Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Office of Secretary Of Defense	DATE: February 2011
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 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total	FY 2013	FY 2014	FY 2015	FY 2016	Cost To Complete	Total Cost
Total Program Element	21.462	22.700	20.372	-	20.372	20.681	20.617	21.587	21.292	Continuing	Continuing
P225: *Joint DOD/DOE Munitions*	21.462	22.700	20.372	-	20.372	20.681	20.617	21.587	21.292	Continuing	Continuing

A. Mission Description and Budget Item Justification

The mission of the Department of Defense (DoD)/Department of Energy (DOE) Joint Munitions Technology Development Program (JMP) is to develop new and innovative warhead, explosive, fuzing, and lifecycle technologies and tools to enable major improvements in non-nuclear munitions. The JMP supports the development and exploration of advanced munitions concepts and enabling technologies that precede Service-specific system engineering. A Memorandum of Understanding signed in 1985 by DoD and DOE provides the basis for the cooperative effort and for cost-sharing the long-term commitment to this effort. The JMP funds budgeted in this justification are matched dollar for dollar by DOE funds. Through this interdepartmental cooperation, DoD's relatively small investment leverages DOE's substantial investments in intellectual capital and highly specialized skills, advanced scientific equipment and facilities, and computational tools not available within DoD. Under the auspices of the JMP, the integration of DOE technologies with Joint and Individual Services' needs has provided major advances in warfighting capabilities over many years and continues to play a crucial role in the exploration, development, and transition of new technologies needed by the Services.

The JMP seeks to develop: improved modeling and simulation tools for munitions design and evaluation, including evaluation of vulnerability (i.e., design of insensitive munitions (IM)); novel experimental techniques and material property databases to support modeling and simulation; higher power and safer explosives and propellants; miniaturized, lower-cost, and higher reliability fuzes, initiators, power systems, and sensors; design tools to enable development of higher performance warheads and weapons—such as penetrators—that are hardened against high impact loads; and tools to assess the health and reliability of the munitions stockpile and predict lifetimes based on these assessments.

The JMP is aligned with Department strategic plans and policies such as:

– Munitions for contingency operations, particularly for the reduction of unintended collateral effects
– Reducing time and cost for acquisition of munitions
– Rapidly transitioning science and technology (S&T) to support the warfighter in today's conflicts
– Establishing future core capabilities and maintaining our national S&T capabilities through joint investment and interagency cooperation and teaming
– Aiding in recruiting and retaining high-caliber scientists and engineers at DoD S&T organizations
– Developing advanced munitions technologies to support the increased role of conventional weapons to deter and respond to non-nuclear attack, as described in the Nuclear Posture Review report
– Developing safer munitions that are compliant with IM standards to meet statutory and Department policy requirements

The JMP has established a successful collaborative community of DoD and DOE scientists and engineers. This community develops technologies of interest to both Departments within a structured framework of technical reviews and scheduled milestones. The JMP is administered and monitored by the Office of the Secretary of Defense (OSD) and reviewed annually by the Technical Advisory Committee (TAC), which is comprised of over 25 senior executives from the Army, Navy, Air Force,

Special Operations Command, the Defense Threat Reduction Agency, OSD, and DOE. Projects are organized in nine Technology Coordinating Groups (TCG) that bring together the disciplines necessary to properly evaluate technical content, relevance, and progress. The TCG conduct semi-annual technical peer reviews of JMP projects and plans. DoD Service laboratory technical experts lead each of the TCG to ensure that the technologies under development address high-priority DoD needs. The JMP also promotes more in-depth technical exchange via short-term visiting scientist and engineer assignments at both the DOE and the DoD laboratories.

The JMP has a long history of successful transitions and significant Return on Investment (ROI).

– The JMP is the primary provider of high performance structural mechanics computer codes used by DoD. According to the FY 2010 High Performance Computing Modernization Program Requirements Analysis Report, the DOE computer codes are used for over 90% of all (classified and unclassified) structural mechanics simulations and for virtually all of the classified calculations run by DoD. The Department expects this heavy reliance on DOE codes to grow for several reasons including: preference for using DOE codes because they are export-controlled; DOE codes are scalable, incorporate multiphysics, and run on massively parallel computer systems; and the Department can obtain source codes to modify for individual Service needs.
– A significant number of defense industrial contractors also use the DOE structural mechanics computer codes.
– CHEETAH, a standalone thermochemical computer code, is the most widely used code by DoD and defense contractors for predicting performance of energetic materials.
– The Army Research & Engineering Development Center (ARDEC) has stated that the DOE computer codes are now routinely used to design all new warheads. The use of these tools has reduced the number of validation tests required for each new warhead from about 5 to 1 with concomitant cost and time savings.
– The Army Research Laboratory has used DOE computer codes to develop and deploy new armor solutions to Iraq and Afghanistan with unprecedented speed.
– New munitions' case material and explosive fill technologies provide the warfighter with a lethal and low collateral damage capability. These technologies have been transitioned to the Focused Lethality Munition variant of the Small Diameter Bomb, which is currently fielded. The technologies are also the basis for a new Precision Lethality Mk-82 weapon that is currently under rapid development to meet a Joint Urgent Operational Need requirement for a low-collateral Mk-82 class weapon.
– The Joint Improvised Explosive Device Defeat Organization (JIEDDO) has supported applications of JMP technologies, including: compact synthetic aperture radar (SAR) systems for counter-IED efforts; pre-deployment training of military personnel by DOE explosive experts on how to recognize feed stocks and processes for homemade explosives; and use of massively parallel, multiphysics computer codes to understand how explosive blast waves cause brain injury and how these injuries could be mitigated.
– An erosive initiator technology developed under the JMP has been transitioned to the Services for use in selectable output weapons and self-destruct capabilities.
– A novel approach to controlling the sensitivity and therefore the initiative of explosives using microwave energy, as well two new, insensitive energetic materials have transitioned to development projects in the Joint IM Technology and Joint Fuze Technology Programs.
– Reliability analysis tools were used by Army Missile Command to assess RAM, AMRAAM, and TOW.
– Robotic demilitarization processing systems were installed at several locations, including a system at Hawthorne Army Depot to recover copper shape charge liners, Comp A5, and grenade bodies.

The JMP also works with the Defense Ordnance Technology Consortium (DOTC) and the National Warheads and Energetics Consortium (NWEC) of industrial suppliers to equitably and efficiently transition JMP technologies to defense industrial contractors. In addition to the computer codes mentioned earlier, the JMP has

transitioned case technology for low-collateral weapons, low-temperature co-fired ceramic technology for smaller, less expensive fuze electronic components, and erosive initiator technology for selectable effects weapons to defense industrial suppliers.

The integrated DoD and DOE efforts within the JMP are transitioning new munitions' technologies to the Department and the defense industrial base through the advanced development process. The JMP is a focal point for collaborative work by nearly 300 DoD and DOE scientists and engineers. Technical leaders from both Departments consider the JMP a model of cooperation, both within their respective departments and between departments. The highly challenging technical objectives of the approximately 35 JMP projects require multi-year efforts and sustained, long-term investments to achieve success.

The JMP projects are divided into five technical focus areas: Computational Mechanics and Material Modeling; Energetic Materials; Initiators, Fuzes, and Sensors; Warhead and Penetration Technology; and Munitions Lifecycle Technologies.

B. Program Change Summary ($ in Millions)	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total
Previous President's Budget	23.276	22.700	22.926	-	22.926
Current President's Budget	21.462	22.700	20.372	-	20.372
Total Adjustments	-1.814	-	-2.554	-	-2.554
• Congressional General Reductions		-			
• Congressional Directed Reductions		-			
• Congressional Rescissions	-	-			
• Congressional Adds		-			
• Congressional Directed Transfers		-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.691	-			
• Defense Efficiency - Baseline Review	-	-	-2.000	-	-2.000
• Other Program Adjustments	-1.123	-	-	-	-
• Defense Efficiency - Reports, Boards, Studies, and Commissions	-	-	-0.525	-	-0.525
• Economic Assumptions	-	-	-0.029	-	-0.029

Change Summary Explanation

Defense Efficiency – Baseline Review. As part of the Department of Defense reform agenda, implements a zero-based review of the organization to align resources to the most critical priorities and eliminate lower priority functions.

Defense Efficiency – Report, Studies, Boards and Commissions. As part of the Department of Defense reform agenda, reflects a reduction in the number and cost of studies below the aggregate level reported in the previous budget submission.

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
Title: Computational Mechanics and Material Modeling	7.941	8.617	7.592

Description: Projects in this technical focus area develop computational tools, material models, and calibration and validation databases which support the design and development of weapon systems. These capabilities are intended to predict complex phenomena across significant length (meso to continuum) and time (microsecond to minute) scales. The tools provide coupled, multi-physics and chemistry modeling capability that are scalable to massively parallel architectures for solving very diverse problems across the weapons systems' research and development and acquisition communities. Numeric tools are the foundation that makes possible the integration of mechanics, materials science, physics, and chemistry. This focus area also includes an extensive experimental component consisting of phenomenological or "discovery" experiments that drive model development; calibration experiments to compliment models; and validation experiments for model and code validation.

The specific projects in computational mechanics and material modeling are:

– CTH, SIERRA code & model development and experiments
– Arbitrary Lagrangian-Eulerian (ALE3D) code & model development and experiments
– DUNE granular flow model development
– Composite case technology and modeling
– Near-field lethality modeling
– Dynamic properties of weapon materials
– Energetic materials and polymers under dynamic and thermal loading
– Fragment impact and response experiments
– Thermal battery performance modeling

FY 2010 Accomplishments:
– CTH Eulerian shock physics hydrocode version 10 released with upgrades in material interface, energy conservation, number of materials, and GUI installer
– Arbitrary Lagrangian-Eulerian Three Dimensions (ALE3D) version 4.12 released with upgrades including: spiral 1 autocontact, 2D detonation shock dynamics, material parameter database, and corner theory yield surface model
– Developed thermal and finite deformation damage models for composite laminates in ALE3D
– Verified and validated shock focusing in DUNE 2D hydrodynamic-structural analysis
– Developed ViscoSCRAM model for plastic-bonded explosive (PBX) N9
– Characterized the strain-rate dependent mechanical properties of high-performance [rocket] propellant (HPP)
– Implemented a glassy polymer model into ALE3D
– Implemented two-component localization model into ABAQUS

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
– Developed dilatational viscoplastic self-consistent model – Developed improved soil material model – Incorporated improved mixture theory-based reactive flow model into CTH – Tested and analyzed the reactive response of heated explosive composites ***FY 2011 Plans:*** – Develop 3D boundary detonation shock dynamics in ALE3D – Implement implicit shells and enhanced tensile plasticity (TEPLA) damage model in ALE3D – Implement finite strain capability for composite damage and temperature-dependent composite properties in ALE3D – Incorporate a coupled yield-damage surface for use in macroconstitutive models – Complete engineered instability and mixed-mode fracture experiments – Develop a rubbery polymers constitutive model – Complete characterization and constitutive model development for rubber insulating materials in rocket motors – Refine next generation high explosive constitutive model – Implement rubber model into ALE3D – Complete PBX-N9 Taylor impact and damage studies – Conduct impact test series on PBX 9501 energetic material – Develop composite plate/shell model – Develop extended finite element method (XFEM) capability for fragmentation problems – Demonstrate mixed FEM capability to remove mesh dependency for localization problems – Release 1D electrochemical model for isothermal, constant rate discharge in thermal batteries – Develop composite micromechanics models for anisotropic equation of state (EOS) – Demonstrate mixed FEM capability to remove mesh dependency for a localization problem – Improve fragmentation simulation capability – Support for beams arbitrarily embedded in solids for modeling of reinforced structures – Expand X-FEM capabilities in SIERRA to include multiple interacting cracks for fragmentation environments – Develop a Predictor-Corrector approach for Fortissimo to improve accuracy of problems with similar impedance mismatches – Develop initial anisotropic composite model and implement into CTH and SIERRA codes ***FY 2012 Plans:*** – Deploy acoustic analysis capability for determining pressures in confined environments – Implement new statistical based models for reactive composite energetics in shock physics analysis – Damage characterization of HPP – Complete initial impact testing on pre-conditioned PBX 9501			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
– For ALE3D: a. Implement spiral 1 embedded grids (shells) b. Develop improved statistical seeding c. Develop a thermal and chemical material model database d. Perform multiscale simulations to understand effect of void distribution on failure e. Add alloys to dislocation dynamics strength model – Compare advanced composite shell element against analytical solutions – Validate a two-component model for fragmentation for select materials – Incorporate reduced-order electrochemical model within SIERRA suite			
Title: Energetic Materials ***Description:*** The goals of this technical focus area are to develop new energetic materials (EM) and supporting technologies to satisfy the competing requirements for smaller, more lethal, and safer munitions. Work is primarily focused on explosives, gun and rocket propellants, and, to a lesser extent, pyrotechnics. The projects include development of: new EM, including new molecules in a range of particle size and morphologies; new EM formulations; a fundamental understanding of energetic properties and performance; and computational tools for analysis of performance and sensitivity. New materials and formulations are developed with the recognition that cost must be feasible, chemical feed stocks reliable, and manufacturing processes suitable for scale-up to production levels. Both federal statute and Department policy direct the development of safer, less sensitive munitions. Making munitions less sensitive while maintaining explosive or propellant performance is a difficult challenge. This goal is best attained through a combination of new EM development, EM characterization, and more sophisticated modeling and simulation tools. It is cost-prohibitive to qualify weapons for compliance with insensitive munitions requirements through testing alone. A better, in many cases the only means to qualify these weapons is with the combination of analysis based on validated computational tools and a few well-designed tests. The Department requires munitions that provide selectable effects. To achieve these effects, weapons designers need to thoroughly understand the performance of EM used in both the main weapon fill and the initiation systems. Distributed fuzing systems can provide selectable effects as well as safer munitions, but such complex small-scale systems require more complete knowledge of EM detonation physics and in, some cases, new EM designed for this application.	4.507	4.694	4.260

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
The desire for smaller and lighter munitions is driven in large part by the increasing dependence on unmanned weapons platforms and to some extent by the need to reduce logistical burden, especially energy consumption. New EM are needed to meet the munitions weight and size requirements while maintaining lethality and safety. The Department is working to increase the range and velocity of weapons and to develop weapons against hardened targets. These applications subject the EM to high accelerations and shock loads. To support the development of these new systems, we need to improve our ability to model EM under impact loads and to characterize relevant properties to determine their ability to survive in these aggressive environments. We may also need to develop new, more robust EM that survive impact loads while maintaining lethality and initiability. The specific projects in the energetic materials technical focus area are: – Synthesis, properties, and scale-up of new energetic compounds – Insensitive munitions and surety – New energetic materials formulation and characterization – CHEETAH thermochemical code development and experiments – Multi-functional energetic materials – Micro- and nano-energetics synthesis and initiation – Hazards analysis of energetic materials – Reaction processes of energetic materials – Microfluidic reactor synthesis of sensitive explosives – Energetics chemistry and properties – Microstructural and kinetic effects on energetic materials behavior – Microwave sensitization and initiation of energetic materials ***FY 2010 Accomplishments:*** – Characterized slow cook-off response of ammonium perchlorate (AP), AP-based composite propellants, and PBX-9502 using Sandia Instrumented Thermal Indicator (SITI) test method – Developed a SITI for characterization of cook-off up to 550 C and applied test to high-temperature EM – Developed a simple model to describe pressure-dependent confined decomposition of explosives – Characterized effects of a high-nitrogen salt on the decomposition of RDX – Characterized interactions between IMX ingredients at low temperatures			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
– Characterized decomposition of guanidine nitrate and FOX-12 and their interactions with other ingredients in new gun propellants – Produced lead azide using a novel microfluidic continuous coaxial flow system – Released CHEETAH 6.0, which includes transport properties prediction and expanded Exp6-Polar products library – Imaged thermal explosion of PBX-9501 using HYDRA high-fidelity X-ray facility – Developed non-prompt ignition and burn model for low-velocity insults and implemented model in ALE3D – Developed and implemented a multiphase convective burn model in ALE3D – Provided several new energetic materials to DoD for evaluation: a. TAG salts of high-nitrogen compounds for gun propellants b. Energetic materials for biodegradation studies c. High-nitrogen compounds for rocket propellants – TAGzT solubility data provided to DoD for toxicology studies – Demonstrated application of microwave energy to increase sensitivity of booster-sized charge on a practical time scale using a reasonable amount of energy, established and investigated two mechanisms for sensitivity increase via application of microwaves – First laboratory-scale x-ray radiography of pre-ignition and thermal explosion experiment – Developed full kinetic model for thermal decomposition of HMX – Synthesized small-scale quantities of high-power, less sensitive explosives LLM-172 and -191 – Demonstrated new synthesis route for LLM-105 explosive, which could reduce production cost and improve production safety – Synthesized two new thermally stable insensitive EM, LLM-190 and -175, and two new high-nitrogen burn rate modifiers for gun propellants, LLM-182, and -181 – Provided ~100g quantities of multifunctional EM based on nickel and aluminum to DoD labs for evaluation – Completed fabrication of freeze-cast processing capability for multifunctional EM			
FY 2011 Plans: – Characterize HNAB (structure-processing relationships, critical thickness) for microenergetic systems – Demonstrate multi-point output in thin-film initiation systems – Transfer SITI test method to DoD labs – Develop correlations between thermal boundary conditions and cook-off violence using pre-ignition models – Determine validity of applying slow cook-off models to fast cook-off – Demonstrate ionic liquid recrystallization of triaminotrinitrobenzene (TATB) – Scale-up of LLM-105 DAPO process to 5 kg – Scale-up LLM-172, -190, and -175 syntheses to ~10-100g scale – Refine fracture models for HPP to simulate impact response			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
– Develop Spiral 1 multiphase convective burn model for HPP – Perform mesoscale modeling of energetic materials – Characterize damage and fracture of HPP – Perform shock initiation energetic materials under pressure to obtain parameters for the ignition and growth reactive flow model – Develop Spiral 1 kinetics model for HPP and other energetic materials to improve thermal response simulation – Determine the role of ignition volume, ignition point, pre-ignition state (pressure, temperature) on a specific explosive violence metric (e.g., case expansion velocity to develop post-ignition deflagration models – Perform thermal explosion imaging of insensitive explosive LLM-105 – Characterize the effect of thermal damage on HPP burn rate – For future release of CHEETAH: a. Validated Cheetah library for Cl, F, B, and Si products b. Develop thermal conductivity and viscosity model for solids c. Test and validate in-line Cheetah modules d. Complete sound speed measurements under pressure for acids, acid mixtures, and boron compounds – Thermal explosion imaging of LLM-105 at HYDRA X-ray facility – Formulate and characterize microwave sensitivity and performance of TATB-based energetic compositions designed to be sensitive to microwave irradiation – Further development of new insensitive energetic booster materials – Develop new synthetic routes for NNQAT and NNQBT (energy greater than HMX), new oxidizers, and new gun propellant additives – Conduct proton radiography experiments of HMX thermal decomposition and ignition – Freeze-cast inert and reactive materials			
FY 2012 Plans: – Demonstrate detonation transfer in deposited energetic films – Complete first phase of aging studies and material characterization of nano- and micro-energetic materials – Determine conditions necessary for propagation of reaction in fast cook-off – Complete initial results from applying reactive flow models for slow cook-off of new HPP – Release CHEETAH 7.0 with expanded equation of state capabilities for new materials – For future release of CHEETAH: a. Develop EOS models for new solids and liquids b. Develop kinetic models for liquid explosives c. Conduct ultra-fast shock measurements on PETN			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
d. Complete limited sound speed measurements under pressure for CO – Demonstrate ionic liquid recrystallization of LLM-105 – Complete synthesis of insensitive explosive LLM-175 – Develop Spiral 2 multiphase convective burn model for HPP – Develop Spiral 1 damage and failure model for HPP – Perform friability testing of HPP – Develop Spiral 2 HPP kinetics model – Model the scaled thermal explosion experiments with convective burn, fragmentation, and venting – Perform thermal response testing of pristine HPP – Implement full-scale kinetic model of HMX thermal decomposition and ignition into ALE3D and other large-scale, multi-physics computer codes. – Establish relationship between internal pressure and convective and conductive burn rates in PBX 9501 – Demonstrate laboratory scale dynamic X-ray capability for studying thermal decomposition and ignition of energetic materials. – Develop model in CTH to simulate pop-plot behavior of one variant of composite energetic material – Complete assessment of freeze-cast technique for fabrication of multifunctional EM			
Title: Initiators, Fuzes, and Sensors	4.078	4.247	3.854
Description: The goals of this technical focus area are to develop new materials, components, diagnostic techniques, and modeling and simulation tools for fuzing systems. Initiators, fuzes, and sensors must work reliably together to prevent unintended detonation, to correctly detect intended targets, and to initiate detonation when required. Projects in this focus area support the Department's needs to miniaturize fuzing systems. Smaller systems are required for several reasons including: compatibility with smaller and lighter weapons systems; trading volume in munitions for other components such as additional explosive, larger power sources, or guidance systems; increasing reliability through redundancy (use two or more smaller initiating systems); and upgrading existing sub-munitions with smarter and more reliable fuzing systems. The miniaturization of fuzing systems requires new material and components, new diagnostic techniques, and improved modeling tools for microdetonics. The Department also needs weapons systems with selectable effects and these effects can be achieved with multi-point initiation systems. Such systems are inherently more complex and require improved characterization of initiator materials and components as well as more sophisticated modeling and simulation tools. To attain greater precision and to avoid unintended collateral effects when weapons are used in the complex environment of counter-insurgency or counter-terrorist operations, target sensors must be reliable and provide high-fidelity discrimination. Two projects in this focus area are developing technologies to achieve this level of performance in compact packages.			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
The specific projects in the initiators, fuzes, and sensors technical focus area are: – Firing systems technology: FireMod firing set code model development and validation – Initiation and detonation physics on the millimeter scale – Safe, arm, fuze, and fire technologies: processing of miniature fuze components, miniature electronic safe and arm detonator designs, and novel fuzing systems – Advanced initiation systems: diagnostics development, microdetonics, miniature initiation systems, and detonators for enhanced safety – MESASAR synthetic aperture radar (SAR) sensors – Vertical cavity surface emitting laser (VCSEL) sensors for proximity fuzing ***FY 2010 Accomplishments:*** – Completed finite element analysis of circuit boards under bending loads – Developed a fault tree for potential field programmable gate array (FPGA) operational failure modes – Developed an analytical basis for predicting how Inertial Measurement Unit (IMU) performance affects SAR quality – Developed an approach to use real-time imagery to correct antenna pointing error in SAR – Developed and validated an approach to an adaptive threshold for endo-clutter ground moving target indicator (GMTI), which lowers false alarm rate – Completed prototype laser emitter and microlens arrays for VCSEL proximity sensor – Successfully captured Schlieren images of DoD Spider and Vari-drive detonators – Successfully tested plane-wave generators – Demonstrated use of James initiation model to determine acceptor/donor charge transfer for LX-16 into ultrafine (UF)-TATB – Determined detonation velocity of UF-TATB as a function of charge diameter and confinement – Fabricated a laboratory version of a 32 volt thin-film thermal battery (TFTB) with 2X improvement in energy density over state-of-the-art designs ***FY 2011 Plans:*** – Develop a nanoscale lead zirconate titanate (PLZT) synthesis route that is available for commercialization (ceramic capacitor application) – Demonstrate >1,000 part batch of energetic materials deposited on micro-electrical mechanical systems (MEMS)-compatible devices – Complete computational analysis of single electronic component packaging on a board in a dynamic environment – Characterize magnetic performance of test toroids for flyback transformers			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
– Equation of state (EOS) refinement and implement model for ignition and growth of thin-pulse shock phenomena in CTH (for chip-slapper development) – Complete electric gun testing of TATB chip slapper – Complete initial retention testing and failure mode characterization for FPGA – Complete fabrication and testing of new monopulse antenna for SAR – Redesign laser, photodetector, microlens array, and device integration based on generation 2 device testing – Provide prototype VCSEL-based proximity sensor to DoD for evaluation – Complete pellet height study of detonator for enhanced safety – Complete microdetonics detonation gap transfer study – Demonstrate explosive drive particle imaging velocimetry (PIV) – Improve functionality in FireMod suite of codes for firing systems – Conduct validation experiments for traditional and 1.6 Hazard class chip slapper detonator designs that were optimized using FireMod – Test capability of electric gun to produce a planewave generator for micro-wedge studies of initiation and detonation on the mm-scale – Fabricate first production 32 volt TFTB with 2X improvement in energy density over state-of-the-art designs ***FY 2012 Plans:*** – Demonstrate detonation transfer in thin-film energetic systems – Build PLZT-based capacitor – Produce narrow particle size distribution TATB for chip slapper initiator – Complete airborne demonstration of a fully integrated multimode SAR algorithm with integrated tracking – Redesign VCSEL proximity sensor components (laser, photodetector, microlens) for manufacturability and complete mass replication process development – Demonstrate explosive drive dynamic optical tomography of surfaces – Complete limited multiframe imaging and analysis of explosive drive using dynamic optical topography of surfaces (DOTS) technique			
Title: Warhead and Penetration Technology ***Description:*** This focus area supports the development of new warheads and penetrator weapons through advances in materials processing and characterization, instrumentation, and computational codes. In recent years there have been very large increases in warhead performance directly attributed to our ability to understand and accurately model the physics and fine details of new warhead designs, and to advances in increasingly sophisticated material processing. The Department's requirement to achieve	3.434	1.565	1.420

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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*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
more precise weapon effects with minimum collateral damage is supported by work on controlled fragmentation, non-fragmenting warhead cases, and multiphase blast explosives (MBX). More recently, increases in performance and reductions in vulnerability (IM) are being achieved through improved warhead integration into munitions using a systems-oriented approach. The goals for penetrator weapons are to investigate, develop, and transition advanced technologies for the design, development, and performance assessment of the next generation of high performance, precision strike weapons. This effort directly supports national initiatives to defeat hard and deeply buried targets, which are proliferating worldwide, and to deny/defeat weapons of mass destruction. The work addresses high-velocity penetration into granular materials (sand and soil), penetration into advanced concrete, new penetrator materials and designs, and non-inertial onboard instrumentation. The specific projects in the warhead and penetration technology focus area are: – Multiphase blast munitions (MBX) technology – Erosive initiation technology – Dynamic behavior of sand – Integrated munitions modeling & experimentation – Modeling of strategic structures – Concrete perforation and penetration modeling & experiments – High-g MEMS sensor development – Structural dynamics and vibration effects – Dynamic characterization of accelerometers – High-speed pressure-shear experiments on granular materials – Explosive/metal interactions – Structure, mechanical & shock-loading response, & modeling of materials – Controlled effects warhead materials ***FY 2010 Accomplishments:*** – Improved MBX model in ALE3D – Measured force history of erosive initiators to support hydrocode improvements – Developed EM screening tests for compatibility with erosive intiators – Completed simulations of ARDEC warhead fragmentation tests using peridynamics code KRAKEN – Implemented user-friendly upgrades to KRAKEN code – Completed fabrication of new test apparatus for study of dynamic transfer of stresses across interfaces			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
– Completed instrumented terminal ballistics and perforation experiments with high-strength concrete – Reported effects of boundary, shape, and deformability on behavior of granular materials under dynamic loading – Completed filled hemi, explosively driven fragmentation of copper, steel, and zirconium – Completed characterization and constitutive modeling of steel for rocket motor casings – Completed initial modeling of effect of shockwave profile on copper spallation ***FY 2011 Plans:*** – Integrate programmed burn meta-model for MBX into ALE3D – Investigate new optical diagnostic techniques for MBX – Complete study of erosive initiator for selectable yield – Complete verification and validation of KRAKEN and release initial version to DoD users – Implement the material point method into CTH for analysis of weapons effects on structures – Complete dynamic testing of a new MEMS-based pressure sensor for penetration tests – Complete testing and analysis of dynamic stress transfer across simple interfaces without chatter – Complete testing and analysis of new commercial high-g accelerometers – Complete dynamic high-pressure/shear experiments on granular materials – Complete study of effects of fracture and fluid interaction on dynamic behavior of granular materials – Conduct explosive-filled hemisphere tests on copper – Apply material particle methods to model detonation of explosive-filled hemisphere – Complete analysis of explosive-filled 4340 steel hemisphere experiments – Complete initial HE sweeping detonation-wave incipient spall testing in steel, copper, and tantalum – Update weapon material database of constitutive properties – Complete characterization/constitutive modeling of 4340 steel as function of heat treatment – Complete initial dynamic tensile extrusion experiments on Zr, DU, Ta, and U-6Nb as function of elevated temperature – Complete initial HE sweeping detonation-wave incipient spall testing in 1018 steel, Cu, and Ta – Complete initial metallographic/OIM analysis of sweeping detonation-wave spallation damage evolution in Cu and Ta – Compare oblique shock modeling simulations to post-mortem analysis of oblique preshocked Cu and Ta to ascertain instability signatures and correlated with fracture/fragmentation – Complete analysis of the influence of stress state on shear localization in high-purity Fe – Develop processing method to produced controlled effects samples for high-explosive loading – Complete scoping simulation studies of fragmentation response using existing particle methods – Produce first batch of powder of controlled effects warhead materials ***FY 2012 Plans:***			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
– Validate liner simulations for MBX – Complete initial discovery experiments of dense particle phase flow in MBX using improved diagnostics – Develop models for dilute flow regime in MBX – Add deviatoric stress capability to material point method capability within CTH – Develop models for transfer of stress waves across interfaces without chatter – Complete limited high-speed pressure-shear experiments on granular materials – Develop first generation sand constitutive models for ALE3D – Complete characterization of 155 HF-1 steel in support of insensitive munitions modeling and simulation – Conduct sweeping detonation-wave incipient spall testing on DU – Complete analysis of Cu fragmentation and study of the effects of inclusions on fragmentation – Complete study of fragmentation of Ag-Cu allow when subjected to prestraining – Complete quasi-static and laser induced shock experiments on first batch of controlled effects warhead materials			
Title: Munitions Lifecycle Technologies	1.502	3.577	3.246
Description: This focus area supports improving the Department's ability to understand, measure, predict, and mitigate safety and reliability problems caused by materials aging and degradation in weapons systems. This area also focuses on developing technologies for the safe and environmentally friendly demilitarization, recycling, and reuse of munitions. Current stockpile assessment methods typically focus on addressing materials aging and reliability problems after they occur, rather than anticipating and avoiding future problems or failure mechanisms. The overall objective of this work is to develop a toolset of computational models that are able to quantitatively predict materials aging processes and ultimately improve the long-term reliability of weapons systems, sub-assemblies, and/or components. This objective is achieved by: identifying aging mechanisms, quantifying the rates at which those aging mechanisms occur, developing predictive models, and using these models to predict the munitions stockpile reliability. An additional objective of this work is to develop technologies and methodologies to enable munitions health management and condition-based maintenance. The specific projects in the warhead and penetration technology focus area are: – Predictive materials aging including: solder interconnect reliability, corrosion of electronics, and adhesive degradation – MEMS reliability – Military use of commercial-off-the-shelf (COTS) electronics – Complex system health assessment ***FY 2010 Accomplishments:***			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2010	FY 2011	FY 2012
– Used a connector corrosion model in an electrical system performance analysis to predict the effect of corrosion on system reliability – Completed a dynamic recrystallization model for whisker growth in solder materials – Determined effects of surface roughness and water on degradation of adhesive strength of polymers on metals – Designed and fabricated a series of MEMS reliability test structures ***FY 2011 Plans:*** – Develop a de-bonding metric for displacement of an adhesive by water – Complete tin whisker validation experiments for dynamic recrystallization (DRX) model – Complete tin whisker validation experiments for DRX model – Complete second phase, electronic package-on-package test vehicle assembly – Demonstrate engineering aging structures integrated into a military system – Validate long-term life predictive models after 7 years of field storage of COTS electronics – Publish practices on Counterfeit Avoidance and Detection of COTS electronics – Develop life prediction models for new COTS materials and technologies – Implement a population reliability summary in SRFYDO reliability analysis software – Complete a case study on environmental science condition-based reliability modeling for a single failure mode from a DoD weapon system – Develop additional reliability assessment tools for evaluating management strategies for future consumption and maintenance of weapons systems – Develop methodology for characterizing future usage patterns based on historical usage information ***FY 2012 Plans:*** – Complete initial tin solder contamination mitigation trials – Develop model to predict debonding in a primer/adhesive system in a humid environment – Generalize weapon system health assessment model to connect environmental to degradation summaries – Develop methodology for selection of lifecycle variables at component level in weapon system health assessment model			
Accomplishments/Planned Programs Subtotals	21.462	22.700	20.372

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

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F. Performance Metrics

1) Transitions of technologies developed by the Program are tracked and documented. In FY10 there were more than 25 transitions to DoD.
2) Attendance and technical interactions at the biannual meetings of the nine Technology Coordinating Groups (TCGs) are tracked and documented
3) Laboratory Five Year Plans are prepared, evaluated, and analyzed by management and technical staff
4) TCG Chairmen's Annual Assessments for each TCG are critically reviewed by the Technical Advisory Committee to determine progress, validate transition plans, and verify relevance of each project
5) Project progress toward goals and milestones is assessed at each biannual TCG meeting and critically reviewed annually by the Technical Advisory Committee
6) Annual technical reports and papers are tracked and documented