Exhibit R-2, PB 2010 Office of Secretary Of Defense **RDT&E Budget Item Justification**	**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development

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	22.392	23.598	23.276						Continuing	Continuing
P225: Joint DOD/DOE Munitions	22.392	23.598	23.276						Continuing	Continuing

A. Mission Description and Budget Item Justification

The mission of the Joint Department of Defense (DoD)/Department of Energy (DOE) Munitions Technology Development Program (JMP) is to develop advanced technologies needed to meet warfighting needs and bring about major improvements in non-nuclear munitions. A Memorandum of Understanding (MOU) between DoD and DOE provides the basis for the long-term commitment to this effort. Under the auspices of the JMP, the fusion of DOE technologies with Joint Services needs has provided major advances in warfighting capabilities for many years and continues to play a crucial role in the exploration, development, and transition of new technologies needed by the Services. The JMP is aligned with Department strategic plans such as the key capability gaps and CoCom (needs consistent with the Research and Engineering (R&E) Metrics for Force Development and is developing needed munitions capabilities and modeling tools for urban combat and counter-terrorism efforts. The JMP provides a proven and successful mechanism for the collaboration of DoD and DOE scientists and engineers so they can develop technologies of interest to both Departments, within a structured framework of technical reviews and scheduled milestones. The JMP has strong support from the Services through the leadership by DoD lab managers and technical experts of JMP technical activities and in collaborations on the transition of new capabilities to industry. This interdepartmental cooperation makes use of the substantial historic investment in scientific resources by the DOE, and the budgeted JMP funds represented in this justification are supplemented by matching DOE funds.

A summary of recent JMP accomplishments and transitions is provided below; detailed technical plans, reports, and presentations are also available. Endorsements from DoD labs indicate a strong history of JMP accomplishments and significant Return on Investment (ROI). The Army's Picatinny Arsenal has stated that modeling and simulation (M&S) tools developed by the JMP are now routinely used to design all new warheads, and the use of these tools has reduced the number of validation tests required for each new warhead from about 5 to 1, resulting in substantial savings. The Army's Army Research Laboratory has demonstrated unprecedented times to deploying new armor solutions to Iraq Theater of Operation (ITO) employing M&S tools developed by the JMP. Compared to recent JMP investments in these M&S tools, an ROI of about 3 can be estimated for these warheads alone, and the tools continue to be used.

Over the last several years, there has been increased emphasis on developing technologies of value to counter-terrorism efforts and Military Operations in Urban Terrain (MOUT). Initial successes have already emerged from this JMP focus, with some products already in the field. A new and rapidly emerging JMP technology which employs Multiphase Blast Explosives (MBX) will enable the use of precision lethality munitions in urban settings with minimal collateral damage. Based on modeling and technologies developed by the JMP, preliminary tests of MBX integrated in a composite case successfully demonstrated minimum collateral damage. In a related activity, the Air Force and the Navy are pursued a Joint Capability Technology Demonstration Program (JCTD) to incorporate MBX technology into the Small

Exhibit R-2, PB 2010 Office of Secretary Of Defense **RDT&E Budget Item Justification**	**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development

Diameter Bomb (SDB) Focused Lethality Munition. Boeing delivered initial weapons for operational assessment, based on these technologies originating from the JMP in FY 2008.

Other JMP transitions include several diverse transitions of the mini Synthetic-aperture radar (SAR)/Microsystems Enabled Scalable Array SAR (MESASAR)-based technologies from defense to science. Two specific DoD transitions include a Unmanned Aerial Vehicle (UAV)-based application and a demo/study for a version of miniSAR being used as a gunship radar upgrade. Cheetah, an advanced themochemical predictive code, developed with JMP funds, reached a milestone with the recent release of version five. This code is used by over 400 DoD and DOE scientific and engineering staff to study and select energetic materials for modern munitions. Further, all new fuze designs being developed by DoD and DOE utilize technologies such as highly compact capacitors, transformers, and sensors developed by the JMP. In addition, state-of-the-art robotic and machine vision discrimination technologies are being successfully applied to munitions demilitarization programs and are being prototyped on several systems, most recently transitioned for a Cluster Bomb Unit (CBU) Download Workcell. A major update to the Constitutive Properties and Constitutive Modeling database was released across the DoD and DOE including data and model parameters for a range of classic and advanced material models for metals and metal alloys, energetic materials, and polymers. New releases of the shock physics code ALE3D and CTH-PRESTO were delivered to the DoD user base and for the Beta Tests under the DoD's High Performance Computing Modernization Office (HPCMO) Multiphase Flow, Target Response (MFT) Portfolio.

The integrated DoD and DOE efforts within the JMP are speeding the realization of new technologies through the advanced development process. The highly challenging technical objectives of the approximately 50 JMP projects require multi-year efforts, and sustained, long-term investments are necessary to achieve success. The JMP is a focal point for collaborative work by over 260 DoD and DOE scientists and engineers, and has been called a model of how the Departments should cooperate, both within their respective organizations (intradepartmental) and with each other (interdepartmental). The JMP also works aggressively, through the Defense Ordnance Technology Consortium (DOTC), to inform industry of the technologies and tools being developed so that they can be transitioned equitably and efficiently for use by our warfighters as quickly as possible.

Projects in the JMP are organized in five munitions technology focus areas. They are: Initiation, Fuzing, and Sensors; Energetic Materials; Computational Mechanics and Material Modeling; Warhead & Penetration Technology; and Munitions Lifecycle Technologies. These focus areas are described more fully in the accompanying R2a project exhibit.

Exhibit R-2, PB 2010 Office of Secretary Of Defense RDT&E Budget Item Justification	DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	23.284	23.727	23.701	
Current BES/President's Budget	22.392	23.598	23.276	
Total Adjustments	-0.892	-0.129	-0.425	
Congressional Program Reductions				
Congressional Rescissions		-0.129		
Total Congressional Increases				
Total Reprogrammings	-0.249			
SBIR/STTR Transfer	-0.643			
Other			-0.425	

Exhibit R-2a, PB 2010 Office of Secretary Of Defense **RDT&E Project Justification**									**DATE:** May 2009	
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)				**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development					**PROJECT NUMBER** P225	
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**
P225: Joint DOD/DOE Munitions	22.392	23.598	23.276						Continuing	Continuing

A. Mission Description and Budget Item Justification

The Joint Department of Defense (DoD)/ Department of Energy (DOE) Munitions Technology Development Program (JMP) is a collaborative, jointly-funded effort between DoD and Department of Energy (DOE), which has the mission to develop new and innovative warhead, explosive, initiation, and lifecycle technologies, as well as enabling tools, in order to bring about major improvements in non-nuclear munitions. The JMP supports the development and exploration of advanced munitions concepts and enabling technologies which precede system engineering. Through a Memorandum of Understanding (MOU) arrangement with DOE, DoD resources are evenly matched. More importantly, this relatively small DoD contribution effectively taps the annual multi-billion dollar DOE Research, Development, Test, and Evaluation (RDT&E) investments by accessing technical experts with highly specialized skills, advanced scientific equipment, unique facilities, and computational tools not available within DoD. These efforts take advantage of the extensive and highly developed technology base resident in the DOE National Laboratories relevant to achieving the JMP goals of developing capable, cost-effective, conventional munitions.

The JMP is aligned with Department strategic plans such as the key capability gaps and CoCom needs consistent with the Research and Engineering (R&E) Metrics for Force Development and is developing needed munitions capabilities and modeling tools for urban combat and counter-terrorism efforts. The JMP provides a proven and successful mechanism for the collaboration of DoD and DOE scientists and engineers so they can develop technologies of interest to both Departments, within a structured framework of technical reviews and scheduled milestones. The JMP has strong support from the Services through the leadership by DoD lab managers and technical experts of JMP technical activities and in collaborations on the transition of new capabilities to industry.

The JMP currently supports about 50 projects which can be summarized in five technical focus areas: Initiation, Fuzing, and Sensors; Energetic Materials; Computational Mechanics and Material Modeling; Warhead and Penetration Technology; and Munitions Lifecycle Technologies. The JMP is administered and monitored by the Office of the Secretary of Defense (OSD), and reviewed annually by the Technical Advisory Committee (TAC) composed of over 25 senior executives from the Army, Navy, Air Force, Special Operations Command, the Defense Threat Reduction Agency (DTRA), OSD, and DOE. Projects are organized in ten Technology Coordinating Groups (TCGs) in order to bring together the disciplines necessary to properly evaluate technical content and progress. DoD Service laboratory technical experts lead each of the Technology Coordinating Groups to ensure that the technologies under development address high priority DoD needs; they also coordinate the semi-annual technical peer-review process.

Please see the corresponding R2 exhibit for additional JMP background information and accomplishments. More details about each of the technical focus areas are described below in the Accomplishments/Planned Program sections.

Exhibit R-2a, PB 2010 Office of Secretary Of Defense **RDT&E Project Justification**		**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Joint DOD/DOE Munitions / Computational Mechanics and Material Modeling	7.605	8.774	8.698	

In the area of Computational Mechanics and Material Modeling, the Joint Department of Defense (DoD)/ Department of Energy (DOE) Munitions Technology Development Program (JMP) is developing the ability to accurately predict the behavior of weapons in operating environments of extreme pressure, temperature, and velocity. This capability is essential to the development of lethal, accurate, and cost effective systems. To meet the needs of the DoD and DOE communities, there is a requirement for validated models using high-performance computing hardware and software that are capable of carrying out a broad class of continuum mechanics simulations where shock waves, nonlinear dynamics, and multi-materials gas dynamics are important. In particular, this aspect of the JMP focuses on significant improvements to material models that accurately represent the materials of interest in dynamic states coupled with numerical and algorithmic improvements to enhance our problem-solving capabilities for munitions development, advanced energetics, and target lethality predictions.

Four general classes of modeling codes offer solutions to the varied requirements posed by the defense community for the shock analysis regime. Eulerian shock physics tools are effective for a large number of conventional weapons and advanced energetics-related simulations. In situations where there is significant material deformation and turbulent mixing, Eulerian formulations are the most efficient. A second class of codes addresses the large, nonlinear dynamics that can be important for weapons design and development. Such Lagrangian calculations provide design information that complements information provided by the Eulerian shock physics codes. For example, many penetration problems involve detailed structural mechanics that are not appropriate for Eulerian codes but can be addressed by Lagrangian methods. A third class of tools combines these capabilities by using Arbitrary Lagrangian-Eulerian (ALE) algorithms to solve the conservation equations appropriate for shock analysis. This class of codes performs a range of simulations such as penetration mechanics, thermal cook-off, and fragment impact, where multi-physics phenomena descriptions are required across a wide range of time scales that cannot be addressed adequately with either Eulerian or Lagrangian codes. These ALE codes and associated validated material models represent the future in modeling complex dynamics encountered in a broad spectrum of applications across the defense community. Meshless Particle Techniques such as the Dual Particle Dynamics (DPD) Code have been under development for several years. Particle codes

Exhibit R-2a, PB 2010 Office of Secretary Of Defense **RDT&E Project Justification**		**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
are particularly effective for problems with severe distortions, damage, and failure, phenomena that can be problematic to capture with the workhorse Lagrangian codes. The Department's utilization of these capabilities has primarily been in the Science and Technology (S&T) community. It is desirable to extend the use of modeling and simulation tools into the engineering design community, and the JMP is pursuing this objective and continues to provide and enhance these advanced modeling tools. *FY 2008 Accomplishments:* Include distribution of a major update to the Constitutive Properties and Constitutive Modeling database across the DoD and DOE. The database included nearly 4500 files of reports and material pedigree, raw test data, and model parameters for a range of classic and advanced material models for metals and metal alloys, energetic materials, and polymers relevant to the DoD and DOE. New code releases (ALE3D and CTH-PRESTO) were delivered to the DoD user base and for the Beta Tests under the DoD's High Performance Computing Modernization Office (HPCMO) Multiphase Flow, Target Response (MFT) Portfolio. The development of Eulerian, Lagrangian, ALE, and meshless codes relevant to the design and evaluation of munitions continued. CTH, a workhorse shock physics code developed by the JMP, is used everywhere from desktop PC's to massively parallel High Performance Computing (HPC) centers across the community. It is the number 1 "go-to" hydrocode for the weapons community, and has been instrumental in the development of a number of DoD weapon systems. CTH continues to be improved and made available to both Departments. Development also continued on the improvement and demonstration of ALE3D, a multi-physics code. Progress continued in the cross DOE laboratory implementation of formalisms for treating anisotropic plasticity in metal and viscous damage in energetic materials into ALE3D and CTH. The JMP also provides a conduit into the DoD for the improved materials models emerging from the DOE Advanced Simulation and Computing Program (ASC), providing high resolution, accurate predictions of materials behavior and failure relevant to the analyses of weapon systems. In 2008 modeling and simulation tools transitioned out of the JMP played important roles in a number of DoD activities related to Global War on Terrorism (GWOT) and Iraq Theater of Operation (ITO). The transition and support for these tools and models, along with user training, were provided to the DoD community.				

Exhibit R-2a, PB 2010 Office of Secretary Of Defense RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: Includes the continued development, extension, and application of the hydrocodes and associated materials models to warhead and explosives design and evaluation. Ongoing code and material model development will focus on greater accuracy, improved physics, extension to mixed phase flow problems, and increased scale of system level simulations. The JMP will continue to support the transition of these tools as well as the training of, and consulting for, the DoD user community. New material models will continue to be migrated into codes, including CTH and ALE3D. Efforts continue to improve the physical underpinning of material models to offer improved fidelity to temperature and strain rate dependence, capture complex load path and stress state dependence. The task for non-shock initiation of energetic materials continues to support the broader evaluation of hazards. Development continues for SIERRA, a new simulation concept for integrating individual physics codes together into a single application, promising to reduce the time needed to apply models to new physical situations. A new emphasis has been placed on improving the multi-phase flow modeling capability in CTH and ALE3D. Numerical methods, e.g. meshless methods, are being developed to overcome deficiencies in hydrocodes to maintain numerical stability and predict damage softening, localization, and failure. These numerical methods will then be incorporated into hydrocodes across DOE and DoD. There is an increased focus on the inclusion of stochastic effects, verification and validation, and quantification of errors and sensitivities of solutions. *FY 2010 Plans:* Includes the continued development, extension, and application of the hydrocodes and associated materials models to warhead and explosives design and evaluation. Ongoing code and material model development will focus on greater accuracy, improved physics, extension to mixed phase flow problems, and increased scale of system level simulations. The JMP will continue to support the transition of these tools as well as the training of, and consulting for, the DoD user community. New material models will continue to be migrated into codes, including CTH and ALE3D. Efforts continue to improve the physical underpinning of material models to offer improved fidelity to temperature and strain rate dependence, capture complex load path and stress state dependence. The task for non-shock initiation of energetic materials continues to support the broader evaluation of hazards. Development continues for SIERRA, a new simulation concept for integrating individual physics codes together into a single application,				

Exhibit R-2a, PB 2010 Office of Secretary Of Defense RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	P225

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
promising to reduce the time needed to apply models to new physical situations. A new emphasis has been placed on improving the multi-phase flow modeling capability in CTH and ALE3D. Numerical methods, e.g. meshless methods, are being developed to overcome deficiencies in hydrocodes to maintain numerical stability and predict damage softening, localization, and failure. These numerical methods will then be incorporated into hydrocodes across DOE and DoD. There is an increased focus on the inclusion of stochastic effects, verification and validation, and quantification of errors and sensitivities of solutions.				
Joint DOD/DOE Munitions / Energetic Materials The energetic materials (EM) focus area is aimed at developing the next-generation of EMs that have increased energy density over those in the current inventory, while attempting to provide enhanced insensitivity to extreme environments. There is a need to develop EMs that, when integrated into munitions, offer advantages of enhanced lethality against a variety of targets. Lighter and/or less bulky munitions significantly reduce the logistics burden of military actions and are also highly desirable. Similarly, a decrease in hazard classification brought about by the use of insensitive energetic materials and better designs will greatly decrease transportation and storage costs. Smarter munitions, capable of selectable, differential output, are another advantage to military agility. Hence, there is also a need for advanced EMs that can be used in small-scale devices such as distributed fuzing systems. In addition, as the operational environments have become more severe, EMs must survive setback forces in guns and severe impact forces in hard-target penetration applications. For enhanced lethality effects, the energy in EMs must be released either in the detonation reaction zone, or early enough in the gas expansion process so that it couples to impulse loading or sustains high temperatures. Increased lethality of EMs and munitions while simultaneously reducing collateral damage is of critical importance. Enhanced lethality requires that the energy be released in an appropriate time domain to allow optimized coupling to the target. Material ingredients that contribute to later energy release offer no enhancement in lethality. For micro devices suitable for distributed fuzing systems, the requirement on energy release is very exacting in order to sustain reaction propagation in environments with extensive shock and heating losses. Like advanced initiation, advanced energetic materials are an enabling technology for the next generation of weapon systems that will be safer, smaller, and more lethal.	4.809	4.831	4.928	

Exhibit R-2a, PB 2010 Office of Secretary Of Defense **RDT&E Project Justification**		**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: This focus area previously developed a thermal laser ignition technique in conjunction with fast temperature diagnostics to enable hard radiation imaging by proton radiography to investigate burning and propagation of a high explosive subsequent to a thermal ignition. This was the first time to physical state and damage evolutions were directly measured during cook-off of a high explosive. Preliminary characterization has been completed in preparation for extending this work to polymer-bonded explosive (PBX) N9. A small scale detonation experiment in the form of the mini-sandwich test was developed for use with conventional high explosives. The newest version of Cheetah 5, thermochemical codes able to predict the performance of new explosives, were distributed to over 400 users and a users tutorial was given to the DoD user base. Syntheses scale up of DAAF and TAGDNAT progresses and samples of the latter were transitioned to the Navy. Samples of DNTF and LLM-172 were delivered to the Army. *FY 2009 Plans:* For EM the mini-sandwich test developed for use with conventional high explosives is being further developed for testing of insensitive high explosives. Cheetah 6 development is ongoing and will include improvements of both the equation of state (EOS) and kinetics models, done in conjunction with targeted experimental measurements. A Java Graphical interface will be developed to insure that the code continues to be user friendly. In addition to continuation of the proton radiography experiments for visualization of slow cook-off, a series of experiments are being developed to use the technique to visualize the detonation front within a detonator-booster-main charge integrated assembly. High explosive formulation efforts continue, including a spray-on formulation. Development of nanoscale, microscale, and mesoscale energetic materials with enhanced performance that are less sensitive and more cost effective enablers for defense transformation will continue. Computer codes for modeling cook-off behavior with coupled thermal/mechanical response will also be developed including numerical methodologies to deal with the flow of energetic materials within confined. A new microreactor technology will be investigated as an alternate method for synthesis of energetic compounds. The development and characterization of an LLM-105 booster composition will continue.				

Exhibit R-2a, PB 2010 Office of Secretary Of Defense RDT&E Project Justification			DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development		**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: For EM the mini-sandwich test developed for use with conventional high explosives is being further developed for testing of insensitive high explosives. Cheetah 6 development is ongoing and will include improvements of both the equation of state (EOS) and kinetics models, done in conjunction with targeted experimental measurements. A Java Graphical interface will be developed to insure that the code continues to be user friendly. In addition to continuation of the proton radiography experiments for visualization of slow cook-off, a series of experiments are being developed to use the technique to visualize the detonation front within a detonator-booster-main charge integrated assembly. High explosive formulation efforts continue, including a spray-on formulation. Development of nanoscale, microscale, and mesoscale energetic materials with enhanced performance that are less sensitive and more cost effective enablers for defense transformation will continue. Computer codes for modeling cook-off behavior with coupled thermal/mechanical response will also be developed including numerical methodologies to deal with the flow of energetic materials within confined. A new microreactor technology will be investigated as an alternate method for synthesis of energetic compounds. The development and characterization of an LLM-105 booster composition will continue.				
Joint DOD/DOE Munitions / Initiators, Fuzes, and Sensors Initiators, fuzes, and sensors are critical components in every munition system. These components must work together to ensure personnel safety by preventing unintended weapon detonation, allow arming of a firing mechanism, detect the target through the use of sensors, and initiate detonation when required. With the increasing need for robust, hard-target-defeat capability, advanced fuze systems must be able to survive and function in increasingly higher-velocity and higher-G penetration environments. Methods for these sub-systems to survive high-G environments include the miniaturization, integration, and/or robust packaging of conventional fuze components such as detonators, switches, transformers, capacitors, sensors, and advanced batteries. In support of this technology area, the Joint Department of Defense (DoD)/Department of Energy (DOE) Munitions Program (JMP) continues to demonstrate advances in miniaturizing high-voltage Electronic Safe and Arm Devices (ESAD), through research and development of low-energy detonator/booster combinations, and with miniature Capacitive Discharge Units (CDUs). This focus builds on recent advances in micro-detonic/energetic materials research	4.424	4.437	4.311	

Exhibit R-2a, PB 2010 Office of Secretary Of Defense **RDT&E Project Justification**		**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
and MicroElectroMechanical Systems (MEMS) device development. Efforts in this portion of the JMP generally advance fuze technology and ultimately provide the DoD and DOE with next generation fuzing components for all weapons, particularly hard-target-defeat munitions (penetrators), and small, intelligent low-cost applications (artillery). Advanced initiation technology is an enabler for the next generation of warheads that can be aimed, are target adaptable, and extremely robust. The primary focus of sensors in this focus area relate to guidance applications for precision weapons. *FY 2008 Accomplishments:* Include several diverse transitions of the Synthetic-aperture radar (SAR)/Microsystems Enabled Scalable Array SAR (MESASAR)-based technologies from defense to science, from Antarctica with the US Coast Guard to the outer space with the National Aeronautics and Space Administration (NASA), from manned to unmanned, and from airborne to space. A first demonstration sample of a nascent spray coated thin film thermal battery was delivered. A new low-cost sprytron triggered switch was built and delivered, providing an improved reliability over current Metal Oxide Semiconductor (MOS) Controlled Thyristor (MCT) high voltage vacuum switches for advanced ESADs. A predictive tool bridging the Spice electrical code and the Kowin hydrocode has been successful completed to predict complex behavior of multipoint firing systems. A suite of new diagnostics are being developed for the study of detonator behavior, with two-dimensional (2D) High Speed Laser Schlieren Movie diagnostic and a 2D Particle Image Velocimetry (PIV) flow diagnostic in FY 2008. *FY 2009 Plans:* This focus area includes design and development of 10- and 20-W solid state power amplifiers using gallium nitride (GaN) monolithic integrated circuits in support of future mini-SAR/MESASAR developments. The Vertical Cavity Surface Emitting Lasers (VCSEL) project continues development of a robust and compact photonic proximity sensor for munitions applications, with applicability as a Height-of-Burst (HOB) sensor. The effort focuses on developing innovative technologies for advanced thermal batteries will proceed to full electrochemical cell fabrication and testing. The further exploration of the effects of firing slappers at the low inductances associated with miniature firing systems will feed into an integrated fire set demonstration. Furthering the development of new diagnostics applying state of the art technologies to improving and expanding the dimensionality, scale, scope and/or accuracy				

Exhibit R-2a, PB 2010 Office of Secretary Of Defense RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
of traditional diagnostics, new three-dimensional (3D) temporally resolved diagnostics will continue to be developed including Dynamic Optical Topography of Surfaces (DOTS), spatial interferometery and structured light techniques. A "hard-science" question associated with miniature munitions is the transfer of detonation from a miniature detonator into the main charge explosive. This could dramatically affect the performance of a small munition. We will continue to study microdetonics, which refers to detonation initiation, acceleration (buildup), and curvature effects in small explosive systems. We plan to conduct numerous small-scale tests to determine the performance of insensitive high explosives of interest. The other portion of the microdetonics effort is to develop the diagnostics for characterizing detonator/booster explosive behaviors and a design code that will make effective use of the microdetonics data for miniature munitions design. Over the next five years, this portion of the JMP will work toward demonstrating emerging technologies that support robust, intelligent fuzing that can survive and function in environments exceeding 30,000 G's. *FY 2010 Plans:* This focus area includes design and development of 10- and 20-W solid state power amplifiers using gallium nitride (GaN) monolithic integrated circuits in support of future mini-SAR/MESASAR developments. The Vertical Cavity Surface Emitting Lasers (VCSEL) project continues development of a robust and compact photonic proximity sensor for munitions applications, with applicability as a Height-of-Burst (HOB) sensor. The effort focuses on developing innovative technologies for advanced thermal batteries will proceed to full electrochemical cell fabrication and testing. The further exploration of the effects of firing slappers at the low inductances associated with miniature firing systems will feed into an integrated fire set demonstration. Furthering the development of new diagnostics applying state of the art technologies to improving and expanding the dimensionality, scale, scope and/or accuracy of traditional diagnostics, new three-dimensional (3D) temporally resolved diagnostics will continue to be developed including Dynamic Optical Topography of Surfaces (DOTS), spatial interferometery and structured light techniques. A "hard-science" question associated with miniature munitions is the transfer of detonation from a miniature detonator into the main charge explosive. This could dramatically affect the performance of a small munition. We will continue to study microdetonics, which refers to detonation initiation, acceleration (buildup), and curvature effects in small explosive systems. We plan to conduct numerous small-scale tests to determine the performance of insensitive high explosives of interest. The				

Exhibit R-2a, PB 2010 Office of Secretary Of Defense **RDT&E Project Justification**		**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
other portion of the microdetonics effort is to develop the diagnostics for characterizing detonator/booster explosive behaviors and a design code that will make effective use of the microdetonics data for miniature munitions design. Over the next five years, this portion of the JMP will work toward demonstrating emerging technologies that support robust, intelligent fuzing that can survive and function in environments exceeding 30,000 G's.				
Joint DOD/DOE Munitions / Munitions Lifecycle Technologies Munitions lifecycle technologies, including stockpile aging, surveillance, demilitarization, and disposal, are developed under the auspices of the Joint Department of Defense (DoD)/ Department of Energy (DOE) Munitions Technology Development Program (JMP) . The Department has a large and growing inventory of conventional munitions in its demilitarization stockpile. Currently, the stockpile includes more than 400,000 tons and is expanding by about 70,000-100,000 tons per year. As the long-term focus for demilitarization and disposal within the DoD turns from open-burn (OB) and open-detonation (OD) to resource recycle and recovery, alternative technologies are required to turn waste materials into useful products. The technologies developed in this portion of the JMP enhance DoD capabilities to field safe, cost-effective processes for disposal, resource recovery, and reutilization of munitions and munitions components. For an aged weapon stockpile that has not reached end of useful life, reliability and surety may change with time because of age-related degradation of constituent materials. Existing stockpile assessment methods typically focus on addressing materials aging and reliability problems after they occur, rather than on anticipating and avoiding future problems or failure mechanisms. The predictive materials aging and reliability portion of the JMP is focused on improving our ability to understand, measure, predict, and mitigate safety and reliability problems caused by materials aging and possible degradation in weapons systems. Together with complementary demilitarization technologies, this focus provides a base of scientific knowledge and understanding that enhances the Department's ability to efficiently support the late phases of weapon lifecycle. *FY 2008 Accomplishments:* This project Included completion of PC-based, component lifetime prediction models. They include a solder interconnect fatigue model, and a temp/humidity life prediction model (predicts Die Crack and Corrosion). These models are being run yearly with environmental data obtained from the dormant	1.591	1.667	1.606	

Exhibit R-2a, PB 2010 Office of Secretary Of Defense RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
storage program in the JMP. They show that, in general, parts studied are robust and are expected to last several decades. In addition, the RRAPDS (Remote Readiness Asset Prognostic/Diagnostic System) Health Monitoring Unit from Redstone Arsenal (collects and stores time-stamped sensor data including temperature, relative humidity, and drop distance) was integrated into the dormant storage program. An engineered aged structure (EAS) system, including hardware and software was also designed for implementation in future plans. The GROMIT software package was completed and an updated version of YADAS software package was released as part of a suite of methods and tools for assessing stockpile reliability based on assessing surveillance data collection activities within a cost-benefit framework. Two case-studies based on DoD systems have been completed for resource allocation. The JMP is continuing to support the transition of these tools as well as the training of, and consulting for, the DoD user community. Robotic technologies for disassembly of munitions employing machine vision improvements where developed, with a robotic demilitarization processes being transitioned for a Cluster Bomb Unit (CBU) Download Workcell. *FY 2009 Plans:* For this thrust area includes continued studies on predictive material aging of solders, including the investigation of tin wiskers, electronics corrosion, and aging of propellants and adhesives. Experimental studies on electroplated tin (Sn) coatings and physical vapor deposition (PVD) thin films are ongoing and two modeling approaches are being considered to describe/predict Sn whisker growth. Further development of the Bayesian approach to system reliability assessment will be conducted. The development of robotic disposal of munitions will continue and new automation technologies for removing and safeing sub-munitions that are automatically armed on exit from a projectile will be developed. A project to develop a solid-phase microextraction-gas chromatographic-mass spectrometric (SPME GC-MS) for monitoring and analysis of propellants is continuing. A focused effort is going into developing broader munitions lifecycle efforts in the areas of stockpile aging and surveillance to complement to strong successes in transitioning of technologies in the areas of demilitarization and disposal. *FY 2010 Plans:* For this thrust area includes continued studies on predictive material aging of solders, including the investigation of tin wiskers, electronics corrosion, and aging of propellants and adhesives. Experimental				

Exhibit R-2a, PB 2010 Office of Secretary Of Defense RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
studies on electroplated tin (Sn) coatings and physical vapor deposition (PVD) thin films are ongoing and two modeling approaches are being considered to describe/predict Sn whisker growth. Further development of the Bayesian approach to system reliability assessment will be conducted. The development of robotic disposal of munitions will continue and new automation technologies for removing and safeing sub-munitions that are automatically armed on exit from a projectile will be developed. A project to develop a solid-phase microextraction-gas chromatographic-mass spectrometric (SPME GC-MS) for monitoring and analysis of propellants is continuing. A focused effort is going into developing broader munitions lifecycle efforts in the areas of stockpile aging and surveillance to complement to strong successes in transitioning of technologies in the areas of demilitarization and disposal.				
Joint DOD/DOE Munitions / Warhead and Penetration Technology In the warhead and penetration technology thrust, a major activity continues to be design and development of technologies and warheads for hard-target-defeat. As hard-target weapons evolve, several technical issues need to be addressed, including penetrators, fuzing, and simulation tools, along with associated validation data. Hardened military facilities are being buried in layered earth and concrete, "cut and cover" constructions, tunneled into mountainsides, or mined into rock far beneath the earth's surface. Buried structures accounted for a significant number of targets attacked by our forces during the Gulf, Afghanistan, and Iraq wars, and much of our military planning is being devoted to defeating them. Thus, a major thrust of the Joint Department of Defense (DoD)/ Department of Energy (DOE) Munitions Technology Development Program (JMP) continues to be hard-target-defeat. As hard-target weapons evolve, several technical issues need to be addressed. Specifically, penetrators striking targets with obliquity or at high angles of attack experience violent dynamic responses that can cause their cases to fail or interfere with the functionality of fuzes. Similarly, oblique, low velocity target impacts can result in ricochet, undesirable shallow trajectories, or bouncing out of the target. In general, new delivery vehicles tend to be smaller and faster, requiring smaller penetrators that carry less payload, and must survive more stressing impacts. Developing improved penetrating weapons depends on a solid understanding of the physics of penetration as well as affordable materials and processes to execute new designs that require more strength and durability from the penetrator. Although we can predict penetration depth with acceptable confidence, there are some targets for which we have insufficient data and experience; consequently, predicting the path a penetrator will take and whether it will survive is much less certain.	3.963	3.889	3.733	

Exhibit R-2a, PB 2010 Office of Secretary Of Defense RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

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

The JMP provides a fundamental penetration technology base that addresses many of these issues and enables our future strike weapons. Additionally, warhead concepts which greatly extend the current range of capabilities in speed and tailored target effects are being explored. With increasing emphasis and interest in defeating targets of military interest in civilian areas, and of defeating and neutralizing Weapons of Mass Destruction (WMD) facilities, the application of energy to targets must be thoroughly controlled and understood. This requirement places increased demands on warhead output and is being pursued under the JMP.

FY 2008 Accomplishments:
In FY08 this project Included the development a Micro Electro Mechanical System (MEMS) pressure sensor has shown promise to provide for the first time the interface pressure between the penetrator and the target. The first generation prototypes of the micromachined pressure sensor were designed, fabricated, and tested in the quasi-static and dynamic modes. A standard test for the fragmentation of high explosive driven metal, the Filled Hemi, was developed to allow the study of fragmentation in a simple spherically driven system. Various effects were and continue to be in the process of being parametrically probed with sufficient statistics to assess the results conclusively, as offered by the small scale test. Particular focus was given to the effect of metallurgy, composition, and heat treatment on natural fragmentation mechanisms. A fragmentation database was initiated to ensure historical data is retained and leveraged and that the considerable quantity of data generated in this prolific focus area is appropriately documented and disseminated. Through the database the JMP is serving as a focal point for fragmentation research across the DoD and DOE. The JMP is also serving as a focal point in the field to ensure investigation of common and well understood materials across numerous research efforts.

FY 2009 Plans:
In FY09 this project will include continued low collateral damage weapon verification and validation testing in comparison with current best baseline munitions. The effort involves the advancement of the science of multi-phase blast explosives (MBX) integrated with composite case penetrators to yield discriminate lethality munitions. This work will include efforts to develop and integrate technology for a new generation of precision lethality munitions based on MBX technology. The goal is to develop the technology for future munitions with two key features: increased near field lethality (at the point of

Exhibit R-2a, PB 2010 Office of Secretary Of Defense RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	P225

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
target engagement) and virtually zero, far field collateral damage (no fragmentation). Both of these features are critical for enabling discriminant lethality for military operations in urban terrain (MOUT) and close air support (CAS). The focus of the planned work is on understanding the science of MBX technology (material characterization, modeling and simulation, energetics, and target interaction effects). This includes the ability to model and design warheads and munitions fracture, failure, and post-fracture behavior including fragmentation. High rate continuum modeling technology will be investigated, developed, and demonstrated to provide the capability to predict and therefore control fracture and post-fracture behavior. Studies will continue toward providing a fundamental understanding of the penetration process by conducting carefully designed experiments and analyses. Linking numerous experimental research efforts in fragmentation across the DoD and DOE with well characterized pedigreed materials will support better leveraging of shared data and focus on the underlying physics of fragmentation. Well-controlled, subscale penetration and perforation experiments are planned with clearly defined experimental variables. Penetrators will be instrumented with on-board accelerometers and data recorders to acquire high quality deceleration data for penetrator response. The on-board accelerometers and data recorders are previous transitions from the JMP. Data from these experiments not only provide a crucial database on the physical phenomena of the penetration process, but also provide researchers with valuable penetration data to benchmark codes and models. *FY 2010 Plans:* In FY10 this project will include continued low collateral damage weapon verification and validation testing in comparison with current best baseline munitions. The effort involves the advancement of the science of multi-phase blast explosives (MBX) integrated with composite case penetrators to yield discriminate lethality munitions. This work will include efforts to develop and integrate technology for a new generation of precision lethality munitions based on MBX technology. The goal is to develop the technology for future munitions with two key features: increased near field lethality (at the point of target engagement) and virtually zero, far field collateral damage (no fragmentation). Both of these features are critical for enabling discriminant lethality for military operations in urban terrain (MOUT) and close air support (CAS). The focus of the planned work is on understanding the science of MBX technology (material characterization, modeling and simulation, energetics, and target interaction effects). This includes the ability to model and design warheads and munitions fracture, failure, and post-				

Exhibit R-2a, PB 2010 Office of Secretary Of Defense **RDT&E Project Justification**		**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603225D8Z Joint DOD/DOE Munitions Technology Development	**PROJECT NUMBER** P225

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
fracture behavior including fragmentation. High rate continuum modeling technology will be investigated, developed, and demonstrated to provide the capability to predict and therefore control fracture and post-fracture behavior. Studies will continue toward providing a fundamental understanding of the penetration process by conducting carefully designed experiments and analyses. Linking numerous experimental research efforts in fragmentation across the DoD and DOE with well characterized pedigreed materials will support better leveraging of shared data and focus on the underlying physics of fragmentation. Well-controlled, subscale penetration and perforation experiments are planned with clearly defined experimental variables. Penetrators will be instrumented with on-board accelerometers and data recorders to acquire high quality deceleration data for penetrator response. The on-board accelerometers and data recorders are previous transitions from the JMP. Data from these experiments not only provide a crucial database on the physical phenomena of the penetration process, but also provide researchers with valuable penetration data to benchmark codes and models.				

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A