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

DATE: February 2003

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602203F Aerospace Propulsion

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	174,292	132,285	101,575	88,859	100,434	109,747	106,982	107,881	Continuing	TBD
3012	Advanced Propulsion Technology	18,435	3,454	13,907	8,009	15,354	20,529	18,829	18,003	Continuing	TBD
3048	Fuels and Lubrication	12,380	17,304	13,754	13,341	14,873	17,134	13,530	13,828	Continuing	TBD
3066	Turbine Engine Technology	46,144	41,496	36,846	32,983	33,189	32,857	35,644	36,438	Continuing	TBD
3145	Aerospace Power Technology	26,726	34,508	22,763	22,841	23,905	23,309	26,921	27,521	Continuing	TBD
4847	Rocket Propulsion Technology	70,607	35,523	14,305	11,685	13,113	15,918	12,058	12,091	Continuing	TBD
	Quantity of RDT&E Articles	0	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 were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities. In Project 4847, space unique includes all Integrated High Payoff Rocket Propulsion Technology activities except Technology for the Sustainment of Strategic Systems and tactical missiles.

(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. The Turbine Engine Technology project develops enabling capabilities to enhance performance and affordability of existing weapon systems. Efforts in this project are part of the Integrated High Performance Turbine Engine Technology and the Versatile Affordable Advanced Turbine Engine programs. The Rocket Propulsion Technology project pursues advances in rocket technologies for space access, space maneuver, and tactical and strategic missiles. Efforts in this project are part of the Integrated High Payoff Rocket Propulsion Technology program to include Technology for the Sustainment Systems. The Aerospace Power project develops efficient energy storage, power generation, and thermal management techniques for ground, air, and space military applications. The Fuels and Lubrication project develops new concepts and technologies to power, cool, and lubricate new and existing engines and directly supports the Integrated High Performance Turbine Engine Technology and the Versatile Affordable Advanced Turbine Engine programs. Finally, the Advanced Propulsion

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion

(U) A. Mission Description Continued

Technology of the Hypersonics Pillar of DDR&E's National Aerospace Initiative (NAI) to include combined cycle, ramjet, and hypersonic scramjet technologies to enable revolutionary propulsion capability for the Air Force. Note: In FY 2003, Congress added $3.0 million for Pulse Detonation Engines; $1.5 million for High Power Advanced Low Mass; $4.0 million for Lithium-ion Battery Development; $2.5 million for PBO Membrane for Advanced/High Performance Fuel Cells; $1.0 million for Unmanned Combat Air Vehicles Integrated Starter Generator; $2.5 million for Advanced Vehicle and Propulsion Center; $7.7 million for Cryo Installation for Jet and Rocket Engine Test Site; $5.7 million for DERF-Sustainment of Strategic Systems; and $2.3 million for Reusable Launch Vehicle Technology.

(U) B. Budget Activity Justification

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

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	178,485	107,659	118,958	
(U)	Appropriated Value	179,811	137,859		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-1,326	-4,915		
	b. Small Business Innovative Research	-3,337			
	c. Omnibus or Other Above Threshold Reprogram		-659		
	d. Below Threshold Reprogram	-6			
	e. Rescissions	-850			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-17,383	
(U)	Current Budget Submit/FY 2004 PBR	174,292	132,285	101,575	TBD

(U) Significant Program Changes:

FY 2004 decreases are primarily due to civilian salaries for space-related activities that were transferred to the new space unique PE 0602500F. Outyear funding for the NAI hypersonic activity will be addressed in the FY05 President's Budget Development.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 3012

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
3012 Advanced Propulsion Technology	18,435	3,454	13,907	8,009	15,354	20,529	18,829	18,003	Continuing	TBD

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 this project in order to align projects with the Air Force Research Laboratory organization. In FY 2003, space unique tasks in this project were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project develops combined/advanced cycle airbreathing high-speed (up to Mach 4) and hypersonic (Mach 4 to 8+) propulsion technologies to enable revolutionary propulsion options for the Air Force. These new engine technologies will enable future high-speed/hypersonic weapons and aircraft 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 DoD and NASA. Efforts include modeling and simulation, proof of concept demonstrations of critical components, advanced component development, and ground-based demonstrations.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $11,785 Demonstrated advanced hydrocarbon scramjet engine technology to enable fuller dominance of space. Conducted detailed analysis for mating scramjet a flight ready engine with flight demonstrator vehicle. Performed trajectory optimization for flight test. Completed design and component development. Initiated fabrication of a flight-ready hydrocarbon fueled scramjet engine, including flight weight fuel cooled structures, flight weight fuel control valves, fuel pump, and engine controller. Evaluated 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. Demonstrated flight weight scramjet start system through ground testing. Verified operation of engine control techniques, based on rapid shock train identification/characterization coupled with fuel control logic, to ensure stable scramjet operation.

(U) $1,200 Conducted 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 capabilities and to meet Air Force Global Reach/Power needs. Conducted system trade studies to determine military payoff and establish component technology goals. Defined component and engine performance objectives to enable development of affordable hypersonic flight demonstrators jointly with NASA and the Defense Advanced Research Projects Agency.

(U) $3,000 Conducted proof-of-concept demonstrations of critical components for advanced and combined cycle engines. Designed, fabricated, and tested sub-scale inlet/combustor/nozzle to identify coupling between engine operating modes and to investigate the transition between modes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
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

Designed and fabricated components capable of withstanding severe temperature and acoustic environments, and demonstrated component structural integrity. Performed ground demonstration of flight-type scramjet engine operation and performance over a broad flight speed envelope.

(U) $2,000 Designed flowpath for advanced and combined cycle engines to demonstrate operation and performance over a broad flight speed envelope. Initiated design of advanced and combined cycle engine components for incorporation into advanced and combined cycle demonstrator engines.

(U) $450 Developed a plasma ignition system coupled with the necessary power source, power conditioning, and control system to eliminate the need to pre-heat fuel or use a silane combustion aid. Investigated 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) $18,435 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $3,454 This project previously included space unique funding, which will be transferred to PE 0602500F, Project 5027. These funds represent the civilian salaries and in-house support for the work effort transferred.

(U) $3,454 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $13,339 Develop advanced hydrocarbon scramjet engine technologies to enable the broad application of hypersonics to meet future warfighter needs and to support flight demonstration consistent with that defined in the High Speed - Hypersonics planning Pillar of the NAI. Develop flight weight engine components including flight weight fuel control valves, fuel pumps, and engine controllers. Fabricate a flight engine consisting of three scramjet engine modules for the joint Air Force and NASA X-43C flight experiment. Evaluate options for scramjet start, including a gas generator/heat exchanger system and coast heating. Verify operation of engine control techniques based on rapid shock train identification and characterization coupled with fuel control logic to ensure stable engine operation. Conduct detailed analysis for mating scramjet flight engines with demonstrator vehicles. Perform trajectory optimization for flight test. Complete preliminary engine design. Complete development of flight weight engine components including 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. Verify operation of engine control techniques, based on rapid shock train identification/characterization coupled with fuel control logic,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
PROJECT: 3012	

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

to ensure stable scramjet operation. Initiate ground testing of the X-43C flight clearance engine. Conduct detailed analysis for mating a scramjet flight engine with the flight demonstrator vehicle. Perform trajectory optimization for flight test.

(U) $568 Conduct assessments, system design trades, and simulations to integrate combined and advanced cycle airbreathing hypersonic propulsion technologies into future missiles, and manned and unmanned aerospace vehicle concepts. Conduct system trade studies to determine military payoff and establish component 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.

(U) $13,907 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.
(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 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion		PROJECT: 3048

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
3048 Fuels and Lubrication	12,380	17,304	13,754	13,341	14,873	17,134	13,530	13,828	Continuing	TBD

(U) A. Mission Description

This project develops improved fuels, lubricants, and combustion concepts for advanced turbine engines, scramjets, pulse detonation, and combined cycle engines. Systems applications include missiles, aircraft, and hypersonic vehicles. Analytical and experimental areas of emphasis include fuels and fuels logistics, lubricants, bearings, electromagnetic rotor, oil-less engine technology, optical diagnostics, and fundamental combustion. Fuels and lubricants for these engines must be thermally stable, cost-effective, and operate over a broad range of conditions. Advanced combustion concepts must be cost effective, durable, and reduce pollutant emissions.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $1,880 Developed low-cost additive approaches to improve fuel properties needed for manned and unmanned systems. Approaches included 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. Initiated development of a computer model based upon chemical structure-activity relationships for fuel additives design and performance modeling.

(U) $450 Studied low-cost approaches to reduce fuel logistics footprint. Screened candidate technologies for fuel field diagnostic techniques. Defined improvements in additive packages to reduce logistics footprint.

(U) $660 Examined hydrocarbon fuel behavior under conditions encountered in combined and advanced cycle engines for low-cost access to space. Determined fuel ignition and combustion property deficiencies. Studied high energy density fuels for combined cycle engine applications. Performed payoff analyses and configuration trade studies to define, focus, and evaluate research in common fuels for future military air and space vehicles. Developed modeling and simulation capability for thermal management systems for aerospace vehicles.

(U) $2,680 Developed and evaluated combustor and propulsion concepts for gas turbine, pulse detonation, and combined and advanced cycle engines for manned and unmanned systems. Completed optimization of the trapped vortex combustor for transition to demonstrator engines. Identified combustor designs to reduce emissions from gas turbine engines. Demonstrated a highly-swirled ultra-compact combustor for use as the main combustor of a gas turbine engine. Investigated non-traditional thermodynamic cycles and propulsion systems through modeling, simulation, and experimentation. Performed payoff analyses and configuration trade studies to define, focus, and evaluate propulsion technology research for revolutionary combustor and propulsion concepts. Continued the development of pulse detonation engine technology and evaluated the performance using hydrocarbon fuel.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
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)	$275	Developed advanced optical and electromechanical diagnostics techniques and devices for fuel systems. Developed revolutionary combustor and propulsion concepts. Investigated pollutant gaseous emissions and particulate formation mechanisms and mitigation techniques in combusting environments.
(U)	$1,484	Conducted research to provide the Air Force with reliable and economical advanced lubricants. Developed and explored advanced bearing and lubricants concepts, components, and materials for improved engine performance, affordability, and engine health monitoring. Performed payoff analyses and configuration trade studies to define, focus, and evaluate research in lubricants and mechanical systems for combined cycle engines.
(U)	$2,000	Developed and explored advanced bearing concepts for small- and intermediate-sized turbine and rocket engine applications. Developed electromagnetic rotor support and power generation concepts, components, and materials for advanced, oil-less engines.
(U)	$2,951	Developed the technology base to build an airbreathing Pulse Detonation Engine for use in an unmanned air vehicle. Pulse Detonation Engines offer potential for low-cost propulsion systems that can be applied to unmanned vehicles and eventually to high-speed combined cycle engines. Initiated the design of key components of the Pulse Detonation Engine including the inlet, intake valve, fuel injector, initiator, controller, and thrust tube. Initiated development of Pulse Detonation Engine performance predictive models using experimental data.
(U)	$12,380	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Programs
(U)	$2,327	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 signatures from propulsion systems. Complete development of an initial computer model based upon chemical structure-activity relationships for fuel additives design and performance modeling.
(U)	$1,128	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 assessments.
(U)	$1,467	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)	$4,020	Continue development, testing, and evaluation of revolutionary combustor, and propulsion concepts for gas turbine, pulsed detonation, and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
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

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 an ultra-compact combustor at design operating conditions for use as an inter-turbine burner. Investigate non-traditional 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 technologies into gas turbine engines.

(U) $475 Develop and demonstrate optical, electromechanical, and laser 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. Initiate evaluation of high intensity laser light interaction with matter.

(U) $1,084 Develop reliable and economical advanced lubricants. Continue development, test, and qualification activities to provide the most reliable and economical advanced turbine engine lubricants for 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) $2,915 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) $940 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 the Versatile Affordable Advanced Turbine Engine program.

(U) $2,948 Establish a design database relevant to the aerothermal and structural design of pulse detonation engines . Continue the design of key

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
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

components to include the inlet, intake valve, fuel injector, detonation initiator, controller, and thrust tube for an airbreathing PDE for use in subsonic and supersonic unmanned air vehicles. Pulse Detonation Engines offer potential for low-cost propulsion systems that can be applied to unmanned vehicles and high-speed combined cycle engines. Perform ground demonstration testing of some of the key components and continue development of Pulse Detonation Engine performance predictive models using experimental data.

(U) $17,304 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $1,858 Continue to develop affordable additive and fuel system approaches to improve fuel properties and to expand the flight envelope for manned and unmanned aircraft systems. Develop approaches to increase JP-8 temperature capability to 900 degrees Fahrenheit, including thermal stability additives, fuel deoxygenation, and improved coatings. Complete development of additive packages to enable JP-8 to achieve jet propulsion thermally stable low temperature (high altitude) performance. Enhance existing fuel modeling and simulation capabilities by incorporation of more realistic additive performance models.

(U) $1,061 Continue to evaluate low-cost approaches to reduce fuel logistics footprints, including field and on-board additive injections. Continue to develop improvements to existing fuel additive packages to simplify logistics and reduce cost. Assess performance of fuels from alternative (non-petroleum) sources, including Fischer-Tropsch fuels. Test candidate technologies for field-fuel quality diagnostics and sensors. Continue investigation of biological contamination in fuels.

(U) $1,026 Develop advanced additive approaches to reduce engine emissions and signature, including biotechnology, molecular imprinting, and nano-scale reactivity enhancement. Verify additive performance in laboratory-scale combustion tests. Develop improved diagnostics for sub-micron scale particulate emissions from combustors.

(U) $482 Continue to assess suitability of fuels for advanced and combined cycle vehicle applications for high-speed aerospace vehicles. Develop fuel property and performance data for industry and Government use in selecting alternative hydrocarbon fuels, in support of Integrated High Payoff Rocket Propulsion Technology hydrocarbon booster engine development efforts. Investigate approaches to assess fuel thermal stability under high heat flux conditions relevant to advanced rockets and combined cycle engines.

(U) $900 Develop approaches to extend the life of endothermic fuels and fuel system components for reusable hypersonic applications. Develop approaches to improve fuel heat sink capability. Develop structural approaches to minimize regenerative cooling heat loads absorbed by endothermic fuel systems. Develop approaches to improve fuel combustion performance, especially during cold start and cycle transition. Improve fuel system modeling and simulation tools to better simulate endothermic fuel behavior.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 3048

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$3,291	Develop, test, and evaluate revolutionary combustor and propulsion concepts for gas turbine, pulsed detonation, and combined-cycle engines for missiles, manned, and unmanned systems. Evaluate the inter-turbine burner combustor at conditions that simulate turbine-wake and turbine-inlet interactions. Perform experiments to validate the high-speed performance of a pure pulsed detonation engine. Investigate the performance of a rudimentary combined-cycle pulsed-detonation engine and evaluate the technical issues associated with incorporating pulsed detonation propulsion technology into gas turbine engines. Perform experiments to evaluate promising fuel additives used to reduce particulates and emissions from gas turbine engines.
(U)	$833	Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary combustor and propulsion systems. Develop and demonstrate sensors for the control of combustor performance and extension of component life. Investigate pollutant emission formation pathways through computational and experimental methods and evaluate methods to reduce gaseous and particulate pollutant emission from legacy and future gas turbine engines. Continue investigation of high intensity laser light interaction with matter.
(U)	$1,799	Continue development, test, and qualification activities to provide the most reliable and affordable advanced turbine engine lubricants for Department of Defense (DoD) and commercial users. Continue development and testing of advanced bearing and lubrication system 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 man-rated, expendable, and uninhabited air vehicle turbine engines. Perform field support activities for aviation lubrication technologies and to support DoD operational units.
(U)	$2,504	Continue development of advanced bearing concepts for small-and intermediate-sized turbine engine applications. Perform full-scale rig testing of electromagnetic rotor support and a power generation system for advanced, oil-less engines, including demonstrators that are part of the Integrated High Performance Turbine Engine Technology program. Continue development and testing of affordable rotor support technology for small- and intermediate-sized turbine engine applications. Continue 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. Perform advanced rotor support and power generation studies and testing for Versatile Affordable Advanced Turbine Engine program requirements.
(U)	$13,754	Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
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 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 3066

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
3066 Turbine Engine Technology	46,144	41,496	36,846	32,983	33,189	32,857	35,644	36,438	Continuing	TBD

Note: In FY 2002, the Hypersonic Technology Program work in this project was 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, augmentor and exhaust systems, thermal management systems, engine inlet integration, mechanical systems, and structural design. This project supports the Integrated High Performance Turbine Engine Technology and Versatile Affordable Advanced Turbine Engine programs, which are joint DoD, NASA and industry efforts to focus turbine propulsion technology on national needs. The FY04 program plan reflects the tech base support for the VAATE activity relative to the TBCC technology development in support of the NAI hypersonics activity.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $29,244 Developed 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. Designed and fabricated 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. Developed improved performance, reduced emissions combustor technologies. Conducted analytical and experimental evaluations of combustor aerodynamics, fuel-air mixing, and liner cooling techniques. Developed affordable, robust, lightweight, and compact combustors such as the Integrated Lightweight Combustor or the Trapped Vortex Combustor configurations. Conducted environmental and structural evaluation of the 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 tested 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) $7,000 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. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Validated the contoured ceramic composite exhaust

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
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. Evaluated temperature, pressure, and vibration of integrated components in a demonstrator engine. Completed reliability testing of a variable displacement vane pump system to eliminate fuel recirculation to tanks, reduce thermal loading, and increase weapon system thermal capacity. Completed fabrication of the non-linear control system to simplify control logic development and provide component performance trend data.

(U) $3,750 Developed 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, thereby greatly expanding the operating envelopes of cruise missiles and unmanned vehicles. Rig tested a composite forward swept fan for reduced weight, improved efficiency, and lower cost. Rig tested low-cost ceramic turbine blades to reduce cooling air and enhance performance.

(U) $2,350 Developed components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. Completed rig testing the splittered, forward swept compressor rotor to validate a high efficiency, high stage loading design. The components enable engines with reduced fuel consumption and lower production and maintenance costs.

(U) $2,300 Upgraded jet engine compressor and turbine aerodynamic test cells to enable assessment of emerging Air Force jet engine technologies supporting fighter and bomber transformational requirements. Increased power capability to 6,000 horse power and developed counter-rotating capability for these facilities.

(U) $1,500 Developed modeling and simulation tools to analyze and predicted the performance of aerospace engines and their components. Improved analytical tools associated with aerospace engines, focusing primarily on high performance, long life, advanced cooling techniques, and combustion stability.

(U) $46,144 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $29,035 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 to enhance overall combustion efficiency resulting in fuel burn reduction. Complete the subscale rotational intentional mistuning experiment and initiate the application of methodology to transonic rig hardware. Modify the spar/shell turbine blade design system using component bench test results and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
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

transition this technology to engine demonstrator testing.

(U) $7,293 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 to provide the component performance trend data necessary for transitioning this technology to the demonstrator engine program.

(U) $3,477 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, thereby 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 ceramics for an advanced turbine rotor blades.

(U) $1,691 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 a supercritical fuel delivery system.

(U) $41,496 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $28,250 Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and high-pressure turbines) for fighters, bombers, sustained hypersonic cruise vehicles, and transports. These components, made with advanced materials like Titanium Matrix Composites, enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Complete 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 full annular aerothermal test of a trapped vortex combustor. Conduct design and begin fabrication of advanced high-pressure turbine rig hardware, employing advanced three-dimensional, low shock loss aerodynamics for increased performance and reduced fuel burn. Develop advanced intentional mistuning methodology and begin experimental verification on transonic rig hardware.

(U) $8,151 Develop turbine engine components (i.e. fans, low pressure turbines, engine controls, exhaust nozzles, and integration technology) for turbofan/turbojet engines for fighters, bombers, sustained hypersonic cruise vehicles, and transports. These components enable aircraft engines

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
PROJECT: 3066	

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Complete design and begin fabrication of an advanced tandem, forward swept fan incorporating hybrid blade construction and composite reinforced disks to achieve high efficiency and stage loading with reduced weight and cost. Conduct testing of advanced control system hardware using component life models to verify real-time computational capabilities for transitioning this technology to a demonstrator engine program. Begin analysis and testing of advanced, low-observable compatible augmentor designs, resulting in improved design rules and tools to improve augmentor operability and reduce screech.

(U) $294 Develop limited life engine components for missile and unmanned air vehicle applications. These components enable engines with reduced cost, reduced fuel consumption, and increased specific thrust, thereby greatly expanding the operating envelopes of cruise missiles and unmanned vehicles. Begin preliminary design of an advanced versatile and affordable high pressure compressor, combustor, and high pressure turbine configurations for expendable engines using rub tolerant ceramic blades to meet the small engine performance and cost reduction objectives of the Versatile Affordable Advanced Turbine Engine program.

(U) $151 Develop turboshaft/turboprop and small turbofan engine components for trainers, rotorcraft, special operations aircraft, and theater transports. Begin preliminary design of advanced versatile and affordable high pressure compressor, combustor, and high pressure turbine configurations for turboshaft/turboprop engines to meet the small engine performance and cost reduction objectives of the Versatile Affordable Advanced Turbine Engine program. Supports the technology base support of TBCC concepts responsive to the High Speed-Hypersonics Pillar of NAI and focused on the tubine engine combined cycle technology requirements for a reusable high speed air vehicle.

(U) $36,846 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion	PROJECT: 3066

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

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

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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

DATE: February 2003

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602203F Aerospace Propulsion

PROJECT: 3145

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
3145	Aerospace Power Technology	26,726	34,508	22,763	22,841	23,905	23,309	26,921	27,521	Continuing	TBD

(U) A. Mission Description

This project develops techniques for efficient power generation, energy storage, and thermal management for military aerospace applications. Power component technologies are developed to increase reliability, maintainability, commonality, and supportability of aircraft and flight line equipment. Research in energy 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 radar, and high power lasers for aerospace platforms. Lightweight power systems suitable for other aerospace applications are also developed.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $9,363 Developed power generation/conditioning/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. Fabricated and began evaluation of advanced switched reluctance machine controllers. Initiated fabrication of Inverter Converter Controller to demonstrate power density improvements. Continued development of high energy density lithium-ion cell and maintenance free battery technologies by testing cells and batteries to load profiles specified in performance requirements for aircraft. Initiated development of lithium polymer cells. Completed design of low-cost, long duration fuel cells for unmanned air vehicle systems. Developed and tested magnetic materials for high temperature generator and magnetic bearing aircraft applications.

(U) $6,000 Developed thermal management, energy storage and power conditioning components, and subsystem technologies for space applications. Fabricated an integrated Power Management and Distribution system for space-based distributed power systems that are half the weight and volume of conventional approaches. Demonstrated a radiation-hardened power semiconductor device. Continued 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. Tested cycle life of high energy density lithium-ion cells and batteries for long-term space applications. Evaluated mechanical pumped-loop for higher-powered spacecraft. Continued work on active two-phase thermal management technologies.

(U) $5,420 Developed cryogenic power generation, high rate batteries, energy storage and power conditioning components, and system technologies with low volume displacement. These technologies enable the delivery of high power for operation of directed energy weapons. Completed component design of high density power conditioning for directed energy weapon systems. Developed high rate (pulse power) lithium-ion batteries. Began development of a thermal management system for cryogenic generator applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
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

(U)	$2,970	Developed and demonstrated 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	Developed 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. Initiated design and fabrication for a model PBO-based membrane in a single cell configuration.
(U)	$991	Developed large ampere-hour rechargeable lithium-ion cell battery technologies 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. Initiated 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	Developed 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)	$26,726	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Programs
(U)	$9,465	Develop power generation/conditioning/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)	$5,030	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 weight and volume of conventional approaches. Fabricate and test full-scale lithium-ion batteries for aerospace spacecraft applications.
(U)	$9,380	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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
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

density power conditioning for directed energy weapon systems. Continue developing higher 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) $1,882 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) $2,430 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. Using results from past single cell research, initiate design and fabrication for a model PBO-based membrane in multi-cell/stack configurations.

(U) $3,889 Initiate development of large ampere-hour cells for lithium-ion cell batteries 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. Next generation, high energy density and high power density rechargeable lithium-ion cell batteries (for future light weight, less expensive advanced spacecraft and aircraft (manned and unmanned) and possibly for high power weapons and ground support equipment) offer advantages over conventional, rechargeable systems by storing the same amount of energy at one-fourth the weight.

(U) $1,459 Develop component and system technologies for the High-Power, Advanced Low-Mass solar thermionic power system, including inflatable concentrator materials and design, thermionic cell materials and advanced converter design, secondary concentrator design, thermal storage materials, and high temperature power conditioning. Potential High-Power, Advanced Low-Mass applications in space are high power (>50 kW) orbital transfer propulsion, communication, radar or direct energy platforms. Component development will be aimed at supporting a ground demonstration of a 5 kW solar-thermionic power system. Performance analyses will continue with an emphasis on studying unique mission capabilities and comparing High-Power, Advanced Low-Mass capabilities and launch characteristics (size, weight, and cost) to that of other space power systems.

(U) $973 Provide hardware and technology to support demonstrations, at an engine manufacturer, of integrated power extraction from an integral starter/generator for Unmanned Combat Air Vehicles. These demonstrations will focus on anticipated Navy and Air Force Unmanned Combat Air Vehicles power requirements. Power generation, conditioning, and distribution technologies for Unmanned Combat Air Vehicles engines will focus on delivering an integral starter/generator . The integral starter/generator allows the engine to be started electrically, provides electrical power to support aircraft operations, and fits internal to the case, thus requiring no aircraft volume. The technologies can also be expanded and applied to a dual-spool engine's low pressure spool resulting in higher levels of power extraction, particularly at high altitudes, and at improved cycle efficiency. Aircraft self-sufficiency, reliability, maintainability, and supportability are all improved while life cycle costs are

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
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

reduced and new capabilities are enabled.

(U) $34,508 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $11,977 Develop power generation/conditioning/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. Complete testing of advanced-switched reluctance machine controllers. Develop preliminary design of optically controlled power electronics. Perform a dynamometer test of a starter/generator applicable for mid-thrust class turbine engine high spool applications. Initiate development of lithium-based solid state electrolyte battery technology.

(U) $2,500 Develop thermal management, energy storage and power conditioning components, and subsystem technologies for aerospace applications. Study advanced packaging techniques for silicon carbide power electronics. Develop integrated aerospace vehicle health monitoring algorithms.

(U) $8,286 Develop power generation, high rate batteries, energy storage and power conditioning components, and system technologies with low volume displacement. These technologies enable the delivery of higher power for operation of directed energy weapons. Design and fabricate advanced capacitors for pulsed power applications. Fabricate and begin testing liquid dielectric high voltage switch. Optimize processing techniques for long length Yttrium Barium Copper Oxide high temperature superconducting components. Fabricate and test small-scale, high rate lithium-ion cells. .

(U) $22,763 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 0603605F, Advanced Weapon Technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
PROJECT: 3145	

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

(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 2003

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602203F Aerospace Propulsion

PROJECT: 4847

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4847 Rocket Propulsion Technology	70,607	35,523	14,305	11,685	13,113	15,918	12,058	12,091	Continuing	TBD

Note: In FY 2003, space unique tasks in this project were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities. In this project, space unique includes all Integrated High Payoff Rocket Propulsion Technology activities except Technology for the Sustainment of Strategic Systems and tactical missiles.

(U) A. Mission Description

This project develops advances in rocket technologies for space access, space 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 program with emphasis on the Technology for the Sustainment of Strategic Systems. Integrated High Payoff Rocket Propulsion Technology is a joint DoD, NASA, and industry effort to focus rocket propulsion technology on national needs.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

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

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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
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) $3,036 Developed advanced technologies and material property enhancements for lightweight components for use in launch and space systems. Developed advanced ablative components using hybrid polymers for use in current and future launch systems. Continued to characterize and develop new high temperature polymer formulations and carbon-carbon materials for use in advanced combustion devices and propulsion systems to meet lower weight and increased strength requirements. Continued to develop advanced materials for use with high-energy propellants. Completed and transitioned advanced high temperature materials to Air Force systems to reduce system weight and cost, and increase performance.

(U) $11,108 Developed propulsion component technology for reliable, safe, and low-cost boost and orbit transfer systems. Completed development of an advanced lightweight rocket engine nozzle for upper stage and space booster applications. Continued development of a low-cost, high discharge pressure turbopump for advanced cryogenic engines. Developed components for hybrid propulsion for space boosters and air-launched missiles. Continued to develop turbomachinery, combustion, and propellant management devices for solid and liquid rockets. Continued developing high temperature turbine materials for oxidizer rich applications. Continued developing advanced lightweight rocket engine nozzles for upper stage and space booster applications. Verified performance and weight improvements of a 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 motors. Developed new fuels and oxidizers for advanced solid propulsion.

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

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

(U) $11,824 Developed materials and processes to dramatically improve performance, durability, and cost of rocket propulsion systems. Evaluated 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. Identified and evaluated the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
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

applications of these materials to turbopump housings, ducts, valves, solid rocket casings, insulation, and nozzle throats. Developed material property databases and initiated a demonstration of suitability for applications using representative geometry and processing conditions for the intended rocket engine components.

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

(U) $7,032 Conducted risk reduction efforts on the Integrated High Payoff Rocket Propulsion Technology program. This included 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. Conducted solid and liquid propellant synthesis and scale-up critical for meeting Integrated High Payoff Rocket Propulsion Technology goals to significantly reduce cost-per-pound of payload to orbit for space launch applications. Conducted interim demonstrations of subsystems (propellant, case, nozzle, and insulation) for missile propulsion demonstration programs. Conducted demonstration of new monopropellant solutions for spacecraft applications such as the TechSat 21 flight experiment.

(U) $10,597 Completed 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. Performed modifications necessary to accommodate multiple users and broader capability on Test Stand 1D. Provided increased capability on Test Stand 2A for high pressure fluid storage and more test configurations.

(U) $70,607 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $17,826 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.

(U) $5,542 Develop missile propulsion technologies for ballistic missile and boost systems. Begin component development and risk reduction efforts for the next phase Technology for the Sustainment of Strategic Systems ballistic missile technology demonstration. Verify performance and weight improvements of rapid densification nozzle technology using improved strategic propellants for future ballistic missiles. Continue to demonstrate

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 4847

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

low-cost, high temperature, non-erosive, lightweight coated carbon-carbon ceramic and hybrid polymer components for solid rocket motors. Formulate and characterize new propellant formulations using new fuels and oxidizers developed the last couple years for the next phase of advanced solid propulsion.

(U) $7,488 Upgrade the existing Jet Engine Test Cell, located on the former Norton Air Force Base in San Bernardino, to enable the development testing of larger rocket engines, including those needing cryogenic propellants. The capability being installed will enable medium-size rockets to be tested and is complimentary to component test facilities at Edwards Air Force Base.

(U) $2,430 Perform the initial Analysis of Alternatives at the Advanced Vehicle and Propulsion Center that will enable the next stage of acquisition planning for the following key Air Force Space Command missions: prompt global strike capability, land-based strategic nuclear deterrent, and operationally-responsive space lift system.

(U) $2,237 Upgrade space infrastructure facilities at Air Force Research Laboratory's Edwards Air Force Base research site to provide data on the responsiveness of candidate new Reusable Launch Vehicle system designs.

(U) $35,523 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $2,337 Continue risk reduction and technology development for Post Boost Control systems and solid rocket motor development FY 2003 work being done in 62500F, BPAC 5026. This work is part of the Technology for the Sustainment of Strategic Systems Phase I. Continue Phase I full-scale risk reduction component developments and testing supporting the advanced Post Boost Control Systems demonstration. Continue risk reduction efforts supporting Phase I missile propulsion demonstration.

(U) $9,668 Develop missile propulsion technologies for tactical, ballistic missile, and boost systems. Continue component development and risk reduction efforts for the next phase Technology for the Sustainment of Strategic Systems ballistic missile technology demonstration. 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. Formulate and characterize new propellant formulations using new fuels and oxidizers developed the last couple years for the next phase of advanced solid propulsion. Continue development of advanced tactical propulsion components.

(U) $2,300 Develop missile propulsion technologies and aging and surveillance technologies for strategic systems. Continue second phase Technology for the Sustainment of Strategic Systems aging and surveillance technology developments in analysis codes, tools, and inspection tools for improved assessment of ballistic missile aging characteristics and status.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602203F Aerospace Propulsion
	PROJECT: 4847

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued
(U) $14,305 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 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.