OSD RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

Date: February 2006

APPROPRIATION/ BUDGET ACTIVITY
RDT&E/ Defense Wide BA# 3

PE NUMBER AND TITLE
0603225D8Z - Joint DoD/DOE Munitions

	Cost ($ in Millions)	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
	Total Program Element (PE) Cost	22.005	24.702	16.862	19.362	24.439	24.374	24.668
P225	Joint DoD/DOE Munitions	22.005	24.702	16.862	19.362	24.439	24.374	24.668

A. Mission Description and Budget Item Justification: (U) The Joint DoD/DOE Munitions Technology Program (JMP) has the mission to explore and develop focused 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 the enabling support for this effort. The fusion of DOE technology with Joint Services needs has provided major advances in warfighting capabilities and plays a crucial role in the exploration, development, and transition of new technologies needed by the Services. The JMP provides a unique opportunity for the collaboration of DoD and DOE scientists so they can explore technologies of interest to both Departments, within a structured framework of technical reviews and scheduled milestones. The interdepartmental collaboration allows exchange of information and achievement of goals of interest to the Department utilizing the substantial investment in the scientific resources of the DOE. The budgeted JMP funds represented here are supplemented by additional matching DOE funds.

(U) Describing the many technical advances and new munitions capabilities that have been developed by the JMP and benefited DoD and DOE is beyond the scope of this document. A summary of recent accomplishments is provided below. In addition, estimating Return on Investment (ROI) is challenging due to the wide diversity of technologies being developed, multi-year nature of all of the projects, and the tremendous range of products and capabilities that are involved. Several endorsements from Department labs indicate a strong history of JMP accomplishments and significant 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 a substantial cost savings. They also estimated a 3-6 month reduction in design time for two recent warheads (Medium Range Munition and Joint Common Missile), and cost savings of more than $5.000 million. Compared to an FY 2005 investment in the M&S tools of $2.100 million, an ROI of $2.400 million can be estimated. This estimate does not include the 50-50 cost sharing of JMP activities by the DOE. Furthermore, many technologies developed by the JMP are transitioned to other agencies such as NASA, which used the Laser Dynamic Range Imager to inspect critical areas of the Space Shuttle "Discovery" on its recent flight in space. This technology was developed by the JMP for munitions guidance applications but was deployed by NASA to assist with the in-flight inspection of the shuttle. The pictures from the Imager resulted in an unprecedented space walk and repair operation which contributed to the safe return of the shuttle. However, it is very difficult to estimate a ROI to the JMP for a situation like this. Efforts are continuing to further quantify ROI for all JMP activities.

(U) Other JMP successes include the transition of four special-purpose shaped charge munitions which are now deployed by the Special Operations Command (SOCOM) for Weapons of Mass Destruction (WMD)-defeat in Global War on Terror (GWOT) applications. A new penetrator weapon, the Tactical Missile System-Penetrator (TACMS-P), benefited from extensive modeling and materials efforts on penetrators supported by the JMP, and has recently flown three successful flight tests. The Army's Multi-Role Armament & Ammunition System (MRAAS) compact multi-purpose shape-charge warhead was developed by the JMP and exceeds Javelin performance while being 24% smaller in diameter and 41% shorter in length. In addition, modeling and metallurgical technology for rhenium materials needed for the Standard Missile-3 (SM-3) Solid Divert and Attitude Control System (SDACS) was transitioned to NSWC-Dahlgren to resolve a critical system problem. Cheetah, an advanced thermochemical code developed and improved with JMP funds, reached a milestone with the release of version four. This code is used by over 300 DoD engineering staff to design modern munitions. Finally, a major accomplishment was achieved with JMP support in Synthetic Aperture Radar (SAR) technology for guidance and targeting applications. A new prototype SAR was designed and built which is both five times lighter and less expensive than the baseline, with no degradation in image quality or resolution. This "mini-SAR" system was successfully fight-tested in the summer of 2005 and is now being transitioned to industry.

OSD RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

Date: February 2006

APPROPRIATION/ BUDGET ACTIVITY	PE NUMBER AND TITLE
RDT&E/ Defense Wide BA# 3	**0603225D8Z - Joint DoD/DOE Munitions**

(U) Over the last four years, there has been increased programmatic emphasis on developing technologies of particular value to counter-terrorism efforts and asymmetric warfare. Initial successes have already emerged from this focus with some products already in the field. The increase in the JMP budget in FY 2004 and beyond was intended specifically to focus additional efforts on exploring and developing technologies to transform the operational capabilities of the warfighter. Two specific efforts were targeted for this increase: the first is a new and rapidly emerging technology employing Dense Inert Metal-loaded Explosives (DIME) which will enable precision lethality munitions usable in urban settings with minimal collateral damage; the second is the increased capabilities and reduced life cycle costs resulting from an understanding of sub-detonic response of energetic materials. This understanding is vital to addressing compliance with insensitive munitions requirements, as well as exploiting deflagration and other sub-detonic responses to achieve selectable weapon output. Based on modeling and technology developed by the Program, preliminary tests of DIME integrated in a composite case successfully destroyed Rocket Propelled Grenades (RPGs) in flight with minimum collateral damage beyond the immediate target area. Further, the Air Force is considering a development program to incorporate DIME technology into the Small Diameter Bomb.

(U) Attaining JMP goals requires simultaneous and coordinated development efforts in the areas of initiation, energetic materials, modeling, warhead integration, and lifecycle technologies. The integrated efforts within the JMP are speeding the transition of new technologies through the development process and the JMP has strong support from all Services and SOCOM. The JMP is a focal point for collaborative work by over 200 DoD and DOE scientists and engineers, and has been called a model for how both 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, 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.

(U) The JMP is divided into five munitions technology areas which are important to the Department. They are: Initiation, Fuzing, and Sensors; Energetic Materials; Computational Mechanics and Material Modeling; Warhead & Integration Technology; and Munitions Lifecycle Technologies. These focus areas are described more fully in the accompanying R-2a project exhibit.

B. Program Change Summary	FY 2005	FY 2006	FY 2007
Previous President's Budget (FY 2006)	25.202	25.102	25.460
Current BES/President's Budget (FY 2007)	22.005	24.702	16.862
Total Adjustments	-3.197	-0.400	-8.598
Congressional Program Reductions		-0.400	
Congressional Rescissions			
Congressional Increases			
Reprogrammings	-2.450		
SBIR/STTR Transfer	-0.713		
Other	-0.034		-8.598

OSD RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

Date: February 2006

APPROPRIATION/ BUDGET ACTIVITY
RDT&E/ Defense Wide BA# 3

PE NUMBER AND TITLE
0603225D8Z - Joint DoD/DOE Munitions

C. Other Program Funding Summary: Not Applicable.

D. Acquisition Strategy: Not Applicable.

E. Performance Metrics:

FY	Strategic Goals Supported	Existing Baseline	Planned Performance Improvement / Requirement Goal	Actual Performance Improvement	Planned Performance Metric / Methods of Measurement	Actual Performance Metric / Methods of Measurement
07						

Comment: (U) A Five Year Plan is prepared annually for the JMP which contains detailed technical and programmatic descriptions of the approximately 50 individual projects under this funding line. Each project description includes a task schedule with associated milestones, whereby progress against the end goals is measured. Technical progress as evidenced by these milestones is reviewed by DoD participants at semi-annual Technology Coordinating Group (TCG) meetings, and by senior executives from the DoD and DOE at annual Technical Advisory Committee (TAC) meetings.

OSD RDT&E PROJECT JUSTIFICATION (R2a Exhibit)

Date: February 2006

APPROPRIATION/ BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
RDT&E/ Defense Wide BA# 3	**0603225D8Z - Joint DoD/DOE Munitions**	**P225**

Cost ($ in Millions)		FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
P225	Joint DoD/DOE Munitions	22.005	24.702	16.862	19.362	24.439	24.374	24.668

A. Mission Description and Project Justification: (U) The Joint DoD/DOE Munitions Technology Program (JMP) is a collaborative, jointly-funded effort between DoD and DOE to develop new and innovative warhead, explosive, initiation, and lifecycle technologies and enabling tools in order to bring about major improvements in non-nuclear munitions. The JMP supports the development and exploration of new munitions concepts and enabling technologies which precede system engineering. Through a Memorandum of Understanding (MOU) funding arrangement with DOE, DoD resources are evenly matched. More importantly, this relatively small DoD contribution effectively taps the annual billion-dollar DOE Research, Development, Test, and Evaluation (RDT&E) investment by accessing specialized skills, scientific equipment, facilities, and computational tools not available within DoD.

(U) These efforts exploit the extensive and highly developed technology base resident in the DOE national laboratories which are relevant to achieving the goal of developing capable, cost-effective, conventional munitions, and leverages DoD investments with matching DOE investments. The JMP currently supports 52 projects which are organized in 5 technical focus areas: Initiation, Fuzing, and Sensors; Energetic Materials; Computational Mechanics and Material Modeling; Warhead and Integration Technology; and Munitions Lifecycle Technologies. Specific Service laboratories lead each of these focus areas. The JMP is administered and monitored by OSD, and reviewed annually by a Technical Advisory Committee (TAC) composed of senior executives from the Army, Navy, Air Force, Special Operations Command, OSD, and DOE. Projects are peer-reviewed semi-annually by DoD Service Laboratory/Technical Center personnel organized in Technology Coordinating Groups (TCGs) in order to monitor technical performance and ensure that the technologies under development address high priority DoD needs.

The JMP is further integrated with Service efforts through the Project Reliance Weapons Panel and by participation in the Defense Technology Area Plan for conventional weapons. The JMP is reviewed under the Technology Area Review and Assessment (TARA) process. After reviewing the JMP, a recent Weapons TARA panel assessed the JMP as follows: broad range of products transitioned to DoD as a result of JMP efforts; effectively leverages DOE expertise and funding; critical computational tools provided to DoD; well integrated into Service efforts; TCGs provide an effective forum for technical collaborations.

Please see the R-2 document for additional JMP background information and justification. More details of each of the technical focus areas are described below.

B. Accomplishments/Planned Program:

Accomplishment/Planned Program Title	FY 2005	FY 2006	FY 2007
(U) Initiation, Fuzing, and Sensors:	4.722	4.546	3.156

(U) Initiators, fuzes, and sensors are critical components in every Department munition system. A fuze must 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 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. One method of surviving high-g environments is through 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 JMP continues to demonstrate advances in

OSD RDT&E PROJECT JUSTIFICATION (R2a Exhibit)		Date: February 2006
APPROPRIATION/ BUDGET ACTIVITY RDT&E/ Defense Wide BA# 3	PE NUMBER AND TITLE **0603225D8Z - Joint DoD/DOE Munitions**	PROJECT **P225**

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 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). 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. Advanced initiation technology is an enabler for the next generation of warheads that can be aimed, are target adaptable, and extremely robust.

(U) Recent Accomplishments:
(U) In the area of Electronic Safe and Arm Devices (ESAD), a batch assembly process for monolithic micro-CDUs was completed. A design for a MEMS-based g-switch with low cross-axis sensitivity was also completed. Both designs are in the process of being transitioned to industry. Component development and evaluation continued for compact firesets. Nanostructure multilayer (NML) technologies for high voltage capacitors and multilayer dielectric breakdown switches successfully produced 20-layer capacitors with up to 102 nF of capacitance in a footprint of 8 mm by 10 mm. These technologies can be integrated into micro-CDUs for smaller and more cost-effective components. Advanced initiation systems work continued with development of diagnostics for monitoring the current distribution in multipoint initiators. The latest miniaturization technology was transitioned to production facilities and to the Services in order to begin implementation. Rapid prototyping of systems for individual control of multiple initiation sites demonstrated 1-by-4 and 4-by-4 arrays of slappers on alumina and printed circuit board substrates. Further experiments were performed to investigate the theory and models of explosive behavior in very small geometries (micro-detonics). Micro-fireset development included the ink-jet deposition of energetics on MEMS-scale substrates. A miniature Synthetic Aperture Radar (mini-SAR) was designed with reduced size and cost (both by a factor of over 4) and a prototype was successfully tested. Initial experiments were performed to measure the run-to-detonation distance for HNS-IV for both low pressure and slapper-driven initiation. The pressure output of a CL-20 based explosive, RSI-007, was measured as a function of pellet size in femtosecond-laser-machined pellets as small as 0.5 mm diameter by 0.5 mm length. A new project was started with a focus on millimeter scale initiation and detonation. This work is attempting to understand the behavior and response of thin layers and small quantities of explosives, as are required for all MEMS-based fuzes and micro-firesets.

FY 2006 / FY 2007 Plans:
(U) The JMP intends to further explore the effects of firing slappers at the low inductances associated with miniature firing systems, and this slapper and firing systems technology will feed into an integrated fireset demonstration in FY 2007. 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, detonation acceleration (buildup), and detonation 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. We have multiple tasks associated with a sophisticated experiment to explore the initiation source. In FY 2005, the NML technology development advanced through the preparation and start-up of a new cleanroom for the cluster tool. In addition, we produced capacitors using baseline processes with enhancements for evaluation in weapons applications. For the mini-SAR development project, existing circuits will be migrated/converted to single a CMOS ASIC. In addition, 10 and 20 W solid state power amplifiers using GaN monolithic integrated circuits will be designed and developed. Finally, a new project focused on developing innovative technologies for advanced thermal batteries has been initiated.

Accomplishment/Planned Program Title	FY 2005	FY 2006	FY 2007
(U) Energetic Materials:	5.681	6.682	4.455

(U) Background:
(U) There is a growing need in the United States to develop energetic materials (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

OSD RDT&E PROJECT JUSTIFICATION (R2a Exhibit)		Date: February 2006
APPROPRIATION/ BUDGET ACTIVITY RDT&E/ Defense Wide BA# 3	PE NUMBER AND TITLE **0603225D8Z - Joint DoD/DOE Munitions**	PROJECT **P225**

guns and severe impact forces in hard-target penetration applications. Work on energetic materials was aligned with the recommendations from the DoD 2000 Weapons TARA, and is coordinated with the recently established national initiative in Advanced Energetic Materials. This aspect of the JMP is aimed at developing the next-generation EMs that have increased energy density over those in the current inventory while maintaining insensitivity to extreme environments. An additional requirement is that the energy be released in an appropriate time domain to allow optimized coupling to the target.

(U) For enhanced lethality effects, the energy in EMs must be released either in the detonation reaction zone, or early enough in the expansion so that it couples to impulse loading or sustains high temperatures. Material ingredients that contribute to energy release later than that offer no enhancement in lethality. A fundamentally new approach to increasing lethality while simultaneously reducing collateral damage is being investigated. Holding much potential for modern warfighting scenarios, this new material formulation provides increased performance while meeting insensitive munitions standards. For microdevices 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.

(U) Recent Accomplishments:
(U) Efforts to synthesize, characterize and scale-up new EMs with increased or tailored performance and decreased sensitivity have been continued. Coordination with the national Advanced Energetic Materials initiative continued to re-invigorate the energetic materials skill base within the Department. The new explosive, LLM-105 (developed by the JMP), continues to look promising as an insensitive main charge and as a booster material. As part of the scale-up of fabrication processes, nearly 4 kg of this material were synthesized for testing at Department labs. A stream of other new energetic materials continues to be developed by JMP activities. Significant progress was made on scale-up and characterization of 3,4-DNP, a candidate melt-castable explosive with good safety characteristics, and samples were delivered to Picatinny Arsenal for testing. Significant effort was also made to synthesize LLM-146, a target insensitive explosive, and material was produced in an impure form. Several candidate gun propellant ingredients were also synthesized with an emphasis on high nitrogen and tetrazole-based materials. JMP scientists synthesized N-hydroxy derivatives of heterocycles which offer the possibility of forming nitrogenous salts. Samples of these materials were provided to NSWC-Indian Head for evaluation. Also, an updated version (#4) of Cheetah, a thermochemical detonation simulation code widely used in the U.S, was released to the DoD for making enhanced performance predictions for an extended set of energetic materials.

(U) FY 2006 / FY 2007 Plans:
(U) Development will be continued of nanoscale, microscale, and mesoscale energetic materials with enhanced performance which are less sensitive and more cost effective enablers for defense transformation. Specific activities will include the investigation of reaction mechanisms and kinetics parameters for the thermal decomposition of selected energetic materials such as HMX and RDX. Computer codes for modeling cookoff behavior with coupled thermal/mechanical response will also be developed. Improved diagnostics for cookoff testing and thermobaric explosive performance of new materials will be evaluated. Technology will be investigated for producing nanoenergetic explosives based on the formation of fine particles from supercritical solutions. New instrumental techniques for collecting spatially resolved data on aging/aged energetic materials are being studied. The development and characterization of an LLM-105 booster composition will continue. Further work is needed on the particle morphology of LLM-105, and continued cooperation between the Departments will help ensure that this compound is given every chance to succeed. Its performance and insensitivity are very attractive, particularly in this era of closer attention to meeting IM criteria. Models for the prediction of response of energetic materials to cookoff will be further developed. Specifically, numerical methodologies to deal with the flow of energetic materials within confined volumes are being addressed, and fracture and fragmentation models are being integrated with the new multi-physics code ALE-3D to allow estimation of fragment sizes and velocities. Burn rates are being measured for pristine and damaged materials based on RDX, HMX, and TNT (alone or in combination with each other and other ingredients), and the basic thermal and mechanical properties of the explosives are being measured as needed if they are not available in the literature.

Accomplishment/Planned Program Title	FY 2005	FY 2006	FY 2007
(U) Computational Mechanics and Material Modeling:	6.070	6.967	5.024

(U) Background:
(U) The ability to accurately predict the behavior of weapons in operating environments of extreme pressure, temperature, and velocity 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

OSD RDT&E PROJECT JUSTIFICATION (R2a Exhibit)

Date: February 2006

APPROPRIATION/ BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
RDT&E/ Defense Wide BA# 3	**0603225D8Z - Joint DoD/DOE Munitions**	**P225**

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 numerical and algorithmic improvements to enhance our problem-solving capabilities for munitions development, advanced energetics, and target lethality predictions with significantly improved material models that accurately represent the materials of interest in dynamic states.

(U) Three 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. To date, 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 this JMP will pursue this objective and continue to provide and enhance these advanced modeling tools.

(U) Recent Accomplishments:
(U) The projects in this focus area relate to the modeling of the mechanical properties of explosives and the generation of test data to validate the computational models. The development of Eulerian, Lagrangian, and ALE codes relevant to the design and evaluation of munitions continued. Emphasis continues on the development and demonstration of ALE3D, a multi-physics code. Significant progress was made on modeling system level responses, blast loading of structures, and multiphase flow. ALE3D was shown to model slow cookoff experiments with high fidelity and is now being used to model fast (laser) cookoff experiments. Progress was made in the development of a formalism for treating anisotropic plasticity. The implementation of this formalism in ALE3D has been extended to include dynamic evolution of the yield surface and rate dependent hardening. The importance of anisotropy to various systems is being evaluated by inserting values of anisotropies in simulations and assessing the significance of the event. 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. The JMP also provides a conduit into the DoD for the improved materials models emerging from the DOE Advanced Strategic Computing Program (ASC), providing high resolution, accurate predictions of materials behavior and failure relevant to the analyses of weapon systems. The transition and support for these tools and models, along with user training, were provided to the DoD community.

(U) FY 2006 / FY 2007 Plans:
(U) The JMP will continue to develop, extend, and apply the hydrocodes and associated materials models to warhead and explosives design and evaluation. Ongoing code and material model development will continue to focus on greater accuracy, improved physics, and extension to mixed phase flow problems. The JMP will continue to support the transition of these tools as well as the training of, and consulting for, the DoD user community. User support for CTH from the JMP will come to an end in FY 2007, and but maintaining this support is being considered by the Services and by specific projects. New materials models will be migrated into CTH. A new thrust in non-shock initiation of energetic materials has been established to support the broader evaluation of hazards. This task is well aligned with, and supports a new project on, munitions impact response analysis. SIERRA, a new modeling concept for integrating individual physics codes together into a single application is under development and promises 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 which supports the DIME initiative within the JMP. A new task started in FY05 uses line Video Image Stabilization and Registration (VISAR) to study the character of the "detonation" wave in DIME materials. Efforts include the study of natural fragmentation processes in ductile metals. 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.

Accomplishment/Planned Program Title	FY 2005	FY 2006	FY 2007
(U) Warhead & Integration Technology:	3.131	3.575	2.455

[redacted]

OSD RDT&E PROJECT JUSTIFICATION (R2a Exhibit)		Date: February 2006
APPROPRIATION/ BUDGET ACTIVITY RDT&E/ Defense Wide BA# 3	PE NUMBER AND TITLE **0603225D8Z - Joint DoD/DOE Munitions**	PROJECT **P225**

(U) Background:
(U) In the area of warhead and integration technology, there is a worldwide trend to harden more military facilities. Increasingly, such 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. A major thrust of the 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.

(U) 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. 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 which is being pursued under the JMP.

(U) Recent Accomplishments:
(U) Integration of all the components necessary for a low collateral damage munitions concept was accomplished. JMP efforts were focused on the use of the Global Local Optimization (GLO) code to evaluate the potential for multi-phase blast (MPB) explosives, including DIME materials, for non-traditional warhead applications where impulse delivery to the target is the primary mechanism of defeat, as opposed to penetration or perforation. The main area of development has been on ways to deflect incoming Rocket Propelled Grenades (RPGs) to protect ground vehicles as part of an active protection system. Significant fundamental progress was made in this area with data showing that non-fragmenting composite cases delivered twice the blast performance compared to traditional steel cases. Progress was also made in Low Collateral Damage Munitions (LCDM) for use on medium and soft targets in urban areas. Munitions designs were completed using composite cases for minimizing lethal fragments, DIME for maximizing blast impulse, and a multipoint initiation system to tailor the amount of explosive that detonates. MPB explosives are showing significant promise for these applications. Low collateral damage versions of a one-half scale Mk 82 bomb in a composite case were tested, and demonstrated significant advantages compared to the baseline steel case (also scaled). New thermographic phosphor and infrared (IR) imaging techniques for capturing the thermal signature of fracture/fragmentation processes were investigated. The thermographic phosphor technique provides more accurate temperatures at high spatial resolution along a single line and can work at comparatively low temperatures. The IR technique provides an image and therefore provides broad coverage. Tests measuring the ring-up temperature in a simple flat plate loaded by a sweeping detonation wave were executed. Some required improvements are being developed. Computational studies were initiated for DIME, high nitrogen explosives (DAATO3.5) and Metastable Interstitial Composites (MIC). These studies are aimed at identifying and understanding the effects and phenomena produced by these unique energetic materials for applications in warhead geometries. Significant efforts also continued on penetrator systems design and testing.

(U) FY 2006 / FY 2007 Plans:
(U) The JMP will continue low collateral damage verification and validation testing in comparison with current best baseline munitions. This work will include efforts to develop and integrate technology for a new generation of precision lethality munitions based on MPB technology. The effort involves the advancement of the science of multi-phase blast explosives (MPBX) integrated with composite case penetrators to yield discriminate lethality munitions. 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 MPBX technology (material characterization, modeling and simulation, energetics, and target interaction effects) and integrating it with composite case technology for application to the development of MPB munitions. 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. Well-controlled, subscale penetration and

OSD RDT&E PROJECT JUSTIFICATION (R2a Exhibit)		Date: February 2006
APPROPRIATION/ BUDGET ACTIVITY RDT&E/ Defense Wide BA# 3	PE NUMBER AND TITLE **0603225D8Z - Joint DoD/DOE Munitions**	PROJECT **P225**

perforation experiments are planned with clearly defined experimental variables. Penetrators will be instrumented with onboard accelerometers and data recorders to acquire high quality deceleration data for penetrator response. 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.

Accomplishment/Planned Program Title	FY 2005	FY 2006	FY 2007
(U) Munitions Lifecycle Technologies:	2.401	2.932	1.772

(U) DoD and DOE efforts on munitions lifecycle technologies, including stockpile aging, surveillance, demilitarization, and disposal, are coordinated under the auspices of the 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.

(U) 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. Efficient management of existing stockpile assets is an economically necessary precursor to weapon systems modernization.

(U) Recent Accomplishments:
(U) In support of rocket motor demilitarization (demil), a stand-off radar sensor for a water-jet cutting tool was designed, and antennas needed for a prototype sensor were built. A watertight enclosure was also built for the electronics and controls of a complete system. This technology will permit more accurate control during the removal of sensitive propellants from rocket motors. Kinetic models were used successfully to correlate the molecular structure of selected explosives with their relative sooting tendencies during combustion. The modeling showed that soot formation occurs during fuel-rich combustion when insufficient oxygen is present to fully react with the hydrocarbon species. With this new understanding of the reaction mechanisms, new approaches can be investigated which will reduce soot and emissions during OB/OD disposal of explosives. Development continued on an instrument for field use in determining the composition in real time of fine particles released by munitions. Efforts were focused on increasing the rate at which analyses can be performed, and progress was made in reducing the time from minutes to seconds. Spectral libraries representing the particles liberated under field conditions during OD were determined. Development of robotic technologies for disassembly of munitions continued with an emphasis on machine vision improvements. Testing was completed and data complied for the elastic, plastic, and creep properties of lead-free solder, and a Unified Creep Plasticity (UCP) constitutive equation was derived to describe fatigue of soldered connections in defense electronics.

(U) FY 2006 / FY 2007 Plans:
(U) The instrument concept design for the rocket motor demil water-jet sensor will be completed for incorporation into washout units. Further, the test bed will be designed and the radar and data acquisition electronics will be completed. Prototype sensors for testing will also be fabricated. The development of a field instrument to identify munitions OB/OD emissions will be continued and particle source signatures for common background aerosols such as soils, sea spray, automobile emissions, common combustion sources, stationary power generation facilities, as well as other primary and secondary atmospheric particle sources, will be determined. This will allow the particles generated during OB/OD operations to be positively attributed to their source. A field demonstration of a prototype instrument operating in open air will be conducted. Chemical kinetic models for combustion of TNT, and RDX will be added to the extensive chemical database already existing for combustion processes. The development of robotic disposal of munitions will be continued amd new automation technologies for removing and safing submunitions that are automatically armed on exit from a projectile will be developed. Also, an ultrasonic sensor feedback system to optimize robot tool positioning will be demonstrated. A new project will develop a network of sensors for monitoring and quantifying the gaseous

OSD RDT&E PROJECT JUSTIFICATION (R2a Exhibit)		Date: February 2006
APPROPRIATION/ BUDGET ACTIVITY RDT&E/ Defense Wide BA# 3	PE NUMBER AND TITLE **0603225D8Z - Joint DoD/DOE Munitions**	PROJECT **P225**

and particulate species of environmental concern in OB/OD plumes. Another new project will demonstrate non-destructive laser-based measurement techniques to quantify and locate TNT, RDX, or HMX surface clumps or residue contamination on steel surfaces. Studies will continue on predictive materials aging of solders, including investigation of tin whiskers, electronics corrosion, and aging of propellants and adhesives.

C. Other Program Funding Summary: Not Applicable.

D. Acquisition Strategy: Not Applicable.

E. Major Performers

Category	Name	Location	Type of Work and Description	Award Date
Labs				
	Lawrence Livermore National Lab	Livermore, CA	Broad scope research will continue in the core areas of warhead technology, energetic materials, component development, munitions lifecycle, and computer simulation and modeling.	21 DEC 2004
	Sandia National Laboratories	Albuquerque, NM	Broad scope research will continue in the core areas of warhead technology, energetic materials, component development, munitions lifecycle, and computer simulation and modeling.	21 DEC 2004