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

APPROPRIATION/BUDGET ACTIVITY				R-1 ITEM NOMENCLATURE							
0400: <i>Research, Development, Test & Evaluation, Defense-Wide</i> BA 2: <i>Applied Research</i>				PE 0602715E: <i>MATERIALS AND BIOLOGICAL TECHNOLOGY</i>							
COST (\$ in Millions)	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total	FY 2013	FY 2014	FY 2015	FY 2016	Cost To Complete	Total Cost
Total Program Element	255.807	312.586	237.837	-	237.837	253.396	290.881	312.941	299.092	Continuing	Continuing
MBT-01: <i>MATERIALS PROCESSING TECHNOLOGY</i>	148.728	184.614	104.538	-	104.538	108.573	114.347	122.543	118.243	Continuing	Continuing
MBT-02: <i>BIOLOGICALLY BASED MATERIALS AND DEVICES</i>	107.079	127.972	35.499	-	35.499	46.023	40.534	58.122	62.849	Continuing	Continuing
MBT-03: <i>TACTICAL AND STRATEGIC ENERGY TECHNOLOGY</i>	-	-	97.800	-	97.800	98.800	136.000	132.276	118.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

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

The Tactical and Strategic Energy Technology project is focused on the unique challenges facing the DoD in developing and demonstrating advanced power generation and energy storage technologies. It will address critical military needs for improved energy efficiency and availability to support a range of military missions that include individual warfighter and small unit operations, large platform operations, and sustainment of forward operating bases. At the individual warfighter and small unit operations level, efforts are addressing the need for mission extending power generation and energy storage technologies with particular emphasis on portability and robustness challenges that are unique to the DoD. At the large platform and forward operations scale, efforts are addressing needs for deployable energy storage and more efficient power generation and distribution technologies. As electronic systems are common to all scales of power generation and energy

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storage and management, this project also investigates improved board-level power conversion and regulation strategies to more efficiently convert and distribute high voltages to locally required low voltages for powering integrated circuits and sensors.

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

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

Project: MBT-01: *MATERIALS PROCESSING TECHNOLOGY*

Congressional Add: *Strategic Materials*

Congressional Add: *Photovoltaic Ribbon Solar Cell Technology Project*

Congressional Add Subtotals for Project: MBT-01

Congressional Add Totals for all Projects

FY 2010	FY 2011
5.000	-
2.880	-
7.880	-
7.880	-

Change Summary Explanation

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

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

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0400: <i>Research, Development, Test & Evaluation, Defense-Wide</i> BA 2: <i>Applied Research</i>				PE 0602715E: <i>MATERIALS AND BIOLOGICAL TECHNOLOGY</i>				MBT-01: <i>MATERIALS PROCESSING TECHNOLOGY</i>			
COST (\$ in Millions)	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total	FY 2013	FY 2014	FY 2015	FY 2016	Cost To Complete	Total Cost
MBT-01: <i>MATERIALS PROCESSING TECHNOLOGY</i>	148.728	184.614	104.538	-	104.538	108.573	114.347	122.543	118.243	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

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

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

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

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

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

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

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

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

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

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

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Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency		DATE: February 2011	
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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2010	FY 2011
<i>FY 2010 Accomplishments:</i> - Achieved an energy density of 250 Wh/L for a 1 cubic millimeter battery and demonstrated progress towards reliable sealing approach for the all metal-ceramic packaging. - Explored the light acquisition, energy capture, and carrier extraction aspects of portable photovoltaic (PV) devices to identify the most advantageous breakthroughs to exploit these devices. - Explored the robust and durable portability and flexibility aspects of portable PV devices to identify most advantageous breakthroughs to exploit these devices. <i>FY 2011 Plans:</i> - Create new portable PV technologies that function at greater than or equal to 16 percent power conversion efficiency (under AM1.5 illumination at one sun) in a form factor amenable to flexible substrates. - Develop new portable PV technologies that allow for low-cost manufacturing at \$3.75 per Watt. - Develop new portable PV technologies that allow for backpack portable PV devices. <i>FY 2012 Plans:</i> - Design portable PV devices that function at greater than or equal to 20 percent power conversion efficiency (under AM1.5 illumination at one sun) and have a minimum radius of curvature of 3 cm. - Design PV devices that are lightweight and man-portable, defined as a density less than or equal to 1500 grams per square meter. - Design portable PV devices that produce at least 80 percent of their specified electrical output after one year duration and after exposure to environmental hazards such as punctures, humidity, temperature extremes, rain, and dust.			
<i>Title:</i> Functional Materials and Devices <i>Description:</i> The Functional Materials and Devices thrust will address problems with high performance functional materials development. Functional materials deployed for applications are most often bulk structures and performance is limited to those properties found in nature. Improved materials require deliberate control at the scale of the relevant phenomena (electron transport, phonon transport, etc.). This thrust will leverage the advanced fabrication capabilities currently available, coupled with design of material and structure, to drive functional materials to high performance for DoD applications by design. Thermoelectric materials for cooling and power generation, and IR emissive materials are examples of near-term materials in which design of structure at the scale of the critical phenomena can have significant impact on their performance. To eliminate the ISR capability gap that currently exists at the soldier-scale, capability will be developed to provide high space/time resolution (mm/ms) throughout the soldier-scale 4 sphere of influence (km/min) by developing task-specific functionality (e.g. hands-free zoom, automated brightness adjustment, threat detection, targeting assistance, change detection, supplementary data overlay, etc.).		3.500	8.000
		7.000	

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

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

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

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

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

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

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2010	FY 2011
- Demonstrated the ability to use JP-8 jet fuel as a source to generate electricity in fuel cells through the use of new catalysts and new fuel cell architectures. - Continued catalyst development and demonstrated a 60 percent carbon yield for converting cellulosic biomass into synthetic fuel components with eight carbons or more.			
Accomplishments/Planned Programs Subtotals		140.848	184.614
		FY 2010	FY 2011
Congressional Add: Strategic Materials		5.000	-
FY 2010 Accomplishments: - Developed a state-of-the-art production process for silicon carbide parts for satellite, high-energy laser, and nuclear applications.			
- Produced a laser mirror that has very low distortion characteristics to enable precision navigation devices.			
- Identified transition opportunities with the Missile Defense Agency.			
Congressional Add: Photovoltaic Ribbon Solar Cell Technology Project		2.880	-
FY 2010 Accomplishments: - Conducted research into photovoltaic ribbon solar cell technology.			
Congressional Adds Subtotals		7.880	-
C. Other Program Funding Summary (\$ in Millions)			
N/A			
D. Acquisition Strategy			
N/A			
E. Performance Metrics			
Specific programmatic performance metrics are listed above in the program accomplishments and plans section.			

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Exhibit R-2A, RDT&E Project Justification: PB 2012 Defense Advanced Research Projects Agency **DATE:** February 2011

APPROPRIATION/BUDGET ACTIVITY				R-1 ITEM NOMENCLATURE				PROJECT			
0400: <i>Research, Development, Test & Evaluation, Defense-Wide</i> BA 2: <i>Applied Research</i>				PE 0602715E: <i>MATERIALS AND BIOLOGICAL TECHNOLOGY</i>				MBT-02: <i>BIOLOGICALLY BASED MATERIALS AND DEVICES</i>			
COST (\$ in Millions)	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total	FY 2013	FY 2014	FY 2015	FY 2016	Cost To Complete	Total Cost
MBT-02: <i>BIOLOGICALLY BASED MATERIALS AND DEVICES</i>	107.079	127.972	35.499	-	35.499	46.023	40.534	58.122	62.849	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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E. Performance Metrics

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

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APPROPRIATION/BUDGET ACTIVITY				R-1 ITEM NOMENCLATURE				PROJECT			
0400: <i>Research, Development, Test & Evaluation, Defense-Wide</i> BA 2: <i>Applied Research</i>				PE 0602715E: <i>MATERIALS AND BIOLOGICAL TECHNOLOGY</i>				MBT-03: <i>TACTICAL AND STRATEGIC ENERGY TECHNOLOGY</i>			
COST (\$ in Millions)	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total	FY 2013	FY 2014	FY 2015	FY 2016	Cost To Complete	Total Cost
MBT-03: <i>TACTICAL AND STRATEGIC ENERGY TECHNOLOGY</i>	-	-	97.800	-	97.800	98.800	136.000	132.276	118.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

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

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

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APPROPRIATION/BUDGET ACTIVITY 0400: <i>Research, Development, Test & Evaluation, Defense-Wide</i> BA 2: <i>Applied Research</i>		R-1 ITEM NOMENCLATURE PE 0602715E: <i>MATERIALS AND BIOLOGICAL TECHNOLOGY</i>		PROJECT MBT-03: <i>TACTICAL AND STRATEGIC ENERGY TECHNOLOGY</i>	
B. Accomplishments/Planned Programs (\$ in Millions)			FY 2010	FY 2011	FY 2012
technologies for resource distribution can be developed for use in military forward operations. These efforts will contribute to improved overall energy efficiency and reduced logistics demands associated with fuel transport to forward operating bases. This thrust will investigate technologies that reduce the dependence on traditional fuel sources and delivery methods, and increase fuel-efficiency to provide more flexibility to military assets in the field. Energy management modeling and design will be utilized to assess host-country resources (e.g. heating fuels, locally-grown biomass, unrefined fuels, waste, and other hydrocarbon rich materials), and advanced power generation technologies (e.g. fuel cells, renewable solar, wind, biofuels, etc.). FY 2012 Plans: - Using data collected from current operations worldwide, construct a baseline modeling tool that depicts how energy is currently generated and distributed in existing military forward operating bases. - Identify emerging smart grid and other energy management tools that may be adapted to a military forward operating environment. - Identify key technology gaps currently precluding the deployment of energy distribution and management systems that can optimally match load with capacity while increasing overall energy efficiency of a forward operating base. - Identify emerging electrochemical and/or electrothermal storage technologies that may facilitate the efficient redistribution of energy resources, including renewable sources such as wind and solar, in a military forward operating environment. - Identify opportunities to leverage host country resources provide feedstocks for on-site generation of fuel and power. - Further develop the energy management modeling tool to incorporate knowledge of indigenous resources, advances in power generation (including renewable - solar, wind, geothermal, etc.), and advances in energy distribution technologies.					
Title: Extreme Environment Energy Program (EEE) Description: Advanced DoD platforms and missions increasingly demand energy generation, storage, and conversion technologies that can function reliably in extreme environments. Adverse conditions to be managed include, for example, optical and ionizing radiation, extremes of temperature, chemical damage, and harsh mechanical loading. Also of interest are energy generation in anaerobic environments, and the development of materials that enable high temperature power generation processes. In addition, environmentally robust energy sources such as existing primary (disposable) batteries can be improved to considerably improve efficiency and make them adaptable to a wide variety of target systems. Another aspect of this program is to adapt advanced wavelength-splitting photovoltaic cells to high altitude and space environments. The overall focus of this program is on developing technologies that significantly improve robustness and adaptability of energy sources for a variety of mission locations and durations. FY 2012 Plans:			-	-	5.000

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

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

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

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

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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