

Edward C. Smith

*The Pennsylvania State University
Department of Aerospace Engineering
231D Hammond Building
University Park, PA 16802
(814) 863-0966
ecs5@psu.edu*

Professional Experience

Professor of Aerospace Engineering, 2004-present, Penn State University
Director, Penn State Vertical Lift Research Center of Excellence

Associate Professor of Aerospace Engineering, 1998-2004, Penn State University
Director, Penn State Rotorcraft Center of Excellence

Assistant Professor of Aerospace Engineering, 1992-1998, Penn State University
Co-Director, Director, Penn State Rotorcraft Center of Excellence (1996-1998)

Areas of research include rotorcraft dynamics and aeromechanics, composite structures, elastomeric materials, adaptive structures, and active vibration control.

Graduate Research Fellow, Rotorcraft Engineering, University of Maryland, 1988-1992.

Undergraduate Research Assistant, Penn State Applied Research Laboratory, Fabrication, and damping characterization testing of metal matrix composite materials 1986-1988.

Visiting Professor of Civil and Mechanical Engineering, United States Military Academy at West Point, July 2014 - December 2014. (sabbatical leave)

Graduate Faculty Member, Graduate Program in Acoustics, Penn State University. 2023-present

Education

Ph.D., Aerospace Engineering
University of Maryland, Center for Rotorcraft Education and Research, August 1992
Dissertation: *Aeroelastic Response and Aeromechanical Stability of Helicopters with Elastically Coupled Composite Rotor Blades*

M.S., Aerospace Engineering,
University of Maryland, Center for Rotorcraft Education and Research, May 1990.

B.S. with High Distinction, Aerospace Engineering, Minor in Mathematics,
The Pennsylvania State University, May 1988.

Honors and Awards

- 2022 Vertical Flight Society Robert Lichten Best Paper Competition Winner (co-authored paper with Jessica Beyer, S. Schmitz, and J. Zhang)
- 2022 Best Paper in Propulsion, 78th VFS Forum, Co-author, May 2022
- 2021 Inaugural Class of Dean's Fellows in the College of Engineering, Penn State - College of Engineering. (January 2017 - December 31, 2021).
- 2019 Best Student Paper (Jefferson Goblet Award), Aerospace Structures/Design at AIAA SCITECH 2019 (student: K. Prakash, co-advisor C. Bakis).
- 2018 NASA Group Achievement Award, NASA Glenn Research Center
- 2018 Best Paper in Propulsion, 74th American Helicopter Society Forum
- 2017 Best Paper, American Helicopter Society Dynamics Session
- 2016 Associate Fellow, American Institute of Aeronautics and Astronautics
- 2013 Best Paper Award - Influence of Aeroelastically Tailored Wing Extensions and Winglets on Whirl Flutter Stability, Asian Rotorcraft Forum
- 2013 President's Award for Engagement with Students
- 2012 American Helicopter Society National Membership Sponsor Award
- 2009 DSCD Rudolf Kalman Best Paper Award "Multi-Harmonic Adaptive Vibration Control of Misaligned Driveline via Active Magnetic Bearings" Paper No. FMANU-DS-06-1012
- 2008 American Helicopter Society Technical Fellow
- 2008 AHS Student Design Competition, co-advised students on 1st Place Design
- 2007 Group Achievement Award to the Heavy Lift Rotorcraft Systems Integration Team
- 2007 Penn State Engineering Society Outstanding Advising Award
- 2007 AHS Student Design Competition, co-advised students on 1st Place Design
- 2006 AHS Student Design Competition, co-advised students on 1st Place Design
- 2002 Penn State Engineering Society Outstanding Research Award which recognizes outstanding engineering researchers for accomplishments in advancing the frontiers of knowledge
- 2002 January Lawrence Sperry Award for extraordinary leadership as founder of a National Rotorcraft Technology Center; for pioneering research in aeroelasticity of composite rotors; and for dedication to Aerospace Engineering Education.
- 2001 American Helicopter Society National Membership Sponsor Award
- 2000 December Member of team which won the National Partnership for Reinventing Government Vice President Al Gore for establishing the National Rotorcraft Technology Center
- 1998 Fall Penn State Senior Engineering Project Advisor, 2nd Place for Product
- 1998 Fall Penn State Senior Engineering Project Advisor, 2nd Place for Presentation
- 1997 Mid-Atlantic AHS Regional Lichten Award for Best New Student Paper, co-authored paper and advised graduate student winner, (J. Keller)
- 1996 American Helicopter Society National Membership Sponsor Award
- 1996 AHS Student Design Competition, co-advised students on 1st Place Design
- 1996 Mid-Atlantic AHS Regional Lichten Award for Best New Student Paper, co-authored paper and co-advised graduate student winner (C. Brackbill)
- 1995 Best Paper Award in Dynamics, Smith, E.C., Beale, M.R., Govindswamy, K., Vascinec, M.J., and Lesieutre, G.A., "Formulation and Validation of a Finite Element Model for Elastomeric Lag Dampers", *Proceedings of the 51st American*

Helicopter Society Forum, May 1995.

1995 American Helicopter Society National Membership Sponsor Award

1994 American Helicopter Society Director's Award

1994 Army Research Office Young Investigator Award

1990 Vertical Flight Foundation - Boeing Helicopters Scholarship

1989 Vertical Flight Foundation - Kaman Corporation Scholarship

1988 Vertical Flight Foundation - American Helicopter Society Scholarship

Minta Martin Fellowship - University of Maryland College of Engineering

Rotorcraft Fellowship - University of Maryland Aerospace Engineering Department

George F. Wislicenus Undergraduate Honors Program - Penn State University/ARL

Sigma Gamma Tau, National Aerospace Engineering Honor Society

Tau Beta Pi, National Engineering Honor Society

Academic and Professional Service Highlights

Faculty Advisor: American Helicopter Society, growth from 12 members to 60+ members (largest university/student chapter within AHS), Co-Advisor, August 1992 – 1996, Advisor, 1996–2015, Co-Advisor (2015-present)

Advisor: College of Engineering Freshman-Sophomore Engineering Advising Center, 1992-1996, 2004, 2009, 2012-13, 2016-present

Committee Chairman: Department of Aerospace Engineering Promotion & Tenure Committee, 2016-2017. Member 2015-2016, 2019-present.

Committee Chairman: Department of Aerospace Engineering Faculty Search Committee, 2017-2019

Committee Chairman: AHS Dynamics Committee, May 2000-2002, 2016-2017

Committee Chairman: AHS Education Committee, 1997-2012

Committee Member: AHS Education Committee, May 1995-present

Committee Member: Army Research Laboratory Mechanical Sciences Division External Review, National Academies, 2013-2017

Committee Member: Department of Aerospace Engineering Undergraduate Studies, 2015-2016

Committee Member: PSU Aerospace Engineering Department Head Search Committee, 2004, 2016

Committee Member: University Faculty Senate Planning Committee, 2002-2004

Committee Member: AHS Dynamics Technical Committee, 1995-2000, 2001-present.

Committee Member: AIAA Structural Dynamics Technical Committee, 1995-1999

Member: American Helicopter Society (now Vertical Flight Society), 1986-present

Board Member: American Helicopter Museum and Education Center, West Chester, PA, 2009-2012

Technical Group Leader: Penn State Center for Acoustics and Vibration (CAV), Rotorcraft Acoustics and Dynamics Group, January 1994-present

Co-Director: Penn State Ben Franklin Center for Structural Health Monitoring (SHM), October 2006-2011

Member: Eighth Editorial Board, Nanjing University of Aeronautics and Astronautics, 2007-2012

Member: Research Steering Committee, Augusta Westland Corporation, January 2006

University Representative: Technical Advisory Committee, NRTC CRI, represents ten Universities and participates in technical evaluation of \$8M in federal/industry annual research activities, 2005-2017

Co-Chairman: 3rd AHS International Basic Research Conference on Rotorcraft Technology, Nanjing, China, October 14-16, 2009

General/Technical Chairman, 8th Army Research Office Workshop on dynamics and Aeroelasticity of Rotorcraft Systems, University Park, PA, October 1999

Feature Editor: AHS *Vertiflite Magazine*, "Profiles of Young AHS Members Series," 1993-1999

Manuscript Reviewer: *AIAA Journal*, *AHS Journal*, *Journal of Aircraft*, *Journal of Smart Materials & Structures*, *Computers and Mathematics with Applications*, *Journal of Fluids and Structures*, *The Aeronautical Journal*, *Aerospace Science and Technology*

Book Reviewer: Provided technical review for Irwin Publishing Inc. of proposed textbook entitled *A First Course in Aircraft Structures*, November 1993, November 1995

Short Course Organizer: Annual Rotorcraft Wing Technology Short Course <http://rotary-wing.outreach.psu.edu/>. Prof. Smith manages this week-long short course in August. He identifies and secures 6 instructors from across the country, sets the curriculum and agenda, and interfaces with marketing and conference planning, services. Prof. Smith is also responsible for executing the lab tour/demos portion of the course. Prof. Smith also serves as the speaker and host of the graduation dinner reception.

Presenter: Poster Presentation at NASA Aerospace Coalition, NASA/US Congress, Washington, DC USA. (June 14, 2017 - June 15, 2017).
Developed poster, traveled to US Congress in Washington DC, presented poster and interacted with congressional staff.

Academic Instruction

Aerospace Structures - Junior level aerospace structures class.

Advanced Aerospace Structures - Senior level aerospace structures class covering elasticity, plate analysis, composite materials, structural dynamics, and aeroelasticity

Structures and Dynamics Laboratory - Senior level laboratory class including experiments and term design projects.

Helicopter Design - Senior level undergraduate team design class. Focused on AHS Design Competition and multidisciplinary design project on remote control helicopters.

Aerospace Vehicle Design and Fabrication - Vertically integrated undergraduate design course involving hands-on laboratory work, supervised design sessions, and complementary lectures.

Behavior of Advanced Composite Structures - Graduate/undergraduate elective focused on analysis of composite structures.

Rotorcraft Dynamics - Graduate elective focused on rotary-wing vibration, response, aeroelastic stability, and aeromechanical stability.

VSTOL/Rotorcraft Aerodynamics – Graduate/undergraduate elective course covering topics in rotorcraft aerodynamics and performance.

Aeroelasticity - Graduate course on classical and modern topics in aeroelasticity including dynamic response, divergence, flutter, control reversal, material tailoring.

Hands-On Helicopters – First year seminar course to introduce engineering concepts via lab demos, tours, and discussions.

Aerospace Explorer – First year seminar course to introduce aerospace engineering discipline and topical areas

Senior Project Advising – Supervised teams of Aerospace, Mechanical, and Electrical Engineering students involved with design, build and test of helicopter hardware.

Research Associates & Post-Doctoral Scholars

Name	Research Area
Dr. ZHANG, Jianhua	Rotorcraft dynamics simulations, and rotor blade design analysis (2001-present)
Dr. SARIBAY, Zihni	Design Analysis of Pericyclic Transmission Systems (January 2010–2013)

Dr. SEMPERLOTTI, Fabio	Structural Health Monitoring (September 2009–April 2010)
Dr. PALACIOS, Jose	De-Icing Systems, Active rotor systems, rotor and airfoil icing (June 2008–2013)
Dr. HAN, Dong	Rotor Blade Loads Control and rotor dynamics (April 2008- April 2010)
Dr. KIM, Jun-Sik	Rotor Dynamics and Smart Structures Programs (January 2006–June 2008, January 2018-December 2018)
Dr. SZEFLI, Joseph	Experimental and Analytical Research Tasks in Support of NRTC Rotorcraft Center Noise and Vibration Control Projects (Sept 2003–November 2005)

Graduate Advisees

Student Name	Type of Degree	Title of Thesis	Degree Date
CHO, Chungik (co-advisor)	PhD	Vibration Control and Stability Augmentation for Electric VTOL	In Progress
McGOVERN, Jeremy	PhD	Pericyclic Transmission For Variable Speed Hybrid Propulsion Rotorcraft	In Progress
RAI, G (co-advisor)	PhD	Elastic Network Vibration Isolators	Dec 2022
BROWN, Avery (co-advisor)	PhD	Manufacturing and Structural Mechanics of Composite Stiffened Panel Structures with Acoustic Black Hole Features	In Progress
XIONG, Yu (co-advisor)	PhD	Investigation of Acoustic Black Holes for Lightweight Aerospace Structures	Dec 2021
PRAKASH, Keerti (co-advisor)	PhD	Modeling of Nanocomposite Damping for Helicopter Rotor Blade Applications	Dec 2020
KROTT, Matthew (co-advisor)	PhD	Fluidic Flexible Matrix Composite Vibration Treatments for Helicopter Airframes and Rotor Blades	Aug 2018
MATHUR, Tanmay (co-advisor)	PhD	Design and Optimization of Bevel Gear Pericyclic Transmission	Aug 2019

TREACY, Shawn (co-advisor)	PhD	Stability Analysis and Experimental Testing of Fluidic Pitch Links In Helicopters with Articulated Rotors	Dec 17
KAMBAMPATI, Sandilya	PhD	Optimization of Composite Tiltrotor Wings With Extensions And Winglets	Aug 16
MIURA, Kentaro (co-advisor)	PhD	Modeling, Design, And Experimental Validation Of A Tailboom Vibration Absorber Using Fluidic Flexible Matrix Composite Tubes	May 16
SCARBOROUGH, Lloyd (co-advisor)	PhD	Vibration Control Via Fluidlastic Devices	May 14
NAMPY, Sreenivas Narayanan	PhD	Advanced Grid-Stiffened Composite Shells for Applications in Heavy Lift Helicopter Rotor Blade Spars	Aug 12
TIWARI, Chandrashekhar (co-advisor)	PhD	Energy Absorbing Load Limiters for Crashworthy Payload Restraint	Aug 12
MARR, Conor (co-advisor)	PhD	Multi State Helicopter Lag Dampers	May 12
ZHU, Yun (co-advisor)	PhD	Structural Tailoring and Actuation Studies for Low Power Ultrasonic De-icing of Aluminum and Composite Plates	Dec 10
SARIBAY, Zihni	PhD	Analytical Investigation of the Pericyclic Variable-Speed Transmission System for Helicopter Main Gearbox	Dec 09
SEMPERLOTTI, Fabio (co-advisor)	PhD	Structural Damage Detection Via Nonlinear System Identification and Structural Intensity Methods	Aug 09
PALACIOS, Jose	PhD	Design, Fabrication, And Testing Of An Ultrasonic De-Icing System For Helicopter Rotor Blades	May 08
KIM, Jun-Sik (co-advisor)	PhD	Design and Analysis of Rotor Systems with Multiple Trailing Edge Flaps and Resonant Actuators	Dec 05
DESMIDT, Hans (co-advisor)	PhD	Robust-Adaptive Active Vibration Control of Alloy and Flexible Matrix Composite Rotorcraft Drivelines via Magnetic Bearings: Theory and Experiment	May 05
SZEFI, Joseph (co-advisor)	PhD	Helicopter Gearbox Isolation Using Periodically Layered Fluid Isolators	Aug 03

HEVERLY, David (co-advisor)	PhD	Optimal Actuator Placement and Active Structure Design for Control of Helicopter Airframe Vibrations	Aug 02
CENTOLANZA, Louis	PhD	Induced Shear Piezoelectric Actuators for Smart Rotor Blades	Aug 01
HOWARD, Anna	PhD	The Aero Mechanical Stability of Soft-Inplane Tiltrotors	Aug 01
KANG, Hao (co-advisor)	PhD	Rotor Blade Lag Damping Using Embedded Chordwise Absorbers	Aug 01
KELLER, Jonathan	PhD	Analysis and Control of the Transient Aeroelastic Response of Rotors During Shipboard Engagement and Disengagement Operations	May 01
STEVENS, Patricia	PhD	Active Interrogation of Helicopter Main Rotor Faults Using Trailing Edge Flap Actuation	May 01
ZHANG, Jianhua (co-advisor)	PhD	Active-Passive Hybrid Optimization of Rotor Blades with Trailing Edge Flaps	May 01
BRACKBILL, Christian (co-advisor)	PhD	Helicopter Rotor Aeroelastic Analysis Using a Refined Elastomeric Damper Model	Dec 00
FLOROS, Matthew	PhD	Elastically Tailored Composite Rotor Blades for Stall Alleviation and Vibration Reduction	Dec 00
GOVINDSWAMY, Kiran (co-advisor)	PhD	Modeling of Strain, Temperature, and Frequency-Dependent Properties of Elastomeric Damper and Bearing Materials	Dec 95
MAWRY, Isabella	MS	Active Fuselage Vibration Control for Coaxial Lift Offset Rotors Using Flexible Fuselage Analysis	In Progress
BEYER, Jessica	MS	Individual Blade Pitch Control (IBC) for Vibration Reduction of Lift Offset Coaxial Rotor Vehicles with Auxiliary Propulsion	In Progress
McGOVERN, Jeremy (Advisor)	MS	Assembly and Experimental Testing of a 50 HP Pericyclic Transmission Gearbox	In Progress
TROWBRIDGE, Michael (co-advisor)	MS		Dec 18

KIM, Jeffrey (co-advisor)	MS	Analysis and Experimental Bench Testing of a Hingeless Rotor Blade with F2MC Lag Dampers	Aug 19
JAEP, D (co-advisor)	MS	Treatment and Distribution of Carbon Nanotubes for High Damping in Carbon Fiber Composites	Dec 2021
BROWN, A (co-advisor)	MS	Acoustic Emission Sensing of Damage in Bonded Elastomeric Bearings	Aug 2021
PRAKASH, Keerti	MS	Experimental Evaluation of Carbon/Epoxy Laminates with Concentrated Carbon Nanotube Interlayers for High Damping Modeling of Polymer/Carbon Nanotube Nanocomposite to Estimate Structural Damping in a Rotorcraft Blade	Dec 17
LANERI, V. (co-advisor)	MS	Benchtop and Rotating Tests of a Fluidic Flexible Matrix Composite Lag Damper for Stiff-Inplane Hingeless Rotor Blades	Aug 20
KOPP, Reed	MS	Multi-Fidelity Modeling of Interfacial Micromechanics For Off-Aligned Polymer/Carbon Nanotube Nanocomposites	Aug 16
CAMERON, Zachary	MS	Examination of Critically Loaded Bearings in the Pericyclic Transmission	May 17
BONDOUX, Alexandre (co-advisor)	MS	Modeling, Design and Testing of A Multi-Cell Periodic Fluidic Flexible Matrix Composite Device	Aug 15
COSTA, Guillermo (Willie)	MS	Design, Fabrication, Test, And Evaluation of Small-Scale Tiltrotor Whirl Flutter Wind Tunnel Models	Aug 15
MAHMOOD, Raheel	MS	High Efficiency Vibrational Energy Harvesters	Dec 14
JOHNSON, Sam	MS	Whirl Flutter Testing of Small-Scale Tiltrotor Systems	May 14
WOZNIAK, Michael	MS	Characterization of Single Crystal Piezoelectric Energy Harvesters	Aug 13
SOLTIS, Jared	MS	Design and Testing of An Erosion Resistant Ultrasonic De-Icing System For Rotorcraft Blades	Aug 13
KURCZEWSKI, Nicolas	MS	Coupled Fluidic Vibration Isolators	May

		for Rotorcraft Pitch Link Loads Reduction	12
HENRY, Todd	MS	Static and Dynamic Characterization of Composite Materials for Future Driveshaft Systems	May 12
OVERMEYER, Austin	MS	Actuator Bonding, Optimization and System Control of a Rotor Blade Ultrasonic Deicing System	May 12
WINSLOW, Anna	MS	Calibration of a Four Degree of Freedom Stewart Platform Sensor Subject to Translational Constraints	Dec 12
HAN, Yigiang	MS	Theoretical and Experimental Study of Scaling Method In The Rotor Blade Ice Accretion Test	Aug 11
QUINTANGELI, Michael	MS	An Energy Harvesting Device for Powering Rotor Loads Monitoring Sensors	Aug 11
ROMANO, Peter	MS	Investigation of Contact Acoustic Nonlinearities in Metal and Composite Airframe Structures via Intensity Based Health Monitoring	Aug 11
CHOEPHEL, Tenzin	MS	Experimental Investigation of Dynamic Roughness as an Aerodynamic Flow Control Method	Dec 10
KONG, William	MS	A Method of Selecting and Configuring Optimal energy Absorbing Cargo Restraint Systems to Improve Crashworthiness	Dec 10
SLABY, Jason	MS	Influence of Pylon Airloads and Composite Tailoring on Aeroelastic Stability of a Forward Swept Wing	Dec 10
SOLLENBERGER, Stanton	MS	Characterization and Modeling Of A Flexible Matrix Composite Material For Advanced Rotorcraft Drivelines	Aug 10
BROUWERS, Edward	MS	The Experimental Investigation of a Rotor Icing Model with Shedding	May 10
SANTARELLI, David	MS	An Energy Harvesting Device for Powering Rotor Load Monitoring Sensors	May 10
WANG, Joseph	MS	Embedded Inertial Dampers for Control of Transient Rotor Loads During Resonance Crossing	May 10

SCHMIDT, Walter	MS	Open-Crack Damage Assessments of Aluminum Panels Using Structural Intensity-Based Techniques	Dec 09
CORL, Jonas	MS	A Comparison of Helicopter Active Rotor Gust Rejection and Vibration, Alleviation Methods	Aug 09
TIWARI, Chandrashekhar	MS	Innovative Energy Absorbing and Load Limiting Devices Based on Composite Tubes	Aug 09
BOSSENBROEK, Kirsten	MS	Damage Tolerance of Layer-Wise Hybrid Laminates Consisting of Glass Reinforced Flexible And Rigid	Aug 08
MONTANYE, Pam	MS	Shipboard Helicopter Gust Response Alleviation Using Active Trailing Edge Flaps	Aug 08
MARR, Conor	MS	The Domain Modeling of Fluidlastic Lead-Lag Dampers	Dec 07
WALCHKO, Joe	MS	Hybrid Feedforward-Feedback Control for Active Helicopter Vibration Suppression	May 07
MAYRIDES, Bryan	MS	Analysis and Synthesis of Highly Flexible Helicopter Drivelines with Flexible Matrix Composite Shafting	Dec 05
NARAYANAN, Sreeni	MS	Structural Behavior and Design of Flexible Matrix Composite Box Beams with Extension Twist Coupling	Aug 05
LEHEN, Francois	MS	Actively Enhanced Periodically Layered Isolator for Helicopter Gearbox Isolation	Dec 04
PALACIOS, Jose	MS	Dynamic Analysis & Experimental Testing of Thin-Walled Structures Driven by Shear Tube Actuators	Dec 04
PETRIE, Jason	MS	Helicopter Rotor Blade Lag Damping Using Fluid Elastic Embedded Chordwise Inertial Dampers	Aug 04
DAVIS, Ronald	MS	The Development of Experimental Teaching Facilities for Rotorcraft Aerodynamics and Dynamics	May 03
OCALAN, Murat	MS	High Flexibility Rotorcraft Driveshafts Using Flexible Matrix Composites & Active Bearing Control	May 02

RAMRAKHYANI, Deepak	MS	Nonlinear Modeling of Elastomeric Materials Using Fractional Derivatives and a Continuously Yielding Plastic Element	May 02
SARKAR, Sumit	MS	Two-Dimensional Finite Element Modeling of Elastomeric Components in the Low Dynamic Shear Strain Amplitude Regime	Dec 98
CENTOLANZA, Louis	MS	Refined Structural Modeling of Thick-Walled, Closed Section Composite Rotor Blades	Dec 97
KELLER, Jonathan	MS	An Experimental and Theoretical Correlation of an Analysis for Helicopter Rotor Blade and Droop Stop Impacts	Dec 97
BYERS, Lynn	MS	Experimental and Analytical Investigation of the Thermomechanical Behavior of Elastomeric Materials	May 97
BRACKBILL, Christian	MS	Thermomechanical Modeling of Elastomeric Materials Using the Method Of Anelastic Displacement Fields	Dec 96
FLOROS, Matthew	MS	Finite Element Modeling of Open Section Composite Beams with Warping Restraint Effects	Aug 96
BEALE, Michael	MS	Material Characterization and Aeroelastic Analysis for Helicopters with Elastomeric Dampers	Aug 95
GEYER, William	MS	Aeroelastic Analysis of Transient Blade Dynamics During Shipboard Engage/Disengage Operations	Aug 95
VASCSINEC, Michael	MS	Dynamics of Helicopter Rotor Systems with Elastomeric Dampers	Dec 94
KOOP, Reed	BS	Ground Resonance Testing of Tiltrotor Models	May 14
WALLIS, Emily	BS	Aerospace Engineering, A Vibration-Based Liquid Water Concentration Sensor for a Rotating Blade Icing Chamber	May 10
SANTO, Angela	BS	Performance of Industrial Fluidlastic™ Mounts and Feasibility for Helicopter Seat Application	Dec 09

CAMPBELL, Alan	BS	A Study of The Aerodynamic Feasibility of Dynamic Roughness for Airfoil Separation Control	May 09
JOSTES, Michael	BS	Ice Detector Liquid Water Concentration Sensing and New Adverse Environment Rotor Test Stand Calibration	May 09
OSTRICH, Adam	BS	The Use of Conductive Carbon Films as Electromechanical Pressure Sensors on Helicopter Blades	May 09
SOLLENBERGER, Stanton	BS	Evaluation of Stress Concentrations in Misaligned Flexible Matrix Composite Driveshafts	May 08
YANG, Tim	BS	Active Flow Control Using Piezoelectrically Actuated Dynamic Roughness	May 08
CLAUSER, Robert	BS	Development of a Tabletop Tiltrotor Model	May 03
PALACIOS, Jose	BS	Helicopter Blade Anti-Icing System	May 03

Journal Publications

Rai, G., Rahn, C., Smith, E., and Marr, C., “3D Printed Circular Nodal Plate Stacks for Broadband Vibration Isolation,” accepted for publication in *Journal of Sound and Vibration*, Feb 2023.

Brown, A, Bakis, C., and Smith E.C., “Effect of Carbon Nanotube Surface Treatment on the Dynamic Mechanical Properties of a Hybrid Carbon/Epoxy Composite Laminate,” revision under review for *Composites Science and Technology*, Vol. 231, 109807, Jan 2023.

Mathur, T. D., Smith, E.C., DeSmidt, H., and Bill, R.C., "System and Component Level Design Procedure for High Reduction Ratio Pericyclic Drive." *Journal of the American Helicopter Society* 67 (3), 2022.

Rai, G., Rahn, C., Smith, E. and Marr, C., “Nodal Beam Stack Vibration Isolators,” *Mechanical Systems and Signal Processing (MSSP)*, 179, 109324, Nov 2022.

Mathur, Tanmay D., Edward C. Smith, and Robert C. Bill, "A Novel Loaded Tooth Contact Analysis Procedure with Application to Internal-External Straight Bevel Gear Mesh in Pericyclic Drive." *Journal of Tribology* 143 (10), 101201, 2021.

Kim, J. J., Brown, A. D., Bakis, C. E., & Smith, E. C. "Hybrid carbon nanotube-carbon fiber composites for high damping." *Composites Science and Technology*, 207, 108712. 2021.

Krott, M.J., Smith, E.C., and Rahn, C.D., "Modeling and Testing of Fluidic Flexible Matrix Composite Lead-Lag Dampers," **65**, 012012 DOI: 10.4050/JAHS.65.012012. 2020.

Prakash, K., Smith, E.C. and Bakis, C.E., "Structural Damping Model for Composite Rotorcraft Blades with Carbon Nanotube Interlayers." *AIAA Journal*, pp.1-9. 2020

Rai, G, Rahn, CD, Smith, E, & Marr, C. "Vibration Isolation Using Continuous Beams." *Proceedings of the ASME 2020 International Mechanical Engineering Congress and Exposition*. Volume 7B: Dynamics, Vibration, and Control. Virtual, Online. V07BT07A046. ASME. 2020.

Prakash, K., Smith, E. (Co-Author), & Bakis, C. E., Modeling of Laminated Reinforced Compositewith Carbon Nanotube Interlayers to Estimate Structural Damping in a Rotorcraft Blade. *2019 AIAA SciTech Forum*. San Diego, CA. 2019.

Zhang, J., Kang, H., & Smith, E. (Co-Author). Wing Extension Design and Tailoring for a ScaledTiltrotor Wind Tunnel Model. *2019 AIAA SciTech Forum*. San Diego, CA. 2019.

Kim, J., Bakis, C. E., & Smith, E. Experimental Evaluation of Carbon Nanotubes for High-Stiffness Damping Augmentation in Carbon/Epoxy Composites. *ASC 33rd Annual Technical Conference 18th US-Japan Conference on Composite Materials*. 2018.

Prakash, K., Smith, E., & Bakis, C. E. Modeling of Polymer/ Carbon Nanotube Nanocomposite to Estimate Structural Damping in a Rotorcraft Blade. *ASC 33rd Annual Technical Conference 18th US-Japan Conference on Composite Materials*. 2018.

Xiong, Y., Smith, E., & Conlon, S. C. Vibroacoustic Properties of Plates with Tuned Acoustic Black Holes. *47th International Congress and Exposition on Noise Control Engineering: Impact of Noise Control Engineering*. 2018.

Mathur, T., Smith, E., DeSmidt, H., & Bill, R. C. Design of a High-Power Density Pericyclic Drive Prototype for Testing at NASA Glenn Transmission Test Facility. *74th American Helicopter Society Forum*. 2018.

Cameron, Z., Smith E., Bill R., & DeSmidt, H., Design Space Exploration of Pericyclic Transmission with Counterbalance and Bearing Load Analysis. *74th American Helicopter Society Forum*. 2018.

Krott, M., Smith, E., Palacios, J., & Rahn, C. Modeling, Development, and Testing of a Fluidic Flexible Matrix Composite Blade Dampers. *74th American Helicopter Society Forum*. 2018.

DeSmidt, H., Bill, R. C., & Smith, E. Structural Dynamics of a Dual Clutch Offset Compound Gear Transmission with Electro-Magnetically Actuated Engagement. *74th American Helicopter Society Forum*. 2018.

Zhang, J., Matthew, F., & Smith, E. Autorotation Performance of Multi-Rotor Aircraft with Partial Power Loss. *Proceedings of the AHS Technical Conference on Aeromechanics Design for Transformative Vertical Flight*. 2018.

Zhang, J., Kang, H., & Smith, E. (2018). Stability Analysis of a Scaled Tiltrotor Model with Wing Extensions and Winglets. *Proceedings of the AHS Technical Conference on Aeromechanics Design for Transformative Vertical Flight*. 2018.

Miura, K., Smith, E., & Rahn, C. Modeling and Design of a Tailboom Vibration Absorber Using Fluidic Flexible Matrix Composite Tubes. *Journal of American Helicopter Society*, 62(4). ISBN/ISSN #/Case #/DOI #: 10.4050/JAHS.62.042009, 2017.

Kambampati, S., & Smith, E. Aeroelastic Optimization of High-Speed Tiltrotor Wings with Wing Extensions and Winglets. *Journal of Aircraft*, 54(5), 1718-1727. ISBN/ISSN #/Case #/DOI #: 10.2514/1.C034195 2017.

Zhang, J., Smith, E., & Zajackowski, F. Analysis of Rotor Start-Up and Shutdown on a Sea-Based Oil Rig. *Journal of Aircraft*, 54(1), 20-35. ISBN/ISSN #/Case #/DOI #: 0021-8669. 2017.

Wozniak, M. V., Conlon, S. C., Smith, E., & Reichard, K. M., "Design, Analysis, and Characterization of Single Crystal Energy Harvesters for Rotorcraft Wireless Sensor Applications," *Journal of American Helicopter Society*, Vol. 60, 2015.

Miller, S., Little, E., Yukish, M., and Bakis, C., and Smith, E., "Rate Effects and Environmental Sensitivity of Textile Energy Absorbers," *Journal of The American Helicopter Society*, DOI: 10.4050/JAHS.60.022009, Volume 60, 022009-1 -022009-10, 2015.

Henry, T., Bakis, C., and Smith, E., "Determination of Effective Ply-Level Properties Of Filament Wound Composite Tubes Loaded In Compression, " *Journal of Testing and Evaluation*, Volume 42, Issue 1, January 2015.

Henry, T. C., Bakis, C. E., Miller, S. W., & Smith, E. Multi-Objective Optimal Design of Composite Rotorcraft Driveshaft Including Strain Rate and Temperature Effects. *Journal of Composite Structures* 128, 42-53. Ms. Ref. No.: COST-D-14-01622. 2015.

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Floros, M. and E.C. Smith, "Finite Element Modeling of Open-Section Composite Beams with Warping Restraint Effects," AIAA Paper 96-1472, *Proceedings of the 37th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, Salt Lake City, Utah, April 1996.

Geyer, W., and E.C. Smith, "Aeroelastic Analysis of Transient Blade Dynamics During Shipboard Engage/Disengage Operations," *Proceedings of the American Helicopter Society Aeromechanics Specialists Conference*, Bridgeport, Connecticut, October 1995.

Govindswamy, K., E.C. Smith, and G.A. Lesieutre, "Aerothermoelastic Behavior of Helicopters with Elastomeric Lag Dampers," *Proceedings of the American Helicopter Society Aeromechanics Specialists Conference*, Bridgeport, Connecticut, October 1995.

Smith, E.C., Beale, M.R., Govindswamy, K., Vascosinec, M.J., and Lesieutre, G.A., "Formulation and Validation of a Finite Element Model for Elastomeric Lag Dampers", *Proceedings of the 51st American Helicopter Society Forum*, May 1995.

Govindswamy, K., Lesieutre, G.A., Smith, E.C., and Beale, M.R., "Characterization and Modeling of Strain-Dependent Dynamic Behavior of Viscoelastic Elastomers in Simple Shear", *Proceedings of the 36th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, April 1995.

Smith, E.C., "Modeling Issues for Tailored Composite Rotor Systems and Elastomeric Lag Dampers", *Army/NASA Comprehensive Analysis Workshop Seminar*, NASA Ames Research Center, CA, March 1995.

Smith, E.C., "Aeroelastic and Aeromechanical Aspects of Elastically Coupled Composite Rotor Blades," *U.S. Army Research Office Beamology Workshop*, Aeroflightdynamics Directorate, ATCOM, NASA Ames Research Center, Moffett Field, CA, October 1992.

Smith, E.C., "Aeroelastic and Aeromechanical Aspects for Helicopters with Elastically Tailored Composite Rotor Blades", *Proceedings of the 5th Workshop on Dynamics and Aeroelastic Stability Modeling of Rotorcraft Systems*, Rennsalaer Polytechnic Institute, October 1993.

Smith, E.C., "Vibration and Flutter of Stiff-Inplane Elastically Tailored Composite Rotor Blades", *Proceedings of the 34th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference*, La Jolla, California, April 1993.

Smith, E.C. and Chopra, I., "Aeromechanical Stability of Helicopters with Composite Rotor Blades in Forward Flight", *Proceedings of the 48th American Helicopter Society Annual Forum*, Phoenix, Arizona, June 3-5, 1992.

Smith, E.C. and Chopra, I., "Aeroelastic Response and Blade Loads of a Composite Rotor in Forward Flight", *Proceedings of the 33rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference*, Dallas, Texas, April 1992.

Smith, E.C. and Chopra, I., "Aeromechanical Stability Prediction of Composite Rotors," *Proceedings of the 4th Workshop on Aeroelastic Stability Modeling of Rotorcraft Systems*, College Park, Maryland, November 1991.

Smith, E.C. and Chopra, I., "Formulation and Evaluation of an Analytical Model for Composite Box-Beams," *Proceedings of the 31st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference*, Long Beach, CA Apr 1990.

Patents

Invention: "Energy Absorbing Stitch Ripping Composite Tubes Containing Collapsible Cells," Tiwari, C., Smith, E., Bakis, C., Yukish, M., and Kong, W., Patent file number: PSU-2008-3475, Docket number: 090530, Application number: 12538978, International application number: PCT/US09/53418, Official filing date: August 11, 2009.

Invention: "Energy Absorbing and Load Limiting Extension-Torsion Coupled Stitch Ripping Composite Tubes," Tiwari, C., Smith, E., Bakis, C., Yukish, M., and Kong, W., Patent file number: PSU-2008-3475, Serial Number: 61088458, Docket number: 080535, Official acceptance date: August 13, 2008.

Invention: "Ultrasonic De-Icing System for Composite Helicopter Blades with Tailored Waveguide," Zhu, Palacios, Smith, Royer, and Rose PSU Invention Disclosure Number 2008-3519.

Preliminary Patent APP: "A Deicing and Ice Avoidance System for Structures," Rose, Smith, Palacios, Royer, and Owens--PSU Invention Disclosure Number 2007-3364.

Provisional Patent: "Ultrasonic Guided Wave Anti-Icing System for Helicopter Rotor Blades and Fixed Wing Aircraft," Rose, Smith, Gao, Palacios, and Zhu--PSU Invention Disclosure Number 2006-3291.

Funded Research Activities

US Army

U.S. Army Contracting Command

"Penn State Vertical Lift Research Center of Excellence (VLRCE) ", **U.S. Army Contracting Command**, \$7,200,000.00 in external sponsor funds (and \$3.3M in Cost Share funds) - Principal Investigator and Center Director (15% - Center Director duties plus 2 tasks as Co-PI). September 2021-September 2026.

"Penn State Vertical Lift Research Center of Excellence (VLRCOE) ", **U.S. Army Contracting Command**, \$7,500,000.00 in external sponsor funds - Principal Investigator and Center Director (15% - lead PI on 2 tasks and Center Director duties). 2016- October 2021.

"Penn State Vertical Lift Center of Excellence (VLRCOE) ", **U.S. Army Contracting Command**, \$6,400,000.00 in external sponsor funds - Principal Investigator and Center Director (15% - lead PI on 2 tasks and Center Director duties). 2011- 2016.

"Penn State Vertical Lift Center of Excellence (VLRCOE) ", **U.S. Army Contracting Command**, \$5,500,000.00 in external sponsor funds - Principal Investigator and Center Director (15% - lead PI on 2 tasks and Center Director duties). 2006- 2011.

"Penn State Rotorcraft Center of Excellence (RCOE) ", **U.S. Army Contracting Command**, \$4,500,000.00 in external sponsor funds - Principal Investigator and Center Director (15% - lead PI on 2 tasks and Center Director duties). 2001- 2006.

"Penn State Rotorcraft Center of Excellence (RCOE) ", **U.S. Army Contracting Command**, \$3,000,000.00 in external sponsor funds – co-Principal Investigator and Center Director (25% - lead PI on 2 tasks and Center Director duties). 1996- 2001.

U.S. Army Research Laboratory

"Wind Tunnel Model Design and Analysis of an Aeroelastically Tailored Wing for Enhanced Whirl Flutter Stability", **U.S. Army Research Laboratory**, \$308,024.00 - Principal Investigator (50%). September 2016 - August 2019,

U.S. Army Research Office

DURIP: Dynamic Test Stand for Fundamental Experiments in Rotor Energy Harvesting Aeroelastic Stability, and Loads, (G. Lesieutre and E. Smith) **Army Research Office**, \$55,000 August 2011-August 2012.

DURIP: Experimental Instrumentation for Active Durable Rotors, (E. Smith) **Army Research Office**, \$70,000, June 2008 - June 2009.

Experimental and Computational Instrumentation for Rotorcraft Research at the Penn State Rotorcraft Center, (E. Smith, L. Long, C. Camci, K. Wang, K. Brentner, and J. Horn), **U.S. Army Research Office**, \$197,700, (\$57,400 additional in Penn State Cost sharing) April 1, 2002 - March 31, 2004.

Active Control of Rotorcraft Noise and Vibration, (E. Smith, L. Long, F. Gandhi, and K. Wang), **U.S. Army Research Office** of Maryland, \$380,364, May 15, 1999 – January 30, 2002.

Eighth ARO Workshop on Aeroelasticity of Rotorcraft Systems, (E. Smith), **U.S. Army Research Office**, \$15,000, April 1, 1999 – March 31, 2000.

Experimental & Computational Instrumentation for Rotorcraft Noise & Vibration Control Research at the Penn State Rotorcraft Center, (E. Smith, L. Long, K. Wang, and G.

Koopmann), **U.S. Army Research Office**, \$250,000, March 2, 1998- March 1, 1999.

Active Control of Coupled Rotor-Drivetrain-Airframe Dynamics, (E. Smith and K. Wang), **U.S. Army Research Office** via University of Maryland MURI on Active Control of Rotorcraft Aeroacoustics and Vibration, \$235,000, August 1996 - August 1999.

Vibration, Stability, and Transient Response of Helicopters with Elastically Tailored Composite Rotor Blades (E. Smith), **U.S. Army Research Office (Young Investigator Program)**, \$204,641 (\$54,641 additional in Penn State Cost Sharing), June 15, 1994 - June 14, 1997.

U.S. Department of Army

Vertical Lift Research Center of Excellence (VLRCE), **US Department of Army**, \$6,848,509, September 2011-September 2016.

Intergovernmental Personnel Act (IPA) Agreement with **Department of the Army, U.S. Military Academia**, Dept of Civil and Mechanical Engineering, U.S. Military Academy, \$47,500, June 2014-May 2015.

Vertical Lift Research Center of Excellence: Vibration Condition Indicator Development, (S. Evans and E. Smith) **US Dept of Army**, \$40,000, January 2010-September 2011.

Vertical Lift Research Center of Excellence: Experimental Measurement of Ice Accretion on Rotating and Simultaneously Oscillating Airfoils, (E. Smith) **US Dept of Army**, \$241,857, May 2009 - September 2011.

Vertical Lift Research Center of Excellence - Additional Funding for Equipment, (E. Smith) **US Dept of Army**, \$102,000, September 2008 - September 2011.

Intensity Based Structural Health Monitoring for Aviation Platforms, (S. Colon and E. Smith) **US Dept of Army**, \$832,395, April 2008 - March 2010.

Vertical Lift Research Center of Excellence, (E. Smith, K. Brentner, L. Long, C. Camci, C. Bakis, K. Koudela, J. Rose, J. Horn, F. Gandhi, M. Maughmer, G. Lesieutre, P. Morris, G. Rajagopalan, N. Koratkar, E. Duque, R. Parker and R. Leach) **US Dept of Army**, \$4,508,217, September 2006 - September 2011.

National Defense Science & Engineering Graduate Fellowship in Aerospace Engineering for Louis Centolanza, (E. Smith), **U.S Department of the Army**, \$111,000, January 1, 1996 – December 31, 1999.

Advanced Rotorcraft Technologies and U.S. Army ATCOM

High Fidelity Helicopter Lag Damper Model for Comprehensive Rotor Analysis, (G. Lesieutre and E. Smith), **Advanced Rotorcraft Technology, Inc.**, \$44,991, October 2011-October 2012.

Refined Modeling for Aeromechanical Stability and Aeroelastic Response of the RAH-66 Comanche Snubber-Damper (E. Smith and G. Lesieutre), **Advanced Rotorcraft Technologies and US Army ATCOM**, \$18,500, January 1, 1995-December 31, 1995.

Army Aviation and Missile Command

OH-58 Tailboom Damage Detection Study, (S. Conlon, S. Evans and E. Smith) **Army Aviation and Missile Command**, \$200,000, September 2010-March 2011.

US Navy

Office of Naval Research

“Advanced damping system for broadband vibration and interior noise control of composite airframes of transport rotorcraft”, **Office of Naval Research**, \$722,366.00 – Co-Principal Investigator: (33%). Submitted June 2020. Funded March 2021,

Actuator Development and Wind Tunnel Testing of Dynamic Roughness Elements for Control of Flow Separation, (E. Smith) **Office of Naval Research**, \$191,882, June 2009 - June 2012.

Innovative Composite Materials for Crashworthy Mounting Systems, (C. Bakis, E. Smith and M. Yukish) **Office of Naval Research**, \$285,153, June 2009 - May 2012.

Naval Rotorcraft Technologies for Enhanced Safety, Survivability and Performance, (E. Smith, K. Brentner, J. Horn, L. Long, K. Wang, C. Rahn, C. Bakis, F. Gandhi, and D. McLaughlin) **US Dept of the Navy**, \$1,465,093, July 2008 - 2010.

DURIP: Experimental Instrumentation for Research on Safety, Survivability, and Enhanced Performance of Naval Rotorcraft, (C. Bakis, E. Smith and K. Wang) **Office of Naval Research**, \$158,800, April 2008- July 2009.

X-Hawk Fancraft Preliminary Risk Reduction Effort, (E. Smith and D. McLaughlin) **Office of Naval Research**, \$478,000, May 2007 - February 2008.

DURIP: Experimental and Computational Instrumentation for Research on Safety, Survivability, and Enhanced Performance of Naval Research, (E. Smith, J. Horn, K. Brentner, C. Bakis, K. Wang and B. Bill) **Office of Naval Research**, \$301,374.00, March 2007- July 2008.

Naval Rotorcraft Technologies for Enhanced Safety, Survivability and Performance, (E. Smith, J. Horn, L. Long, K. Wang, C. Bakis, F. Gandhi, D. McLaughlin, K. Brentner, S. Rao, and M. Yukish) **US Dept of the Navy**, \$1,204,902.00, January 2006 - June 2008.
Training for Use of the Simulation of the Transient Analysis of Rotorcraft Startups and Shutdowns Program, (E. Smith) **U.S. Navy**, \$15,000, November 1, 2000 – March 31, 2001.

Computational and Experimental Investigation of Air Vehicle Aeromechanics During Shipboard Dynamic Interface Operations, (E. Smith and L. Long), **Naval Research Office**,

\$466,771, April 1, 1997 - March 31, 2000.

Analytical Modeling of Rotor Head Failure and Fault Signatures (E. Smith), **Office of Naval Research** via Penn State Integrated Predictive Diagnostics MURI, \$150,000, March 15, 1995 – March 14, 1998.

NASA

National Aeronautics and Space Administration

NASA Aeronautics Scholarship Program (Zachary Cameron), **National Aeronautics and Space Administration**, \$92,000, September 2014-September 2016.

"Modeling Refinements for the Comprehensive Variable-Speed Rotorcraft Propulsion Modeling (CVSRPM) Tool", **National Aeronautics and Space Administration**, \$65,000.00 - Principal Investigator (100%) December 2015

Acoustically Tailored Composite Rotorcraft Fuselage Panels, (S. Hambric, E. Smith and K. Koudela) **National Aeronautics and Space Administration**, \$992,588, December 2010-January 2011.

High Fidelity CFD Analysis and Validation of Rotorcraft Gear Box Aerodynamics, (R. Kunz, L. Long, P. Morris, R. Noach, and E. Smith) **NASA**, \$222,603, September 2010-September 2011

Control Design Methodologies for Improving Rotorcraft Gust Rejection with On-Blade Control, (J. Horn, E. Smith and C. Rahn) **National Aeronautics and Space Administration**, \$140,000, May 2009 - May 2011.

NASA GSRP: Aeroelastic Divergence and Flutter Study of Swept Forward Composite Wings for Folding Tiltrotor Application for Jason Slaby, (E. Smith) **National Aeronautics and Space Administration**, \$60,000, May 2009 - May 2011.

Rotocraft Transmission Noise Path Model Including Distributed Fluid Film Bearing Impedance Modeling, (E. Smith and S. Hambric) **NASA**, \$200,000, October 2008 - March 2010.

Comprehensive Modeling and Analysis of Rotorcraft Variable Speed Propulsion System with Coupled Engine/Transmission/Rotor Dynamics, (E. Smith, K. Wang and H. DeSmidt) **NASA**, \$654,832, January 2007-April 2010.

NASA GRSP for Hans DeSmidt, (E. Smith, and K. Wang), **National Aeronautics and Space Administration**, \$22,000, August 15, 2001 – August 14, 2002.

NASA GRSP for Hans DeSmidt, (E. Smith, and K. Wang), **National Aeronautics and Space Administration**, \$22,000, August 15, 1999 – August 14, 2000.

NASA Ames/Glenn/Langley Research Center

Optimization and Design of Advanced Low-Weight Rotor Systems II, (E. Smith and M.

Maughmer) **NASA Ames Research Center**, \$80,000, January 1, 2005 – December 31, 2005

Optimization and Design of Advanced Low-Weight Rotor Systems, (E. Smith) **NASA Ames Research Center**, \$85,000, January 1, 2004 – December 31, 2004.

Active Vibration Control of a Coupled Tailboom-Driveshaft Structure, (E. Smith, and K. Wang), **NASA Glenn Research Center**, \$24,000, August 15, 2003 – January 2, 2004.

Semi-Autonomous Hand-Launched Rotor-Wing Unmanned Air Vehicles (UAV), (E. Smith, L. Long, and J. Horn), **NASA Ames Research Center**, \$109,000, August 1, 2002 – January 31, 2005.

Active Vibration Control of a Coupled Tailboom-Driveshaft Structure, (E. Smith, and K. Wang), **NASA Glenn Research Center**, \$24,000, August 15, 2003 – January 2, 2004.

Elastomeric Damper Analysis and Experiments, (E. Smith, and G. Lesieutre), **NASA Ames Research Center**, \$19,995, February 1, 2001 – January 31, 2002

National Rotorcraft Technology Center/Rotorcraft Centers of Excellence (RCOE), (E. Smith, and L. Long), Research funding divided among 11 Penn State Faculty, **NASA Ames Research Center**, \$3,020,000, (\$1,291,620 additional in Penn State Cost Sharing and \$40,000 in Penn State Undergraduate Wages), February 1, 2001 – January 31, 2006.

Elastically Tailored Composite Rotor Blades for Alleviation of Blade Stall Effects in High-Speed Flight, (E. Smith), **NASA Langley Research Center** - NASA Graduate Students Researchers Program for Anna Howard, \$88,000, August 15, 1995 – August 15, 2000.

Aeromechanical Analysis for Elastically Tailored Tiltrotors with Soft Inplane Rotor Systems (E. Smith), **NASA Langley Research Center**, \$66,000, August 1995 - August 1998.

INDUSTRY

Bell Helicopter

"V-247 1/4 Scale Download Test", **Bell Helicopter**, \$331,921.00 - Co-Principal Investigator with J. Palacios, March 2020.

Tailboom Vibration Control, **Bell Helicopter**, \$318,103, July 2012-December 2014.
Analysis of Start-up and Shutdown of Rotor in Complex Wind Conditions, **Bell Helicopter**, \$328,880, December 2011-January 2014.

Artificial Tailboom Damping, **Bell Helicopter**, \$33,000.00, December 2011-April 2012.
Fellowship Award Stanton Sollenberger, (E. Smith and C. Bakis) **Bell Helicopter Textron**, \$20,000, August 2009- December 2009.

Development of Lead-Lag Damper Temperature Model for M430 Fluidlastic Damper, (E. Smith and G. Lesieutre) **Bell Helicopter Textron Inc.**, \$20,000, August 2007 - January 2008.

Optimized Ultrasonic Shear Wave Anti-Icing Actuator for Helicopter Blades, (E. Smith and J. Rose) **Bell Helicopter Textron, Inc.**, \$60,000, January 2007 - December 2007.

Development and Testing of a Nonthermal Rotor Blade Anti-Icing System, (E. Smith, and J. Rose) **Bell Helicopter Textron**, \$60,000, August 2006 - December 2006.

Fluid Elastic Damper, (E. Smith and G. Lesieutre) **Bell Helicopter Textron**, \$30,000, June 2006 - December 2006.

Modeling and Characterization of Elastomeric Dampers, (E. Smith, and G. Lesieutre), **Bell Helicopter Textron Inc.**, \$60,000, January 1, 2004 – December 31, 2004.

Fluid and Elastomeric Lag Damper Modeling (E. Smith, and G. Lesieutre), **Bell Helicopter**, \$64,000, April 1, 2002 – December 31, 2003.

Tiltrotor Aeromechanical Stability Analysis, (E. Smith), **Bell Helicopter Textron Inc.**, \$28,387, July 2, 2001 – November 30, 2001.

Ben Franklin Technology

Center of Excellence in Structural Health Monitoring, (C. Lissenden and E. Smith) **Ben Franklin Tech. Center of Central & Northern PA**, \$50,000, January 2007 - June 2009.

Advanced Image Processing System for Non-Destructive Test and Evaluation, (E. Smith), **Ben Franklin Technology Program**, \$60,000, October 1996 - June 1997.

Boeing

Boeing Company Charitable Trust

"Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering AIAA & AHS Activities", **Boeing Company Charitable Trust**, \$9,000.00/year. June 2016-present.

"Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering AIAA & AHS Activities", **Boeing Company Charitable Trust**, \$9,000.00. June 2016 - May 2017,

Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering AIAA & AHS Student Projects/Activities (E. Smith) **Boeing Company Charitable Trust**, \$7,500, January 2010- December 2010.

Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering/Student AIAA & AHS Activities, (E. Smith) **Boeing Company Charitable Trust**, \$7,500, January 2009 - December 2009.

Ice Phobic Coating and Piezoelectric Screening at the Penn State University Icing Laboratory, (E. Smith and J. Rose) **Boeing Company**, \$469,000, August 2008 - July 2011.

Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering/Student AIAA & AHS Activities, (E. Smith) **Boeing Company Charitable Trust**, \$6,750 January 2007-December 2007.

Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering/Student AIAA & AHS Activities, (E. Smith) **Boeing Company Charitable Trust**, \$6,750 January 2006-December 2006.

Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering/Student AIAA & AHS Activities, (E. Smith) **Boeing Company Charitable Trust**, \$7,000, January 2005 - December 2005.

Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering/Student AIAA & AHS Activities, (E. Smith) **Boeing Company Charitable Trust**, \$9,000, January 2004 - December 2004.

Interdisciplinary Rotorcraft Design Projects in Rotorcraft Engineering/Student AIAA & AHS Activities, (E. Smith) **Boeing Company Charitable Trust**, \$1,500, January 2003 - December 2003.

Multidisciplinary Engineering Team for Test and Evaluation of Rotor Wing Unmanned Autonomous Air Vehicles (UAVs), (E. Smith) **Boeing Company Charitable Trust**, \$25,000, January 2002 - December 2002.

Multidisciplinary Engineering Team for Test and Evaluation of Rotor Wing Unmanned Autonomous Air Vehicles (UAVs), (E. Smith), **Boeing Company Charitable Trust**, \$30,000, January 1, 2001 – December 31, 2001.

Multidisciplinary Engineering Team for Test and Evaluation of Rotor Wing Unmanned Autonomous Air Vehicles (UAVs), (E. Smith), **Boeing Company Charitable Trust**, \$25,000, January 1, 1998 – December 31, 1998.

Boeing Rotorcraft

“Compact High Reduction Ratio Pericyclic Transmission for 250 HP Class Rotorcraft Applications,” Principal Investigator, \$125,000, Nov 2021 – May 2023.

Design, Fabrication, and Testing of a Platform for Evaluation of Rotary-Wing Unmanned Autonomous Air Vehicle (UAV) Control Concepts, (E. Smith), **Boeing Defense and Space Group - Helicopters Division**, \$10,000, January 1, 1996 - December 31, 1998.

Experimental Characterization and Analytical Modeling of Thermomechanical and Transient Behavior for Elastomeric Damper and Bearings Materials, (E. Smith and G. Lesieutre), **Boeing Helicopters**, \$35,000, January 1, 1996 – December 31, 1996.

Experimental Characterization and Analytical Modeling of Elastomeric Bearings and Dampers (E. Smith and G. Lesieutre), **Boeing Helicopters**, \$34,000, January 1, 1995-December 31, 1995.

Boeing Prime

Next Generation Rotorcraft Drive Systems (NGRDS) Technology Development Phase II, ARL (**Boeing Prime**), \$16,980, January 2013-December 2013.

Next Generation Rotorcraft Drive Systems (NGRDS) Technology Development, ARL (**Boeing Prime**), \$75,000.00, November 2011-December 2012.

Center for Rotorcraft Innovation

Advanced Drive Systems TAJI 2010, (E. Smith, C. Bakis, and Z. Saribay) **Center for Rotorcraft Innovation**, \$110,000, January 2010-February 2011.

Vehicle Management Systems: Handling Qualities and Gust Alleviation Characteristics of Helicopters Using Active Rotors 2010, (J. Horn, C. Rahn, E. Smith, S. Conlon and J. Zhang) **Center for Rotorcraft Innovation**, \$130,000, January 2010-May 2011.

Advanced Aircraft Crashworthiness TAJI, (E. Smith, C. Bakis and E. Little) **Center for Rotorcraft Innovation**, \$75,000, September 2009 - December 2010.

Advanced Drive System TAJI, (E. Smith, C. Bakis and R. Kunz) **Center for Rotorcraft Innovation**, \$150,000, March 2009 - July 2010.

Condition Based Maintenance Technology Verification and Validation, (E. Smith and J. Rose) **The Center for Rotorcraft Innovations**, \$140,000, February 2009 - June 2010.

Vehicle Management Systems: Handling Qualities and Gust Alleviation Characteristics Of Helicopters Using Active Rotors, (J. Horn, C. Rahn and E. Smith) **Center for Rotorcraft Innovation**, \$130,000, February 2009 - May 2010.

Vibration Data Analysis for Support of On-Board CBM Systems, (E. Smith) **Center for Rotorcraft Innovation** (U.S Department of the Army), \$75,000, September 2008 - August 2009.

Design, Systems Evaluation and Testing of Flexible Composite Driveshafts - Year 3, (E. Smith and C. Bakis) **Center for Rotorcraft Innovation**, \$130,000, January 2008 - July 2009.

Condition Based Maintenance Damage Detection Technology - Year 2, (E. Smith, K. Wang, J. Rose and S. Conlon) **The Center for Rotorcraft Innovations**, \$140,000, June 2007 - July 2008.

Design, Systems Evaluation and Testing of Flexible Composite Driveshafts - Year 2, (E. Smith, C. Bakis and K. Wang) **Center for Rotorcraft Innovation**, \$125,086, January 2007 - July 2008.

Conditioned Based Maintenance Damage Detection Technology - Year 1, (E. Smith, K. Wang, J. Rose and S. Conlon) **Center for Rotorcraft Innovation**, \$140,000, July 2006 - October 2007.

MDO Design and Advanced Simulation of Propulsion - Transmission Systems for High Endurance, (E. Smith, K. Wang, R. Kunz and R. Medvitz) **Center for Rotorcraft Innovation**, \$115,000, July 2006 - August 2007.

Design, Systems Evaluation, and Testing of Flexible Composite Driveshafts - Year 1, (E. Smith, C. Bakis, and K Wang) **Center for Rotorcraft Innovation**, \$105,000, May 2006 - March 2007.

Feature Based Systems, Inc

A Multi-Functional Ultrasonic Ice Protection and Sensing System for Composite Rotor Blade Leading Edges, FBS, Inc. (**Feature Based Systems**), \$104,906.00, August 2011-August 2012.

Innovative Concepts for Composite Leading Edge Self-Monitoring Anti/De-icing System (Base Phase I), (E. Smith) **Feature Based Systems, Inc.**, \$15,000, May 2010-November 2010.

Innovative Concepts for Composite Leading Edge Self-Monitoring Anti/De-icing System (Base Phase 1 Option), (E. Smith and J. Palacios) **Feature Based Systems, Inc.**, \$10,000, May 2010-August 2011.

Innovative Rotor Blade Anti-Icing/De-Icing Technologies - SBIR Phase II, (E. Smith) **Feature Based Systems Inc.**, \$160,000, September 2008 - September 2010.

Innovative Rotor Blade Anti-Icing/De-Icing Technologies – SBIR Phase I, (E. Smith) **Feature Based Systems, Inc.**, \$15,000, October 2007 - April 2008.

Goodrich Corporation

"Penn State Vertical Lift Research Center of Excellence Goodrich Fellow", **Goodrich**, \$275,000.00. September 2016,

Refrigeration System Upgrade and Undergrad Student Funding, (E. Smith and J. Palacios) **Goodrich Corporation**, \$12,000, January 2010- December 2010.

Health Usage Monitoring Device Human Factors Comparison, (S. Evans and E. Smith) **Goodrich Corporation**, \$37,000, July 2009 - December 2009.

Lord Corporation

"Penn State Vertical Lift Research Center of Excellence Support", **Lord Corporation**, \$575,000.00. 2016-October 2021.

"Penn State Vertical Lift Research Center of Excellence Support", **Lord Corporation**,

\$525,000.00. 2011-2016.

"Penn State Vertical Lift Research Center of Excellence Support", **Lord Corporation**, \$200,000.00. 2006-2011.

Alleviation of Aeromechanical Stability and Whirl via Blade-Embedded Elastomer Tuned Mass Dampers for Lag Damping, (E. Smith) **Lord Corporation**, \$45,000, January 2005 - December 2005.

Alleviation of Aeromechanical Stability and Whirl Flutter via Blade-Embedded Elastomer Tuned Massed Dampers of Lag Damping and SMA-based Passive Wing Damping Area. (E. Smith and G. Lesieutre), **Lord Corporation**, \$30,000, January 1, 2004 – December 31, 2004.

Alleviation of Aeromechanical Stability and Whirl via Blade-Embedded Elastomer Tuned Mass Dampers for Lag Damping and SMA-based Passive Wing Damping, (E. Smith) **Lord Corporation**, \$30,000, January 2001 - December 2001.

"Penn State Vertical Lift Research Center of Excellence Support", **Lord Corporation**, \$300,000.00. 2001-2006.

Sikorsky Aircraft Corporation

Aeroelastic Tailoring of Composite Rotor Blades for Vibration Reduction, Stability Augmentation, and Blade Loads Control, (E. Smith), **Sikorsky Aircraft Corporation**, \$19,763, April 10, 2000 – October 31, 2000.

Refined Modeling for the Aeroelastic and Aeromechanical Analysis of Helicopters with Elastomeric Lag Dampers (E. Smith and G. Lesieutre), **Sikorsky Aircraft**, \$15,000, January 1, 1994 – December 31, 1994.

The Johns Hopkins University Applied Physics Laboratory LLC

"Dragonfly: PSU Phase A (Definitized Subcontract to Letter Subcontract Dated May 3, 2018 under Log #209260)", **The Johns Hopkins University Applied Physics Laboratory LLC**, \$93,284.00 Co-Principal Investigator with 4 PSU Faculty, December 2019.

"Dragonfly: PSU Phase A", **The Johns Hopkins University Applied Physics Laboratory LLC(NASA)**, \$294,766.00 - Co-Principal Investigator with 4 PSU Faculty, January 2019 - December 2019,

"Dragonfly: PSU Phase A", **The Johns Hopkins University Applied Physics Laboratory LLC (NASA)**, \$294,766.00 - Co-Principal Investigator with 4 PSU Faculty. May 2018 - April 2019.

United Technologies

United Technologies Corporation

Multidisciplinary Design Projects in Rotocraft Engineering, (E. Smith) **United Technologies Corporation**, \$12,000, January 2010- December 2010.

Multidisciplinary Design Projects in Rotocraft Engineering, (E. Smith) **United Technologies Corporation**, \$12,000, January 2009 - December 2009.

Multidisciplinary Design Projects in Rotocraft Engineering, (E. Smith) **United Technologies Corporation**, \$9,000, January 2008 - December 2008.

Multidisciplinary Design Projects in Rotocraft Engineering, (E. Smith) **United Technologies Corporation**, \$9,000, January 2007 - December 2007.

Multidisciplinary Design Projects in Rotocraft Engineering, (E. Smith) **United Technologies Corporation**, \$10,000, January 2006 - December 2006.

Multidisciplinary Design Projects in Rotorcraft Engineering, (E. Smith) **United Technologies Corporation**, \$9,000, January 2005 - December 2005.

Multidisciplinary Design Projects in Rotorcraft Engineering, (E. Smith) **United Technologies Corporation**, \$10,000, January 2004 - December 2004.

Multidisciplinary Design Projects in Rotorcraft Engineering, (E. Smith) **United Technologies Corporation**, \$10,000, January 2003 - December 2003.

Multidisciplinary Design Projects in Rotorcraft Engineering, (E. Smith) **United Technologies Corporation**, \$10,000, January 2004 - December 2004.

Multidisciplinary Design Projects in Rotorcraft Engineering, (E. Smith) **United Technologies Corporation**, \$10,000, January 2003 - December 2003.

Optimization of Periodically Layered Elastomeric Mounts, (E. Smith), **United Technologies Research Center**, \$20,017, April 15, 2000 – December 22, 2000

Optimization of Layered Elastomeric Mounts, (E. Smith and G. Lesieutre), **United Technologies Research Center**, \$20,000, April 1, 1999 – August 31, 1999.

Development and Validation of a High Frequency Elastomeric Mount Model, (E. Smith and G. Lesieutre), **UTRC**, \$20,000, August 1, 1998 – December 31, 1999.

Characterization and Analysis for High Frequency Elastomeric Mounts, (E. Smith and G. Lesieutre), **UTRC**, \$20,000, June 1997 - December 1997.

Experimental Characterization of Elastomeric Vibration Mounts, (E. Smith and G. Lesieutre), **United Technologies Research Center**, \$10,000, October 1996 - December 1996.

Vertical Lift Consortium, Inc.

"VLC Advanced Drive System 2014", **Vertical Lift Consortium, Inc.** (Army), \$65,000.00 - Principal Investigator (100%) August 2015,

Modeling of Rotor Blade Ultrasonic Deicing and Experimental Comparison with Electrothermal Ice Protection Systems, **Vertical Lift Consortium, Inc.**, \$69,000, June 2013 - September 2014.

Design Evaluation of 2-speed Transmission Systems for Compound Helicopter Main Gearboxes, University of Tennessee - Knoxville (**Vertical Lift Consortium Prime Sponsor**), \$100,278, February 2013-December 2015.

Modeling of Rotor blade Ultrasonic Deicing and Experimental Comparison with Electromechanical Ice Protection Systems, **Vertical Lift Consortium, Inc.**, \$89,000, June 2012-June 2013.

CBM Technology-Emergent Health Monitoring Technologies, **Vertical Lift Consortium, Inc.**, \$172,000, March 2012-May 2013.

Advanced Drive System, Vertical Lift Consortium, Inc., \$123,000, March 2012-October 2013.

Advanced Aircraft Crashworthiness TAJI, (E. Smith, C. Bakis and E. Little) **Vertical Lift Consortium, Inc.**, \$87,500, March 2011-April 2012.

Advanced Drive Systems 2011, (E. Smith, C. Bakis, Z. Saribay, R. Bill and R. Kunz) **Vertical Lift Consortium, Inc.**, \$165,000, March 2011-June 2012.

Centrifugally Powered Pneumatic Actuation of Miniature Trailing Edge Effectors (MiTEs), (E. Smith, M. Maughmer and J. Palacios) **Vertical Lift Consortium, Inc.**, \$75,000, March 2011 - April 2012

Condition Based Maintenance Technology Verification and Validation for Maintenance Credits 2011, (E. Smith, J. Rose, S. Conlon and K. Reichard) **Vertical Lift Consortium, Inc.**, \$100,000, March 2011 - April 2012.

Modeling of Rotor Blade Ultrasonic Deicing and Experimental Comparison with Electrothermal Ice Protection, (E. Smith and J. Palacios) **Vertical Lift Consortium, Inc.**, \$92,000, March 2011-July 2012.

Centrifugally Powered Pneumatic Actuation of Miniature Trailing Edge Effectors (MiTEs), (E. Smith, and M. Maughmer) **Vertical Lift Consortium, Inc.**, \$75,000/year. April 2010-May 2011

Modeling of Rotor Blade Ultrasonic Deicing and Experimental Comparison with Electrothermal Ice Protection, (E. Smith and J. Palacios) **Vertical Lift Consortium, Inc.**, \$85,000/year, April 2010-August 2011.

Condition Based Maintenance Technology Verification & Validation for Maintenance Credits 2010, (E. Smith, J. Rose) **Vertical Lift Consortium, Inc.**, \$165,000, January 2010-June 2011.

VLC Advanced Drive System 2014, **Vertical Lift Consortium, Inc.** (Army), \$210,000, July 2014-August 2015.

Additional Industry and Government

Penn State Vertical Lift Research Center of Excellence Support, (E. Smith) **Aerospace Transmissions, LLC** (Purdy Systems), \$150,000, September 2006 - September 2011.

Wind Turbine Ice Protection Coating Performance and Adverse Environment Erosion Testing, (E. Smith and J. Palacios) **GE Global Research**, \$186,500, October 2010-June 2012.

Actuator Development Support of AERTS Projects, (J. Palacios and E. Smith) **Invercon**, \$6,000, December 2010.

"ITT Acoustics Emissions Test Project", **ITT Connect and Control Technology**, \$25,000.00. December 2019.

"ITT Acoustics Emissions - Technical Discussions", **ITT Enidine Inc.**, \$10,000.00 – Co-Principal Investigator (50%). May 2020,

Energy Harvesting for Direct Loads Monitoring on Rotor Hub Components, (E. Smith) **KCF Technologies, Inc.**, \$32,000, June 2009 - June 2011.

"Survivability Study of Rotorcraft with Power Loss for Multi- Rotor Configuration (Phase II)", National **Institute of Aerospace**, \$58,178.00 - Principal Investigator. December 2017,

Composite Blade Modeling and Aeroelastic Analysis, (E. Smith and M. Floros), **National Renewable Energy Laboratory**, \$20,000 January 8, 2002 – July 8, 2002.

Rotorcraft Center Equipment Augmentation, (E. Smith and L. Long), **National Rotorcraft Technology Center**, \$130,000 (includes 65K in Penn State Cost Sharing), November 1996 - December 1996.

A Multi-year Course in Sailplane Design and Fabrication (E. Smith, M. Maughmer, and D. Jensen), **National Science Foundation**, \$50,000, October 15, 1993 – October 15, 1994.

Transient Response Analysis for Investigation of H-46 Tunnel Strike Phenomenon (E. Smith), **Naval Air Warfare Center-Patuxent River**, \$72,471, March 1, 1994 – March 15, 1996.

Distributed Conformal Actuation for Simultaneously Controlling Flow Separation and Transition Dynamic Roughness, (E. Smith) **Physical Sciences, Inc.**, \$15,000, January 2009-July 2009.

Automated Identification, Selection and Execution of UAS Cargo Delivery to a Landing Zone with Optional Man in the Loop, (S. Evans and E. Smith) **SkEyes Unlimited Corporation**, \$21,000, June 2010-January 2011.

M-10000 Development and Evaluation, (E. Smith), **TechKor Instrumentation**, \$30,000, July 1, 1998 – June 30, 1999.

Single Crystal Piezoelectric Actuators for Adaptive Structures, (E. Smith), **TRS Ceramics Inc.**, \$33,000, January 22, 2004 – September 21, 2004.

Penn State University

Hands on Helicopters 101, (E. Smith), **Penn State University**, \$5,000, May 15, 2001 – June 30, 2002.

Development and Integration of Interactive Software Tools for Aerospace Dynamic Systems Education, (E. Smith), **Penn State College of Engineering**, \$5,000, January 1995 – July 1995.

Computer-Aided Animation for Aerospace Dynamic Systems Education (E. Smith), **Penn State College of Engineering**, \$4,500, January 1994 – July 1994.