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

DATE: February 1999

BUDGET ACTIVITY: 2 - Applied Research

PE NUMBER AND TITLE: 0602211A Aviation Technology

COST (*In Thousands*)	FY1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY2004 Estimate	FY2005 Estimate	Cost to Complete	Total Cost
Total Program Element (PE) Cost	22698	24943	30165	31184	31559	31816	33448	33477	Continuing	Continuing
A47A Aeronautical and Aircraft Weapons Technology	20023	21853	26904	27616	27878	27965	29395	29273	Continuing	Continuing
A47B Vehicle Propulsion and Structures Technology	2675	3090	3261	3568	3681	3851	4053	4204	Continuing	Continuing

A. <u>Mission Description and Budget Item Justification</u>: The objective of this program element (PE) is to conduct applied research in rotary wing vehicle (RWV) technologies for transition to advanced development technology demonstrations that support development of new and / or upgraded DoD / Army rotorcraft systems in support of Joint Vision 2010 and Army After Next. RWV offer a practical solution to many of the DoD / Army's operational needs because of their ability to take off and land vertically and to operate efficiently and effectively at or below tree top level for nap-of-the-earth (NOE) missions. Accordingly, RWVs present unique design challenges and require significantly different analysis compared with traditional fixed wing vehicles, which do not have rotors and do not hover or fly in NOE. The Army Aviation Science and Technology program's functional organization, supported by the National Aeronautics and Space Administration (NASA) at three co-located activities, is the focal point for DoD efforts in rotorcraft technology. Technical areas include aeromechanics, aerodynamics, flight controls, aeroacoustics, structures, propulsion, reliability and maintainability, safety and survivability, mission support equipment, aircraft system synthesis, advanced helicopter analysis, flight simulation, aircrew-aircraft integration, avionics and aircraft weapons integration. The work in this PE is consistent with the Department of Defense Technology Area Plans, DoD Joint Warfighting Science and Technology Master Plan, DoD Reliance Agreements (for which the Army is the lead service for the development of rotorcraft science and technology), the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and coordinated government / industry / academia RWV Technology Development Approach. This PE also supports the National Rotorcraft Technology Center (NRTC), a partnership of government, industry and academia, whose primary objective is to ensure the continued superiority of U.S. military rotorcraft systems through focused technology projects with a near term (2-3 year) return on investment, enabling rapid technology insertion into military and commercial rotorcraft. The Army and NASA provide funding for NRTC which is at least matched by industry. Army, NASA, Navy, and Federal Aviation Administration (FAA) provide staffing and support for the NRTC operations. Technology developed in this PE will support the future DoD Joint Transport Rotorcraft (JTR) identified to potentially replace the aging Army CH4-7D Chinook and Navy CH-53 Super Stallion helicopters. Upgrade activities [as applicable] of Army systems such as the AH-64 Apache, RAH-66 Comanche, UH-60 Blackhawk, Navy SH-60 Seahawk and USMC AH-1 Cobra are supported as well.

Work in this PE 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, Lynn, MA; AlliedSignal Engines, Phoenix, AZ; Sikorsky Aircraft, Stratford, CT; Rolls Royce, Indianapolis, IN; Kaman Aerospace Corp., Bloomfield, CT; Pratt & Whitney, Hartford, CT; Raytheon STX, Washington, D.C.; and United Technologies Research Center, Hartford, CT. Additionally, work in this PE 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,

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2 Exhibit)	DATE February 1999
BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602211A Aviation Technology

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.

Primary in-house developers include Aviation and Missile Command (AMCOM), Redstone Arsenal, AL; Aeroflightdynamics Directorate / AMCOM, NASA Ames Research Center, Moffett Field, CA; Aviation Applied Technology Directorate / AMCOM, Ft Eustis, VA; Vehicle Technology Center (VTC) /Army Research Laboratory (ARL), NASA Langley Research Center, Hampton, VA; and Vehicle Technology Center / ARL, NASA Lewis Research Center, Cleveland, OH.

Technology products from this PE directly transfer to technology demonstrations conducted under PE 0603003A (Aviation Advanced Technology). Joint coordination of efforts, where applicable, is conducted with the NASA Aeronautics Program; PE 0602122N, Aircraft Technology; and PE 0602201F, Aerospace Flight Dynamics. To eliminate duplication, the PE efforts are coordinated throughout the rotorcraft community by joint program reviews, exchange of program data sheets, research and technology resumes, technical reports; inter-service liaison; government/industry/academia participation in the annual program development and refinement process for NRTC projects; attendance at scientific meetings and conferences; participation in the Joint Aeronautical Commander's Group, The Technical Cooperation Program (TTCP), NASA Research and Technology Committees, and the North Atlantic Treaty Organization (NATO) Advisory Group on Aerospace Research and Development (AGARD). Efforts under this PE transition to and provide risk reduction for Demonstration / Validation and Engineering Development programs supported by PE 0603801A (Aviation - Advanced Development), PE 0604801A (Aviation - Engineering Development) and PE 0604270A (Electronic Warfare Development). Some efforts also transition to the field through PE 0203752A (Aircraft Engine Component Improvement Program). In addition, this PE's deliverables provide technical support to PE 0604223A (RAH-66 Comanche), PE 0604816A (AH-64D Longbow Apache), and PE 0203744A (Aircraft Modifications / Product Improvement). Active joint Service programs supported: The Tri-Service Integrated High Performance Turbine Engine Technology (IHPTET) program and Navy / Army Joint Advanced Health and Usage Monitoring System (JAHUMS) Advanced Concept Technology Demonstration (ACTD) program. International Cooperative Agreements include Information Exchange Agreements with the Netherlands, Israel, Japan, Germany, France and the United Kingdom (UK).

B. Program Change Summary	FY 1998	FY 1999	FY 2000	FY 2001
Previous President's Budget (FY 1999 PB)	22211	29746	30041	31734
Appropriated Value	22982	25160		
Adjustments to Appropriated Value				
a. Congressional General Reductions	-771	-217		
b. SBIR / STTR				
c. Omnibus or Other Above Threshold Reductions	-13			
d. Below Threshold Reprogramming	500			
e. Rescissions				
Adjustments to Budget Years Since FY 1999 PB			+124	-550
Current Budget Submit (FY 2000 / 2001 PB)	22698	24943	30165	31184

Change Summary Explanation: Funding – FY 1999 program reduced by Congress (-4586).

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY: 2 - Applied Research	PE NUMBER AND TITLE: 0602211A Aviation Technology / PROJECT: A47A

COST (*In Thousands*)	FY1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY2004 Estimate	FY2005 Estimate	Cost to Complete	Total Cost
A47A Aeronautical and Aircraft Weapons Technology	20023	21853	26904	27616	27878	27965	29395	29273	Continuing	Continuing

Mission Description and Justification: The purpose of this project is to conduct applied research of technologies for DoD / Army RWV systems improvements in operational effectiveness and combat mission capability including increased strategic and tactical mobility / deployability, air-to-ground and air-to-air combat, improved fire power, increased aircraft and aircrew survivability, increased reliability and reduced maintenance, and increased combat sustainability. Work in this project maintains world excellence in rotorcraft technology through the study of advanced technologies and their applications to rotorcraft. Areas of investigation and research consist of the following: fluid mechanics, dynamics, aerodynamics, advanced flight control technology, handling qualities, aircraft avionics and weapons interaction, Infrared (IR) / visual electro-optical (EO) and acoustic signatures reduction, weight reduction, advanced materials applications, internal / external loads, militarization of propulsion / structures technology, engine specific component technologies in support of the DoD Integrated High Performance Turbine Engine Technology (IHPTET) initiative goal demonstrators, advanced smart materials applications, flight simulation, improved aircrew / machine integration and pilot-vehicle interface, improvements in reliability and maintainability, combat damage repair of new materials, vulnerability reduction to Nuclear Biological Chemical (NBC), ballistic, and advanced energy threats, crashworthiness, and logistics reductions. These technologies are being developed for application to current as well as future DoD / Army rotorcraft systems. This project also supports work done under the auspices of the National Rotorcraft Technology Center (NRTC). NRTC addresses five critical military / civil rotorcraft technology thrusts as follows: (a) process and product improvement for affordability, quality and environmental compliance; (b) enhanced rotorcraft performance; (c) passenger and community acceptance; (d) expanded rotorcraft operations; (e) technologies to support harmonized military qualification and civil certification. NRTC projects are identified and developed by industry and evaluated and approved by government on an annual basis to ensure they are supportive of DoD rotary wing goals and objectives.

FY 1998 Accomplishments:

- 6462 - Completed integration and testing of research flight control system components on the Rotorcraft Aircrew Systems Concepts Airborne Laboratory (RASCAL) in-flight simulator (a modified UH-60 helicopter) which will support active flight control demonstrations.
  - Completed and released beta evaluation version of the Control Designer's Unified Interface Tool (CONDUIT) to US rotorcraft manufacturers, which provides a capability to significantly reduce in rotorcraft flight control system development time.
  - Developed cyclic control envelope limiting and queuing in vertical motion piloted simulation, and documented work for transition to the Helicopter Active Control Technology (HACT) program
  - Analytically developed multi-element hi-lift airfoil with reduced drag characteristics as a candidate concept for the variable geometry rotor. Developed design for active-elevon controlled model rotor for vibration control. Completed optimized blade aerodynamic geometry for the Advanced Configuration Rotor (ACR) test article to improve rotor efficiency, reduce noise and vibratory loads. Benchmarked rotor air load prediction capability
  against prediction effectiveness metric required for efficient design of variable geometry rotors.

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602211A Aviation Technology
	PROJECT A47A

- Completed redesign of Man-machine Integrated Design Analysis System (MIDAS) cockpit design tool with new human operator cognitive models and performed part-task simulation studies to verify situation awareness measured predictions.
- Produced draft standard for helmet mounted symbology based on tri-service research in symbology design, dynamics, resolution, and referencing.

FY 1998 Accomplishments: (Continued)

•	1475	- Performed Integrated Flight Fire Control (IFFC) evaluation and simulation to quantify improvements in target engagement timelines and accuracy. - Conducted Airborne Manned / Unmanned Systems Technology (AMUST) performance integration trade studies needed for system definition and development.
•	1500	- Identified improvements needed to tailor existing crashworthiness predictive codes to Army rotorcraft, thereby reducing the development time/cost of future rotorcraft modifications. - Developed and tested 0-256 kHz laser interferometer to support acoustic drive train monitoring.
•	1500	- Provided man-machine integration support to Rotorcraft Pilot Associate.
•	2962	- Performed bond testing of lightweight all-composite joints to validate their structural integrity; fabricated and tested sub-components of metal matrix landing gear to decrease weight; conducted structural dynamic modeling of airframe fittings for improved structural integrity; developed closed-loop cure process to compensate for resin age and variability for improved structural integrity; conducted structural dynamic modeling of airframe fittings for improved structural weight; performed screening tests of advanced polymeric based leading edge materials for low dielectric rotor blade sand / rain erosion protection; defined matrix of advanced engine IR suppression concepts via computational fluid dynamics (CFD) flowfield analysis.
•	995	- Completed design of monolithic ceramic low pressure (LP) turbine airfoil and attachment configuration consistent with IHPTET / Joint Turbine Advanced Gas Generator (JTAGG) Phase III providing higher temperature capability and increased horsepower to weight ratio; completed design of advanced high pressure (HP) reduced stage compressor for IHPTET / JTAGG Phase III providing higher pressure ratio, reduced specific fuel consumption and reduced O and S costs; conducted preliminary design of inter-metallic composite (IMC) spar / shell HP turbine blade; conducted fabrication trials of Army / Air Force cooled ceramic matrix composite (CMC) turbine vane.
•	4200	- Completed component development / test / validation and transition of NRTC technology to government / industry partners from: Health and Usage Monitoring System (HUMS) diagnostic database, resin transfer molded tailrotor blade, main rotor pitch case testing, automated rotor blade surface finish process, high speed blade core carving process, composite swashplate design; tiltrotor groundwash model tests, active horizontal tail control flight test, rotor / antenna interaction prediction model, helicopter maneuver loads data analysis; interior noise reduction isolator mount and prediction methodology, gear design methods testing; simulator evaluation of synthetic vision and decision aiding tools, water and soil crash dynamics and crashworthy fuel tank methodology. - Conducted NRTC Applied Research efforts in the areas of low cost and efficient composite structures, reduced manufacturing and operating costs, active flight controls, increased reliability and flight safety, Master Cure Simulation System, enhanced vehicle performance, noise and vibration reduction, noise certification metric and ultrasafe drivetrain design with an emphasis on technologies validation and technology transition.
•	929	- Provided payment for Defense Finance and Accounting System (DFAS) services.
Total	20023	

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY: 2 - Applied Research	PE NUMBER AND TITLE: 0602211A Aviation Technology / PROJECT: A47A

FY 1999 Planned Program:

- 6866 - Perform sling-load flight-test studies to develop potential for sling load envelope prediction and determine critical handling-qualities criteria.
  - Validate and optimize RASCAL control laws prior to flight testing of research actuation system using CONDUIT methods and Rapid Prototyping Simulation Environment (RIPTIDE).
  - Evaluate oscillatory blade blowing concept to substantially improve rotor stall margins and increase maximum blade loading; evaluate ACR to improve rotor efficiency and reduce loads; use hybrid computational methods to develop approaches for reducing rotorcraft adverse aerodynamic forces and increasing range and speed.
  - Conduct preliminary verification, validation and accreditation for MIDAS human operator models.
  - Perform simulation evaluation of situation awareness measures to minimize spatial disorientation and improve symbology designs; transition results to RAH-66 Comanche and future rotorcraft systems**.**
- 500 - Conduct preliminary design studies for advanced rotor core concepts, including on-blade control, high-lift devices, active twist, and variable diameter rotor to guide critical component fabrication and evaluation.
- 1930 - Conduct preliminary design studies for advanced aerial rocket-to-aircraft integration concepts.
  - Complete airborne unmanned-to-manned systems definition / integration trade study and transition results to 6.3 flight demonstration.
  - Conduct preliminary design for multi-role aviation gun system integration concept for transition to 6.3 flight test demonstration
  - Analyze rotorcraft user avionics requirements, pertinent OSD open systems directives, industry Contractor Off The Shelf (COTS) plug and play common modules and reusable software to identify technical issues and preliminary design criteria for low-cost, common open system architecture solutions.
- 1871 - Conduct test of aluminum matrix landing gear components to verify crashworthiness; select high temperature tolerant material systems for rotorcraft dynamic components for improved environmental durability; conduct testing on composite fuselage joints to validate structural integrity; develop methods to co-cure complex composite rotorblades to reduce cost.
- 1355 - Complete fabrication of ceramic LP turbine providing higher temperature capability and increased horsepower to weight ratio; conduct rig testing; fabricate advanced HP compressor for IHPTET / JTAGG Phase III; complete design of IMC spar / shell HP turbine blade providing higher temperature capability and increased horsepower to weight ratio; complete preliminary design of high strength, lightweight shaft for JTAGG III; fabricate finalized design of an Army / Air Force cooled CMC HP turbine vane.
- 3148 - Complete evaluation of ceramic and polymer based leading edge materials for low dielectric, long life rotor blade protection in sand and rain environments.
  - Bench test preliminary high-efficiency engine IR suppressor that reduce engine performance penalty to signature reduction ratio by 50%.
- 4934 - Complete component development / demonstration / test / validation and transition of NRTC technology to government / industry partners from: corrosion sensors evaluation; integrated helicopter design architecture and tools; composite swashplate fabrication; validated interior noise reduction methodology, models, and mounts; flight test of decision aiding system; large eddy simulation of complex rotorcraft flows; tail buffet alleviation; fatigue behavior of a selectively reinforced aluminum matrix fitting; high speed machining of airframe structures; thermoset materials; low cost fasteners and installation for composites; melt-bond joint technology; and composite life prediction methodology.

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY: 2 - Applied Research	PE NUMBER AND TITLE: 0602211A Aviation Technology
	PROJECT: A47A

FY 1999 Planned Program: (continued)

-Continue NRTC Advanced development efforts in noise certification procedure; water and soil crash dynamics; crashworthy fuel tank design concepts / criteria; active side stick controllers; smart and multifunction rotorcraft antennas; flight management computer technology; and rotorcraft collision avoidance technology

- 933 - Provide payment for DFAS services.
- 316 - Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Programs.

Total 21853

FY 2000 Planned Program:

- 6991 - Evaluate CONDUIT / RIPTIDE-optimized flight control laws using the RASCAL in-flight simulator.
  - Validate partial authority flight control concepts, providing attitude command/attitude hold capability with existing partial authority actuators.
  - Create and analyze conceptual designs of advanced rotorcraft in response to evolving AAN operational concepts. Provide characteristics of these designs for input to war game simulations.
  - Continue verification, validation and accreditation for MIDAS human operator models. Transition tool to industry through cooperative R&D agreements.
  - Perform in-flight validation of advanced situation awareness and HMD evaluation methods in Cobra in-flight simulator.
  - Develop and / or tailor government / industry low cost, common, open system architecture design standards and specifications for DoD rotorcraft platform avionics.
- 7595 - Evaluate VGART core concept applicability based on small- scale demo testing; conduct parametric analysis to determine core concept technology mix potential for transition to Variable Geometry Advancer Rotor Demonstration (VGARD) program.
  - Fabricate large-scale critical components and begin bench tests for VGART core concept candidates.
  - Evaluate core concept initial wind tunnel data to guide variable geometry rotor candidate selection and prioritization for VGARD.
- 2019 - Fabricate complex rotor components in single co-cure to demonstrate lower production cost; conduct durability tests of drive shafts to demonstrate high temperature capability; select smart rotor control concept for improved blade performance; design primary structural concepts for ballistic protection.
- 1330 - Complete rig testing of ceramic LP turbine; conduct combined rig testing of advanced HP compressor for IHPTET / JTAGG Phase III; conduct rig validation testing of Army / Air Force cooled CMC HP turbine vane; complete detailed design of high strength, lightweight shaft for JTAGG III; conduct detailed design of advanced CMC JTAGG III combustor providing higher temperature capability and increased horsepower to weight ratio.
- 2769 - Complete preliminary concept screening, design and fabricate light weight, high-efficiency engine IR suppressor components that reduce suppressor weight by 20%
  - Conduct detailed comparisons of predictive vs. test structural behavior based on results full-scale ACAP crash tests and execute code modifications if necessary; perform component test and evaluation to support digitally-controlled crashworthy landing gear strut for 40% increased gear energy absorption; perform analysis of crashworthy fuel system components and alternative materials to support 30% system weight reduction.

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY: 2 - Applied Research	PE NUMBER AND TITLE: 0602211A Aviation Technology / PROJECT: A47A

FY 2000 Planned Program: (Continued)

- 6200 - Complete component development / test / validation and transition of NRTC technology to government / industry partners from: helicopter maneuver loads, active/passive noise control technology for helicopter interiors, helicopter cabin noise control methodology, resin transfer molded tailrotor blade, planetary ring gear isolation, enhanced aeromechanical stability, high speed blade core carving process, tiltrotor vibration stabilization, vibration benefits analysis helicopter exterior noise reduction, simulator evaluation of synthetic vision and decision aiding tools, water and soil crash dynamics, crashworthy fuel tank methodology, and vibration/stress reduction in airframes.
  - Conduct NRTC technology efforts in the areas of low cost and efficient composite structures, reduced manufacturing and operating costs, integration of helicopter design tools, reliability assessment, multidisciplinary optimization and multi-mission sizing.

Total 26904

FY 2001 Planned Program:

- 7311 - Demonstrate high-agility flight control using rotor state feedback in the RASCAL in-flight simulator providing 15% increase in maneuverability/agility.
  - Conduct vertical motion simulation of external cargo load stabilization allowing higher operational speeds with sling loads.
  - Complete analytical /simulation study of benefits of on-blade control using CONDUIT/RIPTIDE tools.
  - Provide expert analysis and critique of advanced platform designs from the rotorcraft community and assess their applicability to DoD needs.
  - Incorporate human modeling modifications into MIDAS identified by prior year evaluation testing.
  - Demonstrate reductions in crewstation design cycle and crewmember error potential resulting from full-scale application of MIDAS tool.
  - Complete development and tailoring of government / industry low cost, common, open system architecture design standards and specifications based on COTS plug and play common modules and reusable software for rotorcraft platform avionics
- 7023 - Complete bench and wind tunnel testing of critical components for variable geometry rotor core concept technologies.
  - Formulate, select, and recommend rotor system technology configuration for the Variable Geometry Advanced Rotor Demonstration (VGARD) program.
  - Conduct active on-blade control loads modeling tools upgrade for transition to 6.3 VGARD concept mix and pre-design requirements.
- 2530 - Conduct full-scale validation testing of complex, smart rotor components to demonstrate structural integrity and cost reduction; fabricate sub-scale structural armor specimens for ballistic testing.
-
- 1480 - Complete fabrication of advanced CMC JTAGG III combustor; perform combined CMC combustor/CMC turbine vane rig test for validation of JTAGG III life requirements; complete fabrication of high strength, lightweight shaft for JTAGG III.
- 2855 - Demonstrate full-scale, light weight, high-efficiency engine IR suppressor; perform low-energy dynamic impact testing of digitally-controlled crashworthy landing gear strut; perform coupon impact testing of alternative crashworthy fuel system components/designs for system weight reduction; perform conceptual analyses of advanced ballistic protection techniques for Army rotorcraft to achieve 15% net reduction in installed armor weight.

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602211A Aviation Technology
	PROJECT A47A

- Screen low glint canopy coating material specifications.

FY 2001 Planned Program: (Continued)

•	6417	- Complete component development / test / validation and transition of NRTC technology to government/industry partners from: design for tiltrotor noise reduction, tiltrotor performance enhancement, crash safety, damage tolerance for helicopter structures, behavior of fastened airframe joints, high temperature composite applications, composite nondestructive testing, resin properties affecting marcel generation, low cost composite structures, high speed machining of titanium composites, and high speed blade core carving. - Continue NRTC technology efforts in advanced rotor ice protection system, low noise and improved bearing contact bevel cages, rotorcraft antenna technologies, variable speed vapor cycle cooling system, helicopter decision aiding system, floatation loads and stability of aircraft, helicopter operations and approaches, noise abatement and standards simplification, and tiltrotor operations and approach developments.
Total	27616	

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY: 2 - Applied Research	PE NUMBER AND TITLE: 0602211A Aviation Technology / PROJECT: A47B

COST (*In Thousands*)	FY1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY2004 Estimate	FY2005 Estimate	Cost to Complete	Total Cost
A47B Vehicle Propulsion and Structures Technology	2675	3090	3261	3568	3681	3851	4053	4204	Continuing	Continuing

Mission Description and Justification: The purpose of this project is to conduct applied research of generic propulsion and structures technology in support of DoD / Army Rotary Wing Vehicle (RWV) improvements. Areas of investigation and research include concepts of: small airflow gas turbines; high temperature materials; mechanical drive systems; integrated composites structural integrity; low cost manufacturing concepts; aerodynamic loads; and aeroelastic interactions. The propulsion technology in this project supports the goal of the DoD Integrated High Performance Turbine Engine Technology (IHPTET) / Joint Turbine Advanced Gas Generator (JTAGG) program and the Army Aviation Research, Development and Engineering Center (RDEC). The goal of IHPTET is to demonstrate technology which would double propulsion system capability for a wide range of potential future RWV applications.

FY 1998 Accomplishments:

- 1552 - Completed performance testing and Average Passage (APNASA) analysis of the final configuration of the advanced 2-stage high pressure ratio axial compressor, which will aid in design of lighter weight and less costly high compression engines by reducing the number of required stages.
  - Completed the development of a waverotor operating map and characterized the waverotor start-up process. This is an alternative technology path that avoids some of the material and fluid dynamic technology barriers of turbomachinery.
  - Conducted aerodynamic and heat transfer tests for advanced transonic turbine blading to enable development of more efficient turbine cooling designs.
  - Completed seeded fault diagnostic / prognostic spiral bevel gear tests which will validate crack propagation prediction codes for use in future advanced lightweight gear designs.
  - Developed stable operation of high temperature magnetic bearings hardware that will enable operation of critical gas turbine mechanical components in the environmental conditions projected for IHPTET / JTAGG Phase III.
  - Provided methodology and design for control of the compressor stability enhancement system to achieve increased engine operating efficiency.
- 1123 - Prepared soft-inplane hub for the Langley tiltrotor model and completed hover tests, developed baseline rotor system for evaluation of aeroelastic tailored rotor for low vibration, and constructed one integral active-twist 'proof-of-concept' blade in preparations for hover tests in FY99.
  - Updated Finite Element Model (FEM) of the all composite Beechcraft Starship with accurate prediction of the first seven natural frequencies.
  - Validated Innovative Fuselage Concept design for crashworthiness using sub-scale specimens in preparation for full-scale test in FY99.
  - Completed fatigue tests on structural panels to validate fatigue life and crack growth rates of actual riveted aircraft structures.
  - Developed FEM based on solid-to-shell transition elements for debond analysis of stitched interface.

- Developed NDE data fusion software using probability based criteria for combining different methods to classify defects; validated durability and damage tolerance models for composite structures; evaluated NDE methods to measure strength of bonded structures.

Total 2675

FY 1999 Planned Program:

- 1763 - Complete speed and durability testing of oil-free bearing and seal technologies for revolutionary oil-free auxiliary power units and aeropropulsion engines.
  - Develop readiness of micro electromechanical systems (MEMS) micro sensor and actuator technology applied to engine components for control and diagnostic purposes which will improve lightweight engine performance and reliability.
  - Complete analysis and performance testing of an advanced compressor stage for IHPTET / JTAGG Phase III.
  - Conduct validation tests on thermal behavior of high speed gearing in support of advanced lightweight gearing systems.
  - Complete high temperature rig testing of magnetic bearings system.
  - Design and fabricate waverotor topped gas turbine integration experiment.
- 1310 - Evaluate soft-inplane tiltrotor system versus conventional stiff-inplane configuration in the Langley tunnel and evaluate active twist concept for vibration reduction potential in the Transonic Dynamics Tunnel.
  - Incorporate 'Regenerative Electronics' technology power and control into Aeroelastic Rotor Experimental System to reduce power required for on blade active control applications.
  - Acquire modal data for a baseline Aluminum Cylinder (ATC) for correlation with FEM.
  - Develop and test full scale crashworthy fuselage with chosen energy absorbing subfloor.
  - Fabricate and test low-cost structurally efficient concepts for helicopter fuselages.
  - Transition prototype instrument for bond strength measurements.
- 17 - Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Programs.

Total 3090

FY 2000 Planned Program:

- 1844 - Couple a waverotor with a simulated gas turbine engine rig and developed a successful solution to the most challenging waverotor/turbomachinery integration issues.
  - Develop advanced concept configuration for close coupled, compact compressor system; complete multi-stage CFD analysis of configuration.
  - Complete design and fabrication of cooled ceramic matrix composite turbine nozzle airfoils for application to IHPTET/JTAGG phase III.
  - Complete high temperature testing of back-up bearing system to be incorporated into the high temperature magnetic bearing system.
  - Complete design and analysis of oil-free small turbine engine..

- Complete database for face gear design stress allowables, thereby enabling design and development of revolutionary light weight helicopter drive systems.

• 1417 - Investigate active control technology for stability augmentation, conduct first tests of 'active twist' rotor for vibration control, and validate passive structural tailoring concept with model rotor test in Langley tunnel.
- Test 'on-blade' aerodynamic active control devices for vibration reduction in Langley tunnel.
- Conduct experimental program and collect modal test data of the all composite Sikorsky helicopter.
- Complete tension-torsion fatigue testing of Bell ducted tail rotor flexbeam.

FY 2000 Planned Program: (Continued)

- Establish design methodology for compression damage tolerance of impacted composite sandwich panels supporting airframe structural integrity, durability, and reliability. Also supports NASA DEAR program.
- Develop and conduct element and component tests of tailored structures to support RWST demonstration.

Total 3261

FY 2001 Planned Program:

• 1986 - Conduct performance and particle image velocimetry (PIV) experiments on close coupled compact compression system to validate fluid dynamic concepts developed in FY 00.
- Complete performance testing of waverotor topped gas turbine demonstration cycle, thereby verifying enhanced fuel efficiency and power density predicted in cycle analyses.
- Complete thermomechanical fatigue structural durability testing of cooled ceramic matrix composite turbine nozzle airfoil to support IHPTET readiness requirements.
- Complete performance testing and verify loss-of-lubrication tolerance of advanced helical gear drive system.
- Develop surface fatigue database for diamond like coated spur gears.

• 1582 - Collaborate with Industry in aeroelastic stability evaluation of Variable Diameter Tiltrotor concept in Langley Tunnel.
- Complete tests of 'active twist' rotor blade control for vibration in the Langley tunnel, and investigate potential for active twist as primary control for
swashplateless rotor.
- Conduct experiments on finite element model of composite helicopter and correlate with modal test data.
- Predict Boeing-Mesa main rotor flexbeam fatigue life. Supports RWST and the NASA DEAR program.
- Complete element and component tests of tailored structures in support of RWST program.
- Validate strength and stiffness predictions of tailored structures.

Total 3568

THIS PAGE INTENTIONALLY LEFT BLANK