Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification									DATE: May 2009	
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 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
Total Program Element	297.030	282.896	268.859						Continuing	Continuing
MBT-01: MATERIALS PROCESSING TECHNOLOGY	186.811	137.333	131.882						Continuing	Continuing
MBT-02: BIOLOGICALLY BASED MATERIALS AND DEVICES	110.219	145.563	136.977						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.

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	R-1 ITEM NOMENCLATURE PE 0602715E MATERIALS AND BIOLOGICAL TECHNOLOGY

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	301.741	285.264	257.799	
Current BES/President's Budget	297.030	282.896	268.859	
Total Adjustments	-4.711	-2.368	11.060	
Congressional Program Reductions	0.000	-10.768		
Congressional Rescissions	0.000	0.000		
Total Congressional Increases	0.000	8.400		
Total Reprogrammings	3.550	0.000		
SBIR/STTR Transfer	-8.261	0.000		
TotalOtherAdjustments			11.060	

Congressional Increase Details ($ in Millions)

	FY 2008	FY 2009
Project: MBT-01, **Strategic Materials and Silicon Carbide Optics**	0.000	4.400
Project: MBT-01, **Synthetic Fuel Innovation**	0.000	4.000

Change Summary Explanation

FY 2008
The decrease reflects a below threshold reprogramming action and the SBIR/STTR transfer.

FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and execution delays offset by congressional increases identified above.

FY 2010
Increase reflects enhancements to the Biological Systems project to continue prosthetics and neurological systems efforts.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification								DATE: May 2009		
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 NUMBER MBT-01	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
MBT-01: MATERIALS PROCESSING TECHNOLOGY	186.811	137.333	131.882						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 2008	FY 2009	FY 2010	FY 2011
Materials Processing and Manufacturing	12.000	11.285	7.300	

(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 2008 Accomplishments:

- Demonstrated capability to capture salient features of microstructure, converted data into functional entries for physics based model parameters, and demonstrated active reconstruction of microstructure for visualization.
- Demonstrated integration with digital microstructural representation in order to illustrate dynamic effects on salient features in response to extrinsic stimuli.
- Demonstrated the ability to functionalize, disperse and spin single wall nanotube-containing carbon precursor that could be handled with industrial relevant fiber making equipment.
- Demonstrated production of carbon nanotube reinforced graphite fiber at hundreds of meters.
- Demonstrated ability to electrospin small diameter precursor tows.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Designed, built and operated large area lithographic exposure machine subsystems to produce ceramic cores for casting of superalloy turbine blades. *FY 2009 Plans:* - Demonstrate integration of digital microstructural representation, identification of critical features, and physics based models of mechanical behaviors for design of material composition and processing to achieve a set of desired properties. - Demonstrate integration of physics based predictive models of materials performance with digital microstructural representation. - Scale up advanced carbon fiber manufacturing from research line to pilot production line while maintaining properties that are in excess of 1000 Kilos per square inch in strength, 50 Million pounds per square inch in modulus and two percent strain to failure. - Increase nozzle count of the near field electro spinning system to 100 nozzles (from 50) and upgrades of dual coagulation and rinse baths stretching, drying and winding operations. - Demonstrate economical tooling for low volume production of polymer matrix composite (PMC) (10-25 units of a CH-47 helicopter ramp) that operates at less than 200 degrees Celsius cure temperature. - Verify PMC subcomponent (containing critical details) meets static, fatigue, and destructive evaluations. - Demonstrate a technology readiness level of four on full-size manufacturing of non-autoclave PMCs. *FY 2010 Plans:* - Demonstrate ability to scale small diameter tow precursor manufacturing and conversion techniques to full production capacity. - Demonstrate ability to scale Single Wall Nanotube (SWNT) loaded precursor tow manufacturing and conversion techniques to full production capacity. - Demonstrate ability to use fiber as woven mat in pre-preg for composite structures. - Demonstrate carbon fiber properties that are in excess of 1800 Kilos per square inch in strength, 60 Million pounds per square inch in modulus and three percent strain to failure. - Transition non-autoclave tooling and materials/processes to large-scale PMC fabricators.				
Structural Materials and Coatings	12.800	10.000	12.498	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 2008 Accomplishments:* - Developed processing of commercially pure titanium (Ti) from oxide at a production rate of fifty pounds per day. - Demonstrated ten times improvement in fracture toughness for ferrous (Fe) based bulk metallic glasses. - Demonstrated ability to melt and cast fully amorphous calcium (Ca) based metal alloys in large quantities in a production based facility. - Produced aluminum (Al) based amorphous ingots that meet strength and fatigue requirements for use in turbine engine fan blade application. - Demonstrated thermal spray technologies and processes at large scale contractor facility on relevant substrate materials. Thermal spray coatings survived military specification (MILspec) drop tests with no evidence of delamination or cracking. - Developed index matched glass fiber or resin composite systems that can be produced and fabricated into components by conventional composite fabrication techniques. - Demonstrated thin glass laminate materials and structures (fiber loading dependent) with optical transparencies between fifty to seventy-five percent. - Produced and evaluated the efficacy of prototypical shapes (with seams and joints) using transparent composite materials. *FY 2009 Plans:* - Develop processing of commercially pure titanium from oxide at a production rate of 500 pounds per day. - Verify titanium costs are less than four dollars per pound.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Produce solid and hollow sets of aluminum (Al) based amorphous turbine engine fan blades that meet all dimensional and mechanical property requirements. - Construct 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. - Apply Naval Advanced Amorphous Coatings on the Waterborn Mission Zone on Littoral Combat Ship (LCS-1); perform in-field testing and certify coatings for unrestricted use on naval combatants. - Initiate development of regenerative skin to prevent biofouling based upon continuous water activated film formation/dissolution concept. - Establish the conditions necessary to tailor formation and dissolution of the anti-biofouling skin, and their effects on rheological and mechanical properties. *FY 2010 Plans:* - Demonstrate meltless titanium consolidation. - Demonstrate a new alloy that can not be made by conventional processing. - Demonstrate structural amorphous metals in test turbine engines. - Verify integration into fan disk, stability, damage tolerance and coating requirements (if any). - Quantify performance and specific fuel consumption attributes for both military and commercial engines. - Demonstrate coatings of structural amorphous metals fan blades to address galling and environmental requirements. - Demonstrate dual functionality of structural amorphous metals/composite hybrid structures for space. - Demonstrate ability to delay the formation of persistent shear bands from vein structures that lead to crack initiation on a materials surface due to prolonged fatiguing by using magnetic fields in multiple alloy systems, including steels, aluminum (Al), titanium (Ti), and nickel (Ni) based alloy systems. - Determine approximate number of cycles for given loading conditions needed to form veins and subsequent persistent shear bands in order to formulate treatment cycle schedule for various alloy systems. - Identify multiphase composite materials suitable for use at high temperatures. - Determine volume fraction, distribution and morphology to obtain optimum structural properties.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-01	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Determine the effectiveness of the anti-biofouling skin against selected organisms in marine test environments having various hydrogen (pH), salinity and temperature. - Demonstrate circulatory and injection system for the generation of anti-biofouling skins over a significant area (greater than one square foot). - Hybrid multi-material characterization and process development. - Multi-physics computational tool development.					
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 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, and improve the survivability of space structures. *FY 2008 Accomplishments:* - Demonstrated continuous processing and control of nano-textured polymer and glass powder superhydrophobic surfaces at rates up to 2.9 square meters per hour (m/hr). - Produced carbon nanotube based cold cathode for use in ionic thrusters with current density on the order 1800 microampere per centimeter squared (order of magnitude increase in performance over off-the-shelf ionic thruster cathodes). - Demonstrated dramatic increases in cavitation resistance, corrosion resistance, surface hardness and fatigue resistance of IN718 (nickel based super alloy), A286 (austenitic ferrum based super alloy) and SAF2205 (duplex stainless steel) for use on combat ship propulsors without degrading bulk mechanical properties. - Developed flexible and lightweight surface wave controlling and power transmitting media that binds surface waves to within 1 millimeter of the surface, transmits data at greater than 36 megabits per second (Mbps) and transmits power at greater than 300 watts (W). - Began to investigate new membranes and technologies for particle separation to reduce the clogging and fouling of desalination systems.		12.200	10.100	12.700	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Demonstrate robust adherence of glass coating and textured polymer in order to produce superhydrophobic surfaces on various substrates. - Increase carbon nanotube (CNT) cold cathode performance to 4000 microampere per centimeter squared by demonstrating ability to grow multi-wall nanotubes decorated with gallium nickel (GaN) for increased field emission properties. - Demonstrate reduced scattering and losses due to perturbations and damage that might occur on surface wave controlling and power transmitting media. - 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. *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. - Demonstrate functional field emission device using CNT cold cathodes within commercially available Hall effect thruster body. - 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.				
Materials for Force Protection (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.	13.300	11.929	15.200	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated improved ballistic performance with reduced weight as compared with rolled homogeneous armor areal density. - Integrated high performance armor systems onto vehicle platforms in collaboration with the U.S. Army and Marine Corps. - Reduced the cost of hybrid composite armor systems with high throughput manufacturing techniques and by exploiting the benefits of commercial materials. - Demonstrated transparent armor systems with improved ballistic performance and reduced the size of the damage zone. - Demonstrated the importance of shock wave mitigation and projectile tipping mechanisms. - Developed topological armor concepts for explosively formed projectile (EFP) defeat. *FY 2009 Plans:* - Develop lightweight armor systems to mitigate and defeat evolving threats, including EFPs. - Evaluate topological armor concepts for protection against multiple threats. - Optimize transparent armor for fragmentation and armor piercing threats. - Integrate 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. - Demonstrate protective abilities of novel topological armor against EFP threats. - Demonstrate advanced technologies for mitigating EFP derived projectiles. *FY 2010 Plans:* - Demonstrate capability for production of index-matched fiber for transparent armor systems. - Demonstrate interface control of fibers with transparent polymers. - Demonstrate ballistic performance of spinel/index-matched polymers against armor piercings and fragment simulating projectiles. - Establish model for performance of transparent armor systems.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-01	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Demonstrate multi-hit capability of lightweight, mass producible armor. - Understand the defeat mechanisms against blast and fragment penetration to vehicle underbodies as a function of specific layering combinations of composite and metallic materials. - Evaluate the effectiveness of high-strength materials with respect to stiffness, shock isolation, and energy absorption. - Identify the most effective topological features for energy absorption and understand how material and system-level performance can be optimized at a minimum system areal density.					
Prognosis		10.000	3.000	3.000	
(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. *FY 2008 Accomplishments:* - Demonstrated predictive capability of Structural Integrity Prognosis System (SIPS) in predicting the capability and structural life of EA6B aircraft outer wing panel in independent tests on actual wings carried out by NAVAIR on actual hardware. - Identified sensor suites reasoner architecture for SIPS applied to the P3 aircraft. - Identified high-usage P3 aircraft and established agreement with P3 Class Desk for a one year flight test program to validate SIPS in actual aircraft operations under severe operating conditions. - Initiated test for flight operations. *FY 2009 Plans:* - Complete and provide 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).					

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Transition to Air Force Materiel Command. - Demonstrate ESP system on the T700 helicopter engines with specific objective of real time “power available” notification to the pilot. *FY 2010 Plans:* - Initiate complete system analysis for Air Combat Command (ACC) and Air Mobility Command (AMC) legacy aircraft. - Identify sensor requirements and establish virtual sensor logic for parameters not easily measured. - Characterize key materials of interest (metal and composite) and identify damage accumulation mechanisms. - 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.				
Materials for Initiation and Actuation (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 2008 Accomplishments:* - Performed laboratory testing of modulated chemical systems to assess transmission properties including range. - Began to define fundamental trade space for spatial control and destabilization of flame plasmas. - Initiated development of materials that integrate structural integrity and high performance energetics into the same composite material to create multifunctionality in munitions cases thereby enabling substantial increase in performance/reduction in size. - Initiated investigation of methods to control, at the mesoscale, conversion of mechanical to thermal energy in composite systems. - Demonstrated spanwise blade twisting on a representative rotor set.	15.540	15.370	11.025	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-01	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Fabricated, tested, and assessed silent maneuver capability of a nastic skin array on a scale model submersible. *FY 2009 Plans:* - Refine chemical systems to achieve 100-fold increase in transmission duration. - Engineer prototype chemical communications devices consisting of a disposable transmitter and a replicator device, with the form factor of a personal digital assistant, which translates messages into chemistry. - Perform field testing of prototype chemical communications devices. - Laboratory demonstration of fire suppression/manipulation approach, for Class A/B fires. - Conduct rotor stand test of fully actuated one-third scale prop rotor to demonstrate blade synchronization and lift improvement. - Experimentally evaluate combustion driven nastic materials actuator for innovative acoustic applications. - Design material composites that are both high density and highly energetic. - Develop and demonstrate processing methods to increase strength of dense reactive metal composite materials. *FY 2010 Plans:* - Develop prototype fire suppression system, and perform field demonstration for simulated ship hold fire. - Develop methods to rapidly decompose reactive metal composite materials. - Demonstrate the ability to control particle size. - Demonstrate the ability to control dispersion as a function of particle size. - Develop and demonstrate the ability to activate reactive components within composite material. - 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.					
Reconfigurable Structures		11.300	9.700	12.646	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) In the Reconfigurable Structures thrust, new combinations of advanced materials, devices, and structural architectures are being developed to allow military platforms to morph or change shape to adapt optimally to changing mission requirements and unpredictable environments. This includes the demonstration of a morphing aircraft as well as new materials and devices that will enable the military to function more effectively in the urban theater of operations. *FY 2008 Accomplishments:* - Developed soft chemically based materials with the ability to drastically change shape, reconfigure, and perform designated functions. - Formulated general theoretical model for reversible adhesive traction of chemical robots on terrain. - Demonstrated jamming transition which reversibly transforms rigid solid objects into free-flowing particulate matter for aperture traversal. - Elucidated materials dynamics of hyper-flexible caterpillar for translation into synthetic materials. - Demonstrated adhesion repeated 100 times on glass, aluminum, and brick under both wet and dry conditions on a four inch by four inch pad. - Determined proper climbing techniques via biomechanical analysis for maximum rate of climb, moving laterally, and descending using the required attachment-removal-reattachment kinematics. *FY 2009 Plans:* - Engineer soft components from the soft chemically-based materials that enable locomotion and size/shape morphing. - Engineer 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. - Engineer soft payloads with the ability to both traverse openings smaller than their characteristic dimension, and perform work. - Integrate soft payloads into robotic architecture. - Design, refine and finalize pads for hands and feet based upon results of biomechanical analysis and human climbing trials. - Demonstrate an unloaded soldier (150 lb) scaling a series of twenty-five foot walls built from mission relevant materials.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Perform laboratory testing of robot operation 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) scaling a series of twenty-five foot walls built from mission relevant materials.				
Functional Materials and Devices (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 2008 Accomplishments:* - Designed an optical negative index material based modulator for improved optical communications. - Designed a sub wavelength ultra high frequency (UHF) antenna. - Demonstrated delay of 10 gigabits per second optical data stream by more than 75 nanoseconds, and incorporated tunable delay into reconfigurable time-based multiplexer. *FY 2009 Plans:* - Demonstrate a low loss, negative index enabled optical modulator with reduced size and increased speed for military communications. - Demonstrate a sub wavelength UHF antenna with enhanced efficiency for military radar and communication applications. - Demonstrate delay of 40 gigabits per second data stream by more than 1 micro-second, and incorporate tunable delay into reconfigurable optical data buffer. - Demonstrate slow light based compact optical interferometer with greater than three times reduction in optical path length.	10.000	4.871	10.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-01	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Design ultra violet light source with thirty times improvement in average power output. - Design laser-plasma source for collimated proton/ion beam with output energy greater than 10 mega electron volts (MeV). - Demonstrate, in a laboratory environment, a low power room temperature magnetic sensor with a sensitivity of 100 femtotesla root mean square (rms) per square root hertz (or 10 to the minus 13 tesla rms per square root hertz). - Demonstrate a 10 x 10 array of magnetic sensors with an overall sensitivity of 1 picotesla rms per square root hertz at a frequency of 1 Hertz. - Investigate materials to exchange oxygen and carbon dioxide at the high flux rates necessary for performing underwater missions. - Investigate carrier materials to transport oxygen and carbon dioxide at the saturation levels required for performing underwater missions.					
Power Components (U) This thrust explores and develops novel components for use in diverse power systems that will dramatically increase the 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 2008 Accomplishments:* - Initiated development of nano-structured materials that can achieve improved thermoelectric properties. - Initiated development of nano-structured magnetic materials with improved energy product. - Initiated development of nano-structured electrochemical materials with improving energy and power density.		9.100	8.000	9.200	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Developed nano-structured materials and demonstrated the ability to improve thermoelectrics with figures of merit approaching 2.0, magnetics approaching two times current energy product and batteries with 500 watt hours per kilogram (Wh/kg) energy density. - Developed new ceramic and polymer dielectric materials with high permittivity, high breakdown strength and high temperature (greater than 200 degrees Celsius) operation. *FY 2009 Plans:* - Incorporate new dielectric materials into a high energy dense capacitor to achieve 20 joules per cubic centimeter (J/cc) energy density and 100 joules (J) of power. - Demonstrate synthesis of nanocomposite thermoelectric materials with figures of merit greater than two for low, medium and high temperature ranges. - Demonstrate synthesis of nanocomposite magnetic structures with two times energy product. - Demonstrate synthesis of nanocomposite electrochemical materials with power densities approaching 2000 watts per kilogram. *FY 2010 Plans:* - Integrate nano-structured thermoelectric materials into effective structure for military use. - Integrate nano-structured magnetic materials with high energy product into military motor. - Integrate nano-structured electrochemical materials with high energy and power densities into military battery supplies. - Innovatively package the 20 J/cc dielectrics into capacitors with sensing capabilities to provide reliable high power capacitors of 20 J/cc and 400 J. - Design and build system that will transfer power wirelessly with greater than twenty percent efficiency at ranges of up to 10 meters and at ranges up to 1 kilometer. - Demonstrate proof of concept for nano-gap device with an efficiency greater than 8 percent at a temperature difference of 200 degrees C.				
Novel Power Sources (U) The Novel Power Sources thrust will explore new materials solutions to enable power to be efficiently generated and controlled. This includes new materials concepts to increase the efficiency and robustness	9.650	4.000	6.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
of portable fuel cells as well as the exploitation of nanotechnology to increase the efficiency and lower the weight of batteries. A related focus is new catalytic materials and processes for alternative energy sources that are compatible with military logistic fuels. An additional focus is to develop materials to drastically improve the efficiency of low temperature thermoelectric components and develop these components into demonstration systems. *FY 2008 Accomplishments:* - Demonstrated high energy density power sources that enable Unmanned Air Vehicle (UAV) and Unmanned Ground Vehicle (UGV) mission durations that are five times longer than current state-of-the-art batteries allow. - Initiated the development of catalysts powered by sunlight for reducing carbon dioxide and water into syngas (carbon monoxide and hydrogen). - Initiated quick and efficient conversion of cellulosic and lignin biomass into a synthetic fuel with eight carbons or more using chemical catalysts. - Initiated the next generation of fuel cells capable of running on JP-8 without degrading due to coking and sulfur poisoning through the use of novel surface catalysts. *FY 2009 Plans:* - Demonstrate the use of extruded membrane within existing solid oxide fuel cell architecture to operate using JP-8 fuel. - Demonstrate efficiencies of surface catalysts for cogeneration of carbon dioxide and hydrogen powered by sunlight. - Develop 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.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Integrate new catalysts for highly efficient alternative energy systems including fuel cells, biomass conversion systems, and solar fuel systems.				
Very High Efficiency Solar Cell (VHESC) (U) The objective of the Very High Efficiency Solar Cell (VHESC) program is to demonstrate at least fifty percent efficiency in an affordable, manufacturable photovoltaic (PV). This technology breakthrough will provide soldiers with portable power for electronic devices resulting in a dramatic reduction in the complex logistics associated with delivering batteries to troops in the field, while improving mission endurance and individual soldier agility. It will also provide the DoD with a fixed terrestrial renewable energy source. (U) The program addresses all aspects of the high-efficiency PV 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 photovoltaic devices and 2) the development of high-volume cost-effective manufacturing engineering designs and processes for the subsequent future transition to affordable production. *FY 2008 Accomplishments:* - Demonstrated an integrated proof of concept module with greater than forty percent efficiency. - Demonstrated potential cost reduction technologies supporting cost scaling in large scale production. *FY 2009 Plans:* - Design, build and test VHESC engineering prototype modules addressing the program goals.	17.500	21.000	6.600	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop technologies to reduce the costs of the photovoltaic cells and optical components. *FY 2010 Plans:* - Deliver an initial integrated prototype.				
Alternate Power Sources (U) The aim of the Alternate Power Sources thrust is to develop materials and technologies to utilize alternative power sources that have the potential to provide significant strategic and tactical advantages to the DoD. The thrust is very diverse, and includes the development of portable power platforms that efficiently (greater than ninety percent) utilize military waste materials (plastic and paper) for generation of electricity, as well as the development of agricultural plastics that are optimum for electricity generation in these platforms. Very small volume (less than one cubic millimeter) rechargeable micro-batteries with maintained energy density comparable to conventional lithium ion batteries will be developed. *FY 2008 Accomplishments:* - Scaled up 5 kilowatt Mobile Integrated Sustainable Energy Recovery (MISER) process to 60 kilowatt electric generator. - Demonstrated use of mixed plastics and paper as fuel for MISER system. - Improved synthesis (0.5 gallons per liter hour (L/hr)) and polymerization processes for high energy recoverability polymers. - Developed packaged battery of less than 6 cubic millimeters that possessed an energy density of greater than 200 watt hours per liter (Wh/L). - Simulated molecular dynamics of helium-xeon gas mixtures in a collapsing bubble that predicted segregation of helium to the center of the bubble during sololuminescence experiments and produced temperatures as high as 100 million degrees Kelvin, much higher than either helium or xeon alone. - Established the effects of surface area and crystal orientation on degree of deuterium loading and the loading/relaxation dynamics. Correlated these effects with increases in generated excess heat. - Demonstrated ability to control palladium substrate composition, grain structure, and surface morphology conditions, and reliably generated significant excess heat.	9.120	4.707	1.813	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-01	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Further improve packaging and electrode architectures to maintain packaged battery energy density goals of greater than 200 Wh/L, in a volume of less than 1 cubic millimeter. *FY 2010 Plans:* - Continue to improve packaging and utilization of active electrode materials to manufacture a packaged battery with an energy density greater than 350 Wh/L in a volume less than 1 cubic millimeter.					
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 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 2008 Accomplishments:* - Designed, developed, and demonstrated a process pathway for greater than sixty percent conversion (by energy) of crop oil to JP-8. - Elucidated a path to ninety percent conversion of crop oil to JP-8. - Identified technology pathways for the conversion of a broad diversity of cellulosic, algal, and other similar feedstocks to affordable bulk quantities of JP-8. - Developed three processes for crop oil conversion to JP-8. - Produced JP-8 which successfully passed Air Force Research Laboratory military specifications (MILSPECS). - Identified a multitude of feedstocks for conversion to JP-8.		29.500	13.600	23.900	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-01	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Demonstrated the scalability of production technologies for the affordable conversion of crop oil to JP-8 at a cost of greater than five dollars per gallon. *FY 2009 Plans:* - Identify and select 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. - Demonstrate the conversion of cellulosic materials to JP-8 range alkanes with greater than thirty percent efficiency (by energy). - Identify a pathway for the conversion of cellulosic materials to JP-8 range alkanes with greater than fifty percent efficiency (by energy). - Identify 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. - Identify 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. - Explore the size and volume efficiency scaling relationships for various processing technologies for converting indigenous materials to JP-8 and other liquid fuels. - Develop 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.					
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 is exploring the breakthroughs in power generation needed for extremely long duration, unmanned applications including unmanned underwater vehicles (UUVs) and unmanned air vehicles (UAVs). These include energy storage approaches that are structurally efficient as well as energy efficient. It also includes approaches for		5.001	1.371	0.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
efficiently removing the energy at rates commensurate with the high sprint power often required in these applications. Products will transition to the Navy in FY 2009/2010. *FY 2008 Accomplishments:* - Continued development of the direct carbon fuel cell. - Laboratory demonstration of solid oxide fuel cell technology achieved program goals for power density, fuel utilization, and lifetime metrics. *FY 2009 Plans:* - Full scale laboratory demonstration of solid oxide fuel cell/battery power system for a thirty day large scale UUV mission.				
Strategic Materials (U) This program will investigate strategic materials. *FY 2008 Accomplishments:* - Optimized the process for reliable, robust, repeatable, and cost effective Chemical Vapor Composite (CVC) silicon carbide (SiC) manufacturing process for high tech military, space, and industrial applications. *FY 2009 Plans:* - Continue CVC SiC process development. - Demonstrate bonding and integration of CVC SiC assemblies.	5.000	4.400	0.000	
Economic Production of Coal-to-Liquid Fuels (U) This program researched the economic production of converting coal fuels to liquid fuels. *FY 2008 Accomplishments:* - Researched the economic production of converting coal fuels to liquid fuels.	2.400	0.000	0.000	
Reduce Environmental Impact of Coal-to-Liquid Fuels	2.400	0.000	0.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) This program researched ways to reduce the environmental impact of converting coal fuels to liquid fuels. *FY 2008 Accomplishments:* - Researched ways to reduce the environmental impact of converting coal fuels to liquid fuels.				
Synthetic Fuel Innovation (U) This program will research innovative techniques for the development of synthetic fuels. *FY 2009 Plans:* - Research innovative techniques for the development of synthetic fuels.	0.000	4.000	0.000	

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification								DATE: May 2009		
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 NUMBER MBT-02	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 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	110.219	145.563	136.977						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 magnetic 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 2008**	**FY 2009**	**FY 2010**	**FY 2011**
BioRobotics and BioMechanics	6.700	1.000	1.500	
(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. This thrust also includes efforts to develop bioinspired swimming aids that will increase the speed and reduce the metabolic costs for combat divers, and make current devices (fins) obsolete for most tactical scenarios. *FY 2008 Accomplishments:* - Demonstrated mobility and range capability in a militarily relevant environment by traversing five miles of wooded terrain while following a human lead. - Demonstrated dynamic climbing on vertical terrestrial features. - Fabricated sixty oscillating foil devices followed by operational validation; transitioned to the military user.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Establish adaptive materials and controlled devices for biped locomotion. *FY 2010 Plans:* - Demonstrate 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 Plans:* - Investigate new methods of biotemplating and biocatalysis with biological materials (i.e., microtubules, filamentous viruses, peptides, bacteriophages) to facilitate new sensors and devices. - Develop 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.	0.000	1.000	2.000	
Bioinspired Sensors (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	17.233	12.900	23.300	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

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 2008 Accomplishments:

- Completed a series of investigations into bioinspired materials and sensors (e.g., visual, auditory, olfactory, gustatory and tactile) to examine unique characteristics for future sensor designs.
- Designed novel sensor technologies, including a prototype vision sensor based on the properties of the mammalian retina for the creation of high dynamic range sensor capabilities, and tactile sensors for novel situational awareness in robotic platforms.
- Described components for a sensitive, but flexible olfactory system built from and inspired by the structure and components of the mammalian olfactory system.
- Identified methods for high throughput generation of odorant molecules of interest and stable expression of receptor proteins in a cell-based system.

FY 2009 Plans:

- Develop breadboard olfactory system, with emphasis on chip-based, non-cellular expression approaches for detection of relevant odorant molecules.
- Demonstrate rapid detection of defined odorant molecules through the olfactory receptor-based breadboard system.
- Develop method for rapid synthesis of odorant receptors not previously expressed in the system.
- Conduct a design review of breadboard olfaction systems; test and evaluate all approaches simultaneously at an independent testbed.

FY 2010 Plans:

- Develop brassboard olfactory system(s) based on successful previous designs.
- Demonstrate the brassboard’s ability to detect twenty-five individual odorants/chemicals, with a portion contained in a chemical mixture.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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. - Evaluate successful brassboard systems in a final design review for size, weight, power and performance needed in prototype systems. Select design to move forward to prototype. - Understand requirements for optical device capable of reading single neuron motor signals. - Design and begin development of device prototype.				
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, the molecular correlates of muscle fatigue and psychological stress, and natural resistance to disease through dietary nutrients. *FY 2008 Accomplishments:* - Identified genetic indicators of acute mountain sickness and developed approaches to improve cardio-pulmonary function at high altitude. - Demonstrated greater than forty percent improvement from preconditioning prior to high altitude exposure in murine model.	7.101	6.463	7.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-02	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Identify mechanisms to alleviate high altitude illness. - Investigate mechanisms to speed natural acclimatization at high altitudes. - Demonstrate the following in-vitro: mechanisms to increase pulmonary blood flow; methods to increase number of red blood cells; and mechanisms to increase oxygen delivery to muscles. - Position product for use in an FDA Phase I clinical trial by the end of first program phase. *FY 2010 Plans:* - Increase speed acclimatization by providing high altitude cues prior to ascent. - Identify physical adaptation strategies of altitude-adapted people. - Demonstrate high altitude illness prevention in mammals using adaptation strategies of altitude-adapted people.					
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 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 2008 Accomplishments:* - Initiated system-level preliminary design of a prototype soldier-portable digital imaging visual threat cueing system capable of improving current effective detection ranges while simultaneously surveying wide field of view.		9.500	21.400	13.800	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-02	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Evaluated methodologies for inclusion of wide angle optics, large pixel count digital imagers, cognitive visual processing algorithms, brain-derived target detection signatures and low power analog-digital hybrid electronics. - Demonstrated first generation closed loop cognitive device with an integrated cognitive-neural subsystem. - Demonstrated cognitive algorithm performance on image streams generated by breadboard imager, with high likelihood of threat detection. *FY 2009 Plans:* - Demonstrate single path (twenty degree by twenty degree) advanced optics on a breadboard system in a field environment consistent with objective performance and package volume. - Demonstrate human-in-the-loop integration with the breadboard system, harnessing non-invasive neural signatures for threat detection. - 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 sixty seconds of scan time. - Demonstrate composite software system capable of high fidelity threat detection with extremely low false alarm rates. - Test breadboard performance in two operational test locations – Yuma Proving Ground and East Range, Hawaii. *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 metrics.					

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Evaluate device packaging approaches with the knowledge of ruggedization and robustness required for soldier-portable tactical electronic devices. - Complete final optimization of the brassboard components and subsystems.				
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 a neuromorphic vision system. *FY 2008 Accomplishments:* - Completed scaling studies for design of a complete system prototype for biological visual pathway capabilities. - Developed small-scale floating point gate array (FPGA) emulation to test integrated circuit design and demonstrate initial neuromorphic properties of the early visual pathway. - Demonstrated advanced algorithms for visual pathway functionality (saccade, foveate and basic object recognition) on software testbed and validated using topological analysis techniques. *FY 2009 Plans:* - Create neuromorphic FPGA emulation for use as a tool to test advanced algorithms developed by computer vision community. - Develop novel integrated circuit design for the replication of specific visual pathway functions. - Fabricate and complete functional test of a neuromorphic application specific integrated circuit (ASIC) for emulation of basic mammalian visual pathway functionalities.	8.300	9.000	10.500	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-02	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Design next generation ASIC with enhanced visual function capabilities for object recognition. - Test new integrated circuit design in FPGA emulation for desired visual pathway performance. - Fabricate and complete functional test of a neuromorphic application specific integrated circuit (ASIC) for emulation of entire mammalian visual pathway, through object recognition. - Evaluate device packaging approaches with the knowledge of ruggedization and robustness required for airborne unmanned systems.					
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 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 2008 Accomplishments:* - Demonstrated an in vitro delivery system that releases a therapeutic dose of a pain drug based on a chosen biological signal and that the release of the drug can be “shut off” when a biomarker for toxic effect is present. - Demonstrated non-toxicity of drug delivery system materials using cultured mammalian cells.		16.200	17.500	10.377	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Demonstrated in vivo studies of the drug delivery system for demonstration of drug activity without overdose toxicity. - Developed algorithms for bleeder detection, localization, coagulation, and cuff control; validated algorithms with in vitro model; integrated algorithms with hardware into a complete system. - Developed new lightweight fiber-optic sensor to provide real-time tracking information for bleeder. - Developed new capacitive micromachined ultrasound transducer technology and high-voltage application specific integrated circuit technology to reduce system weight. - Stimulated expression of three gene markers of blastema development at non-regenerating wound site in a mammal using bone morphogenetic protein-2 (BMP-2). - Demonstrated greater than twenty percent reduction in scar tissue formation associated with BMP-2-induced blastema formation at tissue wound site. *FY 2009 Plans:* - Initiate in vivo studies of the drug delivery system in live experimental models. - Determine optimal scaffold properties that support induction of pluripotent stem cell-like state from scaffold immobilized fibroblast scar cells. - Determine bone morphogenetic protein-2 (BMP-2) responsive cells and the spatial-temporal kinetics of BMP-2-induced blastema formation at tissue wound site. - Demonstrate blastemal associated initiation of early joint formation at appropriate site during healing. - Design and build 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. - Conduct in vivo and in vitro experiments to determine the effect of physiological variables on the deep bleeder acoustic coagulation (DBAC) algorithm. - Develop and test automated algorithms for bleeder detection, localization, coagulation, and cuff control and integrate into a 2.4 kg prototype cuff. - 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.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-02	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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 BMP-2-induced long bone restoration. - Demonstrate hemostasis in less than four minutes on a high-pressure non-compressible injury model. - Maintain hemostasis in high pressure model for three hours. - Build and demonstrate an automated fieldable prototype DBAC system that operates on batteries. - Optimize automated algorithms for bleeder detection, localization, coagulation, and cuff control with in vivo models.					
Trauma Pod (U) New approaches are necessary to deliver life-saving medical care on the battlefield. Research has demonstrated that several functions that currently take place in an operating room can be automated, such as tool and supply handling. Furthermore, these functions can be conducted faster and more effectively by autonomous machines making it possible to move these functions onto the battlefield. Developing the capability to perform autonomous diagnosis will assist the medic in determining the type and extent of the injury. Innovative procedure modules, imaging and surgical techniques, and a portable tactical platform will allow patient stabilization and provide precious additional time for transport to the combat support hospital. *FY 2008 Accomplishments:* - Developed portable oxygen generator for integration into on-board ventilator system. - Miniaturized and field-certified ventilator system for potential integration into final robotic resuscitation and evacuation system. - Conducted initial studies on the usefulness of heat shock proteins as an immediate therapy for protecting wounded warfighters from adverse effects of shock and other combat related injuries for inclusion as an immediate therapy for evacuated patients.		11.700	12.000	15.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop and test additional fully automated surgical techniques including opening of an airway and insertion of an intravenous line (IV). - Design an integrated system capable of treating pneumothorax, internal hemorrhage, and head trauma. - Demonstrate proof of principle imaging and surgical techniques on material surrogates for human tissues and animal models. *FY 2010 Plans:* - Integrate imaging and surgical modules into a portable tactical platform and test overall system. - Demonstrate imaging and automated imaging diagnosis of a tension pneumothorax, intracerebral bleeding, abdominal bleeding, and retroperitoneal bleeding in an animal model. - Demonstrate surgical techniques of an airway on an anatomical model, and insertion of an IV, relief of tension pneumothorax, and control of internal bleeding on an animal model. - Demonstrate scalability of system.				
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 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 2008 Accomplishments:* - Demonstrated plasma-initiated million-fold reduction in bacterial count and 99.9 percent inactivation of bacterial spore population on artificial skin surfaces. *FY 2009 Plans:* - Investigate bacterial and spore population reduction inside catheter structures. - Determine plasma dose required for million-fold reduction in bacterial population for exposed animal wound model.	1.500	2.900	9.500	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009			
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 NUMBER MBT-02	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Develop skin (dermis & epidermis) construct of size/shape to match bone constructs. - Demonstrate functional repair of denervated muscles using acellular nerve scaffolds. - Scaffold-based differentiation of salivary gland cells with production of amylase. - Demonstrate computer-aided design production of sinus mucosa construct of size/shape to match patient anatomy. - Design plasma-based bandage for wound treatment based on dose response curves from animal wound models. - Develop and perform safety studies to determine effects of plasma dose on mammalian cells. - Design catheter incorporating plasma-based sterilization of insertion wound and of interior catheter lining. - Perform in vitro studies of plasma effects on viral 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 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, molecular targets for the restoration of long term memory using micro-ribonucleic acids (mi-RNA) will be tested in animal models for their efficacy following stress and training; new approaches to 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		2.000	17.800	16.700	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated the usefulness of a neural signature-based triage system to dramatically increase visual throughput to imagery analysts with no loss of target detection accuracy. - Demonstrated the ability of neural signatures to reveal targets in both overhead electro-optical imagery and synthetic aperture radar imagery. - Integrated imagery triage approach and neural signature processing into the imagery analyst footprint, including integration with baseline software and hardware exploitation environment. *FY 2009 Plans:* - Demonstrate two-fold improvement on specific military learning tasks utilizing neuroscience-based accelerated learning techniques. - Investigate task-independent methods for accelerating learning, including improvements to working memory, attention, and engagement. - Determine the stability of neural signatures in complex imagery conditions, including imagery sources and target types. - Initiate controlled operational tests to demonstrate utility of neural signatures in imagery analysis environment to motivate potential transition interest. - Demonstrate applicability of neural signature-based triage for specific analyst derived concept of operations including broad area search. *FY 2010 Plans:* - Evaluate optimal delivery methods of mixtures of short nucleotide sequences for long-term memory enhancement. - Demonstrate a 10x improvement in long term memory performance thirty days after training, using short nucleotide sequences administered in a single animal model prior to training.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop a comprehensive quantitative description of the impact stress has on the brain, including neurophysiological, cognitive and behavioral measures. This includes understanding the processes by which certain individuals are resilient to the negative effects of stress, understanding how to prevent deleterious effects of stress exposure without blocking the biological and behavioral responses necessary for survival. - 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. - 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, while validating utility of neural signature inputs into imagery workflow. - Determine how functional magnetic resonance imaging (fMRI) can be used to identify intent (gold standard). - Demonstrate that electroencephalography (EEG) can provide intent - information equivalent to fMRI.				
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 allows us to appreciate 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 we seek to better understand anatomical, functional and cellular level interactions. The advanced development of these tools will provide a formidable arsenal of diagnostic tools for warfighter performance and care.	3.530	4.500	7.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Demonstrated a new transmission anode X-ray source having 1.2 times higher yield and efficiency and 6 times greater vertex angle than conventional reflection anode X-ray tubes, enabling ultra-compact computed tomography (CT) imaging for battlefield applications. *FY 2009 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. - Start development of a sealed transmission anode X-ray tube having enhanced vertex angle performance (40 degrees) with 2.5 times higher yield and efficiency, and the ruggedness and lifetime characteristics of a conventional sealed X-ray tube. - Start development of an anode test platform, cathode, and high voltage generator for the sealed transmission tube. *FY 2010 Plans:* - Demonstrate that an incident can be fully reverted to initial conditions using only injury and vehicle data. - Attempt to determine directionality, cause, and type of non-lethal injuries to individuals and insults to vehicles from in-theater data, improving responsiveness to threats on the battlefield as new threats emerge. - Simulate elements of data collected from battlefield through existing RealWorld simulation platform. - Demonstrate geographic tracking of disparate events in physical and temporal space.				
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	23.955	24.800	15.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Performed testing and evaluation required for initiation of clinical trials. - Designed and manufactured prototype limb including biomimetic articulation, longevity of power consumption, and strength and weight that emulate form, function, and response of natural biological limbs. - Developed and demonstrated a clinical prototype virtual integration environment. - Initiated clinical testing of initial limb prototype on combat amputees at military medical centers. - Developed strategies and technologies for commercial manufacture. *FY 2009 Plans:* - Integrate sensory feedback into prosthetic devices. - Evaluate sensory feedback in patients with targeted neural re-implantation. - Complete design of chip for transmission of central nervous system motor signals. - Evaluate chip in experimental models. - Demonstrate the ability to implement brain/neural control with sensor feedback in a control architecture that combines the kinetics and mechanics (degrees of freedom) of natural movement, including the realization of proprioception and reflex. - Develop clinical protocol for testing of four-year prosthetic devices at military medical centers. - Initiate manufacture plan consistent with Good Manufacturing Practices (GMP). *FY 2010 Plans:* - 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.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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.				
Biodemilitarization of Munitions (U) Based on results from the External Protection Program in PE 0602383E, Project BW-01, the Biodemilitarization of Munitions program will develop a system for rapid, safe, and effective inactivation of explosive munitions stockpiles in place. If these stockpiles can be removed, the raw materials for constructing improvised explosive devices will be greatly reduced. Chemical and biological technologies and control processes will be developed to alter the explosive fill and enable long-term storage and high-reliability inertion of munitions. *FY 2008 Accomplishments:* - Developed two new methods for penetration of steel munitions that do not require mechanical cutting. - Developed mathematical models that characterize the scaling of these technologies for shells of diverse composition and thickness. - Developed and field tested two new methods (catalytic chemical and electrochemical reduction of the nitrated materials) for in-situ deactivation of composition B explosive (trinitrotoluene (TNT) + trinitramine (RDX)). - Integrated penetration, excavation, and remediation of composition B explosive fill of a 155mm M105 artillery round. *FY 2009 Plans:* - Design, develop, and test solid-state transformation processes. - Conduct a Preliminary Design Review for a demonstration system. - Conduct sensitivity testing to determine intermediate and final inertion products to include yield testing in chamber. - Engineering optimization and testing of integrated system against a cache of fifty munitions. - Transition technology to Army.	2.500	4.300	0.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER MBT-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Blood Pharming	0.000	10.000	5.300	

(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 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 Plans:
- Develop 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.
- Demonstrate greater than or equal to two million-fold expansion from progenitor source to mature RBC.
- Identify at least three stage-specific cell properties (size, shape, biomarker expression) that support automated culture.
- Demonstrate normal RBC function (oxygen binding/release, enzyme content, size, deformability) in vitro.

FY 2010 Plans:
- Demonstrate production of 100 RBC units per week for eight weeks in an automated closed culture system using a renewing progenitor cell population.
- Demonstrate two hundred million-fold expansion of progenitor population to mature RBCs.

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency	RDT&E Project Justification	DATE: May 2009
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 NUMBER** MBT-02

D. Acquisition Strategy

N/A

E. Performance Metrics

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