| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2020 Office of the Secretary Of Defense | **Date:** February 2019 |
|---|---|
| **Appropriation/Budget Activity**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide* I BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z I *Joint DOD/DOE Munitions Technology Development* |

| COST ($ in Millions) | Prior Years | FY 2018 | FY 2019 | FY 2020 Base | FY 2020 OCO | FY 2020 Total | FY 2021 | FY 2022 | FY 2023 | FY 2024 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Program Element | - | 17.959 | 18.602 | 18.773 | - | 18.773 | 19.048 | 19.379 | 19.743 | 20.161 | Continuing | Continuing |
| 225: *Joint DOD/DOE Munitions* | - | 17.959 | 18.602 | 18.773 | - | 18.773 | 19.048 | 19.379 | 19.743 | 20.161 | 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, advanced and disruptive explosive, fuzing, weapons effects, and lifecycle technologies and tools to enable significant improvements in conventional 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. The DoD JMP funds budgeted in this justification are matched, at a minimum, 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 has established a successful collaborative community of DoD and DOE scientists and engineers that develop 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 Munitions Technical Advisory Committee (TAC), which is comprised of munitions laboratory technical directors and senior executives from the Army, Navy, Air Force, Special Operations Command, the Defense Threat Reduction Agency, OSD, and DOE. Projects are organized in eight Technology Coordinating Groups (TCG) that bring together the disciplines necessary to properly evaluate technical content, relevance, and progress. The TCGs conduct semi-annual technical peer reviews of JMP projects and plans. DoD Service laboratory technical experts lead each of the TCGs to ensure that the technologies under development address high-priority DoD gaps, needs, and challenges. 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 also works with the Defense Ordnance Technology Consortium (DOTC) and the National Armaments Consortium (NAC) of industrial suppliers to equitably and efficiently transition JMP technologies to defense industrial contractors.

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 32 current projects require multi-year efforts and sustained, long-term investments to achieve success.

| **Exhibit R-2, RDT&E Budget Item Justification:** PB 2020 Office of the Secretary Of Defense | **Date:** February 2019 |
|---|---|
| **Appropriation/Budget Activity**<br>0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* |

| **B. Program Change Summary ($ in Millions)** | **FY 2018** | **FY 2019** | **FY 2020 Base** | **FY 2020 OCO** | **FY 2020 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 18.662 | 18.644 | 18.827 | - | 18.827 |
| Current President's Budget | 17.959 | 18.602 | 18.773 | - | 18.773 |
| Total Adjustments | -0.703 | -0.042 | -0.054 | - | -0.054 |
| • Congressional General Reductions | - | - | | | |
| • Congressional Directed Reductions | - | - | | | |
| • Congressional Rescissions | - | - | | | |
| • Congressional Adds | - | - | | | |
| • Congressional Directed Transfers | - | - | | | |
| • Reprogrammings | - | - | | | |
| • SBIR/STTR Transfer | -0.667 | - | | | |
| • FFRDC Reduction | -0.036 | -0.042 | - | - | - |
| • Other Program Adjustments | - | - | -0.054 | - | -0.054 |

| **Exhibit R-2A, RDT&E Project Justification:** PB 2020 Office of the Secretary Of Defense | | **Date:** February 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>0400 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* | **Project (Number/Name)**<br>225 / *Joint DOD/DOE Munitions* |

| COST ($ in Millions) | Prior Years | FY 2018 | FY 2019 | FY 2020 Base | FY 2020 OCO | FY 2020 Total | FY 2021 | FY 2022 | FY 2023 | FY 2024 | Cost To Complete | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 225: *Joint DOD/DOE Munitions* | - | 17.959 | 18.602 | 18.773 | - | 18.773 | 19.048 | 19.379 | 19.743 | 20.161 | Continuing | Continuing |

**A. Mission Description and Budget Item Justification**

The JMP seeks to develop technological advances in several munitions subject areas. These include: 1) improved modeling and simulation tools for munitions and system design and evaluation, including evaluation of lethality, vulnerability and the design of energetic materials (EM) and insensitive munitions (IM), 2) novel experimental techniques and material property databases to support modeling and simulation, 3) higher power and safer explosives and propellants, 4) miniaturized, lower-cost, and higher reliability fuzes, initiators, power systems, and sensors, 5) design tools to enable development of higher performance warheads and weapons, such as penetrators, that are hardened against high impact loads, and 6) tools to assess the health and reliability of the munitions stockpile and predict lifetimes based on these assessments. The supporting experimental research requires the development of new technologies related to the synthesis, processing, formulation, and characterization of advanced munition materials, components, and systems. This involves energetic material research, new fuzing concepts, dynamic testing of munition materials, and advanced characterization including high-rate in-situ diagnostics.

The JMP projects are divided into five technical focus areas: 1) Computational Mechanics and Material Modeling, 2) Energetic Materials, 3) Initiators, Fuzes, and Sensors, 4) Warhead and Penetration Technology, and 5) Munitions Lifecycle Technologies.

Each of the 32 projects has a detailed five year plan with objectives, tasks, deliverables and milestones that is approved annually by a group of 20-plus SES from the DoD munitions laboratories.

| **B. Accomplishments/Planned Programs ($ in Millions)** | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***Title:*** Computational Mechanics and Material Modeling<br><br>***Description:*** Projects in this technical focus area develop physics-based computational tools, material models, and calibration and validation databases that support the design and development of weapon systems. These capabilities are intended to predict the complex phenomena across significant length (meso to continuum) and time (nano-seconds to minutes) scales. The tools will provide coupled, multi-physics and chemistry modeling capabilities that are scalable to massively parallel architectures for solving 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: 1) phenomenological or “discovery” experiments that provide the physics basis for model development, 2) experiments directly coupled to model development and application, such as characterization, calibration, and validation experiments, or 3) the development of advanced test methods or device development.<br><br>The specific projects in computational mechanics and material modeling are:<br>- CTH (Sandia code) shock physics and Sierra/Solid Mechanics (SM) codes & model development and supporting experiments. | 6.202 | 6.141 | 6.179 |

| **Exhibit R-2A, RDT&E Project Justification:** PB 2020 Office of the Secretary Of Defense | | **Date:** February 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>0400 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* | **Project (Number/Name)**<br>225 / *Joint DOD/DOE Munitions* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| - Arbitrary Lagrangian-Eulerian Three-Dimensional (ALE3D) code and model development.<br>- Composite case technology and modeling.<br>- Dynamic properties of materials, modeling and validation.<br>- Energetic materials and polymers under dynamic and thermal loading.<br>- Fragment impact and response experiments.<br><br>***FY 2019 Plans:***<br>Release CTH Version 13.0.<br>Release Sierra Mechanics Version 4.52.<br>Determine the effects of thermodynamic non-equilibrium under high strain rate considered using the multi-scale methods in Carta Blanca.<br>Complete Ignition/violence characterization tests on pedigreed PBXN-9, Comp B, and Plastic Bonded eXplosive (PBX) 9501.<br>Release ALE3D Version 4.30.<br>Transfer key portions of Lawrence Livermore National Laboratory's Siboka workflow tools to one or more DoD platforms (Army Armament Research, Development & Engineering Center and Air Force Research Laboratory) for the development of warhead design optimization tools.<br>Continue to improve and release the MIDAS material database to the DoD and the DOE.<br><br>***FY 2020 Plans:***<br>Improved CTH numerics to obtain identical results over all platforms<br>CTH Version 14.0<br>Verify and validate composite models for oblique impact experiments<br>Magnetic ramp compression experiments for insensitive high explosives<br>Improvements to ZAPOTEC (Sandia Code) usability for improved lethality and vulnerability analyses<br>Develop damage-based failure models for Sierra/SM<br>Release ALE3D version 4.34.<br>Extend adaptive mesh refinement capability to 3D in ALE3D<br>Improve accuracy in smooth particle hydrodynamics and adding implicit auto-contact in ALE algorithms<br>Advanced material models for shear localization<br>Deep learning for Fast Running Model (FRM) generation<br>Complete implementation of new porosity based ductile damage model within ABAQUS with micro-inertia and coalescence<br>Effects of thermodynamic non-equilibrium under high strain rate considered using the multi-scale methods in Carta Blanca<br>Ignition and violence characterization tests completed on pedigreed PBXN-9, Comp B, and PBX-9501<br>Review for off-ramp or identification of next polymers of interest for JMP | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Office of the Secretary Of Defense | | Date: February 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>0400 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* | **Project (Number/Name)**<br>225 / *Joint DOD/DOE Munitions* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| Complete PBX-9502 impact test series<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>Small changes reflect minor budget fluctuations. | | | |
| ***Title:*** Energetic Materials (EM)<br><br>***Description:*** The goals of this technical focus area are to develop new Energetic Materials (EMs) 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: 1) new EMs, including new molecules in a range of particle sizes and morphologies, 2) new EM formulations, 3) a fundamental understanding of energetic properties and performance, and 4) computational tools for analysis of performance and sensitivity. New materials and formulations are developed with the recognition that costs must be reasonable, chemical feed stocks reliable, and manufacturing processes suitable for scale-up to production levels.<br><br>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, and 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.<br><br>The Department also needs munitions that provide selectable effects and improved lethality. To achieve these effects, weapons designers need to thoroughly understand the performance of EMs 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 EMs designed for this application.<br><br>The desire for smaller and lighter munitions is driven in part by recommendations of the Long Range Research and Development Program Plan (LRRDPP) and the increasing dependence on unmanned weapons platforms and to some extent by the need to reduce logistical burden, especially energy consumption. New EMs are needed to meet the munitions weight and size requirements while maintaining and improving lethality, effects, and safety.<br><br>In order to clearly establish overmatch, the Department is working to increase the range and speed of weapons and to develop weapons against hardened targets. This thrust includes the development of hypersonic and hyper-velocity weapons. These applications subject EMs to high accelerations and shock loads. To support the development of these new systems, we need | 5.326 | 5.624 | 5.662 |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Office of the Secretary Of Defense | | Date: February 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>0400 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* | **Project (Number/Name)**<br>225 / *Joint DOD/DOE Munitions* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|

to improve our ability to model EM under higher impact loads and to characterize relevant properties to determine their ability to survive in these aggressive environments. DoD may also need to develop new, more robust EMs that survive impact loads while maintaining lethality and the ability to initiate weapons under extreme conditions.

TCG-III is also a forum for the exchange of information on new energetic materials, their performance and sensitivity characteristics, and physical models that can be used to predict the behavior of energetics under adverse and unplanned conditions. It is a venue in which collaboration opportunities can be identified to facilitate the transition of technology developed in the DOE to the DoD.

The specific projects in the energetic materials technical focus area for FY 2018 are:
- Synthesis, properties, and scale-up of new energetic compounds.
- Insensitive munitions and surety.
- Cheetah thermochemical code development and experiments.
- Micro- and nano-energetics synthesis and initiation.
- Hazards analysis of energetic materials.
- Reactive processes in energetic materials.
- Development of tools for energetic material performance characterization.
- Explosives chemistry and properties, and new energetic materials formulation.
- Thermal response of energetic materials.

***FY 2019 Plans:***
Complete graded additive manufactured (AM) booster design experiments on selected designs including non-destructive evaluation of as-printed energetic material.
Integrate code capabilities to facilitate exploratory calculations (e.g., constant volume explosions at user specified conditions, EOS tables for hydro simulations (e.g., LEOS, SESAME), multiple constraints on formulation performance, etc.). Upgrade graphical user interface to maintain and enhance functionality (e.g., heat of formation and density estimates) and compatibility with current versions of major operating systems.
Complete performance testing on energetic binders and then formulate main charge with energetic polymers.
Integrate pre and post-ignition modeling of thermal response in PBX 9501.
Report on ammonium perchlorate (AP) propellant thermal decomposition.
Develop high-speed, high-definition imaging capability and data-extraction method for material behavior and combustion front observation.

***FY 2020 Plans:***

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| Incorporate damage into combustion model and violence assessments<br>Complete characterization of LLM-105 based AM formulation and refine reactive flow model<br>Develop mesoscale modeling approach for obtaining reaction rate of mixtures<br>Design a graded LX-20/LLM-105 architected experiment using latest optimization methods<br>Reactive flow model development for tritonal, Al/HTPB formulations in Cheetah 9.0<br>Synthesis of hexanitrotriimidazole<br>Reduce synthesis conditions of poly-CO using a variety of experimental approaches and final report<br>Transition routes to new energetic plasticizers to ARL<br>Formulation of propellants with energetic polymers<br>Determination of the mechanism of pressurization in HMX-based formulations<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>The increase in FY 2019 funding enables more effort focused on advanced and disruptive energetics #to increase range, speed, lethality, and effects of munitions. | | | |
| ***Title:*** Initiators, Fuzes, and Sensors<br><br>***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: 1) compatibility with smaller and lighter weapons systems, 2) trading volume in munitions for other components such as additional explosives, higher energy and power density power sources, or enhanced guidance systems, 3) increasing reliability through redundancy, for example, using of two or more smaller initiating systems, and 4) upgrading existing sub-munitions with smarter and more reliable fuzing systems.<br><br>The miniaturization of fuzing systems requires new material and components, new power systems, new diagnostic techniques, and improved modeling tools for microdetonics. The Department also needs weapons systems with selectable effects, and these effects may 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. Projects in this focus area are developing technologies to achieve this level of performance in compact packages.<br><br>The specific projects in the initiators, fuzes, and sensors technical focus area are: | 2.927 | 3.177 | 3.217 |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Office of the Secretary Of Defense | | Date: February 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>0400 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* | **Project (Number/Name)**<br>225 / *Joint DOD/DOE Munitions* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| - Firing Systems Technology, comprising FireMod firing set code model development and validation, 1.6 hazard classification detonator development, and initiation and detonation physics on the millimeter scale.<br>- Safe, Arm, Fuze and Fire Technology, comprising Initiation and Detonation, and Advanced Firing System Components.<br>- Advanced Initiation Systems, comprising diagnostics development, microdetonics, miniature initiation systems, and detonators for enhanced safety.<br>- Thermal Battery Performance Modeling to develop a multi-physics modeling capability for thermal batteries.<br>- Thin Film Thermal Batteries to develop, mature, and transition a method to produce a thin, conformal, low-cost thermal battery.<br>- Vertical-Cavity Surface-Emitting Laser (VCSEL) sensors for proximity fuzing of munitions with very low size, weight, and power requirements.<br>- Enabling Robust, Mode-Agile GPS-Denied Weapon Guidance through High-Efficiency Data Processing.<br><br>***FY 2019 Plans:***<br>Demonstrate the ability to model thin-film batteries and couple thermal and electrical performance.<br>Optimization of process to cut metallized glass/epoxy composites without damaging electrodes.<br>Demonstrate 10 Volt (V), 10-cell stack at 1 amphere/square centimeter (A/cm2) with < 50 ms rise to midvoltage and no shorting.<br>Delivery of SAR-on-SAR and ROFEC prototype hardware/software processor solution to DoD customer for evaluation.<br>Refine fabrication and complete optical characterization of VCSEL and complete g-testing.<br>Report status of photoactive high explosives (HE) project capabilities in preparation for specification of down-selected engineering applications, e.g., prompt versus deflagration to detonation transition (DDT) photo-active detonators.<br><br>***FY 2020 Plans:***<br>Transition to additively manufactured VSCEL lens arrays to eliminate manufacturing defects<br>To explore the use of PML capacitor technology for use in CDU (Capacitor Discharge Unit) applications<br>To develop GaN and AlGaN based transistors for high voltage, high current, high di/dt solid state switches (1-2 kV, 50 A/ns) for compact firing sets<br>Incorporate aging into battery design tool<br>Additively manufactured plane wave generator prototypes delivered to DoD (ARDEC)<br>Develop performance metrics for wave-shaping enhanced IM initiation train<br>Status achievements, capabilities, and lessons-learned obtained through collaborative Tailored Flyers research with NSWC/Crane<br>Status development and integration of a “standard” set of experiments necessary for calibration and validation of detonator-scale HE performance in numerical hydrocodes<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Office of the Secretary Of Defense | | Date: February 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>0400 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* | **Project (Number/Name)**<br>225 / *Joint DOD/DOE Munitions* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| The increase of FY 2019 would accelerate the transition of technology to the DoD for advanced modeling to optimize new weapons firing and detonation system design. | | | |
| ***Title:*** Warhead and Penetration Technology | 2.828 | 2.870 | 2.908 |

***Description:*** This focus area supports the development of new warheads and penetrator weapons through advances in materials processing and characterization, instrumentation, and computational codes. Significant increases in warhead performance are 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 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 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 high-strength, high performance, and ultra-high-performance concretes, new penetrator materials and designs, and non-inertial onboard instrumentation.

***FY 2019 Plans:***
Add a granular temperature model to ALE3D for improved modeling of MBX.
Element conversion of finite element modeling and discrete element modeling (FEM-DEM) with improved stability in ALE3D v4.32.
Complete mechanistic mesoscale simulations for concrete penetration.
Develop thermomechanical solution framework for hard-target penetration.
Concrete perforation and penetration modeling and experiments on high performance and ultra-high performance material.
Simulate 3D compact shear sample experiment on two materials of interest – possibly stainless steel or tantalum – using the 3D embedded element formulation.
Exercise new model within CartaBlanca for the sweeping detonation wave damage problem on tantalum.

***FY 2020 Plans:***
Improve gas phase diagnostics to measure aluminum particle temperature over time, and digital image holography improvements to measure particle drag and reaction rates
Generate synthetic fragment data set for improvement and testing of fragment tracking software
Integrate Peridynamics Multiscale (PDMS) into a DoD code such as EPIC
Granular temperature model for Advanced Multidomain Coupling (AMC) in ALE3D

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Office of the Secretary Of Defense | | Date: February 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>0400 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* | **Project (Number/Name)**<br>225 / *Joint DOD/DOE Munitions* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| Scaling law for Jones-Wilcings-Lee (JWL) equation of state with dense particulates in ALE3D<br>White paper on continuum model and selected validation results<br>Progress assessment and final 5-year report on dynamic behavior of concrete<br>Complete characterization and constitutive modeling of AF9628 (Eglin Steel)<br>Demonstrate sweeping wave drive control utility in munitions design<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>The increase of funding from FY 2019 to provide improvements in image-based fragment tracking. Improved data used for model validation for fast-running lethality and collateral damage codes. | | | |
| ***Title:*** Munitions Lifecycle Technologies<br><br>***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. Current stockpile assessment methods typically focus on addressing materials aging and reliability problems after they occur, rather than anticipating, predicting, 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, subassemblies, and/or components. These objectives are 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.<br><br>The specific projects in the munitions lifecycle technologies focus area are:<br>- Predictive Materials Aging, including solder interconnect reliability, corrosion of electronics, and adhesive degradation.<br>- Microelectromechanical systems (MEMS) reliability.<br>- Military use of commercial off-the-shelf (COTS) electronics.<br>- Complex system health assessment.<br>- Physical/chemical reactive transport modeling of material/system aging and reliability.<br><br>***FY 2019 Plans:***<br>Experimentally characterize and model DOE & DoD material(s) of interest based on suspected impact on aging and outgassing.<br>Simulate multi-material experiments (MME) on DoD system (MLRS M26 ignitor).<br>Complete 3D, MME experiments for validation on identified systems of interest.<br>Simulate 3D compact shear sample experiment on two materials of interest – possibly stainless steel or tantalum – using the 3D embedded element formulation.<br>Use 3D experiments to determine outgassing effects of critical materials. | 0.676 | 0.790 | 0.807 |

| **Exhibit R-2A**, **RDT&E Project Justification:** PB 2020 Office of the Secretary Of Defense | | **Date:** February 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>0400 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603225D8Z / *Joint DOD/DOE Munitions Technology Development* | **Project (Number/Name)**<br>225 / *Joint DOD/DOE Munitions* |

| **B. Accomplishments/Planned Programs ($ in Millions)** | **FY 2018** | **FY 2019** | **FY 2020** |
|---|---|---|---|
| Transition tin whisker mitigation to commercial plating houses.<br>Develop datasets for electrochemical kinetics and damage distributions on aluminum under varying humidity and chloride-loading conditions.<br><br>***FY 2020 Plans:***<br>Develop datasets for electrochemical kinetics and damage distributions on aluminum under varying humidity and chloride-loading conditions.<br>Compile long-term performance data for coatings that resist tin whisker penetration<br>Transition material aging and reliability tool to the DoD (NSWC-IH), and close project.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>Small fluctuations reflect minor budget adjustments. | | | |
| **Accomplishments/Planned Programs Subtotals** | 17.959 | 18.602 | 18.773 |

## C. Other Program Funding Summary ($ in Millions)

N/A

**Remarks**

## D. Acquisition Strategy

N/A

## E. Performance Metrics

1. Transition of technologies developed by the Joint DoD/DOE Munitions Technology Program are tracked and documented. In FY 2017, there were over 70 transitions to DoD weapons programs and personnel.
2. Attendance and technical interactions at the semiannual meetings of the eight Technology Coordinating Groups (TCGs) are tracked and documented.
3. Laboratory Five-Year Plans are prepared, evaluated, analyzed and approved by DOE and DoD management and technical staff.
4. TCG Chairmen's Annual Assessments for each TCG are critically reviewed by the Technical Advisory Committee (TAC) to determine progress, validate transition plans, and verify relevance of each project.
5. The five-year plans and all news start projects are approved each year by the TAC. Adjustments are made to the five-year plan based on recommendation of the TAC to meet the most compelling gaps, needs, or challenges of the DoD and the DOE.
6. Project progress toward goals and milestones is assessed at each biannual TCG meeting and critically reviewed annually by the TAC.
7. Annual technical reports, papers, and presentations are tracked and documented.