ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2007

BUDGET ACTIVITY	PE NUMBER AND TITLE
2 - Applied Research	**0602211A - AVIATION TECHNOLOGY**

	COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
	Total Program Element (PE) Cost	38073	40156	42567	42051	41573	41181	41944	40224
47A	AERON & ACFT WPNS TECH	28612	28157	38392	37809	37286	36862	37530	35713
47B	VEH PROP & STRUCT TECH	3999	4285	4175	4242	4287	4319	4414	4511
47C	ROTORCRAFT COMPONENT TECHNOLOGIES (CA)	5462	7714						

A. Mission Description and Budget Item Justification: The Aviation Applied Research Technology program element (PE) conducts research and expands scientific knowledge applicable to both manned and unmanned rotary wing vehicle (RWV) technologies in support of the Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities. Emphasis is on developing rotary wing platform technologies to support manned and unmanned rotary wing vehicle combat and combat support operations for attack, reconnaissance, air assault, survivability, and command and control missions. Technologies that enable autonomous flight, higher aerodynamic loads, lower detectability, and increased maneuverability are emphasized. Increased effort is being placed on technologies to increase both manned and unmanned aircraft survivability, crashworthiness, and crew protection. Prognostics and diagnostics technologies are being developed and evaluated to support Condition Based Maintenance (CBM) efforts desired to reduce Operating and Support (O&S) costs of Current and Future Force airframes. This PE advances integrated unmanned operations through autonomous collaboration and refinement of unmanned technologies. This PE also supports the National Rotorcraft Technology Center (NRTC), a partnership of government, industry, and academia. Project 47C funds congressional special interest items. Efforts under this PE transition to projects supported by PE 0603003A (Aviation - Advanced Technology). Department of Defense (DoD) systems such as the AH-64 Apache, UH-60 Black Hawk, CH-47 Chinook, Armed Reconnaissance Helicopter, Light Utility Helicopter, the U.S. Navy SH-60 Seahawk, and U.S. Marine Corps V-22 Osprey, AH-1 Cobra, and CH-53 Super Stallion benefit and are supported directly or indirectly by this PE. This PE does not duplicate any efforts within the Military Departments and supports Project Reliance for which the Army is the lead service for the maturation of rotorcraft science and technology. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this PE is performed by the Aviation and Missile Research, Development, and Engineering Center, with facilities located at Redstone Arsenal, AL; Fort Eustis, VA; Moffett Field, CA; and Hampton, VA, and at the Army Research Laboratory, with facilities located at Adelphi, MD; Hampton, VA; and Cleveland, OH.

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B. Program Change Summary	FY 2006	FY 2007	FY 2008	FY 2009
Previous President's Budget (FY 2007)	39424	32804	33747	34126
Current BES/President's Budget (FY 2008/2009)	38073	40156	42567	42051
Total Adjustments	-1351	7352	8820	7925
Congressional Program Reductions		-153		
Congressional Rescissions				
Congressional Increases		7800		
Reprogrammings	-1351	-295		
SBIR/STTR Transfer				
Adjustments to Budget Years			8820	7925

FY08 and FY09 funds increased to support additional efforts in aircraft survivability and operational support and sustainment technologies.

Five FY07 congressional adds totaling $7477 (after adjustment for Congressional Undistributed Reductions) were added to this PE.

($1726) Center for Rotorcraft Innovation
($2492) Composite Small Main Rotor Blades
($1054) Aircraft Struc Condition Monitoring f/Diag/Prog
($1246) Limited Visibility Landing System
($959) T&E of Energy Attenuating Seat for Mili Aircraft

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February 2007

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602211A - AVIATION TECHNOLOGY**	**47A**

COST (In Thousands)		FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
47A	AERON & ACFT WPNS TECH	28612	28157	38392	37809	37286	36862	37530	35713

A. Mission Description and Budget Item Justification: The Aeronautical and Aircraft Weapons Technology project develops Rotary Wing Vehicle (RWV) technologies for manned and unmanned Army / Department of Defense (DoD) rotorcraft to increase strategic and tactical mobility / deployability; improve combat effectiveness; increase aircraft survivability; and improve combat sustainability. This project supports the Future Force by providing technology to improve capabilities in Force Application and Focused Logistics. Areas of research involve technology applicable to all aviation platforms, such as enhanced rotor efficiencies, improved survivability, increased structure and airframe capability, improved engine performance, improved sustainability, improved mission avionics performance, and reduced cost of unmanned and manned aerial vehicles. This project supports the National Rotorcraft Technology Center (NRTC), a partnership of government, industry, and academia. The propulsion technologies investigated in this project provide improved specific fuel consumption, horsepower to weight ratios, and operation and support (O&S) cost savings for manned and unmanned systems. These engine component technologies address engine needs for future aircraft with up to a 50 percent endurance and 30 percent payload increase over currently available turbine engines. These component technologies may also lead to a 33 percent increase in payload and a 50 percent reduction in fuel consumption for current rotorcraft; and an 80 percent payload and a 20 percent combat range increase for future rotorcraft. Aircraft survivability component technologies include adaptive Infrared (IR) signature suppression of engine and airframe thermal sources, visual signature control, acoustic signature attenuation, in-cockpit threat situational awareness, and survivability re-route decision aiding systems. Advanced active controls, aerodynamics, handling qualities, and smart materials (materials that respond to specific stimuli) technologies provide rotors and flight controls capable of increased payload, range, agility, maneuverability, and survivability. Manned / unmanned system interfaces, autonomous collaborative flight controls, flight simulation, weapons and sensor integration, pilot-vehicle interface technologies, and advanced mission equipment packages are being pursued that provide full spectrum engagement, precision and selectable lethality, suitable for the target and engagement scenarios. The operations and sustainment technologies provide advanced prognostic / diagnostic algorithms necessary to implement Condition Based Maintenance (CBM). This project leverages work accomplished in collaboration with the National Aeronautics and Space Administration (NASA). Technologies within this project will transition to advanced technology development programs with application to future, as well as current, Army / DoD rotorcraft systems. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this project is performed by the Aeroflight Dynamics Directorate of the Aviation and Missile Research, Development, and Engineering Center (AMRDEC), located at the NASA Ames Research Center, Moffett Field, CA; the NASA Langley Research Center, Hampton, VA; and the Aviation Applied Technology Directorate, Fort Eustis, VA.

Accomplishments/Planned Program:	FY 2006	FY 2007	FY 2008	FY 2009
National Rotorcraft Technology Center (NRTC): In FY06, developed fluid damper and magnetic-particle damper models. Designed, developed, and tested an active hinge pin actuator assembly. Investigated lean qualification methodology for composite materials and processes. Tested an actuation system for download alleviation. Developed simulation models for ad-hoc networking of rotorcraft teams. Investigated loose and tight coupling of Computational Fluid Dynamics (CFD) and Computational Structural Dynamics analyses for improved rotor loads and performance prediction. Designed servoflap-controlled soft torsion rotor system and performed noise abatement/land use planning flight tests. Developed 3-D CFD icing prediction methods. In FY07, incorporate and evaluate fluid damper and magnetic-particle damper models in comprehensive analyses. Design and test wireless proximity sensors. Conduct passive layered	6947	7637	8461	8631

isolator flight test demonstration. Perform simulation test of ad-hoc networking of rotorcraft teams. Develop advanced sensors and networks for a practical condition based maintenance implementation. Design improved crashworthy armored seats. Develop metal matrix composite design for airframe applications. Design drive train torque measurement system. In FY08, will perform wind tunnel tests of rotor designs with improved static/dynamic stall characteristics. Will test oscillatory jets on rotor airfoils. Will perform qualification test on improved drive system gears. Will test improved crashworthy armored seats. Will test metal matrix composite design for airframe applications. Will investigate and evaluate a drive train torque measurement system. In FY09, will perform bird strike and head impact simulations for rotorcraft crashworthiness and survivability. Will conduct certification testing and probabilistic analysis to evaluate damage tolerance methodologies. Will test advanced drive system designs. Will evaluate active crash protection system.				
Rotor Technology: In FY06, initiated development of mach-scale model rotor blades for model subsystem tests. Completed planning for wind tunnel testing of lightweight rotor and hub concept for application of on-blade control, including comprehensive analysis predictions. In FY07, test in wind tunnels, active/passive integration techniques for enhancement of on-blade controls, both for blade section concepts as well as two model rotor designs. Analytical model validation will also be included. In FY08, will evaluate, via wind tunnel tests, on-blade control for model rotor system to include performance enhancement and primary control.	4008	4093	3282	
Robotics Collaboration: In FY06, conducted simulations and assessments of three technical approaches to Autonomous Collaborative UAV behaviors at contractor and government facilities, and flight tested one of the three approaches using multiple small UAVs.	2872			
Aircraft Survivability Technologies: In FY06, evaluated the effectiveness of and refined the Threat Lethality Predictor (TLP) system and associated algorithms, which provides highly-accurate, on-aircraft, near real-time assessments of infrared and radar threats' ability to engage, with and without countermeasures, and in terrain clutter. In FY07, develop cognitive decision aiding (CDA) planners that enable a manned/unmanned team to respond to pop-up threats as a team, and not just as individual platforms. Integrate the CDA planners with the TLP algorithms. Develop CDA-TLP specific cockpit controls, displays, and aural cues. Refine performance and mission effectiveness goals using simulation. In FY08, will initiate development of crash criteria (that establishes required G-loads that structures such as engines and transmissions must withstand before breaking-away during a crash and threatening the integrity of crew occupied areas) for "full-envelope crashworthiness" based on rotorcraft size class and mission type. Will develop conventional ballistic threat and advanced crew protection concepts followed by preliminary designs for selected concepts. Will investigate specific technologies to reduce susceptibility to MANPADS threats including large engine (15,000 shp class) infra-red (IR) suppressors and tailorable visual/EO airframe coatings and films. In FY09, will develop updated design guidelines based on emerging criteria. Will complete preliminary design of candidate IR suppressors, followed by component fabrication, component-level testing, and conclude with subsystem-level evaluation. Will perform experimental testing on the most promising of the large-engine IR suppressors and tailorable visual/EO airframe coatings and films examined in FY08.	4032	4108	7800	7186
Rotorcraft Airframe Technology: In FY06, generated and evaluated structures that incorporate ballistic protection and survivability features and evaluated and refined concepts that contain self-sensing and self-healing components. In FY07, refine multifunctional structure technology, reducing parasitic weight by adding capabilities to primary structure (e.g., integrated armor). Modify technologies to improve structural efficiency and lower design load uncertainty on airframe/rotor structures. Develop criteria using a strain-allowable approach for repair and continued use of ballistically damaged, life-limited, dynamic structures. In FY08, will develop integrity management by fusing loads monitoring and damage detection capabilities to improve safety and survivability. Will evaluate ballistic properties and effectiveness of reduced-weight multifunctional structural armor. In FY09, will conduct laboratory testing to evaluate strain-allowable integrity approach; and will develop emerging platform concepts and validate modeling fidelity.	2236	2447	1261	4221
Advanced Engines: In FY06, completed design of advanced ceramic matrix composite power turbine for improved performance with	977	1391	1980	2050

reduced weight. Developed advanced foil bearing with the goal of eliminating need for lubricants and reducing supportability costs. Tested foil bearing via rig-test to validate weight reduction and reduced maintainability issues. Completed fabrication and conducted rig-test of 700 horsepower class ceramic turbine to validate improved performance and reduced weight. In FY07, complete fabrication and conduct test of advanced ceramic matrix composite power turbine blades to validate improved performance, reduced weight and increased durability. In FY08, will complete design of advanced compressor for improved engine performance and reduced weight; and will complete advanced combustor design, fabrication, and evaluation. In FY09, will complete design of advanced inlet particle separator that will improve engine performance and durability. Will complete fabrication of advanced compressor for improved engine performance and reduced weight. Will complete advanced combustor rig-test to validate improved performance and weight.				
Network Operations and System Integration and Intelligent and Active Control: In FY06, began development of the technologies for autonomous low-altitude obstacle avoidance. Tested low-altitude 2D autonomous navigation through obstacle field using laser radar and stereo cameras. Investigated 3D obstacle avoidance in a simulation environment to help decide on best technical approach. Applied control law analysis tools using the Rotorcraft Air Crew Systems Concepts Airborne Laboratory (RASCAL) in-flight simulator for the UH-60M upgrade fly-by-wire control system. In FY07, validate closed-loop individual blade control model with full-scale wind tunnel test. Complete external load stabilization testing with aerodynamically active sling loads in actual flight. Digital Situational Awareness Testbed: In FY06, developed interface testbed for investigating control/display variants for control of multiple UAVs from mobile platform. In FY07, will develop guidelines for control of multiple UAVs from a single station (either airborne or ground). In FY08, will develop and evaluate supervisory control interface for multiple heterogenous UAVs. In FY09, will conduct tests of supervisory control techniques for control of multiple UAVs. Advanced Rotary Wing Concepts: In FY06, initiated integration of advanced targeting and stabilization technologies to provide a precision attack capability for rotary wing UAVs. In FY07, support flight test demonstrations of precision attack capability from test bed UAVs operating in support of manned aviation and ground troops in a MOUT environment. In FY08, will conduct flight test demonstrations using different sensors and weapons systems to gauge precision to be expected from rotary wing UAVs in varying flight modes, i.e., high and low hover, firing on the move, and moving targets. In FY09, will assess stability of weapons platforms in varying wind and environmental conditions to predict affect on weapons' precision.	7540	8233	8408	7571
System Concepts Studies: In FY08, will examine rotorcraft technology areas to determine where science and technology investments can best be invested to meet the emerging needs of the user. Possible investigations may include the Joint Multi-Role Aircraft, Optimum Speed Rotor, Quad Tilt-Rotor, Advancing Blade Concept, and Optimum Speed Tilt-Rotor. In FY09, will continue to study new technology areas in concert with the requirements generation process and planning guidance to determine future investment needs.			2150	3000
Durability and Sustainment Techs: In FY08, will initiate development of prognostic algorithms for dynamic rotor head components. Will develop predictive models for hydraulics and actuators used for aircraft flight controls (based on Failure Modes, Effects, and Criticality Analysis and manufacturer's analysis of failed components). Will evaluate the predictive models based on the fusion of the data-driven and model-based approaches, with bench testing of components to verify the models. Will determine placement of corrosion sensors for use in development of corrosion assessment algorithms. Will perform rig-testing of ceramic components to characterize the failure modes. Will embed sensors in structural components and assess feedback to form basis of damage detection algorithms. Will evaluate sensor and loads monitoring feedback methods for structural diagnostics/prognostics, and reduction of uncertainty in probabilistic methods for life management. In FY09, will perform rig-testing of dynamic rotor head components, begin bench testing of flight control algorithms on hydraulic actuators, initiate development of prognostic algorithms for ceramic components, develop the corrosion damage algorithms, and assess structural damage detection algorithms. Will evaluate sensor and loads monitoring feedback methods for structural diagnostics/prognostics, and reduction of uncertainty in probabilistic methods for life management.			5050	5150
Small Business Innovative Research/Small Business Technology Transfer Programs		248		

Total	28612	28157	38392	37809

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47B VEH PROP & STRUCT TECH	3999	4285	4175	4242	4287	4319	4414	4511

A. Mission Description and Budget Item Justification: The Vehicle Propulsion and Structures Technology project investigates engine, drive train, and airframe technologies for Department of Defense (DoD) rotorcraft in support of the Future Force, and where feasible, exploits opportunities to enhance Current Force capabilities. The intent is to significantly increase strategic and tactical mobility/deployability, increase reliability, reduce maintenance costs, and increase combat sustainability - all focused on a large reduction in the vehicle's logistics footprint for manned and unmanned rotorcraft. Problems being addressed in propulsion technology include increased fuel efficiency and reduced propulsion systems weight. Technical barriers include temperature limitations for materials, accurate modeling for flow physics, and accurate prediction of propulsion system mechanical behavior. The problem being addressed in structures technology is the inadequacy of current analytical tools to design for acceptable reliability and durability, which leads to heavier, more costly designs, and poor life cycle management. Technical barriers include inadequate structural analysis design tools, inadequate structural dynamics modeling methods for the rotating and fixed system components, inadequate modeling of rotor aeromechanical phenomena, incomplete and non-parametric loads data, and inaccurate inspection and tracking methodologies. Technical solutions are pursued through propulsion and structures research - with a focus on applications towards heavy lift technologies while supporting both manned and unmanned vehicle requirements. Propulsion research is focused on fluid mechanics, high temperature materials, and mechanical behavior for significantly improved small airflow turbine engines, transmissions, gears, bearings, and shaft components for advanced drive trains at significantly reduced weight and cost. This propulsion research supports the goals of the DoD Versatile Advanced Affordable Turbine Engine (VAATE) program. Structures research is focused on the effects of aerodynamic loads, aeroelastic interactions, integrated composites, structural integrity, low cost manufacturing, and crashworthiness that will provide improved rotor and airframe structure subsystems. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this project is performed by the Army Research Laboratory (ARL) located at facilities at the NASA Glenn Research Center, Cleveland, OH, and the NASA Langley Research Center, Hampton, VA.

Accomplishments/Planned Program:	FY 2006	FY 2007	FY 2008	FY 2009
Rotor and Structure Technology: This research devises improved tools and methodologies to more accurately design for acceptable reliability and durability, resulting in platforms that are lighter in weight and less costly to acquire and maintain. In FY06, evaluated reliability, durability, and damage tolerance for tailored and multi-functional composite structures; conducted wind-tunnel tests on a Quad-Tiltrotor model; conducted hover experiments on an advanced active twist rotor system using AH-64A Apache as baseline. In FY07, conduct a wind-tunnel test in cooperation with Bell Helicopter to evaluate a new heavy lift tiltrotor hub design and explore computational prognostic and diagnostic methods to support innovative Army reliability initiatives for the Future Force. In FY08, will investigate aeromechanics design tools to enable the evaluation of new small-scale unmanned air vehicles and micro-scale flapping-wing air vehicles. In FY09, will evaluate new multi-functional structural concepts based on biological systems that are key enablers for future microsystems development.	1555	994	1731	1795
Propulsion & Drive Train Technology: This research investigates high temperature materials, advanced models for flow physics, and improved methods for predicting propulsion system mechanical behavior to increase fuel efficiency and reduce propulsion systems weight. In FY06, completed full-scale rig testing and analysis of the lubrication and thermal behavior of high-speed rotorcraft helical gears to allow operation for 30 minutes after loss-of-lubrication supply; performed rotor-dynamic tests of an oil-free foil air bearing	2444	3280	2444	2447

technology that will reduce engine maintenance costs by 50% and weight by 15%. In support of the Unmanned Air Vehicle Systems (UAV) Technology Demonstration program, validated active stall control technology and evaluated environmental and thermal barrier coatings for silicon nitride turbine nozzles. In FY07, define thermal behavior and lubrication technologies of high speed, high performance gears, including loss of lubricant conditions, using modeling and a representative high-speed gear train; evaluate heavy-fuel concepts for potential fuel cell applications; complete performance and endurance tests of innovative non-contacting air-to-air seal technology for military helicopter and UAV class engines. In support of the UAV Technology Demonstration program, experimentally evaluate a low conductivity thermal barrier coating system for metals. In FY08, will assess and quantify the baseline performance of model-based diagnostic methodology to accurately detect, determine trends, and isolate engine faults and will experimentally evaluate mechanical properties of advanced gear materials to assess their feasibility for use in rotorcraft transmissions. In FY09, will assess the durability of advanced environmental barrier coatings to improve the design of hot section engine components and will experimentally evaluate variable speed transmissions sub-scale components that will enable improvements in rotorcraft maneuverability and noise reduction.				
Small Business Innovative Research/Small Business Technology Transfer Programs		11		
Total	3999	4285	4175	4242