the tools used for the facile engineering of biological systems. The Surprise Avoidance in Engineering Biology Research (SAEBR) program will enlist leading experts across the engineering biology field to assess potentially surprising/unanticipated applications enabled by newly designed tools, technologies, and methodologies as well as their potential for misuse. Applied research in this area will focus on understanding how current tools and technologies may be safeguarded against potential misuse. ***FY 2015 Plans:*** - Begin evaluating how emerging engineering biology technologies can be safeguarded against misuse. - Begin identifying molecular signatures that can distinguish "natural" organisms from synthetic strains.	-	-	5.500
Title: Adaptive Immunomodulation-Based Therapeutics ***Description:*** The Adaptive Immunomodulation-Based Therapeutics program will develop platform technologies that can interrogate and define the biological pathways leading to an immune response with the goal of developing and demonstrating new therapeutic interventions. One approach to achieve this capability will require the development of new tools to stimulate and measure responses of the nervous system in order to map the bioelectric code that controls the immune response as well as other critical organ functions. This program will also develop capabilities for serial measurements of metabolic state to identify correlates for health and early detection of disease. An additional approach involves characterizing the host response in patients with severe infections, and translating this response into a quantitative framework that can be used to guide modulation of the immune response. A further line of effort will pursue a detailed understanding of infectious diseases circulating in a community, with an aim to build capacity for the response to a crisis through managing current infectious disease challenges. The effort will employ sophisticated laboratory testing to evaluate the evolution of pathogens. Test beds in communities will be developed to evaluate the predictive algorithms by tracking infections in a community; influenza is an example of an infection that will be monitored. Advances made under the Adaptive Immunomodulation-Based Therapeutics program will improve our response capability against severe infectious diseases and biological threats and offer new avenues for treating disease with no available drugs, such as multiple drug resistant organisms. The ultimate goals for the Adaptive Immunomodulation-Based Therapeutics program are to enable an autonomous and continuous sense and response capability to regulate the human immune response and to develop decision support tools that help manage infectious diseases in a community. It is anticipated	-	-	10.000

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	192.349	233.469	179.203	-	179.203	183.439	184.458	187.536	192.637	-	-
ELT-01: *ELECTRONICS TECHNOLOGY*	-	192.349	233.469	179.203	-	179.203	183.439	184.458	187.536	192.637	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

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

Change Summary Explanation

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

FY 2014: Decrease reflects a reduction for program growth.

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

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

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

FY 2013 Accomplishments:

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

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

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

FY 2013 Accomplishments:

- Demonstrated highly linear time delay unit monolithic microwave integrated circuit for beam-steering applications in wideband phased arrays.
- Demonstrated micro electro-mechanical systems (MEMS)-based channelized RF receiver topology for use in high-speed spectrum sensing applications from 0.02 - 6 gigahertz (GHz) with a scan rate > 5 terahertz per second.
- Demonstrated world's first signal classification application-specific integrated circuit for the purpose of signal classification. Power consumption is sufficiently low to allow 170 hours of continuous classification on a single charge of a typical smartphone battery.
- Demonstrated initial hardware implementations of developed signal recognition concepts/techniques.
- Demonstrated simulations of direction-of-arrival hardware with 1.7 picoJoule/operation, which is 2 orders of magnitude lower than conventional processors.
- Developed efficient and robust computer-aided design optimization algorithms for RF-FPGA programming including development of an emulation board for demonstrating these concepts.
- Demonstrated usage of MEMS switches for reconfiguration of piezoelectric resonators/filters.
- Demonstrated multi-channel filter manifold design showing the capability for switching resonators in and out of a filter for near-arbitrary transfer function control.
- Developed flexible and programmable hybrid phase-locked loop with frequency tuning range up to 19 GHz.
- Completed DC-to-20 GHz circuit for military applications, with both coarse- and fine-grained on-the-fly reconfigurability, all on a single monolithic integrated circuit fabricated in a commercial foundry process.
- Demonstrated novel phase change material switches for use in RF-FPGAs with insertion loss <0.15 dB out to 50 GHz and < 0.5 dB out to 100 GHz with isolation > -10 dB over the full 100 GHz.

FY 2014 Plans:

- Demonstrate reconfigurable RF circuit (RF-FPGA) technologies at the component and system levels along with the necessary computer-aided design approaches.
- Demonstrate the applicability of one RF hardware design for 5 different application spaces, as a prototype for how ART technology can lead the way to life-cycle cost reduction.
- Demonstrate advanced concepts for signal recognition at the hardware level and initiate plans for transitioning these approaches to relevant DoD systems.
- Demonstrate applicability of tunable filters for dynamic frequency allocation in a fielded radio system.

FY 2015 Plans:

- Demonstrate final circuit design technologies including microwave switches, frequency synthesis and RF functionality.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate a fully reconfigurable RF filter element with serial addressing of the components in an appropriate package form factor. - Optimize the RF phase-change switch technology and perform a final RF-FPGA demonstration. - Implement transition plans for a fully reconfigurable RF circuit technology at the component and system levels.			
Title: Nitride Electronic NeXt-Generation Technology (NEXT) ***Description:*** To realize high performance analog, Radio Frequency (RF) and mixed-signal electronics, a next-generation transistor technology with high cutoff frequency and high breakdown voltage is under development. This technology will enable large voltage swing circuits for military applications that the current state-of-the-art silicon transistor technology cannot support. The objective of the Nitride Electronic neXt-generation Technology (NEXT) program is to develop a revolutionary, wide band gap, nitride transistor technology that simultaneously provides extremely high-speed and high-voltage swing [Johnson Figure of Merit (JFoM) larger than 5 Terahertz (THz)-V] in a process consistent with large scale integration of enhancement/depletion (E/D) mode logic circuits of 1000 or more transistors. In addition, this fabrication process will be reproducible, high-yield, high-uniformity, and highly reliable. The accomplishment of this goal will be validated through the demonstration of specific program Process Control Monitor (PCM) Test Circuits such as 5, 51 and 501-stage ring oscillators in each program phase. The impact of this next-generation nitride electronic technology will be the speed, linearity, and power efficiency improvement of RF and mixed-signal electronic circuits used in military communications, electronic warfare and sensing. ***FY 2013 Accomplishments:*** - Demonstrated world record, wide-bandgap nitride transistor technology with operation up to 450 GigaHertz (GHz) through scaling efforts for self-aligned structures with short gate length, novel barrier layers, and reduced parasitic elements. - Increased the Technology Readiness Level (TRL) of the transistor fabrication process for future power switching and Monolithic Microwave Integrated Circuit (MMIC) capability using advanced wide band gap devices. - Continued to improve the versatility and circuit design potential of the NEXT MMIC process by successfully integrating Schottky diodes. ***FY 2014 Plans:*** - Complete enhancement / depletion mode transistor scaling development for fully self-aligned nitride transistors with full process compatibility. - Develop NEXT process development kit for circuit designers. - Design and fabricate RF or mixed signal demonstration circuits based on latest NEXT transistors and integration processes. ***FY 2015 Plans:*** - Establish the baseline of the high-speed / high breakdown voltage NEXT fabrication technology with high reproducibility and yield.	8.360	8.080	4.280

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Design, fabricate, and test military-relevant circuits, such as RF power amplifiers, using the developed NEXT transistor technology. - Complete NEXT process design kit to allow external circuit designers to utilize NEXT technology in other advanced circuit designs.			
Title: Diverse & Accessible Heterogeneous Integration (DAHI) ***Description:*** Prior DARPA efforts have demonstrated the ability to monolithically integrate different semiconductor types to achieve near-ideal "mix-and-match" capability for DoD circuit designers. Specifically, the Compound Semiconductor Materials On Silicon (COSMOS) program enabled transistors of Indium Phosphide (InP) to be freely mixed with silicon complementary metal-oxide semiconductor (CMOS) circuits to obtain the benefits of both technologies (very high speed and very high circuit complexity/density, respectively). The Diverse & Accessible Heterogeneous Integration (DAHI) effort will take this capability to the next level, ultimately offering the seamless co-integration of a variety of semiconductor devices (for example, Gallium Nitride, Indium Phosphide, Gallium Arsenide, Antimonide Based Compound Semiconductors), microelectromechanical (MEMS) sensors and actuators, photonic devices (e.g., lasers, photo-detectors) and thermal management structures. This capability will revolutionize our ability to build true "systems on a chip" (SoCs) and allow dramatic size, weight and volume reductions for a wide array of system applications. In the Applied Research part of this program, high performance RF/optoelectronic/mixed-signal systems-on-a-chip (SoC) for specific DoD transition applications will be developed as a demonstration of the DAHI technology. To provide maximum benefit to the DoD, these processes will be transferred to a manufacturing flow and made available (with appropriate computer aided design support) to a wide variety of DoD laboratory, Federally Funded Research and Development Center (FFRDC), academic and industrial designers. Manufacturing yield and reliability of the DAHI technologies will be characterized and enhanced. This program has basic research efforts funded in PE 0601101E, Project ES-01, and advanced technology development efforts funded in PE 0603739E, Project MT-15. ***FY 2013 Accomplishments:*** - Continued fabrication and testing of higher complexity new generation of heterogeneously-integrated wideband, ultra-high-linearity analog-to-digital converters with in situ silicon-enabled calibration and linearization. - Demonstrated ultra-wideband Analog-to-Digital Converter (ADC) with signal-to-noise-and-distortion ratio (SINAD) of over 30 Decibels (dB) at input frequencies of up to 20GHz with instantaneous bandwidth of 6GHz. - Completed final multi-project wafer run of multi-user two-technology compound-semiconductor-on-silicon foundry process. - Demonstrated a wide array of RF/mixed-signal components utilizing heterogeneous integration, including low-noise amplifiers, high-speed track-and-hold circuits, RF digital-to-analog converters, and tunable bandpass filters, which demonstrate the advantages of heterogeneous integration over single-technology integrated circuits.	27.153	34.385	33.400

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

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015

atomic technologies. Advanced micro-fabrication techniques under development will enable the fabrication of a single package containing all the necessary devices in a volume the size of a sugar cube. Co-location of atomic physics and MEMS-based devices opens the possibility for utilization of combinatorial algorithms to enable fast start-up time and increased bandwidth of MEMS with the long-term stability and accuracy of MEMS sensors, thus effectively providing very accurate navigation devices in highly dynamic environments. The small SWaP+C of these technologies will enable ubiquitous guidance and navigation on all platforms, including guided munitions, unmanned aerial vehicles (UAVs), and individual soldiers.

The successful realization of micro-PNT depends on the development of new microfabrication processes and novel material systems for fundamentally different sensing modalities, understanding of the error sources at the micro-scale, and understanding of scaling relationships for the size-reduction of sensors based on atomic physics techniques. The micro-PNT program includes research into novel techniques for fabrication and integration of three-dimensional MEMS devices as well as theoretical and experimental studies of new MEMS architectures and geometries for inertial sensing. Atomic physics research includes the development of new geometries and architectures for atomic inertial sensing and the development of techniques for improving the sensitivity and accuracy of miniaturized devices. Advanced research for the program is budgeted in PE 0603739E, Project MT-12.

FY 2013 Accomplishments:
- Developed architecture for co-integrated clock, accelerometers, and gyroscope on a single chip with a volume of less than ten cubic millimeters.
- Demonstrated algorithmic techniques for on-chip error correction of an inertial sensor (improving bias stability to 100 parts-per million (ppm)).
- Demonstrated fabrication and functionality of an integrated calibration micro-stage.
- Explored and developed predictive models of error sources for gyroscope and accelerometers.
- Identified physical and algorithmic self-calibration techniques to compensate for stability and drift of inertial sensors, effective to 100 (ppm) scale factor and bias stability.
- Developed design space for chip-scale, atomic navigation sensor.
- Developed hemispherical shell micro-resonators from novel materials (diamond, nickel alloy).
- Developed new fabrication processes for improved packaging and narrow electrode gap alignment.

FY 2014 Plans:
- Demonstrate a prototype miniature inertial sensor based on atomic physics.
- Demonstrate laboratory functionality of a MEMS-based IMU with a volume of less than 10mm^3.
- Use predictive error models of gyroscopes and accelerometers to achieve better than 10ppm long term stability of scale factor and bias.

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate low damping of 3D hemispherical micro-gyroscopes, capable of operating with a high dynamic range in whole angle mode. - Demonstrate on-chip calibration with co-fabricated characterization stages. - Demonstrate improved functionality of Disc Resonant Gyroscope (DRG) with integrated quartz crystal oscillator. ***FY 2015 Plans:*** - Demonstrate on-chip calibration stages to track bias and scale factor stability repeatable to <100ppm. - Demonstrate a 10mm^3 silica IMU. - Demonstrate a miniaturized, low-drift Nuclear Magnetic Resonance (NMR) gyroscope. - Demonstrate a micro-hemispherical resonant gyroscope, operating in both whole-angle mode and rate mode.			
Title: Microscale Plasma Devices (MPD) ***Description:*** The goal of the Microscale Plasma Devices (MPD) program is to design, develop, and characterize MPD technologies, circuits, and substrates. The MPD program will focus on development of fast, small, reliable, high-carrier-density, micro-plasma switches capable of operating in extreme conditions, such as high-radiation and high-temperature environments. Specific focus will be given to methods that provide efficient generation of ions that can perform robust signal processing of radio frequency (RF) through light electromagnetic energy over a range of gas pressures. Applications for such devices are far reaching, including the construction of complete high-frequency plasma-based circuits, and microsystems with superior resistance to radiation and extreme temperature environments. It is envisaged that both two and multi-terminal devices consisting of various architectures will be developed and optimized under the scope of this program. MPDs will be developed in various circuits and substrates to demonstrate the efficacy of different approaches. MPD-based microsystems are demonstrated in DoD applications where electronic systems must survive in extreme environments. The MPD applied research program is focused on transferring the fundamental scientific advances funded by PE 0601101E, Project ES-01 to produce complex circuit designs that may be integrated with commercial electronic devices. It is expected that the MPD program will result in the design and modeling tools, as well as the fabrication capabilities necessary to commercially manufacture high-performance microscale-plasma-device-based electronic systems for advanced DoD applications. ***FY 2013 Accomplishments:*** - Verified initial microplasma modeling simulation results against microscale plasma device measurement results to begin optimization of the microplasma modeling-and-simulation design tool (MSDT) for commercial development of microplasma-based electronics. - Investigated the use of microscale plasma devices for protection of sensor systems in extreme environments.	6.138	6.300	2.000

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

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

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Achieve a safe in vivo nanoplatform sensor to detect five military-relevant analytes (e.g. glucose, nucleic acids) in a large animal with a robust signal for at least twelve months. - Achieve a safe and effective in vivo nanoplatform therapeutic to reduce a military-relevant pathogen or disease cofactor in a large animal by at least 90%. - Update regulatory approval pathway with results from safety and efficacy testing.			
Title: Pixel Network (PIXNET) for Dynamic Visualization	14.000	23.700	17.500
Description: The PIXNET program addresses the squad level capability gap for target detection, recognition and identification in all-weather and day/night missions. The vision of the program is to offer the warfighter a small and versatile infrared (IR) camera that would be affordable for individual soldiers and provide multiple IR band imagery with fusion capability to take full advantage of different wavelength-band phenomenology in a compact single unit. In the future, the availability of the PIXNET camera would enable a peer-to-peer networked system for image sharing within a squad, thereby providing a better common operating picture of the battlefield and significantly enhancing the warfighter's situational understanding. The program aims to develop a low size, weight and power (SWaP), low cost, soldier-portable multiband infrared camera that will provide real-time single and multiple band imagery using thermal and reflected-illumination bands. The camera will also provide fused reflective and thermal band imagery on demand. The use of fused imagery in the PIXNET design will allow the soldier to detect camouflaged targets and distinguish targets from decoys. The PIXNET camera will eliminate limitations posed by current capability, allowing detection, recognition and identification of targets whether in daylight or no-light conditions. The PIXNET program will focus on a significant reduction in SWaP and cost of infrared sensor components to enable portability and ability to deploy widely to all participants in the theater. The emphasis on a small form will naturally enable new opportunities such as surveillance with small Unmanned Aerial Vehicles (UAV)s, rifle sights with multiple bands, and vehicle-mounted, helmet-mounted and handheld surveillance systems. The phenomenology of different infrared wavelengths will be exploited. The combination of a smart phone and PIXNET camera at the soldier level will enable more effective tactics, techniques and procedures (TTP) over the current capability. The PIXNET program takes advantage of the computing capability of smart phones to process and fuse multicolor images and send them as videos or still images to the warfighter's helmet-mounted display via a wireless or wired connection. PIXNET capability could be further exploited to enable a fully networked system, such as the Nett Warrior integrated multiple soldier systems capability, with multi-spectral still image and video sharing. ***FY 2013 Accomplishments:*** - Conducted multicolor fusion tests using separate video imagery in visible, shortwave and longwave to determine phenomenological advantages. - Identified several Key Performance Parameters (KPPs) for the brass board design of the PIXNET camera.			

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

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FY 2014 Plans: - Initiate development of common hardware components for phased-array elements that can be seamlessly integrated into a wide range of platforms and implement the first iteration of the common components in a state-of-the-art fabrication process. - Initiate the development of digital array systems with performance capabilities that evolve with Moore's law at commercial time scales. - Initiate the development of electromagnetic (EM) interface elements capable of reconfiguring for various array use cases and operational specifications. - Demonstrate reconfigurability of EM interface components for various array performance specifications and demonstrate compatibility with common digital back-end. - Identify government application spaces and transition paths that will make use of ACT common modules and reconfigurable antenna apertures. ***FY 2015 Plans:*** - Continue development of common hardware components for phased-array elements that can be seamlessly integrated into a wide range of platforms and implement the second iteration of the common components in a state-of-the-art fabrication process and test functionality in a laboratory environment. - Demonstrate Common Module hardware viability through government testing of delivered hardware components in a government furnished system platform. - Continue the development of EM interface elements capable of reconfiguring for various array use cases and operational specifications, and demonstrate tuning over an octave of bandwidth and over multiple polarization settings. - Continue to demonstrate reconfigurability of EM interface components for various array performance specifications, and demonstrate compatibility with common digital back-end. - Continue to identify government application spaces and transition paths for the ACT Common Module and reconfigurable antenna apertures.			
Title: Micro-coolers for Focal Plane Arrays (MC-FPA) ***Description:*** The Micro-coolers for Focal Plane Arrays (MC-FPA) program will develop low Size, Weight, Power, and Cost (SWaP-C) cryogenic coolers for application in high performance IR cameras. The sensitivity of an IR focal-plane array (FPA) is improved by cooling its detectors to cryogenic temperatures. The disadvantages of state-of-the-art Stirling cryo-coolers used for high performance IR FPAs are large size, high power and high cost. On the other hand, thermoelectric (TE) coolers used in low performance IR cameras are relatively small, high power, and it is difficult to achieve temperatures below 200 Kelvin (K). To reduce IR camera SWaP-C, innovations in cooler technology are needed. This program will exploit the Joule-Thomson (J-T) cooling principle, in a silicon-based MEMS technology, for making IR FPA coolers with very low SWaP-C. MEMS microfluidics,	-	5.000	1.500

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piezoelectric MEMS, and complementary metal-oxide semiconductor (CMOS) electronics will be used to demonstrate an integrated cold head and compressor, all in a semiconductor chip. Since a J-T cooler works by cooling from gas expansion, the coefficient of performance is expected to be much higher than state-of-the-art TE coolers, while being significantly smaller than Stirling coolers. The chip-scale J-T cooler will be designed for pressure ratios of 4 or 5 to 1 with high compressor frequency in a small volume. The goal of the MC-FPA program will be to demonstrate cooling down to 150 K. The chip-scale micro-coolers will cost less and will be significantly smaller than current Stirling coolers. Once the proof-of-principle is demonstrated, the subsequent program effort will focus on transitioning to chip-scale manufacture on 8-12 inch wafers, resulting in cooler costs decreasing to as low as $50. An extended wavelength-range short-wave IR detector will be integrated with a micro-cooler for demonstration of the MC-FPA. The basic research component of this program is budgeted under PE 0601101E, Project ES-01. ***FY 2014 Plans:*** - Develop detector design for response in 1-2.4 microns. - Perform materials growth and characterization for detector fabrication. - Process Cadmium Zinc Telluride (CdZnTe) substrates for epitaxy. - Complete initial analysis to determine input cell design for readout integrated circuit (ROIC). - Fabricate and test a single stage MC-FPA. - Develop 640X480 extended shortwave infrared (1-2.4 micrometer cutoff) FPA. - Design a readout integrated circuit (ROIC) for the IR FPA chip. - Demonstrate camera electronics for the FPA with provision for chip-scale micro-cooler. ***FY 2015 Plans:*** - Fabricate 3-stage J-T micro-cooler. - Hybridize FPA to ROIC and integrate 3-stage J-T micro-cooler with complete backend packaging. - Complete camera integration & housing. - Complete camera tests and demo.			
Title: Vanishing Programmable Resources (VAPR) ***Description:*** The Vanishing Programmable Resources (VAPR) program will create electronic systems capable of physically disappearing (either in whole or in part) in a controlled, triggerable manner. The program will develop and establish an initial set of materials and components along with integration and manufacturing capabilities to undergird a fundamentally new class of electronics defined by their performance and transience. These transient electronics ideally should perform in a manner comparable to Commercial Off-The-Shelf (COTS) systems, but with limited device persistence that can be programmed, adjusted in real-time, triggered, and/or sensitive to the deployment environment. Applications include sensors for conventional indoor/ outdoor environments (buildings, transportation, materiel), environmental monitoring over large areas, and simplified diagnosis, treatment, and health monitoring in the field. VAPR will build out an initial capability to make transient electronics a deployable	-	9.645	5.500

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*

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

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Identified applications where a cluster of photonically optimized microprocessors is useful and designed the cluster architecture, photonic network, and parallel algorithms for community analysis on large graphs. ***FY 2014 Plans:*** - Demonstrate a photonic link between a CMOS chip and a DRAM chip consuming low (few picojoule (pJ)) energy/bit employing foundry-compatible photonic devices and respective control and driver circuits. - Fabricate and test optical receiver circuits with 200 nanoseconds (ns) locking time and consuming 10 pJ/bit. - Design and test new algorithms that effectively parallelize graph analytic problems, taking advantage of the high bandwidth photonic interconnects. - Study and optimize the material stack for fabricating an on-chip, uncooled laser operating at 1550 nm and ~ 10% wall plug efficiency.			
Title: Advanced X-Ray Integrated Sources (AXIS) ***Description:*** The Advanced X-Ray Integrated Sources (AXIS) program developed tunable, mono-energetic, spatially coherent X-ray sources with greatly reduced size, weight and power while dramatically increasing their electrical efficiency through application of micro-scale engineering technologies such as MEMS and NEMS. Such X-ray sources enabled new versatile imaging modalities based on phase contrast techniques which are 1000X more sensitive than the conventional absorption contrast imaging. Such imaging modalities enabled design verification of integrated circuits to validate trustworthiness as well as Forward Surgical Team imaging of soft tissues and vascular injuries from blunt trauma without the injection of a contrast enhancing agent. The radiation dose required for imaging will also be reduced. The Applied Research component of this effort focused on applying basic research discoveries to the development of a compact, pulsed X-ray source. Such sources are a necessary component to enable future technologies with high-speed motion tomographic imaging capabilities and the design verification of integrated circuits. This program also included related basic research efforts funded under PE 0601101E, Project ES-01. ***FY 2013 Accomplishments:*** - Fabricated and demonstrated a short-lifetime photoconductor switched tip-on-post (Spindt) field emitter with short pulse duration, high pulse repetition rate, and low emittance. - Began fabrication of an advanced hard X-ray source based on a whispering gallery mode resonator with multi-layer reflectivity for confinement and gain. - Coordinated the development of devices capable of producing synchrotron-quality X-rays by integrating the most successful components (cathodes, accelerators, undulators & lasers) in the program.	8.000	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Obtained X-ray images from an array of micro-focused X-ray sources fabricated for the AXiS program.			
Title: Quantum Information Science (QIS) ***Description:*** The Quantum Information Science (QIS) program explored all facets of the research necessary to create new technologies based on quantum information science. Research in this area has the ultimate goal of demonstrating the potentially significant advantages of uniquely quantum effects in communication and computing. The QIS program addressed the fundamental material science and physics associated with uniquely quantum effects in materials. The primary technical challenges include loss of information due to quantum decoherence and the practical limitations associated with operation temperatures, susceptibility to electronic and magnetic noise, coupling between quantum devices, etc. Theoretical efforts in QIS investigated novel techniques for preserving coherence, distributing quantum entanglement, and efficiently modeling quantum operations. Complementary experiments sought to demonstrate quantum devices with better coherence properties than existing devices and to implement entangling operations between two or more quantum devices. Future technologies utilizing quantum information science could enable ultra-secure communications; faster algorithms for optimization and simulation in logistics, war gaming, and pharmaceutical development; and new methods for image and signal processing in measurement and signature intelligence activities (MASINT). ***FY 2013 Accomplishments:*** - Improved speed and accuracy of numerical modeling of quantum device operation. - Developed design, growth, and fabrication techniques for enhancement-mode quantum devices with improved performance. - Demonstrated coupling of a spin qubit to a superconducting resonator for transport of quantum information over centimeter-scale distances.	1.138	-	-
Title: Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) ***Description:*** The vision of the Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) program was the development of biological-scale neuromorphic electronic systems for autonomous, unmanned, robotic systems where humans are currently the only viable option. Successful development of this technology could revolutionize warfare by providing intelligent terrestrial, underwater, and airborne systems that remove humans from dangerous environments and remove the limitations associated with today's remote-controlled robotic systems. Applications for neuromorphic electronics include not only robotic systems, but also natural human-machine interfaces and diverse sensory and information integration applications in the defense and civilian sectors. ***FY 2013 Accomplishments:*** - Fabricated neuromorphic chips of 1 million neurons performing behavioral tests in the virtual environment.	6.842	-	-

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

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

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

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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F. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	168.376	144.804	129.723	-	129.723	178.043	186.011	189.790	193.755	-	-
AIR-01: *ADVANCED AEROSPACE SYSTEMS*	-	168.376	144.804	129.723	-	129.723	178.043	186.011	189.790	193.755	-	-

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

A. Mission Description and Budget Item Justification

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

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

Change Summary Explanation

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

FY 2014: Decrease reflects a reduction for prior year carryover.

FY 2015: Decrease reflects transition of LRASM work to the Services and drawdown of the Persistent Close Air Support program.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

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

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

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated studies on integration with existing Service systems and systems architectures. ***FY 2014 Plans:*** - Define the launch and recovery technique through evaluations and trade studies. - Complete studies on integration with existing Service systems and systems architectures. - Study aircraft design trades and approaches to best meet performance goals at minimum lifecycle cost. - Begin development of simulation and control schemes to achieve high precision approach. - Identify equipment and interface requirements for ship launch and recovery systems. ***FY 2015 Plans:*** - Continue technology maturation and preliminary design. - Initiate risk reduction simulations and testing. - Begin fabrication and testing of demonstrator system hardware.			
Title: Aerial Reconfigurable Embedded System (ARES)	-	23.000	23.000
Description: Current and future land and ship-to-shore operations will require rapid and distributed employment of U.S. forces on the battlefield. The Aerial Reconfigurable Embedded System (ARES) program will develop a vertical take-off and landing (VTOL), modular unmanned air vehicle that can carry a 3,000 lb useful load at a range of 250 nautical miles on a single tank of fuel. ARES will enable distributed operations and access to compact, high altitude landing zones to reduce warfighter exposure to hostile threats and bypass ground obstructions. ARES modular capability allows for different mission modules to be quickly deployed at the company level. This enables the flexible employment of the following capabilities: cargo resupply, casualty evacuation, reconnaissance, weapons platforms, and other types of operations. The enabling technologies of interest include adaptive wing structures, ducted fan propulsion system, lightweight materials, and advanced flight controls for stable transition from vertical to horizontal flight. Additionally, the program will explore new adaptable landing gear concepts to enable operations from irregular landing zones and moving launch/recovery platforms. ARES vehicles could be dispatched for downed airman recovery, for evacuating injured personnel from difficult-to-access locations, or to resupply isolated small units. ARES is well suited for enhanced company operations concepts which would provide the warfighter/team increased situational awareness for operations in an urban environment. In FY13, this program was funded from PE 0602702E, Project TT-07. The anticipated transition partners for this effort are the Army, Marine Corps, and Special Operations Forces. ***FY 2014 Plans:*** - Complete Critical Design Review for the ARES system. - Fabricate custom components, acquire powerplant and drivetrain components. - Perform one third scale powered tunnel test of flight module with cargo module. - Conduct component testing and static propulsion testing, showing feasibility and function of critical technology components.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete development of flight control software to ensure successful flight and ground testing. - Conduct subsystem testing and integration of components into the full scale prototype ARES system. - Complete hardware-in-the-loop and software-in-the-loop testing with fully integrated full scale prototype ARES system. - Conduct a test readiness review in preparation for ground and test demonstrations of the prototype vehicle. ***FY 2015 Plans:*** - Conduct ground demonstrations of the prototype vehicle. - Conduct flight test demonstrating that the prototype meets program objectives.			
Title: Hypersonic Air-breathing Weapon Concept (HAWC) ***Description:*** The objective of the Hypersonic Air-breathing Weapon Concept (HAWC) program, an outgrowth of the Integrated Hypersonics program, is to develop and demonstrate technologies that will enable transformational changes in responsive, long-range strike against time-critical or heavily defended targets. HAWC will pursue flight demonstration of the critical technologies for an effective and affordable air-launched hypersonic cruise missile. These technologies include advanced air vehicle configurations capable of efficient hypersonic flight, hydrocarbon scramjet-powered propulsion to enable sustained hypersonic cruise, thermal management approaches designed for high-temperature cruise, and affordable system designs and manufacturing approaches. HAWC technologies also extend to reusable hypersonic air platforms for applications such as global presence and space lift. The HAWC program will leverage advances made by the previously funded Falcon, X-51, and HyFly programs. This is a joint program with the Air Force, and HAWC technologies are planned for transition to the Air Force after flight testing is complete. ***FY 2014 Plans:*** - Conduct hypersonic air-breathing missile objective system trades studies and conceptual design definition. - Derive hypersonic air-breathing missile demonstration system design from the objective system and begin developing the suite of enabling technologies. - Begin developing flight testing plans for the hypersonic air-breathing missile demonstrator. - Initiate risk reduction testing of enabling subsystem technologies for the hypersonic air-breathing missile demonstrator. ***FY 2015 Plans:*** - Continue risk reduction testing of subsystem technologies for hypersonic air-breathing missile demonstrator. - Complete preliminary design of hypersonic air-breathing missile flight demonstration system. - Complete detailed plans for flight testing of the air-breathing missile demonstration system. - Begin procurement of long lead hardware for hypersonic air-breathing missile flight demonstration vehicle.	-	15.000	25.000
Title: Tactical Boost Glide	-	28.000	15.000

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

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

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

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

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

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

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D. Other Program Funding Summary ($ in Millions)

Line Item	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
• Integrated Sensor Is Structure: *Air Force PE 0305205F, Project 675372F*	13.001	1.000	-	-	-	-	-	-	-	Continuing	Continuing
• Integrated Sensor Is Structure:: *Air Force PE 0603203F, Project 665A*	0.750	-	-	-	-	-	-	-	-	-	-
• Triple Target Terminator (T3): *Air Force*	41.730	-	-	-	-	-	-	-	-	Continuing	Continuing

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	136.427	142.546	179.883	-	179.883	169.626	227.139	231.935	242.587	-	-
SPC-01: *SPACE PROGRAMS AND TECHNOLOGY*	-	136.427	142.546	179.883	-	179.883	169.626	227.139	231.935	242.587	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

Change Summary Explanation

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

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

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

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

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

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015

support and space system user data to rapidly identify threat activities, propose mitigating countermeasures, and verify the effectiveness of selected responses. Critical technologies include accessing disparate sources of relevant data, model-based situational awareness, and candidate response generation and evaluation. Particular emphasis will be placed on the ability to continuously adapt to changes in defended system components and usage patterns as well as validation of system integrity. SDA will demonstrate new approaches to collection of data utilizing a variety of collection modalities, ranging from fusion of observations from non-traditional sources, such as amateur astronomers, to evaluation of sparse aperture imaging techniques.

Also funded within this program is the Galileo effort which, will develop technology to image a Geosynchronous Earth Orbit (GEO) satellite from the ground. Galileo will utilize fixed mobile telescopes, each with adaptive optics and a guide star, to create multiple baselines that can be used to reconstruct the image through an inverse Fourier transform. The potential transition customer is the Air Force.

FY 2013 Accomplishments:
- Commenced radiometric data processing efforts.
- Completed SpaceView initial demonstration, providing Space Situational Awareness (SSA) data from amateur astronomer sources.
- Developed requirements performance models for the Galileo imaging system.
- Developed plans for risk-reduction experiments necessary to complete a detailed Galileo system design.

FY 2014 Plans:
- Demonstrate the advantages of a having a collaborative network of users with access to data from numerous distributed sensors over the traditional sensor-centric architecture.
- Expand SpaceView amateur network.
- Initiate and demonstrate StellarView network of academic astronomy data providers.
- Initiate novel dynamic database to collect networked source information for validation.
- Demonstrate intuitive applications and adaptive understanding capabilities of the next-generation space information fusion center.
- Complete risk reduction experiments and begin preliminary system design for the Galileo interferometer.
- Study the application of quantum optical sensing methods to Space Domain Awareness challenges of object detection and imaging.
- Commence Phase 1 of an un-cued low inclined LEO object detection capability.
- Demonstrate preliminary capability of the Allen Telescope Array to passively detect and track satellites.
- Commence astrometric data processing and validation efforts.
- Commence Galileo Phase 2A risk reduction experiments to lead to possible future comprehensive demonstration.

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

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

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

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

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Identify potential effort to provide high resolution capability with light weight optics by leveraging a precision interferometric approach combined with novel image reconstruction algorithm and photonic integrated circuit.			
Title: System F6	30.000	3.000	-
Description: The objective of the System F6 program is to demonstrate the feasibility and benefits of satellite architecture technologies which facilitate a fractionated architecture wherein the functionality of a traditional "monolithic" spacecraft is replaced by a cluster of wirelessly-interconnected spacecraft modules. Each such "fractionated" module could contribute a unique capability, for example, computation and data handling, communications relay, guidance and navigation, payload sensing, or it can replicate the capability of another module; the cluster would deliver a comparable mission capability to a monolithic spacecraft. The fractionated modules would fly in a loose, proximate cluster orbit capable of semi-autonomous reconfiguration or a rapid defensive scatter/re-gather maneuver. The System F6 program will develop key technologies to facilitate fractionated and disaggregated architectures. The F6 Technology Package (F6TP), a suite of technologies, components, and algorithms that enables semi-autonomous multi-body cluster flight and secure, distributed, real-time sharing of various spacecraft resources at the cluster level will also be developed. Multiple versions of the F6 Technology Package will be developed on the basis of open-source interface standards, software, and reference designs termed the F6 Developer's Kit (FDK). The utility of the architecture in low earth orbit (LEO) is significantly enabled by persistent broadband connectivity to the ground which allows resource sharing between space-based modules and terrestrial network nodes. A solution to enable high-availability, low-latency, persistent, high-bandwidth communication with LEO spacecraft will be developed in the course of the F6 program. ***FY 2013 Accomplishments:*** - Completed initial version of FDK software and demonstrated functionality in representative orbital conditions. - Completed initial release of the FDK. - Conducted preliminary design review (PDR) for the F6TP. - Conducted critical design review (CDR) for the F6TP. - Took delivery of the F6TP breadboards. - Completed FDK documentation for the wireless intermodule communications and information assurance platform architectures. ***FY 2014 Plans:*** - Complete F6TP engineering development units. - Complete flight unit of the persistent broadband terrestrial connectivity terminal for LEO fractionated clusters. - Complete a fully-functional, well-documented, value-centric architecture and design tool for adaptable space systems. - Complete cluster flight application software development and testing.			

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

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D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
Total Program Element	-	92.291	107.080	92.246	-	92.246	83.198	97.496	107.594	114.417	-	-
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	-	36.797	32.336	12.386	-	12.386	-	-	-	-	-	-
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	55.494	74.744	79.860	-	79.860	83.198	97.496	107.594	114.417	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

Change Summary Explanation

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

FY 2014: Decrease reflects a reduction for prior year carryover.

FY 2015: Decrease reflects programs in thermal imaging coming to an end, micro position, navigation and timing scaling back and elimination of maskless nano-writer follow-on.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
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COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	-	36.797	32.336	12.386	-	12.386	-	-	-	-	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)	35.492	27.725	12.386
Description: The Micro-Technology for Positioning, Navigation, and Timing (Micro-PN&T) program is developing low size, weight, power, and cost (SWaP+C) inertial sensors and timing sources. This suite of sensors, when integrated into an inertial measurement unit (IMU), will enable self-contained navigation and timing in the absence of signals from the Global Positioning System (GPS), due to environmental interference or adversary action such as GPS jamming. The Micro-PNT program is developing miniature high performance gyroscopes, accelerometers, and clocks, based on both solid state and atomic technologies. Advanced micro-fabrication techniques under development will enable the fabrication of a single package containing all the necessary devices in a volume the size of a sugar cube. The small SWaP+C of these technologies will enable ubiquitous guidance and navigation on all platforms, including guided munitions, unmanned aerial vehicles (UAVs), and individual soldiers. The successful realization of Micro-PN&T requires the development of new microfabrication processes and novel material systems for fundamentally different sensing modalities, understanding of the error sources at the micro-scale, and development of micro-scale systems for sensors based on atomic physics techniques. Innovative 3-D microfabrication techniques under development will allow co-fabrication of dissimilar devices on a single chip, such that clocks, gyroscopes, accelerometers, and			

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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

E. Performance Metrics

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

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	55.494	74.744	79.860	-	79.860	83.198	97.496	107.594	114.417	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	189.909	239.078	243.265	-	243.265	227.402	216.559	237.068	228.998	-	-
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	-	11.442	-	-	-	-	-	-	-	-	-	-
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	-	104.901	152.913	135.633	-	135.633	141.332	204.559	225.068	220.998	-	-
CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*	-	16.833	10.120	2.707	-	2.707	-	-	-	-	-	-
CCC-06: *COMMAND, CONTRO AND COMMUNICATION SYSTEMS*	-	56.733	76.045	104.925	-	104.925	86.070	12.000	12.000	8.000	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*

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

Change Summary Explanation

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

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

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	-	11.442	-	-	-	-	-	-	-	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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

E. Performance Metrics

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

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	-	104.901	152.913	135.633	-	135.633	141.332	204.559	225.068	220.998	-	-

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

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Fixed Wireless at a Distance	8.189	15.500	3.000
Description: Unlike commercial wireless communications, the military cannot count on a set of secure, fixed cell towers to establish wireless networks capable of receiving and distributing large amounts of data from distributed sources. Rather, such communication must rely on approaches such as balloons and temporary communication towers that have a high logistical burden and are extremely vulnerable. Building upon technologies investigated under other High-Capacity Links technologies programs within this project, the Fixed Wireless at a Distance program will overcome these limitations by developing a re-locatable, long-range (10-100s of km) communication infrastructure that provides high-capacity (10s of megabits per second) data links from within a protected space. The key innovation in this program is the use of a large number of rapidly deployable, distributed, ground-based antenna arrays that can form a coherent aperture for directional transmission and reception of information to/from tactical wireless networks. Program challenges include the fundamental limits (power and extent) of transmitter gain as well as the rapid and practical deployment of the ground-based arrays. When completed, the Fixed Wireless at a Distance program will significantly extend the reach of tactical communication systems without the need for vulnerable and costly infrastructure. Technologies developed in this program will transition to the Navy and Air Force.			
FY 2013 Accomplishments: - Assessed the fundamental limits of transmitter gain for a distributed ground-based wireless network.			

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

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

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Build and evaluate the hardware and software capable of spatially multiplexing and de-multiplexing multiple mmW signals. - Evaluate mmW spatial multiplexing approaches to distances at or beyond the Rayleigh Range.			
Title: Mobile Hotspots	17.100	17.678	13.650
Description: Communications requirements are growing exponentially due to the proliferation of high-data rate sensors (full motion video), Unmanned Aerial Vehicles (UAVs), and the emergence of the Soldier/Marine as both an operator and a sensor within military networks. However, limited spectrum availability results in a large disparity between capacity requirement and availability. Supporting the development of Advanced Networks technologies, Mobile Hotspots will develop an airborne high capacity data distribution network to interconnect groups of tactical users in a manner that is conceptually similar to the commercial tiered approach of interconnecting cell towers and wireless hotspots. Mobile Hotspots will exploit advances in millimeter-wave technology and airborne networking to develop a self-organizing, 1 Gbps mobility tactical airborne network formed from highly-directional communications links to interconnect mounted and dismounted warfighters, dispersed tactical operations centers, and intelligence, surveillance, and reconnaissance (ISR) assets. Low size, weight, and power (SWaP) designs will be integrated with commercial and military communications equipment and mounted on tactical UAVs and ground vehicles to provide network access to mobile users via infrastructureless hotspots that are compatible with existing radios. The Mobile Hotspots program is targeted to transition to the Army and Marine Corps Expeditionary Forces. ***FY 2013 Accomplishments:*** - Explored steerable antenna concepts, self-organizing network protocols, and efficient power amplifier implementations in a network topology to include UAVs, dismounted soldiers, and mobile platforms. - Explored variable data rates, signal processing, and ad-hoc networking as a means to achieve range extensions in varying conditions. - Evaluated capabilities of critical technologies in ground-based laboratory and field evaluations. - Conducted system design trades for integration into a UAV pod and onto a tactical ground vehicle. ***FY 2014 Plans:*** - Manufacture antenna, amplifier, modem, and networking hardware needed to implement a self-organizing network comprising at least five hotspot nodes interconnected by 1 gigabit per second point-to-point millimeter-wave links to form a tactical airborne network. - Integrate the Mobile Hotspots technology into pods for mounting on UAVs and tactical ground vehicles. - Evaluate initial capabilities of the Mobile Hotspot prototype network and millimeter-wave tactical airborne network in an initial ground-based field experiment. - Identify and implement system and subsystem improvements in preparation for final field experimentation and flight tests. ***FY 2015 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Conduct ground testing of integrated air and ground vehicle systems to validate system operation and performance. - Conduct flight tests to evaluate system performance in various air-to-air, air-to-ground, and multi-node networking configurations.			
Title: Content-Based Mobile Edge Networking (CBMEN) ***Description:*** The CBMEN program's goal is to provide tactical warfighters operating at the edge with interactive, on-demand access to relevant information and a greater ability for real-time sharing of new operational content. This content can include images, video, maps, situational awareness, and command and control information. Advances in communications technologies are enabling high-capacity communications in remote environments. However, the current centralized or regional storage and dissemination of information presents reliability and capacity challenges with distributing relevant information to users at the edge. Commercial industry has developed approaches to the autonomous dissemination of high demand information by using distributed servers and advanced networking and information database technologies, combined with highly-reliable fixed networking infrastructure that have embedded complex information exploitation tools. The commercial system is enabled by infrastructure that is not available to the warfighter. This Advanced Networks technologies program will leverage commercial technologies to develop, prototype, and demonstrate the networking technologies and information dissemination techniques needed to enable efficient and robust content distribution using dynamic, mobile, and ad hoc military networks. CBMEN will be installed and demonstrated on existing radios. Capabilities from this effort will transition to the DoD. ***FY 2013 Accomplishments:*** - Developed extended small unit scenarios for simulation and demonstration. - Extended CBMEN software architecture for security and efficiency. - Integrated hardware and software products to demonstrate CBMEN technologies in small unit scenario. - Demonstrated limited content applications in a dynamic small unit mobile environment. ***FY 2014 Plans:*** - Develop objective metrics for advanced scenarios and simulation development for program evaluation and analysis. - Develop representative military small unit scenarios for simulations, over-the-air testing, demonstration, and transition. - Demonstrate CBMEN software for content naming, distribution, management, and security in a dynamic mobile environment. - Begin advanced development of CBMEN enabling technologies with increased scale, dynamics, and content rich applications.	19.732	13.510	-
Title: Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS) ***Description:*** The Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS) program goals are to develop and demonstrate Advanced Networks technologies and system concepts that will enable densely deployed radio networks to compensate for limitations of the physical layer of a low-cost wireless node. WNaN/AWNS networks will manage node configurations and the topology of the network to reduce the demands on the physical and link layers of the network. The	15.565	7.500	-

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
spectrum loss into a net gain of up to hundreds of MHz in capacity. Technology from this program will be made available to the DoD. ***FY 2014 Plans:*** - Develop concepts and management policies for enabling radars and communications networks to share spectrum spatially and temporally. - Develop models and simulation capability for research on spectrum sharing between radar and communications systems. - Assess the limits on achievable spectral reuse between radar and communications in order to evaluate sharing concepts and implementations. - Assess threats to military systems created by sharing spectrum information with non-military users. ***FY 2015 Plans:*** - Model and assess multiple mechanisms for spatial and temporal spectrum sharing between radars and communications networks. - Develop and assess a baseline set of strategies to defend military systems against threats created by sharing spectrum information between military radars and commercial communications systems. - Develop concepts for a control system to manage mechanisms for spectrum sharing between radars and communication systems. - Demonstrate technologies for signal separation between radar and communications systems operating at the same time, place, and frequency. - Develop concepts and approaches for a joint system design between military radar and military communications systems operating in a shared spectrum allocation that improves overall performance in electronic countermeasure operating environments.			
Title: Advanced RF Mapping ***Description:*** One of the key advantages on the battlefield is the ability to actively sense and manipulate the radio frequency (RF) environment, enabling reliable and assured communications, as well as effectively mapping and manipulating the adversary's communications in ways that defy their situational awareness, understanding, or response. Current approaches are emitter-based, with the signal processing techniques focused on array and time-based processing for each emitter. As the RF environment becomes more complex and cluttered, the number of collection assets and the required level of signal processing inhibits our capability to pervasively sense and manipulate at the precision (time, frequency, and space) required for effective action. To address these Radio Frequency and Spectral Sensing (RF/SS) challenges, the Advanced RF Mapping program will develop and demonstrate new concepts for sensing and manipulating the RF environment based on distributed rather than centralized collection. This approach will take advantage of the proliferation of RF devices, such as radios and cell phones, on the battlefield. To leverage these existing devices effectively, the program will develop new algorithms that can map the RF	10.300	19.500	17.762

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

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015

Description: Commercial Test and Measurement equipment has advanced greatly with the emergence of sophisticated cellular and wireless local area network technology and can be used to intercept, analyze, and exploit our military communications signals. The Computational Leverage Against Surveillance Systems (CLASS) program, working to expand Low Probability of Detection/Anti-Jam (LPD)/(AJ) technologies, seeks new ways to protect our signals from exploitation by increasingly sophisticated adversaries, in ways that can be maintained as commercial technology advances. Three different techniques are in development: 1) Waveform Complexity uses advanced communications waveforms that are difficult to recover without knowledge and understanding of the signals itself; 2) Spatial Diversity uses distributed communications devices and the communication environment to disguise and dynamically vary the apparent location of the signal; and 3) Interference Exploitation makes use of the clutter in the signal environment to make it difficult for an adversary to isolate a particular signal. The program's objective is to make modular communications technology that is inexpensive to incorporate in existing and emerging radio systems (<$100 incremental cost) but pushes adversaries to need more than 1,000x our processing power - supercomputer-level processing power. Another track of the program will extend the CLASS technology to provide LPD communications. These techniques will drastically reduce the detectability of communications signals beyond current capabilities. Scalable performance will allow LPD techniques to better trade information rate for communications capacity. Technologies from this program are planned to transition to the Services.

FY 2013 Accomplishments:
- Integrated hardware and firmware technology into volume integrated circuits.
- Developed test and application driver software for CLASS technology.
- Initiated development of modular CLASS products.
- Developed LDP signaling techniques.

FY 2014 Plans:
- Develop operational concepts for distributed airborne operations.
- Conduct RF transceiver studies for airborne operations.
- Finalize design of CLASS RF and modem integrated circuits; release to foundry for fabrication.
- Integrate application driver software for CLASS technology in preparation for Application Specific Integrated Circuits (ASIC) testing.
- Produce modular CLASS products and develop board for ASIC testing and a radio product module.
- Leverage advancements towards an alternative development environment for communications systems that takes advantage of commercial smartphone development environment methodology.
- Develop an alternative generalized reference architecture that supports communications system integration specifically, and that supports future revisions for other electronic systems anticipated in airborne force projection systems.

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

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

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

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

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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

E. Performance Metrics

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

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*	-	16.833	10.120	2.707	-	2.707	-	-	-	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

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

FY 2015 Plans:

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency												Date: March 2014
Appropriation/Budget Activity 0400 / 3					R-1 Program Element (Number/Name) PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*				Project (Number/Name) CCC-06 / *COMMAND, CONTRO AND COMMUNICATION SYSTEMS*			
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
CCC-06: *COMMAND, CONTRO AND COMMUNICATION SYSTEMS*	-	56.733	76.045	104.925	-	104.925	86.070	12.000	12.000	8.000	-	-

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

A. Mission Description and Budget Item Justification

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	2.760	-	-	-	-	-	-	-	-	-	-
CLP-01: *CLASSIFIED DARPA PROGRAMS*	-	2.760	-	-	-	-	-	-	-	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

Change Summary Explanation

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

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

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

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Details will be provided under separate cover.

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	221.490	259.006	386.926	-	386.926	390.744	356.083	318.096	294.181	-	-
NET-01: *JOINT WARFARE SYSTEMS*	-	69.610	36.745	63.144	-	63.144	82.067	94.266	134.741	150.029	-	-
NET-02: *MARITIME SYSTEMS*	-	41.464	50.853	80.882	-	80.882	100.877	117.817	140.355	144.152	-	-
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	110.416	171.408	242.900	-	242.900	207.800	144.000	43.000	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

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

Change Summary Explanation

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

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

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
NET-01: *JOINT WARFARE SYSTEMS*	-	69.610	36.745	63.144	-	63.144	82.067	94.266	134.741	150.029	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

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

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

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

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

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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

E. Performance Metrics

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

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
NET-02: *MARITIME SYSTEMS*	-	41.464	50.853	80.882	-	80.882	100.877	117.817	140.355	144.152	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

FY 2013 Accomplishments:

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

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

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

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

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

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

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

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-06 / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	110.416	171.408	242.900	-	242.900	207.800	144.000	43.000	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency											Date: March 2014	
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*							
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
Total Program Element	-	272.095	276.364	312.821	-	312.821	279.927	280.978	300.409	309.318	-	-
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	-	52.368	53.329	55.743	-	55.743	55.412	55.904	72.557	80.404	-	-
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	-	102.497	105.288	104.811	-	104.811	91.323	109.194	137.188	147.920	-	-
SEN-03: *EXPLOITATION SYSTEMS*	-	47.557	40.197	64.071	-	64.071	63.246	70.880	74.664	80.994	-	-
SEN-06: *SENSOR TECHNOLOGY*	-	69.673	77.550	88.196	-	88.196	69.946	45.000	16.000	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency					Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*		R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*			
B. Program Change Summary ($ in Millions)	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO**	**FY 2015 Total**
Previous President's Budget	299.438	286.364	276.749	-	276.749
Current President's Budget	272.095	276.364	312.821	-	312.821
Total Adjustments	-27.343	-10.000	36.072	-	36.072
• Congressional General Reductions	-0.389	-			
• Congressional Directed Reductions	-27.449	-10.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	8.146	-			
• SBIR/STTR Transfer	-7.651	-			
• TotalOtherAdjustments	-	-	36.072	-	36.072

Change Summary Explanation

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

FY 2014: Decrease reflects a reduction to eliminate program growth.

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

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	-	52.368	53.329	55.743	-	55.743	55.412	55.904	72.557	80.404	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Adaptable Navigation Systems (ANS)	14.802	15.991	15.982
Description: The Adaptable Navigation Systems (ANS) program will provide the U.S. warfighter with the ability to effectively navigate all environments including when Global Positioning System (GPS) is unavailable due to hostile action (jamming) or blockage by structures, foliage, or other environmental obstacles. The ANS approach relies on three major technology innovations. The first is development of a new type of inertial measurement unit (IMU) that requires fewer GPS position fixes. Using cold atom technology, this IMU exceeds the performance of strategic-grade IMUs, with comparable size, weight, and power (SWaP). The second innovation uses Signals of Opportunity (SoOp) from a variety of ground-, air-, and space-based sources, as well as natural SoOps to reduce dependency on GPS position fixes. These will be received on the Services' forthcoming software-defined radios and will use specially tailored algorithms to determine position. The third technology innovation allows SoOp-based position information to be combined with inertial and other sensors to enable flexible navigation systems that can be reconfigured in the field to support any platform or environment. This capability will enhance new advanced component technology for positioning, navigation, and timing (PNT) emerging from other programs in the form of Micro Electro-Mechanical System devices, clocks, and new aiding sensors. Recent advances in mathematics, data abstraction, and network architectures will build upon these capabilities by enabling "plug-and-play" integration of both existing and future navigation components and processing to allow real-time reconfiguration of navigation systems. If successful, major improvements in navigation accuracy and system cost could also be realized. Early transition partners would include all Services, with emphasis on platforms and users that must operate in multiple environments, such as Naval forces.			

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	-	102.497	105.288	104.811	-	104.811	91.323	109.194	137.188	147.920	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

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

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

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency									Date: March 2014			
Appropriation/Budget Activity 0400 / 3					R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*				Project (Number/Name) SEN-03 / *EXPLOITATION SYSTEMS*			
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
SEN-03: *EXPLOITATION SYSTEMS*	-	47.557	40.197	64.071	-	64.071	63.246	70.880	74.664	80.994	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

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

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency											Date: March 2014	
Appropriation/Budget Activity 0400 / 3					R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*				Project (Number/Name) SEN-06 / *SENSOR TECHNOLOGY*			
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
SEN-06: *SENSOR TECHNOLOGY*	-	69.673	77.550	88.196	-	88.196	69.946	45.000	16.000	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	70.839	-	-	-	-	-	-	-	-	-	-
SB-01: *SMALL BUSINESS INNOVATION RESEARCH*	-	70.839	-	-	-	-	-	-	-	-	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

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

A. Mission Description and Budget Item Justification

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

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

Change Summary Explanation

FY 2013: Increase reflects SBIR/STTR transfer.

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

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

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

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Not applicable.

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

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	64.248	71.659	71.362	-	71.362	72.390	74.068	77.712	79.711	-	-
MH-01: *MANAGEMENT HQ - R&D*	-	64.248	71.659	71.362	-	71.362	72.390	74.068	77.712	79.711	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

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

A. Mission Description and Budget Item Justification

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

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

Change Summary Explanation

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

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

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

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

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0305103E / *CYBER SECURITY INITIATIVE*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	1.961	-	-	-	-	-	-	-	-	-	-
CYB-01: *CYBER SECURITY INITIATIVE*	-	1.961	-	-	-	-	-	-	-	-	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

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

A. Mission Description and Budget Item Justification

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

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

Change Summary Explanation

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0305103E / *CYBER SECURITY INITIATIVE*

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

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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