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

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602203F Aerospace Propulsion

	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	144,355	178,485	107,659	118,958	114,560	114,674	115,981	Continuing	TBD
3012	Advanced Propulsion Technology	0	21,436	3,637	14,894	12,909	12,903	12,945	Continuing	TBD
3048	Fuels and Lubrication	8,501	12,549	15,060	16,009	16,201	15,513	14,847	Continuing	TBD
3066	Turbine Engine Technology	40,168	44,864	43,630	41,359	38,146	38,025	38,874	Continuing	TBD
3145	Aerospace Power Technology	26,727	27,376	26,890	27,831	28,090	28,688	29,266	Continuing	TBD
4847	Rocket Propulsion Technology	68,959	72,260	18,442	18,865	19,214	19,545	20,049	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0

Note: In FY 2002, the Hypersonic Technology Program work performed in PE 0602203F, Project 3066; PE 0603202F, Project 668A; and PE 0603216F, Project 681B was transferred to Project 3012 in this PE in order to align projects with the Air Force Research Laboratory organization. In FY 2003, only the space unique tasks in Projects 3012 and 4847 will be transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

In FY 2003, this program anticipates receiving $5.7 million from the Cost of War Transfer Account. These funds are not included in the FY 2003 Air Force baseline. Funding will be used for rocket propulsion technologies in support of the Technology for Sustainment of Strategic Systems program.

(U) A. Mission Description

This program develops propulsion and power technologies to achieve enabling and revolutionary aerospace technology capabilities. The program has five projects, each focusing on a technology area critical to the Air Force: 1) The Turbine Engine Technology project develops enabling capabilities to enhance performance and affordability of existing weapon systems. Turbine Engine Technology project efforts are part of the Integrated High Performance Turbine Engine Technology (IHPTET) program; 2) The Rocket Propulsion Technology project pursues advances in rocket technologies for space access and maneuver, and tactical and strategic

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion

(U) A. Mission Description Continued

missiles. Rocket Propulsion Technology project efforts are part of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program; 3) The Aerospace Power project develops efficient energy storage and generation techniques for ground, air, and space military applications; 4) The Fuels and Lubrication project develops new concepts and technologies to power, cool, and lubricate new and existing engines; and 5) The Advanced Propulsion Technology project develops combined cycle and advanced airbreathing hypersonic propulsion technologies to enable revolutionary propulsion options for the Air Force. Note: In FY 2002, Congress added $3.0 million for Pulse Detonation Engines; $3.0 million for magnetic bearing cooling turbine; $1.0 million for Poly (p-phenylene-2,6-benzobisoxazole) (PBO) Membrane Fuel Cells; $1.0 million for lithium ion battery technology for aircraft, spacecraft, and handheld applications; $1.0 million for lithium ion battery technology for solid state lasers; $1.5 million for Engineering Tool Improvement Program for High Cycle Fatigue; $2.3 million for Jet Engine Test Cell upgrade; $7.1 million for the IHPRPT program; and $10.7 million for Air Force Research Laboratory test stand upgrades at Edwards Air Force Base.

(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	123,618	149,211	136,547	
(U)	Appropriated Value	124,762	179,811		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions		-1,326		
	b. Small Business Innovative Research	-2,963			
	c. Omnibus or Other Above Threshold Reprogram	23,700			
	d. Below Threshold Reprogram				
	e. Rescissions	-1,144			
(U)	Adjustments to Budget Years Since FY 2002 PBR			-28,888	
(U)	Current Budget Submit/FY 2003 PBR	144,355	178,485	107,659	TBD

(U) Significant Program Changes:

FY 2003 decreases are primarily due to space-related actvities being transferred to new space-unique PE 0602500F.

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

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602203F Aerospace Propulsion

PROJECT: 3012

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
3012 Advanced Propulsion Technology	0	21,436	3,637	14,894	12,909	12,903	12,945	Continuing	TBD

Note: In FY 2002, the Hypersonic Technology Program work formerly performed in PE 0602203F, Project 3066; PE 0603202F, Project 668A; and PE 0603216F, Project 681B, has been transferred into this Project in order to align projects with the Air Force Research Laboratory organization. In FY 2003, space unqiue tasks will be transferred to PE 0602500F, Project 5027, in conjunction with the Space Commission recommendation to consolidate all space-unique activities.

(U) A. Mission Description

The Advanced Propulsion Technology project develops combined/advanced cycle airbreathing hypersonic propulsion technologies to enable revolutionary propulsion options for the Air Force. These new engine technologies will enable future high-speed weapons, aircraft, and space launch concepts. The primary focus is on hydrocarbon fueled engines capable of operating over a broad range of flight Mach numbers. Technologies developed under this program enable capabilities of interest to both Department of Defense and National Aeronautical and Space Administration (NASA). Efforts include modeling and simulation, proof of concept demonstrations of critical components, advanced component development, and ground-based demonstrations.

(U) FY 2001 ($ in Thousands)

(U) $0 This work is performed in PE 0602203F, Project 3066; PE 0603202F, Project 668A; and PE 0603216F, Project 681B.

(U) $0 Total

(U) FY 2002 ($ in Thousands)

(U) $14,450 Demonstrate advanced hydrocarbon scramjet engine technology to enable fuller dominance of space. Conduct detailed analysis for mating scramjet flight ready engine with flight demonstrator vehicle. Perform trajectory optimization for flight test. Complete design and component development. Initiate fabrication of flight-ready hydrocarbon fueled scramjet engine, including flight weight fuel cooled structures, flight weight fuel control valves, fuel pump, and engine controller. Evaluate options for scramjet start, including gas generator / heat exchanger system, barbotage fuel injection with plasma ignition, and silane injection with a mechanical throat or air throttle. Demonstrate flight weight scramjet start system through ground testing. Verify operation of engine control techniques, based on rapid shock train identification/characterization coupled with fuel control logic, to ensure stable scramjet operation.

(U) $1,376 Conduct assessments, system design trades, and simulations to integrate combined and advanced cycle airbreathing hypersonic propulsion technologies into future missiles, manned and unmanned air vehicles, and access to space concepts. The goal is to improve warfighting capability and meet Air Force Global Reach/Power needs. Conduct system trade studies to determine military payoff and establish component

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 3012

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

technology goals. Define component and engine performance objectives to enable development of affordable hypersonic flight demonstrators jointly with NASA and the Defense Advanced Research Projects Agency (DARPA).

(U) $3,030 Conduct proof-of-concept demonstrations of critical components for advanced and combined cycle engines. Design, fabricate, and test sub-scale inlet/combustor/nozzle to identify coupling between engine operating modes and investigate transition between modes. Design and fabricate components capable of withstanding severe temperature and acoustic environments, and demonstrate component structural integrity. Perform ground demonstration of flight-type scramjet engine operation and performance over a broad flight speed envelope.

(U) $2,100 Design flowpath for advanced and combined cycle engines to demonstrate operation and performance over a broad flight speed envelope. Initiate design of advanced and combined cycle engine components for incorporation into advanced and combined cycle demonstrator engines.

(U) $480 Develop plasma ignition system coupled with necessary power source, power conditioning, and control system to eliminate need to pre-heat fuel or use silane combustion aid. Investigate magnetohydrodynamic power generation and extraction from a hydrocarbon fueled scramjet flow path to provide energy for directed energy weapons and plasma generation for hypersonic vehicle drag reduction and scramjet combustion enhancement.

(U) $21,436 Total

(U) FY 2003 ($ in Thousands)

(U) $3,637 This project previously included space unique funding, which has been transferred to PE 0602500F, Project 5027. These funds represent the civilian salaries and in-house support for the work effort transferred and will be transferred at a later date.

(U) $3,637 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0601102F, Defense Research Sciences.

(U) PE 0602201F, Aerospace Flight Dynamics.

(U) PE 0602602F, Conventional Munitions.

(U) PE 0602702E, Tactical Technology.

(U) PE 0603211F, Aerospace Structures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 3012

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

(U) PE 0603216F, Aerospace Propulsion and Power Technology.

(U) PE 0603601F, Conventional Weapons Technology.

(U) Program is reported to/coordinated by the Joint Army/Navy/NASA/Air Force (JANNAF) Executive Committee.

(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 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602203F Aerospace Propulsion

PROJECT: 3048

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
3048 Fuels and Lubrication	8,501	12,549	15,060	16,009	16,201	15,513	14,847	Continuing	TBD

(U) A. Mission Description

This project develops improved fuels, lubricants, and combustion concepts for advanced turbine engines, scramjets, and combined cycle engines. Systems applications include missiles, aircraft, and hypersonic vehicles for space access. Fuels and lubricants for these engines must be thermally stable, cost-effective, and operate over a broad range of conditions. Analytical and experimental areas of emphasis include fuels and fuels logistics; advanced combustion and propulsion concepts; and lubricants, bearings, electromagnetic rotor, and oil-less engine technology. Note: In FY 2002, Congress added $3.0 million for Pulse Detonation Engines.

(U) FY 2001 ($ in Thousands)

(U) $2,298 Developed high thermal stability hydrocarbon fuels to provide higher heat capacity and operating temperatures and reduced pollutant emissions and signatures for aerospace systems. Evaluated a low-cost fuel additive in small-scale laboratory devices and a reduced scale fuel system simulator. This additive could increase JP-8 thermal stability by 225 degrees Fahrenheit and heat sink capacity by five-fold. Evaluated low-cost fuel additives in research scale combustors to reduce pollutant emissions (particulates) by 50% in aircraft engines.

(U) $2,839 Developed revolutionary combustion concepts for combined cycle engines and pulse detonation engines. Continued development of novel gas turbine combustor designs including inter-turbine burner. Continued optimization of Trapped Vortex Combustor for inclusion in high performance, low emissions gas turbine engine demonstrators. Conducted preliminary design of pulse detonation engine for military applications. Developed and tested multi-tube, high frequency, demonstrator pulse detonation engine to enable high-performance, low-cost propulsion. Demonstrated an inter-turbine burner concept at representative engine operating conditions. Demonstrated advanced optical diagnostic techniques for health monitoring and control of advanced military combustors.

(U) $2,586 Continued development of lubrication and diagnostic systems technologies to permit efficient high-speed rotation of turbine engine components. This technology includes conventional and advanced lubricants and mechanical systems such as magnetic levitation and solid and vapor lubrication for advanced engines with operating conditions that exceed the capabilities of conventional approaches. Emphasis is placed on demonstrating full-scale magnetic bearing hardware at engine conditions projected for advanced demonstrator engines. Continued maturation of small prototype diagnostic units for engine health monitoring based on evolving needs of near-term production and demonstrator engines.

(U) $778 Developed, formulated, and evaluated affordable advanced fuel additives using novel synthesis techniques, computational chemistry, and bench scale rigs to reduce particulate emissions (i.e., smoke and soot) by 70%, and increase JP-8 fuel high temperature stability to 900 degrees

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
PROJECT: 3048	

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

Fahrenheit and low temperature properties to -70 degrees Fahrenheit. The focus is on enhancing aircraft survivability and operating envelope, and reducing maintenance costs. Developed novel magnetic bearings and vapor phase lubrication concepts for advanced lubrication subsystems. Formulated models to simulate advanced lubrication system behavior.

(U) $8,501 Total

(U) FY 2002 ($ in Thousands)

(U) $1,940 Develop low-cost additive approaches to improve fuel properties needed for manned and unmanned systems. Approaches include flow improving additives for low temperature properties to enable replacement of specialty fuels with JP-8; thermal-oxidative and pyrolytic deposit-reducing additives to increase the temperature limit of JP-8 to 900 degrees Fahrenheit; and particulate reducing additives to reduce soot emissions and infrared signature from propulsion systems. Initiate development of a computer model based upon chemical structure-activity relationships for fuel additives design and performance modeling.

(U) $453 Study low-cost approaches to reduce fuel logistics footprint. Screen candidate technologies for fuel field diagnostic techniques. Define improvements in additive packages to reduce logistics footprint.

(U) $665 Examine hydrocarbon fuel behavior under conditions encountered in combined and advanced cycle engines for low-cost access to space. Determine fuel ignition and combustion properties deficiencies. Study high energy density fuels for combined cycle engine applications. Perform payoff analyses and configuration trade studies to define, focus, and evaluate research in common fuels for future military air and space vehicles. Develop modeling and simulation capability for thermal management systems for aerospace vehicles.

(U) $2,730 Develop and evaluate combustor and propulsion concepts for gas turbine, pulse detonation, and combined and advanced cycle engines for manned and unmanned systems. Complete optimization of the trapped vortex combustor for transition to demonstrator engines. Identify combustor designs to reduce emissions from gas turbine engines. Demonstrate a highly-swirled ultra-compact combustor for use as the main combustor of a gas turbine engine. Investigate non-traditional thermodynamic cycles and propulsion systems through modeling, simulation, and experimentation. Perform payoff analyses and configuration trade studies to define, focus, and evaluate propulsion technology research for revolutionary combustor and propulsion concepts. Continue the development of pulse detonation engine technology and evaluate performance using hydrocarbon fuel.

(U) $275 Develop advanced optical and electromechanical diagnostics techniques and devices for fuel systems. Develop revolutionary combustor and propulsion concepts. Investigate pollutant gaseous emissions and particulate formation mechanisms and mitigation techniques in combusting environments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 3048

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U)	$1,490	Conduct research to provide the Air Force with reliable and economical advanced lubricants. Develop advanced bearing and lubricants concepts, components, and materials for improved engine performance, affordability, and engine health monitoring. Perform payoff analyses and configuration trade studies to define, focus, and evaluate research in lubricants and mechanical systems for combined cycle engines.
(U)	$2,025	Develop advanced bearing concepts for small- and intermediate-sized turbine and rocket engine applications. Develop electromagnetic rotor support and power generation concepts, components, and materials for advanced, oil-less engines.
(U)	$2,971	Develop the technology to build an airbreathing Pulse Detonation Engine (PDE) for use in an unmanned air vehicle. PDEs offer potential for low-cost propulsion systems that can be applied to unmanned vehicles and eventually high-speed combined cycle engines. Fabricate and integrate key components of the PDE including the inlet, intake valve, fuel injector, initiator, controller, and thrust tube. Initiate development of PDE performance predictive models using experimental data.
(U)	$12,549	Total

(U) FY 2003 ($ in Thousands)

(U)	$2,400	Develop low-cost additive approaches to improve fuel properties needed for manned and unmanned systems. Approaches include flow improving additives for low temperature properties to enable replacement of specialty fuels with JP-8; thermal-oxidative and pyrolytic deposit-reducing additives to increase the temperature limit of JP-8 to 900 degrees Fahrenheit; and particulate reducing additives to reduce soot emissions and infrared signature from propulsion systems. Complete development of an initial computer model based upon chemical structure-activity relationships for fuel additives design and performance modeling.
(U)	$1,200	Study low-cost approaches to reduce fuel logistics footprint, including field additization of locally-available fuels to produce a JP-8-quality fuel. Define improvements in additive packages and fuel dispensing methods to reduce logistics footprint, including on-board fuel evaluation and additization. Screen candidate technologies for fuel field diagnostic techniques, including on-line quality assessment.
(U)	$1,560	Investigate hydrocarbon and other high energy density fuel behavior under conditions encountered in combined cycle engines for low-cost access to space. Continue analyses and configuration trade studies to define and evaluate common fuels for future aircraft and military vehicles. Assess additive approaches to improve thermal stability and ignition/combustion properties in reduced scale component testing.
(U)	$4,200	Continue development, testing, and evaluation of revolutionary combustor, and propulsion concepts for gas turbine, pulsed detonation, and combined and advanced cycle engines for missiles, manned and unmanned systems, and access to space. Perform modeling and simulation along with experiments to identify fuel additives and combustor designs to reduce emissions from gas turbine engines. Demonstrate a full-annular ultra-compact combustor at design operating conditions for use as an inter-turbine burner. Investigate non-traditional

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion / PROJECT: 3048

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

thermodynamic cycles for military propulsion systems through simulation/modeling and experimentation. Continue to perform payoff analyses and configuration trade studies to define, focus, and evaluate propulsion technology research for revolutionary combustor and propulsion concepts. Investigate inlet and nozzle configurations for a pulsed detonation engine and investigate incorporating pulsed detonation propulsion technology into gas turbine engines.

(U) $500 Develop and demonstrate optical and electromechanical diagnostic tools and sensors for application to revolutionary combustor and propulsion systems. Investigate pollutant emissions formation pathways through computational and experimental methods. Evaluate methods to reduce gaseous and particulate pollutant emissions from legacy and future gas turbine engines.

(U) $1,100 Develop reliable and economical advanced lubricants. Continue development, test, and qualification activities to provide the most reliable and economical advanced turbine engine lubricants to the Air Force. Develop and test advanced bearing and lubrication system concepts, components, and materials for improved engine performance, affordability, and engine health monitoring. Continue to perform payoff analyses and configuration trade studies to define, focus, and evaluate research in lubricants and mechanical systems for combined cycle engines. Perform field support activities for aviation lubrication technologies.

(U) $3,100 Develop advanced bearing concepts for small- and intermediate-sized turbine engine applications. Design, fabricate, and test electromagnetic rotor support and power generation concepts, components, and materials for advanced, oil-less engines, including demonstrators that are part of the Integrated High Performance Turbine Engine Technology program. Continue development and initiate testing of air and foil bearing technology for small- and intermediate-sized turbine engine applications. Initiate development of modeling and simulation capabilities to advance design, shorten development time, and reduce testing requirements for mechanical and electromagnetic rotor support and power generation systems. Commence advanced rotor support and power generation studies for Versatile Affordable Advanced Turbine Engine program requirements.

(U) $1,000 Develop thermal management concepts and analysis tools for long-range strike applications of varying speed classes. Conduct fuel trade studies to identify fuel options and capability shortfalls for long-range strike applications. Develop diagnostic approaches and sensors for control of fuel/thermal management systems across the flight envelope. Continue development of engine fuel system and thermal management components identified in Versatile Affordable Advanced Turbine Engine program.

(U) $15,060 Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE: February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 3048

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

(U) Related Activities:

(U) PE 0601102F, Defense Research Sciences.

(U) PE 0602805F, Dual Use Science and Technology.

(U) PE 0603216F, Aerospace Propulsion and Power 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.

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

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602203F Aerospace Propulsion

PROJECT: 3066

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
3066 Turbine Engine Technology	40,168	44,864	43,630	41,359	38,146	38,025	38,874	Continuing	TBD

Note: In FY 2002, the Hypersonic Technology Program work in this project will be transferred within this PE into Project 3012, in order to align projects with the Air Force Research Laboratory organization.

(U) A. Mission Description

The Turbine Engine Technology project develops technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. Analytical and experimental areas of emphasis are fans and compressors, high temperature combustors, turbines, internal flow systems, controls, exhaust systems, and structural design. This project supports the Integrated High Performance Turbine Engine Technology (IHPTET) program, a joint Department of Defense, National Aeronautics and Space Administration (NASA), and industry effort to focus turbine propulsion technology on national needs. The program also supports design activities for the next-generation turbine engine development effort, the Versatile, Affordable, Advanced Turbine Engine. Note: In FY 2002, Congress added $1.5 million for Engineering Tool Development Program and $2.3 million for Jet Engine Test Cells.

(U) FY 2001 ($ in Thousands)

(U) $26,308 Developed core engine components (compressors, combustors, and high-pressure turbines) for turbofan/turbojet engines for fighters, attack aircraft, bombers, and transports. These components provide aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Completed rig testing of a state-of-the-art four-stage compressor and delivered to core engine for complete environmental characterization. Completed compressor rig testing of a high response air valve for active stability control capability for increased stage loading, reduced stage count, and increased stall margin. Developed a reduced order model for intentional mistuning validation and initiate experimental validation. Fabricated the spar/shell turbine blade with enhanced internal convection and limited transpiration cooling technologies and three-dimensional features yielding reduced cooling air at higher design operating temperatures.

(U) $6,762 Developed turbine engine components (fans, low pressure turbines, engine controls, exhaust nozzles, and integration technology) for turbofan/turbojet engines for fighters, attack aircraft, bombers, and transports to provide aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Rig tested exhaust nozzle hardware capable of fluidic injection to delete the requirement for complex, heavy, expensive variable geometry exhaust systems. Fabricated contoured ceramic composite exhaust nozzle hardware. Performed elevated fuel temperature rig testing of the variable displacement vane pump, which eliminates fuel recirculation to tanks, thereby reducing thermal loading and allowing increased thermal capacity to be used elsewhere in the weapon system. Completed design of the non-linear control system, which simplifies control logic development and provides component performance trend data.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 3066

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

(U)	$3,673	Developed components for expendable engines for missile and unmanned air vehicle applications to provide expendable engines with reduced cost, reduced fuel consumption, and increased specific thrust, greatly expanding the operating envelopes of cruise missiles. Fabricated low-cost ceramic turbine blades yielding reduced need for cooling air and higher performance.
(U)	$1,776	Developed components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. Initiated rig testing of splittered, forward swept compressor rotor to validate high efficiency, high stage loading design, leading to engines with reduced fuel consumption, fewer parts, and lower production and maintenance.
(U)	$1,649	Designed, developed, and tested propulsion components to demonstrate performance and durability of advanced hypersonic propulsion concepts in support of Defense Advanced Research Projects Agency (DARPA) missile demonstration. Continued testing of scramjet engine components (e.g., inlet, combustor, and nozzle) capable of demonstrating positive thrust at Mach 4-8 while withstanding severe internal conditions.
(U)	$40,168	Total

(U) FY 2002 ($ in Thousands)

(U)	$28,179	Develop core turbine engine components (compressors, combustors, and high-pressure turbines) for turbofan/turbojet engines for fighters, attack aircraft, bombers, and transports. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycles costs. Design and fabricate a high-pressure ratio compressor including an active stability control system for reduced fuel burn, and high reaction blading and engine stall avoidance techniques for reduced maintenance costs. Develop improved performance, reduced emissions combustor technologies. Conduct analytical and experimental evaluations of combustor aerodynamics, fuel-air mixing, and liner cooling techniques. Develop affordable, robust, lightweight, and compact combustors such as the Integrated Lightweight Combustor or Trapped Vortex Combustor configurations. Conduct environmental and structural evaluation of spar/shell turbine blade with enhanced internal convection, limited transpiration cooling technologies, and three-dimensional features to reduce cooling air at high design operating temperatures. Rig test a non-contacting stress measurement system allowing durable measurement of vibratory response of rotating blades. This technology enables replacements for limited life strain gages, reducing core engine components development and maintenance costs.
(U)	$6,900	Develop turbine engine components (fans, low pressure turbines, engine controls, exhaust nozzles, and integration technology) for turbofan/turbojet engines for fighters, attack aircraft, bombers, and transports. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Validate the contoured ceramic composite exhaust

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 3066

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

nozzle hardware in a high temperature environment. Evaluate temperature, pressure, and vibration of integrated components in a demonstrator engine. Complete reliability testing of variable displacement vane pump system to eliminate fuel recirculation to tanks, reduce thermal loading, and increase weapon system thermal capacity. Complete fabrication of the non-linear control system to simplify control logic development and provide component performance trend data.

(U) $3,711 Develop components for limited life engines for missile and unmanned air vehicle applications. These components enable engines with reduced cost, reduced fuel consumption, and increased specific thrust, greatly expanding the operating envelopes of cruise missiles and unmanned vehicles. Rig test a composite forward swept fan for reduced weight, improved efficiency, and lower cost. Rig test low-cost ceramic turbine blades to reduce cooling air and enhance performance.

(U) $2,311 Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. Complete rig testing the splittered, forward swept compressor rotor to validate high efficiency, high stage loading design. The components enable engines with reduced fuel consumption and lower production and maintenance costs.

(U) $2,278 Upgrade jet engine compressor and turbine aerodynamic test cells to enable assessment of emerging Air Force jet engine technologies supporting fighter and bomber transformational requirements. Increase power capability to 6000 horse power and develop counter-rotating capability for these facilities.

(U) $1,485 Develop modeling and simulation tools to analyze and predict the performance of aerospace engines and their components. Improve analytical tools associated with aerospace engines with the main focus on high performance, long life, advanced cooling techniques, and combustion stability.

(U) $44,864 Total

(U) FY 2003 ($ in Thousands)

(U) $30,380 Develop core engine components (compressors, combustors, and high-pressure turbines) for turbofan/turbojet engines for fighters, attack aircraft, bombers, long-range strike/next generation bombers, and transports. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Perform testing on a high-pressure ratio compressor including an active stability control system for reduced fuel burn, and high reaction blading and engine stall avoidance techniques for reduced maintenance cost. Conduct testing on an active combustion control high response fuel valve to reduce acoustically coupled fatigue and enhance overall combustion efficiency resulting in fuel burn reduction. Complete subscale rotational intentional mistuning experiment and initiate application of methodology to transonic rig hardware. Modify the spar/shell turbine blade design system using component bench test

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 3066

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

results and transition this technology to engine demonstrator testing.

(U) $7,750 Develop turbine engine components (fans, low pressure turbines, engine controls, exhaust nozzles, and integration technology) for turbofan/turbojet engines for fighters, attack aircraft, bombers, long-range strike/next generation bombers, and transports. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Conduct testing of a non-linear control system to simplify control logic development and provide the component performance trend data necessary for transitioning this technology to the demonstrator engine program.

(U) $3,700 Develop components for limited life engines for missile and unmanned air vehicle applications. These components enable engines with reduced cost, reduced fuel consumption, and increased specific thrust, greatly expanding the operating envelopes of cruise missiles and unmanned vehicles. Conduct rig test of an enhanced fan flow control treatment for an all-composite, forward swept shrouded rotor. Design rub tolerant ceramic for an advanced turbine rotor blades.

(U) $1,800 Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. Conduct durability tests of Ceramic Matrix Composite materials under high temperature/high pressure/high moisture conditions to validate composite integrity and life models. Perform rig tests to demonstrate the feasibility of a very high fuel/air ratio combustor with supercritical fuel delivery system.

(U) $43,630 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Materials:
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602102F, Materials.
(U) PE 0603216F, Aerospace Propulsion and Power Technology.
(U) PE 0602122N, Aircraft Technology.
(U) PE 0603210N, Aircraft Propulsion.
(U) PE 0603003A, Aviation Advanced Technology.
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
PROJECT: 3066	

(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: 0602203F Aerospace Propulsion

PROJECT: 3145

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
3145 Aerospace Power Technology	26,727	27,376	26,890	27,831	28,090	28,688	29,266	Continuing	TBD

(U) A. Mission Description

This project develops techniques for efficient energy generation and storage for military ground, air, and space applications. Power component technologies are developed to increase reliability, maintainability, commonality, and supportability of aircraft and flight line equipment. Research in power storage technologies enables the 10-20 year long-term energy storage goals of Air Force unmanned vehicles. Electrical power generation and thermal management technologies are enabling for all future military directed energy weapon systems. This project supports development of very high output power systems suitable for applications to air moving target indication (AMTI) radar, high power lasers for air and space platforms, and orbiting/maneuvering vehicles. Lightweight power systems suitable for other space applications are also developed. Note: In FY 2002, Congress added $3.0 million for magnetic bearing cooling turbine; $1.0 million for Poly (p-phenylene-2,6-benzobisoxazole) (PBO) Membrane Fuel Cells; $1.0 million for lithium ion battery technology for aircraft, spacecraft, and handheld applications, and $1.0 million for lithium ion battery technology for solid state lasers.

(U) FY 2001 ($ in Thousands)

(U) $5,479 Developed power generation, conditioning, and distribution; energy storage; and thermal management component and subsystem technologies for manned and unmanned aircraft systems. These technologies improve aircraft self-sufficiency, reliability, maintainability, and supportability while reducing life cycle costs and enabling new capabilities. Continued development of high energy density lithium ion cell and maintenance free battery technology by testing cells and batteries to load profiles specified in performance requirements for aircraft.

(U) $8,633 Developed thermal management, energy storage, and power conditioning components, and subsystem technologies for air moving target indication radar, high power lasers for space platforms, and orbiting/maneuvering vehicles. Continued development of high energy density polycrystalline capacitors, high voltage/high power diamond switches, and distributed power for laser diodes to enable high power lasers on air and space platforms. Developed small-scale heat pipes for passive power electronics cooling for improved power density. Evaluated cycle life for long-term space applications of high energy density lithium ion cells and batteries.

(U) $470 Developed cryogenic power generation, high rate batteries, energy storage and power conditioning components, and system technologies with low volume displacement for delivery of high power for operation of directed energy weapons. Continued development of Yttrium Barium Copper Oxide coated conductors.

(U) $956 Designed, fabricated, and evaluated lithium ion cells for battery applications for high power military requirements such as pulse power weapons for space and aircraft, burst communication devices, and on-the-soldier weapons and communications equipment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 3145

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

(U)	$3,634	Continued development of turbomachinery incorporating magnetic bearings to provide augmented cooling and electrical power to Air Force systems. Designed and fabricated ground test turbomachinery equipment for aircraft application. Evaluated feasibility of magnetic bearings to meet directed energy weapon and Expeditionary Air Force ground support power applications.
(U)	$2,486	Developed the Poly(p-phenylene-2, 6-benzobisoxazole) (PBO) membrane for use in Proton Exchange Membrane direct methanol fuel cells. Characterized physical and electrochemical properties of the membranes.
(U)	$1,721	Modified the Variable Displacement Vane Pump (VDVP) design for test on an engine with commercial applications. Fabricated a VDVP design for advanced tactical aircraft applications and evaluated initial endurance and damage tolerance.
(U)	$3,348	Initiated concepts for an integrated vehicle-power-generation-weapon system. Initiated simulation and design of electrical components for magneto-hydrodynamic (MHD) and electro-magneto-hydrodynamic power systems to provide high power sources for hypersonic systems and directed energy weapons. Enables MHD pressure control of hypersonic engine inlet.
(U)	$26,727	Total

(U) FY 2002 ($ in Thousands)

(U)	$9,663	Develop power generation, conditioning, and distribution; energy storage; and thermal management component and subsystem technologies for manned and unmanned aircraft systems. These technologies improve aircraft self-sufficiency, reliability, maintainability, and supportability while reducing life cycle costs and enabling new capabilities. Fabricate and begin evaluation of advanced switched reluctance machine controllers. Initiate fabrication of Inverter Converter Controller to demonstrate power denisty improvements. Continue development of high energy density lithium ion cell and maintenance free battery technology by testing cells and batteries to load profiles specified in performance requirements for aircraft. Initiate development of lithium polymer cells. Complete design of low-cost, long duration fuel cells for unmanned air vehicle systems. Develop and test magnetic materials for high temperature generator and magnetic bearing aircraft applications.
(U)	$6,236	Develop thermal management, energy storage and power conditioning components, and subsystem technologies for space applications. Fabricate an integrated Power Management and Distribution system for space-based distributed power systems that are half the weight and volume of conventional approaches. Demonstrate radiation-hardened power semiconductor device. Continue development of high energy density polycrystalline capacitors, high voltage/high power diamond switches, and distributed power for laser diodes to enable the use of high power lasers on air and space platforms. Test cycle life of high energy density lithium ion cells and batteries for long-term space applications. Evaluate mechanical pumped-loop for higher power spacecraft. Continue work on active two-phase thermal management technologies.
(U)	$5,534	Develop cryogenic power generation, high rate batteries, energy storage and power conditioning components, and system technologies with

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE: February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 3145

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

low volume displacement. These technologies enable delivery of high power for operation of directed energy weapons. Complete designing high density power conditioning for directed energy weapon systems. Develop high rate (pulse power) Lithium Ion batteries. Begin development of a thermal management system for cryogenic generator applications.

(U) $2,970 Develop and demonstrate magnetic bearings for cooling turbine/power generation systems. Magnetic bearings provide increased cooling package reliability and longer life cycles over conventional turbine systems with rolling element bearings or air bearings. This task optimizes the controls for an integrated cooling turbine-generator trim load and advanced magnetic bearing cooling turbine systems.

(U) $991 Develop Poly(p-phenylene-2, 6-benzobisoxazole) (PBO)-based membrane fuel cells. PBO membrane fuel cells offer a lower cost, lighter weight, higher performance, and more energy efficient fuel cell over existing proton exchange membrane fuel cells. Initiate design and fabrication for a prototype PBO-based membrane in a single cell configuration.

(U) $991 Develop large ampere-hour rechargeable lithium-ion cell battery technology for future spacecraft and aircraft. Lithium-ion batteries offer advantages over conventional systems by storing the same amount of energy at one-fourth the weight. Potential applications for rechargeable lithium-ion batteries include satellite energy storage, manned and unmanned aircraft, planetary orbiters, and ground support equipment. Initiate development of large ampere-hour cells that address cycle life technical issues for aircraft and Low Earth Orbit space applications and also address calendar life technical issues paramount for Geosynchronous Earth Orbit applications.

(U) $991 Develop high pulse power rechargeable lithium-ion cell battery technology that maximizes current capacity under high discharge rates required for solid state lasers. Potential high power military applications could include pulse power weapons for spacecraft and aircraft. This effort will focus on proper design and fabrication techniques beginning with relatively small ampere-hour cells.

(U) $27,376 Total

(U) FY 2003 ($ in Thousands)

(U) $9,850 Develop power generation, conditioning, and distribution; energy storage; and thermal management component and subsystem technologies for manned and unmanned aircraft systems. These technologies improve aircraft self-sufficiency, reliability, maintainability, and supportability while reducing life cycle costs and enabling new capabilities. Conduct testing of advanced switched reluctance machine controllers. Fabricate and conduct tests on full-scale lithium ion batteries and fuel cells for manned and unmanned vehicles. Continue development of lithium polymer cells.

(U) $5,340 Develop thermal management, energy storage and power conditioning components, and subsystem technologies for aerospace applications. Test and demonstrate an integrated Power Management and Distribution system for space-based distributed power systems that are half the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
PROJECT: 3145	

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

weight and volume of conventional approaches. Fabricate and test full-scale lithium-ion batteries for aerospace spacecraft applications.

(U) $9,700 Develop cryogenic power generation, high rate batteries, energy storage and power conditioning components, and system technologies with low volume displacement. These technologies enable delivery of high power for operation of directed energy weapons. Fabricate and test high density power conditioning for directed energy weapon systems. Continue developing high rate (pulse power) lithium ion batteries. Initiate testing of a thermal management system with Yttrium Barium Copper Oxide coated wire and coils for cryogenic generator applications.

(U) $2,000 Develop high density electrical power system and thermal management technologies for a next generation aerospace long-range strike vehicle. Develop power and thermal requirements for a long-range strike aircraft incorporating advanced weapon systems and initiate compact high power conditioning, energy storage, and thermal management component designs that optimize secondary power system size, weight, and efficiency.

(U) $26,890 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602102F, Aerospace Flight Dynamics.
(U) PE 0602605F, Directed Energy Technology.
(U) PE 0602805F, Dual Use Science and Technology.
(U) PE 0603205, Flight Vehicle Technology.
(U) PE 0603605F, Advanced Weapon Technology.
(U) PE 0603216F, Aerospace Propulsion and Power 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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE: February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 3145

(U) E. Schedule Profile Continued

(U) Not Applicable.

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

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602203F Aerospace Propulsion

PROJECT: 4847

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
4847 Rocket Propulsion Technology	68,959	72,260	18,442	18,865	19,214	19,545	20,049	Continuing	TBD

Note: In FY 2003, space unique tasks in this project will be transferred to PE 0602500F, Project 5026, in conjunction with the Space Commission recommendation to consolidate all space-unique activities.

(U) A. Mission Description

This project develops advances in rocket technologies for space access, maneuver, and for tactical and strategic missiles. Analytical and experimental areas of emphasis are propellants, combustion, rocket materials, strategic sustainment, and novel space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of future space and missile launch sub-systems. Technologies are developed to reduce the weight and cost of components using new materials, and improved designs and manufacturing techniques. All efforts in this project are part of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program, a joint Department of Defense, National Aeronautics and Space Administration (NASA), and industry effort to focus rocket propulsion technology on national needs. Note: In FY 2002, Congress added $7.1 million for the Integrated High Payoff Rocket Propulsion Technology Program and $10.7 million for upgrading Air Force Research Laboratory Test Stands at Edwards Air Force Base.

(U) FY 2001 ($ in Thousands)

(U) $4,433 Developed high-energy density and non-toxic propellants for increased space launch payload capability. Refined production of lab-scale quantities of high-energy density propellants with additives at desired concentrations in preparation for scale-up to maximize future propulsion system performance. Scaled-up selected propellants for testing and evaluation. Continued to develop, characterize, and model new and advanced propellants for scale-up and testing. Optimized synthetic routes for polymer binders and fuel formulations with specific impulse (Isp) exceeding that available from current systems. Developed high-energy oxidizer formulations for combustion with high-energy fuels to yield greatly enhanced performance. Continued research in the area of low-cost, non-toxic mono-propellants for current and future launch systems. Characterized, studied, and evaluated selected propellants in advanced combustion devices to determine compatibility and performance. Developed and characterized advanced propellants for use in revolutionary launch and spacecraft propulsions systems. Provided technical expertise for the continued use of energetic chemical rocket propellants in existing rocket propulsion systems.

(U) $2,793 Developed advanced liquid engine combustion technology for improved performance while preserving chamber lifetime and reliability needs for engines used in heavy lift space vehicles. Continued to characterize, study/evaluate injector performance with application to combustor chamber/injector compatibility to prevent damage to test and operational combustion devices; continued to support commercially developed injectors using unique Air Force test facilities. Developed, analyzed, and modeled advanced combustion devices and injectors that are

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion / PROJECT: 4847

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

compatible with new energetic propellants. Developed and evaluated through analysis and modeling advanced/revolutionary propulsion concepts with enhanced performance and reliability.

(U) $5,111 Continued to develop advanced material technology for lightweight components and material property enhancements for use in launch and space systems. Developed advanced ablative components using hybrid polymers for use in current and future launch systems Characterized and developed new high temperature polymers and carbon-carbon materials for use in advanced combustion devices and advanced propulsion systems, for lower weight and increased strength requirements. Developed advanced materials for use with high-energy propellants. Transitioned advanced high temperature materials to the commercial industry and Air Force systems for reduced system weight/cost and increased performance.

(U) $2,092 Continued the development of analytical tools for prediction of propellant life. Continued the transition to industry the tools and techniques used to determine the age life of strategic systems and other solid rocket motors.

(U) $18,735 Continued to develop propulsion component technology for reliable, safe, and low-cost boost and orbit transfer systems. Continued to develop design and processing techniques for high-strength, low-weight engine and motor components (metals and non-metals). Continued development of advanced lightweight rocket engine nozzle for upper stage and space booster applications. Initiated development of a low-cost, high discharge pressure turbopump for advanced cryogenic engines. Continued to develop liquid oxidizer for hybrid propulsion technologies for space boosters and air launched missiles. Continued developing and demonstrating advanced materials for rocket engine components and continue to develop turbomachinery, combustion devices, and propellant management devices for solid and liquid rockets. Continued development of high temperature oxygen rich turbine materials for applications to oxidizer rich turbomachinery. Continued application of advanced Aluminum Metal Matrix Composite Materials to rocket turbomachinery housings and rocket structural hardware. Continued characterizing new refractory combustion materials and devices to apply to liquid-propellant rocket engines with dramatic weight reductions. Verified performance and weight improvements of rapid densification nozzle technology using improved strategic propellants for future ballistic missiles. Continued to demonstrate low-cost, high temperature, non-erosive, lightweight coated carbon-carbon ceramic and hybrid polymer components for solid rocket space boosters and missiles. Fabricated and tested advanced lightweight rocket engine nozzle for upper stage and space booster applications. Continued characterizing new refractory combustion materials and devices to apply to liquid-propellant rocket engines with dramatic weight reductions. Continued to develop and characterize components applicable to liquid propulsion (cryogenic and storable). Initiated feasibility studies concerning rocket based combined cycle engines.

(U) $6,975 Continued development of missile propulsion technology, aging and surveillance technology, and Post Boost Control Systems (PBCS) for sustainment of current Intercontinental Ballistic Missile fleet. Completed development of compatible case/liner, insulator, and case systems for

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 4847

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

higher combustion temperature propellants. Completed design and begin fabrication of solid rocket motor test hardware. Initiated a project to develop an advanced lightweight solid rocket motor. Continued development of tools to increase the capability to determine the service life of strategic systems and other solid rocket motors. Completed the development of the advanced PBCS. Continued to develop technologies that are readily available over the life of strategic systems, which may also be potentially advantageous to the development of the next generation strategic systems.

(U) $5,120 Continued developing solar electric and solar thermal propulsion technologies for stationkeeping, repositioning, and orbit transfer for large communication satellites and satellite constellations. Continued Hall thruster development efforts to meet Air Force need for orbit transfers using electric propulsion. Continued development of propulsion systems, including pulsed plasma thrusters, for microsatellites (< 25 kg) needed for advanced Air Force imaging missions. Continued developing solar thrusters and concentrators for future orbital transfer vehicles. Performed preliminary characterization of concentrator surface roughness. Fabricated an advanced solar thermal thruster and integrate with an inflatable concentrator. Began development of an electrically controlled solid propellant.

(U) $12,600 Upgraded and activated rocket engine test stand to enable system level research and test capabilities for new and existing rocket engines. Upgraded test stand for liquid oxygen/kerosene engine research. Prepared test stand to support Integrated High Payoff Rocket Propulsion Technology hydrocarbon boost engine test.

(U) $11,100 Upgraded and activated rocket component test stand 2A at Edwards Air Force Base, California, to support component level research of advanced rocket propulsion systems. Installed high-pressure piping and data acquisition system components.

(U) $68,959 Total

(U) FY 2002 ($ in Thousands)

(U) $5,122 Develop, characterize, and test strained-ring, unsaturated hydrocarbons and energetic, reduced-toxicity monopropellants to increase space launch payload capability. Refine synthesis methods of new propellants to facilitate the transition from producing lab-scale quantities to producing sufficient material to meet operational requirements. Continue scale up of selected propellants for laboratory and demonstrator engine evaluations. Develop high-energy-density oxidizers and polymeric binders (i.e., linked heterocyclic compounds), and optimize paths for incorporating these materials into propellants with significantly enhanced performance. Continue evaluating the potential of monopropellants comprised of reduced-toxicity ionic salts to reduce the cost of space access and space operations. The goal is monopropellants with performance equivalent to bipropellants. Continue to evaluate selected propellants in advanced combustion devices to determine materials compatibility and performance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 4847

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U) $2,475 Develop advanced liquid engine combustion technology to improve performance while preserving chamber lifetime and reliability in heavy lift space vehicle engines. Continue to characterize, study, and evaluate injector performance to ensure chamber/injector compatibility and prevent damage to test and operational combustion devices. Continue to develop, analyze, and model advanced combustion devices and injectors compatible with new energetic propellants. Continue to model and analyze advanced propulsion concepts with enhanced performance and reliability such as laser-propelled lightcraft and rocket-based combined cycle engines.

(U) $3,036 Develop advanced technologies and material property enhancements for lightweight components for use in launch and space systems. Develop advanced ablative components using hybrid polymers for use in current and future launch systems Continue to characterize and develop new high temperature polymers and carbon-carbon materials for use in advanced combustion devices and propulsion systems to meet lower weight and increased strength requirements. Continue to develop advanced materials for use with high-energy propellants. Complete and transition advanced high temperature materials to Air Force systems to reduce system weight and cost, and increase performance.

(U) $12,600 Develop propulsion component technology for reliable, safe, and low-cost boost and orbit transfer systems. Complete development of advanced lightweight rocket engine nozzle for upper stage and space booster applications. Continue development of a low-cost, high discharge pressure turbopump for advanced cryogenic engines. Develop components for hybrid propulsion for space boosters and air-launched missiles. Continue to develop turbomachinery, combustion, and propellant management devices for solid and liquid rockets. Continue developing high temperature turbine materials for oxidizer rich applications. Continue developing advanced lightweight rocket engine nozzles for upper stage and space booster applications. Verify performance and weight improvements of rapid densification nozzle technology using improved strategic propellants for future ballistic missiles. Continue to demonstrate low-cost, high temperature, non-erosive, lightweight coated carbon-carbon ceramic and hybrid polymer components for solid rocket motors. Develop new fuels and oxidizers for advanced solid propulsion.

(U) $7,038 Develop missile propulsion technology, aging and surveillance technology, and Post Boost Control Systems for sustainment of current Intercontinental Ballistic Missile fleet. Continue to develop an advanced lightweight solid rocket motor. Complete development of tools to enhance the capability to determine the service life of strategic systems and other solid rocket motors. Begin full-scale testing of the advanced Post Boost Control Systems. Complete efforts for prediction of solid motor life and transition into damage assessment models.

(U) $7,375 Develop solar electric and thermal propulsion technologies for stationkeeping, repositioning, and orbit transfer for large communication satellites and satellite constellations. Continue Hall thruster development efforts to achieve Air Force orbit transfers using electric propulsion. Continue development of microsatellites (< 25 kg) propulsion systems (e.g., plasma thrusters) for advanced imaging missions. Continue developing solar thrusters and concentrators for future orbital transfer vehicles. Evaluate electrically controlled solid propellant. Design high

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE: February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 4847

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

power solar thermal components

(U) $11,985 Develop materials and processes to dramatically improve performance, durability, and cost of rocket propulsion systems. Evaluate new candidate materials for rocket engines such as Metal Matrix Composites, Discontinually Reinforced Materials, Ceramics, Ceramic Metallics, and Advanced Composites for use in liquid oxygen, liquid hydrogen, high-temperature, and high-pressure environments. Identify and evaluate the applications of these materials to turbopump housings, ducts, valves, solid rocket casings, insulation, and nozzle throats. Develop material property databases and initiate demonstration of suitability for application using representative geometry and processing conditions for the intended rocket engine components.

(U) $5,000 Develop rocket component of a hydrocarbon fueled rocket based combined/combination cycle engine for rapid acess to space. Initiate studies to establish optimum propulsion cycle and operating conditions. Initiate detailed design of high pressure turbopumps for hydrocarbon propellants. Initiate hydrocarbon thrust chamber design, focusing on affordable, lightweight materials and propellants to provide optimal heat transfer. Evaluate rocket engine health management and prognostic systems. Initiate scale-up and testing of new high density strained-ring hydrocarbon propellants. Evaluate combustion and thermal stability properties of select new hydrocarbon propellants. Produce sufficient quantities of propellants for 100-200 lb thrust level rocket engine demonstrations.

(U) $7,032 Conduct risk reduction efforts on the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program. This includes adding an alternate, high temperature material into the hot gas valve for development and testing of lower cost, higher performance Post Boost Control System propulsion materials, a key portion of the Technology for the Sustainment of Strategic Systems program. Conduct solid and liquid propellant synthesis and scale-up critical for meeting IHPRPT goals to significantly reduce cost-per-pound of payload to orbit for space launch applications. Conduct interim demonstrations of subsystems (propellant, case, nozzle, and insulation) for missile propulsion demonstration programs. Conduct demonstration of new monopropellant solution for spacecraft applications such as the TechSat 21 flight experiment.

(U) $10,597 Complete refurbishment and modernization of a large liquid rocket engine test stand and a component test stand to meet increased demand for liquid rocket test capability at Edwards Air Force Base. Perform modifications necessary to accommodate multiple users and broader capability on Test Stand 1D. Provide increased capability on Test Stand 2A for high pressure fluid storage and more test configurations.

(U) $72,260 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2002
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 4847

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$18,442	This project previously included space unique funding which has been transferred to PE 0602500F, Project 5026. These funds represent the civilian salaries for the work effort transferred and will be transferred at a later date.
(U)	$18,442	Total

(U) B. Project Change Summary

Not applicable.

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

(U) Related Activities:
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602114N, Power Projection Applied Research.
(U) PE 0602303A, Missile Technology.
(U) PE 0602805F, Dual Use Science and Technology.
(U) PE 0603302F, Space and Missile Launch Technology.
(U) PE 0603311F, Ballistic Missile Technology.
(U) PE 0603401F, Advanced Spacecraft 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.