RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research			R-1 ITEM NOMENCLATURE Materials & Biological Technology PE 0602715E					
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	271.356	298.147	306.022	303.363	281.107	288.107	288.107	298.107
Materials Processing Technology MBT-01	162.908	169.052	195.432	200.814	195.772	192.772	192.772	202.772
Biologically Based Materials and Devices MBT-02	108.448	129.095	110.590	102.549	85.335	95.335	95.335	95.335

(U) Mission Description:

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

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

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

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(U) **Program Change Summary:** *(In Millions)*	**FY 2006**	**FY 2007**	**FY 2008**	**FY 2009**
Previous President's Budget	288.753	297.277	308.261	315.107
Current Budget	271.356	298.147	306.022	303.363
Total Adjustments	-17.397	.870	-2.239	-11.744
Congressional program reductions	-10.000	-3.130		
Congressional increases	0.000	4.000		
Reprogrammings	0.000			
SBIR/STTR transfer	-7.397			

(U) Change Summary Explanation:

FY 2006	The decrease reflects the SBIR/STTR transfer and the Section 8040 rescission.
FY 2007	The increase reflects a congressional add to Strategic Materials which is offset by a congressional cut to Neurotechnology for Intelligence Analysts and a reduction for Section 8106 Economic Assumptions.
FY 2008/2009	Changes reflect minor repricing of materials and biological systems programs.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Materials & Biological Technology PE 0602715E, Project MBT-01				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Materials Processing Technology MBT-01	162.908	169.052	195.432	200.814	195.772	192.772	192.772	202.772

(U) Mission Description:

(U) The major goal of this 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 improvements in logistics.

(U) Program Accomplishments/Planned Programs:

	FY 2006	FY 2007	FY 2008	FY 2009
Materials Processing and Manufacturing*	22.000	23.150	29.299	31.500

*Previously this was part of Structural Materials

(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. Finally, new materials, coating and fibers are being developed that will directly improve the performance and/or lifetimes of DoD systems and components.

(U) Program Plans:

- Demonstrate and validate mathematical models and other critical technical issues for the accelerated insertion of materials that will allow designers to cut the insertion time of new materials by over 50 percent using materials of high value to DoD (turbine metals, aircraft structures).

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- Explore techniques for large volume, low cost synthesis and assembly of nanomaterials and nanotubes with controlled attributes that are suitable for high toughness fibers and reinforcements; demonstrate these reinforcement concepts in structural composites in defense applications such as advanced blast and ballistic damage tolerance.
- Demonstrate novel, cost effective processing routes for aerospace grade (low oxygen) titanium metal and alloys. Explore processing routes for other structural materials of interest to defense.
- Develop and demonstrate manufacturing technologies that can lead to significant reduction in DoD system cost, especially for low volume.
- Demonstrate novel and reproducible process routes for directed, localized and controlled microstructure modification to achieve substantial improvements in structural material properties of interest to defense, including bronze castings for Navy applications.
- Develop and verify models that predict bulk amorphous metal formation and behavior; use these models to produce amorphous materials and coatings with superior properties (including increased fracture toughness and high strain rate behavior and long-term corrosion resistance in saline environment) over crystalline material.
- Demonstrate structural materials fabrication (forming, joining, etc.) technologies that yield bulk amorphous metals suitable for defense applications, including composites for space applications with 25% reduction in weight and 50% increase in specific properties and aluminum based amorphous alloys for turbine blade applications.

	FY 2006	FY 2007	FY 2008	FY 2009
Multifunctional Materials and Structures*	7.400	17.233	25.500	26.000

*Previously this was part of Structural Materials

(U) The Multifunctional Materials and Structures thrust is developing approaches for producing materials and structures that are explicitly tailored for multiple functions and/or unique mechanical properties. Included in this thrust are efforts that will lower the weight and increase the performance of aircraft, ground vehicles, blast/ballistic protection and spacecraft structures. This includes new approaches for topologically controlled armor and new structural designs aimed at defeating explosively formed projectiles (EFPs).

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(U) Program Plans:

- Develop multifunctional materials concepts designed to provide significant improvement in the capabilities of defense systems by providing additional functions (e.g., self-healing, thermal control, blast protection, and power) to load bearing structures, quantify their performance and fabricate specific prototype systems.
- Develop a low cost, protective system based on novel material structures and topology to protect troops and trucks against ballistic threats, shrapnel and blasts from improvised explosive devices.
- Establish and demonstrate up to 20% performance improvements and engine durability of high performance gas turbine engines based on vaporization cooling.
- Demonstrate that nano boron carbide powders can be pressurelessly sintered to produce armor exceeding the Level IV Department of Justice (30 cal AP) standard but at a lower cost and with the ability to produce complex shapes for greater comfort and protection.

	FY 2006	FY 2007	FY 2008	FY 2009
Prognosis*	19.559	10.669	12.000	12.000

*Previously this was part of Structural Materials

(U) The Prognosis thrust is aimed at demonstrating a revolutionary new concept that uses 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 aircraft structures and engines for advanced jet aircraft. Also included are sensor and model development required to support the damage prediction.

(U) Program Plans:

- Develop models, mathematical techniques and novel sensors that when integrated with sensor data will capture the physics of failure and behavior prediction in materials suitable for assessing in-situ damage accumulation and will also provide current state awareness and structural performance prediction for defense systems.
- Demonstrate the use of flight information to predict life and failure of critical structural components thereby increasing the useful life by five times.

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	FY 2006	FY 2007	FY 2008	FY 2009
Smart Materials*	13.344	15.968	21.000	21.000

*Previously this was part of Smart Materials and Actuators

(U) This thrust is developing the next generation of smart materials for application in new DoD systems. Included in this thrust are concepts to yield "intrinsically smart" materials that provide self-diagnosis and/or self-repair. Also included are approaches to demonstrate the ability to dramatically change the structural and/or electromagnetic properties of a material in real time. Finally, new smart materials that are inspired by nature that can move rapidly, but with high force will be demonstrated.

(U) Program Plans:

- Develop and demonstrate novel fluidic and mechanical devices, and their associated driving electronics that exploit smart material transducers in order to create new high power actuators for a variety of military applications.
- Demonstrate that nano-tubes applied to a surface can diminish the heat transfer linkage between the thin boundary layer that surrounds a high speed vehicle and the heat flux into the vehicle, thereby providing a low weight, thermal barrier.
- Develop new materials that will intelligently adapt properties (e.g., modulus, strength) in response to the environment.
- Demonstrate that materials systems based with distributed force and displacement capability can produce large forces at moderate bandwidth such as helicopter blades.
- Develop technologies to create multifunctional surfaces that exhibit the desired and critical characteristics specifically designed for improving surface structural and electromagnetic properties.
- Develop chemical systems that are able to transmit optical signals at stand-off distances.

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	FY 2006	FY 2007	FY 2008	FY 2009
Reconfigurable Structures*	14.000	22.000	21.234	18.064

*Previously this was part of Smart Materials and Actuators

(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.

(U) Program Plans:

- Design, demonstrate, and validate an integrated, untethered, and self-powered exoskeleton system for augmenting the locomotion and strength of soldiers. The interface of the machine and human will be dramatically enhanced by the development of novel sensor architectures and control algorithms.
- Demonstrate capabilities of the exoskeleton against specific military metrics and transfer to the Army.
- Develop, design, and test the actuators, materials, and control architectures necessary for achieving precise shape change in an airframe to demonstrate the advantages and enable capabilities afforded by the ability to change shape (morphing).
- Demonstrate capabilities of morphing aircraft technology in a wind tunnel.
- Develop new technologies that enable reversible adhesion with adhesive strengths greater than 1 Mega Pascals (MPa).
- Develop a rapidly deployable and reversible, portable lightweight barrier to control enemy mobility in urban areas such as intersections, alleyways, doorways, etc.
- Develop and demonstrate key smart materials technologies for plasma fueled and turbulence harvesting aircraft, including low power magnetic structures and the ability to reconfigure electromagnetic fields. Develop ultra-light high temperature capability for hypersonic vehicles using novel approaches to enable reduced thermal load, boundary layer control and virtual shape control.
- Leverage new materials concepts to develop new climbing devices and techniques that will enable quick and easy access to upper floors and rooftops of buildings.
- Develop soft chemically based materials with the ability to drastically change shape, reconfigure, and perform function.

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	FY 2006	FY 2007	FY 2008	FY 2009
Functional Materials and Devices	36.855	25.000	29.399	29.250

(U) In this thrust, new materials and concepts are being applied to the development of functional materials and devices. A fundamental principle 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. Among the materials being developed in this thrust are new permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings and actuators. Engineered materials (metamaterials) are being developed that provide dramatically new electromagnetic behavior across the complete array of Defense applications. Also, this thrust exploits nanostructured materials to slow light, to produce negative index materials as well as to demonstrate an array of other functional devices (antennas, dosimeters, etc.).

(U) Program Plans:

- Develop and demonstrate novel magnetic meta-materials for DoD motor applications including: 1) high temperature, high strength soft magnetic materials for rotor and stator applications in turbine environments; and 2) permanent magnets with superior energy products.
- Develop and demonstrate novel microwave meta-materials that will enable novel antenna and radar designs with reduced size and improved bandwidth and efficiency.
- Develop and demonstrate novel materials that can be remotely switched between two stable electromagnetic and/or structural configurations, including munitions with controllable sensitivity.
- Extend the frequency of operation and/or operational bandwidth of "negative index" or "left handed" materials to demonstrate novel radio frequency (RF) and optical applications for Defense. Specific demonstrations include the reduction of ultra-high frequency (UHF) antenna size by a factor of 20 with no loss in gain and approaches for sub-wavelength focusing at infrared (IR) wavelengths.
- Develop new functional materials and devices that slow light pulses, resulting in opportunities such as tunable delay lines for optical signal processing, high-speed RF signal processing applications, and single-photon quantum devices.
- Develop high-efficiency nanostructure antenna elements and evaluate overall performance when combined into an antenna array.
- Demonstrate electric field independence and low loss electrodes.
- Select and optimize novel heterostructures capable of defining the region of photonic sensitivity.

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– Design materials and device architectures for a flexible wearable platform that records the real-time exposure to traumatic blast pressures due to an explosion.

	FY 2006	FY 2007	FY 2008	FY 2009
Materials for Power*	19.400	15.552	19.000	21.000

*Previously this was part of Materials for Logistics (Air, Water, Power)

(U) The Materials for Power 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 of portable fuel cells as well as the exploitation of nanotechnology to increase the efficiency and lower the weight of batteries. New materials and designs will also be applied to the development of novel mesoscale engines (e.g., Stirling, water lubricated steam engines) that will provide needed power on the battlefield. 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, as well as approaches to generate energy directly from heat. Finally, solar cells will be developed that will demonstrate at least 50% efficiency in an affordable, manufacturable photovoltaic (PV) device through the development and fabrication of novel components such as device-grade quality PV materials, electronic doping, nanostructure process control, and the integration of the process capabilities with current micro- and nano-fabrication tools.

(U) Program Plans:

– Develop and demonstrate in a real military environment an efficient, low cost, 400 Watt Stirling engine for Defense applications, including powering of small, motorized vehicles.
– Design, develop, and demonstrate robustness of portable power sources in the 20 Watt power range suitable for several mission scenarios including: 1) a three hour micro air vehicle reconnaissance mission; 2) a three day land warrior mission; and 3) a ten day special operation forces mission.
– Demonstrate the design of lightweight, rugged packaging and power control strategies for man-portable fuel cells that will allow robust, orientation invariant operation throughout a military mission and demonstrate this capability in concert with military transition partners.
– Demonstrate concepts for highly power-dense, man-portable kilowatt generators that will reduce the logistics burden for the soldier in the field.

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- Demonstrate materials and components for a hybrid superconducting power system for a terrestrial (>5 MW) application that has high efficiency and reliability and the potential for significantly reduced size (10x) and weight (5x).
- Develop and demonstrate enabling direct thermal to electric conversion technologies with potential for high (> 20%) conversion efficiencies and high (> 1 W/cm^2) power densities for DoD and commercial power generation applications.
- Demonstrate efficiency of solar cell optics and converter technologies in high, mid, and low energy photon environments.
- Demonstrate an integrated solar cell of at least 10 cm^2 area, delivering 500 W/m^2.
- Develop novel concepts for extremely high efficient solar cells (>50%) and novel solar cell configurations for battlefield deployment.
- Increase energy/power density for same weight/volume enabling 15lb weight reduction for dismounted soldier on 3-day mission.

	FY 2006	FY 2007	FY 2008	FY 2009
Alternate Power Sources*	15.300	26.980	27.000	27.000

*Previously part of Materials for Logistics (Air, Water, Power)

(U) The Alternate Power Sources thrust is examining novel approaches to obtaining power in the battle environment. This included an effort to demonstrate the feasibility of open ocean, littoral and freshwater prototype fuel cell systems, capable of generating continuous, unattended electrical power for greater than 10 years. Also being developed are concepts to covert military waste (plastic, paper, food) directly into energy at over 90% conversion efficiencies. Additionally, this thrust is exploring longer term, higher risk approaches to obtaining and using energy. A pathway to self-sustainable agriculture-sourced production of an alternative to petroleum-derived JP-8 that will meet all DoD needs will be investigated to achieve a 60% (or greater) conversion efficiency, by energy content, of crop oil to JP-8 surrogate and elucidate a path to 90% conversion.

(U) Program Plans:

- Demonstrate processes that can convert military waste directly into usable power for the military.
- Exploit advances in nanotechnology to achieve battery systems with a 3X increase in energy density to 400 Watt hours/kg, and a 5X increase in power density to 1000 Watt/kg with a 30% decrease in weight.
- Explore unconventional power sources that might yield new, efficient approaches to providing power to the battlefield.

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- Establish techniques for suppression of neutron and gamma emission in compact alpha emitter nuclear power generators (a safety issue) and verify methods for suppression of radiation-induced damage in nuclear energy converter mechanisms.
- Designed, fabricated and tested laboratory models for sediment mounted and water column microbial fuel cells.
- Designed, fabricated and tested preliminary sediment mounted and water column microbial fuel cells.
- Developed preliminary models for estimating power output as a function of microbial speciation and chemical reductant/reactant concentrations.
- Design, develop, and demonstrate a process pathway for >60% conversion (by energy) of crop oil to jet fuel surrogate.
- Elucidate a path to 90% conversion of crop oil to jet fuel surrogate.

	FY 2006	FY 2007	FY 2008	FY 2009
Long Duration Power Concepts*	7.923	8.500	11.000	15.000

*Previously this was part of Materials for Logistics (Air, Water, Power)

(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 efficiently removing the energy at rates commensurate with the high sprint power often required in these applications.

(U) Program Plans:

- Develop novel power components (e.g., fuel cells, structural batteries) that have the potential for demonstrating energy densities in the range of 1000-1500 Watt-hours per liter (W-hr/l) for UUV applications.
- Demonstrate a 300% increase in small UAV endurance by harvesting solar thermal energy conversion to efficient propulsive power.

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	FY 2006	FY 2007	FY 2008	FY 2009
Strategic Materials	2.550	4.000	0.000	0.000

(U) Program Plans:
- Development continued on reliable, robust, repeatable, and cost effective Chemical Vapor Composite (CVC) SiC manufacturing process for high tech military, space, and industrial applications.

	FY 2006	FY 2007	FY 2008	FY 2009
Water Harvesting Technologies	2.377	0.000	0.000	0.000

(U) Program Plans:
- Developed and demonstrated unique, energy-saving concepts for obtaining water from non-traditional sources (e.g. water-from-air), for the individual warfighter and small groups of soldiers.

	FY 2006	FY 2007	FY 2008	FY 2009
MMI/MBI Nanotechnology Solutions	0.400	0.000	0.000	0.000

(U) Program Plans:
- Investigated new approaches and accelerated the research of leading-edge nano-scale technologies for potential Defense applications.

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	FY 2006	FY 2007	FY 2008	FY 2009
Characterization, Reliability & Applications of 3-D Microstructures	1.800	0.000	0.000	0.000

(U) Program Plans:

– Continued the development of key technologies behind a packaging concept that used a stacked multi-chip module approach to reduce interconnect length and increased physical connectivity between layers of electronics.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research			R-1 ITEM NOMENCLATURE Materials & Biological Technology PE 0602715E, Project MBT-02					
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Biologically Based Materials and Devices MBT-02	108.448	129.095	110.590	102.549	85.335	95.335	95.335	95.335

(U) Mission Description:

(U) This 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 materials synthesis. It also supports a major thrust that will revolutionize the development of prosthetics for wounded soldiers.

(U) Program Accomplishments/Planned Programs:

	FY 2006	FY 2007	FY 2008	FY 2009
Bioinspired Locomotion and Sensing*	31.193	33.000	21.620	15.214

*Previously this was part of Bioinspired and Bioderived Materials

(U) The Bioinspired Locomotion and Sensing thrust explores approaches to capture the biological systems' ability to move and sense and emulate these in man-made robotic or sensor systems. This includes providing robotics with the mobility required to provide support to soldiers in all terrains, including climbing. This thrust also includes a program to develop synthetic optics that mimics the advantages and adaptability of biological lenses and sensors that can detect infrared (IR) and vibration at biological levels, which are far below that of current man-made detectors.

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(U) Program Plans:

- Explore new bioinspired locomotion in robotic systems and develop power efficient, systems-level bio-locomotion for mobility in rough/loose terrain and in unusual locomotion environments, i.e., vertical (>60°) and inverted surfaces.
- Demonstrate biomimetic sensory prototypes and materials that collect electromagnetic olfactory and visual inputs.
- Develop signal transduction technology that directly converts biological macromolecular activity (sensing/binding/conformation changes) into an appropriate electrical or optical signal output for the development of biomimetically based sensors (uncooled IR, optical, etc.).
- Develop material systems based on biological principles that distribute the force and displacement capability of a hydraulic system continuously throughout a structure. Demonstrate these materials in systems that require large forces at moderate bandwidth such as helicopter blades.
- Develop new biomimetically based swimming devices that will double the speed for combat swimmers, including SEALS and Marines, while decreasing energy consumed by a factor of eight.
- Develop new materials that will allow the demonstration of lightweight, compact, bio-inspired optical devices. Demonstrations will include a 30x zoom lens of a size to fly on the Pointer unmanned air vehicle (UAV) and a variable field of view (90-180 degrees) lens that will fly on the Dragon Eye UAV.
- Define new, malleable materials that utilize biomimetic principles of design (e.g., emulate skin, bone, muscle, nerve endings and self-repair features) for locomotion and actuation.

	FY 2006	FY 2007	FY 2008	FY 2009
Bioderived Materials*	14.000	15.000	19.000	19.000

*Previously this was part of Bioinspired and Bioderived Materials.

(U) The Bioderived Materials thrust explores the use of biological materials to support Defense needs. This includes using biological systems (e.g., plants) directly as sensors as well as exploiting the work and energy harvesting capabilities of biological motors.

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(U) Program Plans:

- Developed an initial understanding of fish (bony and elasmobranch) sensory and sensory-motor capabilities to provide the basis for developing associated biomimetic sensor systems.
- Developed a preliminary understanding of basic sensory and motor responses using both external and internal stimulation.
- Determine and quantify the mechanism of motor function, motor performance, and efficiency for several types of biomolecular motors through computational models and experimental measurements.
- Demonstrate the utility of biomotors for specific DoD applications including high sensitivity biosensors, high efficiency solar cells and the emulation of natural muscle activity.
- Exploit stealthy sentinels, including the development of critical materials/device interfaces to address teleoperation and autonomous navigation, for their ability to be remotely guided to operationally relevant sites and generate environmental information (chemical, biological, and visual).
- Leverage naturally occurring plants to enable long duration, unattended sensors including camouflaging the device/antenna and extracting energy.

	FY 2006	FY 2007	FY 2008	FY 2009
Maintaining Combat Performance*	21.770	27.777	20.000	19.061

*Previously this was part of Biochemical Materials

(U) The Maintaining Combat Performance thrust utilizes breakthroughs in biology, physiology, and neuroscience 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°F to 125°F), oxygen deficiency in mountains, personal loads in excess of 100lbs, dehydration, psychological stress, prolonged periods without adequate sleep or nutrition, 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 balance of the warfighter's complex duties requires constant peak physical and mental performance. 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

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approach for soldier cooling, which is now being evaluated by troops in the far forward combat areas. Another example is research on the fundamental neurophysiologic causes of cognitive deterioration following sleep deprivation; this research has led to safe nutritional and training approaches that promise to minimize the adverse effects of short-term sleep deprivation, which is an inherent component of current operational scenarios.

(U) Program Plans:

- Develop prototype threat-warning devices by integrating electronics imaging systems with in-line bio-derived image processing algorithms.
- Implement new non-invasive biological sensors to create practical, prototype devices for using neurological signals to improve the throughput and accuracy of intelligence imagery analysis.
- Develop safe dietary formulations that are effective at maintaining the health of troops in combat.
- Develop methods for regulating core body temperature so that physical performance is maintained during training and in extreme combat environments.
- Develop an understanding of the biochemical and physiological causes of decreased cognitive performance during sleep deprivation through studying animal model systems, synaptic function, and transcranial magnetic stimulation (TMS).
- Demonstrate and validate approaches to develop biomaterials and other concepts that extend the cognitive performance capabilities of warfighters during extended periods of sleep deprivation and stress.
- Demonstrate physiological approaches to enable warfighters to conduct operations at high altitudes without prolonged altitude acclimatization.
- Develop and validate approaches that will restore the function of auditory structures injured by blast and other acoustic insults.
- Develop medical technologies that improve the effectiveness of battlefield pain management, without risk of overdose.
- Develop and validate methods for selectively reducing metabolic requirements following severe blood loss in order to extend the period of survival.
- Demonstrate induced desiccation strategies for platelets that allow prolonged periods (> 24 months) of dry storage with recovery of all critical clotting functions when rehydrated.

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	FY 2006	FY 2007	FY 2008	FY 2009
Tactical Biomedical Technologies*	18.485	22.318	21.590	22.000

*Previously this was part of Biochemical Materials

(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. Ultimately, this thrust will develop and demonstrate tele-robotic, semi-autonomous trauma pods that will bring life-saving surgical care directly to the front lines. 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, like an active battlefield. And 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. Overall, this thrust recognizes the unique medical and surgical needs of warfighters, and will develop innovative technologies to save warfighters lives and restore their function to normal.

(U) Program Plans:

- Develop a lightweight version of the Life Support for Trauma and Transport (LSTAT) portable intensive care platform with innovative technologies to make the system available in the far forward battlefield for combat casualty care of wounded soldiers.
- Define and demonstrate new operating room technologies for the battlefield that reduce the need for operating personnel.
- Develop and demonstrate devices to locate and coagulate bleeding using focused acoustic energy.
- Develop a device to allow automatic insertion of an intravenous catheter in a battlefield environment, even by unskilled personnel.
- Develop novel biochemical feedback mechanisms and nanotechnology-based delivery systems to create a feedback regulated battlefield drug delivery system.
- Extend 3-D imaging approaches to a virtual autopsy capable of a more rapid and accurate post mortem wound assessment.

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- Develop new bio-mechanical technologies that will significantly enhance the growth of bone in limbs injured by blast and fragmentation.
- Demonstrate the ability of plasma (ionized gases) to sterilize wound sites and battlefield medical devices.
- Develop technologies for the assessment of oxygen saturation, blood pressure, heart rate, EEG, respiratory rate, and temperature from a distance of one meter in a simulated battlefield environment.
- Develop a cognitive rehabilitation environment and explore techniques to dramatically decrease the time from battlefield injury to return to the unit.
- Develop a transportable Magnetic Resonance Imaging (MRI) system capable of field deployment to in-theater Combat Support Hospitals (CSHs) for diagnosis and assessment of traumatic brain injuries (TBI) to front-line soldiers, sailors, and airmen.

	FY 2006	FY 2007	FY 2008	FY 2009
Bio-Magnetic Interfacing Concepts (BioMagnetICs)	6.000	4.000	2.000	1.000

(U) The Bio-Magnetic Interfacing Concepts (BioMagnetICs) Materials program will develop and demonstrate novel capabilities for integrating nanomagnetics with biology and will demonstrate the advantages of magnetics as a powerful new transduction mechanism for detecting, manipulating, and controlling biological function in single cells and biomolecules. The state-of-the-art research "tools" that have allowed researchers to observe the most fundamental units of biology (cells, DNA, proteins, etc.) do not possess the resolution, precision, or high throughput capacity to enable manipulation and/or functional control of large numbers of cells and biomolecules. Such a capability would have a pervasive and paradigm shifting impact on future military and civilian applications of biotechnology including chem-bio detection, therapeutics, and medical diagnostics. Nanoscale magnetics offers the promise of a robust, non-invasive, non-destructive, multiplexing, and high throughput interface that is compatible with the nanometer scale at which the biochemistry of cellular function exists.

(U) Program Plans:

- Develop and demonstrate a portable, magnetics-based DNA detection and readout capability for rapid determination of specific biological warfare agents.
- Develop and demonstrate remotely addressable, magnetics-based biochemical sensors.

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- Develop the capability to use magnetics to rapidly filter biotoxins from humans.
- Conduct "Proof of concept" demonstrations of the potential for portability and compact packaging of BioMagnetICS based sensor and diagnostic devices.

	FY 2006	FY 2007	FY 2008	FY 2009
Revolutionizing Prosthetics	15.000	25.000	23.500	22.000

(U) The goal of this program is to dramatically change the state of the art of 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—essentially switches. This makes it difficult for wounded soldiers to return to military service. The needed advances will be accomplished by exploiting the dramatic breakthroughs of the Human Assisted Neural Devices program (PE 0601101E, Project BLS-01) as well as advances in biointerfaces, structural and smart materials, microelectronics and MEMS, and information sciences.

(U) Program Plans:

- Demonstrate the ability to implement brain/neural control with sensory feedback in a control architecture that combines the kinetics and mechanics (degrees of freedom) of natural movement, including the realization of proprioception and reflex activity.
- Develop and demonstrate new materials, microprocessors, sensors and actuators that are both biocompatible and emulate form, function and response of natural biological limbs.
- Develop and demonstrate new distributed power sources that greatly improve the longevity of limb operation.
- Develop and demonstrate new approaches to limb healing and prosthetic integration that will dramatically decrease healing time and alleviate the discomfort of wearing prosthetic devices.
- Demonstrate a neurally controlled prosthetic limb that has the full functionality of a natural limb and transition to Walter Reed Medical Center.

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	FY 2006	FY 2007	FY 2008	FY 2009
Biodemilitarization of Munitions	0.000	0.000	2.880	4.274

(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 explosive IEDs will be greatly reduced. Chemical and biological technologies and control processes will be developed that will rapidly perforate munition casings and alter the explosive fill. The perforation and explosive alteration technologies will be integrated into a fieldable system and tested against munitions stockpiles.

(U) Program Plans:
- Investigate technologies, for rapidly perforating diverse types of munitions casings.
- Investigate technologies for rapidly inactivating diverse types of explosive fill.
- Develop mathematical models that describe the perforation and inactivation technologies.
- Integrate technologies into a prototype system.
- Test system against explosive munitions with 155 mm projectiles.
- Develop prototype fieldable system.
- Test system against munitions stockpiles.

	FY 2006	FY 2007	FY 2008	FY 2009
Bio-Fabrication (B-FAB)	2.000	2.000	0.000	0.000

(U) The Bio-Fabrication (B-FAB) program will demonstrate the feasibility of using biochemical processes as a new nanofabrication toolset to synthesize and manufacture chemicals, materials, and devices of high value to the DoD. Such approaches would be useful as part of the nanostructure for highly efficient solar cells. Other targets for demonstration within this program include scalable technologies for opto-electronic materials and devices, mechanical materials, and site-directed-synthesis.

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(U) Program Plans:

- Develop bioenabled routes for the fabrication of relevant electronic, optical, or structural materials.
- Demonstrate the essential capacity for the fabrication of the materials at the scale of interest (2-20nm range control).
- Develop computational, fabrication, and process control tools for the design, manipulation, and optimization of the bioprocess or bio-pathway with the target properties necessary for the fine-scale manipulation of bio-fabrication.
- Develop and demonstrate the capability to produce bio-fabricated materials with chemically and/or spatially modulated properties, possibly including controlled doping (n-type, p-type), stacked nano-layers, quantum dots, or 3-D articulated structures in a candidate electronic, optical, or mechanical device material.
- Demonstrate the integrability of bio-fabrication processes with current fabrication and/or micro-fabrication toolsets.
- Design, develop, and demonstrate integrated bio fabricated electronic, optical, or mechanical devices with improved or otherwise unattainable performance or cost characteristics.

(U) Other Program Funding Summary Cost:

- Not Applicable.