

# ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2005

BUDGET ACTIVITY  
2 - Applied Research

PE NUMBER AND TITLE  
0602211A - AVIATION TECHNOLOGY

COST (In Thousands)	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
Total Program Element (PE) Cost	38654	47780	34295	32370	33376	33746	34035	34282
47A AERON & ACFT WPNS TECH	34033	36636	30238	28203	29129	29457	29712	29929
47B VEH PROP & STRUCT TECH	3646	3906	4057	4167	4247	4289	4323	4353
47C ROTORCRAFT COMPONENT TECHNOLOGIES (CA)	975	7238	0	0	0	0	0	0

**A. Mission Description and Budget Item Justification:** The Aviation Applied Research Technology program element (PE) conducts research and expands scientific knowledge in the area of manned and unmanned rotary wing vehicle (RWV) technologies in support of the Future Force and Joint Vision 2020, and, where feasible, exploits opportunities to enhance Current Force capabilities. Based on the Army transformation, this PE investigates technologies applicable to all aviation systems, both manned and unmanned, while providing opportunities for technology insertion into the Current Force systems. Unmanned RWVs bring unprecedented agility, maneuverability, and lethality to the Future Force, while providing improved survivability and reduced logistics costs. Emphasis is on maturing rotary wing platform technologies to support manned and unmanned teaming in 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. These technologies are assessed for their ability to support the long-term sustainability and reduced logistics required of Future Force airframes. Unmanned technologies are directed toward compatibility with the A-160 Hummingbird, the FireScout, the Organic Air Vehicle (OAV), and the Micro Air Vehicle (MAV). This PE also supports the National Rotorcraft Technology Center (NRTC), a partnership of government, industry and academia, and adds a major focus to mature unmanned rotorcraft technologies. Project 47C fund Congressional special interest items. Efforts under this PE transition to projects supported by PE 0603003A (Aviation - Advanced Technology). Upgrade activities of Department of Defense (DoD) systems such as the AH-64 Apache, UH-60 Black Hawk, CH-47 Chinook; the U.S. Navy SH-60 Seahawk; and U.S. Marine Corps V-22 Osprey, AH-1 Cobra and CH-53 Super Stallion are included in 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, Redstone Arsenal, AL and the Army Research Laboratory, Adelphi, MD, with facilities located at Fort Eustis, VA; Ames Research Center, Moffett Field, CA; Glenn Research Center, Cleveland, OH; and Langley Research Center, Hampton, VA.

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<b><u>B. Program Change Summary</u></b>	<b>FY 2005</b>	<b>FY 2006</b>	<b>FY 2007</b>
Previous President's Budget (FY 2005)	41629	40127	40057
Current Budget (FY 2006/2007 PB)	47780	34295	32370
Total Adjustments	6151	-5832	-7687
Net of Program/Database Changes			
Congressional Program Reductions	-655		
Congressional Rescissions			
Congressional Increases	7550		
Reprogrammings			
SBIR/STTR Transfer	-744		
Adjustments to Budget Years		-5832	-7687

## Change Summary Explanation:

FY06 - Funds realigned (\$5832K) to higher priority requirements.

FY07 - Funds realigned (\$7687K) to higher priority requirements.

Five FY05 Congressional Adds totaling \$7550 were added to this PE.

FY05 Congressional Adds with no R-2As:

(\$2398) Center for Rotorcraft Innovation, Project 47C: The purpose of this one year Congressional add is to fund a Center for Rotorcraft Innovation. No additional funding is required to complete this project.

(\$479) Composite Small Main Rotor Blades, Project 47C: The purpose of this one year Congressional add is to fund research in composite small main rotor blades. No additional funding is required to complete this project.

(\$1007) Mono Tiltrotor/Army Rotorcraft, Project 47C: The purpose of this one year Congressional add is to fund research in mono tiltrotors for

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<p>rotorcraft. No additional funding is required to complete this project.</p> <p>(\$2397) Silver Fox UAV, Project 47C: The purpose of this one year Congressional add is to fund research on the Silver Fox UAV. No additional funding is required to complete this project.</p> <p>(\$959) Xenon Light Source for Non-Lethal Deterrence from Small UAVS, Project 47C: The purpose of this one year Congressional add is to fund research into xenon light source for non-lethal deterrence from small UAVs. No additional funding is required to complete this project.</p>		

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COST (In Thousands)			FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
47A	AERON & ACFT WPNS TECH		34033	36636	30238	28203	29129	29457	29712	29929
<p><b><u>A. Mission Description and Budget Item Justification:</u></b> 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 and Joint Vision 2020 by providing technology to improve capabilities in Force Application and Focused Logistics. Areas of research are on technology applicable to all aviation platforms, with a focus on unmanned aerial vehicle (UAV) systems, manned and unmanned teaming, and opportunities for application on manned systems. These system technologies will provide 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, and adds a major focus to mature UAV designs and other unmanned rotorcraft technologies. The propulsion component technologies investigated in this project will provide improved specific fuel consumption, horsepower to weight ratios, and operation and support (O&amp;S) cost savings for manned and unmanned Future Force systems. These engine component technologies address engine needs for future UAVs, such as the A-160 Hummingbird, with up to a 50% endurance and 30% payload increase over currently available turbine engines. These component technologies will also enable engine demonstrations for manned systems, providing a 33% increase in payload and a 50% reduction in fuel consumption for CH-47 Chinook; and an 80% payload increase and a 20% 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 survivable re-route decision aiding systems. Advanced active controls, aerodynamics, handling qualities, and smart materials (materials that respond to specific stimuli) technologies will 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. This project also supports work accomplished in collaboration with the National Aeronautics and Space Administration (NASA) and work done under the auspices of the NRTC. Technologies researched 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.</p>										

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**0602211A - AVIATION TECHNOLOGY**PROJECT  
**47A****Accomplishments/Planned Program**

National Rotorcraft Technology Center (NRTC) - In FY04, conducted component research in the areas of crashworthiness, advanced structures, advanced low-cost composite manufacturing, structural joining technologies, and rotorcraft transmission technologies. NRTC performed applied research efforts in composite durability and damage tolerance, and integrated helicopter design technology. In FY05, conduct research and component testing in technologies that enable rotorcraft performance improvement, limited authority flight control, damage tolerance, and rotorcraft transmission advances. In FY06, will conduct research and component testing in the areas of damage tolerance of materials, rotorcraft integrated analysis and design, advanced transmission technologies, health monitoring technology, rotor load prediction analysis, and gear noise technologies. In FY07, will conduct research and component testing in technologies that enhance manned and unmanned rotorcraft capabilities using active rotor controls, intelligent flight controls, smart composite structures, advanced manufacturing technologies, and advanced subsystem technologies.

FY 2004

6959

FY 2005

7086

FY 2006

7270

FY 2007

7504

Rotor Technology [Includes the Low Cost Active Rotor (LCAR) program and the Lightweight Active Rotor Concept (LARC) program] - In FY04, designed model rotor concepts to demonstrate a 40% vibration reduction and control system weight savings. In FY05, integrate selected candidate lightweight rotor and hub concepts for application of on-blade control and begin integrated concept subsystem tests. In FY06, will start fabrication of Mach-scale model rotor blades and complete model subsystem tests. In FY07, will complete model blades for the LARC rotor and begin evaluation of on-blade primary flight control.

4288

3680

4100

4127

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<b>Accomplishments/Planned Program (continued)</b>		FY 2004	FY 2005	FY 2006	FY 2007
Survivability [Includes the Manned / Unmanned Rotorcraft Enhanced Survivability program] - In FY04, developed a software design for the real-time Survivability Planner Associate Re-router, tailored to small unit manned / unmanned team operations. Matured a family of intelligent sentinel agents to monitor threat-warning sensors. In FY05, construct a database of threat sensors, multi-spectral signatures, and clutter and jammer effects. Demonstrate real-time threat lethality predictor, with and without jamming, in 3-dimensional terrain environment. In FY06, will integrate intelligent decision aid agent to provide cueing for 'what to do' given threat array. Will integrate intelligent decision aid agent, along with cooperative/collaborative behaviors, to provide cueing for the manned / unmanned team to respond as a team, and not just as individual platforms. In FY07, will demonstrate the Survivability Planner Associate Re-Router (SPAR) system software on manned and unmanned mission management simulators. SPAR will be integrated into an existing manned mission management simulation system and demonstrated using the Advanced Concept Research Tool (ACRT) Longbow Apache simulator at the Army Aviation Center Directorate at Fort Rucker Alabama and an existing unmanned air vehicle mission management simulation system and demonstrated at Lockheed Martin, Owego, New York.		3692	3685	3932	4108

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PROJECT

47A

## Accomplishments/Planned Program (continued)

Structures and Airframe [Includes the Survivable, Affordable, Repairable Airframe Program (SARAP)] - In FY04, designed and fabricated smart re-configurable airframe and rotors structures for bench tests. Designed and evaluated multifunctional structures for reduced signature, weight, and enhanced survivability. Investigated technologies for affordable, low weight, reparable structures that enhance ballistic and crash survivability. In FY05, validate and disseminate improved loads determination tools that are 25% more accurate. Conduct bench tests on smart re-configurable airframe and rotors structures. Standardize (Joint Service) test methods for durability and damage tolerance certification / qualification of composite structures. Demonstrate field and depot level advanced composite airframe inspection and repairs. Evaluate conceptual re-configurable panels, blades and self-healing structures. In FY06, will generate and evaluate structures that incorporate ballistic protection and survivability features. Will evaluate and mature concepts that are self-sensing and self-healing (smart parts). In FY07, will validate Mode III and Mixed-Mode (II & III) fracture mechanics failure modes and test methods to support Durability and Damage Tolerance (D&DT) certification methodology for composite structures. Will generate technologies to reduce structural integrity uncertainty for lower load factors on airframes/rotors.

FY 2004

2624

FY 2005

2310

FY 2006

2323

FY 2007

2469

Propulsion [Includes the Small Heavy Fuel Engine (SHFE) program]- In FY04, conducted rig test of advanced power turbine providing increased cycle efficiency and reduced engine weight. Completed fabrication of 700 horsepower class compressor for improved full- and part-power performance. Completed design of advanced foil bearing. In FY05, conduct rig test of 700 horsepower compressor for improved performance. Complete fabrication and component evaluations of advanced foil bearing. Complete fabrication of 700 horsepower class ceramic turbine and rig hardware. Start design of ceramic matrix composite power turbine blades. In FY06, will complete design of advanced ceramic matrix composite power turbine blades. Will demonstrate advanced foil bearing via rig test. Will conduct rig test of 700 horsepower class ceramic turbine. In FY07, will complete fabrication of advanced ceramic matrix composite power turbine blades. Will complete design of advanced technology combustor.

1379

1425

1477

1530

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PROJECT

**47A**

## Accomplishments/Planned Program (continued)

Networked Operations and System Integration [Includes the Precision Automated Landing Adaptive Control Experiment (PALACE), flight controls, human factors, and weapons integration concepts]. PALACE - In FY04, evaluated control law and sensor optimization in simulation for precision autonomous landing of UAVs. Modified a (Yamaha) RMAX rotorcraft surrogate UAV for precision autonomous landing experiments. Awarded three contracts to develop seven different operationally relevant behaviors for UAVs, e.g., cooperative reconnaissance and security, avenge kill/team protection, etc. In FY05, flight-demonstrate precision autonomous landing of VTOL UAV to unprepared site in GPS denied environment. Complete piloted simulation investigating advanced operator interface and control methods for airborne control of tactical UAVs. Research autonomous control laws and operator interface for UAV cargo rotorcraft/sling load handling qualities. Generate software to implement the seven UAV behaviors and integrate the software in a government simulation facility for evaluation. Award a contract option for a flight demonstration. In FY06, will demonstrate rotorcraft UAV autonomous flight, navigation, and landing in an obstacle environment with passive/active imaging sensors. Will define mission-specific optimal levels of control for UAV operations. Will conduct an experiment to define crew sensor display configurations for control of multiple UAVs. Will validate closed-loop individual blade control (IBC) algorithms using data from full-scale wind tunnel test. In FY07, will conduct simulation demonstration of synthetic vision system for UAV operations. Will conduct initial human factors experiments in adaptive levels of control for UAV operations. Will conduct flight demonstration of multi-vehicle collaboration in low altitude surveillance with heterogeneous platforms/sensors. Will complete RASCAL JUH-60A flight test of tactile cueing and advanced control laws suitable for advanced utility

FY 2004

FY 2005

FY 2006

FY 2007

10166

13315

5503

2734

Networked Operations and System Integration [Includes Part 1 of the Unmanned Autonomous Collaborative Operations (UACO) ATO program. Part 2 of UACO is under 63003/313] - In FY04, conducted requirements analysis and concept definition studies for multi-UAV control to handle multiple integrated mission operations. In FY05, conduct preliminary design of UAV "swarm" control for vehicle, mission equipment, and flight management architectures. Evaluate system performance, effectiveness, and risk. In FY06, will conduct simulation demonstrations at the contractor and government facilities, and flight test autonomous collaborative UAV behaviors from one of the three contractors using multiple small UAVs. Will initiate integration of airborne sniper capability for Vigilante test-bed UAV. In FY07, will conduct flight test demonstrations of airborne sniper capability using Vigilante UAV and airborne control from a UH-1 or Blackhawk.

4925

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5731



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<u>Accomplishments/Planned Program (continued)</u>		FY 2004	FY 2005	FY 2006	FY 2007
Totals		34033	36636	30238	28203

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PROJECT  
**47B**

COST (In Thousands)	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
	Actual	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
47B VEH PROP & STRUCT TECH	3646	3906	4057	4167	4247	4289	4323	4353

**A. Mission Description and Budget Item Justification:** The Vehicle Propulsion and Structure Technology project investigates engine, drivetrain and airframe technologies for Army 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. The 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 inability to design for acceptable reliability and durability with current tools, 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. The propulsion research is focused on fluid mechanics, high temperature materials, and mechanical behavior for significantly improved small airflow turbine engines, transmissions, and gears, bearings, and shaft components for advanced drivetrains at significantly reduced weight and cost. This propulsion research supports the goals of the DoD Versatile Advanced Affordable Turbine Engine (VAATE) program. The 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.

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PROJECT	47B
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## 2 - Applied Research

## 0602211A - AVIATION TECHNOLOGY

47B

<b><u>Accomplishments/Planned Program</u></b>	<b>FY 2004</b>	<b>FY 2005</b>	<b>FY 2006</b>	<b>FY 2007</b>
Rotor & Structure Technology [Includes the Survivable, Affordable, Repairable Airframe Program (SARAP), the Low Cost Active Rotor program, and the Lightweight Active Rotor Concept program] - In FY04, investigated reliability-based design methods, durability and damage tolerance analysis methods, crashworthiness concepts, and Non-Destructive Evaluation (NDE) methods on selected airframe and rotor hub components; investigated advanced design concepts for on-blade active control rotor systems; designed a composite active tail system wind-tunnel testbed based on the AH-64D; and completed study of soft-inplane rotor systems for application to a heavy lift tiltrotor. In FY05, validate reliability-based design methods, durability and damage tolerance analysis methods, lightweight crashworthy concepts, and advanced NDE methods in support of SARAP; complete wind-tunnel demonstration of new lightweight and stable heavy lift tiltrotor concept. In FY06, will conduct hover and wind tunnel experiments on advanced active twist rotor system using AH-64D Apache as baseline; evaluate reliability, durability and damage tolerance for tailored and multi-functional composite structures. In FY07, will conduct wind-tunnel test in cooperation with Bell Helicopter to evaluate new heavy lift tiltrotor hub design; develop multi-functional structural concepts and design tools to reduce ballistic vulnerability for airframes applicable to heavy lift rotorcraft.	1846	1946	1604	980

FY 2005

FY 2006

FY 2007

1946

1604

980

<b><u>Accomplishments/Planned Program</u></b>	<b>FY 2004</b>	<b>FY 2005</b>	<b>FY 2006</b>	<b>FY 2007</b>
Rotor & Structure Technology [Includes the Survivable, Affordable, Repairable Airframe Program (SARAP), the Low Cost Active Rotor program, and the Lightweight Active Rotor Concept program] - In FY04, investigated reliability-based design methods, durability and damage tolerance analysis methods, crashworthiness concepts, and Non-Destructive Evaluation (NDE) methods on selected airframe and rotor hub components; investigated advanced design concepts for on-blade active control rotor systems; designed a composite active tail system wind-tunnel testbed based on the AH-64D; and completed study of soft-inplane rotor systems for application to a heavy lift tiltrotor. In FY05, validate reliability-based design methods, durability and damage tolerance analysis methods, lightweight crashworthy concepts, and advanced NDE methods in support of SARAP; complete wind-tunnel demonstration of new lightweight and stable heavy lift tiltrotor concept. In FY06, will conduct hover and wind tunnel experiments on advanced active twist rotor system using AH-64D Apache as baseline; evaluate reliability, durability and damage tolerance for tailored and multi-functional composite structures. In FY07, will conduct wind-tunnel test in cooperation with Bell Helicopter to evaluate new heavy lift tiltrotor hub design; develop multi-functional structural concepts and design tools to reduce ballistic vulnerability for airframes applicable to heavy lift rotorcraft.	1846	1946	1604	980

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Accomplishments/Planned Program (continued)			FY 2004	FY 2005	FY 2006	FY 2007
<p>Propulsion &amp; Drive Train Technology [Includes the Rotorcraft Drive System for the 21st Century (RDS21) program and the Small Heavy Fuel Engine (SHFE) program] – RDS21 - In FY04, analyzed performance of a compact high performance two-stage engine compressor and cooled monolithic ceramic and ceramic matrix composite turbine nozzles. Researched a full 3-dimensional distributed propulsion simulation. In FY05, conduct experiments and computer simulations of active stall control technologies to extend stable engine operation. Investigate autonomous propulsion system technology for future UAV propulsion control and operation. In FY06, will demonstrate and validate active stall control technology and transition to government and industry. In FY07, will 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. SHFE – In FY04, determined the optimal pinion tooth design for face gear endurance tests in support of the RDS21 program. In FY05, perform laboratory endurance tests of face gears to evaluate strength and durability. In FY06, will evaluate environmental and thermal barrier coatings for silicon nitride turbine nozzles. Will complete 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. Will perform rotor-dynamic tests of an oil-free foil air bearing technology that will reduce engine maintenance costs by 50% and weight by 15%. In FY07, will evaluate heavy-fuel concepts for potential fuel cell applications. Will complete performance and endurance tests of innovative non-contacting air-to-air seal technology for military helicopter and UAV class engines. Will demonstrate and test a low conductivity thermal barrier coating system.</p>			1800	1960	2453	3187
Totals			3646	3906	4057	4167