Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	238.172	270.207	312.586	0.000	312.586	254.218	273.710	279.524	292.860	Continuing	Continuing
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	117.721	141.362	175.586	0.000	175.586	134.218	153.710	159.524	172.860	Continuing	Continuing
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	120.451	128.845	137.000	0.000	137.000	120.000	120.000	120.000	120.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technologies related to those materials and biological systems that make possible a wide range of new military capabilities.

(U) The major goal of the Materials Processing Technology project is to develop novel materials, materials processing techniques, mathematical models, and fabrication strategies for advanced structural and functional materials and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of materials including: structural materials and devices, smart materials and actuators, functional materials and devices, and materials that are enabling for improvements in logistics.

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

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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	282.896	268.859	0.000	0.000	0.000
Current President's Budget	238.172	270.207	312.586	0.000	312.586
Total Adjustments	-44.724	1.348	312.586	0.000	312.586
• Congressional General Reductions		-1.132			
• Congressional Directed Reductions		-7.000			
• Congressional Rescissions	-8.776	0.000			
• Congressional Adds		9.480			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-28.000	0.000			
• SBIR/STTR Transfer	-7.948	0.000			
• TotalOtherAdjustments	0.000	0.000	312.586	0.000	312.586

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2009	FY 2010
Project: MBT-01: *MATERIALS PROCESSING TECHNOLOGY*		
Congressional Add: *Strategic Materials*	4.400	5.000
Congressional Add: *Synthetic Fuel Innovation*	4.000	0.000
Congressional Add: *Center for Nonproliferation Studies, Monterey Institute for International Affairs*	0.000	1.600
Congressional Add: *Photovoltaic Ribbon Solar Cell Technology Project*	0.000	2.880
Congressional Add Subtotals for Project: MBT-01	8.400	9.480
Congressional Add Totals for all Projects	8.400	9.480

Change Summary Explanation

FY 2009

Decrease reflects Omnibus Reprogramming action for the H1N1 vaccine development, Section 8042 rescission of the FY 2010 Appropriations Act, internal below threshold reprogramming and SBIR/STTR transfer.

FY 2010

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Increase reflects the congressional adds (as identified above) offset by reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts.

FY 2011

Not Applicable

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	117.721	141.362	175.586	0.000	175.586	134.218	153.710	159.524	172.860	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The major goal of the Materials Processing Technology project is to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of materials including: structural materials and devices, functional materials and devices, and materials that are enabling improvements in logistics.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Materials Processing and Manufacturing	11.466	13.300	18.100	0.000	18.100

(U) The Materials Processing and Manufacturing thrust is exploring new manufacturing and processing approaches that will dramatically lower the cost and decrease the time it takes for DoD systems to be fabricated. It will also develop approaches that yield new materials and materials capabilities that cannot be made through conventional processing approaches. Included are disruptive manufacturing approaches for raw materials and components.

FY 2009 Accomplishments:

- Expanded advanced carbon fiber manufacturing techniques from research line to pilot production line while maintaining properties that are in excess of 500 Kilos per square inch in strength, and 42 million pounds per square inch in modulus.
- Made over 180,000 ft of nanotube enhanced carbon fiber for testing and evaluation.
- Demonstrated ability to use fiber as woven mat in pre-preg for composite structures.
- Demonstrated economical tooling for low volume production of polymer matrix composite (PMC) (10-25 units of a hat stiffened plate) that operates at less than 200 degrees Celsius cure temperature.

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Verified PMC subcomponent (containing critical details) meets static, fatigue, and destructive evaluations. - Demonstrated a technology readiness level of four on full-size manufacturing of non-autoclave PMCs. *FY 2010 Plans:* - Demonstrate ability to control defect type, size, and concentration to optimize carbon fiber properties. - Start evaluation and testing by Air Force Composites Testing Lab to establish first generation advanced carbon fiber insertion points within Air Force (AF) systems. - 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 induced by post-processing neutron irradiation, covalent element (B, N, P, S, etc.) doping, and/or high-strength magnetic field graphene plane alignment. - Transition non-autoclave tooling and materials/processes to large-scale PMC fabricators. - Produce functional, integrally cored molds suitable for turbine foil casting trials at commercial foundry. - Demonstrate capability of out-of-the-autoclave PMC curing 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. - Expand the application of manufacturable 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. *FY 2011 Base Plans:* - Demonstrate microstructure/property/process relationship needed for overcoming critical defect limitations in carbon fiber performance for structural applications.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate ability to control defect type, size, and concentration to optimize carbon fiber properties. - Demonstrate successful casting of superalloy turbine blades using ceramic molds made or produced via direct digital manufacturing. - Produce and orient seed crystals in a robust and scalable manner for use in solid state self assembly of single crystals. - Control grain growth during single crystal self assembly to produce single crystals without trapped porosity and low dislocation densities. - Demonstrate GRIN lenses in imaging and non-imaging applications such as a high-resolution imager for a micro-UAV and solid state-tracking solar concentrator, and demonstrate the manufacture of custom lenses in single and high volume lots.					
Structural Materials and Coatings	8.791	15.498	16.452	0.000	16.452
(U) 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 2009 Accomplishments:* - Completed flow model for 500 pounds per day reactor. - Created energy blueprints for 500 pounds per day prototype reactor. - Verified titanium costs are less than four dollars per pound. - Produced solid and hollow sets of aluminum (Al) based amorphous turbine engine fan blades that meet all dimensional and mechanical property requirements. - Constructed structural unitized multifunctional calcium (Ca) based amorphous metal hybrid panel to validate performance of thermal management and load carrying capability over the temperature range of minus 200 to plus 200 degrees Fahrenheit.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrated reproducible, corrosion-resistant, wear-resistant, and impact-resistant naval advanced amorphous coatings for corrosion prevention and non-skid applications. - Finalized preparations for applications of naval advanced amorphous coatings in small-scale demonstrations on naval combatants. - Initiated development of regenerative skin to prevent biofouling based upon continuous water activated film formation/dissolution concept. - Established initial conditions necessary to tailor formation and dissolution of the anti-biofouling skin, and these conditioned effects on rheological and mechanical properties. *FY 2010 Plans:* - Demonstrate commercially pure titanium from oxide at a production rate of 500 pounds per day. - Quantify structural amorphous metal performance and specific fuel consumption attributes for both military and commercial engines. - Demonstrate coatings of structural hybrid amorphous metal fan blades that successfully meet galling and environmental requirements. - Identify multiphase composite materials suitable for use at high temperatures. - Determine composite material volume fraction, distribution and morphology to obtain optimum structural properties including compressive strength, damage tolerance and environmental resilience. - Identify 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. - Begin 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). - Initiate 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 Computational Hydro-acoustic (CHA) models).					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Demonstrate meltless titanium consolidation. - Plan for space launch of structural amorphous composite hybrid panels. - Demonstrate mechanical properties of unreinforced and reinforced multiphase polymers. - Establish structural properties of composite materials as a function of temperature. - Establish damage tolerance following subsonic and supersonic foreign object impact. - 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 and initiate verification of the coupling software environment including the hybrid multi-material rotor (HMMR) model/domain code coupling.					
Multifunctional Materials and Structures (U) 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.).	10.810	13.200	25.416	0.000	25.416

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Demonstrated robust adherence of glass coating and textured polymer in order to produce superhydrophobic surfaces on various substrates. - Increased carbon nanotube (CNT) cold cathode performance to 120 milliampere per centimeter squared, and demonstrated ability to grow multi-wall nanotubes decorated with gallium nitride (GaN), ruthenium oxide (RuO2), boron (B), and titanium nitride (TiN) for increased field emission properties. - Demonstrated reduced scattering and losses due to perturbations and damage that might occur on surface wave controlling and power transmitting media. - Initiated the design of new membranes and technologies for particle separation to reduce the clogging and fouling of desalination systems. - Decreased state-of-the-art (SOA) response time for electrochemical double layer capacitor by a factor of 1000 (SOA was approximately 10 milliseconds; tested capacitor responded in approximately 20 microseconds). *FY 2010 Plans:* - Demonstrate ability to multiplex surface waves and power transmission onboard spacecraft. - Demonstrate ability to surface harden appropriate naval alloys and geometries for propulsion systems in large scale. - Finalize the design of new membranes and technologies for particle separation to reduce the clogging and fouling of desalination systems. - Design novel membranes and technologies for removing dissolved salts and contaminants from seawater. - Demonstrate 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.). - Develop a wide range 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.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Demonstrate ability to reconfigure hardware systems on surface wave control and power transmission materials. - Qualify carburized materials for unlimited naval use. - Design new membranes with high flux transport properties that are robust enough to double the lifetime over current membranes. - Demonstrate a portable seawater desalination system that provides thirty gallons per hour (gph) potable output from seawater using novel membranes and technologies while requiring significantly less energy and maintenance than current military systems. - Design novel membranes and technologies that will desalinate seawater at seventy five gph with twice the lifetime of existing desalination systems. - Proof of concept demonstrating feasibility of local control of chemistry for synthesis of customizable and adaptive surfaces and thin films with superior mechanical, electrical, optical, functional, etc. properties (example: diamond on temperature-sensitive surfaces such as polymers). - Demonstrate local control of chemistry for synthesis of customizable and adaptive surfaces and thin films with superior mechanical, electrical, optical, functional, etc. properties (example: diamond on temperature-sensitive surfaces such as polymers). - Prototype a hybrid energy storage system to maximize run time of DoD portable electronics through more efficient extraction of electrical energy from portable energy storage systems (batteries, fuel cells, etc.). - Engage DoD customers and commercialization partners for hybrid energy storage. - Develop new coatings, surface treatments, and multifunctional structures to extend lifetime and/or increase performance of materials (friction and wear, corrosion resistance, environmental capability, etc.) in critical DoD applications. - 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.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiate the design of a structural sub-assembly that incorporates 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.					
Materials for Force Protection	6.771	15.200	16.020	0.000	16.020
(U) 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 2009 Accomplishments: - Continued to develop lightweight armor systems to mitigate and defeat evolving threats, including EFPs. - Evaluated selected topological armor concepts for protection against multiple threats. - Demonstrated continued enhancement to transparent armor against fragmentation and armor piercing threats. - Integrated high performance armor systems with enhanced protection against evolving threats, including EFPs, into vehicle platforms in collaboration with the U.S. Army and Marine Corps. - Demonstrated performance of lightweight armor against explosively formed projectile threats.					
FY 2010 Plans: - Demonstrate production capability of index-matched fiber for transparent armor applications. - Develop glass/ceramic formulation and processing technologies to enable multi-hit performance of transparent armor equivalent to that of opaque armor. - Evaluate the effectiveness of high-strength materials with respect to stiffness, shock isolation, and energy absorption to establish the basis for improved armor performance against blast and fragment penetration to vehicle underbodies.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Identify the most effective topological features for energy absorption and apply to optimize armor performance at a minimum system areal density against blast and fragment penetration to vehicle underbodies. *FY 2011 Base Plans:* - Demonstrate multi-hit performance of transparent armor equivalent to that of opaque armor. - Optimize the most promising composite designs and evaluate effectiveness for improved armor performance against blast and fragment penetration to vehicle underbodies with full-scale testing. - Develop a lightweight electromagnetic configuration that is powered by capturing kinetic energy from threat projectiles. - Through capturing kinetic energy, develop the capability to rapidly amplify power through magnetic flux compression by at least two orders of magnitude. - Initiate development of multi-functional material systems for vehicles that incorporate functionalities such as embedded antennas, sensors, and/or energy storage into vehicle structural and armor subsystems. - Develop new 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 to desired geometries.					
Prognosis (U) 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.	3.000	3.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Completed and provided a functional engine system prognosis (ESP) system applicable to the legacy (F100/F110) fleets that incorporates all physics-and data-driven models, exploits the available sensor packages, and incorporates all local and supervisory reasoners interfaced to the aircraft Digital Enhanced Engine Controller (DEEC)/Modern Digital Engine Controller (MDEC) for Oklahoma City Air Logistics Center (OC-ALC). - Transitioned to Original Equipment Manufacturers for incorporation in their engine designed and support tools. - Demonstrated ESP system on the T700 helicopter engines with specific objective of real time “power available” notification to the pilot. *FY 2010 Plans:* - Develop data mining tools for extracting key parameters from actual flight data and feed into damage models. - Evaluate P3 flight data and test Prognosis systems versus legacy method. - Demonstrate the capability to predict the performance, life, and reliability of the full P3 weapons system. - Identify rapid methods to optimize, qualify, and implement technologies into weapon systems of new materials. - Initiate study on damage accumulation mechanisms in composite structures. *FY 2011 Base Plans:* - Identify and validate damage models to metals other than aluminum and organic matrix components based on flight spectrum loading. - Establish probability of detection/probability of false alarm for applicable sensor suite. - Exploit the life-limiting, extreme-value probabilistic behavior of materials, structures, and processes in propulsion and aircraft systems.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Define protocol for global-local sensing technology and integration at a full systems level with state health information sufficient to prevent all future Class-A events and major aircraft down-time while assuring required combat capability. - Investigate processes and technologies for rapid certification and qualification of materials and structures that lead to reduced time to implementation. - Establish models that provide an adaptive tool that provides a “virtual twin” so that mission scenarios can be exercised and damage predicted.					
Materials for Initiation and Actuation	8.000	6.088	5.230	0.000	5.230
(U) The Materials for Initiation and Actuation program explores and develops materials for initiation and propagation of mechanical and/or chemical effects. Included efforts are bio-inspired 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 2009 Accomplishments:* - Refined chemical communications systems to achieve 100-fold increase in transmission duration. - Demonstrated breadboard chemical communications devices consisting of a disposable transmitter and a replicator device that translate messages into chemistry. - Completed laboratory demonstration of flame suppression/manipulation using electric and acoustic fields. - Conducted rotor stand test of fully actuated one-third scale prop rotor to demonstrate blade synchronization and lift improvement. - Experimentally evaluated combustion driven nastic materials actuator for innovative acoustic applications. - Initiated design of material composites that are both high density and highly energetic. - Initiated development of processing methods to increase strength of dense reactive metal composite materials.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Continue fundamental fire suppression investigations to understand scaling behavior and to determine best approaches for large scale system. - Perform fire suppression demonstration on a class A/B fire approximately 1 square meter in size. - Demonstrate the ability to achieve high density, high enthalpic energy, and high strength in the same material composite. - Demonstrate the ability to control particle size upon initiation and decomposition of reactive material. - Demonstrate the ability to ignite and combust reactive particles upon initiation and dispersion. - Develop integrated array sub-system of nastic materials acoustic sources and conduct experimental characterization of the array sub-system. - Complete preliminary design of acoustic demonstration system. *FY 2011 Base Plans:* - Demonstrate both structural and energetic function in a single material composite and the ability to produce multiple samples with specified properties in sizes greater that one half pound. - Demonstrate ability to command 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.					
Reconfigurable Structures (U) In the Reconfigurable Structures thrust, new combinations of advanced materials, devices, and structural architectures are being developed to allow military platforms to morph or change shape 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.	8.112	9.646	9.770	0.000	9.770

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Engineered soft components from the soft chemically-based materials that enable locomotion and size/shape morphing. - Engineered materials and soft components into robotic architecture with the ability to locomote, traverse openings smaller than the characteristic dimension of the robot, and reconstitute size/shape. - Designed, refined, and finalized reattachable pads (magnets and microspines) for hands and feet based upon results of biomechanical analysis and human climbing trials. - Demonstrated an unloaded soldier (150 lb) using reattachable pads (magnets and microspines) to scale a series of twenty-five foot walls built from mission-relevant materials. *FY 2010 Plans:* - Perform laboratory testing of engineered soft material robot operations and optimize design. - Perform laboratory demonstrations of robot function. - Develop engineering model for soft robots, and design prototype robots for selected applications. - Develop prototype robots for selected applications. - Demonstrate a fully loaded soldier (300 lb) wearing reattachable pads (magnetic and microspines) scaling a series of twenty-five foot walls built from mission- relevant materials using Z-MAN technology. - Demonstrate an unloaded soldier (150 lb) using reattachable pads (gecko nanoadhesives) to scale a series of twenty-five foot walls built from mission-relevant materials. *FY 2011 Base 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. - Perform field testing of prototype robots and transition to end user. - Demonstrate a fully loaded soldier (300 lb) using reattachable pads (gecko nanoadhesives) to scale a series of twenty-five foot walls built from mission-relevant materials.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Transition Z-MAN prototype technologies to military services.					
Functional Materials and Devices	4.871	5.000	7.500	0.000	7.500
(U) The goal of this thrust is to design material microstructures at the scale appropriate to exploit fundamental interactions with the environment in order to create materials with unique properties. Examples include nanostructured materials to slow light, negative refractive index systems, sensors that will enable room temperature sensitivity not currently available, and an array of other functional devices (antennas, dosimeters, etc.). *FY 2009 Accomplishments:* - Demonstrated a low loss, negative index enabled optical modulator with reduced size and increased speed for military communications. - Demonstrated a sub wavelength UHF antenna with enhanced efficiency for military radar and communication applications. - Demonstrated reconfigurable optical data buffer with tunable delay for 40 gigabits per second data packet of up to 500 nano-second with 25 pico-second reconfiguration time. - Devised slow light-based techniques for processing optical data headers. - Began synthesis of medium-wave infrared colloidal quantum dots. - Demonstrated nitrate detection ink. - Demonstrated peroxide detection ink. *FY 2010 Plans:* - Design broadband, frequency comb spectroscopy system with sensitivity better than ten parts per billion acetylene at 1.5 microns. - Evaluate performance improvements from, and system configuration changes needed to, shift comb central wavelength from 1.5 microns to 3 microns. - Demonstrate structural control methodology application to superconducting materials. - Demonstrate multiphoton excitation at short-wave infrared wavelengths.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Demonstrate significant improvements in thermoelectric materials' figure of merit at cryogenic temperature ranges (100K-200K) for solid state refrigeration. - Demonstrate improved efficiency of infrared emitting materials. - Demonstrate modeling capabilities capable of predicting material performance. - Construct compact broadband, multipass optical cavity to enable signal multiplication at final system wavelength. - Design and construct compact broadband heterodyne detection system. - Demonstrate the detection system's spectral sensitivity better than 500 parts per trillion of acetylene in atmospheric pressure air in less than one minute.					
Power Components (U) 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 new permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors and generators, as well as high energy density capacitors. Radically new thermal electric 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. Materials technology is also being developed to enhance power conditioning for large power applications such as Navy ships. *FY 2009 Accomplishments:* - Initiated scale-up from benchtop to an industrial manufacturer a capacitor that achieves 20 joules per cubic centimeter (J/cc) energy density and 100 joules (J) of energy. - Synthesized and electrochemically tested nanostructured and nanoparticulate lithium-based materials for use as the cathode material in an all solid-state battery.	6.000	8.700	8.650	0.000	8.650

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrated performance of thermoelectric materials optimized for use at specific temperature ranges. - Improved deposition techniques for thermoelectric materials resulting in 4 times greater figure of merit than previous results. - Engineered thermo-tunneling device structure for patterned gap supports and reduced die dimensions. *FY 2010 Plans:* - Integrate nanostructured thermoelectric materials into effective structure for military use. - Integrate nanostructured magnetic materials with high energy product into military motor. - Integrate nanostructured electrochemical materials with high energy and power densities into military battery supplies for the field. - Demonstrate packaged capacitors with 20 J/cc energy density and 100 J of energy. - Demonstrate nanogap thermo-tunneling device with an efficiency greater than 8 percent at a temperature difference of 200 degrees Celsius. *FY 2011 Base 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. - Integrate the 20 J/cc dielectrics into capacitors with sensing capabilities and fault tolerance to provide reliable high power capacitors of 20 J/cc and 400 J. - Begin to transition high energy dense capacitor technology to Air Force for improved weapons capabilities. - Demonstrate nanogap thermo-tunneling device with efficiency greater than 16 percent at a temperature difference of 350 degrees Celsius.					
Novel Power Sources	4.000	6.050	3.000	0.000	3.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Novel Power Sources thrust will explore new materials solutions that enable power to be efficiently generated and controlled. The primary focus is 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. This thrust will also investigate technologies for tactical energy harvesting and/or generation. *FY 2009 Accomplishments:* - Developed extruded membrane within existing solid oxide fuel cell architecture to operate using JP-8 fuel. - Developed surface catalysts for cogeneration of carbon dioxide and hydrogen powered by sunlight. - Developed design strategies using catalysts for reducing carbon dioxide with sunlight, using JP-8 as fuel for fuel cells, and converting cellulosic biomass into an appropriate JP-8 precursor. *FY 2010 Plans:* - Continue catalyst development and initiate testing of catalysts powered by sunlight for reducing carbon dioxide and water into syngas (carbon monoxide and hydrogen). - Continue catalyst development and initiate testing of catalysts capable of quickly and efficiently converting cellulosic biomass into a synthetic fuel with eight carbons or more. - Identify and characterize new catalysts for highly efficient alternative energy systems including fuel cells, biomass conversion systems, and solar fuel systems. *FY 2011 Base Plans:* - Develop conceptual designs for revolutionary technologies for the portable harvesting and/or generation of energy at the tactical level. - Investigate physics of alternative wind energy extraction approaches.					
Very High Efficiency Solar Cell (VHESC)	20.129	4.800	2.000	0.000	2.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) 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 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 to reduce the considerable logistical burden of supplying energy (e.g., batteries and fuel) to the warfighter in the field. (U) 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 and 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. Future program phases will address both the technology development and manufacturing concept and engineering development necessary for the effective implementation of the VHESC technology in an affordable product. The key focus areas of future phases will be: 1) the system-integrated design optimization of the non-imaging lateral optics subsystem and the corresponding PV devices and 2) the development of high-volume cost-effective manufacturing engineering designs and processes for the subsequent future transition to affordable production. *FY 2009 Accomplishments:* - Designed, built, and tested VHESC engineering prototype modules addressing the program goals.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Developed technologies to reduce the costs of the PV cells and optical components. *FY 2010 Plans:* - Deliver an initial integrated prototype. - Conduct demonstration necessary for the effective implementation of the VHESC technology in an affordable product. *FY 2011 Base Plans:* - Evaluate further development and improvements in solar cell technology for future DoD applications.					
Alternate Power Sources (U) The Alternate Power Sources thrust aims to develop materials and technologies to utilize alternative power sources that have 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 with 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. This thrust also looks at alternative portable energy storage and/or power distribution and control technologies. *FY 2009 Accomplishments:* - Further improved polymer/ceramic composite sealing and photovoltaic performance in thin film packaged batteries that possess energy densities greater than 200 watt hours per liter (Wh/L) in a volume of less than 1 cubic millimeter. - Developed packaging protocol to produce large arrays of electrochemically inert, gold packaged lithium ion microbatteries.	2.500	7.500	15.500	0.000	15.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Increase the reliability and manufacturing yield of packaged batteries with energy densities greater than 350 Wh/L in a volume less than 1 cubic millimeter. - Explore the light acquisition, energy capture, and carrier extraction aspects of portable photovoltaic (PV) devices to identify most advantageous breakthroughs to exploit these devices. - Explore the robust and durable portability, and flexibility aspects of portable PV devices to identify most advantageous breakthroughs to exploit these devices. - Develop conceptual designs for revolutionary technologies for portable energy storage and/or power distribution and control technologies at the tactical level. *FY 2011 Base Plans:* - Create new portable photovoltaic (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. - Develop new portable PV technologies that allow for backpack portable PV devices. - Establish proof-of-concept for tactical energy storage and/or power distribution and control technologies. - Initiate development of tactical energy generating storage and/or power distribution and control technology prototypes.					
Biofuels (U) 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 will meet 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	13.500	23.900	32.948	0.000	32.948

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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 to produce substantial quantities of JP-8 and other useful liquid fuels from indigenously available or harvestable resources near desired locations worldwide. *FY 2009 Accomplishments:* - Identified and selected technology pathways for the development of man- and vehicle-portable systems capable of producing JP-8 and other useful liquid fuels from a broad diversity of feedstocks. - Demonstrated the conversion of cellulosic materials to JP-8 range alkanes with greater than thirty percent efficiency (by energy). - Identified a pathway for the conversion of cellulosic materials to JP-8 range alkanes with greater than fifty percent efficiency (by energy). - Identified multiple pathways for conversion of algal oils to JP-8 range alkanes at a cost of less than two dollars of triglyceride oil per gallon. - Identified one pathway for the conversion of algal oils to JP-8 range alkanes at a cost of less than one dollar triglyceride oil per gallon. - Explored the size and volume efficiency scaling relationships for various processing technologies for converting indigenous materials to JP-8 and other liquid fuels. - Developed preliminary designs for vehicle-portable and man-portable liquid fuel production systems. *FY 2010 Plans:* - Develop a qualification plan that specifies a path to support the full DoD qualification of the developed BioFuel as an acceptable alternative to JP-8. - Perform fleet-test of Biodiesel 25 with twenty-five percent hydrocarbon base to demonstrate possibilities of 100 percent biological jet fuel with hydrocarbon base. *FY 2011 Base Plans:* - Demonstrate system scale up to 4000 liters per month capacity and validate cost goal.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Evaluate sensitivity of biofuel cost of production in multiple locations. - Establish commercialization path to include production, co-product application, and transition to DoD program of record.					
Universal Batteries (U) 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 Base Plans:* - Analyze key primary battery needs, design appropriate power management circuitry and fabricate prototype battery units. - 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.	0.000	0.000	10.000	0.000	10.000
Long Duration Power Concepts (U) The requirement for generating power over long duration missions proposes unique challenges in energy storage, power conditioning and overall integration. This thrust explored the breakthroughs in power generation needed for extremely long duration, unmanned applications including unmanned underwater vehicles (UUVs). These included energy storage approaches that are efficient as well as energy efficient. It also evaluated approaches for efficiently removing the energy at rates commensurate with the high sprint power often required in these applications.	1.371	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Conducted a full scale laboratory demonstration of solid oxide fuel cell/battery power system for a thirty day large scale UUV mission.					
Accomplishments/Planned Programs Subtotals	109.321	131.882	175.586	0.000	175.586

	FY 2009	FY 2010
Congressional Add: Strategic Materials *FY 2009 Accomplishments:* - Continued chemical vapor composited (CVC) silicon carbide (SiC) process development. - Demonstrated bonding and integration of CVC SiC assemblies. *FY 2010 Plans:* - Continue research into promising areas of strategic materials.	4.400	5.000
Congressional Add: Synthetic Fuel Innovation *FY 2009 Accomplishments:* - Researched innovative techniques for the development of synthetic fuels.	4.000	0.000
Congressional Add: Center for Nonproliferation Studies, Monterey Institute for International Affairs *FY 2010 Plans:* - Initiate research of nonproliferation studies.	0.000	1.600
	0.000	2.880

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Photovoltaic Ribbon Solar Cell Technology Project *FY 2010 Plans:* - Conduct research into photovoltaic ribbon solar cell technology.		
Congressional Adds Subtotals	8.400	9.480

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	120.451	128.845	137.000	0.000	137.000	120.000	120.000	120.000	120.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) 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.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
BioRobotics and BioMechanics	1.000	1.500	0.000	0.000	0.000
(U) The BioRobotics and BioMechanics thrust explores approaches to capture biological systems' ability to move and sense, and emulate them in man-made robotic or sensor systems. The effort includes providing robotics with the mobility required to provide support to soldiers in all terrains, including climbing. *FY 2009 Accomplishments:* - Studied adaptive materials and controlled devices for biped locomotion. - Developed algorithms for robotic arm control.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Investigate capability to actuate over efficiently large displacement at frequencies exceeding ten hertz.					
Bioderived Materials (U) The Bioderived Materials thrust explores 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 include 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 2009 Accomplishments:* - Investigated new methods of biotemplating and biocatalysis with biological materials (i.e., microtubules, filamentous viruses, peptides, bacteriophages) to facilitate new sensors and devices. - Studied novel surfaces that have tunable properties, e.g., texture, hydrophobicity, optical reflectance/ transmission, and absorption. *FY 2010 Plans:* - Characterize the electronic and optoelectronic properties of novel biomaterials to develop high performance sensors and devices with new and unique capabilities. - Exploit unique structures found in biological systems that could enable new multifunctional materials. *FY 2011 Base Plans:* - Develop inexpensive processing techniques at ambient conditions for hybrid inorganic-organic structures with customized programmable biotemplates to create high performance sensors and devices with new and unique capabilities. - Demonstrate biotemplate membranes capable of energy harvesting at 15 percent greater efficiency.	1.000	2.000	3.700	0.000	3.700

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate bio-inspired infrared imaging device at 128 x 128 pixel resolution.					
Bioinspired Sensors	12.900	18.300	3.000	0.000	3.000
(U) 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 2009 Accomplishments: - Developed breadboard olfactory system, with emphasis on chip-based, non-cellular expression approaches for detection of relevant odorant molecules. - Demonstrated rapid detection of defined odorant molecules through the olfactory receptor-based breadboard system. - Developed methods for rapid synthesis of odorant receptors not previously expressed in the olfactory breadboard system. - Completed a design review of breadboard olfaction systems; conducted test and evaluation of all approaches simultaneously at an independent testbed.					
FY 2010 Plans: - Develop brassboard olfactory system(s) based on successful previous designs. - Demonstrate the olfactory brassboard's ability to detect twenty-five individual odorants/chemicals, with a portion contained in a chemical mixture.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate detection and identification of odorants at a probability of detection greater than or equal to ninety percent. - Determine relative concentration of individual odorant(s) in mixture. *FY 2011 Base Plans:* - Complete design finalization for olfactory brassboard system prototype. - Transition technology to DoD partner.					
Maintaining Combat Performance (U) 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 extremes of temperature (-20 degrees F to 125 degrees F), oxygen deficiency in mountains, personal loads in excess of 100 lbs, dehydration, psychological stress, and even performance of life-sustaining maneuvers following combat injury. Not only must troops maintain optimum physical performance, but also peak cognitive performance, 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 troops in the far forward combat areas. Other examples include fundamental research elucidating the biological mechanisms of adaptation to extreme altitude, and the molecular correlates of muscle fatigue and psychological stress. *FY 2009 Accomplishments:* - Identified mechanisms to alleviate high altitude illness.	6.463	12.100	13.300	0.000	13.300

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Identified the following for high altitude illness: mechanisms to increase pulmonary blood flow; methods to increase number of red blood cells; and mechanisms to increase oxygen delivery to muscles. *FY 2010 Plans:* - Investigate mechanisms to speed natural acclimatization at high altitudes. - Develop strategies based on identified mechanisms to accelerate natural altitude acclimatization from 4 weeks to 48 hrs. - Determine pharmacological markers to alleviate high altitude illness. - Develop field-deployable drug 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 to prepare Investigational New Drug (IND) application for use in an FDA Phase I clinical trial. *FY 2011 Base Plans:* - Complete 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. - Complete dosing requirements and efficacy demonstration for initiation of an FDA Phase II clinical trial.					
Cognitive Technology Threat Warning System (CT2WS) (U) 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	16.000	13.800	11.700	0.000	11.700

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
imaging threat queuing systems capable of effective 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 2009 Accomplishments:* - Demonstrated single path (twenty degree by twenty degree) advanced optics on a breadboard system in a field environment consistent with objective performance and package volume. - Demonstrated human-in-the-loop integration with the breadboard system, harnessing non-invasive neural signatures for threat detection. - 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 sixty seconds of scan time. - Demonstrated composite software system capable of high fidelity threat detection with extremely low false alarm rates. - Tested breadboard performance during week-long operational test at Yuma Proving Ground, AZ. *FY 2010 Plans:* - Develop integrated brassboard designs consistent with desired threat cueing performance. - Increase field of view to 120 degrees x twenty degrees while maintaining size, weight and power constraints. - Demonstrate 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. - Complete critical design review of bench-integrated prototype system evaluations that demonstrate the capability of the design to meet the objective system program performance. - Evaluate device packaging approaches with the knowledge of ruggedization and robustness required for soldier-portable tactical electronic devices.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Complete final optimization of the brassboard components and subsystems. *FY 2011 Base 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. - Execute a Memorandum of Agreement with Service transition partner(s) for test and evaluation.					
Neovision2 (U) 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 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 2009 Accomplishments:* - Created neuromorphic floating point gate array (FPGA) emulation for use as a tool to test advanced algorithms developed by vision research community. - Designed novel integrated circuit design for the replication of specific visual pathway functions.	9.000	10.868	12.500	0.000	12.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Fabricated and completed functional test of a neuromorphic FPGA for emulation of basic mammalian visual pathway functionalities. *FY 2010 Plans:* - Design next generation neuromorphic vision system capable of emulating entire mammalian visual pathway, through object recognition. - Fabricate breadboard neuromorphic object recognition system(s) with enhanced visual function capabilities beyond state of the art. - Test new neuromorphic object recognition system(s) against desired visual pathway performance, including probability of detection >90 percent, >10 object categories and recognition within 5 seconds. - Evaluate device packaging approaches with the knowledge of ruggedization and robustness required for robotic and airborne unmanned systems. *FY 2011 Base Plans:* - Incorporate further refinements and developments of visual pathway algorithms and neuromorphic hardware into current design(s). - Develop brassboard neuromorphic vision system(s) inclusive of retinal input to subsequent output. - Fabricate 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 in real time, less than 2 seconds to recognition. - Conduct extensive testing for object recognition performance with probability of detection >95 percent, greater than 20 object categories with an imaging range of 4 kilometers; evaluate as compared to standard target recognition systems currently in use.					
Tactical Biomedical Technologies (U) The Tactical Biomedical Technologies thrust will develop new approaches to deliver life-saving medical care on the battlefield, as well as novel technologies for reconstruction and rehabilitation of	11.700	15.777	19.600	0.000	19.600

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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. *FY 2009 Accomplishments:* - Demonstrated extended survival time using an FDA-approved estrogen product after 60% total blood volume loss in swine hemorrhage model. - Developed a physiological-based pharmacokinetic/pharmacodynamic model of the cardiovascular system to aid in determining appropriate estrogen doses in humans suffering lethal hemorrhage. - Demonstrated blastemal associated initiation of early joint formation at appropriate site during healing. - The Deep Bleeder Acoustic Coagulation (DBAC) program is currently developing a portable, non-invasive, automated system for the detection, localization, and coagulation of deep bleeders that is operable in the combat environment by minimally trained personnel. The stationary wrap-around device must prove to be lightweight and operate on batteries. To this end, one therapy module and one detection and localization (D&L) module with weight commensurate to meet a full 40 x 80 cm cuff weight of less than or equal to 4.8 kg was successfully designed and built.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Conducted in vivo and in vitro experiments to determine the effect of physiological variables on the DBAC algorithm. - Developed and tested automated algorithms for bleeder detection, localization, coagulation, and cuff control and integrated into a 2.4 kg prototype cuff. - Identified two materials capable of infiltrating into both penetrating noncompressible wounds and surface wounds for potential use in new wound-healing technology. - Determined specific wound biomarkers for targeting hemostatic (stops bleeding) materials. *FY 2010 Plans:* - Demonstrate in vivo induction of restorative skeletal muscle repair by transplant of induced pluripotent cells. - Determine transition kinetics from joint formation to bone morphogenic protein-2 (BMP-2)-induced long bone restoration. - Develop a material that can be delivered to a closed, intracavity space and binds specifically to damaged tissue as demonstrated in situ by immunohistology. - Demonstrate that hemostatic material does not induce intracavity scar formation within 28 days when left at the wound site. - Build and demonstrate an automated laboratory prototype DBAC system. - Optimize automated algorithms for bleeder detection, localization, coagulation, and cuff control with in vivo models. *FY 2011 Base Plans:* - Demonstrate compatibility with FDA-approved agents that control pain, infection, and inflammation. - Achieve wound treatment system unit specs including coverage of at least 0.20 square meters of tissue area, mass of less than 200 grams, and a volume less than 150 ml. - Demonstrate hemostasis in less than four minutes on a high-pressure non-compressible injury model. - Maintain hemostasis in high pressure model for three hours.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate DBAC system is capable of detecting and localizing clinically significant bleeder sizes, tracking the movement of the site based on tissue and patient movement, coagulating the bleeder, and determining completion of coagulation without a human decision maker in the loop. - Initiate development of an advanced computational fluid-structures interaction capability than can accurately simulate shock/blast interaction with the cranium, couple this energy with brain tissue, and account for shock wave dispersion, coalescence, and localization at specific locations within the brain. - Initiate development of an experimental capability to validate the fluid dynamics, materials, and mechanics components of the computational capability to determine biological damage and begin to correlate these results with neurological observations. - 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.					
Trauma Pod (U) The Trauma Pod program evaluated new approaches to deliver life-saving medical care on the battlefield. The effort explored innovative procedure modules, imaging and surgical techniques, and a portable tactical platform that could allow patient stabilization and provide precious additional time for transport to the combat support hospital. *FY 2009 Accomplishments:* - Conducted needs assessment study on technology gaps among in-theater medical providers and identified immediate need for portable imaging technologies capable of detecting high-risk injuries such as pneumothorax and closed head injury.	2.000	0.000	0.000	0.000	0.000
Biological Interfaces (U) 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	2.900	3.500	3.000	0.000	3.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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 2009 Accomplishments:* - Investigated bacterial and spore population reduction using plasma in non-uniform substrates. - Initiated studies of plasma dose required for million-fold reduction in bacterial population in animal wound model. *FY 2010 Plans:* - Complete studies of plasma dose required for million-fold reduction in bacterial population for porcine wound model. - Develop and perform safety studies to determine effects of plasma dose on mammalian cells. - Perform in vitro studies of plasma effects on viral pathogens. - Design plasma-based bandage for wound treatment based on safety studies and dose response curves from animal wound models. *FY 2011 Base Plans:* - Design self-sterilizing catheter incorporating plasma-based sterilization of catheter insertion point and interior catheter surface. - Design appropriate test procedure to evaluate treatment efficacy of plasma-based bandage and/or self-sterilizing plasma catheter for wound treatment based on dose response curves from animal wound models. - Perform in vivo animal wound studies to determine efficacy of plasmas for sterilizing viral wound pathogens.					
Neuroscience Technologies (U) The Neuroscience Technologies thrust leverages recent advances in neurophysiology, neuro-imaging, cognitive science and molecular biology to sustain and protect the cognitive functioning of	17.800	16.700	16.000	0.000	16.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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. For example, new approaches for using neural signals to make human-machine systems more time efficient and less workload intense will also 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 warfighter cognitive performance both prior to and during deployment. *FY 2009 Accomplishments:* - Demonstrated two-fold improvement on specific military learning tasks utilizing neuroscience-based accelerated learning techniques. - Investigated task-independent methods for accelerating learning, including improvements to working memory, attention, and engagement. - Confirmed the stability of neural signatures in complex imagery conditions, including imagery sources and target types. - Completed controlled operational tests to demonstrate utility of neural signatures in imagery analysis environment to motivate potential transition interest. - Demonstrated applicability of neural signature-based triage for specific analyst derived concept of operations including broad area search.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop a comprehensive quantitative description of the impact stress has on the brain and leverage cutting-edge technologies and recent advances in molecular neurobiology, neuroimaging and molecular pathway modeling as applied to animal models of acute and chronic stress. - Identify and characterize the genetic and molecular targets behind the adaptive vs. dysfunctional response to stress, exploring a minimum of four stressors (cognitive, physical, social sleep deprivation, illness, etc). - Develop training applications to implement the acceleration methodologies for specific Army, Navy, and Air Force operational tasks. - Implement task-independent methods for accelerating learning to existing training paradigms within the Services. - Demonstrate significant increase in imagery throughput and analytic product generation on specific operational tasks in the authentic imagery analysis environment. - Develop prototype systems that utilize neural signatures to speed analysis and improve quality and accuracy of imagery exploitation. - Initiate transition of technologies and methodologies to operational use including access to classified imagery, while validating utility of neural signature inputs into imagery workflow. - Characterize the underlying neural processes of three or more components of cognition. - Demonstrate correspondence between neural processes and each cognitive component. - Establish temporal sequencing of cognitive components. *FY 2011 Base Plans:* - 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 vs. dysfunctional responses to stress.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Establish an in vivo anatomical and molecular pathway that causes stress related dysfunction in an animal model and identify three targets for modulation. - Demonstrate that modulation of the identified and validated targets/pathways improves stress-induced cognitive dysfunction in a minimum of 75% 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. - Demonstrate improved cognitive model performance using neural representations of cognition. - Demonstrate improvement in cognitive model performance compared to non-neural approach on at least one task to which previously identified cognitive components contribute. - Show improvement in cognitive model ability to predict individual's cognitive behavior in at least two different, never-before-encountered, tasks and task environments.					
Military Medical Imaging (U) 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.	4.000	8.000	8.100	0.000	8.100

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Investigated rapid mission rehearsal thrust technologies and explored capability to augment simulation platforms with advanced physics and physiologic modeling. - Identified DoD agencies that acquire data on medical outcomes, materiel damage, and mission briefings in order to incorporate that information into simulation platforms for after-action forensic reconstruction. *FY 2010 Plans:* - Incorporate rapid mission rehearsal thrust technologies with computer-aided forensic methods into after-action review to aid in reconstructing incidents from existing data. - Utilize reconstructed scenarios for assessment of “lessons learned” and to gain immediate and relevant tactical battlefield knowledge. - 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. - Simulate 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. - Demonstrate geographic tracking of disparate events in physical and temporal space. *FY 2011 Base Plans:* - Manufacture sensors as needed to fill in capability gaps with existing sensor suites. - Enable near-real time capability to determine cause and type of insult to vehicular armor. - Integrate all databases with data fusion engine appended onto RealWorld simulation platform. - Demonstrate ability to automatically detect, track, and analyze similar events and incidents in temporal and physical space.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Focus X-rays with orbital angular momentum through a model of skin and bone. - Develop X-ray optics for scanning.					
Revolutionizing Prosthetics (U) 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, fully 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 return to military service. 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 2009 Accomplishments:* - Integrated sensory feedback into prosthetic devices. - Evaluated sensory feedback in patients with targeted neural re-implantation. - Completed design of chip for transmission of central nervous system motor signals. - Evaluated chip in experimental models. *FY 2010 Plans:* - Develop clinical protocol for testing of four-year prosthetic devices at military medical centers. - Initiate manufacture plan consistent with Good Manufacturing Practices (GMP). - Complete clinical and take home trials supporting FDA submission criteria. - Support experiments to determine potential level of direct neural control for upper-extremity prosthetic. - Finalize mechanical arm design and ensure readiness for wide-scale manufacture and production.	24.800	15.000	12.000	0.000	12.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete qualification testing and demonstrations of central and peripheral multimodal neural interfaces suitable for submission to FDA. - 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.					
Biodemilitarization of Munitions (U) Based on results from the External Protection Program in PE 0602383E, Project BW-01, the Biodemilitarization of Munitions program evaluated a system for rapid, safe, and effective inactivation of explosive munitions stockpiles in place. Chemical and biological technologies and control processes were developed to alter the explosive fill and enable long-term storage and high-reliability inertion of munitions. *FY 2009 Accomplishments:* - Designed, developed, and tested solid-state transformation processes. - Conducted a Preliminary Design Review for a demonstration system. - Conducted sensitivity testing to determine intermediate and final inertion products to include yield testing in chamber.	3.442	0.000	0.000	0.000	0.000
Blood Pharming (U) The overall 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 of the Phase II effort 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. Central to Phase II work will be the demonstration of a two hundred million-fold expansion of progenitor cell populations to mature RBCs. To realize these goals, Phase II will capitalize advances	7.446	5.300	4.100	0.000	4.100

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
in cell differentiation, expansion, and bioreactor technology developed in Phase I of 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. Phase I was completed in PE 0601101E, Project BLS-01, Biological Adaptation, Assembly and Manufacturing Program. *FY 2009 Accomplishments:* - Demonstrated greater than or equal to two million-fold expansion from progenitor source to mature RBC. - Demonstrated characteristic functions of RBC (oxygen binding/release, enzyme content, size, deformability) in vitro. - Developed strategies for production of ten RBC units per week for four weeks in an automated closed culture system using a non-renewing (replaceable) progenitor cell population. *FY 2010 Plans:* - Demonstrate production of 10 RBC units per week for four weeks in an automated closed culture system using a renewable progenitor cell population. - Demonstrate one billion-fold expansion of progenitor population to mature RBCs. - Demonstrate magnetic isolation of mature enucleated RBCs at a rate greater than one million cells per second. *FY 2011 Base Plans:* - Demonstrate immunogenicity of bioreactor-developed RBCs in an in vivo model. - Demonstrate efficacy of bioreactor-developed RBCs as a transfusion product in an in vivo trauma model.					
BioDesign	0.000	0.000	6.000	0.000	6.000

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	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) 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 identifying the origin and source of synthetic biologicals (e.g., genes or proteins) allowing for traceability and prevention of manipulation (“tamper proof” synthetic biological). *FY 2011 Base Plans:* - Demonstrate computation protein conformation algorithms that model one residue per minute with 99.5% accuracy for every one kilodalton of mass regardless of protein class. - Develop conformation prediction algorithms for biomimetic polymers and biological-nonbiological hybrids involving unnatural amino acids or inorganic materials. - Demonstrate a robust understanding of the collective mechanisms that contribute to cell death. - Identify and initiate strategies that would enable a new generation of regenerative cells that could ultimately be programmed to live indefinitely until needed for an injury repair or therapeutic application. - Develop genetically encoded locks to create "tamper proof" DNA and protect commercial applications. - 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 on a handgun.					
Pathogen Defeat	0.000	0.000	4.000	0.000	4.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY*	PROJECT MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) 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 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. *FY 2011 Base Plans:* - Determine methods to predict intent of biohackers. - Begin to examine virus mitigation and frequency across the globe to predict the timing and geographic location of reassortment events. - Identify low-resource requirement bioweapons and respective countermeasures. - Develop processes to accurately predict the drift and shift of viral reservoirs. - Create viral reservoir specific countermeasures that prevent emergence of novel highly lethal pathogens.					
Reliable Neural-Interface Technology (RE-NET) (U) 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 technologies needed 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.	0.000	6.000	20.000	0.000	20.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY*	PROJECT MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Advance peripheral nervous system (PNS) interface technology to increase the channel count and hence neural information content, while not compromising the existing long-term reliability capability. - Perform fundamental tissue-response-assessment experiments using both existing and new central nervous system (CNS) interface technology. - Develop statistically validated models of electrode channel loss as well as methods to predict long-term interface failure. *FY 2011 Base Plans:* - Advance CNS interface technology to increase its functional lifetime, while not compromising their ability to obtain large amounts of neural information. - Demonstrate advanced Reliable CNS Interface (RCI) technology in models with systems that have at least 100 channels and do not lose more than 1% of the channels per year.					
Accomplishments/Planned Programs Subtotals	120.451	128.845	137.000	0.000	137.000

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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