

Eric Greenwood II

Curriculum Vitae

☎ 202.230.7621

✉ eric.greenwood@nasa.gov

<https://ericgreenwood.net/>

Research Interests Theoretical and experimental rotorcraft aerodynamics and acoustics

Research Experience

2008-Present **Research Aerospace Engineer**, *NASA Langley Research Center*, Hampton, VA.

- Developed new rotorcraft aerodynamic and acoustic models and analysis techniques
 - Fundamental Rotorcraft Acoustic Modeling from Experiments (FRAME): parameter identification approach for rotorcraft aeroacoustics
 - Dynamic prescribed wake model for transient maneuvering flight
 - Fast quasistatic acoustic modeling approach for arbitrary maneuvers
 - Virtual in-flight observer transformation of ground-based acoustic signals
 - Main and tail rotor harmonic noise separation from measurements
 - A method of producing helicopter noise abatement information for any conventional helicopter using machine learning techniques, including neural networks, support vector machines, and random forest / decision trees
- Designed and executed numerous acoustic flight tests of rotorcraft
 - NASA Mobile Acoustic Facility team lead (~\$1M–\$2M per year funding from NASA, US Army, other US Government agencies, and industry)
 - Designed experimental procedures to quantify and understand helicopter noise due to: steady turning flight, acceleration, transient roll and pitch maneuvers, changes in vehicle trim, changes in vehicle weight or drag, changes in ambient atmospheric conditions
 - Developed in-flight instrumentation for various test programs
 - Developed experimental techniques to measure helicopter aerodynamic performance with limited instrumentation
- Improved understanding of the underlying physics of rotor noise generation
 - First validated predictions of helicopter noise for maneuvering flight
 - Applied nondimensional rotor noise scaling theory to show that ambient conditions can cause significant changes to helicopter noise characteristics
- Developed new rotorcraft noise reduction technologies, including:
 - Real time helicopter noise awareness display (patent pending)
 - Low noise operation planning and near-real-time dynamic replanning

2017-Present **Advisor**, *Harmony Aeronautics / Texas A&M University*, College Station, TX.

- Advising team seeking to win the \$2M Boeing GoFly competition by designing and building the world's quietest passenger-carrying VTOL aircraft
- Developed acoustic design code for hovering coaxial rotors
- Designed novel rotor blade shape to minimize unsteady loading noise (pat. pending)
- Devised subscale experiments to validate acoustic performance

- 2005-2008 **Graduate Research Assistant**, *University of Maryland*, College Park, MD.
- Supported several acoustic flight test campaigns
 - Developed new methods for characterizing helicopter noise radiation
 - Developed acoustic/performance models for several commercial helicopters
 - Participated in subscale rotor aerodynamic and acoustic testing

Education

- 2008-2011 **Ph.D., Aerospace Engineering**, *University of Maryland*, College Park, MD.
Title *Fundamental Rotorcraft Acoustic Modeling from Experiments (FRAME)*
Advisors Fredric H. Schmitz and James E. Hubbard, Jr.
- 2005-2008 **M.S., Aerospace Engineering**, *University of Maryland*, College Park, MD.
Title *A Physics-Based Approach to Characterizing Helicopter External Noise Radiation from Ground-Based Noise Measurements*
Advisor Fredric H. Schmitz
- 2000-2005 **B.S., Mechanical Engineering**, *Rochester Institute of Technology*, Rochester, NY.

Awards and Honors

- 2018 American Helicopter Society François-Xavier Bagnoud Award
2018 American Helicopter Society Forum Best Acoustics Paper
2018 GoFly Phase I Award: Texas A&M “Harmony” Ultra-Quiet VTOL
2016 NASA Early Career Achievement Medal
2016 NASA Group Achievement Award for the “Altitude Variation Flight Test”
2016 American Helicopter Society Forum Best Acoustics Paper
2015 American Helicopter Society Forum Best Acoustics Paper
2012 American Helicopter Society Forum Best Acoustics Paper
2011 American Helicopter Society Forum Best Acoustics Paper
2007 Vertical Flight Foundation Scholarship
2007 AHS/NASA Lichten Internship Award
2007 American Helicopter Society Forum Best Acoustics Paper

Scientific and Professional Societies

- 2006-Present Vertical Flight Society (VFS) née American Helicopter Society (AHS)
 - 2018-Present, Technical Director, Hampton Roads Chapter
 - 2006-2012, Associate Member, Acoustics Technical Committee
- 2017-Present Helicopter Association International (HAI)
 - 2017-Present, Member, Fly Neighborly Committee
- 2002-Present American Institute for Aeronautics and Astronautics (AIAA)
- 2008-2010 Society for Industrial and Applied Mathematics (SIAM)

Other Professional Service

- Referee Journal of the American Helicopter Society, Journal of Aircraft, International Journal of Aeroacoustics, Journal of Sound and Vibration, Applied Acoustics, Noise Mapping
- Reviewer NASA NRA, NASA SBIR, US Army SBIR, US Army STTR, US Army RIF, Vertical Lift Research Center of Excellence, FAA ASCENT
- Judge AHS Student Design Competition, AIAA Hampton Roads Section Laurence Bement Young Professional Paper Award, AHS Tidewater Engineering and Science Fair Award, Real World Design Challenge
- Committee Member Hardwick, J.R., *Synthesis of Rotorcraft Noise from Flyover Data*, Thesis, Virginia Tech, 2014.

Invited Presentations

- 2018 **Rensselaer Polytechnic Institute AIAA-NENY**, On-Demand Aeroacoustic Modeling for Low Noise Rotorcraft Operations.
- 2018 **Pennsylvania State University Center for Acoustics and Vibration**, Rotorcraft Aeroacoustic Modeling using Parameter Identification Methods.
- 2018 **Pennsylvania State University American Helicopter Society Chapter**, Learning to Fly Quietly: Flight Experiments with Helicopters.
- 2018 **NASA Urban Air Mobility Noise Working Group**, Acoustic Data Needs for Urban Air Mobility Vehicles.
- 2018 **NASA Acoustics Technical Working Group**, Real Time Helicopter Noise Awareness Display.
- 2018 **DATAWorks 2018: Defense and Aerospace Test and Analysis Workshop**, Building a Universal Helicopter Noise Model Using Machine Learning.
- 2018 **American Helicopter Society Transformative VTOL Workshop**, Concepts for Low Noise Rotorcraft Operation.
- 2017 **University of Florida Mechanical and Aerospace Engineering Department**, Rotorcraft Aeroacoustics Experimental Flight Research.
- 2017 **American Helicopter Society Noise Panel**, Real-Time Helicopter “Fly Neighborly” Guidance.
- 2017 **NASA Acoustics Technical Working Group**, Helicopter Flight Procedures for Community Noise Reduction.
- 2016 **NASA Acoustics Technical Working Group**, Helicopter Source Noise Variation with Altitude.
- 2015 **Aeronautics Research Mission Directorate Technical Seminar**, An Overview of Rotorcraft Acoustic Flight Testing.
- 2015 **NASA/FAA Technical Interchange Meeting**, Fundamental Rotorcraft Acoustic Modeling from Experiments.
- 2015 **NASA Acoustics Technical Working Group**, Modeling and Data Extraction Techniques using Flight Test Data.

- 2013 **American Helicopter Society Noise Panel**, Why are helicopters still considered noisy.
- 2012 **NASA Acoustics Technical Working Group**, Fundamental Rotorcraft Acoustic Modeling from Experiments.
- 2011 **DARPA**, Eglin 2011 NASA/Bell/Army Flight Test Program and Capabilities.
- 2010 **AHS Federal City Chapter**, Griffin: Innovative Engineering for Exceptional Performance.
- 2009 **SAE-A21 Aircraft Noise Measurement Helicopter PWT**, A Physics-Based Approach to Characterizing Helicopter External Noise Radiation from Ground-Based Noise Measurements.
- 2007 **AHS Southeast Region**, Helicopter External Noise Radiation in Turning Flight.

Archival Journal Publications

Greenwood, E., Sim, B. W., and Boyd, D. D., “The Effects of Ambient Conditions on Helicopter Harmonic Noise Radiation: Theory and Experiment,” *AIAA Journal*, submitted.

Greenwood, E. and Rau, R., “A Maneuvering Flight Noise Model for Helicopter Mission Planning,” *Journal of the American Helicopter Society*, submitted.

Greenwood, E., “Helicopter Flight Procedures for Community Noise Reduction,” *Journal of the American Helicopter Society*, in preparation.

Greenwood, E. and Sim, B. W., “Effects of Crosswind Flight on Rotor Harmonic Noise Radiation,” *Journal of Aircraft*, Vol. 55, (5), September 2018, pp. 2137–2148.

doi: 10.2514/1.C034634

Greenwood, E. and Schmitz, F. H., “A Parameter Identification Method for Helicopter Noise Source Identification and Physics-Based Semiempirical Modeling,” *Journal of the American Helicopter Society*, Vol. 63, (3), July 2018, pp. 1–14.

doi: 10.4050/JAHS.63.032001

Greenwood, E., Schmitz, F. H., and Sickenberger, R. D., “A Semiempirical Noise Modeling Method for Helicopter Maneuvering Flight Operations,” *Journal of the American Helicopter Society*, Vol. 60, (2), April 2015, pp. 1–13.

doi: 10.4050/JAHS.60.022007

Stephenson, J. H., Tinney, C. E., Greenwood, E., and Watts, M. E., “Time frequency analysis of sound from a maneuvering rotorcraft,” *Journal of Sound and Vibration*, Vol. 333, (21), October 2014, pp. 5324 – 5339.

doi: 10.1016/j.jsv.2014.05.018

Greenwood, E. and Schmitz, F. H., “Separation of Main and Tail Rotor Noise from Ground-Based Acoustic Measurements,” *Journal of Aircraft*, Vol. 51, (2),

March 2014, pp. 464–472.
doi: 10.2514/1.C032046

Greenwood, E. and Schmitz, F. H., “Effects of Ambient Conditions on Helicopter Rotor Source Noise Modeling,” *Journal of Aircraft*, Vol. 51, (1), January 2014, pp. 90–103.
doi: 10.2514/1.C032045

Conference Papers

Greenwood, E., “Dynamic Replanning of Low Noise Rotorcraft Operations,” Vertical Flight Society 75th Annual Forum, May 2019, in preparation.

Christian, A., Caston, J., and Greenwood, E., “Regarding the Perceptual Significance and Characterization of Broadband Components of Helicopter Source Noise,” Vertical Flight Society 75th Annual Forum, May 2019, in preparation.

Kellen, A., Halder, A., Benedict, M., and Greenwood, E., “Acoustic Analysis of a UAV-Scale Cycloidal Rotor: An Experimental and Computational Approach,” Vertical Flight Society 75th Annual Forum, May 2019, in preparation.

Greenwood, E., “Estimating Noise Abatement Information with Machine Learning,” American Helicopter Society 74th Annual Forum, May 2018.

Stephenson, J. H., Scudder, K., and Greenwood, E., “Rotorcraft and unmanned aerial system noise measurement technology development and challenges,” *The Journal of the Acoustical Society of America*, Vol. 144, (3), 2018, pp. 1829–1829.
doi: 10.1121/1.5068057

Greenwood, E., “Real Time Helicopter Noise Modeling for Pilot Community Noise Awareness,” NOISE-CON 2017, June 2017.

Greenwood, E., “Helicopter Flight Procedures for Community Noise Reduction,” American Helicopter Society 73rd Annual Forum, May 2017.

Greenwood, E., Sim, B. W., and Boyd, D. D., “The Effects of Ambient Conditions on Helicopter Harmonic Noise Radiation: Theory and Experiment,” American Helicopter Society 72nd Annual Forum, May 2016.

Watts, M. E., Greenwood, E., and Stephenson, J. H., “Measurement and Characterization of Helicopter Noise at Different Altitudes,” American Helicopter Society 72nd Annual Forum, May 2016.

Malpica, C., Greenwood, E., and Sim, B. W., “Parametric Investigation of the Effect of Hub Pitching Moment on Blade Vortex Interaction (BVI) Noise of an Isolated Rotor,” American Helicopter Society 72nd Annual Forum, May 2016.

Malpica, C., Greenwood, E., and Sim, B. W., “Helicopter Non-Unique Trim Strategies for Blade-Vortex Interaction (BVI) Noise Reduction,” American

Helicopter Society Technical Meeting on Aeromechanics Design for Vertical Lift, January 2016.

Greenwood, E., Rau, R., May, B., and Hobbs, C., “A Maneuvering Flight Noise Model for Helicopter Mission Planning,” American Helicopter Society 71st Annual Forum, May 2015.

Stephenson, J. H. and Greenwood, E., “Effects of Vehicle Weight and True versus Indicated Airspeed on BVI Noise During Steady Descending Flight,” American Helicopter Society 71st Annual Forum, May 2015.

Greenwood, E. and Sim, B. W., “The Effects of Crosswind Flight on Rotor Harmonic Noise Radiation,” American Helicopter Society 69th Annual Forum, May 2013.

Greenwood, E., Schmitz, F. H., and Sickenberger, R. D., “A Semi-Empirical Noise Modeling Method for Helicopter Maneuvering Flight Operations,” American Helicopter Society 68th Annual Forum, May 2012.

Watts, M. E., Snider, R., Greenwood, E., and Baden, J., “Maneuver Acoustic Flight Test of the Bell 430 Helicopter,” American Helicopter Society 68th Annual Forum, May 2012.

Greenwood, E. and Schmitz, F. H., “The Effects of Ambient Conditions on Helicopter Rotor Source Noise Modeling,” American Helicopter Society 67th Annual Forum, May 2011.

Greenwood, E. and Schmitz, F. H., “A Parameter Identification Method for Helicopter Noise Source Identification and Physics-Based Semi-Empirical Modeling,” American Helicopter Society 66th Annual Forum, May 2010.

Greenwood, E. and Schmitz, F. H., “Separation of Main and Tail Rotor noise Ground-Based Acoustic Measurements using Time-Domain De-Dopplerization,” 35th European Rotorcraft Forum, September 2009.

Greenwood, E., Schmitz, F. H., and Gopalan, G., “Helicopter External Noise Radiation in Turning Flight: Theory and Experiment,” American Helicopter Society 63rd Annual Forum, May 2007.

Schmitz, F. H., Greenwood, E., Sickenberger, R. D., Gopalan, G., Sim, B. W.-C., Conner, D. A., Morales, E., and Decker, W., “Measurement and Characterization of Helicopter Noise in Steady-State and Maneuvering Flight,” American Helicopter Society 63rd Annual Forum, May 2007.

Technical Reports

Watts, M. E., Greenwood, E., Smith, C. D., and Stephenson, J. H., “Noise Abatement Flight Test Data Report,” Technical Report TM-2019-XXXXXX, NASA Langley Research Center, in press.

Conner, D. A., Stephenson, J. H., Sim, B. W., Watts, M. E., Greenwood, E., and Smith, C. D., “Joint Eglin Acoustics Week 2013 Data Report,” Technical Report TM-2017-219681, NASA Langley Research Center, November 2017.

Boyd, D. D., Greenwood, E., Watts, M. E., and Lopes, L. V., “Examination of a Rotorcraft Noise Prediction Method and Comparison to Flight Test Data,” Technical Report TM-2017-219370, NASA Langley Research Center, January 2017.

Watts, M. E., Greenwood, E., Sim, B. W., Stephenson, J. H., and Smith, C. D., “Helicopter Acoustic Flight Test with Altitude Variation and Maneuvers,” Technical Report TM-2016-219354, NASA Langley Research Center, December 2016.

Watts, M. E., Greenwood, E., Smith, C. D., Snider, R., and Conner, D. A., “Maneuver Acoustic Flight Test of the Bell 430 Helicopter Data Report,” Technical Report TM-2014-218266, NASA Langley Research Center, May 2014.