Exhibit R-2a, RDT&E Project Justification								Date: February 2003
Appropriation/Budget Activity RDT&E, Defense Wide/BA 3				Project Name and Number Joint DoD/DOE Munitions PE 0603225D8Z				
Cost ($ in millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
DoD/DOE Munitions/P225	18.982	18.623	25.011	25.351	25.293	25.594	26.027	25.982

A. Mission Description and Budget Item Justification:

(U) The Joint DoD/DOE Munitions Technology Program has the mission of exploration and development of technologies intended to bring about major improvements in non-nuclear munitions technology. A memorandum of understanding between DoD and DOE provides the necessary basis for long-term commitment of resources of the DOE and a similar long-term commitment of the enabling DoD support for this effort. The continuous fusion of DOE technology with Service needs has provided major advances in warfighting capabilities and plays a crucial role in the exploration, development, and transition of new technologies of interest to the Services. The program provides a unique opportunity for the collaboration of DoD and DOE scientists to explore technologies of programmatic interest to both departments, within a structured program of established Departmental reviews and milestones. The interdepartmental collaboration allows exchange of information and the focusing on achievement of goals of interest to the Department, utilizing the substantial investment in the scientific resources of the DOE. The budgeted program funds represented here are supplemented by additional matching DOE funds.

(U) Over the last two years, there has been an increased programmatic emphasis on developing technologies of particular value to counter-terrorism capabilities and asymmetric warfare. Initial successes have already emerged from this focus with products currently in the field. The increase in Budget for FY2004 and beyond is designed specifically to focus additional program efforts on exploring and developing technologies to transform the operational capabilities of the warfighter. Two specific efforts are targeted for this increase: The first is the support of a new and rapidly emerging technology employing inert-loaded explosives which will enable precision lethality munitions; The second is the support of accelerated development of advanced initiation systems which will provide increased reliability, capability, and fieldability of Service munitions. The inclusion of precision lethality munitions within the Joint Program is significant from a number of points of view. The program goal is the development of the understanding as well as the demonstration of the capability for a precision lethality munition, which combines substantially increased lethality within a prescribed region, with a low collateral damage beyond that region. Other anticipated characteristics of the precision lethality munitions are a reduced size over current munitions and satisfaction of insensitive munition requirements. The attainment of this goal requires simultaneous developments in the multiple program areas of energetic materials, computations and modeling, composites, penetration and warhead technology. This integrated effort within the Joint Program is a new approach which we believe will speed the transition of new technology through the development process. This effort has the strong support of all the Services and Special Operations Command. The advanced initiation systems effort is intended to develop a capability for the rapid fabrication and evaluation of multi-point initiation systems, which are critical to miniature, adaptable output munitions. The capability will greatly reduce the time and cost to design, develop, and implement the required advanced initiation systems. All Services have needs for the miniature, highly reliable, and adaptable initiation systems targeted by this development effort.

(U) The program effort is divided into five technology areas of interest to Department munitions, each of which is described below.

(U) The fuze is a critical component in every Department munition system. A fuze must ensure personnel safety by preventing unintended weapon detonation, know when to allow arming of a firing mechanism, detect the target through the use of sensors, and initiate detonation when required. With a growing emphasis on hard target defeat, advanced fuze systems must be able to survive and function in increasingly higher-velocity, 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, and sensors. In support of this technology area this program continues to demonstrate advances in miniaturizing high-voltage Electronic Safe and Arm Devices (ESAD) through research and development of low-energy detonator / booster combinations and miniature capacitive discharge units (CDUs). This focus builds on recent advances in micro-detonic/energetic materials research, and MEMS Safe and Arm Devices (MEMS-SAD). Efforts in this portion of the program generally advance fuze technology development and ultimately provide the DoD and DOE with viable 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 program 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 will be aimable, target adaptable, and survivable. This area is targeted for increased funding as described above.

(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 impact the logistics burden on military actions. Smarter munitions, capable of selectable, differential output, are another boon to military agility. Hence, there is also need for advanced EMs that can be used in small-scale devices such as distributed fuzing systems. In addition, as the intended environments have become more severe, EM's must survive setback forces in guns and severe impact forces in hard-target penetration applications. Work in energetic materials was aligned with the recommendations from the DoD 2000 Weapons Technology Area Review and Assessment (TARA) and is coordinated with the recently established national initiative in advanced energetic materials. This aspect of the program is aimed at developing the next-generation of EMs that have increased energy density over those in our current inventory while remaining insensitive to extreme environments. An additional requirement is that the energy be released in an appropriate time domain to allow optimized coupling to the target. For enhanced lethal effects the energy 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 munition 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 enabling technology for the next generation of weapon systems that will be safer, smaller and more lethal.

(U) The ability to accurately predict the behavior of weapons in their operating environment 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 capabilities using high-performance computing hardware and software that are sufficient to carry out a broad class of continuum mechanics simulations where shock waves, nonlinear dynamics, and multi-material gas dynamics are important. In particular, this aspect of the program 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 material in dynamic states. Three general classes of codes offer solutions to the varied requirements posed by the defense community in the shock analysis regime. Eulerian shock physics tools are effective for a large number of conventional weapons and advanced energetics related simulations. Anywhere there is very large 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. A third class of tools combines 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, which cannot be addressed adequately with either Eulerian or Lagrangian codes. These codes and associated validated material models represent the future in modeling complex dynamics encountered in a broad spectrum of applications across the defense community.

(U) There is a worldwide trend to harden more military facilities. Increasingly, these 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 and Balkan wars, and much of our military planning is being devoted to defeating them. A major thrust of this program 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 with high angles of attack experience violent dynamic responses that can fail their cases or interfere with the functionality of fuzes. Similarly, oblique, low velocity target impacts can result in ricochet, undesirable shallow trajectories, or bouncing out of the target. In general, new delivery vehicles tend to be smaller and faster, requiring smaller penetrators that carry less payload and must survive more stressing impacts. Developing improved penetrating weapons depends on a solid understanding of the physics of penetration as well as affordable materials and processes to execute new designs that require more strength and durability from the penetrator. Although we can predict penetration depth with acceptable confidence, there are some targets for which we have insufficient data and experience; consequently, predicting the path a penetrator will take and whether it will survive is much less certain. This program 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 WMD facilities, the application of energy to target must be thoroughly controlled and understand. This requirement places need demands on warhead output, which are being pursued under this program.

(U) DoD and DOE efforts toward munitions lifecycle technologies including stockpile aging, surveillance, demilitarization and disposal are coordinated under the auspices of this program. 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 it is expanding by about 70,000-100,000 tons per year. As the long term focus for demilitarization and disposal in DoD turns from open-burn and open-detonation to resource recycle and recovery, alternative technologies are required to turn waste materials into useful products. The technologies developed in this portion of the program enhance DoD capabilities to field safe, cost-effective processes for disposal, resource recovery, and reutilization of munitions and munitions components. For an aged weapons stockpile that has not reached end of useful life, reliability and surety will change with time because of the 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 this program is focused on improving our ability to understand, measure, predict, and mitigate safety and reliability problems caused by materials aging 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 system modernization.

B. Accomplishments/Planned Program

Accomplishment/Effort/Subtotal Cost	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Initiation and Fuzing	3.290	3.610	5.231	5.251

(U) **FY 2002 Accomplishments:**

(U) In FY 2002, improvement of electronic safing, arming and firing systems continued with a focus on miniaturization, cost reduction and shock survivability for hard target penetrators. This year, miniaturization of the next generation microCDU began with modeling of the discrete electronic components and the goal of reaching a final volume of 0.020 in^3 . The components were assembled and mounted onto a CDU flex cable configuration designed to wrap around the ceramic capacitor, operated at 1000 V, and successfully demonstrated to hold off 1500V. In late FY2002 detonation of HNS or CL-20 explosive with this microCDU design will be demonstrated. In support of a viable fuze industrial base, work commenced with Raymond Engineering and other suppliers on improving the manufacturing process for chip detonators and characterizing their performance. Nanostructured Multi Layer (NML) technology has the potential of reducing the size of a fireset capacitor by a factor of 10 to 100. Towards this goal, a four layer NML capacitor was successfully produced which enabled the realization of an NML capacitor in a single assembly with half the volume of the previous configuration. Work on the solid dielectric break down switch was deferred until FY 2003 in order to focus on NML capacitor miniaturization and build upon the demonstrated success. As low voltage fuze architectures are developed, it is anticipated that the ability to physically move or block fire train elements (e.g. micro energetic materials) will be a primary feature of out-of-line systems. In support of these architectures, the ability to integrate micro energetic materials with MEMS devices will become a crucial technology. Accordingly, in FY 2002 processes to preferentially load or coat simple MEMS structures with film energetic materials were investigated. Specifically, methods for patterning explosive materials using both reactive ion etch and lift-off techniques were studied. As a result, a dedicated EM deposition system is being established which will enable the production of microenergetic devices by sequential CHNO deposition. The testing program to evaluate the long-term performance and reliability of chip slappers in realistic military environments continued in FY 2002 with the addition of a large quantity of slapper test data to the statistical database. Towards the program goal of demonstrating a prototype ESAD in a high-velocity penetrator in FY2003, characterization of detonators, capacitors, and switches in shock environments continued for application to hard target munitions. A principal issue in multipoint initiation systems remains determination of the physical reasons for power-sharing inefficiencies and/or current oscillations in multipoint slapper arrays. In order to address this issue, current distribution was measured for incorporation into a validated electrical model that can be used to optimize multipoint array design. Support and development of the knowledge base tool for preservation of advanced initiation technology continued with an expanded scope that included other fireset components beyond detonators. A new initiative to focus and apply mature microfuze technology towards expanded and enhanced Special Operations Forces (SOF) and other warfighting capabilities was initiated in FY 2002. The resulting technology will enable lower cost development of initiation systems for multi-mode, adaptable output munitions of interest to all the Services.

(U) FY 2003 Plans:

(U) Development and demonstration of improved components and architectures for robust, low-cost, miniature safing, arming and firing systems will continue. Individual control of multiple initiation sites within a warhead using silicon fireset circuits will be demonstrated. Initial testing of extrudable explosive formulations will be completed with a focus on the energy required for direct slapper initiation. Component development and evaluation will continue and commercial sources for a robust manufacturing technology base will be explored. An integrated capacitor and switch in a single package will be demonstrated for use as a next generation microfuze component. Current state of the art micro-fuze technology will be applied and focused on Special Operations Forces (SOF) requirements in order to enhance and expand SOF capabilities in various mission scenarios. The latest miniaturization technology will be transitioned to production-type facilities and to the Services in order to begin exploitation. The study to understand and predict instabilities in multiple-slapper, highly miniaturized systems will be completed towards the design of highly reliable and uniquely flexible ordnance systems. Experiments will be performed that will enable development of the theory and models of explosive behavior in very small geometries (microdetonics). Work with the Services in areas of landmine alternatives, multi-mode and multi-mission munitions, integrated logic/fireset functions, and innovative solutions will continue. Materials resulting from new formulations and the sol-gel process will be characterized and performance tested. MEMS devices will be characterized and tested in stressing high-g environments.

(U) FY 2004 Plans:

(U) Conduct tests to demonstrate and evaluate the utility of rapidly prototyped multipoint initiation systems to enhance the performance of munitions. Evaluate reduction in development cycle time and cost achieved by rapid prototyping. Continue component miniaturization and cost reduction efforts. Demonstrate a packaged microtransformer for use in miniaturized munitions. Complete streak photography and VISAR diagnostic measurements for improved slapper detonator efficiency. Perform Detonation Shock Dynamics (DSD) analysis of initiation system transfer into a main charge. Implement viable multipoint diagnostics, such as magnetic probes or PVDF gauges, onto an array for use in warhead evaluation tests. Continue Development of MEMS CDU components. Demonstrate a packaged MEMS-SAD.

(U) **FY 2005 Plans:**

(U) Complete set of environmental tests on second generation Silicon Fireset assemblies. Implement a 6 kV single n-MCT switch sufficient for initiating a multipoint array. Design a minimum energy slapper and extrudable explosive system for use in adaptable warheads. Towards a miniature, optically charged fireset, complete development of very small 10 layer capacitors and begin integration of nanostructure multilayer capacitor and switch. Continue detonator designs requiring reduced micro joules of stored energy to fire. Complete prototype impact triggered MEMS fuze. Transition rapid prototyping technology.

Accomplishment/Effort/Subtotal Cost	FY 2002	FY 2003	FY 2004	FY 2005
Energetic Materials	6.992	5.573	6.900	7.150

(U) **FY 2002 Accomplishments:**

(U) Concern from the DoD 2000 Weapons TARA regarding the need to maintain weapon lethality as weapon and platform size decrease were addressed in efforts to synthesize, characterize and scale-up new energetic materials with increased or tailored performance and decreased sensitivity. The development and characterization of new insensitive and new high-energy, high power materials continued with synthesis based on theoretical molecular design and insight. Two patents were issued in FY 2002 for new energetic materials which exhibit characteristics particularly well suited for defense applications. The first is a mixture of two novel high nitrogen materials (DAAF and DAAzF) which exhibits higher detonation velocities than PBX 9502 with improvement in the failure diameter. The second patent was issued for the highest density CHN molecule known (DAAT) which exhibits very high burn rates and was successfully detonated in a standard Navy LEEFI detonator. Efforts sponsored under this program to exploit opportunities in nano-energetics by developing nano-structured and engineered energetic materials, including sol-gel derived materials, and evaluating their effectiveness and utility for warhead applications continued. With the completion of the LLM-105 synthesis and scale-up work, FY2002 efforts focused on formulation for evaluation and eventual qualification as a Navy booster material. The creation of new HEDMs continued, along with the development and implementation of accurate techniques for determining crystal structure and energy content of the newly synthesized materials. Thermochemical codes predict the performance of new explosives and are invaluable in explosive formulation efforts.

In FY 2002, Cheetah thermochemical code development turned towards implementing more sophisticated kinetic models into the code that account for differences
in explosive microstructure including explosive particle morphology for more accurate detonation product equations of state. FY 2002 improvements in Cheetah extend its applicability to thermobaric materials. Efforts to develop and validate computational tools for predicting munition system response to operational threat and accident environments continued. The first generation of simulation tools for munitions response to accident environments were exercised against test data to validate the codes and expand their ability to predict weapon system performance and response in accident situations. The joint experimental program with Navy to measure the violence of reaction in cookoff accidents was expanded to testing and analyses of munitions scale devices. This effort will be completed at the end of FY 2002 and culminate in application of the resulting predictive capability to late FY 2002 tests at NSWC China Lake. Experiments to determine mechanical properties of both fielded high explosives and their constituents continued for development and validation of high explosive mechanical response models. Specifically, PBXN-110 and Al-Teflon materials were characterized in support of ongoing Navy applications.

(U) <u>FY 2003 Plans:</u>

(U) Efforts to synthesize, characterize and scale-up new energetic materials with increased or tailored performance and decreased sensitivity will be continued. Coordination with the national advanced energetics initiative will also continue towards re-invigorating the energetic materials skill base within the Department. A summary report documenting the synthesis and scale up of LLM-105 as a booster explosive will be distributed to the energetics and fuzing communities in completion of the effort. FY 2002 advances in sol-gel metal oxide chemistry will be applied and focused on applications development and testing in support of Service initiatives. Energy and performance measurements of CO-derived and nitrogen HEDM's micro-samples will be completed and the synthesis of additional extended solid HEDMs will be explored. In FY 2003, Cheetah 4 will be released to the DoD community for performance predictions of an extended set of energetic materials. Development of ignition phenomenology models and design of ignition location experiments will be completed in support of the effort to validate and expand codes for predicting weapon system performance and response in accident situations. The effort to preserve and transition energetic materials technology generated by the community will continue with the distribution of an extended APEX database that will include over 500 energetic materials of different molecular structure. Support of enabling energetic materials technologies for low collateral damage munitions will expand with the development of near-field and far-field product equations of state for the baseline explosive fill selected in FY 2002. Energetic materials requirements for SOF focused microfuze technology activities will be supported through testing of different nano-fuel/oxidizer formulations and incorporation of multi-layer energetic materials into propagation micro-channels.

(U) <u>FY 2004 Plans:</u>

(U) Continue development of nanoscale, microscale and mesoscale energetic materials with enhanced performance that are less sensitive and cost effective enablers for defense transformation. Demonstrate and characterize sensitivity and burning of hydrogen and nitrogen mixtures with nano-metals. Complete composite case explosive pressing for low collateral damage efforts. Initiate processing and scale up of low collateral damage energetic materials. Towards the next generation enhanced blast weapons, measure metal dispersal using optical or flash x-ray and conduct high pressure and temperature ignition tests.

(U) <u>FY 2005 Plans:</u>

(U) In the area of high nitrogen energetic materials, continue measurements of burn rates and pressure-time histories for burning HN mixtures with nano Al, metals, and MIC; complete performance and sensitivity testing of azo-formamidines. Continue updating APEX explosives database on an 18 month cycle. Complete synthesis of ANTZ based target molecules as a new insensitive energetic material ingredient and synthesis precursor. Complete sol-gel metal oxides weaponization. Continue low collateral damage explosive scale up and performance characterization efforts. Complete analysis of Navy fast cookoff experiments. Deliver high explosive grain scale continuum model for use in predicting the performance of plastic bonded explosives.

Accomplishment/Effort/Subtotal Cost	FY 2002	FY 2003	FY 2004	FY 2005
Computational Mechanics and Material Modeling	2.410	2.560	3.980	4.000

(U) **FY 2002 Accomplishments:**

(U) Predicting the behavior of weapons in their operating environment is essential to the development of lethal, accurate, and cost effective systems. Lagrangian and Eulerian hydrocodes, coupled code systems, arbitrary Lagrangian-Eulerian (ALE) codes, and supporting materials models and constitutive relations developed at the nuclear weapons laboratories have been improved and adapted to DoD problems and transitioned to the DoD user community for use in warhead design and evaluation. This program provides prompt and direct access to the substantial investments in computational mechanics and materials modeling by the DOE and acts as the conduit for direct transition. Specific activities supporting the technology transition include distribution of computational tools to the DoD community, support of DOE codes on centralized DoD computing systems, training of the user community, and consulting as needed.

(U) FY 2003 Plans:

(U) The development of Eulerian, Lagrangian, coupled and ALE codes relevant to the design and evaluation of munitions will continue. Efforts will continue in the development, implementation and validation of material constitutive and failure models supporting the simulation of warhead formation and warhead/target interactions. The program also provides a conduit to the improved materials models emerging from the DOE Advanced Strategic Computing Initiative providing high resolution, accurate predictions of materials behavior and failure relevant to the analyses of weapon systems. The transition and support of these tools and models along with user training will be provided as needed. A particular new effort in this year is the development of a mixed phase flow calculational capability to describe inert particle loaded explosives. This capability is essential to the understanding of low collateral damage phenomena.

(U) FY 2004 Plans:

(U) Continue to develop, extend and apply the hydrocodes and associated materials models for warhead 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. Continue to support the transition of these tools, the training, and consulting for the DoD user community.

(U) FY 2005 Plans:

(U) Complete tensile plasticity and damage model extension for use within warhead design codes. Towards a robust, mesh free warhead design tool, begin extension of Dual Particle Dynamic (DPD) methodology to three dimensions. Complete integration of CTH and NEVADA design tools. Complete fragment explosive initiation modeling in support of DoD initiatives. Continue advanced material model implementation for warhead design and evaluation. Validate predictive capability for low collateral damage munition performance and effect..

Accomplishment/Effort/Subtotal Cost	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**
Warhead Technology	3.830	4.650	5.950	6.000

(U) **FY 2002 Accomplishments:**

(U) In FY 2002, design improvements for hard target penetrators were explored that add penetration capability and survivability and increase payload volume. Data from the final Monolithic Ballasted Penetrator prototype test was evaluated, an industrial supplier was developed, and the technology was transitioned to the TACMS Penetrator Demonstration ACTD. In order to resolve differences between various computational models and penetrating weapon design tools, data from a series of 14 instrumented penetration tests was distributed to over 150 researchers in the penetration community and then used to benchmark a majority of the computational tools used for designing penetrators. A miniaturized 3-axis accelerometer and data recorder that is able to survive high velocity hard target penetration events was developed in FY 2002. This new diagnostic supports continued studies of oblique penetration and code validation and benchmarking of tools used to predict lateral loading of the penetrator and its components. A penetrator is currently being designed to house this data recorder that will be used for upcoming oblique penetration experiments into rock and concrete targets. Initial heat treatment studies on a candidate replacement material for current high alloy steels were completed. Although the resulting microstructure and hydrogen content did not yield steel with the required toughness for penetrator applications, the approach holds the promise of reducing initial material costs and, perhaps more importantly, cutting delivery times for starting ingots from several months to a few days or weeks. In FY 2002 the composites effort shifted attention to understanding the failure of metal matrix composite materials in support of stronger and lighter military systems. Specifically, work is currently underway to characterize the fatigue lifetime of unidirectional composites at elevated temperature to assess material performance in gun barrels. A new project was initiated to develop the underlying technologies needed for a low collateral damage munition which will provide an enhanced alternative to the use of inert munitions against soft targets in urban areas. The initial effort focused on the development and characterization of a new explosive material with increased near-field impulse.

(U) FY 2003 Plans:

(U) Integration of all the components necessary for a low collateral damage munitions concept will occur. Energetic formulation, composite, case, and performance predictions based on modeling to date, will be combined in this effort. Near term applications of this technology are believed possible based on these tests. Efforts to provide enabling technologies for defeat of hardened military targets will continue in FY 2003. Fabrication processes for the new Air Force low-cost penetrator steel, including weldability and melt processes to optimize properties and castability, will be explored. The experimental hard target test-bed program will be completed by conducting instrumented penetration tests on well-characterized concrete targets using the new miniaturized 3-axis data recorder to gather the data necessary for code validation. The focus will be on obtaining data that reveals the dynamic rotations of the penetrator during entry and the resulting trajectory. The data will be provided to the DoD community for use in validating and benchmarking hard target design tools. The development and integration of the computational, explosive, penetration, and composite material technologies required for an enhanced alternative to the use of inert munitions against soft targets in urban areas will be accelerated. The study on the texture effect on shaped charge jets will be concluded and techniques for application to next generation warhead concepts will be evaluated. Temperature measurements of shocked materials will be completed and the results provided to the DoD community for model validation and warhead design. Focus will continue on the science-based technology projects relating warhead performance to material properties under dynamic conditions as a prelude to improved computational modeling and the transition of improved warhead designs to developmental and fielded weapon systems. The simulations of the Ta liner test-bed experiments will be continued in order to assess the utility of the new materials models in the warhead design process. Advanced aimable warheads which exploit individually controlled, distributed micro-firesets will be developed and testing will be initiated.

(U) FY 2004 Plans:

(U) Continue Low collateral damage verification and validation testing in comparison with current best baseline munition. Use test data to evaluate simulation capability in predicting target damage. Continue the study of advanced hard target penetrator concepts and adapt designs to state-of-the-art materials and manufacturing methods. Complete instrumented oblique penetration tests using the 3 axis data recorder. Complete target size penetration tests aimed at reducing the cost of penetration tests for the community by obtaining evidence of a size scale effect. Continue target diameter benchmarking efforts in support of size-scale effect testing. Continue improvements in modeling of target entry dynamics and trajectory predictions via field testing and analysis.

(U) FY 2005 Plans:

(U) Complete low collateral model development test series. Transition capability to identified Department program offices. Complete characterization of low cost, high hardness candidate penetrator materials. In the area of design improvements for hard target penetrators, complete survivability design concepts. Continue improvements to the hard target response predictive capability established in the Peridynamic design tool. Complete push control studies using alternative reactive warhead materials. Continue efforts towards an FY 2006 demonstration of energy coupling enhancement through initiation.

Accomplishment/Effort/Subtotal Cost	FY 2002	FY 2003	FY 2004	FY 2005
Munitions Lifecycle Technologies	2.460	2.230	2.950	2.950

(U) **FY 2002 Accomplishments:**

(U) In the area of munitions life cycle technologies, the process to convert picric acid/explosive-D from the demilitarization inventory into TATB has been successfully transitioned from DOE to DoD. In FY 2002, femtosecond laser cutting was successfully demonstrated in the 10 kg explosive tank. This is significant because it gives us the capability to cut systems containing larger amounts of explosives and thus, makes it possible to test mock-ups of weapons systems as well as complete systems. In addition, the process has been successfully extended to cutting propellants; this is a significant milestone that opens the possibility of using the femtosecond laser to demilitarize rocket weapon systems. Determination of a portion of the optimum cutting parameters, safety limits, and geometry limits for munitions related materials and high explosives was also completed. Work on the robotic workcell focused on adapting the system to the disassembly of Adam mine rounds and completing the vision and control algorithms, as well as the associated hardware, necessary to demonstrate completely automated disassembly of a cluster munition with safing of the individual submunitions by FY 2003. The development of materials and system aging models continued with a focus on predicting the reliability of solder interconnects, plastic encapsulated microcircuits, propellants, and adhesive joints. A new project was initiated to characterize the particle emissions generated from open burn/open detonation (OB/OD) events. The result of the work will be an instrument which can satisfy present and future anticipated regulatory requirements on particle emissions from OB/OD events. Laboratory experiments were performed to generate particle signatures anticipated in larger scale events. Open air detonation experiments in support of sensor development and testing are planned using a 30 meter release stack.

(U) FY 2003 Plans:

(U) Femtosecond laser technology for demilitarization using live munitions will be demonstrated in FY 2003. Mid-scale testing of sensors that can detect particle emissions in explosive events will commence. The small and mid-scale sensor test results will be used to generate a data base and analysis tools for standoff identification and specification of particles generated in detonation events. Dissassembly and handling of ADAM mine projectiles will be demonstrated. The technology for standoff monitoring of OB/OD events at DoD demilitarization sites will be transitioned to a commercial partner. In the predictive materials aging and reliability area, measurements of the electrical response of dormant storage munition electronic components will commence. Under the aging of propellants task, the physical and chemical characterization of aged propellant will be completed in order to ascertain critical aging phenomena pertinent to stockpiled munitions. An associated new start will commence aimed at developing a stand-off sensor to be incorporated into a water jet cutting head for faster and safer washout of demilitarized large rocket motors. A new microsystems reliability effort will commence aimed at enabling qualified microsystems in fielded weapon systems. A prototype microsystem assembly process will be demonstrated and initial designs of MEMS reliability monitors will be completed.

(U) FY 2004 Plans:

(U) Complete transfer femtosecond laser cutting technology to the DoD. Complete real time particle size and composition analysis open air testing. Demonstrate M483A1 disassembly technologies. Complete isothermal fatigue experiments for solder interconnect reliability studies. Transfer electronic corrosion predictive model to Service demilitarization efforts. Continue identification of critical DoD electronic components susceptible to corrosion failure. Complete studies aimed at determining propellant thermal decomposition kinetics. Continue analysis of DoD aged samples and participation in Predictive Service Life Technology program reviews as requested. Complete MEMS reliability monitor verification tests.

(U) FY 2005 Plans:

(U) Complete testing of stand-off sensor for rocket motor demilitarization. Complete explosive combustion studies for predicting toxic emissions in OB/OD events. Prototype, design, and fabricate M77 grenade handling and safing hardware. Continue identification and analysis of non-plastic encapsulated critical DoD weapon components. Measure age dependent weapon adhesive joint toughness at various temperature levels and high humidity. Apply interfacial fracture mechanics methodology to existing DoD/DOE weapon systems. Continue HX-874 propellant binder aging studies.

C. Other Program Funding Summary: N/A

D. Acquisition Strategy: N/A

E. Major Performers: The work is performed in-house at the three DOE National Laboratories responsible for nuclear weapons RDT&E: Lawrence Livermore, Los Alamos, and Sandia National Laboratories.