Exhibit R-2a, RDT&E Project Justification

DATE: February 2005

BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY

PROJECT NUMBER AND TITLE: 4866 Lasers & Imaging Technology

Cost ($ in Millions)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
4866	Lasers & Imaging Technology	26.725	28.215	22.737	25.642	24.701	24.857	25.061	25.272	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

This project examines the technical feasibility of moderate to high power lasers and associated optical components required for Air Force missions including long- and short-range weapons, weapon support such as aimpoint selection, and force protection. The technologies developed in this project are not uniquely space-oriented. Technologies applicable for a wide range of vehicles including unmanned combat air vehicles and fighters are being developed. High power solid state and chemical laser devices, optical components, advanced beam control and atmospheric compensation technologies, laser target vulnerability assessment techniques, and advanced optical processes and techniques are developed. Advanced, short-wavelength laser devices for applications such as illuminators and imaging sources for target identification and assessment are developed.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2004	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Develop high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications.	4.826	7.420	6.124	5.887

(U) In FY 2004: Performed sub-scaled evaluation of optimized high pressure ejector nozzles and integrated iodine atom generation for airborne applications. Evaluated the feasibility of low-flow rate basic hydrogen peroxide and zero-gravity singlet delta oxygen generator concepts for airborne applications. Investigated the feasibility of electrical regeneration of laser consumables to reduce chemical laser logistics tail.

(U) In FY 2005: Evaluate enhanced, scaled-up versions of the high pressure ejector nozzles incorporating iodine atom generation as appropriate for potential long-range technology insertion into airborne laser applications. Investigate scalability of high performance zero-gravity singlet delta oxygen generator concepts for airborne laser applications. Demonstrate chemical regeneration techniques or single pass singlet delta oxygen generators to reduce the weight of chemicals required for each mission. Demonstrate beam control technology applicable to future airborne lasers.

(U) In FY 2006: Continue to investigate scalability of high performance zero-gravity singlet delta oxygen generator concepts for airborne laser applications. Demonstrate advanced chemical and electrical singlet oxygen generator technology to help improve current levels of performance. Investigate laser/fiber pumped molecular gas lasers. Develop advanced diagnostics for chemical oxygen iodine laser performance measurements to identify potential enhancements. Begin work on technologies that would increase the range of future high power airborne lasers. Investigate chemical-electrical hybrid laser technologies that offer potential for power scaling and component size and weight reduction.

(U) In FY 2007: Continue work on technologies that would increase the range of future high power airborne

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lasers. Evaluate and refine advanced chemical laser technologies demonstrated in FY 2006. Develop additional advanced diagnostics for chemical oxygen iodine laser performance measurements to identify potential enhancements. Develop chemical-electrical hybrid laser technologies that offer potential for power scaling and component size and weight reduction.

(U)

(U)	MAJOR THRUST: Develop moderate power solid state laser device, beam control, and associated technologies for airborne tactical applications, primarily aircraft self-defense with integrated sensors. Technologies being addressed include; tailored high-brightness, multi-wavelength compact lasers and advanced beam control techniques to minimize platform vibration, atmospheric jitter, and aero-optical effects.	4.200	5.458	6.888	9.435

(U) In FY 2004: Collected aero-optical data from tactical aircraft to anchor computer models. Addressed thermal management issues and packaging/integration/test issues for tactical laser applications on airborne platforms. Demonstrated improvements in semiconductor laser efficiency and operating temperatures that could enable future tactical systems and combat identification systems.

(U) In FY 2005: Develop laser component technologies for detecting, identifying, tracking, and defeating electro-optic targets from airborne tactical platforms. Design and fabricate new laser structures for near-infrared, mid-infrared, and long-wavelength operation. Focus development on power scaling, lower weight, reduced volume, robustness, improved beam quality, and higher efficiency. Develop laser system for optical augmentation to detect optical threats such as sniper scopes. Develop integrated aero-optical wavefront sensor beam control technology for tactical applications. Identify inertial reference unit operating requirements for these laser applications and evaluate existing advanced inertial reference unit technology. Test tactical beam control propagation codes.

(U) In FY 2006: Develop laser component technologies for detecting, identifying, tracking, and defeating electro-optic targets from airborne tactical platforms. Enhance new laser structures for near-infrared, mid-infrared, and long-wavelength operation focusing on power scaling, lower weight, reduced volume, robustness, improved beam quality, and higher efficiency. Develop single- and multi-wavelength packaging and delivery methods. Begin development of system-level solutions to aero-optical issues involving tactical laser applications on airborne platforms. Transition most promising concepts to field testing. Assess laser requirements for destroying detectors in the threat sensors. Analyze the failure modes and other effects when various optics are damaged. Complete integrated aero-optical wavefront sensor development. Complete evaluation of advanced inertial reference unit. Continue testing of tactical beam control propagation codes.

(U) In FY 2007: Design and develop laser sources for jamming/damaging optical threats. Focus on higher efficiency and higher reliability. Perform ground testing of ultra-short pulse laser sources to evaluate

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	tactical applications. Continue development of system-level solutions to aero-optical issues involving tactical laser applications on airborne platforms. Investigate technologies for tracking in clutter and tactical platform disturbance mitigation. Develop selected technologies for transition from laboratory to field testing.				
(U)					
(U)	MAJOR THRUST: Perform system assessments to include vulnerability assessments on potential high-energy laser targets. Provide critical design data for laser systems to defeat these targets. Develop directed energy concepts and identify issues relating to system architectures, technology readiness, technology tradeoffs, mission effectiveness, and military utility.	0.904	0.955	1.145	1.305
(U)	In FY 2004: Identified system constraints and performance degradation in environments such as battlefield conditions and weather. Performed susceptibility experiments to quantify damage thresholds on indium antimony focal plane arrays. Initiated the development of a vulnerability database on threats to electro-optical sensor systems. Established a classified database of high energy laser data and reports.				
(U)	In FY 2005: Identify additional laser system constraints and performance degradation in real world situations, including battlefield conditions and weather. Investigate the integration of technologies into relay mirror concepts. Perform system assessments of laser systems on tactical and bomber platforms.				
(U)	In FY 2006: Perform lethality assessment studies to assess the effectiveness of the various laser concepts in relevant scenarios. Validate vulnerability assessment models by performing mid-scale and full-scale demonstration experiments. Simulate and investigate advanced adaptive optics for uplink beam control. Develop and evaluate two-beam propagation techniques for tracking and illumination of a cruise missile through an airborne relay mirror. Simulate and investigate tactical and bomber defense laser system technologies.				
(U)	In FY 2007: Perform additional lethality assessment studies to assess the effectiveness of the various laser concepts in relevant scenarios. Continue mid-scale and full-scale demonstration experiments to validate vulnerability assessment models. Investigate the scalability, affordability, and application of selected relay mirror, bomber defense, and tactical laser systems.				
(U)					
(U)	MAJOR THRUST: Develop scalable high power solid state laser technologies for applicable next-generation laser device applications such as tactical airborne laser weapons.	6.265	3.611	6.385	6.769
(U)	In FY 2004: Demonstrated all-fiber approach to beam combining at tens of watts with ytterbium-doped fiber lasers/amplifiers.				
(U)	In FY 2005: Demonstrate one kilowatt packaged breadboard fiber laser module that could be a building-block for future directed energy, megawatt-class solid state lasers. Demonstrate wavelength versatile laser at five watt power levels in the various wavelengths.				

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(U)	In FY 2006: Investigate and demonstrate alternative laser architectures and gain media. Demonstrate wavelength versatile laser at greater than five watt power levels in the various wavelengths. Refine laser technologies to obtain architectures that are favorable in terms of size, weight, efficiency, affordability, reliability, maintainability, supportability, environmental acceptability (air, land, and maritime), and ruggedness for tactical laser weapon applications.				
(U)	In FY 2007: Work on scaling modular lasers up to the weapon class power level. Refine technologies to obtain architectures that are favorable in terms of size, weight, efficiency, affordability, reliability, maintainability, supportability, environmental acceptability (air, land, and maritime), and ruggedness for tactical laser weapon applications.				
(U)					
(U)	MAJOR THRUST: Develop broadly applicable technologies to support future tactical and strategic relay mirrors systems.	0.141	0.331	0.554	0.604
(U)	In FY 2004: Selected the best lightweight, low power optics candidate technologies for airborne relay mirrors and started development of these optics for potential evaluation on a small-scale (with 50-cm primary optics) bifocal relay testbed.				
(U)	In FY 2005: Investigate and integrate technologies onto an airborne relay mirror breadboard for further evaluation.				
(U)	In FY 2006: Simulate and investigate advanced adaptive optics for uplink beam control. Develop and evaluate two beam propagation techniques for tracking and illumination of a cruise missile through an airborne relay mirror. Design low-altitude relay mirror field experiments.				
(U)	In FY 2007: Continue investigation of advanced adaptive optics techniques for uplink beam control.				
(U)					
(U)	MAJOR THRUST: Develop optical and beam control technologies to enhance high energy laser beam propagation over long distances in the atmosphere.	3.488	3.006	1.641	1.642
(U)	In FY 2004: Evaluated the performance of various wavefront sensors to maximize the ability to correct atmospheric effects on laser beams through laboratory demonstrations. Evaluated a compensated beacon illumination technique. Evaluated novel tracking algorithms. Completed initial evaluations using physics level wave optics simulations of several advanced concepts designed to improve performance of the Airborne Laser (ABL). These concepts included a compensated beacon approach, a focused track illuminator concept, several advanced tracking algorithms, and an adaptive reconstructor concept.				
(U)	In FY 2005: Develop optical components and complete active tracking experiments. Demonstrate advanced tracking methods and adaptive optics compensation techniques that double the Strehl ratio (peak intensity on target) in stressing atmospheric turbulence. Anchor wave optics propagation code to recent actual beam control performance. Complete concept evaluations using the ABL wave optics code				

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	that includes more detailed models of the ABL beam control system. Complete field testing of advanced tracking algorithms and adaptive optics techniques at the North Oscura Peak propagation range.				
(U)	In FY 2006: Demonstrate high-bandwidth active tracking of uncooperative targets. Begin development of predictive processing techniques to correct atmospheric turbulence-induced track jitter. Experimentally characterize turbulence-induced track jitter over large apertures. Develop and evaluate sensor data, tools, and processes to support an end to end model-based analysis approach for a range of beam control applications.				
(U)	In FY 2007: Demonstrate active tracking of small/dim targets in conjunction with compensated laser illumination and overall laser system performance characterization. Continue development of predictive processing techniques to correct atmospheric turbulence-induced track jitter. Begin field experiments to measure track jitter compensation.				
(U)					
(U)	CONGRESSIONAL ADD: National High Energy Laser Consortium.	0.486	0.000	0.000	0.000
(U)	In FY 2004: Developed a comprehensive five-year plan to create a joint government - industrial partnership to sustain the national industrial base in high powered lasers.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Stabilized Fiber Laser Pump Development.	4.471	0.000	0.000	0.000
(U)	In FY 2004: Developed single mode devices (optical fibers) to allow wavelength stabilized operation at ytterbium absorption peaks by integrating a grating into the optical fiber structure to control its operating frequency and to make it less susceptible to temperature changes.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Adaptive Optics Lasercom.	1.944	2.478	0.000	0.000
(U)	In FY 2004: Designed, developed, and began integration of existing technology for air-to-air optical communication with performance goal of 2.5 gigabit per second. Designed airborne experiment using unmanned air vehicle simulator aircraft and ground facilities at the North Oscura Peak, White Sands Missile Range, New Mexico, test site.				
(U)	In FY 2005: Develop and test advanced technologies for a 2.5 gigabit per second air-to-air-to-ground optical communications system on a government test range. Interface with other Air Force and				

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Department of Defense agencies to incorporate joint requirements into system performance.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(U)

(U)	CONGRESSIONAL ADD: Ultra-Short Pulse Laser technology Development.	0.000	4.956	0.000	0.000

(U) In FY 2004: Not Applicable.

(U) In FY 2005: Develop ultra-short pulse laser technology to obtain high-average, high-peak power. Investigate system engineering issues to package the ultra-short pulse laser technology into a low-weight, low-volume component. Investigate the relevance of ultra-short pulse laser technology for man portable and vehicle portable applications.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(U)	Total Cost	26.725	28.215	22.737	25.642

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

	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost

(U) Related Activities:

(U) PE 0601108F, High Energy Laser Research Initiatives.

(U) PE 0602500F, Multi-Disciplinary Space Technology.

(U) PE 0602890F, High Energy Laser Research.

(U) PE 0603444F, Maui Space Surveillance System.

(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.

(U) PE 0603605F, Advanced Weapons Technology.

(U) PE 0603924F, High Energy

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

Laser Advanced Technology Program.
PE 0603883C, Ballistic
(U) Missile Defense Boost Phase Segment.
This project has been coordinated through the
(U) Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

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DATE: February 2005

BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY

PROJECT NUMBER AND TITLE: 4867 Advanced Weapons & Survivability Technology

	Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
4867	Advanced Weapons & Survivability Technology	14.102	15.379	14.972	16.960	16.129	16.395	16.530	16.662	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

This project explores high power microwave (HPM) and other unconventional weapon concepts using innovative technologies. Technologies are developed that support a wide range of Air Force missions such as the potential disruption and degradation of an adversary's electronic infrastructure and military capability. This effect can often be applied covertly with no collateral structural or human damage. Targeted capabilities include local computer and communication systems, as well as large and small air defense and command and control systems. This project also provides for vulnerability assessments of representative U.S. strategic and tactical systems to HPM weapons, HPM weapon technology assessment for specific Air Force missions, and HPM weapon lethality assessments against foreign targets.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2004	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Investigate and develop technologies for narrowband and wideband HPM components to support multiple Air Force applications such as the disruption of electronic systems and subsystems.	6.830	7.355	7.160	6.976

(U) In FY 2004: Developed compact repetitively operated source technologies. Conducted pulsed atmospheric breakdown experiments. Integrated explosive generator development experiments with compact single-shot HPM sources. Investigated conformal phased array antenna for HPM systems. Developed sub-scale (laboratory) repetitively pulsed multi-gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Conducted laboratory evaluation of nanotechnology developed cathodes and anodes for repetitively pulsed HPM experiments. Utilized nanotechnology and other technologies to reduce the HPM source weight. Conducted a sub-scale (laboratory) wideband technology target identification experiment.

(U) In FY 2005: Investigate higher-power compact repetitively operated sources. Further improve the electrical efficiency of wideband HPM sources in order to achieve greater range, longer lifetime, and smaller packaging. Conduct pulsed atmospheric breakdown experiments. Conduct explosive generator development experiments to support compact single-shot HPM sources. Conduct a sub-scale (laboratory) repetitively pulsed gigawatt class experiment. Develop conformal phased array antenna for HPM systems. Select a repetitively pulsed multi-gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Utilize nanotechnology components (nanotubes) to continue development of cathodes and anodes for repetitively pulsed high power microwave (HPM) experiments. Develop target identification concept using wideband technology. Further develop wideband technology target identification source to demonstrate increased standoff range.

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(U) In FY 2006: Develop a compact repetitively pulsed gigawatt-class HPM source. Develop a conformal high power phased array antenna for the compact pulsed HPM source. Develop compact permanent magnets for the compact pulsed gigawatt HPM source. Develop a compact pulse power system to drive the HPM source. Conduct laboratory measurements of the compact pulsed gigawatt HPM demonstration unit. Develop vacuum systems that are compact and can be installed in an airborne platform. Develop compact solid-state wideband source and antenna for target identification. Develop target identification algorithms. Conduct target identification field experiments to determine optimal design.

(U) In FY 2007: Conduct measurements using the compact repetitively pulsed gigawatt-class HPM demonstration unit. Improve the compact HPM source and conformal antenna that they can be integrated into an airborne platform. Develop a command and control system for the airborne platform HPM unit. Implement nanotechnology to reduce the HPM source weight and size. Develop a compact portable wideband target identification system.

(U)

(U) MAJOR THRUST: Develop and use the ability to assess the effects/lethality of HPM directed energy weapon technologies against representative air and ground systems.	2.086	2.313	2.164	2.256

(U) In FY 2004: Conducted susceptibility tests to determine relative importance of source parameters in causing the desired effects on targets. Used current effects data and results in narrowband and wideband HPM experiments. Refined HPM codes to predict probability of effect on target equipment and to guide experiment direction. Developed better modeling techniques to incorporate HPM technologies into warfighting/wargaming activities. Further validated additional/modified computer codes' ability to adequately predict the electromagnetic coupling to, and probability of effect on, target equipment within complex structures.

(U) In FY 2005: Conduct further susceptibility tests to determine relative importance of source parameters to cause desired effects on targets. Proceed with the refinement of codes to predict probability of effect on target equipment and to guide experiment direction. Refine modeling techniques to incorporate HPM technologies into warfighting/war gaming activities. Proceed with validation of computer codes' ability to adequately predict the electromagnetic coupling to, and probability of effect on, target equipment within complex structures.

(U) In FY 2006: Continue to advance elemental modeling methodology to predict target susceptibility through modeling. Develop advanced descriptions of target functional behavior for insertion into modeling and simulation codes. Continue susceptibility testing of electronic targets.

(U) In FY 2007: Predict susceptibility of relevant current electronic systems. Conduct further experiments on the systems and compare predictions with experiments. Adjust models as required.

(U)

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(U)	MAJOR THRUST: Develop and apply sophisticated models to enhance the development of high power microwave (HPM) and related technology.	0.726	0.782	0.758	0.777
(U)	In FY 2004: Investigated plasma models and develop physics algorithms for HPM technologies. Developed improved algorithms for higher frequency wideband HPM modeling. Performed further virtual modeling for HPM component technologies.				
(U)	In FY 2005: Investigate/enhance plasma models and develop the physics algorithms for use with HPM technologies. Develop improved algorithms for higher frequency wideband HPM modeling. Investigate methods for integration of electromagnetic and acoustic software with thermal and electron transport codes for high-fidelity surface simulations. Apply virtual modeling for HPM component technologies.				
(U)	In FY 2006: Validate plasma model on dielectric pulse power interfaces and antenna breakdown. Improve the fidelity of the solution to electromagnetic models by statically refining the numerical grid and by having a boundary conformal solution. Continue integration of electromagnetic codes with thermal and electron transport codes.				
(U)	In FY2007: Validate integration of electromagnetic codes with thermal and electron transport codes for HPM sources and components. Continue improving the fidelity of the solution to electromagnetic models by automatically refining the numerical grid.				
(U)					
(U)	MAJOR THRUST: Investigate HPM technologies that support offensive and force protection airborne tactical applications made possible by the increased power available on future aircraft.	4.460	4.929	4.890	6.951
(U)	In FY 2004: Investigated enhanced source components of promise, especially plastic-laminate pulse forming lines, with an integrated Marx pulser. Modeled and performed simulation of the complete source. Completed determination of effect of air breakdown on transmitted HPM pulse over time. Finished initial aircraft integration report on source effects on the aircraft and command and control issues between the HPM source and the aircraft.				
(U)	In FY 2005: Improve the HPM effects modeling and simulation database so it is warfighter friendly. Upgrade source models to include aircraft concept of operations. Proceed with source self-mitigation efforts, so as not to interfere with host platform. Begin source to aircraft command and control efforts. Complete current source component study of plastic-laminate pulse forming lines with integrated Marx pulser. Test source upgrades and their effect of the aircraft, as well as the command and control interface.				
(U)	In FY 2006: Refine high power microwave (HPM) system source code to reflect payload to platform integration issues such as thermal, x-ray, and electrical issues. Examine the status of power conditioning subsystems to determine their applicability to an airborne experiment. Ensure understanding of air breakdown potentials given specific antenna interfaces. Continue refinement of solid state subsystem				

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designs.

(U) In FY 2007: Further develop HPM source materials and assess applicability of solid state subsystem designs supporting a ruggedized high power airborne system. Extend HPM system source code to reflect multiple options for high power subsystem components. Improve air breakdown predictions with specific antenna compositions. Refine existing beam control/antenna concepts to meet airborne requirements for Active Denial including addressing issue related to propagation, breakdown, and radomes. Research, study, and identify advanced technologies or data (effects, safety, stabilization, engagement) that could enhance the airborne Active Denial conceptual approach.

(U) Total Cost	14.102	15.379	14.972	16.960

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

	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost

(U) Related Activities:

(U) PE 0602202F, Human Systems Technology.

(U) PE 0603605F, Advanced Weapons Technology.

(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.