ED HABTOUR, Ph.D., P.E.

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CAREER SUMMARY

Principle Member of Technical Staff at Sandia National Laboratories (SNL) with a multidisciplinary background in unmanned aerial systems, soft & compliant robots, nonlinear structural dynamics, adaptive and smart structures, and biomimicry. Associate editor for ASME Journal of Nondestructive Evaluation, Diagnostics & Prognostics in Engineering Sys. Founder of The Open Lab at SNL.

Research Interest

- Nonlinear Aero-Structures: modeling interactions and interfaces, structural control and health monitoring
- Emergent Dynamics: nature-inspired machines, modular and multifunctional structures
- Soft & Compliant Robots: bio-inspire mechanisms, non-traditional architectured materials and algorithms

Employment

Principle Member of Technical Staff at Sandia National Laboratories	Apr 2019 - Present
Visiting Scientist, Applied Mechanics, Univ. of Twente, Enschede, NL	Oct 2017 – Feb 2019
Diagnostics & Prognostics Team Lead, Army Research Lab, APG, MD	Jul 2011 – Mar 2019
Technical Assistant to Army Research Lab Chief Scientist, ALC, MD	Apr 2016 – Sep 2017
Reliability Engineer, Army Materiel Sys Analysis & Activity, APG, MD	Mar 2008 – Jul 2011
Mechanical Systems Engineer, Northrop Grumman Inc., Annapolis, MD	May 2006 – Jan 2007
Thermal Engineer, Swales Aerospace Inc., Beltsville, MD,	May 2004 – May 2006
Research Tech, Space Dynamics Laboratory, Logan, UT	Jun 2002 – Apr 2004
Research Tech, Materials and Systems Research, Inc., Salt Lake City, UT	Sep 1999 – Sep 2001

Education

Ph.D./MS Mechanical Engineering, University of Maryland, College Park	Aug 2015/2014
Focus: Nonlinear Structural Dynamics	
MS Computational Engineering, Purdue University	Dec 2011
Focus: Computational Mechanics	
ME Mechanical Engineering, Johns Hopkins University	May 2006
Focus: Thermo-Fluids	
BS Mechanical Engineering, Utah State University (Cum Laude)	May 2004

Licenses and Certificates

Professional Eng. License, Mech. Systems & Materials	Dec 2015 – Dec 2019
System Engineering Level I and II	2009

Projects

Vertebrae-Like Structures with Soft Actuations: (Habtour Lead PI and 1 Co-PI, 2018 – 2021): Investigate the dynamic behavior of nature-inspired modular structures with soft artificial muscles to improve the efficiency of current control systems. Develop simplified models enough to provide fast control schemes. Compare the influence of geometric modulation to active soft materials.

Identification of Rare Events in Nonlinear Dynamical Systems: (Habtour Co-PI and 1 Lead PI, 2019 – 2020): Develop detection algorithms using distortion rate theory to identify rare events in noisy nonlinear dynamical systems. Create efficient mathematical schemes to quantify the magnitude of

these events and detect instabilities and recovery time.

Soft Actuation Modeling: (Habtour Lead PI and 2 Co-PIs, 2016 – 2019): Modeled the actuation and nonlinear response of untethered stretchable displays for tactile interaction, and 3D printed soft matter with electrically distributive actuation. The model combined materials, electromechanical and geometric nonlinearities into a unified and simplified equation of motion.

Reliability State Awareness Test–bed (Habtour Lead PI and 2 Co-PIs, 2014 – 2017): Simulate operational conditions in the laboratory to develop and evaluate new US Army robotics and unmanned systems. Capabilities are: multiaxial shakers, biaxial loading, and unmanned vehicles adaptive control.

Bio-inspired Damage Precursors Sensing (Habtour Lead PI and 3 Co-PIs, 2015 – 2019): Detect precursors to fatigue damage using multifunctional structures capable identifying and preventing crack initiation and allowing components to adapt to their own health.

Improved Reliability Tests with Multiaxial Vibration (Single PI, 2011 – 2017): Identified and tracked failure mechanics of components with an emphasis on micromechanics of constitutive and damage behavior. Mitigated failures in components exposed to “real world” multiaxial vibration.

Active Structures to Suppress Fire and De-ice Aircraft: (Habtour Co-PI and 1 Co-PI, 2012 – 2016) Develop lightweight multifunctional structure to suppress fire in an aircraft without the use of chemicals. Provide de-icing functionality when needed.

Aeroelastic Stability (Habtour Co-PI, 1 PI, 2012 – 2017): Developed a hybrid nanocomposites and flexible structures to passively enhance aeromechanical stability of the aircraft, and reduced vibration transmission and flow separation.

Lifecycle Model for Components (Single PI, 2011 – 2013): Developed analytical model to predict life of structures and electronics under complex vibrations.

Future Combat System (Lead Project Engineer, 2009 – 2011) Evaluated the thermal, vibration performance of electronic systems in Unmanned Ground Vehicles and smart projectiles. Enhanced reliability through physics of failure analysis.

Advanced SEAL Delivery System (Project Engineer, 2006 – 2007): Provided reliability analysis, which included finite element method, thermo-fluid models, design, and lifecycle testing.

Prometheus (High Temperature Heat Pipe) (Support Engineer, NASA, 2005 – 2006) Developed prototype heat pipes for Rankine space-based nuclear power conversion cycle. Resolved issues related to material compatibility, thermal stresses, and non-condensable gas.

ST-8 NASA Advanced Technology (Support Engineer, 2004 – 2006): Developed miniaturized passive/active thermal bus to regulate temperature for small spacecraft.

GOES-ABI (Research Tech, 2004 – 2006, Maintained stable operational temperature for GOES): Provided engineering support for building the thermal system for the Geostationary Operational Environmental Satellite.

Bio-Sample Cold Cell for International Space Station (ISS) (Research Tec, 2003 – 2004): Designed and analyzed the performance of a bio-container to preserve space samples.

High Temperature Heating Element (Research Tec, 1999 – 2001) Designed and analyzed performance of high temperature heating elements (2100^{o}C).

Solid Oxide Fuel Cell (Research Tech, 1999 – 2001, Produced clean energy to sustain small buildings): Fabricated and evaluated performance of ceramic composite fuel cell.

Professional and International Service

Professional Societies:

Senior Member of IEEE, and member of ASCE-EMI, ASME, SAIM

Advisory Boards:

Mechanical Engineering Department, New Mexico Institute of Mining and Technology

Committees and Panels

ASME Adaptive Structures, Materials and Systems Technical Committee, EMI Structural Health Monitoring & Control Committee, IEEE Standards for Structural Health Monitoring of Electronics

Review Panels: National Science Foundation, Army Research Office, Office of Naval Research

Chaired and co-chaired several conference sessions

Scientific Journals:

Associate Editor: ASME J of NDE Diagnostics & Prognostics of Enging Sys

Reviewer: Nonlinear Dynamics, Fluids and Structures, Journal of Applied Mechanics, Experimental Mechanics, Composites and Structures, AIAA Journal, J of Enging Mater and Technology, J of Composite Mater, Electronics Reliability, IEEE Transactions on Reliability, J of Electronics Packaging

Honors and Awards

Department of the Army Engineers-Scientist Exchange Program, 2017-2018

Department of the Army Commander's Award for Civilian Service Medal, 2017

Army Research Laboratory Vehicle Tech Directorate Science Award, 2016

Army Research Laboratory Customer Service Award, 2017, 2016, 2014 and 2013

Department of the Army Achievement Award, 2015 and 2014

Evans/P.K. McElroy Best Paper Award, IEEE RAMS, 2010

Special Act/Service Award, Department of the Army, 2010

Army Superior Unit Award, Department of the Army, 2009

Keynote & Invited Talks

[1] Bridging the Scales in Structural Health Monitoring. *ASME SMASIS* Louisville, KY Sep 9-10, 2019.
[2] The Scientists' War: Essential Research Areas for Technological Superiority in Future Conflicts *SPIE 2017* Warsaw Poland Sep 11-14, 2017.
[3] A Fiber Optic Conjugate Stress Sensor for Structural Health Monitoring of a Polymer Composite Material. *EMI 2017* San Diego CA Jun 5-7, 2017.
[4] Rethinking Structural Health Monitoring: Outsmarting Fatigue. *ASME SMASIS* Stowe VT Sep 28-30, 2016.
[5] Materials Damage Precursor *NAVAIR Structural Mechanics TIM* Falls Church VA Jun 26, 2015.
[6] Nonlinear Dynamic Effects in Vibration Durability of Electronics Systems. *8th Int Conf Integrated Power Elec Sys* Nuremberg Germany Feb 25-27, 2014.
[7] Dynamic Characterization of Circuit Card Assemblies Using Multi-Degree-of-Freedom Random Vibration. *Accelerated Stress Testing & Reliability Workshop* San Francisco CA Sep 28-30, 2011.

Journal Publications

[8] Montoya, A, E Habtour, F Moreu. Quantifying information without entropy: identifying infinitesimal surprises in dynamical systems. *Applied Physics Letters*, Submitted.
[9] Wiersinga, P J, E Habtour, A De Bore. Exploiting instabilities in vertebrae-like structures for soft-robotic control. *Biomimetic and Bioinspiration*, In Review.
[10] E Habtour, M Kuiper, R De Wilde, D Bradford, S Sawaya, C O'Malley. Influence of hard-soft segmentation on energy storage and release in nature-inspired limbless vertebrae. *Biomimetic and Bioinspiration*, In preparation.
[11] Habtour, E, Cole D P, Kube C M, Henry T C, Haynes R A, Gardea F, Sano T, Tinga T. Structural state awareness through integration of global dynamic and local material behavior. *J of Intelligent Material Systems and Structures* (2019).
[12] Peele, B, S Li, C Larson, J Cortell, E Habtour, and R Shepherd. Untethered stretchable displays for tactile interaction. *Soft Robotics* (2019).
[13] Haghiashtiani, G, F Gardea, E Habtour, M C McAlpine. 3D printed electrically-driven soft actuators. *Extreme Mechanics Letters* 21 (2018).
[14] Habtour, E, M Robeson, A Dasgupta, S Vantadori. The Influence of Phase on the Response of a Structure under Combined Rotational and Transverse Vibration. *MSSP* 100 (2018).
[15] Vantadori, S, A Carpinteri, R Haynes, G Fortese, E Habtour, C Ronchei, D Scorza. Methodology for Assessing Embryonic Cracks Development in Structures under High Cycle Multiaxial Random Vibrations. *Fatigue Fract Engng Mater Struct* 41.1 (2018).

[16] Borel, C, E Habtour, G H Goldman. Optical methods for modeling and experimental detection of sound sources behind windows. *J of Acoustical Society of America* 141.5 (2017).
[17] Aliev, A E, N K Mayo, R H Baughman, B T Mills, E Habtour. Subwoofer and nanotube butterfly acoustic flame extinction. *Physics D: App Phys* 50.29 (2017).
[18] Cole, D P, E Habtour, T Sano, A Dasgupta. Local Mechanical Behavior of Steel Exposed to Nonlinear Harmonic Oscillation. *Experimental Mech* 57.7 (2017).
[19] Henry, T C, J C Riddick, B Mills, E Habtour. Composite Driveshaft Prototype Design and Survivability Testing. *J Composite Mater* 51.16 (2017).
[20] Cipra, R, E Habtour, J Riddick, F Barthelat, T Siegmund. Manufacture and Mechanics of Topologically Interlocked Material Assemblies. *App Mech Reviews* 68.4 (2016).
[21] Owolabi, G, A Peterson, E Habtour, J Riddick, M Coatney, A Olasumboye, D Bolling. Dynamic Response of Acrylonitrile Butadiene Styrene under Impact Loading. *Intl J Mech & Mater Enging* 11.3 (2016).
[22] Habtour, E, D Cole, R Sridharan, A Dasgupta. Damage Precursor Detection for Structures Subjected to Rotational Base Vibration *Intl J Nonlinear Mech* 82 (2016).
[23] Ernst, M, E Habtour, A Dasgupta. Examining Steinberg's Octave Rule Applicability for Electronic Systems Exposed to Multiaxial Vibration. *IEEE Trans on Components, Packaging & Manuf Tech* 6.4 (2016).
[24] Habtour, E, D Cole, V Weiss, M Robeson, R Sridharan, A Dasgupta. Detection of Fatigue Damage Precursor Using a Nonlinear Vibration Approach. *Struct Control & Health Monitoring* 23 (2016).
[25] Glaz, B J, J C Riddick, E Habtour, H Kang. Interfacial Strain Energy Dissipation of Hybrid Nanocomposite Beams Under Axial Strain Fields. *AIAA J* 53.6 (2015).
[26] Feng, Y, T Siegmund, E Habtour, J Riddick. Impact Mechanics of Topologically Interlocked Material Assemblies. *Int J Impact Enging* 7 (2015).
[27] Ernst, M, E Habtour, M Paulus, M Robeson, M Pohland, A Dasgupta. Comparison of Electronic Component Durability under Uniaxial and Multiaxial Random Vibrations. *J of Electronics Packaging* 137.1 (2014).
[28] Habtour, E, W Connon, M Pohland, S C Stanton, M Paulus, A Dasgupta. Review of Response and Damage of Linear and Nonlinear Systems under Multiaxial Vibration. *Shock & Vib* (2014).
[29] Habtour, E, M Paulus, A Dasgupta. Modeling approach for Predicting the Rate of Frequency Change of Notched Beam Exposed to Gaussian Random Excitation. *Shock & Vib* (2013).
[30] Habtour, E, C Cholmin, M Osterman, A Dasgupta. Novel Approach to Improve Electronics Reliability in the Next Generation of US Army Small Unmanned Vehicles under Complex Vibration Conditions. *Int J Failure Analysis & Prevention* 12 (2012).
[31] Geetha, V, E Habtour, G Drake. Improving the Reliability in the Next Generation of US Army Platforms through Physics of Failure Analysis. *Int J Failure Analysis & Prevention* 12 (2012).
[32] Paulus, M, E Habtour, A Dasgupta. Life Estimation Model of a Cantilevered Beam Subjected to Complex Random Vibration. *Fatigue Fract Enging Mater Struct* 35.11 (2012).

Conference Proceedings

[33] Haynes, R A, E Habtour, T C Henry, D P Cole, V Weiss, A Kontsos, B Wisner. Damage Precursor Indicator for Aluminum 7075-T6 Based on Nonlinear Dynamics. *SEM/IMAC Nonlinear Dynamics*, Springer, 1 (2019).
[34] Habtour, E, D Di Maio, A Homborg, T Tinga. Connecting nonlinearities: damage precursors detection and control methodology. *Int Conf on Noise & Vib Engineering* Leuven Belgium, Sep 17-19, 2018.
[35] Habtour, E, A Homborg, D Di Maio, R Haynes, T Tinga. Utilizing Force-State Mapping for Detecting Fatigue Damage Precursors in Aerospace Applications. *European Workshop on Structural Health Monitoring* Manchester UK Jul 9-13, 2018.
[36] Habtour E, A Dasgupta, S Vantadori. Cross-Axis Coupling and Phase Angle Effects Due to Multiaxial Vibration. Fracture, *SEM Fatigue, Failure and Damage Evolution,* Springer 7 (2018).
[37] Patra, S, S Banerjee, E Habtour, R Haynes. A Novel Ultrasonic Technique for the Detection of Distributed Precursor Damages in Composites. *ASME IMECE* Phoenix AZ Nov 11-17, 2016.
[38] Vantadori, S, A Carpinteri, R Haynes, G Fortese, E Habtour, C Ronchei, D Scorza. A Multiaxial Frequency-Domain Criterion for High-Cycle Random Vibration Fatigue. *Int Conf on Metallurgy & Mater* Sofia Bulgaria Sep 26-28, 2016.
[39] Kube, C M, A P Arguelles, E Habtour. Finite Amplitude Wave Propagation in Anisotropic Materials.

Quantitative NDE Atlanta GA Jul 17-22, 2016.
[40] Kube, C M, R Rodriguez R, E Habtour, L J Holmes. Attenuation of Ultrasonic Waves Generated from Laser Ultrasound during Annealing of Steel, a Comparison between Theory and Experiment and Potential Application to Additive Manufacturing. *Quantitative NDE* Atlanta GA Jul 17-22, 2016.
[41] Habtour, E, D Cole, C M Kube. A Svenskensen, M Robeson, A Dasgupta. Damage Precursor Index Methodology for Aviation Structures. *8th EWSHM* Bilbao Spain Jul 5-8, 2016.
[42] Janapat, V, S V Yadav, A Kumar, R Ikegami, E Habtour. Fatigue Crack Quantification Approach Based on Multi-Path Unit-Cell Concept in Sensor Network. *8th EWSHM* Bilbao Spain Jul 5-8, 2016.
[43] Lee, A, E Habtour, S A Gadsden. Proposed Health State Awareness of Helicopter Blades Using an Artificial Neural Network Strategy. *SPIE Signal Proc* Baltimore MD 2016.
[44] Peterson, A, D Bolling, A Olasumboye, E Habtour, J Riddick, M Coatney, G Owolabi. Dynamic Behavior of Acrylonitrile Butadiene Styrene Under Impact Loads. *ASME IMECE* 9 Houston TX Nov 13–19, 2015.
[45] Habtour, E, D Cole, A Dasgupta. Local Mechanical Characterization of Structural Damage Precursor. *ASME SMASIS* Colorado Springs CO Sep 21-23, 2015.
[46] Habtour, E, D Cole, R Sridharan, A Dasgupta. Utilizing Nonlinear Dynamic Parameters and Micromechanics to Enhance Damage Precursor Detection. *10th IWSHM* Stanford CA Sep1-3, 2015.
[47] Sridharan, R, E Habtour, A Dasgupta, E Lin. Dynamic Response of Large Electronic Components Undergoing Multiaxial Vibratory Excitation. *ASME InterPACK* Jul 6-9, 2015.
[48] Glaz, B, J Riddick, E Habtour, H Kang. Interfacial Strain Energy Dissipation of Hybrid Nanocomposite Beams Under Axial Strain Fields. *AIAA/ASME/ASCE* Baltimore MD Jan 13-17, 2014.
[49] Habtour, E, B Werner, A Hilburn, H Saraidaridis. Physics of Failure for Portable Electronic Devices in Military Applications. *59th Reliability & Maintainability* Orlando FL, Jan 28-31, 2013.
[50] Paulus, M, E Habtour, A Dasgupta. Finite Element Modeling of Time to Failure Using Stress Intensity Factor. *82nd Shock & Vib* Baltimore MD Oct 30 – Nov 3, 2011.
[51] Habtour, E, D Mortin, M Osterman, A Dasgupta. Novel Approach to Improve Electronics Reliability in the Next Generation of US Army Small Unmanned Vehicles under Complex Vibration Conditions. *Applied Sys Health Management* Virginia Beach VA May 10-12, 2011.
[52] Geetha, V, E Habtour, G Drake. Improving the Reliability in the Next Generation of US Army Platforms through Physics of Failure Analysis. *Applied Sys. Health Management* Virginia Beach VA May 10-12, 2011.
[53] Habtour, E, G Drake, C Davies. Modeling Damage in Large and Heavy Electronic Components Due to Dynamic Loading. *57th Reliability & Maintainability* Lake Buena Vista FL Jan 24-27, 2011.
[54] Habtour, E, D Mortin, C Choi, A Dasgupta. Novel Approach to Improve Electronics Reliability in the Next Generation of US Army Unmanned Ground Vehicles under Complex Vibration Conditions. *2nd Annual Ground Vehicle Sys Enging & Tech* Dearborn MI Aug 17-19, 2010.
[55] Habtour, E, G Drake, A Dasgupta, M Al-Bassyiouni, C Choi. Improved Reliability Testing with Multiaxial Electrodynamics Vibration. *56th Reliability & Maintainability* San Jose CA Jan 25-28, 2010.
[56] Habtour, E, M Nikitkin. Miniature Multiple Evaporator Multiple Condenser Loop Heat Pipe. *19th Annual AIAA/USU Small Satellite* Logan UT Aug 08-11, 2005.

Conference Presentations

[57] Habtour E, T Tinga, L Cordova Gonzalez, D Di Maio, K van Loobergen, T Tinga, D Cole, *ASME SMASIS*, Louisville, KY Sep 9-11, 2019.
[58] Dragman T, E Habtour, T Tinga, D Cole, Detection of Precursors to Damage in Aerostructures *ASME SMASIS*, Louisville, KY Sep 9-11, 2019.
[59] Haghiashtiani, G, F Gardea, E Habtour, M C McAlpine. 3D Printing Dielectric Elastomer Actuators for Soft Robotic Applications. *MRS* Boston MA Nov 26 - Dec 1, 2017.
[60] Feng, Y, E Habtour, J Riddick, T Siegmund. Damage Analysis of a Hybrid Energy Absorption Layer Based on the Principle of Topologically Interlocking Materials. *ASME IMECE* San Diego CA Nov 15-21 2013.
[61] Ernst, M, C Choi, E Habtour, A Dasgupta, Physics of Failure Models for Multiaxial Vibration Fatigue in Electronic Assemblies. *IEEE Accelerated Stress Testing & Reliability Workshop* Toronto Ontario Canada Oct 17-19 2012.
[62] Habtour, E, M Ernst, M Paulus, A Dasgupta, T Riely. Dynamic Characterization of Circuit Card

Assemblies Using Multi-Degree-of-Freedom Random Vibration *IEST 58th* Orlando FL May 1-3 2012.

[63] Habtour, E, W Connon. Dynamic Technical Discussion: Multi-axial Vibration Research Thrusts, Gaps and the Path Forward. *IEST 58th* Orlando FL May 1-3 2012.

[64] Habtour, E, G Drake, A Dasgupta, M Al-Bassyiouni. Improved Qualification Testing with Six DOF Electrodynamic Vibration. *RDECOM Reliability Enging Challenges & Solutions Workshop* College Park MD Sep 22-23 2009.

Seminars

[65] Connecting and Exploiting Nonlinearities for Improving Fitness of Military Platforms, the Netherlands Defence Academy, Den Helder Netherlands Oct 10, 2018.

[66] Research Programing in Military Laboratory, the Netherlands Ministry of Defense, Utrecht Netherlands, Mar 2, 2018.

[67] Sandia National Laboratories. Achieving Resilient in Dynamical Systems: Exploiting the Interplay amongst Dynamic, Geometric and Material Nonlinearities. Albuquerque NM Sep 20, 2017.

[68] Naval Undersea Warfare Center. From Reliability to Resilience. Keyport WA Aug 14, 2017.

[69] Naval Undersea Warfare Center. Developing Integrated and Converged Research Portfolio for Government Laboratories, Keyport WA Aug 15, 2017.

[70] Stevens Institute of Technology. Bio-resilience: Engineering Driven by the Whys before the Hows, Hoboken NJ Mar 14, 2017.

[71] Massachusetts Institute of Technology. Exploiting Nonlinear Dynamic Parameters to Outsmart Fatigue in Rotorcrafts. Boston MA Mar 31, 2016.

[72] University of South Carolina. Damage Precursor: Defeating Fatigue in Army Rotorcrafts. Columbia SC Nov 10, 2015.

[73] Sandia National Laboratories. Multiaxial Vibration Testing: Changing the Way We Design for Reliability. Albuquerque, NM, Jul 22, 2015.

[74] Howard University. Structural Nonlinearity under Multiaxial Vibration, Analytical and Experimental Approach. Washington DC Nov 8, 2013.

[75] University of Maryland. Multi-Degree of Freedom Vibration Testing for Durability Assessment of Electronic Assemblies. College Park MD Sep 21, 2011.

Technical Reports

[76] Friedman, A, B T Mills, E Habtour. Joint Aircraft Survivability Program Final Test Report for the Acoustic Fire Suppression. *Report* ARL-TR-7802 Sep 2016.

[77] Habtour, E. Physics of Failure Analysis for Airport Surveillance Radars (ASR) Resistor R20. *AMSAA Report* TR-2010-40 Sep 2010.

[78] Werner, B, E Habtour. Excalibur Projectile (XM982) Physics of Failure Reliability Analysis. *AMSAA Report* TR-2011-35 Sep 2011.

[79] Habtour, E. Physics of Failure Analysis for Airport Surveillance Radars (ASR) Resistor R20. *AMSAA Report* TR-2010-40 Sep 2010.

[80] Abdurahman, H, G Chary, E Habtour, G Dogum, M Shepler. Future Combat System GSTAMIDS GPR Physics of Failure Reliability Analysis *AMSAA Report* TR-2010-16 Apr 2010.