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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army **Date:** February 2016

Appropriation/Budget Activity 2040: <i>Research, Development, Test & Evaluation, Army / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602211A / <i>Aviation Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	62.046	56.884	65.914	-	65.914	65.902	68.583	69.932	63.601	-	-
47A: <i>AERON & ACFT Wpns Tech</i>	-	54.212	48.377	56.159	-	56.159	55.468	57.886	59.024	52.400	-	-
47B: <i>Veh Prop & Struct Tech</i>	-	7.834	8.507	9.755	-	9.755	10.434	10.697	10.908	11.201	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) conducts air vehicle component design, fabrication and evaluation to enable Army aviation transformation. Emphasis is on developing aviation platform technologies to enhance manned and unmanned air vehicle combat and combat support operations for attack, reconnaissance, air assault, survivability, logistics and command and control missions. Project 47A researches and evaluates components and subsystems for air vehicles in the areas of aviation and aircraft weapons technology. Project 47B researches and evaluates components and subsystems for air vehicles in the areas of propulsion and structures. Focus areas include: engines & drive trains; rotors & vehicle management systems; platform design & structures; aircraft & occupant survivability; aircraft weapons & sensors; maintainability & sustainability; and unmanned & optionally manned systems. This PE supports the National Rotorcraft Technology Center (NRTC), a partnership of government, industry, and academia.

Work in this PE contributes to the Army Science and Technology (S&T) air systems portfolio and is fully coordinated with efforts in PE 0603003A (Aviation-Advanced Technology), PE 0602624A (Weapons and Munitions Technology), PE 0602303A (Missile Technology) and PE 0603710A (Night Vision Advanced Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering S&T focus areas and the Army Modernization Strategy. Work in this PE is performed by the Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC), located at Redstone Arsenal, AL; Joint Base Langley Eustis, VA; National Aeronautics and Space Administration (NASA) Ames Research Center, Moffett Field, CA; NASA Langley Research Center, Hampton, VA; and at the Army Research Laboratory (ARL), located at Adelphi, MD; Aberdeen Proving Ground, MD; Hampton, VA; and Cleveland, OH.

B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	63.414	56.884	65.914	-	65.914
Current President's Budget	62.046	56.884	65.914	-	65.914
Total Adjustments	-1.368	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.368	-			

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
47A: <i>AERON & ACFT Wpns Tech</i>	-	54.212	48.377	56.159	-	56.159	55.468	57.886	59.024	52.400	-	-

A. Mission Description and Budget Item Justification

This project designs and evaluates technologies for Army/Department of Defense (DoD) vertical lift and unmanned air systems to increase strategic and tactical mobility/deployability, improve combat effectiveness, increase aircraft and crew survivability; and improve combat sustainability. Areas of research address desired characteristics 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. This project supports the National Rotorcraft Technology Center (NRTC), a partnership of government, industry, and academia. This project leverages work accomplished in collaboration with the National Aeronautics and Space Administration (NASA). Technologies within this project transition to advanced technology development programs with application to future, as well as current, Army/DoD aircraft systems.

Work in this project is fully coordinated with Program Element (PE) 0603003A (Aviation Advanced Technology) and work in this project related to aircraft weapons integration is also fully coordinated with PE 0602624A (Weapons and Munitions Technology), PE 0602303A (Missile Technology), and PE 0603710A (Night Vision Advanced Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Aviation Development Directorate of the Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC), (located at the NASA Ames Research Center, Moffett Field, CA, NASA Langley Research Center, Hampton, VA; and Joint Base Langley Eustis, VA).

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2015	FY 2016	FY 2017
Title: National Rotorcraft Technology Center (NRTC)	4.947	4.704	4.686
Description: NRTC focuses government, U.S. rotorcraft industry, and academia resources on the development of pre-competitive, high-priority, military technology to maintain U.S. preeminence in rotorcraft capabilities.			
FY 2015 Accomplishments: Developed industry accepted criteria and repair methods for lightly damaged gear tooth repair, enhanced understanding of surface finish effect on gear noise; improved fatigue life and stress corrosion cracking mitigation for magnesium castings; and explored laser scanning technology to improve the fidelity and speed of housings and dynamic components inspection techniques.			
FY 2016 Plans:			

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Conduct industry-collaborative research in rapid certification of complex aviation systems; extreme reliability; structural integrity; aeromechanics modeling, design, and analysis of complex systems; advanced vehicle management systems and controls; component design and analysis tools; and design of transmission and drives component technology for reduced rotorcraft procurement and sustainment costs.</p> <p>FY 2017 Plans: Will conduct industry-collaborative research in extreme reliability of aviation systems; structural integrity; aeromechanics modeling, design, and analysis of complex systems; advanced vehicle management systems and controls; component design and analysis tools; cargo handling and delivery; advanced aircraft mission systems; naval operations; and design of transmission and drives component technology for reduced rotorcraft procurement and sustainment costs.</p>				
<p>Title: Rotors & Vehicle Management Technologies</p> <p>Description: Design and investigate advanced airfoil and rotor blade technologies, including active control elements, to support goals of increased hover and cruise efficiency. Design and evaluate advanced flight control and vehicle management component technologies to support goals of increased maneuverability, reliability, and reduced weight and cost.</p> <p>FY 2015 Accomplishments: Conducted studies on the highly complex, non-linear, downwash/outwash flow field beneath a sub-scale rotor in hover to refine current physical understanding and non-intrusive diagnostics techniques; improved the accuracy and efficiency of computational software that models full-vehicle rotorcraft aerodynamics on high-performance parallel computers; analyzed performance, aerodynamics and structural dynamics for advanced rotorcraft configurations; updated Aeronautical Design Standards (ADS-33) to integrate lessons learned from the Degraded Visual Environment-Mitigation (DVE-M) Program and slung load handling qualities measurements into new requirements; developed and simulated methods of controlling dual lift configurations; and analyzed and simulated flight control concepts for advanced rotorcraft configurations.</p> <p>FY 2016 Plans: Develop and assess high-fidelity computational models of complete rotorcraft for the aerodynamics and dynamics in both straight and level and maneuver flight. Complete last phase of downwash/outwash flow field beneath a sub-scale rotor in hover parametric study to refine current physical understanding of the complex, non-linear, coupled, downwash/outwash interactional flow field and enable refinement of modeling and simulation tools using measured downwash/outwash data. Develop innovative diagnostic techniques to measure and improve understanding of interactional aerodynamic phenomena. Integrate rotors and vehicle management system technologies to reduce rotor loads, reduce hub and airframe drag and improve vehicle performance. Conduct flight experiments of dual-lift flight control. Integrate flight control and handling qualities analysis into Army preliminary design tools NASA Design and Analysis of Rotorcraft (NDARC) for advanced rotorcraft configurations. Conduct piloted handling</p>		8.586	9.431	10.795

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>qualities experiments toward new/revised ADS-33 quantitative and qualitative criteria to address advanced rotorcraft concepts and missions supporting the Future vertical Lift (FVL).</p> <p>FY 2017 Plans: Will apply and explore next generation airfoils, active flow control concepts, and advanced rotors and VMS technologies in benchtop, sub-scale and full-scale experiments to improve the current physical understanding of interactional aerodynamics to enable adverse force reduction necessary for high speed forward flight. Will refine models and simulations relevant to advanced high speed, lift offset, and compound configurations. Will continue development of innovative diagnostic techniques to measure and improve understanding of interactional aerodynamic phenomena. Will continue to improve the accuracy and efficiency of high-fidelity computational fluid dynamics simulations on high-performance parallel computers; software will be optimized to efficiently scale on thousands of processors and new heterogeneous parallel computer hardware architectures; will develop new computational methods to automate the computational mesh generation and computational fluid dynamics solutions relevant to advanced aerodynamic vertical lift configurations. Will publish validated flight control analysis, design, and optimization methods in the open literature. Will extend Modernized Control Laws (MCLAWS) with mission adaptive autonomy (MAA). Will refine and update flight control design methods and tools (CIFER, CONDUIT, RIPTIDE) as needed to support advanced high-speed configurations. Will revise/develop ADS-33 criteria for advanced high-speed configurations and missions based on Joint Multi-Role Technology Demonstrator (JMR TD) lessons learned.</p>				
<p>Title: Aircraft and Occupant Survivability Technologies</p> <p>Description: Investigate advanced technologies to reduce susceptibility and vulnerability of aircraft to damage from threats or accidents, as well as technologies to defeat small arms, rocket and missile threats.</p> <p>FY 2015 Accomplishments: Completed performance and material analyses of lightweight composite transparent armor system and validated analyses through laboratory test; completed chemical analysis of JP-8 and alternative fuel blends; completed fabrication of test specimens for crashworthy ballistic fuel containment systems, and validated analyses through laboratory tests; leveraged flight test in part and full mission simulators to validate performance models of active crash protection system algorithms; completed the development of electro-optical (EO) /infrared (IR) materials, and conducted sub-scale testing of developed EO/IR materials for signature control and environmental durability; investigated preliminary near real-time survivability route planning algorithms; investigated Adaptive IR engine suppressor capability designed to optimize IR signature reduction and aircraft lift and range performance</p> <p>FY 2016 Plans: Develop and evaluate composite armor integrated into primary load bearing structure systems to improve conventional threat protection while reducing overall system weight. Evaluate passive and active energy attenuating devices integrated into primary structure to improve crashworthiness while reducing overall system weight. Conduct ballistic and crash experiments on lightweight</p>		9.108	4.494	6.095

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>composite armor components and energy attenuating devices to verify performance. Develop next generation ballistic, crash, and directed energy weapon protection and fuel containment technologies.</p> <p>FY 2017 Plans: Will evaluate application of advanced systems/subsystems and configurations that provide lightweight, high performance threat protection against non-conventional weapons to include directed energy. Will continue to develop and evaluate active crash protection and crashworthy ballistic tolerant fuel containment systems for full spectrum crashworthiness. Will continue to evaluate holistic survivability technology solutions through integrated survivability assessment trade studies for FVL concept aircraft. These trades will include multi-layered survivability concepts with seeker/guidance agnostic technologies to address operations in the emerging threat environment. Will develop hardware, integrate, and investigate adaptive engine exhaust suppressor systems on an engine test stand to evaluate IR signature and engine performance of the integrated system.</p>				
<p>Title: Engine and Drives Technologies</p> <p>Description: Design and evaluate advanced turboshaft engine component technologies to support goals of reduced fuel consumption, engine size, weight, and cost, as well as improved reliability and maintainability. Design and evaluate advanced drive system component technologies to support multi-speed transmissions, lighter weight gearboxes, and reduced costs, while improving reliability and maintainability</p> <p>FY 2015 Accomplishments: Completed investigation of advanced variable speed power turbine for improved performance and operational capability; completed alternate engine concepts design and analysis effort; performed conceptual design analysis of advanced integrated engine/flight controls with integrated health management for reduced weight/cost and improved reliability/fault detection; designed/fabricated clutchless concepts for multi-speed gearbox component testing; developed integral shaft/bearing races to reduce weight in large gearboxes and investigated new high-strength, corrosion resistant materials for drive system applications.</p> <p>FY 2016 Plans: Perform the conceptual design and determine the benefits of advanced integrated engine controls technologies such as distributed controls and more electric controls for improved aviation system engine performance, weight, and maintainability; develop design of a smart, adaptable, and efficient sand filtration system for improved engine performance and durability; and design drive train technologies with multi-speed (ability to vary shaft speed between 50 and 100%) to support development of next generation rotorcraft transmission and Future Vertical Lift objectives</p> <p>FY 2017 Plans: Will finalize the design of the smart, adaptable, and efficient sand filtration technology for improved engine performance and durability and begin fabrication of hardware for validation test; will investigate alternative adaptable engine architectures/components in support of alternative concept engine and FVL objectives; will validate through experimentation drive train</p>		4.974	3.600	6.608

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
component technologies with multi-speed (ability to vary shaft speed between 50 and 100%) in support of next generation rotorcraft transmission and FVL objectives.				
<p>Title: Platform Design & Structures Technologies</p> <p>Description: Enables new rotorcraft configurations by evaluating critical advanced aviation technologies using design and analysis methods with greater modeling fidelity with an ultimate goal of reducing the timelines associated with overall design of new aircraft. Introduces high fidelity methodology for improved performance and design predictions earlier in the development and acquisition process. Use physics of failure modeling and coupled discipline analysis to drastically improve component and system reliability. Work is coordinated with Aviation Component Failure Modeling efforts in PE 0602211, Project 47B at Army Research Laboratory (ARL).</p> <p>FY 2015 Accomplishments: Continued enhancement and refinement of vehicle costing methodologies, analytical efficiencies and accuracy; applied modeling and simulation tools to design and perform analysis of the Family of Systems (FoS) for FVL to support "Zero Maintenance" helicopter concepts; investigated and developed physics of failure modeling to improve reliability of system components, and to enable damage tolerant component design; investigated methods to monitor component loads and integrate with aircraft controls to stay within component failure limits; and investigated modeling and simulation methods to reduce the time required to design and develop new aircraft</p> <p>FY 2016 Plans: Continue enhancement of the Integrated Design Environment (IDE) for conceptual design of advanced rotary wing concepts with the addition of methodologies for airfoil design, signatures, operational impact of downwash/outwash, stability & control, and design optimization and sensitivity analysis. Apply modeling and simulation tools to support design of FVL/novel concepts and analysis of their operational feasibility. Enhance probabilistic structural integrity and useful life analytical techniques through improved damage initiation and propagation models; develop and perform investigation of high-strain capable, multifunctional structures that offer improvements in structural efficiency and enable ultra-reliable, operationally durable designs.</p> <p>FY 2017 Plans: Will continue to develop and mature robust analyses that use integrated physics and probabilistic based methods to assess and manage structural integrity; verify the performance of operationally durable airframe technologies and designs. Will begin integration of total survivability features into ultra-reliable, multifunctional structures to include multifunctional structural armor and crash protection solutions. Will facilitate maturation of IDE</p>		7.334	7.331	6.322
<p>Title: Unmanned and Optionally Manned Technologies</p> <p>Description: Design and develop collaboration and cooperation algorithms to support goal of intelligent teaming for manned-unmanned operations. Design and develop advanced unmanned aerial system (UAS) components to support goal of improved</p>		6.351	6.603	6.909

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>small UAS performance. When applicable, technologies in this area are leveraged to support mitigation of degraded visual environments (DVE).</p> <p>FY 2015 Accomplishments: Developed optimal human-machine visual, aural, and tactile interfaces for manned-unmanned teaming (MUM-T) that supports efficient mission execution and safe flight operations with high situational awareness for pilots and unmanned aerial system operators. Built upon previous sensor and symbology efforts, design and develop methods to optimally blend forward-looking synthetic and enhanced vision sensor information with cueing symbology that aids the helicopter pilot or operator in control of the helicopter in DVE; and investigated advanced technologies to increase task and mission effectiveness of unmanned aerial systems when partnered with ground and airborne soldiers, including autonomous behaviors, perception, autonomy architectures, and human aiding.</p> <p>FY 2016 Plans: Investigate optimal human-machine visual, aural, and tactile interfaces for manned-unmanned teaming that support efficient mission execution and safe flight operations with high situational awareness for pilots and unmanned aerial system operators. Optimally blend plan-view and forward-looking synthetic and enhanced vision sensor information with symbology, aural, and haptic cueing that aids the helicopter pilot or operator in control of the helicopter in complex environments. Include close proximity flight in a simulation environment and develop technology for a simulation experiment. Develop data fusion technologies of both on and off board sensors in a simulation environment.</p> <p>FY 2017 Plans: Will develop algorithms for increased autonomy applicable across a range of UASs including autonomous flight controls, behaviors to support tactical missions, open architectures, and contingency management to support mission execution independent of a constant data link to a ground control station. Improvements to autonomous flight controls will support more reliable, more robust flight operations independent of a human operator or pilot, and enable improved mission capable UAS flight operations. Will develop integration approaches between emerging multi-national open architecture frameworks and interfaces. The open architecture approach is a key enabling technology to rapidly develop and transition new autonomous concepts.</p>				
<p>Title: Aircraft Weapon & Sensor Technologies</p> <p>Description: Design and develop innovative approaches for integrating advanced weapons and sensors on aircraft platforms, including smart dispensers, data transfer, and post-launch weapon communication.</p> <p>FY 2015 Accomplishments:</p>		1.579	1.604	1.625

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Investigated integrated targeting/intelligence, surveillance, and reconnaissance (ISR) sensors and alternative targeting sensors; assessed emerging lethal and non-lethal deterrent weapons capabilities for development and aircraft integration; and prepared the lightweight remote control system for follow on testing.</p> <p>FY 2016 Plans: Develop sensor integration architecture and networking standards to enable the capability to quickly and easily integrate sensor systems on to Army aircraft, and to enable more seamless sensor and imaging data fusion. Conduct lab based sensor networking and experimentation to verify the enhanced sensor integration and fusion capabilities. Conduct a Common Gun study to determine the requirements and feasibility of a common gun system on FVL, Apache, and other Army aircraft systems, operating across a range of missions. Continue to support Aviation and Missile Research, Development, and Engineering Center (AMRDEC) Missile PE 0603313A, and Communications and Electronics Research, Development, and Engineering Center (CERDEC) Night Vision and Electronic Sensors Directorate (NVESD), PE 0603710A for the design and development of an organically launched sensor system that will be deployed from Army aircraft with a wide range of sensing capabilities.</p> <p>FY 2017 Plans: Will investigate image integration techniques for use in target location to reduce the sensor to shooter timeline and improve lethality. Will investigate using current on-board sensors and advance weapons techniques to assess the potential supplement as an active protection system.</p>				
<p>Title: Maintainability & Sustainability Technologies</p> <p>Description: Develop prognostic and system health assessment technologies to enable an enhanced Condition Based Maintenance supportability structure and posture for application towards an ultra-reliable, low maintenance design approach that significantly reduces unscheduled maintenance, inspections and operations and sustainment costs.</p> <p>FY 2015 Accomplishments: Developed embedded multi-functional sensors with built-in processing and communications; developed health assessment systems to support adaptive controls; developed technologies for component self-assessment, usage tracking and embedded history; and investigated technologies to provide health monitoring to support and optimize design efficiencies.</p> <p>FY 2016 Plans: Investigate use of wireless communication technologies to reduce wiring weight associated with prognostics and diagnostics; Integrate health assessment technologies into Joint Common Architecture (JCA)/avionics/cockpit; will develop fly-by-wire (FBW) with CBM monitoring capability; Develop miniaturized wireless sensors with on-component processing, history and parts tracking; Develop improved fleet management capability with autonomous logistics for parts/production control; Investigate technologies for in-flight data transmission to ground.</p> <p>FY 2017 Plans:</p>		3.504	2.104	3.619

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Will perform investigation of technologies and methodologies to enable more efficient designs and reduce the maintenance burden for future and current fleet of vertical lift aircraft. Will perform experiments of on-engine, adaptive engine controls to optimize performance, component life and maintenance schedule based on engine health. Will begin investigation of in-flight, real-time, automated methods to adjust rotor system track and balance to reduce aircraft vibration and loads. Will investigate improved failure detection within a planetary system, reduced size and weight impact of advanced sensor technologies, and a methodology to allow operations above maximum continuous rating for limited periods of time. Will investigate a proper level of autonomy to the condition assessment process for a composite airframe and provide decision support for repair decisions with a repair integrity assessment approach. Will continue development of a comprehensive integrated aircraft wide electrical system capability for diagnostics, fault isolation, and generate trendable health indicators. Will continue investigation of reliability criteria for design tools, methodologies, and materials to facilitate the optimization of future rotorcraft designs.</p>				
<p>Title: Survivability For Degraded Visual Environment (DVE) Operations</p> <p>Description: Research advanced sensor and cockpit display technologies to provide ability to maintain terrain and obstacle situational awareness during aircraft induced (brown-out & white-out) and environmentally induced (rain, snow, smog, fog, smoke, low light, etc.) DVE. Work in this area is being done in coordination with efforts at Army CERDEC, PE 603710A, Night Vision Advanced Technology.</p> <p>FY 2015 Accomplishments: Investigated multi-resolution fusion sensor package comprised of a 94 GHz millimeter wave radar, a laser radar (LADAR) and an infrared (IR) camera; investigated alternative fusion techniques with a different form of LADAR and an IR camera; conducted experiments focused on optimizing the forward flight modernized control laws (MCLAWS) of the Blackhawk UH-60 aircraft in preparation for a planned Fiscal Year (FY) 2016 DVE-M flight test; and explored the value of additional cueing techniques such as tactile and aural technologies in the AMRDEC simulation facility at Redstone Arsenal, Alabama. This work fed a 6.3 DVE-M tech demo effort beginning in FY16.</p> <p>FY 2016 Plans: Execute a second iteration of experimentation at United States Army Aeromedical Research Laboratory (USAARL) simulation facility (Fort Rucker, AL) focusing on symbology, tactile and aural technologies trades and optimization. Continue software algorithm and materiel component design and development for execution of sensor fusion involving LADAR, RADAR & IR systems for two separate DVE Mitigation Program lines of effort. Execute system integration design and substantiation of two multi-modality sensor fusion packages; this includes mechanical, electrical and instrumentation packages, a "best of breed" symbology set for all modes of flight (landing, take-off, enroute), and appropriate advanced cueing tactile and aural elements that were identified in USAARL simulator experiments.</p> <p>FY 2017 Plans:</p>		7.829	8.506	9.500

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Will continue experimentation and development of MCLAWS to incorporate capability developments such as coupled flight, power management guidance, and sensor coupled optionally piloted flight. Will continue complex computing design studies to determine best open systems architecture to handle processing power requirements, data rates, and latency while retaining interface to existing and future architectures. Will complete two software algorithm and materiel component design and development lines of effort. Will develop sensor fusion efforts involving LADAR, RADAR & IR systems for FY20 milestone DVE-M flight demonstration. Will refine a "best of breed" symbology set for all modes of flight (take-off, enroute, landing), and appropriate advanced cueing tactile and aural elements that were identified in USAARL simulator experiments; will develop intuitive cueing system that provides spherical situational awareness.			
Accomplishments/Planned Programs Subtotals	54.212	48.377	56.159

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

UNCLASSIFIED

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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
47B: <i>Veh Prop & Struct Tech</i>	-	7.834	8.507	9.755	-	9.755	10.434	10.697	10.908	11.201	-	-

A. Mission Description and Budget Item Justification

This project investigates engine, drive train, and airframe enabling technologies such as multifunctional materials, fluid mechanics and high temperature, high strength, low cost shaft materials. Additional areas of research include platform, aerodynamic, transmission, and control technologies for implementation in handheld autonomous Unmanned Aerial Systems (UAS) and failure analysis and prediction models and techniques to support a "zero maintenance helicopter" concept.

Work in this project complements and is fully coordinated with Program Element (PE) 0603003A (Aviation Advanced Technology) and leverages basic research performed in PE 0601104/Project H54 (Micro Autonomous Systems Technology Collaborative Technology Alliance) and PE 0601104/Project H09 (Robotics Collaborative Technology Alliance).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) at the National Aeronautics and Space Administration (NASA) Glenn Research Center, Cleveland, OH, the NASA Langley Research Center, Hampton, VA, and the Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2015	FY 2016	FY 2017
Title: Rotor and Structure Technology	2.342	2.547	2.589
Description: Devise improved tools and methodologies to more accurately design for improved component reliability and durability, resulting in platforms that are lighter in weight and less costly to acquire and maintain. Investigate rotors and structures to significantly improve rotorcraft range and speed.			
FY 2015 Accomplishments: Investigated novel approaches to improve rotorcraft vehicle maintainability; investigated the feasibility of aeroelastic/aeromechanical stability enhancement of composite rotor blades through novel material concepts; developed wind-tunnel models to study advanced active-control helicopter rotor systems; provided advanced structural dynamics models of rotorcraft fuselage structures; and explored and evaluated plasma discharge based active flow control techniques for rotor dynamic stall alleviation and diffuser augmented rotor systems.			
FY 2016 Plans:			

UNCLASSIFIED

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Design and develop smart materials that can self-sense, self-heal and self-reconfigure to facilitate damage/health assessment of aviation component structures; evaluate material/component damage sensing strategies; conduct modeling and simulation of damage detection; and investigate data fusion techniques for assessing material/component failure in aircraft.</p> <p>FY 2017 Plans: Will capture material damage precursors using test coupons in a laboratory environment for aircraft structural materials; develop a computational tool to calculate the optimum flight path of multi-rotor rotorcraft in auto-rotative flight, and validate the predictions of the tool by comparing to higher-fidelity methods for steady autorotation or empirical measurements to establish fast engineering computational tools to examine and advance optimum flight paths for next generation Army rotorcraft; use established co-axial computational model(s) to assess technologies, including active flow control, structural shape morphing, and blade pitch control, for potential increase in maximum flight speed with the same safety margins; apply models to assess performance improvement.</p>				
<p>Title: Engine and Drive Train Technology (previously titled Propulsion and Drive Train Technology)</p> <p>Description: Investigate high temperature materials, advanced models for flow physics and improved methods for predicting propulsion system mechanical behavior to increase fuel efficiency and reduce propulsion system weight.</p> <p>FY 2015 Accomplishments: Evaluated the benefits of advanced technologies such as improved fuel spray, multi-fuel capability, etc., for aviation system engine performance and durability at sea level and simulated altitude conditions; and demonstrated drive train technologies with 50% increase in time-to-scuffing-failure after lubricant supply is terminated in a simulated gear environment and identified promising technologies to achieve +50% oil-out time in support of next generation rotorcraft transmission objectives.</p> <p>FY 2016 Plans: Investigate coupled physics-based probabilistic design of ultra-lightweight hybrid gear; validate component modeling on extended design space for variable-speed turbine; and investigate novel micro injector technology for UAS engines using both analysis and modeling to mature optimization tools for efficient fuel combustion to increase UAS mission capabilities.</p> <p>FY 2017 Plans: Will investigate the performance of an ultra-lightweight hybrid gear under simulated load conditions and compare it with state-of-the-art metal gears to assess its potential applicability to future Army vertical lift vehicles; investigate the potential of a new class of high temperature shape memory alloys and other active and passive smart materials to enable shape changing turbine airfoils to allow blade optimization for aerodynamic performance and thermodynamic enhancements which could result in improved fuel consumption for Army vertical lift vehicles. Will also investigate injection technologies, micro nozzle and outward opening nozzles, that offer the potential to shorten liquid fuel penetration length and increase the rate of fuel injection at lower fuel pressures, to realize heavy-fuel operated small UAS and man portable generator engines.</p>		3.040	3.198	2.678
<p>Title: Micro/Small Scale Unmanned Aerial Systems</p>		1.475	1.762	3.488

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016		
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602211A / <i>Aviation Technology</i>	Project (Number/Name) 47B / <i>Veh Prop & Struct Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Description: Investigate platform, aerodynamic, actuation, transmission, and control technologies for handheld autonomous UAS. Handheld autonomous UAS will provide small units with significantly increased tactical mobility and deployability by extending soldier perception to real-time local Intelligence, Surveillance, and Reconnaissance (ISR) with handheld organic assets that help to minimize the supporting infrastructure needed for deployment.</p> <p>FY 2015 Accomplishments: Implemented open loop control strategies employing active aerodynamic or elastic actuation to aircraft form factors for achieving gust and other disturbance rejection capability; incorporated bio-inspired sensors for enhanced state and disturbance awareness; evaluated technologies addressing the communication and processing needs of size, weight, and power constrained platforms; established an aeromechanics analysis tool integrating fluid dynamics and structural dynamics solvers; investigated wing flexibility/morphing for performance enhancements; and performed quantitative technology and tradeoff analyses of independent flapping wing control for maneuvering micro aerial vehicles (MAVs). This effort is coordinated with PE 0601104A/Project H54 (Micro Autonomous Systems Technology Collaborative Technology Alliance).</p> <p>FY 2016 Plans: Investigate a span-adaptive wing which yields relatively consistent performance across its span range while responding to slowly varying conditions in a wind tunnel; and validate with low degree-of-freedom surrogates, energy conservative behaviors inspired from biology.</p> <p>FY 2017 Plans: Will incorporate span adaptation in a closed-loop responding to sensory or operational inputs; assess measures of effectiveness for three-dimensional (3D) printed Unmanned Aerial Vehicles (UAVs) validated by analysis under controlled conditions and develop and assess a tradespace analysis methodology to enable design of scaleable UAV platforms that takes into account different size platforms and specific missions.</p>				
<p>Title: Aviation Component Failure Modeling</p> <p>Description: Develop failure analysis and prediction models and techniques to support a "zero maintenance helicopter" concept. Work is coordinated with Aviation component and system reliability efforts in PE 0602211A/Project 47A at the U.S. Army Aviation and Missile Research, Development and Engineering Center.</p> <p>FY 2015 Accomplishments: Developed and improved failure models to characterize and categorize specific material damage precursors relevant to aviation components; developed a probabilistic framework for predicting remaining useful life of vehicle platforms; investigated the</p>		0.977	1.000	1.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Army	Date: February 2016
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Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602211A / <i>Aviation Technology</i>	Project (Number/Name) 47B / <i>Veh Prop & Struct Tech</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
integration of advanced aviation component health monitoring techniques into health-usage monitoring systems (HUMS); and developed self-sensing structural material technologies that incorporate damage precursor detection philosophy. <i>FY 2016 Plans:</i> Develop the Virtual Risk-informed Agile Maneuver Sustainment (VRAMS) concept, which evaluates technologies to autonomously provide state awareness at the material level and automate stress-reduction methods; investigate a “virtual reality” concept for self-diagnostics of real-time material state and automated solutions for self-directed maneuver alternatives in real-time. This effort will enables fatigue-free and zero-maintenance aircraft components. <i>FY 2017 Plans:</i> Will conduct nonlinear failure analysis; perform physics-based modeling; and determine analytical methods to utilize material damage precursors to assess remaining useful life for aviation structural components.			
Accomplishments/Planned Programs Subtotals	7.834	8.507	9.755

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A