PE NUMBER: 0602203F
PE TITLE: Aerospace Propulsion

Exhibit R-2, RDT&E Budget Item Justification

DATE **February 2007**

BUDGET ACTIVITY
02 Applied Research

PE NUMBER AND TITLE
0602203F Aerospace Propulsion

Cost ($ in Millions)		FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
	Total Program Element (PE) Cost	153.760	218.657	179.161	217.394	222.201	184.034	175.557	179.428	Continuing	TBD
3012	Advanced Propulsion Technology	19.272	29.825	21.984	21.639	23.203	23.141	22.936	23.461	Continuing	TBD
3048	Fuels and Lubrication	20.723	24.599	17.349	26.088	26.678	19.067	17.954	18.301	Continuing	TBD
3066	Turbine Engine Technology	33.107	42.568	51.506	83.546	76.501	46.558	40.753	41.676	Continuing	TBD
3145	Aerospace Power Technology	45.414	44.595	30.784	31.125	35.072	34.205	33.314	34.066	Continuing	TBD
33SP	Space Rocket Component Tech	0.000	58.085	46.819	45.915	48.989	49.192	48.478	49.494	0.000	0.000
4847	Rocket Propulsion Technology	35.244	18.985	10.719	9.081	11.758	11.871	12.122	12.430	Continuing	TBD

Note: In FY 2007, Project 33SP, Space Rocket Component Technology was transferred from PE 0602500F, Multi-Disciplinary Space Technology, Project 5026, Rocket Propulsion Component Technology, and Project 5027, High Speed Airbreathing Propulsion Technology, in order to more effectively manage and provide oversight of the efforts. In FY 2007, Project 3012, Advanced Propulsion Technology, combined efforts with a thrust from Project 33SP, Space Rocket Component Technology, in order to more effectively manage cooperative Combined Cycle Engine (CCE) developments. Funds for the FY 2006 Congressionally-directed Notre Dame Center for Flow Physics and Control in the amount of $3.0 million were moved to PE 0601102F, Defense Research Sciences, from PE 0602203F, Aerospace Propulsion, for execution. Funds for the FY2006 Congressionally-directed Lightweight Photovoltaic Electricity and Hydrogen for Portable, On-Demand Power for Defense Applications in the amount of $1.0 million were moved to PE 0602601F, Space Technology, from PE 0602203F, Aerospace Propulsion, for execution. Funds for the FY 2007 Congressionally-directed High Energy Laser for Detection Inspection and Non-Destructive Testing in the amount of $2.7 million are in the process of being moved to the Defense Advanced Research Projects Agency, from PE 062203F, Aerospace Propulsion, for execution. The funding in this PE has been increased to provide emphasis on component development in support of adaptive cycle technologies, improved fuel efficiency, and highly efficient embedded turbine engines.

(U) A. Mission Description and Budget Item Justification

This program develops propulsion and power technologies to achieve enabling and revolutionary aerospace technology capabilities. The program has six projects, each focusing on a technology area critical to the Air Force. The Advanced Propulsion Technology develops high-speed airbreathing propulsion engines to include combined cycle, ramjet, and hypersonic scramjet technologies to enable revolutionary propulsion capability for the Air Force. The Fuels and Lubrication project evaluates fuels, lubricants, and combustion concepts and technologies for new and existing engines and directly supports the Versatile Affordable Advanced Turbine Engine (VAATE) program. The Turbine Engine Technology project develops enabling capabilities to enhance performance and affordability of existing weapon systems to include efforts that are part of the VAATE program. The Aerospace Power Technology project develops electrical power and thermal management technologies for ground, air, and space military applications that are part of the High Power Aircraft (HiPAC) program. The Space Rocket Component Technology project develops advances in rocket propulsion technologies for space access, space maneuver, and ballistic missiles. The Rocket Propulsion Technology project develops advances in rocket technologies for the sustainment of strategic systems and tactical rockets to include efforts that are part of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) and Technology for the Sustainment Systems (TSSS) programs. Finally, the adaptive cycle technologies project develops component technologies for an adaptive cycle engine architecture to provide optimized performance/fuel efficiency for widely varying mission needs. Note: In FY 2007, Congress added $1.0 million for Advanced High Speed Propulsion Development; $3.9 million for X-51 Robust Scramjet Flight Research; $2.7 million for

High Energy Laser for Detection Inspection and Non-Destructive Testing; $2.0 million for Ultrafast, Ultraintense Laser Microfabrication and Diagnostics; $1.7 million for Hybrid Bearings; $2.0 million for Research Institute for Environmental Studies (TRIES); $3.9 million for Active Combustion Control System for Military Aircraft; $1.8 million for Active Combustion Control Systems for Military Aircraft; $1.0 million for Advanced Affordability Assurance Tools for the Versatile Affordable Advanced Turbine Engine (VAATE) Initiative; $1.4 million for the Intelligent Engine Technology Development for UAVs; $1.1 million for VAATE TMC FLADE Technology Demonstration; $1.3 million for Advanced Energy Technology for Munititions - Dominator Program; $1.0 million for the Affordable Lightweight Power Supply; $2.5 million for Chemical Hydride Power System; $1.1 million for High Flux ESC System with TES for Military High Energy Laser; $1.0 million for Integrated Electric Starter/Generator; $5.2 million for Manufacturing of High Energy Superior Lithium Battery Technology; $1.3 million for MEPS Thermal Management; $1.0 million for Military Purpose Electrolyte Supported Fuel Cells; $1.4 million for Advanced Liquid Rocket Booster Technology; $3.2 million for Advanced Vehicle and Propulsion Center; $3.6 million for Center for Solar Electricity and Hydrogen; $2.8 million for Engineering Tool Improvement Program (ETIP); $1.6 million for Methane Second Stage Rocket Engine; $1.7 million for Advanced Vortex Hybrid Propulsion System; $1.0 million for Aerospace Lab Equipment Upgrade; and $1.0 million for Solid Boost Propulsion Technology for the Sustainment of Strategic Systems. This program is in Budget Activity 2, Applied Research, since it develops and determines the technical feasibility and military utility of evolutionary and revolutionary technologies.

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

		FY 2006	FY 2007	FY 2008	FY 2009
(U)	Previous President's Budget	155.673	170.885	159.359	167.671
(U)	Current PBR/President's Budget	153.760	218.657	179.161	217.394
(U)	Total Adjustments	-1.913			
(U)	Congressional Program Reductions				
	Congressional Rescissions	-0.018	-0.828		
	Congressional Increases		42.600		
	Reprogrammings	0.656	6.000		
	SBIR/STTR Transfer	-2.551			

(U) Significant Program Changes:

Not Applicable.

C. Performance Metrics

(U) Under Development.

Exhibit R-2a, RDT&E Project Justification

DATE **February 2007**

BUDGET ACTIVITY
02 Applied Research

PE NUMBER AND TITLE
0602203F Aerospace Propulsion

PROJECT NUMBER AND TITLE
3012 Advanced Propulsion Technology

Cost ($ in Millions)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
3012 Advanced Propulsion Technology	19.272	29.825	21.984	21.639	23.203	23.141	22.936	23.461	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

Note: In FY 2006 and FY 2007, funding was increased to accelerate efforts to develop technologies to support an Air Force scramjet effort. In FY 2007, Project 3012, Advanced Propulsion Technology, absorbed Combined Cycle Engine (CCE) efforts from Project 33SP, Space Rocket Component Technology, in order to more effectively manage cooperative CCE developments.

(U) A. Mission Description and Budget Item Justification

This project develops combined/advanced cycle airbreathing high-speed (up to Mach 4) and hypersonic (Mach 4 to 8+) propulsion technologies to provide 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 Department of Defense and NASA. Efforts include modeling, simulations, and proof of concept demonstrations of critical components; advanced component development; and ground-based demonstrations.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Develop advanced fuel-cooled scramjet engine technologies to support flight demonstration and enable the broad application of hypersonics to meet future warfighter needs. Note: In FY 2006 and FY 2007, funding supports significant ground testing that will wrap up in FY 2007.	7.575	12.109	1.188	1.245

(U) In FY 2006: Developed and demonstrated flight weight engine components and a control system with closed loop controller. Tested flight weight scramjet engine with flight weight fuel control valves and closed loop engine controls at Mach 5. Performed trajectory optimization for flight test. Evaluated options for scramjet start, including gas generator/heat exchanger system, barbotage fuel injection, plasma ignition, and silane injection with a mechanical throat or air throttle. Verified operation of engine control techniques, based on rapid shock train identification/ characterization coupled with fuel control logic, to ensure stable scramjet operation. Designed, fabricated, and initiated ground test of a flight weight, fixed geometry inlet scramjet engine with improved operability to reduce flight test risk.

(U) In FY 2007: Continue development and demonstration of flight weight engine components and a control system with closed loop controller. Continue performing trajectory optimization for flight test. Continue evaluating options for scramjet start, including gas generator/heat exchanger system, barbotage fuel injection, plasma ignition, and silane injection with a mechanical throat or air throttle. Continue verification of operation of engine control techniques, based on rapid shock train identification/ characterization coupled with fuel control logic, to ensure stable scramjet operation. Complete ground test of a flight weight, fixed geometry inlet scramjet engine with improved operability to reduce flight

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(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
test risk.				
(U) In FY 2008: Continue development and demonstration of flight weight engine components and advanced engine control logic. Continue performing trajectory optimization for flight test. Continue evaluating options for scramjet start, including gas generator/heat exchanger system, barbotage fuel injection, plasma ignition, and silane injection with a mechanical throat or air throttle. Initiate design and testing of advanced scramjet start techniques. Continue verification of operation of engine control techniques, based on rapid shock train identification/ characterization coupled with fuel control logic, to ensure stable scramjet operation.				
(U) In FY 2009: Continue development and demonstration of flight weight engine components and advanced engine control logic. Continue performing trajectory optimization for flight test. Continue evaluating options for scramjet start, including gas generator/heat exchanger system, barbotage fuel injection, plasma ignition, and silane injection with a mechanical throat or air throttle. Complete ground testing of advanced scramjet start techniques. Continue verification of operation of engine control techniques, based on rapid shock train identification/ characterization coupled with fuel control logic, to ensure stable scramjet operation.				
(U)				
(U) MAJOR THRUST: Conduct assessments, technology design trades, and simulations to integrate combined cycle engines (CCEs) and advanced cycle airbreathing hypersonic propulsion technologies into future missiles and into manned and unmanned air and space vehicle concepts. CCEs require the development and demonstration of components to integrate scramjets with high speed turbines and/or rocket engines for efficient propulsion over a broad range of Mach numbers.	1.062	2.239	1.991	2.371
(U) In FY 2006: Performed 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 DARPA. Developed advanced components for turbine-based and rocket-based CCEs, with initial emphasis on advanced inlets for turbine-based CCEs capable of operating from Mach 0 to Mach 8. Designed sub-scale inlet test article.				
(U) In FY 2007: Continue trade studies to determine military payoff and establish component technology goals. Continue defining component and engine performance objectives to enable development of affordable hypersonic flight demonstrators jointly with NASA and DARPA. Continue development of advanced components for turbine-based and rocket-based CCEs. Fabricate and initiate test of advanced inlets for turbine-based CCEs capable of operating from Mach 0 to Mach 8.				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
(U) In FY 2008: Continue trade studies to determine military payoff and establish component technology goals. Continue defining component and engine performance objectives to enable development of affordable hypersonic flight demonstrators jointly with NASA and DARPA. Continue development of advanced components for turbine-based and rocket-based CCEs. Complete testing of advanced inlets for turbine-based CCEs capable of operating from Mach 0 to Mach 8. Design an advanced nozzle for turbine-based and rocket-based CCEs.				
(U) In FY 2009: Continue trade studies to determine military payoff and establish component technology goals. Continue defining component and engine performance objectives to enable development of affordable hypersonic flight demonstrators jointly with NASA and DARPA. Continue development of advanced components for turbine-based and rocket-based CCEs. Conduct testing of advanced nozzles for turbine-based and rocket-based CCEs.				
(U)				
(U) MAJOR THRUST: Develop robust hydrocarbon fueled scramjet engine components and technologies to improve performance, operability, durability, and scalability for future missiles and for aerospace vehicles. Note; Starting in FY 2008, efforts shift towards much larger hot section testing and voluminous test data will be required to correlate the combustion scaling phenomena to the original baseline configuration to provide the knowledge to scale the scramjet configuration to larger applications potentially up to space launch.	9.665	10.595	18.805	18.023
(U) In FY 2006: Developed advanced engine components to improve scramjet operating margin and to establish scramjet scaling laws for reusable applications. Developed variable geometry techniques to decrease scramjet take-over from Mach 4.5 to Mach 3.5 to provide robust options for CCEs. Fabricated and initiated test of scramjet combustors sized for reusable applications with improved structural efficiency. Developed low internal drag flame stabilization devices and flight test engine components.				
(U) In FY 2007: Continue development of advanced engine components to improve scramjet operating margin and to establish scramjet scaling laws for reusable applications. Continue development of variable geometry techniques to decrease scramjet take-over from Mach 4.5 to Mach 3.5 to provide robust options for CCEs. Complete test of scramjet combustors sized for reusable applications with improved structural efficiency. Initiate development of improved durability engine concepts. Continue development of low internal drag flame stabilization devices and flight test engine components.				
(U) In FY 2008: Continue development of advanced engine components to improve scramjet operating margin and to establish scramjet scaling laws for reusable applications. Continue development of				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
variable geometry techniques to decrease scramjet take-over from Mach 4.5 to Mach 3.5 to provide robust options for CCEs. Complete test of scramjet combustors 5 to 10 times baseline size for reusable applications with improved structural efficiency. Initiate development of improved durability engine concepts. Continue development of low internal drag flame stabilization devices and flight test engine components.				
(U) In FY 2009: Continue development of advanced engine components to improve scramjet operating margin and to establish scramjet scaling laws for reusable applications. Complete development of variable geometry techniques to decrease scramjet take-over from Mach 4.5 to Mach 3.5 to provide robust options for CCEs. Continue sector testing of large scale scramjet combustors 20 to 50 times baseline size for reusable applications with improved structural efficiency. Continue development of improved durability engine concepts. Continue development of low internal drag flame stabilization devices and flight test engine components.				
(U)				
(U) CONGRESSIONAL ADD: Information Assurance Initiative.	0.970	0.000	0.000	0.000
(U) In FY 2006: Implemented improvements supporting technology infrastructure security with upgrades in electronic security of doors, security of video teleconferencing systems and for a central public address systems and separate research and development network.				
(U) In FY 2007: Not Applicable.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Advanced High Speed Propulsion Development.	0.000	0.996	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Enhance the nation's ability to test and analyze high speed propusion systems such as scramjets and combined cycle engines.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: X-51 Robust Scramjet Flight Research.	0.000	3.886	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Investigate the integration of alternative high speed combined cycle engine configurations				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
(such as circular and rectangular scramjets) for potential flight demonstration under X-51 follow-on efforts.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U) Total Cost	19.272	29.825	21.984	21.639

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

	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:										
(U) PE 0601102F, Defense Research Sciences.										
(U) PE 0602201F, Aerospace Flight Dynamics.										
(U) PE 0602500F, Multi-Disciplinary Space Tech.										
(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										

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

Committee.

(U) This project has been coordinated through the Reliance 21 process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE **February 2007**

BUDGET ACTIVITY **02 Applied Research**

PE NUMBER AND TITLE **0602203F Aerospace Propulsion**

PROJECT NUMBER AND TITLE **3048 Fuels and Lubrication**

Cost ($ in Millions)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
3048 Fuels and Lubrication	20.723	24.599	17.349	26.088	26.678	19.067	17.954	18.301	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

Note: The funding in this project has been increased to provide emphasis on component development in support of adaptive cycle technologies. Funds for the FY 2007 Congressionally-directed High Energy Laser for Detection Inspection and Non-Destructive Testing in the amount of $2.7 million are in the process of being moved to the Defense Advanced Research Projects Agency, from PE 062203F, Aerospace Propulsion, for execution.

(U) A. Mission Description and Budget Item Justification

This project evaluates fuels, lubricants, mechanical systems, and combustion concepts for advanced turbine engines, scramjets, pulse detonation, and combined cycle engines, and technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. Applications include missiles, aircraft, sustained high-speed vehicles, and responsive space launch. Analytical and experimental areas of emphasis include fuels and fuels logistics, lubricants, bearings, electromagnetic rotor, oil-less engine technology, optical diagnostics, fundamental combustion, and detonations. 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. A portion of this project supports adaptive cycle technologies. This effort develops component technology for an adaptive cycle engine architecture that provides optimized performance/fuel efficiency for widely varying mission needs.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Develop low-cost additive and fuel system approaches to improve fuel properties and to expand the flight envelope for manned and unmanned aircraft. Determine fuel cooling requirements and specifications for an adaptive cycle engine architecture. Design, fabricate, and test of key thermal management technologies. Note: Increased funding in FY2008 and out due to emphasis on component development in support of adaptive cycle technologies.	1.751	2.162	3.053	6.764

(U) In FY 2006: Conducted lab-scale evaluation of approaches to increase JP-8 temperature capability to 900 degrees Fahrenheit including thermal stability additives, fuel deoxygenation, advanced alternative energy fuels, and improved materials and coatings. Developed initial engine thermal management models, aiming toward system-level models of advanced aircraft. Developed laboratory-scale combustion tests for evaluating combustion performance of fuels and additives at low fuel and air temperatures.

(U) In FY 2007: Continue conducting lab-scale evaluation of approaches to increase JP-8 temperature capability to 900 degrees Fahrenheit including thermal stability additives, fuel deoxygenation, advanced alternative energy fuels, and improved materials and coatings. Initiate effort to validate component performance models on aircraft thermal management simulator. Continue to develop approaches to assess and improve additive combustion behavior at low fuel and air temperatures. Test fuel candidates in bench scale rigs simulating advanced high Mach propulsion systems.

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
(U) In FY 2008: Continue conducting lab-scale evaluation of approaches to increase JP-8 temperature capability to 900 degrees Fahrenheit including thermal stability additives, fuel deoxygenation, advanced alternative fuels, and improved materials and coatings. Continue effort to validate component performance models on aircraft thermal management simulator. Complete the development of approaches to assess and improve additive combustion behavior at low fuel and air temperatures. Continue to test fuel candidates in bench scale rigs simulating advanced high Mach propulsion systems and the Highly Efficient Embedded Efficient Turbine Engine. Develop a robust mechanical and integrated engine thermal management system (mechanical and fuel systems) for optimum engine performance and durability at sustained supersonic cruise conditions.				
(U) In FY 2009: Continue conducting lab-scale evaluation of approaches to increase JP-8 temperature capability to 900 degrees Fahrenheit including thermal stability additives, fuel deoxygenation, advanced alternative energy fuels, and improved materials and coatings. Continue effort to validate component performance models on aircraft thermal management simulator. Continue to test fuel candidates in bench scale rigs simulating advanced high Mach propulsion systems and the Highly Efficient Embedded Turbine Engine. Conduct full-scale component rig testing of mechanical components with prototype lubricants. Conduct simulated high-Mach tests of an integrated thermal management system and mechanical system components.				
(U)				
(U) MAJOR THRUST: Develop advanced additive approaches to reduce engine emissions and signature (including nano-scale additives), as well as advanced emission diagnostic test protocols.	1.085	1.339	1.273	1.721
(U) In FY 2006: Assessed novel fuel additives including nano-technologies and fuels derived from alternative energy resources to reduce emissions in laboratory scale combustion rigs. Developed higher-pressure laboratory-scale combustion tests and diagnostics for sub-micron particulate investigations.				
(U) In FY 2007: Complete assessing novel fuel additives including nano-technologies and fuels derived from alternative energy resources to reduce emissions in laboratory scale combustion rigs. Initiate higher-pressure measurements of additive and fuel effects on sub-micron particulate generation during combustion.				
(U) In FY 2008: Complete assessing novel fuel additives including nano-technologies to reduce emissions in laboratory scale combustion rigs. Initiate improvement of combustion models for kerosene fuels. Continue higher-pressure measurements of additive and fuel effects on sub-micron particulate generation during combustion.				

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
(U)	In FY 2009: Continue higher-pressure measurements of additive and fuel effects on sub-micron particulate generation during combustion. Initiate study of NOx/soot tradeoffs in combustor design. Continue improvement of combustion models for kerosene fuels				
(U)					
(U)	MAJOR THRUST: Study and evaluate low-cost approaches to reduce fuel logistics footprint to simplify logistics and reduce cost (including field and on-board additive injections and improvements to existing fuel additive packages), as well as study fuel logistics vulnerabilities and develop detection and mitigation technologies.	1.085	1.339	1.273	1.721
(U)	In FY 2006: Assessed fuel additives optimization for logistics footprint reduction. Investigated performance of Fischer-Tropsch (F-T) and other alternative fuels for aircraft and other field hardware. Completed investigation of supply chain biological contamination and the impact on fuel logistics. Evaluated nano-technology fuel sensors and biological mitigation techniques. Completed development of advanced field diagnostics techniques for fuel properties and bio-contamination.				
(U)	In FY 2007: Continue to investigate performance of F-T and other alternative fuels for aircraft and other field hardware. Continue evaluation of advanced nano-technology fuel sensors, nano-technology fuel additives, and novel detection and mitigation technologies for biological growth.				
(U)	In FY 2008: Expand investigation of the performance of alternative fuels to include bio-derived fuels. Initiate development of bioreactors to simulate biological growth in aircraft fuel systems and ground storage facilities. Initiate development of knowledge base for certification of Fischer-Tropsch fuels for all Air Force tactical vehicles Continue evaluation of advanced nano-technology fuel sensors, nano-technology fuel additives, and novel detection and mitigation technologies for biological growth.				
(U)	In FY 2009: Continue to investigate performance of biomass-derived fuels for aircraft and other field hardware. Initiate extension of knowledge base to other alternative fuels, such as those derived from biomass. Continue development of bioreactors to simulate biological growth in aircraft fuel systems and ground storage facilities. Continue development of knowledge base for certification of Fischer-Tropsch fuels for all Air Force tactical vehicles.				
(U)					
(U)	MAJOR THRUST: Investigate hydrocarbon and other high energy density fuels for advanced and combined cycle engines for high-speed aerospace vehicles and low-cost boost applications.	0.543	0.670	0.637	0.861
(U)	In FY 2006: Assessed advanced hydrocarbon propellant stability under high heat flux conditions for advanced rockets and combined cycle engines.				
(U)	In FY 2007: Continue to assess advanced hydrocarbon propellant stability under high heat flux				

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
	conditions. Collect improved fuel property data for hydrocarbon propellant database.				
(U)	In FY 2008: Complete study of refined kerosene propellants under high heat flux conditions, while continuing to study synthesized high-energy hydrocarbons. Continue to improve fuel property database and share with industry to improve design tools.				
(U)	In FY 2009: Continue study of high-energy hydrocarbon propellant candidates. Complete improved physical property database for kerosene propellants at high pressure. Continue to collect improved physical property for high energy hydrocarbons and improve physical property models.				
(U)					
(U)	MAJOR THRUST: Develop, test, and evaluate revolutionary combustor and propulsion concepts for gas turbine, pulsed detonation, and combined cycle engines for missiles, manned and unmanned systems, and reuseable access to space; perform payoff analyses and configuration trade studies for these systems; and evaluate the combustion and emissions characteristics of fuels and fuel additives.	3.781	4.695	4.436	5.996
(U)	In FY 2006: Evaluated advanced combustion system performance at realistic operating conditions. Investigated larger-scale inter-turbine burner concepts at relevant engine operating conditions to increase mission flexibility. Developed a Pulse Detonation Engine (PDE) turbine-based hybrid concept. Conducted experiments to validate chemical kinetics of practical fuels at high pressure and temperature. Performed modeling and simulation of advanced combustion systems to decrease design cycle time, optimize compact combustor, and augmentor designs, and to understand physical parameters controlling combustion processes. Evaluated and developed novel lightweight, high performance augmentor concepts.				
(U)	In FY 2007: Continue evaluating advanced combustion system performance at realistic operating conditions. Continue investigating inter-turbine burning concepts for large gas turbine engines. Continue integration of PDE into turbine-based hybrid concept. Evaluate and optimize advanced combustor, augmentor, and PDE concepts using modeling and simulation tools.				
(U)	In FY 2008: Demonstrate small-scale inter-turbine burner (ITB) concepts in a relevant engine environment. Investigate the scalability of inter-turbine burners for large engines. Assess an integrated pulsed detonation/hybrid turbine concept performance with component fabrication and evaluation. Investigate combustor and augmentor systems for high-altitude low-high mach applications. Evaluate and optimize advanced combustor, augmentor, and PDE concepts using modeling and simulation tools.				
(U)	In FY 2009: Evaluate advanced combustion system performance at realistic operating conditions. Demonstrate small-scale ITB concepts in small engine. Identify concept designs of inter-turbine burning concepts for large gas turbine engines. Optimize component efficiency of the integrated pulsed				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
detonation/hybrid turbine. Evaluate and optimize advanced combustor, augmentor, and PDE concepts using modeling and simulation tools covering wider flight conditions and applications.				
(U)				
(U) MAJOR THRUST: Develop approaches to extend the life of endothermic fuels and fuel system components for sustained supersonic and reusable hypersonic cruise applications.	0.543	0.670	0.637	0.861
(U) In FY 2006: Evaluated, at a laboratory scale, approaches to improve fuel heat sink and provide thermal management capability for high speed systems. Evaluated surface/catalyst effects on coke reduction to improve fuel heat sink capability and increase fuel system life. Assessed unconventional approaches to increase fuel heat sink, such as steam reforming.				
(U) In FY 2007: Continue development of improved surfaces/catalysts to mitigate coking and thus improve fuel heat sink capability. Continue assessment of unconventional approaches to increase fuel heat sink and minimize regenerative cooling heat loads, including low heat rejection structures.				
(U) In FY 2008: Evaluate improved coke-mitigating surfaces/catalysts with 2nd generation endothermic fuels in bench-scale heat exchanger rigs. Assess unconventional approaches to increase fuel heat sink and minimize regenerative cooling heat loads in panel tests. Initiate study of relationship between fuel structure/properties and combustion behavior including blowout.				
(U) In FY 2009: Continue bench-scale tests to evaluate improved surfaces/catalysts for 2nd generation endothermic fuels. Continue assessment of unconventional approaches to increase fuel heat sink and minimize regenerative cooling heat loads. Continue study of relationship between fuel structure/properties and combustion behavior including blowout.				
(U)				
(U) MAJOR THRUST: Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies.	0.681	0.840	0.799	1.080
(U) In FY 2006: Applied advanced laser diagnostics for accurate measurements inside advanced gas turbine combustion systems to improve design cycle time. Developed sensor technologies for use in intelligent gas turbine engine combustion systems for enhanced operability, increased durability and performance. Investigated high intensity laser light with matter for micromachining and diagnostic capabilities.				
(U) In FY 2007: Continue application of advanced diagnostics in a relevant gas turbine combustion system environment. Apply diagnostics to sensor development and validate sensors in relevant gas turbine engine system. Conduct experiments to obtain benchmark-quality data for improvement of combustion modeling and simulation tools.				
(U) In FY 2008: Demonstrate high-bandwidth (e.g., MHz-rate) planar laser-induced fluorescence for				

Exhibit R-2a, RDT&E Project Justification		DATE February 2007
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT NUMBER AND TITLE 3048 Fuels and Lubrication

(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
high-speed digital imaging of key combustion species in fundamental laboratory flames and relevant engine environments. Apply terahertz radiation (T-rays) for combustion temperature sensing and non-destructive inspection/evaluation of turbine engine components. Integrate current and next-generation combustion diagnostics to support RDT&E of augmentor solutions for fighter aircraft.				
(U) In FY 2009: Develop high-speed techniques for measuring carbon monoxide (CO) to evaluate CO oxidiation/combustion efficiency in near-constant-volume-combustion turbine environments. Exploit ultrafast (e.g., femtosecond), ultraintense (e.g., terawatt) laser systems to generate ultrashort x-ray bursts for soot-mitigation studies and dense-fuel-spray imaging. Develop multi-pulse femtosecond ballistic imaging to understand and improve fuel sprays in combustor, augmentor, scramjet, and rocket applications.				
(U)				
(U) MAJOR THRUST: Develop, test, and qualify advanced turbine engine lubricants for the Air Force and DoD. Establish target requirements and transition opportunities for new oils by working with DoD agencies, industry, and users. Generate and maintain military specifications for aviation engine lubricants, as well as continued field support activities for aviation lubrication technologies and DoD operational units.	2.105	2.598	2.470	3.339
(U) In FY 2006: Developed and tested advanced bearing and lubrication system concepts, components, and materials for improved engine performance, affordability, and engine health monitoring, which are applicable to man-rated, expendable, and Unmanned Aerial Vehicle (UAV) turbine engines. Testing focused on enhanced 5 centiStokes (cSt) high thermal stability (HTS) lubricant candidates and new elastomer compatibility test method. Designed test approaches for enhanced high thermal stability oils for new, legacy, and commercial turbine engines. Developed Technology Development Roadmap for 7cSt ester lubricant for high Mach/high temperature military and commercial turbine engines. Tested prototype Joint Oil Program (JOP) lubricants with mechanical hardware in preparation of new fighter demonstration engines.				
(U) In FY 2007: Begin technology insertion of advanced bearing and lubrication system concepts, components, and materials for improved engine performance, affordability, and engine health monitoring into demonstrator cores and engines. Continue testing to focus and develop lubricants and mechanical systems for man-rated, expendable, and UAV turbine engines. Initiate 7cSt ester lubricant development for high Mach/high temperature military and commercial turbine engines. Coordinate and support demonstration of JOP lubricants in new fighter asset engines. Deliver military specifications and test methods for DoD lubricants to support new fighter engines.				

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		FY 2006	FY 2007	FY 2008	FY 2009
(U)	**B. Accomplishments/Planned Program ($ in Millions)**				
(U)	In FY 2008: Complete qualification testing of the enhanced 5cSt ester candidate(s), transition to demo engine program and draft new oil specification. Ramp up qualification testing of hi-mach 7cSt ester in preparation of FY11 engine demo. Develop an integrated and effective bearing / oil health monitoring system with prognostics capability to address critical DoD safety, readiness, and life-cycle cost concerns. Conduct technology assessment of long-term, low-temperature (hi-altitude) performance of engine lubricants and develop concepts for efficient mechanical system for highly efficient embedded turbine engines.				
(U)	In FY 2009: Finalize and field new enhanced 5cSt oil specification. Conduct qualification testing of new hi-mach 7cSt ester lubricant. Demonstrate an integrated bearing / oil health monitoring / prognostic system in full-scale setting and validate life models. Fabricate and test an efficient mechanical system for highly efficient embedded turbine engine.				
(U)					
(U)	MAJOR THRUST: Develop and test advanced bearing material technology and bearing concepts for small, intermediate, and large-sized turbine engine applications.	2.361	2.914	2.771	3.745
(U)	In FY 2006: Conducted airfoil bearing testing of large shaft diameter sizes to determine load capacity and rotor size limitations of this technology. Developed and tested affordable rotor support technology for small-, intermediate-, and large-sized turbine engine applications. Improved modeling and simulation tools for advance design, which will shorten development time, and reduce test requirements for mechanical and electromagnetic rotor support and power generation systems. Modeled airfoil bearings for advanced engine rotor support and power generation. Initiated full-scale tests of hybrid (metal/ceramic) bearing technology for the new fighter demonstrator engines with lubricant from the JOP. Studied mechanical systems and thermal management concepts for turbo accelerators in combined cycle engines.				
(U)	In FY 2007: Conduct airfoil bearing tests in larger shaft diameter sizes to determine load capacity and rotor size limitations of this technology. Develop and test of affordable rotor support technology for small-, intermediate-, and large-sized turbine engine applications. Validate modeling and simulation tools to advance design, shorten development time, and reduce test requirements for mechanical and electromagnetic rotor support and power generation systems. Improve the modeling of airfoil shaft bearings and initiate evaluation of insertion opportunities for advanced engine rotor support and power generation. Transition/transfer airfoil bearing technology to bearing and engine companies. Demonstrate hybrid (metal/ceramic) bearing and JOP lubricants in new fighter demonstrator engines. Initiate programs for hardware needed for optimum thermal protection designs for high mach/high				

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
	temperature turbine engines and accelerators. Expand the previous studies of advanced rotor support and power generation for turbine and combined cycle engines.				
(U)	In FY 2008: Demonstrate new fatigue and spall propagation resistant bearing materials in advanced demo engines with enhanced 5cSt oil. Conduct subscale fatigue life and spall propagation studies of bearing materials with hi-mach 7cSt oil candidates. Develop preliminary design of propfan gearbox and conduct trade study of energy efficient mechanical system components (ie. rolling element vs. foil vs. magnetic bearing) for highly efficient embedded turbine engine.				
(U)	In FY 2009: Complete subscale fatigue life and spall propagation studies of bearing materials with hi-mach 7cSt oil candidates and begin full-scale tests. Fabricate and test propfan gearbox. Down select mechanical system components and complete detailed design for highly efficient embedded turbine engine.				
(U)					
(U)	CONGRESSIONAL ADD: Ultrafast, Ultraintense Laser Microfabrication and Diagnostics (formerly Intense, Ultrafast Laser Microfabrication and Diagnostics).	1.358	0.996	0.000	0.000
(U)	In FY 2006: Developed technology to exploit characteristics of intense, ultrafast lasers for sensors and weapons systems. Investigated these systems for use in gas turbine engine diagnostics. Developed a new generation of extreme light diagnostics that can be used to analyze and evaluate materials, aid in the development and validation of system design and life prediction models, and perform inspections for fleet maintenance.				
(U)	In FY 2007: Continue to establish the technical base required to evaluate and develop ultrafast, ultraintense lasers for fabrication, inspection, and repair of components for aerospace propulsion and other weapon systems.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Wavelength Agile Spectral Harmonic Oxygen Sensor.	0.970	0.000	0.000	0.000
(U)	In FY 2006: Designed, fabricated, and tested a second generation oxygen sensor to measure oxygen concentration in high-performance fuel tanks. Conducted environmental testing of the sensor under simulated fuel tank conditions and performed Category A flight testing to aid in modification of the design, resulting in a third generation sensor design. Also conducted an evaluation of second generation sensor specifications and certification plan.				
(U)	In FY 2007: Not Applicable.				

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		FY 2006	FY 2007	FY 2008	FY 2009
(U)	**B. Accomplishments/Planned Program ($ in Millions)**				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Hybrid Bearings.	2.036	1.694	0.000	0.000
(U)	In FY 2006: Developed advanced hybrid bearing technology for use in high performance turbine engines. Conducted bearing fatigue life testing of advanced Pyrowear 675 (P675) hybrid bearings and P675 heat treatment optimization and characterization. Developed critical flaw models for Silicon Nitride (Si3N4) bearing balls, and experimentally validated models. Also, investigated advanced Non-destructive Evaluation (NDE) methods for Si3N4 bearing balls and conducted full-scale bearing performance testing of advanced hybrid bearings. Note: Moved to PE 0602203F from PE 0603112.				
(U)	In FY 2007: Develop a suite of advanced hybrid bearing technologies for transition to JSF thrust growth and advanced VAATE turbine engines.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Pulse Detonation Engine (and Laser Induced Thermal Acoustics Instrument).	2.424	0.000	0.000	0.000
(U)	In FY 2006: Worked to enhance capability to demonstrate detonation initiation techniques in an integrated test rig. Conducted test firings with multiple detonation initiation methods in parallel attempting to provide technology risk reduction and alleviate detonation initiation difficulties.				
(U)	In FY 2007: Not Applicable.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Research Institute for Environmental Studies.	0.000	1.992	0.000	0.000
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Accelerate the development and demonstration of a modular, portable wastewater treatment system that can meet EPA standards and can be deployed to forward bases within 24 hours.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: High Energy Laser for Detection Inspection and Non-Destructive Testing	0.000	2.690	0.000	0.000

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(U) B. Accomplishments/Planned Program ($ in Millions)

	FY 2006	FY 2007	FY 2008	FY 2009
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Develop high-energy laser techniques for use as a non-destructive technique for inspection of gas turbine engine components.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U) Total Cost	20.723	24.599	17.349	26.088

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

	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(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 21 process to harmonize efforts and eliminate duplication.										

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE **February 2007**

BUDGET ACTIVITY **02 Applied Research**

PE NUMBER AND TITLE **0602203F Aerospace Propulsion**

PROJECT NUMBER AND TITLE **3066 Turbine Engine Technology**

Cost ($ in Millions)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
3066 Turbine Engine Technology	33.107	42.568	51.506	83.546	76.501	46.558	40.753	41.676	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

Note: The funding in this project has been increased to provide emphasis on adaptive cycle technologies, increased fuel efficiency, and highly efficient embedded turbine engines. Funds for the Fiscal Year 2006 Congressionally-directed Notre Dame Center for Flow Physics and Control in the amount of $3.0 million were moved to PE 0601102F, Defense Research Sciences, from PE 0602203F, Aerospace Propulsion, for execution.

(U) A. Mission Description and Budget Item Justification

This 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, integrated power and thermal management systems, engine inlet integration, mechanical systems, and structural design. This project supports the Integrated Versatile Affordable Advanced Turbine Engine (VAATE) program, which is a joint DoD, NASA, and industry efforts to focus turbine propulsion technology on national needs. The program plan reflects the technology base support for VAATE activity applicable to global responsive strike, capable unmanned warfighting, tactical and global mobility, responsive space lift, and persistent Intelligence, Surveillance, and Reconnaissance. A portion of this project supports adaptive cycle technologies . This effort develops component technology for an adaptive cycle engine architecture that provides optimized performance/fuel efficiency for widely varying mission needs. A portion of the project supports the Energy Conservation - Assured Fuels Initiative. This effort identifies, develops and demonstrates technologies that enable the use of domestic fuel sources for military energy needs.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and high-pressure turbines) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports. Identify, develop and demonstrate technologies that enable the use of domestic fuel sources for military energy needs. Develop advanced concepts, designs, design rules, and computational tools to support component research and rig testing of components for an adaptive cycle engine. Develop advanced concepts, designs, design rules, and computational tools to support research and rig testing of component technologies to substantially improve specific fuel consumption by increasing overall pressure ratio and turbine rotor inlet temperature; by improving component efficiencies; and by reducing cooling air and pressure losses. Note: Increased funding in FY 2008 and out due to emphasis on increased fuel efficiency, adaptive cycle technologies, and highly efficient embedded turbine engines.	16.200	17.700	33.664	60.113

(U) In FY 2006: Developed and applied advanced modeling and simulation rules and tools for advanced components (high cycle fatigue, computational fluid dynamics, cycle analyses, propulsion system models, component life models, probabilistic models, etc.). Incorporated advanced materials systems into innovative designs (gamma titanium aluminides, metal matrix composites, ceramics, new metallic alloys, etc.). Developed and extended analytical methods to predict integrally bladed rotor and airfoil

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(U) B. Accomplishments/Planned Program ($ in Millions) FY 2006 FY 2007 FY 2008 FY 2009

durability, and damage tolerance. Conducted bench and rig tests of advanced components for validation, including an advanced metal foam heat exchanger.

(U) In FY 2007: Continue to develop and apply advanced modeling and simulation rules and tools for advanced components. Incorporate advanced materials into innovative designs and analyze Ceramic Matrix Composite (CMC) turbine blades, turbine vanes, and turbine rear frame. Design and analyze tiled turbine airfoil technology to reduce cooling flow and increase life. Design and demonstrate a very short, high efficiency afterburner concept. Conduct rig tests and design optimization of effective, durable, radiation barrier coatings to reduce the radiant heat loads on hot section components. Design, fabricate, and rig test fan/radial compressor internal aerodynamics, large radius rotating air seals, a low profile annular combustor, and a large-scale casting of fan/radial compressor.

(U) In FY 2008: Continue to develop and apply advanced modeling and simulation rules and tools for advanced components. Develop and optimize novel dual fuel burner. Determine suitability of latest Titanium Aluminide materials for Mach 4 compressor application. Develop and apply advanced modeling and simulation rules and tools to significantly improve component efficiencies, enabling reduced fuel consumption in emerging and future gas turbine propulsion systems. Develop and apply advanced modeling and simulation rules and tools to initiate definition and design of lightweight, simple, adaptive cycle features. Develop and apply advanced modeling and simulation rules and tools to initiate definition and design of an efficient, wide-flow range compressor. Develop and apply advanced modeling and simulation rules and tools to initiate definition and design of an efficient, very high pressure ratio compressor and associated thermal management features that will offer a step change improvement in engine SFC.

(U) In FY 2009: Continue to develop and apply advanced modeling and simulation rules and tools for advanced components. Conduct rig testing of advanced high pressure turbine vane and blade nano-laminate thermal barrier coating (TBC) applied. Begin to develop computational fluid dynamics methodology for analyzing turbine flows. Begin to develop CMC lifing models. Conduct bench and rig tests for validation of components with significantly improved efficiency. Conduct rig testing of lightweight, simple, adaptive cycle features, an efficient, wide-flow range compressor, an efficient, high temperature turbine capable of operating over large swings in required work, and an efficient, lightweight, LO-compatible exhaust system. Fabricate and rig test an efficient, very high pressure ratio compressor and associated thermal management features that will offer a step change improvement in engine SFC.

(U)

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		FY 2006	FY 2007	FY 2008	FY 2009
(U)	**B. Accomplishments/Planned Program ($ in Millions)**				
(U)	MAJOR THRUST: Develop turbofan/turbojet engine components (i.e., fans, low pressure turbines, engine controls, exhaust nozzles, and integration technologies) for turbofan/turbojet engines for fighters, bombers, sustained supersonic strike and hypersonic cruise vehicles, and transports.	10.311	11.000	12.486	16.524
(U)	In FY 2006: Developed and applied advanced modeling and simulation rules and tools for advanced components (high cycle fatigue, computational fluid dynamics, cycle analyses, propulsion system models, component life models, probabilistic models, etc.). Applied advanced materials systems to innovative designs (gamma titanium aluminides, metal matrix composites, ceramics, advanced metallic alloys, etc.). Developed new and innovative design concepts, and conducted bench and rig tests of advanced components for validation.				
(U)	In FY 2007: Identify and quantify sources of variability and uncertainty affecting turbine blade durability performance (oxidation, creep, thermal material fatigue, high cycle fatigue, etc.). Apply advanced materials systems to innovative designs to determine wear reduction, improve load capacity, and increase temperature capability of five centi-stokes oil and to assess aerodynamics, operability, aeromechanics, and acoustic characteristics of a counter-rotating fan-on-blade (FLADE) concept. Conduct design optimization for turbine blade microcircuit cooling. Test pilot and fuel injection concepts in a single-flameholder rig to evaluate fundamental capabilities.				
(U)	In FY 2008: Continue to develop and apply advanced modeling and simulation rules and tools for advanced components. Conduct risk reduction testing of variable bypass ratio fan concept. Develop and rig test reheat augmentor technology to significantly decrease burning length. Design and fabricate an advanced lightweight, variable area exhaust nozzle.				
(U)	In FY 2009: Continue to develop and apply advanced modeling and simulation rules and tools for advanced components. Develop durable damping/erosion coating systems. Conduct rig testing of advanced fan design for application to a variable cycle engine concept.				
(U)					
(U)	MAJOR THRUST: Develop limited life engine components for missile and unmanned air vehicle applications, including long-range supersonic and hypersonic vehicles. These efforts enable engines with reduced cost, reduced fuel consumption, and increased specific thrust, thereby greatly expanding the operating envelopes of missiles and unmanned vehicles.	3.278	3.530	3.969	5.188
(U)	In FY 2006: Completed conceptual design of an advanced versatile and affordable high-pressure core and low-pressure component configurations for expendable engines using rub tolerant ceramic blades to meet the small engine performance and cost reduction objectives. Applied advanced materials to innovative designs and analyze a slinger-fed, dual-fuel compact recirculation combustor (CRC).				

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		FY 2006	FY 2007	FY 2008	FY 2009
(U)	**B. Accomplishments/Planned Program ($ in Millions)**				
	Developed and applied advanced modeling and simulation rules and tools for advanced components (i.e., high cycle fatigue (HCF), computational fluid dynamics (CFD), cycle analyses, propulsion system models, component life models, probabilistic models, etc.). Completed detailed design, computational fluid dynamics, and performed analyses for a fuel-cooled turbine. Developed new and innovative design concepts, and conducted bench and rig tests of advanced components for validation.				
(U)	In FY 2007: Rig test a slinger-fed, dual-fuel CRC. Continue to develop and apply advanced modeling and simulation rules and tools for advanced components (i.e., high cycle fatigue, computational fluid dynamics, cycle analyses, propulsion system models, component life models, probabilistic models, etc.). Rig test a fuel-cooled turbine. Design and analyze a five-stage forward swept compressor.				
(U)	In FY 2008: Utilize data from high speed turbine engine testing of a wide-range, lightweight carbon-carbon variable area exhaust nozzle and a compact, carbon-carbon ramburner to update and validate advanced modeling and simulation rules and tools.				
(U)	In FY 2009: Utilize data from high speed turbine engine testing of a fuel cooled turbine and a slinger-fed, dual-fuel CRC to update and validate advanced modeling and simulation rules and tools.				
(U)					
(U)	MAJOR THRUST: Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports.	1.088	1.173	1.387	1.721
(U)	In FY 2006: Developed and applied advanced modeling and simulation rules and tools for advanced components (i.e., HCF, CFD, cycle analyses, propulsion system models, component life models, probabilistic models, etc.). Completed conceptual design of advanced versatile and affordable high-pressure core engine component configurations for turboshaft/turboprop engines to meet the small engine performance and cost reduction objectives. Applied advanced materials systems to design and analyze a high heat release combustor. Developed new and innovative design concepts and conducted bench and rig tests of advanced components for validation.				
(U)	In FY 2007: Continue to develop and apply advanced modeling and simulation rules and tools for advanced components. Apply advanced materials systems to innovative designs and analyze a nano-laminate thermal barrier coating. Develop new and innovative design concepts and conduct bench and rig tests for validation of a high heat release combustor design and an advanced forward swept, centrifugal compressor design.				
(U)	In FY 2008: Develop new and innovative design concepts and conduct bench and rig tests for validation of a mixed flow turbine design.				
(U)	In FY 2009: Utilize data from efficient small scale engine testing of an advanced forward swept,				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
centrifugal compressor and a silicon nitride mixed flow turbine to update and validate advanced modeling and simulation rules and tools.				
(U)				
(U) CONGRESSIONAL ADD: VAATE TMC FLADE Technology Demonstration (formerly VAATE-Titanium Matrix Composites).	1.745	1.096	0.000	0.000
(U) In FY 2006: Utilized previous Titanium Matrix Composites (TMC) modeling predictions to evaluate design options for a TMC advanced fan blisk for application to a variable cycle engine.				
(U) In FY 2007: Continue development of Titanium Matrix Composites for advanced turbine engine components.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Intelligent Engine Software Development for Advanced Turbine Engines.	0.485	0.000	0.000	0.000
(U) In FY 2006: Developed a generic, model-based reasoning software product that includes the model representation and implementation process, as well as the generic reasoning algorithm suite that can traverse the model for ground-based troubleshooting and fault isolation applications. Developed specific modeling toll interfaces that allow the generic reasoning algorithms to work with different modeling approaches and data structure, such as the DSI eXpress model that is currently used in various Air force programs. Conducted research related to P-SAR and Multi-service implementations. Developed and implemented an automated learning process and algorithm suite that will allow the fault/failure mode and maintenance task reasoners to improve over the life cycle of the product. Selected and developed a specific engine model for use with the reasoning algorithms.				
(U) In FY 2007: Not Applicable.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Active Combustion Control System for Military Aircraft.	0.000	3.885	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Develop advanced Active Combustion Control System (ACCS) components for use in ongoing and future engine development programs.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
(U)				
(U) CONGRESSIONAL ADD: Active Combustion Control Systems for Military Aircraft.	0.000	1.793	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Develop advanced active combustion control system components for use in ongoing and future engine development programs.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Advanced Affordability Assurance Tools for the Versatile Affordable Advanced Turbine Engine (VAATE) Initiative.	0.000	0.996	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Develop state-of-the-art computer software tools that will estimate development, production, and maintenace costs for advanced technology turbine engines.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Intelligent Engine Technology Development for UAVs.	0.000	1.395	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Develop turbine engine life management software to reduce overall engine maintenance costs.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U) Total Cost	33.107	42.568	51.506	83.546

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

	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Materials:										
(U) PE 0601102F, Defense Research Sciences.										
(U) PE 0602102F, Materials.										
(U) PE 0603216F, Aerospace Propulsion and Power										

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

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 21 process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

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BUDGET ACTIVITY **02 Applied Research**

PE NUMBER AND TITLE **0602203F Aerospace Propulsion**

PROJECT NUMBER AND TITLE **3145 Aerospace Power Technology**

Cost ($ in Millions)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
3145 Aerospace Power Technology	45.414	44.595	30.784	31.125	35.072	34.205	33.314	34.066	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

Note: Funds for the FY 2006 Congressionally-directed Lightweight Photovoltaic Electricity and Hydrogen for Portable, On-Demand Power for Defense Applications in the amount of $1.0 million were moved to PE 0602601F, Space Technology, from PE 0602203F, Aerospace Propulsion, for execution. Funds for the FY 2006 Congressionally-directed Advanced Energy Technology for Munitions - Dominator Program in the amount of $2.8 million were moved to PE 0602203F, Aerospace Propulsion, from PE 0602602F, Conventional Munitions, for execution.

(U) A. Mission Description and Budget Item Justification

This project develops electrical and thermal management technologies for military aerospace applications. Power component technologies are developed to increase reliability, maintainability, commonality, affordability, and supportability of aircraft and flight line equipment. Research is conducted in energy storage and hybrid power system technologies to enable special purpose applications. Electrical power and thermal management technologies enable all future military directed energy weapon systems. This project supports development of electrical power and thermal management component and systems suitable for applications to legacy and future aircraft platforms including strike and mobility concepts. Lightweight power systems suitable for other aerospace applications are also developed.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Develop electrical power and thermal management component and subsystem technologies for manned and unmanned aircraft systems. These technologies improve aircraft range, self-sufficiency, reliability, maintainability, and supportability, while reducing life cycle costs and enabling new capabilities. Develop hybrid electrical power and thermal management, including energy conversion/storage, components and subsystem technologies for special purpose applications enabling long endurance missions. Note: Increased funding in FY 2008 due to emphasis on component development in support of electric hybrid special programs.	11.053	11.614	16.531	17.345

(U) In FY 2006: Developed next generation solid state lithium-based electrolyte and developed thin film cells with high voltage battery cathodes. Performed system design and analysis and developed breadboard of a high power fuel cell for manned and unmanned vehicles.

(U) In FY 2007: Fabricate and characterize next generation solid state lithium-based thin film cells. Complete testing of an advanced switched reluctance machine controller. Complete preliminary aircraft thermal management studies and identify high efficiency design candidates.

(U) In FY 2008: Develop and design high efficiency, high power, high temperature power electrical components. Develop and test air vehicle electromagnetic and radio frequency effects immune components. Design and fabricate thermal management components and subsystems. Initiate studies, modeling & simulation, and develop preliminary designs for energy harvesting and energy dense, long endurance battery and fuel cell components and subsystems. Develop and test rechargeable/refuelable,

Exhibit R-2a, RDT&E Project Justification		DATE February 2007
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	B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
	lightweight, energy dense, high power hybrid battery, fuel cell and power management components and subsystems.				
(U)	In FY 2009: Fabricate, integrate, and test high efficiency, high power, high temperature power electrical components. Initiate integration and test air vehicle electromagnetic and radio frequency effects immune components. Integrate and test thermal management components and subsystems. Integrate and initiate subsystems test of flight-weight, efficient, energy harvesting, hybrid battery and fuel cell components.				
(U)					
(U)	MAJOR THRUST: Develop electrical power and thermal management, energy conversion/storage and power conditioning components, and subsystem technologies for aerospace applications. Note: In FY 2007, this activity will be completed.	4.146	3.997	0.000	0.000
(U)	In FY 2006: Completed testing a silicon carbide packaging concept for power electronic device development. Scaled-up sub-scale spray cooling flight tests to ten kilowatt (kW) and expanded modeling efforts to support the scale-up. Developed flight experiment for two-phase active thermal management system.				
(U)	In FY 2007: Complete scale-up, modeling efforts and flight tests of ten kW spray cooling technology.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	MAJOR THRUST: Develop lightweight electrical power and thermal management component and subsystem technologies with low volume displacement to enable delivery of high power for operation of directed energy weapons.	14.020	14.638	14.253	13.780
(U)	In FY 2006: Developed conductor configuration, tested, and delivered a coil of alternating current tolerant high temperature superconducting material. Initiated preliminary design of high rate lithium-ion (liquid) battery system for directed energy applications. Completed design of proof-of-concept superconducting generator and began fabrication.				
(U)	In FY 2007: Continue design of high rate lithium-ion (liquid) battery system for directed energy applications. Complete fabrication and begin testing proof-of-concept superconducting generator.				
(U)	In FY 2008: Develop and initiate design of a flight-weight superconducting generator, high rate charge/discharge energy storage and high voltage/current components and subsystems. Develop concept designs for superconducting multimegawatt generator.				
(U)	In FY 2009: Complete design and fabrication of superconducting generator, energy storage and				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
conditioning components and subsystems.				
(U)				
(U) CONGRESSIONAL ADD: Cell-Level Battery Control.	0.970	0.000	0.000	0.000
(U) In FY 2006: The individual Application Specific Integrated Circuits and controller were integrated with Li-ion batteries to form a new power supply for the Battlefield Air Operations (BAO) kit. This technology could also be applied to fighter aircraft or for Unmanned Aerial Vehicles (UAV) batteries.				
(U) In FY 2007: Not Applicable.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Center for Security of Large-Scale Systems.	1.358	0.000	0.000	0.000
(U) In FY 2006: Developed optimization strategies, prognostics, and health monitoring (PHM) systems for military platforms. Applied Distributed Heterogeneous Optimization (DHO) and PHM to prospective military platforms with specific focus on near-space vehicles and more-electric power-optimized aircraft. Conducted tests and used prototype hardware to validate DHO and PHM strategies.				
(U) In FY 2007: Not Applicable.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Integrated Power and Aircraft Technologies.	5.139	0.000	0.000	0.000
(U) In FY 2006: Developed and demonstrated an integrated power unit (IPU) as a multi-function turbogenerator with maximized power density (kW/ft3) and minimized logistics requirements. Designed and demonstrated an engine-internal generator(s) for propulsion engines for an unmanned aircraft. Developed technologies for superconducting generators of 1-5 Megawatt (MW) power range with minimized size/weight requirements for a generator and its cryocooling subsystem. Developed technologies and dynamic models of a 1-5 MW pulse-power generation system for a directed energy application, with a conventional generator as the power source. Developed simulations and models of this 1-5 MW pulse power system in an aircraft-installed configuration to identify energy flow and thermal management requirements as well as benefits in utilizing recent thermal management technologies. Designed, built, and demonstrated various components supporting an "all-electric engine" that does not require an external gearbox drive or its accessories.				
(U) In FY 2007: Not Applicable.				

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		FY 2006	FY 2007	FY 2008	FY 2009
(U)	**B. Accomplishments/Planned Program ($ in Millions)**				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: High Flux ESC System with TES for Military High Energy Laser.	1.261	1.096	0.000	0.000
(U)	In FY 2006: Developed spray cooling technology critical for cooling high heat flux tactical lasers on space and air vehicles. Evaluated scalability and reliability of the evaporative spray cooling thermal management system. Scaled TMS to cool up to 30 kW of waste heat with an energy storage capacity of 2 Megajoules. Designed and evaluated cooling system to operate in harsh environmental conditions such as variable gravity and extreme temperatures.				
(U)	In FY 2007: Continue development of evaporative spray cooling techniques for cooling high heat flux tactical lasers.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Affordable Lightweight Power Supply Development.	1.745	0.996	0.000	0.000
(U)	In FY 2006: Demonstrated a novel membrane electrode assembly (MEA) employing advanced electrolyte and/or catalysts with vastly superior performance compared to conventional MEA's at high temperatures and low relative humidity. Further developed these components to improve longevity and mechanical integrity under harsh operating conditions. Constructed and tested MEA's of various sizes and short-stack fuel cells with enhanced performance that lead to improved power density, reduction in cost per kW of power and the utilization of high energy fuels.				
(U)	In FY 2007: Continue to develop alternative high performance electrolytes and low-cost MEA's, which are capable of operating at high temperatures, zero or reduced humidities and which enable decreased system complexity and improved utilization of high energy fuels.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: MEPS (Multimegawatt Electric Power System) Thermal Management.	1.358	1.295	0.000	0.000
(U)	In FY 2006: Performed trade studies that investigate the possible thermal management approaches to the removal of heat from a high power microwave and the subsequent elimination of this heat from the airborne weapon/power system. Performed a sub-scale thermal management demonstration of the heat removal technique. Developed a technique that prevents over-temperature damage from occurring to the				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
microwave device in the event that the cooling technique ceases to function properly.				
(U) In FY 2007: Continue the development of a multimegawatt electric power system.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Chemical Hydride Power System (formerly Portable Power Solution Employing Chemical Hydrides).	1.649	2.491	0.000	0.000
(U) In FY 2006: Aided transition of the fuel cell power unit to the Battlefield Renewable Integrated Tactical Energy System (BRITES) through continued refinement of the energy storage cartridge. Various aspects of the cartridge performance were examined with respect to orientational dependence, ruggedness, and cost effectiveness. Multiple cartridges were constructed and evaluated and a detailed analysis of their performance and reliability was presented. Additionally, advanced methodologies for increasing cartridge energy density were explored. In particular, non-aqueous fuel hydrolysis was examined.				
(U) In FY 2007: Further develop the technologies necessary to improve the reliability and compactness of chemical hydride replacement cartridges for Airman portable power systems.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Advanced Energy Technology for Munitions - Dominator Program	2.715	1.295	0.000	0.000
(U) In FY 2006: Developed lightweight fuel cell stack materials to increase system power density. Additional goalsinclude development of lightweight recuperators, heat exchanges, and cathode air blowers. Advanced fuel processing catalysts that are capable of logistic fuel operability were also studied.				
(U) In FY 2007: Continue development of a compact, flight weight solid oxide fuel cell based power system for the Area Dominator munition.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Integrated Electrical Starter/Generator	0.000	0.996	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Develop technologies necessary to raise the technology readiness level of integral				

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
	starter/generators. Efforts will include a detailed design of a production-configuration Inverter-Converter Controllers (ICCs).				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Manufacturing of High Energy Superior Lithium Battery Technology	0.000	5.181	0.000	0.000
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Develop the Superior Lithium Polymer Battery (SLPB) technology for a 5, 28 and 270 VDC advanced military aircraft battery with a goal cycle life equal to 5000 cycles at 80 percent Depth of Discharge.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Military Purpose Electrolyte Supported Fuel Cells	0.000	0.996	0.000	0.000
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Develop high power dense advanced solid oxide fuel cell stack technology for UAV applications. Specific objectives include stack scale-up, internal reformation development, and system modeling.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)	Total Cost	45.414	44.595	30.784	31.125

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

	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(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										

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

Science and Technology.

(U) PE 0603605F, Advanced Weapon Technology.

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

(U) This project has been coordinated through the Reliance 21 process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

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BUDGET ACTIVITY **02 Applied Research**

PE NUMBER AND TITLE **0602203F Aerospace Propulsion**

PROJECT NUMBER AND TITLE **33SP Space Rocket Component Tech**

Cost ($ in Millions)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
33SP Space Rocket Component Tech	0.000	58.085	46.819	45.915	48.989	49.192	48.478	49.494	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

Note: In FY 2007, efforts were transferred from PE 0602500F, Multi-Disciplinary Space Technology, Project 5026, Rocket Propulsion Component Tech, and Project 5027, High Speed Airbreathing Propulsion Technologies, to this Project in order to more effectively manage and provide oversight of the efforts. In FY 2007, Project 3012, Advanced Propulsion Technology, absorbed the efforts of a thrust from Project 33SP, Space Rocket Component Technology, in order to more effectively manage cooperative Combined Cycle Engine (CCE) developments.

(U) A. Mission Description and Budget Item Justification

This project develops advances in rocket propulsion technologies for space access, space maneuver, tactical and ballistic missiles. Analytical and experimental areas of emphasis are propellants, propellant management, combustion, rocket material applications, Technology for Sustainment of Strategic Systems (TSSS) Phase 1, and novel space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of future space and missile launch subsystems. 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 contribute to the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program, a joint Department of Defense, NASA, and industry effort to focus rocket propulsion technology on national needs. This project also develops revolutionary, airbreathing, hypersonic propulsion technology options to enable affordable, on demand access to space for the Air Force. The short-term focus is on hydrocarbon fueled engines capable of operating over a broad range of Mach numbers and longer term focus will be on hydrogen fueled scramjet powered engines that can enable the higher Mach numbers to achieve access to space. Technologies developed under this program enable capabilities of interest to both the Department of Defense and the NASA. Efforts include modeling and simulation, proof of concept tests of critical components, advanced component development, and ground-based tests.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Develop, characterize, and test advanced hydrocarbons, energetics, solid propellant ingredients, and reduced-toxicity monopropellants to increase space launch payload capability and refine new propellants synthesis methods. Efforts include evaluation and development of reduced-toxicity ionic salt, high-energy-density oxidizers, nano-materials, catalyst, and polymeric binders; development of supporting computational tools; determining optimized paths for incorporating these materials into propellants; and for selected propellants perform laboratory and demonstrator engine evaluations. Efforts seek monopropellants with performance equivalent to bipropellants that reduce the cost of space access and space operations. Phases are referring to the IHPRPT program phases.	0.000	3.602	3.989	4.581

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Further downselect and continue scaling-up promising high energy-density materials candidates. Evaluate scaled-up and new selected propellants in advanced combustion devices to determine materials compatibility and performance to include supporting large-scale motor tests.

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
Continue to model and analyze advanced propulsion concepts with enhanced performance and reliability such as rocket-based combined cycle engines.				
(U) In FY 2008: Initiate evaluation and development of potential hydrocarbon fuel additives to improve performance of kerosene. Continue downselect process and continue scaling-up promising high energy-density materials candidates. Develop new high engergy-density, high nitrogen ingredients. Develop proof of concept for new computational code to predict molecular properties of propellant ingredients. Evaluate scaled-up propellants in advanced combustion devices to determine materials compatibility and performance to include supporting large-scale motor tests. Continue exploration and development of ionic liquids meeting Phase III goals.				
(U) In FY 2009: Continue evaluation and development of potential hydrocarbon fuel additives to improve performance of kerosene. Continue downselect process and continue scaling-up promising high energy-density materials candidates. Continue development and characterization of high nitrogen ingredients. Evaluate scaled-up propellants in advanced combustion devices to determine materials compatibility and performance to include supporting large-scale motor tests. Continue exploration and development of ionic liquids meeting Phase III goals. Initiate scale up of promising ionic liquids for further characterization. Continue proof of concept for new computational code to predict molecular properties.				
(U)				
(U) MAJOR THRUST: Develop advanced liquid engine combustion technology for improved performance, while preserving chamber lifetime and reliability needs for engine uses in heavy lift space vehicles. Efforts include modeling and analyzing advanced propulsion concepts with enhanced performance and reliability such as aerovehicles and potential launch systems. Phases are referring to the IHPRPT program phases.	0.000	7.861	8.126	6.003
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Continue to characterize, study, and evaluate shear coaxial injector performance to ensure chamber/injector compatibility and prevent damage to upper stage engines. Continue to develop, analyze, and transition advanced combustion device technology, including injectors and chambers suitable for advanced synthetic hydrocarbon fuels capable of meeting or exceeding the Phase III goals. Develop improved understanding of fundamental combustion and fluid flow/heat transfer processes leading to new methodologies for thermal management, scaling, and combustion instabilities in hydrocarbon fueled liquid rocket engines, reducing the need for conducting large numbers of costly				

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(U) B. Accomplishments/Planned Program ($ in Millions) FY 2006 FY 2007 FY 2008 FY 2009

full-scale component and engine tests. Develop, scale-up, and transition new energetic advanced hydrocarbon fuels and additives for rocket propulsion, including space storable high energy, non-toxic fuels.

(U) In FY 2008: Characterize, study, and evaluate shear coaxial injector performance to ensure chamber/injector compatibility and prevent damage to upper stage engines. Develop, analyze, and transition advanced combustion device technology, including injectors and chambers suitable for advanced synthetic hydrocarbon fuels capable of meeting or exceeding the Phase III goals. Develop improved understanding of fundamental combustion and fluid flow/heat transfer processes leading to new methodologies for thermal management, scaling, and combustion instabilities in hydrocarbon fueled liquid rocket engines, reducing the need for conducting large numbers of costly full-scale component and engine tests. Develop scale-up, and transition new energetic advanced hydrocarbon fuels and additives for rocket propulsion, including space storable high energy, non-toxic fuels. Conduct validation and verification of advanced multi-phase modeling and simulation (M&S) capabilities. Perform pre-selection of most promising advanced propulsion concepts; apply realistic computational models to optimize performance. Continue and refine experimental demonstrations of proof-of-concepts, continue development of realistic computational models. Continue system trade studies with improved performance models to evaluate potential return on investment.

(U) In FY 2009: Characterize, study, and evaluate shear injector performance to ensure chamber/injector compatibility and prevent damage to engines. Develop, analyze, and transition advanced combustion device technology, including injectors and chambers capable of meeting or exceeding the Phase III goals. Develop improved understanding of fundamental combustion and fluid flow/heat transfer processes leading to new methodologies for thermal management, scaling, and combustion instabilities in hydrocarbon fueled liquid rocket engines, reducing the need for conducting large numbers of costly full-scale component and engine tests. Develop, scale-up, and transition new energetic advanced hydrocarbon fuels and additives for rocket propulsion, including space storable high energy, non-toxic fuels. Evaluate novel nozzle cooling channels for use with hydrocarbon fuels in the high heat flux test rig. Conduct validation and verification of advanced M&S capabilities. Perform pre-selection of most promising advanced propulsion concepts; apply realistic computational models to optimize performance. Continue and refine experimental demonstrations of proof-of-concepts, continue development of realistic computational models. Continue system trade studies with improved performance models to evaluate potential return on investment.

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
(U)				
(U) MAJOR THRUST: Develop advanced material applications for lightweight components and material property enhancements for use in advanced combustion devices and propulsion systems for current and future rocket propulsion systems.	0.000	5.513	5.932	6.713
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Continue developing new advanced ablative components using hybrid polymers. Continue to characterize and finalize processing parameters of new nano-reinforced high temperature polymers and scale-up processing of carbon-carbon materials. Continue developing new advanced materials for use with high-energy propellants. Continue to explore using nanocomposites for liquid rocket engine tanks and optimize processing technology using multifunctional nanomaterials.				
(U) In FY 2008: Continue developing new advanced ablative components using hybrid polymers. Continue to characterize and finalize processing parameters of new nano-reinforced high temperature polymers and scale-up processing of carbon-carbon materials. Continue developing new advanced materials for use with high-energy propellants. Continue to explore using nanocomposites for liquid rocket engine components and optimize processing technology using multifunctional nanomaterials. Evaluate new class of hydrophobic and oleophobic materials.				
(U) In FY 2009: Continue developing new advanced ablative components using hybrid polymers. Continue to characterize and finalize processing parameters of new nano-reinforced high temperature polymers and scale-up processing of carbon-carbon materials. Continue developing new advanced materials for use with high-energy propellants. Continue to explore using nanocomposites for liquid rocket engine components and optimize processing technology using multifunctional nanomaterials. Continue to characterize and understand the mechanisms behind a new class of hydrophobic and oleophobic materials.				
(U)				
(U) MAJOR THRUST: Develop advanced liquid engine technologies for improved performance, while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles.	0.000	25.244	22.533	21.179
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Continued advance modeling and simulation tool development for advanced cryogenic liquid rocket upper stage technologies. Continue development of advanced cryogenic upper stage technologies - turbopumps and thrust chambers. Evaluate third set of potential hydrocarbon fuels and adjust/modify/ develop fuel characterization test rig. Complete development of second concept for				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
lightweight nozzles for liquid rocket engines. Start hydrocarbon boost technology development for future spacelift concepts including materials scale-up efforts to improve life and weight of the liquid engine components.				
(U) In FY 2008: Complete advance modeling and simulation tool development for advanced cryogenic liquid rocket upper stage technologies. Continue enabling hydrocarbon boost technology development for future spacelift concepts. Initiate engine health monitoring effort supporting the hydrocarbon boost technology development effort. Also initiate Phase III efforts developing hydrocarbon engine technologies using fuels other than kerosene.				
(U) In FY 2009: Continue enabling hydrocarbon boost technology development for future spacelift concepts. Develop engine health monitoring technologies supporting the hydrocarbon boost technology development effort. Develop advanced hydrocarbon engine technologies using fuels other than kerosene that address Phase III goals.				
(U)				
(U) MAJOR THRUST: Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for stationkeeping, repositioning, and orbit transfer for large communication satellites, microsatellites, and satellite constellations. Phases are referring to the IHPRPT program phases.	0.000	6.660	6.239	7.439
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Continue Hall thruster Phase III development efforts. Continue evaluating Phase III plasma thrusters for microsatellites propulsion systems. Initiate scale-up testing Phase III monopropellants. Initiate assessment of advanced chemical propulsion technology developments for satellite thrusters. Initiate development of advanced multi-mode chemical-electric propulsion concepts for satellites.				
(U) In FY 2008: Continue Hall thruster Phase III development efforts. Continue evaluating Phase III plasma thrusters for microsatellites propulsion systems. Continue scale-up testing Phase II and III monopropellants. Continue assessment of advanced chemical propulsion technology developments for satellite thrusters. Continue development of advanced multi-mode chemical-electric propulsion concepts for satellites. Initiate development of alternative propulsion concepts and associated modeling, simulation, and analysis tools to augment or replace Hall Thrusters in the future.				
(U) In FY 2009: Continue Hall thruster Phase III development efforts. Continue evaluating Phase III plasma thrusters for microsatellites propulsion systems. Continue scale-up testing Phase II and III monopropellants, evaluate advanced ingnition schemes and chamber concepts. Continue assessment of				

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(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
advanced chemical propulsion technology developments for satellite thrusters, begin component developments. Continue development of advanced multi-mode chemical-electric propulsion concepts for satellites, down-select to single design concept and begin component developments. Initiate development of alternative propulsion concepts and associated modeling, simulation, and analysis tools to augment or replace Hall Thrusters in the future.				
(U)				
(U) MAJOR THRUST: Conduct assessments, design trades, and simulations to integrate combined cycle engines (CCEs) and advanced cycle airbreathing hypersonic propulsion technologies in support of the development of affordable, on-demand access to space vehicles to meet future warfighter needs. Note: In FY 2008, this effort will transfer within this PE to Project 623012, Advanced Propulsion Technologies, to consolidate and better manage this cooperative CCE effort.	0.000	0.239	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Conduct trade studies to determine military payoff and establish component technology goals. Continue to define new component and engine performance objectives to enable development of affordable hypersonic CCEs.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Advanced Liquid Rocket Booster Technology.	0.000	1.395	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Develop hydrocarbon boost rocket engine technologies for the Air Force.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Advanced Vehicle and Propulsion Center.	0.000	3.188	0.000	0.000
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Perform technical support and analysis for the Prompt Global Strike Analysis of Alternatives (AoA). Conduct facility upgrades to support upcoming testing which support planning efforts for Land-based Strategic Deterrent and Operationally Responsive Spacelift activities.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				

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(U) B. Accomplishments/Planned Program ($ in Millions)

	FY 2006	FY 2007	FY 2008	FY 2009
(U) CONGRESSIONAL ADD: Engineering Tool Improvement Program (ETIP) Note: In FY 2006, this add was found in PE 0602500F, Multi-Disciplinary Space Technology, Project 5026, Rocket Propulsion Component Technology. In FY 2007, this add was titled Engineering Tool Improvement Program (ETIP) and transferred from PE 0602500F, Multi-Disciplinary Space Technology, Project 5026, Rocket Propulsion Component Technology to better manage development efforts.	0.000	2.789	0.000	0.000
(U) CONGRESSIONAL ADD: Methane Second Stage Rocket Engine.	0.000	1.594	0.000	0.000
(U) Total Cost	0.000	58.085	46.819	45.915

(U) In FY 2006: Not Applicable.
(U) In FY 2007: Develop advanced rocket engine modeling, simulation, and analysis tools for propulsion and integrating them into seamless suite of tools for scientists and engineers to use in developing advanced propulsion technologies.
(U) In FY 2008: Not Applicable.
(U) In FY 2009: Not Applicable.

(U) In FY 2006: Not Applicable.
(U) In FY 2007: Develop liquid oxygen, liquid methane pressure fed second stage rocket engine technologies for the Air Force.
(U) In FY 2008: Not Applicable.
(U) In FY 2009: Not Applicable.

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

	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Not Applicable.										

(U) D. Acquisition Strategy

Not Applicable

Exhibit R-2a, RDT&E Project Justification

DATE **February 2007**

BUDGET ACTIVITY **02 Applied Research**

PE NUMBER AND TITLE **0602203F Aerospace Propulsion**

PROJECT NUMBER AND TITLE **4847 Rocket Propulsion Technology**

Cost ($ in Millions)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
4847 Rocket Propulsion Technology	35.244	18.985	10.719	9.081	11.758	11.871	12.122	12.430	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

This project develops technologies for the sustainment of strategic systems (including solid boost/missile propulsion, post boost control, aging and surveillance efforts) and tactical rockets. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of these systems. Technologies are being accomplished in two phases and are developed to reduce the weight by 15 percent (Phase I)/20 percent (Phase II) and cost of components 25 percent (Phase I)/35 percent (Phase II) through the use of new materials, and improving designs and manufacturing techniques. Aging and surveillance efforts could reduce lifetime prediction uncertainties for individual motors by 50 percent, enabling motor replacement for cause (Phase II). All efforts in this project are part of the Technology for the Sustainment of Strategic Systems program and support the Integrated High Payoff Rocket Propulsion Technology program.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Develop missile propulsion and boost technologies for tactical and ballistic missile systems. Efforts support the Technology for the Sustainment of Strategic Systems program - Phase II. Note: Decreased funding in FY 2008 and out due to post boost control system component technology maturation and effort completions.	10.292	12.003	8.229	5.096

(U) In FY 2006: Enhanced component development and risk reduction efforts for the Phase II ballistic missile technology demonstration. Developed rapid densification nozzle technology using improved strategic propellants for future ballistic missiles to enhance performance and weight. Demonstrated low-cost, high temperature, non-erosive, lightweight coated carbon-carbon ceramic and hybrid polymer components for solid rocket motors. Formulated and characterized new propellant formulations using new fuels and oxidizers developed over the last couple of years for the next phase of advanced solid propulsion. Developed the modeling and simulation tool for solid rocket motors to be used in developing components for the TSSS Phase II Missile Propulsion Demonstration. Developed advanced tactical propulsion technologies.

(U) In FY 2007: Initiate component development and risk reduction efforts for the Phase II Missile Propulsion demonstration. Verify development of rapid densification nozzle technology using improved strategic propellants for future ballistic missiles to enhance performance and weight. Continue demonstrating low-cost, high temperature, non-erosive, lightweight coated carbon-carbon, ceramic and hybrid polymer components for solid rocket motors. Continue development of advanced tactical propulsion technologies. Complete formulation and characterization of new propellant formulations using new fuels and oxidizers developed over the last couple of years for the next phase of advanced

Exhibit R-2a, RDT&E Project Justification		DATE February 2007
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT NUMBER AND TITLE 4847 Rocket Propulsion Technology

(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
solid propulsion. Conduct sub-scale tests to characterized and validate physics in rocket motor environments and incorporate into modeling and simulation tool developments for solid rocket motors to be used in developing components for the Phase II Missile Propulsion Demonstration.				
(U) In FY 2008: Continue component development and risk reduction efforts for the Phase II Missile Propulsion demonstration. Conduct sub-scale testing of rapid densification nozzle technology using improved strategic propellants for future ballistic missiles to enhance performance and weight. Continue demonstrating low-cost, high temperature, non-erosive, lightweight coated carbon-carbon, ceramic and hybrid polymer components for solid rocket motors. Complete modeling, simulation, and analysis tool development efforts. Continue development of advanced tactical propulsion technologies.				
(U) In FY 2009: Continue component development and risk reduction efforts for the Phase II Missile Propulsion demonstration. Complete verification development of rapid densification nozzle technology using improved strategic propellants for future ballistic missiles to enhance performance and weight. Continue demonstrating low-cost, high temperature, non-erosive, lightweight coated carbon-carbon, ceramic and hybrid polymer components for solid rocket motors. Down-select final sub-scale components, begin fabrication for sub-scale testing in FY 2010. Components will then be feed into upcoming Missile Propulsion Demo for scale-up and demonstration. Continue development of advanced tactical propulsion technologies.				
(U)				
(U) MAJOR THRUST: Develop missile propulsion technologies and aging and surveillance technologies for ballistic missile. Efforts support the Technology for the Sustainment of Strategic Systems program Phase II. Note: In FY 2007, this activity ramps up as it begins fabrication and testing of multiple demonstrator subsystems supporting future demonstrations across FY 2008 and beyond.	1.388	3.296	2.490	3.985
(U) In FY 2006: Completed analysis of existing sensor technologies for use in assessment of ballistic missile aging characteristics and status. Identified and evaluated existing and advanced sensors that can be embedded or attached to solid rocket motors. Developed the aging and surveillance models and tools necessary to translate and integrate sensor data into existing aging and surveillance tool suite.				
(U) In FY 2007: Continue advanced service life prediction technology program developing and applying existing and advanced sensors that can be embedded or attached to solid rocket motors and the aging and surveillance models and tools that can translate and integrate the sensor data into existing aging and surveillance tool suite.				
(U) In FY 2008: Continue advanced service life prediction technology program developing and applying existing and advanced sensors that can be embedded or attached to solid rocket motors and the aging				

Exhibit R-2a, RDT&E Project Justification		DATE February 2007
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT NUMBER AND TITLE 4847 Rocket Propulsion Technology

(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2006	FY 2007	FY 2008	FY 2009
and surveillance models and tools that can translate and integrate the sensor data into existing aging and surveillance tool suite.				
(U) In FY 2009: Complete advanced service life prediction technology program developing and applying existing and advanced sensors that can be embedded or attached to solid rocket motors and the aging and surveillance models and tools that can translate and integrate the sensor data into existing aging and surveillance tool suite. Begin efforts to integrate advanced aging and surveillance technologies into demonstrations to validate and verify efforts to reduce uncertainties and accurately model motor behavior.				
(U)				
(U) CONGRESSIONAL ADD: Advanced Vehicle and Propulsion Center (AVPC).	4.170	0.000	0.000	0.000
(U) In FY 2006: Performed technical support and analysis for the Prompt Global Strike Analysis of Alternatives (AoA). Conducted facility upgrades, which supported testing for planning efforts related to Land-based Strategic Deterrent and Operationally Responsive Spacelift activities.				
(U) In FY 2007: Not Applicable.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: Jet and Rocket Engine Test Site (JRETS) testing at San Bernardino International Airport.	17.454	0.000	0.000	0.000
(U) In FY 2006: Upgraded JRETS test capabilities to a fully operational status in support of government and commercial jet and rocket engine test programs.				
(U) In FY 2007: Not Applicable.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				
(U) CONGRESSIONAL ADD: High Regression Rate Hybrid Rocket Fuels.	0.970	0.000	0.000	0.000
(U) In FY 2006: Conducted scale-up testing and technology maturation efforts for high regression rate hybrid rocket fuels for use in space launch vehicles.				
(U) In FY 2007: Not Applicable.				
(U) In FY 2008: Not Applicable.				
(U) In FY 2009: Not Applicable.				
(U)				

Exhibit R-2a, RDT&E Project Justification

DATE **February 2007**

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT NUMBER AND TITLE
02 Applied Research	**0602203F Aerospace Propulsion**	**4847 Rocket Propulsion Technology**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009
(U)	CONGRESSIONAL ADD: Aerospace Lab Equipment Upgrade.	0.970	0.996	0.000	0.000
(U)	In FY 2006: Obtained high speed and visualization tools for university educational and research purposes.				
(U)	In FY 2007: Upgrade/augment existing university facilities/capabilities to train future aerospace engineers.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Advanced Vortex Hybrid Propulsion System.	0.000	1.694	0.000	0.000
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Develop small launch vehicle size engines that utilize vortex combustion processes to generate improved performance and/or operability. Tasks include developments in propellant storage tanks as well as the engine designs. Engine concepts to be examined include LOx/Propane vortex cold-wall chamber as well as vortex hybrid designs.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Solid Boost Propulsion Technology for the Sustainment of Strategic Systems.	0.000	0.996	0.000	0.000
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Develop technologies that aid in the sustainment of strategic solid rocket motors.				
(U)	In FY 2008: Not Applicable.				
(U)	In FY 2009: Not Applicable.				
(U)	Total Cost	35.244	18.985	10.719	9.081

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

	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:										
(U) PE 0601102F, Defense Research Sciences.										
(U) PE 0602114N, Power Projection Applied Research.										

Exhibit R-2a, RDT&E Project Justification		DATE February 2007
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT NUMBER AND TITLE 4847 Rocket Propulsion Technology

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

(U) PE 0602303A, Missile Technology.

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

(U) PE 0603311F, Ballistic Missile Technology.

(U) PE 0603401F, Advanced Spacecraft Technology.

(U) This project has been coordinated through the Reliance 21 process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.