David Joe Willis

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Education

- **Doctor of Philosophy, Aerodynamics**—June 2006
  Massachusetts Institute of Technology, Cambridge, MA
  - Department of Aeronautics and Astronautics
  - Thesis: An Unsteady, Accelerated, High Order Panel Method with Vortex Particle Wakes
  - Committee: J. Peraire (Supervisor), J.K. White (Supervisor), M. Drela

- **Master of Science**—February 2003
  Massachusetts Institute of Technology, Cambridge, MA
  - Department of Aeronautics and Astronautics
  - Thesis: A pFFT Accelerated, High Order Potential Flow Solver
  - Supervisors: J. Peraire, J.K. White

- **Bachelors of Engineering**—June 2000
  Carleton University, Ottawa, Canada
  - Department of Mechanical and Aerospace Engineering

Honors/Affiliations

- Recipient of a PGS-B Natural Sciences and Engineering Research Council of Canada Graduate Fellowship, accepted at MIT, 2004
- Senate Medal for Outstanding Academic Achievement, Carleton University, 2000
- Dean's Honour List 1996 - 2000
- Recipient of a PGS-A Natural Sciences and Engineering Research Council of Canada Graduate Fellowship, Declined, 2000
- Rolls-Royce Scholarship, Carleton University, 1999
- Faculty Scholarship, Carleton University, 1996-2000
- Commissioner's Commendation for exemplary professionalism in rescuing a private citizen, Canadian Coast Guard, 1999

Research Experience

- **Research Scientist**—June 2007 - Present
  Massachusetts Institute of Technology, Cambridge, MA
  - Ongoing development of multifidelity computational aero-elastic methods for the analysis of bio-inspired flapping flight
  - Examination of potential flow methods (eg: *HallOpt*: A wake only Hall approach, *FastAero*: A 3D accelerated panel method) as rapid analysis methods for bio-inspired flight
  - Ongoing computational analysis of bat flight using potential flow methods
  - Ongoing development of methods to accurately mesh wing surfaces from high speed stereo-video experiments of bat flight
  - Collaborators: J.Peraire, M. Drela, J.K. White, S. Swartz, K.S. Breuer, D. H. Laidlaw

- **Postdoctoral Research Associate**—July 2006 - June2007
  Joint Appointment: Massachusetts Institute of Technology, Cambridge, MA and Brown University, Providence, RI
  - Ongoing development of multifidelity computational aero-elastic methods for the analysis of bio-inspired flapping flight
  - Examination of potential flow methods (eg: *HallOpt*: A wake only Hall approach, *FastAero*: A 3D accelerated panel method) as rapid analysis methods for bio-inspired flight
  - Ongoing computational analysis of bat flight using potential flow methods
  - Ongoing development of methods to accurately mesh wing surfaces from high speed stereo-video experiments of bat flight
  - Collaborators: J.Peraire, M. Drela, J.K. White, S. Swartz, K.S. Breuer, D. H. Laidlaw

- **Research Assistant**—January 2001 - June 2006
  Massachusetts Institute of Technology, Cambridge, MA
  - Developed *FastAero*: An accelerated, high order boundary element method for unsteady potential flow aerodynamics
  - Examination of automatic wake generation strategies for unsteady potential flows
  - Supervisors: J. Peraire, J.K.White

Research Interests

- Biologically-inspired low- and moderate- Reynolds number flapping propulsion and flight
- Optimization of passive fluid-structure interactions for minimum power flapping propulsion and flight
- Migratory flight, ground effect flight and other biologically inspired energy saving strategies
- Development of rapid computational prototyping and simulation algorithms and tools for unsteady fluid dynamics and aero-elastic design and analysis
- Accelerated, high order boundary element methods for aerodynamics and hydrodynamics
- Machine vision and image processing for scientific kinematical analysis
- UAV and MAV platforms
- Future Directions: sustainable wind energy for developing nations, gender and culture in engineering education, CFD for body-free surface interactions

Teaching Experience

- **Teaching Assistant: Numerical Methods for Partial Differential Equations**—February 2005 - May 2005
  Massachusetts Institute of Technology, Cambridge, MA
  - Numerical methods for PDE's course for graduate students
  - Assisted with the development and grading of homework problem sets
  - Presented weekly recitations and office hours

- **Teaching Assistant: Numerical Methods for Partial Differential Equations**—February 2002 - May 2002
  Singapore-MIT Alliance: Massachusetts Institute of Technology, Cambridge, MA
  - Numerical methods for PDE's course for graduate students
  - Assisted with the development and grading of homework problem sets
  - Presented weekly recitations and office hours

  - Interacted over the internet with students in Singapore to address course questions

- **Teaching Assistant: Human Factors Engineering**—September 2000 - December 2000
  Massachusetts Institute of Technology, Cambridge, MA
  - Assisted with the development of laboratory exercises
  - Managed and monitored laboratory experiments
  - Graded student homework problem sets

- **Individual Class Lectures**—2005-2006
  Brown University, Providence, RI
  - **EN-186: Advanced Fluid Dynamics Class (Prof. K.S.Breuer)**
  - 3 Class lectures on potential flow theory (Fall 2006)
  - 1 Class lecture on Modern Panel Methods (Fall 2005)
  - **CS-137: Visualization in Science (Profs. D.Laidlaw, S.Swartz, D.Fritz)**
  - 1 Class lecutre on Introductory Classical Aerodynamics

- **Student Intern/Observer**—February 2004-May 2004
  Museum of Science, Boston, MA
  - Practical component of an education course
  - Observation of hands on engineering activities
  - Assisted museum employees with engineering based activities for visitors
  - Informally observed parent-child gender interactions

- **Math and Science Tutor**—September 2002 - May 2003
  Boston Chinatown Neighborhood Center, Boston, MA
  - Volunteer after school mathematics and science tutor for students aged 10-12
  - Evaluated student's development and wrote progress reports

- **Freelance Language Tutor**—September 2003 - May 2004
  Boston, MA
  - Tutored a Korean adult in English communications including conversation, essay writing, and grammar skills

- **MIT's 2004 SPLASH Weekend Instructor**—Spring 2004
  Massachusetts Institute of Technology, Cambridge, MA
  - Gave a 2-hour instructional seminar on Introductory Aerodynamics
  - Gave a 2-hour instructional seminar on Sports Aerodynamics

- **Textbook Typesetter**—June 1999 - August 1999
  Carleton University, Ottawa, ON, Canada
  - Typesetter for Mathematics Textbook on Introductory Calculus
  - Responsible for typesetting two chapters of a calculus textbook in LaTeX

Teaching Interests

- Instructional Courses of Interest: Theoretical and Computational Aerodynamics, Incompressible and Compressible Fluid Mechanics, Numerical Methods for Engineers

Conference Papers and Journal Publications

- **D.J.Willis**, J.K.White and J.Peraire, *A pFFT Accelerated Linear Strength BEM Potential Solver*, presented at MSM '04 7th Int. Conf. on Modeling and Simulation of Microsystems, March 7-11, 2004, Boston, MA.
- **D. J. Willis**, J. White and J. Peraire, *A pFFT Accelerated BEM Linear Strength Potential Solver*, Proceedings of 5th International symposium on computational technologies for fluid/thermal/stress systems with industrial applications, CFD for design and optimization, San Diego, 2004.
- **D.J.Willis**, J.Peraire and J.K.White, *FastAero - a Precorrected FFT - Fast Multipole Tree Steady and Unsteady Potential Flow Solver*, presented at SMA Symposium, Singapore 2005.
- **D.J.Willis**, J.Peraire and J.K.White, *A Combined pFFT-Multipole Tree Code, Unsteady Panel Method with Vortex Particle Wakes*, Proceedings of the 43rd AIAA Aerospace Science Meeting, AIAA Paper 2005-0854, Reno, NV, Jan. 2005.
- **D.J.Willis**, J.Peraire and J.K.White, *A Combined pFFT-Multipole Tree Code, Unsteady Panel Method with Vortex Particle Wakes*, Int. J. Numer. Meth. Fluids, October 2005
- **D.J.Willis**, J.Peraire, and J.K.White, *A Quadratic Basis Function, Quadratic Geometry, High Order Panel Method*, Proceedings of the 44th AIAA Aerospace Sciences Meeting, AIAA-2006-1253, Reno, Nevada, 2006.
- C.J.Sequeira, **D.J.Willis**, and J.Peraire, *Comparing Aerodynamic Models for Numerical Simulation of Dynamics and Control of Aircraft*, Proceedings of the 44th AIAA Aerospace Sciences Meeting, AIAA-2006-1254, Reno, Nevada, 2006.
- **D.J.Willis**, J.Peraire, M.Drela and J.K.White, *A Numerical Exploration of Parameter Dependence in Power Optimal Flapping Flight*, Proceedings of the 24th Applied Aerodynamics Conference, AIAA-2006-2994, San Francisco, California, 2006.
- Swartz S., Diaz J., Riskin D.K., Song A., Tian X., **Willis, D.J.**, and Breuer, K.S. *Wing Structure and the Aerodynamic Basis of Flight in Bats*, Proceedings of the 45th AIAA Aerospace Science Meeting, Reno NV. Jan 2007.
- **D. J. Willis**, K.S.Breuer, J. Peraire. *A Computational Investigation of Bio-Inspired Formation Flight and Ground Effect.* Proceedings of the 25th AIAA Applied Aerodynamics Conference, Miami, FL, 2007.
- **D. J. Willis**, P.-O.Persson, M.Drela, K.S.Breuer, S.M.Swartz, J. Peraire. *A Computational Framework for Fluid Structure Interaction in Biologically-Inspired Flapping Flight*, Proceedings of the 25th AIAA Applied Aerodynamics Conference, Miami, FL, 2007.
- J. P. Bardhan, M. D. Altman, **D. J. Willis**, S. M. Lippow, B. Tidor and J. K. White. *Numerical Integration Techniques for Curved-Element Discretizations of Molecule-Solvent Interfaces.*, Journal of Chemical Physics, 127, 014701, 2007.

Conference and Journal Papers in Submission and Pending

- A. Forsberg, J. Chen, M. Kostandov, **D. Willis**, D.H.Laidlaw, *The Effect of Using Large, High Resolution Stereoscopic Displays for Flow Visualization (sap 0583)*, submitted to SIGGRAPH 2007.
- Riskin, D.K., **Willis, D.J.**, Diaz, J.-I., Hedrick, T.L., Kostandov, M., Chen, J., Laidlaw, D.H., Breuer K.S., and Swartz, S.M., *Proper Othogonal Decomposition as a toll for analyzing the omplex kinematics of bat flight*, submitted, July 2007.
- **Willis, D.J.**, Kostandov, M., Riskin, D. K., Laidlaw, D.H., Breuer K.S., and Swartz, S.M., *Modelling the Flight of a Bat*, submitted to the 2007 NSF-Science Magazine Visualization Challenge, May 2007.

Conference Abstracts and Presentations

- **D.J.Willis**, J.Peraire, M. Drela, and J.K.White, *A Computational Framework for Investigating Parameter Dependence in Flapping Flight*, presented at 7th World Congress on Computational Mechanics, Los Angeles, 2006.

- **D.J.Willis**, P.-O. Persson, J.Peraire and K.S.Breuer, *Parametric Dependencies in Aero-Elastic, Articulated, Flapping Flight*, presented at the American Physical Society, 59th Annual Meeting of the DFD, Tampa, FL, 2006.
- **D.J.Willis**, P.-O. Persson, M.Drela, J.Peraire and K.S.Breuer, *A Multifidelity Framework for Modeling Biologically Inspired Flapping Flight*, presented at the 14th International Conference for Finite Elements in Flow Problems, Santa Fe, NM, 2007.
- **D.J.Willis**, E.Israeli, P.-O. Persson, M.Drela, J.Peraire and K.S.Breuer, *Examining the exploitation of passive structural compliance in flapping wings*, presented at the 4th Massachusetts Institute of Technology Conference on Fluid and Solid Mechanics, 2007.

Leadership and Non-Research Employment Experience

- **Coxswain, Inshore Rescue Boat Program**—Summer 1999 and Summer 2000
  Canadian Coast Guard, Halifax, NS, Canada
  - Canadian Coast Guard IRB Coxswain Leadership Training
  - Leader of an inshore rescue boat team during rescue operations including:
  - *medical evacuations*
  - *search for survivors*
  - *man-overboard operations*
  - *towing disabled vessels*
  - *general water safety instruction and education*

- **Deckhand, Inshore Rescue Boat Program**—Summer 1997 and Summer 1998
  Canadian Coast Guard, Halifax, NS, Canada
  - Deckhand of an inshore rescue boat team during rescue operations
  - Fast Rescue Craft Operation Training

- **President of the MIT Triathlon Club**—June 2002-August 2003
  Cambridge, MA
  - Second President and Founding Member of the MIT Triathlon Club
  - Promoted strategies for increasing club membership
  - Led funding acquisition and sponsorship solicitation activities