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

February 2002

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

	COST (In Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
	Total Program Element (PE) Cost	30216	43859	43692	34857	34792	36368	37167
47A	AERON & ACFT WPNS TECH	26688	40211	39453	30517	30357	31674	32363
47B	VEH PROP & STRUCT TECH	3528	3648	4239	4340	4435	4694	4804

A. Mission Description and Budget Item Justification: The Aviation Technology program element (PE) conducts applied research and expands scientific knowledge in the area of manned and unmanned rotary wing vehicle (RWV) technologies in support of the Objective Force and Joint Vision 2020. Based on the Army transformation, this PE has been refocused to investigate technologies applicable to unmanned systems and supports selected opportunities for manned systems. Unmanned rotary wing vehicles bring unprecedented agility, maneuverability, and lethality to the Objective Force while providing reduced signature and logistics. Emphasis will be placed on developing unmanned combat, reconnaissance, and communications relay capability. Technologies will be investigated that enable the autonomous flight, higher aerodynamic airframe loads, and increased maneuverability than possible with unmanned aerial vehicles. These technologies also will be assessed for their ability to support the long-term sustainability and reduced logistics required of Objective Force airframes. This PE also supports the National Rotorcraft Technology Center (NRTC), a partnership of government, industry and academia, and adds as a major focus to develop organic air vehicles designs and other unmanned rotorcraft technologies. Efforts under this PE transition to projects supported by PE 0603003A (Aviation - Advanced Technology). Upgrade activities of DoD systems such as the RAH-66 Comanche, AH-64 Apache, UH-60 Black Hawk, Navy SH-60 Seahawk and USMC AH-1 Cobra are included in this PE. The cited work is consistent with the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and Project Reliance for which the Army is the lead service for the maturation of rotorcraft science and technology. The program element contains no duplication with any effort within the Military Departments. 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. This PE supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

B. Program Change Summary	FY 2001	FY 2002	FY 2003
Previous President's Budget (FY2002 PB)	30794	49265	31564
Appropriated Value	31080	44265	0
Adjustments to Appropriated Value	0	0	0
a. Congressional General Reductions	0	-406	0
b. SBIR / STTR	-417	0	0
c. Omnibus or Other Above Threshold Reductions	0	0	0
d. Below Threshold Reprogramming	0	0	0
e. Rescissions	-447	0	0
Adjustments to Budget Years Since FY2002 PB	0	0	12128
Current Budget Submit (FY 2003 PB)	30216	43859	43692

Change Summary Explanation:

FY 02: Congressional decrement of $5 million to fund National Aeronautics and Space Administration shortfall.

FY 03: Program growth to support investigation into the Unmanned Armed Combat Rotorcraft (UCAR).

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

February 2002

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

COST (In Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
47A	AERON & ACFT WPNS TECH	26688	40211	39453	30517	30357	31674	32363

A. Mission Description and Budget Item Justification: The Aeronautical and Aircraft Weapons Technology project investigates rotary wing vehicle (RWV) technologies for unmanned and manned Army / DoD rotorcraft for increased strategic and tactical mobility / deployability; improved combat effectiveness; increased aircraft survivability; and improved combat sustainability. This project supports the Objective Force and Joint Vision 2020 by providing technology to improve capabilities in Dominant Maneuver, Precision Engagement and Focused logistics. Areas of research are focused on technology application to UAV systems and supports selected opportunities for manned systems. These technologies will provide higher performance, improved survivability, improved sustainability, and reduced cost for propulsion of unmanned and manned aerial vehicles. This project will begin research for the Unmanned Combat Armed Rotorcraft (UCAR), a long endurance, armed, rotary wing platform. UCAR will be capable of performing suppression of enemy air defense (SEAD) and, like Comanche, putting weapons on a target using Loitering Attack Missile-Aviation (LAM-A). The propulsion component technology investigated in this project provides improved specific fuel consumption, horsepower to weight ratios, and operation & support (O&S) savings for future and current rotorcraft engines. Advanced active controls, aerodynamics, handling qualities, acoustic signature attenuation and smart materials (materials that respond to specific stressors) technologies will provide rotors and flight controls with increased payload / range, maneuverability / agility and survivability. Unmanned/manned system interface, flight simulation, weapons integration, and pilot-vehicle interface technologies are focused on research of advanced mission equipment packages that will provide increased lethality and mission operational effectiveness. This project also supports work done by NASA and work done under the auspices of the National Rotorcraft Technology Center (NRTC). Technologies researched within this project will transition to advanced development technology demonstration programs with application to future, as well as current, Army / DoD rotorcraft systems. Work in this project is performed by contractors including: Boeing Company, Mesa, AZ and Philadelphia, PA; Bell Helicopter Textron Incorporated, Ft. Worth, TX; Lockheed Martin, Atlanta, GA; General Electric Aircraft Engines, Lynn, MA; Honeywell, Phoenix, AZ; Sikorsky Aircraft Corporation, Stratford, CT; Rolls-Royce/Allison, Indianapolis, IN; Kaman Aerospace Corp., Bloomfield, CT; Pratt & Whitney, Hartford, CT; Raytheon Company, Arlington, VA; and United Technologies Research Center, Hartford, CT. Additionally, work in this project is performed by universities including Arizona State University, AZ; Georgia Institute of Technology, GA; Naval Postgraduate School, Monterey, CA; California Polytechnic University, San Luis Obispo, CA; Ohio State University, OH; Penn State University, PA; Purdue University, IN; Texas A&M, TX; University of Southern California, CA; University of Florida, FL; University of Illinois, IL; University of Maryland, MD; University of Michigan, MI; University of Utah, UT; Virginia Polytechnic Institute and State University, VA; Wichita State University, KS; Cornell University, NY; Iowa State University, IA; Prairie View A&M College, TX; University of Dayton, OH; University of Texas Automation and Robotics Institute, TX; University of Alabama, Huntsville. This project supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2001 Accomplishments:

- 6980
  - Conducted analytical / simulation validation of active / passive external cargo load stabilization allowing higher operational speeds and flight test evaluation of Control Designer's Unified Interface (CONDUIT) / Real-Time Interactive Prototype Technology Integration/Development Environment (RIPTIDE) optimized control laws to achieve a high bandwidth in-flight simulation capability.
  - Conducted initial study of analytical / simulation study of interactions of flight control and Individual Blade Control (IBC) rotorcraft control.
  - Matured hardware and performed flight test evaluation using Rotorcraft-Aircrew Systems Concepts Airborne Laboratory (RASCAL) for envelope limiting / cueing concepts.
  - Validated partial authority flight control concepts, providing attitude command/attitude hold capability with existing partial authority actuators in a joint flight test experiment in National Research Council (NRC) in-flight simulator (Ottawa, Canada).
  - Prepared and evaluated human model for Man-Machine Integrated Design and Analysis System (MIDAS) and transitioned tool to NASA and industry for further development and possible commercialization.
  - Created and analyzed conceptual designs of advanced rotorcraft in support of activities like the Army Science Board and the Integrated Concept Team (ICT) for Aviation Science and Technology.
  - Authenticated a Commercial Off-the-Shelf (COTS) based, open systems mission processor hosting Apache Longbow operational flight program (OFP) applications in an Apache-like laboratory environment. Used COTS operating system and open graphics language as the host software environment. Integrated the mission processor with the network components (data buses, network interfaces, switches) and authenticated performance with Comanche OFP applications in a Comanche-like laboratory setting.
- 6967
  - Completed bench and wind tunnel testing of critical components for variable geometry rotor core concept technologies.
  - Formulated, selected, and recommended rotor system technology configuration for the 6.3 Variable Geometry Advanced Rotor Demonstration (VGARD) program.
  - Completed core concept applicability based on small scale validation testing.
  - Conducted active on-blade control loads modeling tools upgrade for transition to 6.3 VGARD concept mix and pre-design requirements.
- 6101
  - Conducted component research / test / validation and transition of NRTC technology to government / industry partners in the areas of rotorcraft performance improvement and exterior noise reduction.
  - Improved prediction methods for complex rotorcraft applications.
  - Improved tiltrotor shipboard handling qualities.

FY 2001 Accomplishments: (Continued)

- Performed NRTC advanced technology research efforts in low noise, improved bevel gear design concepts, advanced transmission technology, variable speed vapor cycle system, health and usage monitoring (HUM) smart transducer data bus research, antenna technology, composite durability and damage tolerance, non-deterministic fatigue life methodology, and integrated helicopter design technology.

• 2710
- Authenticated full-scale, light weight, high-efficiency engine infrared (IR) suppressor; performed low-energy dynamic impact testing of load adaptive crashworthy landing gear strut; performed coupon impact testing of alternative crashworthy fuel system components / designs for system weight reduction; performed conceptual analyses of advanced ballistic protection techniques for Army rotorcraft to achieve 15% net reduction in installed armor weight; affirmed 50% assembly labor reduction for complex composite rotorcraft assemblies; applied smart materials to adaptive airframe structures to reduce vibration; matured more accurate structural load predictions to reduce airframe weight and development time; evaluated durable composite rotorcraft structural concepts to reduce weight and operational costs.

- Screened low glint canopy coating material specifications.

• 2450
- Designed and authenticated smart material actuator and global control schemes that can alter the structural response of an airframe in-flight in response to changing mission conditions.

- Utilized modeling and simulation to predict the performance and screened candidate adaptive landing gear concepts; conducted design support tests on most promising concept.

- Identified smart material/actuator technology that can be integrated into adaptive helicopter airframe structure for active control of loads/vibration; screened innovative technologies applicable to high reliability control signal and power requirements of evolving advanced rotor concepts.

• 1480
- Fabricated high strength, lightweight shaft providing a reduction in the number of bearings required; fabricated advanced fuel control providing improved engine/airframe performance and affordability; designed advanced inlet particle separator providing increased separation efficiency and durability and reduced engine losses.

Total 26688

FY 2002 Planned Program

- 9087 - Perform preliminary simulation/flight test validation of autonomous guidance control laws using unmanned rotorcraft and piloted simulation quantifying benefit of "high situation awareness" rotorcraft cockpit displays emphasizing obstacle/traffic avoidance.

  - Install test monitoring equipment on aircraft and perform flight test planning for passive external load stabilization.

  - Affirm significant improvement in agility and all-weather operations using rotor state feedback in RASCAL.

  - Conduct wind tunnel test of integrated flight/rotor control using on-blade flaps.

  - Flight validate tactile cueing (real-time feedback of aircraft limits to pilot's sidestick controller)/active sidestick benefit for rotorcraft maneuver limiting.

  - Produce rotorcraft primary flight display symbology aeronautical design guide, incorporating findings from other services/government labs.

- 6610 - Conduct component maturation / test / validation and transition of NRTC technology to government / industry partners in the areas of: unmanned rotorcraft, rotorcraft interior noise reduction, rotorcraft interactional aerodynamics, rotorcraft performance improvement, carefree maneuvering technology, enhanced handling qualities for night operations, limited authority flight control technology, damage tolerance, crashworthiness and advanced structures, advanced low-cost composite manufacturing, structural joining technologies, rotorcraft transmission casting technologies, and enhance non-destructive engineering development.

  - Perform NRTC advanced technology maturation efforts in improved bevel gear design concepts, advanced transmission technology, HUM smart transducer data bus maturation, antenna technology, composite durability and damage tolerance, non-deterministic fatigue life methodology, and integrated helicopter design technology.

- 4118 - Conduct research on the application of autonomous controls on single and multiple teamed unmanned aerial vehicles.

  - Conduct research on the application of autonomous controls applied to terrain and obstacle avoidance.

  - Conduct research on the application of autonomous controls applied to mission flight.

- 3721 - Build and validate super lightweight thermal insulation components that reduce density by 50% over current state-of-the-art COTS insulation. - Conduct analytic screening of advanced aircraft camouflage designs that reduce visual signatures in both desert and vegetated environments by 50% compared to current coatings.

- 2568 - Design, modify, test full-scale adaptive landing gear shock strut to affirm a 50% improvement in crash energy attenuation.

  - Perform detailed design of control and actuation concepts for an adaptive structure concept capable of reducing airframe loads/vibration at a 50% reduction in weight penalty compared to current parasitic approaches.

  - Conduct detailed design of high reliability adaptive structure hardware for transferring flight critical control signals.

FY 2002 Planned Program (Continued)

- 12362 - Research and evaluate NASA and NRTC designs for UAV heavy-fuel internal combustion engines.
  - Research and validate NASA and NRTC simulation models for candidate Unmanned Combat Armed Rotorcraft (UCAR) airframe concepts.
  - Define NASA and NRTC candidate autonomous modes of operation for UCAR.
  - Research NASA and NRTC human systems interface alternatives for implementation in UCAR.
  - Research concepts for integrating air-to-ground sensors, designators, and Netfires (LAM-A and PAM-A) to demonstrate cooperative manned-unmanned systems capabilities.
  - Research real-time synthetic vision-based guidance and trajectory capability for precision maneuvering in combat.
- 1745 - Test Metal Matrix Composite (MMC) shaft and validate weight reductions; upgrade simulation software/hardware and perform final closed loop bench test of advanced fuel control; design and fabricate advanced inlet particle separator providing increased separation efficiency and durability and reduced engine losses; design advanced power turbine providing increased cycle efficiency and reduced engine weight.

Total 40211

FY 2003 Planned Program

- 10547 - Flight validate passive load stabilization.
  - Research control system/handling qualities criteria for Objective Force rotorcraft, to include tilt-rotor.
  - Research autonomous control laws and operator interface for small scale UAV Vertical Take-Off and Landing (VTOL) aircraft.
  - Flight validate elements of high situation awareness display technology, including cockpit display of traffic information (CDTI).
  - Refine display research / evaluation methodology for associated unmanned aerial vehicle aeronautical design guide.
  - Conduct research for candidate autonomous modes of operation for UAV.
  - Continue research of designs for UAV heavy-fuel internal combustion engines.
  - Improve and apply methodology for conceptual design of advanced rotorcraft to meet evolving needs.
- 6775 - Conduct component research / test / validation and transition of NRTC technology to government / industry partners in the areas of rotorcraft interactional aerodynamics, rotorcraft performance improvement, carefree maneuvering technology, enhanced handling qualities for night operations, limited authority flight control technology, damage tolerance, crashworthiness and advanced structures, advanced low-cost composite manufacturing, structural joining technologies, and rotorcraft transmission technologies.

FY 2003 Planned Program (Continued)

- Perform NRTC advanced technology research efforts in improved bevel gear design concepts, HUM smart transducer data bus research, composite durability and damage tolerance, non-deterministic fatigue life methodology, and integrated helicopter design technology.

- 4065 - Establish loads and affordability baselines for the swashplate-less rotor geometry; design rotor for the swashplate-less concept.
- 3932 - Fabricate and validate canopy glint suppression materials to reduce solar glint signatures of current transparency materials by 50% without adversely impacting optical clarity and night vision device performance.
- 2415 - Investigate the applicability of smart materials to the research of high reliability actuation devices/concepts for on-blade control surfaces associated with advanced rotor concepts. Create and validate models for each of the major process variability drivers. Trade-off enhanced process control versus relaxed design tolerances. Investigate application of smart actuation / adaptive structural concepts to "reconfigure" airframes subject to damage
- 1719 - Fabricate rig test of advanced inlet particle separator providing increased separation efficiency and reduced engine losses and O&S costs; fabricate advanced power turbine providing increased cycle efficiency and reduced engine weight.
- 10000 - Conduct research and evaluate design for UCAR heavy fuel engines.- Conduct research and evaluate technologies to reduce UCAR acoustic signature.

- Conduct reserach on candidate autonomous modes of operation and selected human system interface options for UCAR.
- Conduct research on selected concepts on UCAR for integrating air-to-ground sensors, designators, and NetFires.
- Conduct research on real-time synthetic vision-based guidance and trajectory capability for UCAR precision maneuver in combat operations.

Total 39453

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February 2002

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COST (In Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
47B	VEH PROP & STRUCT TECH	3528	3648	4239	4340	4435	4694	4804

A. Mission Description and Budget Item Justification: The Vehicle Propulsion and Structure Technology project investigates engine, drivetrain and airframe technologies for Army / DoD rotorcraft that significantly increase strategic and tactical mobility/deployability, increase reliability, reduce maintenance costs and increase combat sustainability. 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 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, incomplete loads/usage data, and inaccurate inspection and tracking methodologies. Technical solutions are pursued through: 1) propulsion research 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; and 2) structures research focused on aerodynamic loads, aeroelastic interactions, integrated composites, structural integrity, low cost manufacturing and crashworthiness that will provide improved rotor and airframe structures subsystems. This propulsion research supports the goals of the DoD integrated high performance turbine engine technology (IHPTET) / Joint Turbine Advanced Gas Generator (JTAGG) program. This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2001 Accomplishments:

- 2131 - Conducted air injection feedback control experiments on a turbine engine centrifugal compressor stage that indicated the potential for a 20-50% extension in stable operating range. This means improved operability over a broader range of adverse environmental conditions.

  - Completed baseline performance database of engine components for a compact two-stage compressor that will reduce engine size, weight, and fuel consumption.

  - Established feasibility of effective cooling geometrics for ceramic matrix composite turbine nozzle airfoil to support IHPTET very high temperature operating requirements.

  - Established baseline thermal behavior of an advanced helical gear drive system and determined performance of SiC pressure sensor for engine component applications that will contribute to drive train and advanced engine reliability and durability and to improve engine diagnostics.

FY 2001 Accomplishments: (Continued)

- Completed engine combustor and compressor simulations using improved software that validated substantial reductions in engine design turnaround times.

• 1397 - Successfully assessed aeroelastic stability of variable diameter tiltrotor concept in support of the Vertical Take-off and Landing capability for the Objective Force.

- Completed wind tunnel tests of active twist rotor for the complete flight envelope. Major improvements in vibration. Technology transitioned to Industry.

- Completed preliminary lab assessments of "Regenerative Electronics" power and control system to improve response time performance and reliability.

- Determined bondline interfacial effects on adhesive bond strength of composite structures for improved vehicle structural reliability.

- Completed static experiments to correlate strength and stiffness predictions of tailored composite panels to improve the prediction accuracy for future tiltrotor thin wing designs.

Total 3528

FY 2002 Planned Program

• 1987 - Conduct experiments using innovative Micro Electro Mechanical Sensor (MEMS) air injection technology (zero net mass flow) in the diffuser of a centrifugal compressor to extend compressor stability operating range.

- Conduct performance experiments on compact high performance two-stage compressor to enable reduced engine weight and size.

- Optimize processing parameters for fabrication of ceramic matrix composite turbine nozzles in support of high temperature IHPTET requirements.

- Complete baseline experiments of unique, high speed/high temperature gas path seal rig to enable reduction of engine secondary air flow losses, thereby improving efficiency.

- Complete thermal experiments on high-speed helical gear design to enhance future drive system reliability.

• 1661 - Assess the 'closed-loop' control actuation capability of Active Twist Rotor (ATR) for vibration reduction and to determine potential for noise reduction.

FY 2002 Planned Program (Continued)

- Investigate concepts for a Low Cost Active Rotor (LCAR) which provides for "Full Authority" control, eliminating the need for a rotor swashplate.

- Perform comparison studies of soft-inplane blade and hub loads versus conventional stiff-inplane hub to improve understanding of the tiltrotor stability boundary and to extend its performance envelope and investigate 3D finite element model of hybrid rotor hub flexbeam concept for improved rotorcraft structural integrity.

- Perform component experiments using thermal non-destructive evaluation (NDE) measurements to correlate bondline geometry with bond strength for an improved understanding of vehicle structural reliability and durability.

- Investigate airframe concepts for application to large-scale, pressurized rotorcraft fuselages in support of the Objective Force rotorcraft.

Total 3648

FY 2003 Planned Program

• 2529

- Assess MEMS air injection technology capability to provide extended stability operating range in a centrifugal compressor.

- Complete experimental evaluation of cooled monolithic ceramic and ceramic matrix composite turbine nozzles under simulated high temperature engine conditions in support of IPHTET requirements.

- Complete experiments on foil bearing for oil-free, small turbine engine applications.

- Establish high speed, high power face gear allowable stress levels for application to advanced rotorcraft transmissions.

• 1710

- Investigate design concepts (using advanced design comprehensive method) of "Full Authority" on-blade active control rotor system taking advantage of best smart actuators available to enhance control and performance.

- Acquire smart actuator materials to enable construction of "Full Authority" "Low Cost Active Rotor" rotor blades.

- Conduct static and fatigue experiments of scaled hybrid flexbeams to validate improved design criteria for fatigue durability and damage tolerance.

- Perform characterization experiments to evaluate strength and damage tolerance of pressurized airframe components to be used on Objective Force rotorcraft.

Total 4239