PE NUMBER: 0602605F
PE TITLE: DIRECTED ENERGY TECHNOLOGY

Exhibit R-2, RDT&E Budget Item Justification

DATE: February 2004

BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY

	Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
	Total Program Element (PE) Cost	35.661	42.077	36.532	38.540	44.413	43.223	43.065	0.000	0.000
4866	Lasers & Imaging Technology	20.966	27.478	20.991	23.231	26.715	26.146	25.939	0.000	0.000
4867	Advanced Weapons & Survivability Technology	14.695	14.599	15.541	15.309	17.698	17.077	17.126	0.000	0.000

Note: In FY 2003, space unique tasks in Project 4866 were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description and Budget Item Justification

This program covers research in directed energy technologies, primarily lasers and high power microwaves, that are not space unique. In lasers, this includes moderate to high power lasers (solid state and chemical) and associated optical components and techniques. In advanced weapons, this program examines technologies such as narrowband and wideband high power microwave devices and antennas. Both areas also provide vulnerability/lethality assessments of representative systems. Note: In FY 2004 Congresses added $2.5 million for the 975 millimeter Stabilized Fiber Laser Pump Development, $2.1 million for the Stabilized Fiber Laser Pump Development, $2.0 million for Adaptive Optics Lasercom, and $0.5 million for the National High Energy Laser Consortium.

This program is in Budget Activity 2, Applied Research, since it develops and determines the technical feasibility and military utility of evolutionary and revolutionary technologies.

(U) B. Program Change Summary ($ in Millions)

		FY 2003	FY 2004	FY 2005
(U)	Previous President's Budget	37.547	35.359	36.239
(U)	Current PBR/President's Budget	35.661	42.077	36.532
(U)	Total Adjustments	-1.886	6.718	
(U)	Congressional Program Reductions		-0.022	
	Congressional Rescissions		-0.360	
	Congressional Increases		7.100	
	Reprogrammings	0.383		
	SBIR/STTR Transfer	-2.269		
(U)	Significant Program Changes:			

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2004

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 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
4866 Lasers & Imaging Technology	20.966	27.478	20.991	23.231	26.715	26.146	25.939	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique tasks in Project 4866 were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(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 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Civilian salaries.			
(U) In FY 2003: This project previously included space unique tasks which have been transferred to PE 0602500F, Multi-disciplinary Space Technology. These funds represent the associated civilian salaries that were inadvertently left behind.	2.484	0.000	0.000
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) MAJOR THRUST: Develop advanced laser remote optical sensing technology to support standoff detection of chemical/biological aerosols for signature intelligence on weapons of mass destruction; bomb damage assessment; target characterization; and theater intelligence, surveillance, and reconnaissance.	1.661	0.000	0.000
(U) In FY 2003: Developed design and hardware for differential absorption laser radar applications. Investigated issues for an airborne system. Effort was terminated in order to fund higher priority efforts.			
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) MAJOR THRUST: Develop high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications.	4.222	4.594	5.121
(U) In FY 2003: Improved high pressure ejector nozzle performance and iodine atom generation for potential long-range			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT NUMBER AND TITLE **4866 Lasers & Imaging Technology**

	technology insertion into applications such as airborne lasers. Investigated low-flow rate basic hydrogen peroxide and zero-gravity singlet delta oxygen generators for airborne applications. Investigated a combustor-driven one kilowatt supersonic all gas-phase iodine laser. Improved the efficiency of the radio frequency-pumped overtone carbon monoxide laser in various spectral bands of interest for infrared countermeasure and remote sensing applications.			
(U)	In FY 2004: Perform sub-scaled evaluation of optimized high pressure ejector nozzles and integrated iodine atom generation for airborne applications. Evaluate the feasibility of low-flow rate basic hydrogen peroxide and zero-gravity singlet delta oxygen generator concepts for airborne applications. Investigate 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.			
(U)				
(U)	MAJOR THRUST: Develop high energy laser technologies for airborne tactical applications, including air-to-air and surface-to-air scenarios. Technologies being addressed include lasers for long-range detection of targets in clutter; high power, high-brightness, multi-wavelength compact lasers; and advanced beam control techniques to minimize platform vibration, atmospheric jitter, and aero-optical effects.	4.726	4.252	4.677
(U)	In FY 2003: Investigated laser sources and supporting technology for detecting, identifying, tracking, and defeating electro-optic targets. Demonstrated 30-watt, near-diffraction-limited, 1.5 micron eye-safe laser. Addressed packaging issues for advanced tactical applications. Conducted research on solid state laser technologies that support the enhanced Battlefield Air Operations Kit.			
(U)	In FY 2004: Collect aero-optical data from tactical aircraft to anchor computer models. Address thermal management issues and packaging/integration/test issues for tactical laser weapon applications on airborne platforms. Demonstrate improvements in semiconductor laser efficiency and operating temperatures that could enable future tactical systems and combat identification systems.			
(U)	In FY 2005: Address and evaluate system-level solutions for detecting, identifying, tracking, and defeating electro-optic targets. Evaluate potential system-level solutions to issues involving tactical laser weapons applications on airborne platforms.			
(U)				
(U)	MAJOR THRUST: Perform vulnerability assessments on potential high-energy laser targets to provide critical design data for laser systems to defeat these targets.	1.387	0.522	0.560
(U)	In FY 2003: Updated lethality assessment methodology by anchoring modeling tools to empirical data. Performed			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT NUMBER AND TITLE **4866 Lasers & Imaging Technology**

	finite state modeling of laser targets to better understand vulnerabilities and identify indicators for battle damage assessment.			
(U)	In FY 2004: Identify system constraints and performance in degraded situations, including battlefield conditions and weather.			
(U)	In FY 2005: Identify additional laser system constraints and performance in real world situations, including battlefield conditions and weather.			
(U)				
(U)	MAJOR THRUST: Develop scalable, high power fiber laser, conventional bulk solid state laser, and high-brightness diode laser technologies for next-generation electric laser device applications such as unmanned aerial vehicle designators/imagers and tactical airborne lasers.	6.210	7.367	6.611
(U)	In FY 2003: Demonstrated coherent beam combining of multiple high-power fiber amplifiers in a master oscillator, power amplifier configuration with free space optics.			
(U)	In FY 2004: Demonstrate 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 demonstrating the building-block technology of future directed energy, megawatt-class electric lasers. Demonstrate wavelength versatile integrated laser/nonlinear optics at five watt power levels.			
(U)				
(U)	MAJOR THRUST: Develop broadly applicable technologies to support future tactical and strategic relay mirrors systems.	0.276	0.873	0.361
(U)	In FY 2003: Developed light weight, low power optics for relay mirrors.			
(U)	In FY 2004: Select the best lightweight, low power optics candidate technologies for airborne relay mirrors and start 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)				
(U)	MAJOR THRUST: Develop optical and beam control technologies to enhance high energy laser beam propagation over long distances in the atmosphere.	0.000	2.770	3.661
(U)	In FY 2003: Not Applicable. Funds were redirected for FY 2003 to support higher Air Force priorities.			
(U)	In FY 2004: Evaluate the performance of various wavefront sensors to maximize the ability to correct atmospheric effects on laser beams through laboratory demonstrations. Evaluate a compensated beacon illumination technique. Evaluate novel tracking algorithms. Anchor wave optics propagation code to actual beam control performance.			
(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			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT NUMBER AND TITLE **4866 Lasers & Imaging Technology**

	stressing atmospheric turbulence. Anchor wave optics propagation code to recent actual beam control performance.			
(U)				
(U)	CONGRESSIONAL ADD: National High Energy Laser Consortium.	0.000	0.500	0.000
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Develop 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)				
(U)	CONGRESSIONAL ADD: Stabilized Fiber Laser Pump Development.	0.000	4.600	0.000
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Develop 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)				
(U)	CONGRESSIONAL ADD: Adaptive Optics Lasercom.	0.000	2.000	0.000
(U)	In FY 2003: Not Applicable:			
(U)	In FY 2004: Design, develop, integrate, and test a technique for air-to-air optical communication. Package existing technology for airborne evaluation using unmanned air vehicle simulator aircraft and ground facilities at the North Oscura Peak, White Sands Missile Range, New Mexico, test site. Performance goal is 2.5 gigabit per second to be verified by in-house analysis.			
(U)	In FY 2005: Not Applicable.			
(U)	Total Cost	20.966	27.478	20.991

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 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									

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT NUMBER AND TITLE 4866 Lasers & Imaging Technology

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

(U) 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 Laser Advanced Technology Program.

(U) PE 0603883C, Ballistic Missile Defense Boost Phase Segment.

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

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2004
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 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
4867	Advanced Weapons & Survivability Technology	14.695	14.599	15.541	15.309	17.698	17.077	17.126	0.000	0.000
	Quantity of RDT&E Articles	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 2003	FY 2004	FY 2005
(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.	5.992	7.070	7.450

(U) In FY 2003: Developed technology for compact repetitively operated sources. Further improved the electrical efficiency of wideband HPM sources in order to achieve greater range, longer lifetime, and smaller packaging. Conducted pulsed atmospheric breakdown experiments. Conducted explosive generator development experiments to support compact single-shot HPM sources. Conducted a sub-scale (laboratory) repetitively pulsed gigawatt class experiment. Developed conformal phased array antenna for HPM systems. Selected a repetitively pulsed multi-gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Utilized nanotechnology components (nanotubes) to develop cathodes and anodes for repetitively pulsed HPM experiments. Developed target identification concept using wideband technology.

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

(U) In FY 2005: Investigate 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

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT NUMBER AND TITLE **4867 Advanced Weapons & Survivability Technology**

	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 HPM experiments. Develop target identification concept using wideband technology. Further develop wideband technology target identification source to demonstrate increased standoff range.			
(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.	2.567	2.160	2.315
(U)	In FY 2003: Conducted susceptibility tests of representative command and control warfare targets. Conducted susceptibility tests to determine relative importance of source parameters in causing the desired effects on targets. Implemented effects data and results into narrowband and wideband HPM experiments. Refined codes for better prediction of probability of effect on experimental targets and to guide program direction. Developed better modeling techniques to incorporate HPM technologies into warfighting/wargaming activities. Validated specific computer codes' ability to adequately predict the electromagnetic coupling to, and probability of effect on, experimental targets within complex structures. Supported implementation of predictive models into existing engagement models.			
(U)	In FY 2004: Conduct susceptibility tests to determine relative importance of source parameters in causing the desired effects on targets. Use current effects data and results in narrowband and wideband HPM experiments. Refine HPM codes to predict probability of effect on target equipment and to guide experiment direction. Develop better modeling techniques to incorporate HPM technologies into warfighting/wargaming activities. Further validate 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)				
(U)	MAJOR THRUST: Develop and apply the theory of advanced computation to enhance the development of HPM and related technology.	0.760	0.752	0.791
(U)	In FY 2003: Investigated numerical dispersions and enhanced plasma models and physics algorithms for HPM technologies. Performed virtual prototyping for HPM component technologies.			
(U)	In FY 2004: Investigate plasma models and develop physics algorithms for HPM technologies. Develop improved algorithms for higher frequency wideband HPM modeling. Perform further virtual prototyping for HPM component			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT NUMBER AND TITLE **4867 Advanced Weapons & Survivability Technology**

	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 prototyping for HPM component technologies.			
(U)				
(U)	MAJOR THRUST: Investigate HPM technologies that support offensive advanced airborne tactical applications made possible by the increased power available on future aircraft.	4.512	4.617	4.985
(U)	In FY 2003: Studied enhanced source components of promise and began modeling and simulation of a complete source. Determined effect of air breakdown on transmitted HPM pulse over time. Studied aircraft integration issues of interest to determine effectual lethality of various concepts.			
(U)	In FY 2004: Investigate enhanced source components of promise, especially plastic-laminate pulse forming lines, with an integrated Marx pulser. Model and perform simulation of the complete source. Complete determination of effect of air breakdown on transmitted HPM pulse over time. Finish 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. Produce a model of a complete HPM source. 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)				
(U)	MAJOR THRUST: Further develop active denial technologies to support airborne agile combat support applications.	0.864	0.000	0.000
(U)	In FY 2003: Developed computational physics algorithms for next-generation airborne millimeter wave sources by modeling sub-scale pieces of existing active denial sources to verify validity of computational approach. Developed preliminary design of a ground-based megawatt-class airborne source demonstrator. Transferred to PE 0603605F in FY 2004 for a ground-based demonstration of airborne applicable technologies.			
(U)	In FY 2004: Not Applicable. Note: Transferred to PE 0603605F for FY 2004 and out for a ground-based demonstration of airborne applicable technologies.			
(U)	In FY 2005: Not Applicable.			
(U)	Total Cost	14.695	14.599	15.541

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT NUMBER AND TITLE 4867 Advanced Weapons & Survivability Technology

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

(U) PE 0602202F, Human Systems Technology.

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.