RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)

DATE: February 2003

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	33,557	37,547	35,359	36,239	39,551	45,174	43,760	43,556	Continuing	TBD
4866	Lasers & Imaging Technology	18,840	21,777	20,635	20,854	23,881	27,218	26,510	26,283	Continuing	TBD
4867	Advanced Weapons & Survivability Technology	14,717	15,770	14,724	15,385	15,670	17,956	17,250	17,273	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	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

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.

(U) B. Budget Activity Justification

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) C. Program Change Summary ($ in Thousands)

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	34,616	39,936	40,251	
(U)	Appropriated Value	34,678	39,936		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-62	-2,325		
	b. Small Business Innovative Research	-893			
	c. Omnibus or Other Above Threshold Reprogram		-64		
	d. Below Threshold Reprogram	-2			

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY

(U) C. Program Change Summary ($ in Thousands) Continued

		FY 2002	FY 2003	FY 2004	Total Cost
	e. Rescissions	-164			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-4,892	
(U)	Current Budget Submit/FY 2004 PBR	33,557	37,547	35,359	TBD

(U) Significant Program Changes:

The adjustment in FY 2004 is due to the delayed transfer of the civilian salaries associated with the space unique efforts previously transferred to PE 0602500F, Multi-disciplinary Space Technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY / PROJECT: 4866

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4866 Lasers & Imaging Technology	18,840	21,777	20,635	20,854	23,881	27,218	26,510	26,283	Continuing	TBD

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

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) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,504 Developed and tested advanced long-range optical technologies to support beam projection and imaging applications. Developed novel, advanced optical devices for faster corrections, increased resolution, and larger apertures. Tested and characterized these devices in a laboratory environment. Emphasized extending the wavelength coverage and decreasing number of system components to increase payoff to space-based optical systems. Produced one-meter class membrane mirror with near final curvature and demonstrated holographic correction of the mirror surface.

(U) $4,521 Developed high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Investigated high pressure ejector nozzle performance and iodine atom generation for potential long-range technology insertion into applications such as airborne lasers. Continued development of a subsonic all gas-phase iodine laser. Began design of a combustor-driven one kilowatt supersonic all gas-phase iodine laser. Conducted a study of the radio frequency-pumped overtone carbon monoxide laser in various spectral bands of interest for infrared countermeasures and remote sensing applications.

(U) $3,518 Developed and demonstrated high energy laser technologies for airborne tactical applications, including air-to-air and surface-to-air scenarios. Technologies addressed included lasers for long-range detection of targets in clutter and advanced beam control techniques to minimize platform vibration, atmospheric jitter, and aero-optic effects. Developed and demonstrated multifunctional laser components capable of detecting, identifying, tracking, and defeating electro-optic targets. Investigated packaging issues for advanced tactical applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT 4866

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U)	$5,540	Developed low-cost, scalable, high power solid state laser architectures for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapon applications including tactical airborne lasers. Began developing promising solid state laser technologies that provide benefits such as low-cost, high efficiency (approaching 30%), compactness, and scalability. Developed integration technologies necessary for combining multiple fiber laser modules including coherent, spectral, and nonlinear optical beam combining technologies.
(U)	$528	Developed 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. Completed phase II experiments for frequency agile heterodyne receiver development for improved sensitivity.
(U)	$2,238	Assessed the vulnerability of six satellites (U.S. and foreign) to the effects of directed energy weapons, primarily high energy lasers. Updated previously completed assessments on catalogued satellites. Started development of finite state models for satellites to be used with observables to produce a more complete space situational awareness posture.
(U)	$991	Developed the Tactical Operations System Simulator to model, evaluate, trade, and optimize directed energy concepts and tactical employment. Developed software/hardware simulation tools to assess performance, demonstrate military utility to the warfighter, and identify requirements and technology shortfalls. Integrated tools to provide a government systems engineering, simulation, and operational research capability.
(U)	$18,840	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,484	This project previously included space unique tasks which have been transferred to PE 0602500F, Multi-disciplinary Space Technology. These funds represent the civilian salaries for the transferred work efforts.
(U)	$365	Develop and demonstrate generic technologies to support future tactical or strategic relay mirrors systems. These technologies include beam control; beam acquisition, tracking, and pointing; dual line of sight pointing; lightweight optics; and beam stabilization. Develop light, low power optics for relay mirrors.
(U)	$4,310	Develop high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Improve high pressure ejector nozzle performance and iodine atom generation for potential long-range technology insertion into applications such as airborne lasers. Investigate low-flow rate basic hydrogen peroxide and zero-gravity singlet delta oxygen generators for airborne applications. Begin construction of a combustor-driven one kilowatt supersonic all gas-phase iodine laser. Improve the efficiency of the radio frequency-pumped overtone carbon monoxide laser in various spectral bands of interest for infrared countermeasure and remote sensing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT 4866

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

applications.

(U) $4,978 Develop and demonstrate 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. Continue developing laser sources and supporting technology for detecting, identifying, tracking, and defeating electro-optic targets. Demonstrate 30-watt, near-diffraction-limited, 1.5 micron eye-safe laser. Address packaging issues for advanced tactical applications.

(U) $6,504 Develop scalable, high power solid state laser architectures for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapon applications including tactical airborne lasers. Develop promising solid state laser technologies for a FY 2004 demonstration of attributes such as low-cost, high efficiency, compactness, and scalability. Demonstrate technologies necessary for scaling solid state laser powers to 10 kilowatts.

(U) $1,749 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. Continue design and development of hardware for differential absorption laser radar applications. Investigate issues for an airborne system.

(U) $1,387 Perform vulnerability assessments on potential high energy laser targets to provide critical design data for laser systems to defeat these targets. Continue to update lethality assessment methodology by anchoring modeling tools to empirical data. Perform finite state modeling of laser targets to better understand vulnerabilities and identify indicators for battle damage assessment.

(U) $21,777 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,100 Develop and demonstrate generic technologies to support future tactical or strategic relay mirrors systems. These technologies include beam control; beam acquisition, tracking, and pointing; dual line of sight pointing; lightweight optics; and beam stabilization. Select the best lightweight, low power optics candidate technologies for airborne relay mirrors and start development of these optics for potential demonstration on a small-scale (with 50-cm primary optics) bifocal relay testbed.

(U) $4,594 Develop high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Perform sub-scaled demonstration of optimized high pressure ejector nozzles and integrated iodine atom generation for airborne applications. Demonstrate low-flow rate basic hydrogen peroxide and zero-gravity singlet delta oxygen generator concepts for airborne applications. Demonstrate the feasibility of electrical regeneration of laser consumables to reduce chemical laser logistics tail.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY / PROJECT: 4866

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$4,252	Develop and demonstrate 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. 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 for tactical systems and combat identification systems.
(U)	$7,367	Develop scalable, high power solid state laser architectures for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapon applications such as tactical airborne lasers. Demonstrate laboratory operation of a solid state laser with a power level of 10 kilowatts or more. Investigate system-level issues such as weight and volume.
(U)	$552	Perform vulnerability assessments on potential high energy laser targets to provide critical design data for laser systems to defeat these targets. Develop models and tools for tactical aircraft self-protection using high power solid state lasers against surface-to-air missiles. Identify system constraints and performance in degraded situations, including battlefield conditions and weather.
(U)	$2,770	Develop and evaluate beam control/compensation techniques for atmospheric attenuation and distortion on laser beam propagation from airborne platforms. These efforts enhance high energy laser delivery from future airborne laser weapon systems to missile targets. Evaluate the performance of various wavefront sensors to maximize the ability to correct for atmospheric disturbances through laboratory demonstration. Initiate demonstration and evaluation of the compensated beacon illumination technique. Anchor wave optics propagation code to the demonstrated beam control performance.
(U)	$20,635	Total

(U) B. Project Change Summary

Not Applicable.

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

(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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY
PROJECT: 4866	

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

(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.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT: 4867

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4867	Advanced Weapons & Survivability Technology	14,717	15,770	14,724	15,385	15,670	17,956	17,250	17,273	Continuing	TBD

(U) A. Mission Description

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) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,136 Investigated and developed technologies for narrowband and wideband HPM components to support multiple Air Force applications such as the disruption of electronic systems and subsystems. Continued to improve the electrical efficiency of wideband HPM sources in order to achieve greater range, longer lifetime, and smaller packaging. Integrated pulsed power and HPM source to show capability for single shot technologies. Selected a repetitively pulsed gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Continued development of component technologies – pulsed power, sources, and antennas – for repetitively pulsed airborne and munitions systems. Developed and patented cathode and anode components for repetitively pulsed HPM experiments. Designed high efficiency repetitively pulsed HPM source. Conducted laboratory test of frequency agile HPM source. Continued development of compact repetitively operated sources. Continued pulsed atmospheric breakdown experiments. Continued explosive generator development experiments to support compact single-shot HPM sources.

(U) $2,869 Developed and used the ability to assess effects/lethality of HPM weapon technologies against representative air and ground military systems. Continued to conduct susceptibility tests on representative command and control warfare targets. Conducted susceptibility tests of high repetitively pulsed effects on targets. Implemented effects data and results into narrowband and wideband HPM experiments and demonstrations. Continued validation of computer codes' ability to predict the wideband electromagnetic coupling to increasingly complex structures. Continued to expand range of predictability of HPM narrowband effects models to damage or disrupt military electronic targets of interest. Continued validation of predictability of models. Continued developing better HPM source modeling techniques to incorporate HPM technologies into warfighting/wargaming activities.

(U) $3,917 Investigated HPM technologies that support advanced airborne tactical applications made possible by the increased power available on future

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT 4867

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

aircraft. Began study to determine feasibility and cost of construction for a novel effects experiment test chamber while upgrading existing test facility. Continued development of high power microwave (HPM) effects database including modeling and simulation of HPM illumination verses target effects. Initiated study of enhanced source components of promising concepts identified by the trade off studies to include an HPM repetitively pulsed source on an aerial platform. Studied aircraft integration issues.

(U) $1,795 Further developed active denial technologies to support airborne agile combat support applications. Began engineering design of improved millimeter wave sources for airborne active denial. Enhanced in-house capabilities for airborne system development including source modeling using computer simulations and upgrading of research equipment.

(U) $14,717 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $7,031 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. Continue development of compact repetitively operated sources. Continue to improve the electrical efficiency of wideband HPM sources in order to achieve greater range, longer lifetime, and smaller packaging. Continue pulsed atmospheric breakdown experiments. Continue explosive generator development experiments to support compact single-shot HPM sources. Conduct a subscale (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.

(U) $2,600 Develop and use the ability to assess effects/lethality of HPM directed energy weapon technologies against representative air and ground targets. Continue to conduct susceptibility tests of representative command and control warfare targets. Continue to conduct susceptibility tests to determine relative importance of source parameters in causing the desired effects on targets. Continue to implement effects data and results into narrowband and wideband HPM experiments and demonstrations. Refine codes for better prediction of probability of effect on experimental targets and to guide program direction. Continue development of better modeling techniques to incorporate HPM technologies into warfighting/wargaming activities. Continue validation of computer codes' ability to adequately predict the electromagnetic coupling to, and probability of effect on, experimental targets within complex structures. Support implementation of predictive models into existing engagement models.

(U) $760 Develop and apply theory of advanced computation to enhance the development of HPM and related technologies. Investigate numerical

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT 4867

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

dispersions and enhance plasma models and physics algorithms for high power microwave (HPM) technologies. Perform virtual prototyping for HPM component technologies.

(U) $4,503 Investigate HPM technologies that support advanced airborne tactical applications made possible by the increased power available on future aircraft. Continue studying enhanced source components of promise and begin modeling and simulation of a complete source. Determine effect of air breakdown on transmitted HPM pulse over time. Continue aircraft integration issue studies of interest to determine effectual lethality of each concept.

(U) $876 Further develop active denial technologies to support airborne agile combat support applications. Continue development of computational physics algorithms for next-generation airborne millimeter wave sources by modeling subscale pieces of existing active denial sources to verify validity of computational approach. Begin design of a ground-based megawatt-class airborne source demonstrator. This work will transfer to PE 0603605F in FY 2004 for a ground-based demonstration of airborne applicable technologies.

(U) $15,770 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,741 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. Continue development of compact repetitively operated sources. Continue pulsed atmospheric breakdown experiments. Integrate explosive generator development experiments with compact single-shot HPM sources. Continue development of conformal phased array antenna for HPM systems. Develop subscale (laboratory) repetitively pulsed multi-gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Conduct laboratory test of nanotechnology developed cathodes and anodes for repetitively pulsed HPM experiments. Utilize nanotechnology and other technologies to reduce the HPM source weight. Conduct a subscale (laboratory) wideband technology target identification experiment.

(U) $758 Develop and apply theory of advanced computation to enhance the development of HPM and related technologies. Continue the investigation of plasma models and develop physics algorithms for HPM technologies. Develop improved algorithms for higher frequency wideband HPM modeling. Continue to perform virtual prototyping for HPM component technologies.

(U) $2,810 Develop and use the ability to assess the effects/lethality of HPM directed energy weapon technologies against representative air and ground systems. Conduct susceptibility tests to determine relative importance of source parameters in causing the desired effects on targets. Implement effects data and results into narrowband and wideband HPM experiments and demonstrations. 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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY / PROJECT: 4867

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

warfighting/wargaming activities. Continue validation of computer codes' ability to adequately predict the electromagnetic coupling to, and probability of effect on, target equipment within complex structures.

(U) $4,415 Investigate high power microwave (HPM) technologies that support offensive advanced airborne tactical applications made possible by the increased power available on future aircraft. Continue studying enhanced source components of promise especially plastic-laminate pulse forming lines with integrated Marx pulser. Continue modeling and 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 between the HPM source and the aircraft.

(U) $14,724 Total

(U) B. Project Change Summary

Not Applicable.

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

(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.

(U) E. Schedule Profile

(U) Not Applicable.