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

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY

	COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	31,110	34,616	39,936	40,251	40,748	42,266	43,078	Continuing	TBD
4866	Lasers & Imaging Technology	15,685	19,435	23,174	24,359	24,332	25,519	25,977	Continuing	TBD
4867	Advanced Weapons & Survivability Technology	15,425	15,181	16,762	15,892	16,416	16,747	17,101	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0

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

(U) A. Mission Description

This PE 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 PE 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 2002, Congress added $1 million for Tactical/Operations System Simulator.

(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 2001	FY 2002	FY 2003	Total Cost
(U)	Previous President's Budget	32,041	36,678	37,827	
(U)	Appropriated Value	32,337	34,678		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions		-62		

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

		FY 2001	FY 2002	FY 2003	Total Cost
	b. Small Business Innovative Research	-774			
	c. Omnibus or Other Above Threshold Reprogram				
	d. Below Threshold Reprogram	-157			
	e. Rescissions	-296			
(U)	Adjustments to Budget Years Since FY 2002 PBR			2,109	
(U)	Current Budget Submit/FY 2003 PBR	31,110	34,616	39,936	TBD

(U) Significant Program Changes:
Not Applicable.

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

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY

PROJECT: 4866

COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
4866 Lasers & Imaging Technology	15,685	19,435	23,174	24,359	24,332	25,519	25,977	Continuing	TBD

Note: In FY 2003, space unique tasks in Project 4866 will be 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 that are not space unique. 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 2001 ($ in Thousands)

(U) $2,091 Developed long-range optical technologies for increased resolution, characterization, and data fusion applications. Explored lightweight membrane mirror issues for scaling to very large size (~ 10-meter mirrors). Addressed issues associated with producing a mirror close to required curvature and demonstrated holographic correction capability on scaled optics in laboratory environment.

(U) $724 Developed and field tested novel, advanced optics technologies to support beam projection and imaging applications associated with large aperture lightweight optics. The novel, advanced optics components that provide optical compensation for beam projection and imaging technology were scaled up in size and integrated into laboratory/field tests and demonstrations. Additional improvements and techniques to extend the wavelength regime and reduce the number of such components were pursued.

(U) $4,769 Developed high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Performed engineering validation of advanced chemical oxygen iodine laser nozzle concepts which include iodine atom production techniques and integrated ejector nozzle concepts. Continued to develop/refine a subsonic all gas phase iodine laser demonstrator. Improved radio frequency pumped carbon monoxide supersonic laser for carbon monoxide overtone lasing.

(U) $2,684 Developed laser source, beam control, and target coupling technologies to counter current and next generation air-to-air and surface-to-air missile threats to aircraft. Developed an electrically pumped mid-infrared solid state laser operating at room temperature. With increased power and pulse duration, this will lead to eliminating the optical pump source and cryogenic cooler for mid-infrared lasers. Investigated novel materials effects associated with ultra-fast lasers for countering focal plane array seekers. Obtained a high fidelity surrogate seeker for

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BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY / PROJECT: 4866

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

laboratory effects testing. Developed a moderate power ultra-fast laser source for investigations of novel atmospheric propagation characteristics.

(U) $5,417 Developed low-cost, scalable, high power solid state laser architectures by integrating fiber lasers with diode-laser pump sources for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapons applications such as space-based lasers and airborne lasers. Developed promising fiber laser technologies exhibiting attributes such as low-cost, high efficiency, compactness and scalability that will enable applications that require laser mobility. Developed integration technologies for demonstration of power greater than 100 watts.

(U) $15,685 Total

(U) FY 2002 ($ in Thousands)

(U) $1,504 Develop and field test advanced long-range optical technologies to support beam projection and imaging applications. Develop novel, advanced optical devices for faster corrections, increased resolution, and larger apertures. Test and characterize these devices in a laboratory environment. Emphasize extending the wavelength coverage and decreasing number of system components. Decreasing the number of system components and extending the wavelength coverage have major applications to space-based optical systems. Produce one-meter class membrane mirror with near final curvature and demonstrate holographic correction of the mirror surface.

(U) $5,073 Develop high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Optimize high pressure ejector nozzle performance and iodine atom generation for potential long-range technology insertion into applications such as airborne lasers. Investigate low basic hydrogen peroxide flow rate 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 countermeasures and remote sensing applications.

(U) $3,561 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, advanced beam control to control platform vibration, atmospheric jitter, and aero-optic effects. Develop and demonstrate multifunctional laser components capable of detecting, identifying, tracking, and defeating electro-optical targets.

(U) $5,540 Develop low-cost, scalable, high power solid state laser architectures for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapons applications such as space-based lasers and airborne lasers. Begin developing promising

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

fiber laser technologies exhibiting attributes such as low-cost, high efficiency (approaching 30%), compactness, and scalability. Develop integration technologies necessary for combining multiple fiber laser modules including coherent, spectral and nonlinear optical beam combining technologies.

(U) $528 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. Complete Phase II experiments for frequency agile heterodyne receiver development.

(U) $2,238 Assess the vulnerability of six satellites (U.S., NATO, and foreign) to the effects of directed energy weapons, primarily high energy lasers. Update previously completed assessments on catalogued satellites. Fuse finite state models with other satellite data and observables to produce a more complete space situational awareness posture.

(U) $991 Develop the Tactical Operations System Simulator to model, evaluate, trade, and optimize directed energy concepts and tactical employment. Develop software/hardware simulation tools to assess performance, demonstrate military utility and benefits to the warfighter, and to identify requirements and technology shortfalls. Integrate tools to provide a government systems engineering, simulation, and operational research capability.

(U) $19,435 Total

(U) FY 2003 ($ in Thousands)

(U) $2,822 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 and they will be transferred at a later date.

(U) $4,995 Develop high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Perform scaled demonstration of optimized high pressure ejector nozzles incorporating iodine atom generation as appropriate for potential long-range technology insertion into airborne laser applications. Investigate low flow rate basic hydrogen peroxide and zero-gravity generator concepts and complete the design of the most promising concept for fabrication and bench testing. In concert with generator development, investigate means to cut the chemical laser logistic trail through chemical regeneration or single pass singlet delta oxygen generators. Demonstrate an enhanced overtone carbon monoxide laser in configuration suitable for transition to potential airborne infrared countermeasure applications. Improve 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) $4,981 Develop and demonstrate high-energy laser technologies for airborne tactical applications, including air-to-air and surface-to-air scenarios.

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

Technologies being addressed include lasers for long-range detection of targets in clutter, high-power compact lasers, advanced beam control to control platform vibration, atmospheric jitter, and aero-optical effects. Continue developing laser sources and supporting technology for detecting, identifying, tracking, and defeating electro-optical targets. Demonstrate 30-watt, near-diffraction-limited, 1.5 micron laser.

(U) $7,136 Develop low-cost, scalable, high power solid-state laser architectures by integrating fiber lasers with diode-laser pump sources for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapons applications such as space-based and airborne lasers. Develop promising fiber laser technologies for a demonstration of attributes such as low-cost, high efficiency, compactness, and scalability. Develop integration technologies necessary for combining multiple fiber laser modules exhibiting powers near one kilowatt.

(U) $1,760 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. Initial design and development of flight-qualifiable hardware for differential absorption laser radar applications.

(U) $1,480 Perform vulnerability assessments on potential high energy laser targets to provide critical design data for laser systems to defeat these targets. Update lethality assessment methodology by anchoring modeling tools to empirical data. Conduct vulnerability experiments to update data used for lethality assessments, system effectiveness, and system concept definition. Perform lethality assessments on potential high-energy laser concepts to provide critical data for designing laser systems.

(U) $23,174 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

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

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

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

(U) PE 0603605F, Advanced Weapons Technology.

(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.

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(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602605F DIRECTED ENERGY TECHNOLOGY

PROJECT: 4867

COST ($ in Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
4867	Advanced Weapons & Survivability Technology	15,425	15,181	16,762	15,892	16,416	16,747	17,101	Continuing	TBD

(U) A. Mission Description

High power microwave (HPM) and other unconventional weapon concepts using innovative technologies are explored in this project. Technologies 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 are developed. This effect can often be applied covertly with no collateral structural or human damage. These 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 2001 ($ in Thousands)

(U) $2,846 Investigated and developed technologies for multi-pulsed narrowband and wideband HPM components to support multiple Air Force applications. Continued investigation of better source modeling techniques in order to incorporate HPM technologies into warfighting/war gaming activities. Investigated high efficiency repetitively-pulsed HPM source. Developed frequency agile HPM source. Developed compact repetitively operated sources. Started pulsed atmospheric breakdown experiments. Started explosive generator development experiments to support compact single-shot HPM sources.

(U) $1,801 Assessed effects/lethality of HPM weapon technologies against representative air and ground military systems. Continued to conduct susceptibility tests of representative command and control warfare targets. Investigated effects on targets of HPM sources pulsed at high repetition rates.

(U) $1,932 Investigated and developed wideband HPM technologies that support command and control warfare and other wideband applications. Researched advanced antenna designs driven by mission concepts. Continued applied research to improve wideband HPM sources in order to achieve greater range or smaller packaging. Continued advancement of computer codes' ability to predict the electromagnetic coupling to target equipment and probability of effect inside increasingly complex structures. Expanded HPM effects prediction models for implementation into engagement scenario models. Researched methods to enhance HPM source technology such as power throughput for solid state switches and high repetition rates for high pressure gas switches.

(U) $2,673 Developed narrowband HPM technologies that support suppression of enemy air defenses through the use of reusable airborne platforms and munitions. Continued to expand range of predictability of HPM narrowband effects models for military electronic targets of interest.

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(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

Continued validation of predictability of models. Continued investigation of pulsed power and HPM source capability to support an integrated experiment to show proof-of-principle capability for single shot technologies. Completed design of subscale (laboratory) breadboard HPM system to validate approach and capability for repetitively pulsed technologies for high power microwave (HPM) munitions and airborne electronic attack. Continued development of component technologies – pulsed power, sources, and antennas – for repetitively pulsed airborne and munitions systems.

(U) $3,491 Investigated HPM technologies that support offensive and defensive advanced airborne tactical applications, to include airborne and munitions platforms, made possible by the increased power available on future aircraft. Investigated enhanced sources for the most promising concepts identified by the FY 2000 tradeoff study. Continued to develop HPM effects database of commercial-off-the-shelf sources, missile targets, and aircraft platforms.

(U) $1,883 Assessed the vulnerability of seven satellites (U.S., NATO, and foreign) to the effects of directed energy weapons, primarily high energy lasers. Updated previously completed assessments on catalogued satellites. Began developing finite state models to predict satellite performance from observed behavior to support space situational awareness. Compiled assessment data and models into easily accessible folders for satellite characterization.

(U) $799 Investigated the best means for active denial technologies to support agile combat support applications. Continued development of millimeter wave sources for active denial technology and conducted experiments including beam transport and power extraction. Investigated millimeter wave source enhancement technologies using computer simulations.

(U) $15,425 Total

(U) FY 2002 ($ in Thousands)

(U) $6,600 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 to improve the electrical efficiency of wideband HPM sources in order to achieve greater range, longer lifetime, or smaller packaging. Integrate pulsed power and HPM source to show capability for single shot technologies. Select a repetitively pulsed multi-gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Continue development of component technologies – pulsed power, sources, and antennas – for repetitively pulsed airborne and munitions systems. Design high efficiency repetitively pulsed HPM source. Conduct laboratory test of frequency agile HPM source. Continue development of compact repetitively operated sources. Continue pulsed atmospheric breakdown experiments. Continue explosive generator development experiments to support compact single-shot HPM sources.

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

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

(U) $3,917 Investigate HPM technologies that support offensive and defensive advanced airborne tactical applications, to include airborne and munitions platforms, made possible by the increased power available on future aircraft. Develop enhanced sources for the most promising concepts identified by the tradeoff study to include an HPM repetitively pulsed source on an unmanned aerial platform. Continue to perform effects experiments upon targets of interest to determine effectual lethality of each concept. Continue development of HPM effects database and characterize commercial-off-the-shelf sources and aircraft platforms.

(U) $1,795 Investigate the best means for active denial technologies to support agile combat support applications. Conduct preliminary design study of millimeter wave sources for active denial technology, including airborne active denial. Conduct experiments including power combining, depressed collector, and modulation schemes. Investigate source enhancement technologies using computer simulations.

(U) $15,181 Total

(U) FY 2003 ($ in Thousands)

(U) $7,638 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 laboratory testing of frequency agile HPM source. Continue development of compact repetitively operated sources. 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.

(U) $2,600 Assess effects/lethality of HPM directed energy weapon technologies against representative air and ground military systems. Continue to conduct susceptibility tests of representative command and control warfare targets. Continue to conduct susceptibility tests of high repetitively pulsed effects on targets. Continue to implement effects data and results into narrowband and wideband HPM experiments and demonstrations. Support refinement of codes to predict probability of effect on target equipment and to guide experiment direction. Continue development of better source modeling techniques to incorporate HPM technologies into warfighting/wargaming activities. Continue validation of computer

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

codes' ability to accurately predict the electromagnetic coupling to, and probability of effect on, target equipment 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 technology. Investigate numerical dispersions and enhance plasma models and physics algorithm development for HPM technologies. Perform virtual prototyping for HPM component technologies.

(U) $4,888 Continue to investigate high power microwave (HPM) technologies that support offensive and defensive advanced airborne tactical applications, to include airborne and munitions platforms, made possible by the increased power available on future aircraft. Down select improved sources for the most promising concepts identified by the trade-off study to include an HPM repetitively pulsed source on an air platform. Continue to perform effects experiments upon targets of interest to determine effectual lethality of each concept. Continue development of HPM effects database and continue to characterize commercial-off-the-shelf sources and aircraft platforms.

(U) $876 Continue investigation of best means for active denial technologies to support Agile Combat Support applications. Complete design study of millimeter wave sources for active denial technology and associated support subsystems. Begin virtual prototyping of millimeter wave source. Investigate source enhancement technologies using computer simulations.

(U) $16,762 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.