Exhibit R-2a, RDT&E Project Justification							Date: February 2003	
Appropriation/Budget Activity RDT&E, Defense Wide/BA 2				Project Name and Number ***High Energy Laser Development** **PE 602890D8Z**				
Cost ($ in millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Total Program Element (PE) Cost	35.231	43.901	0	0	0	0	0	0
High Energy Laser Initiative/P890	35.231	43.901	0	0	0	0	0	0

A. Mission Description and Budget Item Justification:

*** Beginning in FY 2004, High Energy Laser Development, will be transferred to the Air Force under PE-0602890F for management and execution responsibility and will result in a more appropriate policy-level role for OSD.**

(U) BRIEF DESCRIPTION OF ELEMENT

(U) This program element funds High Energy Laser (HEL) applied research aimed at translating fundamental scientific knowledge into proof-of-concept solutions relevant to HEL systems. HEL weapons systems have many potential advantages, including speed-of-light time-to-target, high precision, nearly unlimited magazine depth, low cost per kill, and reduced logistics requirements because of no need for stocks of munitions or warheads. As a result, HELs have the potential to perform a wide variety of military missions, including some that are impossible, or nearly so, for conventional weapons. These include interception of ballistic missiles in boost phase, defeat of high-speed, maneuvering anti-ship and anti-aircraft missiles, and the ultra-precision negation of targets in urban environments with no collateral damage. Research conducted under this program element develops the technology necessary to enable these and other HEL missions.

(U) This program element is part of an overall DOD initiative in HEL science and technology being conducted by the HEL Joint Technology Office (JTO). The goals of this HEL JTO funded research are to provide the technology to make HEL systems more effective and also to make them lighter, smaller, cheaper, and more easily supportable on the battlefield. In general, efforts funded under this program element are chosen for their potential to have major impact on multiple HEL systems and on multiple Service missions. As a result of this focus and of close coordination with the military departments and defense agencies, this program element complements other DOD HEL programs that are directed at more specific Service needs.

(U) A broad range of technology is addressed in key areas such as chemical lasers, solid-state lasers, beam control, optics, propagation, and free-electron lasers. Research is conducted by Government laboratories, industry, and universities. The program element funds theoretical, computational, and experimental investigations. In many cases, these three types of investigations are combined under a single effort, thereby creating synergistic effects between various scientific approaches, and greatly enhancing the potential for breaking through the technology barriers that currently prevent HELs from being fielded as viable weapon systems. DOD intends to transition successful systems concepts developed under this program element into advanced technology demonstrations for particular mission needs.

B. Accomplishments/Planned Program

(U) This program element will execute applied research under a comprehensive, prioritized investment plan for HEL science and technology. Pursuant to Congressional direction the DOD has developing a comprehensive, prioritized investment plan for HEL science and technology. This investment plan was developed by the HEL JTO, in coordination with the military departments and the defense agencies. The plan, which was completed by the beginning of FY 2002, will form the basis for the expanded work to be conducted under this program element in FY 2003 and beyond. The HEL JTO coordinates updates and revisions to the plan through the Technology Council (TC). The TC is comprised of S&T executives from the Army, Navy, Air Force, DARPA, MDA, and DTRA. Major, but not necessarily exclusive, emphasis will be placed on the tactical mission-type scenarios and applications in which HELs can contribute. Work will be conducted in the following technical thrust areas:

	FY 2002	FY 2003	FY 2004	FY 2005
Solid State Lasers	11.865	14.381	0	0

(U) Solid-State Lasers

(U) **FY 2002 Accomplishments:** Solid-state lasers have potential as future HEL weapon laser devices because they require only electrical energy in order to run, thereby greatly simplifying systems engineering and supportability. These devices have the potential to eliminate the need for munitions resupply on the battlefield in key mission areas such as tactical strike and air defense. Solid-state-laser technology development emphasizes combining fiber-laser modules, scaling up power in diode-pumped lasers, and testing new systems concepts. Results of these activities are key to developing solid-state lasers with weapons-class power levels. Examples of FY 2002 solid-state-laser technology-development activities include the following:

- Developing 1 kilowatt-class fiber-laser amplifiers and designing and experimentally testing methods for coherently phasing groups of fiber-laser amplifiers to increase total output power to the 10 to 100 kilowatts level
- Developing new high-power, high-reliability diode-pumped laser power supplies for fiber lasers and amplifiers, to withstand the thermal and material stresses of sustained high-power operation at powers in excess of 1 kilowatt, thereby providing a cornerstone for the development of future lighter, more lethal, more affordable, and more supportable solid-state-laser HEL weapon systems
- Developing, fabricating, and demonstrating a design for a thin-disk (as opposed to bar-like) solid-state laser at a 300 to 500 Watt power level, as a step toward the future development of 8 kilowatt disk-based laser devices, thereby potentially easing thermal-management problems on future high-power solid-state lasers
- Developing, fabricating, and demonstrating amplifiers and correcting mirrors as a means of mitigating the thermal distortions on 300 Watt average power/5 kilowatt peak power solid state lasers, thereby taking an initial step towards scaling the technology to 100 kilowatt and enabling extremely high-power solid-state lasers

(U) **FY 2003 Plans:** Solid-state-laser work will focus on phasing of fiber lasers, the design and manufacture of reliable diode lasers as pump sources, and the thermal control of laser media. There were several applied research projects that began in this thrust area in FY 2002. The efforts were selected based on the competitive evaluation of proposals submitted under the Service & Agency call for proposals. The majority of technical efforts that began in FY 2002 are expected to continue in FY 2003. This includes the following projects: Advanced CW solid State Lasers, Diode-Pulped Oxygen Iodine Laser, Loop Phase Conjugate Mirror Study and High Power Radiation Balanced Laser Development.

	FY 2002	FY 2003	FY 2004	FY 2005
Beam Control	6.798	8.000	0	0

(U) Beam-Control Technology Development

(U) **FY 2002 Accomplishments:** Beam-control technology development centers on those technologies directly applicable to surface, air, and space mission

areas, as well as development of supporting technologies. Results of these activities will be transitioned to near-term HEL systems and will also serve to enhance the HEL-related technology base and industrial capability. Examples of FY 2002 beam-control technology development activities include the following:

- Developing high-power coatings and substrates, thus reducing the weight and increasing the affordability of HEL subsystems
- Conducting ground-to-space compensated laser beam propagation from a weapons-class aperture (e.g., several meters), thereby demonstrating key Ground Based Laser technologies for future space and missile-defense applications
- Developing advanced adaptive-optics component-level and subsystem-level technologies and control methodologies, thereby contributing to increasing the effective range of future HEL weapons
- Designing, fabricating, and testing novel concepts for adaptive optics, which promise to greatly decrease complexity and weight and increase affordability while still allowing HEL weapons to compensate for atmospheric turbulence
- Designing and fabricating new optical wavefront sensing devices that operate even in conditions of extremely high turbulence, thereby allowing beam-control subsystems to operate effectively even at low altitudes (e.g., for tactical laser systems)

(U) **FY 2003 Plans:** Tactical beam control work will focus on the development and testing of techniques for pointing and tracking in cluttered tactical backgrounds, the development and testing of thermal-blooming compensation and turbulence compensation in tactical scenarios, and demonstrating beam control on appropriate tactical platforms. Beam control component technology efforts will focus on improving components that will be capable of supporting multiple HEL missions. This area will also help enhance the fragile manufacturing base in this critical area. There were several applied research projects that began in this thrust area in FY 2002. The efforts were selected based on the competitive evaluation of proposals submitted under the Service & Agency call for proposals. The majority of technical efforts that began in FY 2002 are expected to continue in FY 2003. This includes the following projects: Inferred Wavelength Focal Plane Arrays for Tracking and Wavefront Sensing, Rapid High Energy Laser Beam Steering Mirror System, Advanced Beam Control for Tactical Applications, Tactical Beam Control for Airborne Platforms, 3D Pointing and Tracking for HELs and Laboratory Investigations of Thermal Blooming and Turbulence.

	FY 2002	FY 2003	FY 2004	FY 2005
Chemical Lasers	3.424	3.500	0	0

(U) Chemical Lasers

(U) **FY 2002 Accomplishments:** Chemical-laser technology efforts concentrate on developing improved predictive and design capabilities, new chemical-laser concepts, and higher performance and more supportable chemical-laser technologies. Despite the fact that chemical lasers are the most mature of the HEL laser device technologies, further technology development has the potential to greatly enhance their viability as weapon systems. Results of these activities will result in chemical lasers that are lighter and more affordable. Examples of FY 2002 chemical-laser technology-development activities include the following:

- Developing more sophisticated computational models for accurate performance prediction, thereby greatly improving design capabilities for future Hydrogen Fluoride/Deuterium Fluoride (HF/DF) and Chemical Oxygen Iodine (COIL) chemical lasers, particularly in the critical area of mixing nozzle design
- Designing, testing, and fabricating advanced mixing nozzles on HF/DF laser devices, thereby improving performance, reducing weight, and increasing effective magazine size on future space-based and ground-based HEL weapon systems
- Installing and testing a 20 kilowatt closed-cycle (sealed exhaust) COIL device as a means of assessing closed cycle COIL performance and supporting design of future closed-cycle chemical lasers, thereby offering the potential for chemical lasers that can reuse their chemical supplies, which greatly improves their supportability
- Designing, fabricating, and testing a novel means of delivering iodine chemicals to a COIL laser system in a way that eliminates the need for complex chemical tanks, thereby reducing weight and increasing reliability of future airborne chemical-laser-based HEL weapon systems, as well as simplifying iodine-associated logistics requirements

(U) **FY 2003 Plans:** Chemical-laser research will include efforts to develop COIL lasers appropriate for space-based and tactical applications. It is planned to select one applied research proposal to begin in FY 2003 in this thrust area. The evaluation will be based on the competitive evaluation of proposals submitted

under the Service & Agency call for proposals. The applied research conducted in this thrust area will build on the technical experience from past projects related to Chemical Laser development.

(U) **FY 2004 – FY 2005 Plans:** Chemical-laser research will include efforts to develop and demonstrate closed-cycle chemical lasers, especially COIL-derived lasers, appropriate for space-based and tactical applications. The anticipated payoffs are tactically-suited chemical lasers of high power that are supportable on the battlefield. Specific objectives include (1) optimizing performance of chemical feed systems, mixing nozzles, exhausts, and other components, (2) developing and testing new processes and chemistries for running chemical lasers using a closed as opposed to open architecture, and (3) developing means of regenerating chemical laser fuels so they can be reused.

	FY 2002	FY 2003	FY 2004	FY 2005
Mission and Systems Analysis/Program Mgt	2.733	3.200	3.360	3.700

(U) Mission and Systems Analysis/Program Management

(U) **FY 2002 Accomplishments:** This program element funded two detailed studies that examine potential military missions for which HELs present unique solutions because of their inherent characteristics (i.e., speed-of-light, possibility of graduated effects, precise target selectability, nearly unlimited magazine size, reduced logistics requirements, etc.) as compared to today's conventional weapons. These studies are being used to focus the investment strategy for technology development. Additional activities of a programmatic nature that are funded by this program element include the operation of the Joint Technology Office (JTO), which moved to Albuquerque, New Mexico during FY 2002, and funding several workshops designed to bring together experts for exchanges of ideas and gathering input for investment strategy development.

(U) **FY 2003 Plans:** Mission and System Analysis studies are planned to continue to examine potential military missions for which HELs present unique solutions because of their inherent characteristics (i.e., speed-of-light, possibility of graduated effects, precise target selectability, nearly unlimited magazine size, reduced logistics requirements, etc.) as compared to today's conventional weapons. These studies are being used to focus the investment strategy for technology development. Additional activities of a programmatic nature that are funded by this program element include the operation of the Joint Technology Office (JTO), which moved to Albuquerque, New Mexico during FY 2002, and funding several workshops designed to bring together experts for exchanges of ideas and gathering input for investment strategy development.

	FY 2002	FY 2003	FY 2004	FY 2005
Atmospheric Characterization	3.923	4.200	0	0

(U) Atmospheric Characterization

(U) **FY 2002 Accomplishments:** Atmospheric Characterization development efforts are aimed at making precise absorption measurements in interesting atmospheric windows, measuring and assimilating information on turbulence at locations relevant to tactical HEL systems, and developing and testing real-time characterization tools to assist the HEL operator. Examples of FY 2002 atmospheric characterization efforts include the following:

- Developing modeling tools and conducting analysis of existing theater atmospheric data for tactical applications
- Conducting environmental effects simulation efforts for tactical HEL systems
- Conducting atmospheric absorption model validation and improvement analysis

(U) **FY 2003 Plans:** Atmospheric characterization for tactical scenarios will concentrate on understanding atmospheric limitations in low-altitude tactical scenarios and on developing advanced adaptive-optics technology to increase lethal range in these scenarios. There were two applied research projects that began in this thrust area in FY 2002. The efforts were selected based on the competitive evaluation of proposals submitted under the Service & Agency call for proposals. The technical efforts that began in FY 2002 are expected to continue in FY 2003. The projects from this thrust area are as follows: Characterization of Atmospheric Effects on Tactical HEL Systems and Effects of Nonlinear Processes on Pulsed HEL Propagation in the Atmosphere.

	FY 2002	FY 2003	FY 2004	FY 2005
Lethality	3.056	3.560	0	0

(U) Lethality

(U) **FY 2002 Accomplishments:** Lethality technology development concentrates on developing a strong scientifically based understanding of laser kill mechanisms so that HEL systems can to optimized to produce the maximum kill probability for the minimum system size and cost. Examples of FY 2002 Lethality activities include the following:

- Developing theory and conducting experiments to improve the capability to model the interaction between extremely short laser pulses and various classes of electronic and structural materials, thereby enhancing lethality and damage assessment and countermeasures of targets when struck by HEL pulses
- Developing and validating a three-dimensional, time-dependent, particle-based computer code that will more accurately predict damage levels at much lower computational costs, thereby ultimately reducing the cost of HEL systems design

(U) **FY 2003 Plans:** Lethality work will develop a firm scientific understanding of the relative advantages of repetitively pulsed and continuous-wave lasers for defeating different targets of interest. A multi-service team of technical experts in the lethality field was established during FY 2002 in order to conduct applied research in this technical thrust area. This approach is strongly compliant with the mission of the office. This technical effort will be continued in FY 2003.

A major focus for FY 2003 is the Joint-High Power Solid State Laser (Joint HPSSL) project. The objective is accelerate the demonstration of the Solid State Laser at initial weapon grade power levels. The power scaling will be 25kW in two years leading to 100kW in an additional two years.

	FY 2002	FY 2003	FY 2004	FY 2005
Free Electron Lasers	3.432	5.610	0	0

(U) Free Electron Lasers

(U) **FY 2002 Accomplishments:** Free electron laser (FEL) development concentrates on building the FEL technology base with the overall objective of making the FELs more lethal, smaller, and lighter. Specifically, the FY 2002 FEL activities included the following:

- Designing and testing new technology for using permanent magnets on FELs, which simplify FEL design and increase affordability because permanent magnets eliminate the need for costly electromagnets
- Developing and validating a cryogenically cooled sapphire MW-class FEL in order to extend FEL resonator performance as far as technically feasible
- Performing detailed engineering analysis of the high average power FEL drive laser to identify the performance scaling and technology limits and establish optimal hardware configuration

(U) **FY 2003 Plans:** Free-electron-laser (FEL) work will focus on technologies to scale to high power and technologies to permit FELs to be fielded on military platforms. There were several applied research projects that began in this thrust area in FY 2002. The efforts were selected based on the competitive evaluation of proposals submitted under the Service & Agency call for proposals. The majority of technical efforts that began in FY 2002 are expected to continue in FY 2003. This includes the following projects: FEL Cryogenic Mirror Development, High-average-current RF Photoinjector for 100 KW FEL, Injector Drive Laser Development, Development of Tailored Wide Band Gap Photocathodes for the 100 KW FEL and Simulation of High Efficiency Phase Displacement Undulators and Multiphoton Atmospheric Effects.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Optics	0.000	0.250	0	0

(U) Advanced Optics

(U) **FY 2003 Plans:** Advanced optics work will focus on the development and demonstration of large, lightweight deployable optics to reduce system weight while increasing laser intensity on target for space-based and other HEL systems. It is planned to select one applied research proposal to begin in FY 2003 in this thrust area. The evaluation will be based on the competitive evaluation of proposals submitted under the Service & Agency call for proposals. The applied research conducted in this thrust area will build on the technical experience from past projects related to Advanced Optics development.

	FY 2002	FY 2003	FY 2004	FY 2005
Modeling and Simulation	0.000	1.200	0	0

(U) Modeling and Simulation

(U) **FY 2003 Plans:** Modeling and simulation efforts will be increased with the goal of providing a fully realistic model of end-to-end system performance, from birth of photons in the laser to their death at the target, thereby improving the design of HEL systems and reducing the need for expensive field testing.