

IAN A. WAITZ

Jerome C. Hunsaker Professor and Department Head
Department of Aeronautics and Astronautics
Massachusetts Institute of Technology

Building 33, Room 207
77 Massachusetts Avenue, Cambridge, Massachusetts 02139
(617) 253-0218, iaw@mit.edu
<http://web.mit.edu/aeroastro/www/people/waitz/>

Born January 25, 1964, Ann Arbor, Michigan
U. S. Citizen

Education:

Ph. D.	1991	Aeronautics, California Institute of Technology
M. S.	1988	Aeronautics, George Washington University
B. S.	1986	Aerospace Engineering, The Pennsylvania State University

History of MIT Appointments:

Charles Stark Draper Assistant Professor	July 1991	October 1991
Rockwell International Assistant Professor	November 1991	November 1994
Assistant Professor	December 1994	June 1997
Associate Professor w/o tenure	July 1997	June 1998
Associate Professor with tenure	July 1998	June 2001
Full Professor	July 2001	present
Associate Head, Aero and Astro	August 2002	December 2003
Deputy Head, Aero and Astro	January 2003	June 2005
Department Head, Aero and Astro	February 2008	present

Overview:

Ian A. Waitz is the Jerome C. Hunsaker Professor and Head of the [Department of Aeronautics and Astronautics](#) at MIT. He is also the Director of the Partnership for AiR Transportation Noise and Emissions Reduction ([PARTNER](#)), an FAA/NASA/Transport Canada-sponsored Center of Excellence. His principal areas of interest are the modeling and evaluation of climate, local air quality and noise impacts of aviation, including the assessment of technological, operational and policy options for mitigating these impacts. He has written approximately 75 technical publications including a [report to the U.S. Congress on aviation and the environment](#), holds three patents and has consulted for many organizations. He has served as an associate editor of the *AIAA Journal of Propulsion and Power*. In 2003 Professor Waitz received a

IAN A. WAITZ

NASA Turning Goals Into Reality Award for Noise Reduction. He was awarded the FAA 2007 Excellence in Aviation Research Award. He is a Fellow of the AIAA, and an ASME and ASEE member. He teaches graduate and undergraduate courses in the fields of thermodynamics and energy conversion, propulsion, and experimental projects. He was honored with the [2002 MIT Class of 1960 Innovation in Education Award](#) and appointment as an [MIT MacVicar Faculty Fellow](#) in 2003.

Teaching Experience:

Environmental Aerospace Engineering. Developed to address the growing impact of environmental concerns on aerospace systems. Concentration on aircraft emissions and noise is set within a broad contextual backdrop, including discussions of ethics, regulatory measures, environmental assessment, global change, economics, urban planning, and policy.

Aircraft Propulsion and Gas Turbines Graduate level course devoted to performance and characteristics of aircraft engines and industrial gas turbines as determined by the thermodynamic and fluid mechanic behavior of components: inlets, compressors, combustors, turbines and nozzles.

Internal Flows in Turbomachines. Advanced graduate level course covering concepts of rotational flows, inherent unsteadiness of turbomachines, boundary layers, and wakes and losses in turbomachines.

Thermal Engineering: Junior level undergraduate course in thermodynamics and heat transfer.

Experimental Projects I and II. Selection and detailed planning of an individual research project during the first semester, is followed by construction and experimentation during the second semester. Formal written and oral presentations are made by each of the students.

Unified Engineering. Sophomore level undergraduate course presents the fundamentals of solid mechanics, fluid mechanics, dynamics, thermodynamics and propulsion, and forms the foundation for all other courses taught by the department. The course is the equivalent of four semester-long courses, and is cooperatively taught over the period of a year by several faculty.

Research Interests:

Aviation Environmental Portfolio Management Tool: Working with an international team of researchers under FAA sponsorship to develop an aviation system environmental-economic model to better inform national and international policy-making. The model will enable better assessment of the interdependencies among aviation-related noise and emissions effects, and will provide comprehensive assessments of aviation environmental impacts under different technology, operations, policy, market and environmental scenarios. Participants include Georgia Institute of Technology, Harvard School of Public Health, BB&C, ICF, MVA, Vital Link Policy Analysis, MITRE, Volpe National Transportation Systems Center, and Wyle Laboratories. (Active)

Alternative Fuels for Aviation: Sponsored by FAA and DOD to explore the potential to reduce aviation environmental impacts via alternative fuels while taking into account the full lifecycle of these fuels. (Active)

IAN A. WAITZ

Impacts of Aircraft Emissions on Air Quality and Public Health: Working with researchers at Cambridge University, University of North Carolina, Boise State University, Harvard School of Public Health, Stanford University, and the University of Houston under FAA and other sponsorship to perform air quality simulations and health impacts assessments of aviation emissions. The work includes a study with FAA and EPA of U.S. air quality impacts in response to the Energy Policy Act of 2005, assessments of the impacts of low sulfur and alternative fuels, analyses of the global effects of cruise level emissions, and development of reduced order models for use in policy analyses. (Active)

Chemical and Microphysical Processes in the Turbine, Exhaust Nozzle, and Plume: To aid in assessing the atmospheric effects of current and future aircraft, working with Aerodyne Research Incorporated under FAA, NASA and DOD sponsorship to conduct numerical investigations of the chemistry and microphysics of primary pollutant species, short-lived radicals, and particulate matter, downstream of the combustor, in the turbine, exhaust nozzle, and plume. (Active)

Environmental Design Space: Working with researchers from the Georgia Institute of Technology Aerospace Systems Design Laboratory under FAA sponsorship to develop aircraft system-level tools for assessing tradeoffs and interdependencies among technological and operational strategies for minimizing noise, local air quality and climate change impacts of aircraft. (Inactive)

System for Assessing Global Aviation Emissions: Worked with researchers from the MIT International Center for Air Transportation and the Volpe National Transportation Systems Center through funding from the FAA to develop an internationally-accepted model for assessing emissions from aircraft (SAGE). (Inactive)

Operational Strategies for Contrail Mitigation: Used an aviation system model to assess the costs and benefits of aircraft trajectory and routing changes as a means to reduce contrail and aviation-induced cirrus cloudiness. (Inactive)

The Economic Value of Silence: Worked with researchers from Cambridge University on the Silent Aircraft Initiative to assess the impact of low noise technology and operational procedures on airline financial performance and regional economic performance. (Inactive)

Robust Aerothermodynamic Design of Gas Turbine Engines Worked with a group of researchers within the Gas Turbine Laboratory to develop methods for designing gas turbine cycles and components to minimize performance variability in response to operating and manufacturing variability. (Inactive)

Micro-Engines: Conducted experimental and numerical research in micro-scale combustion systems to support the development of a 1mm² inlet area micro-gas turbine generator using silicon microfabrication technology. (Inactive)

High Fuel-Air Ratio Combustor and Turbine Research: Conducted numerical and experimental work to understand unique reacting flow physics and heat transfer effects within very high temperature gas turbine cycles. (Inactive)

Reduction of turbomachinery fan noise: Numerical simulations and experiments to investigate the impact of various blade wake management strategies on rotor-stator interaction tone noise. (Inactive)

IAN A. WAITZ

Ejectors for jet noise reduction: Advanced mixer/ejector devices were studied both computationally and experimentally to provide insight into basic fluid mechanics and acoustics in an effort to develop design procedures for these devices. (Inactive)

Consulting:

9/91 - 11/92	California Institute of Technology, Pasadena, California Supersonic combustion, testing and analysis
3/93 - 1/95	PRC Inc., Mt. Laurel, New Jersey Internal flow design and analysis
7/94 - 3/95	Thermo Energy Systems Corporation, Waltham, Massachusetts Analysis of novel fluid-dynamic power generation scheme
11/94 - 3/95	Cummins Engine Company, Inc., Columbus, Indiana Analysis of gas-turbine technology trends for power generation markets
3/95 - 1/96	Visidyne, Inc., Burlington, Massachusetts Analysis of flow diagnostic techniques
1/96 – 10/98	General Electric, Aircraft Engines Group, Lynn, Massachusetts Gas turbine test facility evaluation
12/95 - 6/97	Allison Advanced Development Company, Indianapolis, Indiana Conducted wind-tunnel experiments
8/96-8/96	Volvo Aero, Trollhättan, Sweden Professional development course
2/96-3/96	Rasor Associates, Inc., Sunnyvale, California Evaluation of combustion process
12/96 - 2/97	CFD Research Corporation, Huntsville, Alabama Micro-combustion processes
8/27-9/27	Russell & DuMoulin, Vancouver B.C., Canada Aircraft noise
3/95 - 5/98	Telectro-Mek, Inc., Fort Wayne, Indiana Development of thrust measuring systems for aircraft
2/96 – present	United Technologies Corporation, East Hartford, Connecticut Gas turbine combustion, noise and professional development courses
9/97 - 10/97	Deka Research and Development Corp., Manchester, New Hampshire Combustor design
10/97 – 2/00	Skadden, Arps, Slate, Meagher & Flom LLP, Los Angeles, CA Gas turbine combustion processes
3/98 – 9/98	WorkSmart Energy Enterprises, Inc., Chevy Chase, MD Evaluated the technical feasibility of utilizing company's invention to improve heat engine efficiency
8/98-5/04	U.S. Environmental Protection Agency

IAN A. WAITZ

	Aircraft technology for low emissions
4/99-9/02	Naval Facilities Engineering Service Center Pollution prevention technology development
10/99-6/02	Institute for Defense Analyses Defense Science Study Group
4/00-12/00	Universal Technology Corporation Joint Strike Fighter Independent Technical Review Team (Air Quality & Noise)
6/01-9/01	Tamarac, LLC Gas turbine durability
11/01-12/03	Meggitt Avionics, Inc. Engine diagnostics
5/02-12/02	U.S. General Accounting Office Aircraft emissions
8/02-12/02	Raytheon Missile Systems
8/02-present	Rolls-Royce, plc Chair, Environmental Advisory Board
9/02-1/04	Alstom Power, Inc Gas turbine design and performance
9/07-present	Wyle Laboratories Consultant for ACRP 02-06, Greenhouse Gas Emissions Inventories for Airports, and ACRP 02-09, Development Plan for a Multimodal Noise and Emissions Model
3/09 – 7/09	Pru Stevens, Barrister, Christchurch NZ Expert opinion on aircraft noise trends
11/08 – 9/09	Cambridge Systematics Contributions to 2009 DOT Report to Congress on Transportation's Role in Reducing U.S. Greenhouse Gas Emissions

Professional Activities:

Associate Editor, *AIAA Journal of Propulsion and Power*, 1996-99

AIAA Fellow (2005), Chair of Turbine Engine Committee 1996-98, AIAA Air-Breathing Propulsion Technical Committee 1995-1999

Member ASME Turbomachinery Committee

Member American Society of Engineering Education

Lead Author, United Nations Environment Programme, Intergovernmental Panel on Climate Change, Special Report on Aviation and the Global Atmosphere, 1999

Defense Sciences Study Group, Class of 2000-2001

IAN A. WAITZ

Joint Strike Fighter Independent Technical Review Team for Air Quality and Noise, 2000
NRC Committee on Aeronautics Research and Technology for Environmental Compatibility, 2000-2001
NASA Aircraft Engine Emissions Characterization and Inventory Committee, 2001-2003
NASA Quiet Aircraft Technology Technical Working Group, 2001-2003
Duke University Mechanical Engineering Undergraduate Advisory Board, 2001-present
Defense Science Board Task Force on B-52 Re-Engining, 2002
Member of U.S. Delegation to ICAO Committee on Aviation and Environment/6 (as an advisor), 2004
FAA National Particulate Roadmap, Impacts Team lead, 2004-present
Director of Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), an FAA/NASA/Transport Canada-sponsored Center of Excellence, 2004-present
Director, Congressional Study on Long-Term Environmental Improvements for Aviation, 2004-2005
NRC Committee to Assess the Integrated Plan for a Next Generation Air Transportation System (JPDO), 2004-2005
National Academy of Engineering, Steering Committee for Technology for a Quieter America Study, Chair Cost-Benefit Analysis Subcommittee, 2006-present
Transportation Research Board/National Academy of Sciences Study on Transportation and Greenhouse Gas Reduction, Committee member, 2007-present

Honors and Awards:

Raymond L. Bisplinghoff Faculty Fellow	July 2000 – June 2003
MIT Class of 1960 Innovation in Education Award	2002
MIT MacVicar Faculty Fellow	2003 – present
NASA 2003 Turning Goals Into Reality Award For Noise Reduction	2003
Elected Fellow, AIAA	2006
FAA 2007 Excellence in Aviation Research Award	2007

Publications:

Combustion, Emissions, and Environmental Impacts

“Aircraft Impacts on Local and Regional Air Quality in the United States,” G. Ratliff, C. Sequeira, I. Waitz, M. Ohsfeldt, T. Thrasher, M. Graham, and T. Thompson,

IAN A. WAITZ

Partnership for AiR Transportation Noise And Emissions Reduction, Project 15 Final Report, PARTNER-COE-2009-002, www.partner.aero, October 2009.

“Near-Term Feasibility of Alternative Jet Fuels,” J. I. Hileman, D. S. Ortiz, J. T. Bartis, H.M. Wong, P. E. Donohoo, M. A. Weiss, and I. A. Waitz, jointly published by the RAND Corporation (TR544) and the Partnership for AiR Transportation Noise and Emissions Reduction, www.partner.aero, October 2009.

Transportation in a Climate-Constrained World, A. Schafer, J. Heywood, H. Jacoby, and I. Waitz, *MIT Press*, June 2009.

“The Other Climate Threat: Transportation,” A. Schäfer, H. D. Jacoby, J. B. Heywood, and I. A. Waitz, *The American Scientist*, Volume 97, 2009.

“A Methodology for Integrated Conceptual Design of Aircraft Configuration and Operation to Reduce Environmental Impact,” A. March, I. Waitz, and K. Willcox, *AIAA-2009-7026*, 9th AIAA Aviation Technology, Integration, and Operations Conference (ATIO), 21-23 September, 2009, Hilton Head, South Carolina.

“Transport Impacts on Atmosphere and Climate: Metrics,” J.S. Fuglestvedt, K. P. Shine, T. Berntsen, D. S. Lee, R. Sausen, A. Stenke, R. B. Skeie, G. J. M. Velders, and I. A. Waitz, *Atmospheric Environment*, [doi:10.1016/j.atmosenv.2009.04.044](https://doi.org/10.1016/j.atmosenv.2009.04.044), 2009.

“Air Transport and the Environment,” K. Marias and I. A. Waitz, chapter in *The Global Airline Industry*, Edited by P. Belobaba, A. Odoni, and C. Barnhart, John Wiley & Sons, April 2009

“Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories,” B. Kim, I. A. Waitz, M. Vigilante, and R. Bassarab, *Airport Cooperative Research Program Report Number 11*, Transportation Research Board, 2009

“Summarizing and Interpreting Aircraft Gaseous and Particulate Emissions Data,” P. D. Whitefield, P. Lobo, D. E. Hagen, M. T. Timko, R. C. Miake-Lye, C. Taylor, G. Ratliff, S. Lukachko, C. Sequeira, J. Hileman, I. A. Waitz, S. Webb, T. G. Thrasher, M. R. Ohsfeldt, H. K. Kaing, and S. C. Essama, *Airport Cooperative Research Program Report Number 9*, Transportation Research Board, 2008.

“Assessment of the Impact of Reduced Vertical Separation Minimum (RVSM) on Aircraft-Related Fuel Burn and Emissions for the Domestic United States,” A. Malwitz, S. Balasubramanian, G. Fleming, T. Yoder and I. A. Waitz, *AIAA J. of Aircraft*, Volume 46, Number 1, Jan.-Feb., 2009.

“Microphysical Modeling of Ground-Level Aircraft-Emitted Aerosol Formation: Roles of Sulfur-Containing Species,” H.-W. Wong, P. E. Yelvington, M. T. Timko, T. B. Onasch and R. C. Miake-Lye, J. Zhang and I. A. Waitz, *AIAA Journal of Propulsion and Power*, Vol. 24, No. 3, May-June 2008, pp. 590-602.

“Assessing the Impact of Aviation on Climate,” K. Marais, S. P. Lukachko, M. Jun, A. Mahashabde, and I. A. Waitz, *Meteorologische Zeitschrift*, April 2008

“System for assessing Aviation’s Global Emissions (SAGE): Part 1, Model Description and Inventory Results,” B. Y. Kim, G. G. Fleming, J. J. Lee, I. A. Waitz, J-P. Clarke, S. Balasubramanian, A. Malwitz, K. Klima, M. Locke, C. A. Holsclaw, L. Q. Maurice and M. L. Gupta, *Transportation Research, Part D*, Vol 12, pp. 325-346, 2007.

IAN A. WAITZ

“System for assessing Aviation’s Global Emissions (SAGE): Part 2, Uncertainty Assessment,” J. J. Lee, I. A. Waitz, B. Y. Kim, G. G. Fleming, L. Q. Maurice and C. A. Holsclaw, *Transportation Research, Part D*, Vol 12, pp. 381-395, 2007

“A Comparison of Two Methods for Predicting Emissions from Aircraft Gas Turbine Combustors,” D. L. Allaire, I. A. Waitz, K. E. Willcox, GT2007-28346, *Proceedings of the ASME Turbo Expo 2007: Power for Land, Sea and Air*, May 14-17, 2007

"The evolution of carbonaceous aerosol and aerosol precursor emissions through a gas turbine engine," K. Brundish, A. Clague, C. Wilson, R. C. Miake-Lye, R. Brown, J. Wormhoudt, S. P. Lukachko, A. Chobot, C Yam, I. Waitz, D. Hagen, P. D. Whitefield, *AIAA Journal of Propulsion and Power*, Volume 23, Number 5, September-October, 2007.

“Impact of Manufacturing Variability on Combustor Liner Durability,” S.D. Bradshaw and I. A. Waitz, GT2006-91098, Proceedings of the ASME Turbo Expo, May 2006, *ASME J. of Engineering for Gas Turbines and Power*, Volume 131, Issue 3, May 2009.

“Aviation and the Environment: A National Vision Statement, Framework for Goals and Recommended Actions,” I. A. Waitz, J. Townsend, J. Cutcher-Gershenfeld, E. M. Greitzer and J. L. Kerrebrock, *Report to the United States Congress*, on behalf of the U.S. DOT, FAA and NASA, December 2004 (delivered to Congress January 2006).

"Water Injection: Could it Reduce Airplane Maintenance Costs and Airport Emissions?" D. L. Daggett, R. C. Hendricks, A. Mahashabde and I. A. Waitz, ISABE-2005-1249, *17th International Symposium on Airbreathing Engines*, Munich, Germany, September 4-9, 2005.

“Engine Design and Operational Impacts on Particulate Matter Precursor Emissions,” S. P. Lukachko, I. A. Waitz, R. C. Miake-Lye and R. C. Brown, GT2005-69112, Proceedings of the ASME Turbo Expo, June 2005, *Journal of Engineering for Gas Turbines and Power*, Vol 130, Issue 2, February 2008.

“Post Combustion Evolution of Soot Properties in an Aircraft Engine,” P. M. Dakhel, S. P. Lukachko, I. A. Waitz, R. C. Miake-Lye and R. C. Brown, GT2005-69113, Proceedings of the ASME Turbo Expo, June 2005, *AIAA Journal of Propulsion and Power*, Volume 23, Number 5, September-October, 2007.

"NO and NO2 Emissions Ratios Measured from in Use Commercial Aircraft During Taxi and Take-Off," S. C. Herdon, J. H. Shorter, M.S. Zahniser, D.D. Nelson, Jr., J. Wormhoudt, J. Jayne, R. C. Brown, R. C. Miake-Lye, I. A. Waitz, P. Silva, T. Lanni, K. Demerjian, and C. E. Kolb, *Environmental Science and Technology*, vol. 38, pp 6078-6084, American Chemical Society, 2004.

“Aviation Emissions and Abatement Policies in the United States: A City-Pair Analysis,” S. Jamin, A. Schafer, M. E. Ben-Akiva, and I. A. Waitz, *Journal of Transportation Research, Part D*, Volume 9, No. 4, pp. 294-314, July, 2004.

“Gas Turbine Engine Durability Impacts of High Fuel-Air Ratio Combustors: Near Wall Reaction Effects on Film-Cooled Backward-Facing Step Heat Transfer,” D. Milanes, D. R. Kirk, K. Fidkowski and I. A. Waitz, GT2004-53259, Proceedings of ASME Turbo Expo, June 2004, *Journal of Engineering for Gas Turbines and Power*, Volume 128, Issue 2, pp. 318-325, April, 2006.

IAN A. WAITZ

“Aircraft and Energy Use,” J. J. Lee, S. P. Lukachko and I. A. Waitz, invited chapter in *Encyclopedia of Energy*, by Academic Press/Elsevier Science, San Diego California, 2003

"Military Aviation and the Environment: Historical Trends and Comparison to Civil Aviation," I. A. Waitz, S. P. Lukachko, and J. J. Lee, AIAA-2003-2620, invited contribution to AIAA/ICAS International Air and Space Symposium and Exposition, Dayton, Ohio, July 14-17, 2003; *AIAA Journal of Aircraft*, vol.42 no.2 (pp 329-339) 2005.

“Historical Fuel Efficiency Characteristics of Regional Aircraft from Technological, Operational, and Cost Perspectives,” R. Babikian, S. P. Lukachko and I. A. Waitz, *Journal of Air Transport Management*, Volume 8, No. 6, pp. 389-400, Nov. 2002.

"Gas Turbine Engine Durability Impacts of High Fuel-Air Ratio Combustors. Part 1: Potential for Oxidation of Partially-Reacted Fuel," S. P. Lukachko, D. R. Kirk and I. A. Waitz, *GT-2002-30077*, Proceedings of ASME Turbo Expo, Amsterdam, The Netherlands, June 2002. *Journal of Engineering for Gas Turbines and Power*, Vol. 125, July 2003.

"Gas Turbine Engine Durability Impacts of High Fuel-Air Ratio Combustors. Part 2: Near-Wall Reaction Effects on Film-Cooled Heat Transfer," D. R. Kirk, G. R. Guenette, S. P. Lukachko and I. A. Waitz, *GT-2002-30182*, Proceedings of ASME Turbo Expo, Amsterdam, The Netherlands, June 2002. *Journal of Engineering for Gas Turbines and Power*, Vol. 125, July 2003.

“Historical and Future Trends in Aircraft Performance, Cost and Emissions,” Lee, J. J., Lukachko, S. P., Waitz, I. A., and Schafer, A., (invited contribution) *Annual Review of Energy and the Environment*, Volume 26, 2001.

“Mobility 2001”, Marks, D., et al., World Business Council for Sustainable Development, Switzerland, 2001.

“Aviation and Climate Change,” R.C. Miake-Lye, I.A. Waitz, D.W. Fahey, C.E. Kolb, H.L. Wesoky, and C.C. Wey, *Aerospace America*, September, 2000.

“Heterogeneous Reactions in Aircraft Gas Turbine Engines,” R.C. Brown, R. C. Miake-Lye, S. P. Lukachko and I. A. Waitz, *Geophysical Research Letters*, Vol. 29, No. 10, February, 2002.

“Turbine and Nozzle Effects on Emissions,” I. A. Waitz et al., Part 7 of Chapter 7 (Aircraft technology and relation to emissions) of Part 2 (Aviation technology and emissions mitigation) of UN sponsored Intergovernmental Panel on Climate Change (IPCC) Special Report on Aviation and the Global Atmosphere, 1999.

“Confined Swirling Flows with Heat Release and Mixing,” D. Underwood, I. A. Waitz, and E. M. Greitzer, *Journal of Propulsion and Power*, Volume 16, Number 2, March-April, 2000, pp. 169-177.

“Production of Sulfate Aerosol Precursors in the Turbine and Exhaust Nozzle of an Aircraft Engine,” S. P. Lukachko, I. A. Waitz, R. C. Miake-Lye, R. C. Brown, and M. A. Anderson, *Journal of Geophysical Research*, Volume 103, No. D13, July 10, 1998.

“Effects of Engine Aging on Aircraft NO_x Emissions,” S. P. Lukachko, I. A. Waitz, Paper 97-GT-386, ASME Turbo Expo, Orlando, Florida, June 2-5, 1997.

“Chemical Processes in the Turbine and Exhaust Nozzle,” S. P. Lukachko, I. A. Waitz, R. C. Miake-Lye, R. C. Brown, and M. R. Anderson, M. R., presented at the International

IAN A. WAITZ

Colloquium on the Impact of Aircraft Emissions upon the Atmosphere, Paris, France, October 15-18, 1996.

"Streamwise Vorticity Enhanced Mixing in a Reacting Shear Layer," D. S. Underwood, and I. A. Waitz, *AIAA Journal of Propulsion and Power*, Volume 12, No. 4, July-August, 1996.

"Investigation of a Contoured Wall Injector for Hypervelocity Mixing Augmentation", I. Waitz, F. Marble, and E. Zukoski, *AIAA Journal*, Vol. 31, no. 6, June 1993.

"Vorticity Generation by Contoured Wall Injectors", I. Waitz, F. Marble, and E. Zukoski, presented at the AIAA/SAE/ASME 28th Joint Propulsion Meeting, Nashville, Tennessee, July 6-8, 1992.

"A Systematic Experimental and Computational Investigation of a Class of Contoured Wall Fuel Injectors," I. Waitz, F. Marble, and E. Zukoski, AIAA 92-0625 presented at the AIAA 30th Aerospace Sciences Meeting, Reno, Nevada, January 6-9, 1992.

"Planar Rayleigh Scattering Results in Helium-Air Mixing Experiments in a Mach 6 Wind Tunnel," B. Shirinzadeh, I. A. Waitz, J. Balla, M. E. Hillard, J. B. Anders, and R. J. Exton *Applied Optics*, Vol. 31, No. 30, October, 1992.

"Shock Enhancement and Control of Hypersonic Mixing and Combustion", F. Marble, E. Zukoski, J. Jacobs, G. Hendricks, and I. Waitz, AIAA 90-1981, presented at the AIAA/SAE/ASME/ASEE 26th Joint Propulsion Conference, Orlando, Florida, July 16-18, 1990.

Aircraft Noise

"Challenges and Promises in Mitigating Transportation Noise," I. A. Waitz, R. J. Bernhard, C. E. Hanson, *The Bridge*, National Academy of Engineering, Vol. 37, Fall 2007.

"Assessment of Silent Aircraft-Enabled Regional Development and Airline Economics in the UK," R. Tam, P. Belobaba, K. R. Polenske, I. A. Waitz, *45th AIAA Aerospace Sciences Meeting and Exhibit*, 8 - 11 Jan 2007

"Trailing Edge Blowing for Reduction of Turbomachinery Fan Noise," J. M. Brookfield and I. A. Waitz, AIAA Paper 98-2321, 4th AIAA/CAES Aeroacoustics Conference, Toulouse, France, June 2-4, 1998, *AIAA Journal of Propulsion and Power*, Volume 16, Number 1, January-February 2000, pp.57-64

"Aeroacoustic Measurement of Transient Hot Nozzle Flows," D. R. Kirk, D. O. Creviston and I. A. Waitz, 5th AIAA/CAES Aeroacoustics Conference Proceedings, 1999, *AIAA Journal of Propulsion*, Volume 17, Number 4, July—August 2001, pp. 928-935.

"A Mixer-Ejector Noise-Suppressor Model," D. Tew, and I. Waitz, , AIAA Paper 97-1682, AIAA Aeroacoustics Conference Proceedings, May 1997, *AIAA Journal of Propulsion and Power*, Volume 14, No. 6, November-December 1998.

"Transient Testing Techniques for Jet Noise Measurements," J. M. Kerwin, I. A. Waitz, AIAA Paper 97-1684 , AIAA Aeroacoustics Conference Proceedings, May 1997.

"Impact of Compressibility on Mixing with Large-Scale Streamwise Vortices," D. Tew, and I. Waitz, AIAA Paper 97-2637, AIAA Joint Propulsion Conference, June 1997. *AIAA Journal* v. 42, Number 11, pp. 2393-2396, 2004.

IAN A. WAITZ

"Preliminary Assessment of Wake Management Strategies for Reduction of Turbomachinery Fan Noise," I. A. Waitz, J. M. Brookfield, J. Sell, and B. J. Hayden, CEAS/AIAA 95-102, *AIAA Journal of Propulsion and Power*, Volume 12, Number 4, July-August, 1996.

"The Role of Streamwise Vorticity in Compressible Mixing Downstream of Lobed Mixers," D. Tew, I. Waitz, J. Hermanson, and E. Greitzer, AIAA 95-2746, presented at the 31st AIAA/ASME/SAE/ASEE Joint Propulsion Conference, San Diego, CA, July 10-12, 1995.

Gas Turbine Engines

"Impact of Compressibility on Mixing Downstream of Lobed Mixers," D. E. Tew, J. C. Hermanson and I. A. Waitz," *AIAA Journal* v. 42, Number 11, pp. 2393-2396, 2004.

"Endwall Blockage in Axial Compressors," S. A. Khalid, A. S. Khalsa, I. A. Waitz, E. M. Greitzer, C. S. Tan, N. A. Cumpsty, J. Adamczyk, and F. E. Marble, ASME Turbo Expo, Stockholm, Sweden, June 1998, *ASME J. of Turbomachinery*, Vol. 121, No. 3, pp.499-511, July, 1999.

"Rotor Wake Decay: Effect of Swirl," J. M. Brookfield, I. A. Waitz, J. Sell," ASME Paper 96-GT- 495, ASME Turbo Expo, Orlando, Florida, June 2-5, 1997, and *AIAA Journal of Propulsion and Power*, Volume 14, No. 2, March-April, 1998.

"Enhanced Mixing with Streamwise Vorticity," I. A. Waitz, J. K. Elliot, A. K. S. Fung, J. M. Kerwin, J. K. Krasnodebski, M. N. O'Sullivan, Y. J. Qiu, D. E. Tew, E. M. Greitzer, F. E. Marble, C. S. Tan, and T. G. Tillman, *Progress in Aerospace Sciences*, Vol 33, Number 5/6, May/June 1997.

"A Computational Study of Viscous Effects on Lobed Mixer Flow Features and Performance," M. N. O'Sullivan, I. A. Waitz, E. M. Greitzer, C. S. Tan, and W. N. Dawes, *AIAA Journal of Propulsion and Power*, Volume 12, Number 2, March-April 1996.

"Vortices in Aero-Propulsion Systems", I. Waitz, E. Greitzer, and C. Tan, in *Fluid Vortices*, ed. S. Green, Kluwer Academic Publishing, 1994.

"Enhanced Mixing in Gas Turbine Propulsion Systems," I. A. Waitz, T. G. Tillman, D. C. McCormick, *Global Gas Turbine News*, International Gas Turbine Institute, August 1993.

Micro Heat Engines

"Microcombustors for Rotating Machinery," C. M. Spadaccini and I.A. Waitz, chapter in *Multi-Wafer Rotating MEMS Machines*, J.H. Lang (ed.), MEMS Reference Shelf, 445 DOI 10.1007/978-0-387-77747-4_9, C _ Springer Science+Business Media, LLC 2009

"Microcombustion," C. M. Spadaccini and I. A. Waitz, chapter in *Comprehensive Microsystems*, eds. Y. B. Gianchandani, O.Tabata, and H. Zappe, Elsevier, New York, NY, 2007

"Catalytic Combustion Systems for Micro-Scale Gas Turbine Engines," C. M. Spadaccini, J.-W. Peck, and I. A. Waitz, GT2005-68382, Proceedings of the ASME Turbo Expo, June 2005, *Journal of Engineering for Gas Turbines and Power*, Volume 129, Issue 1, pp. 49-60, January 2007.

IAN A. WAITZ

"High Power Density Silicon Combustion Systems for Micro Gas Turbine Engines," C. M. Spadaccini, A. Mehra, J. Lee, X. Zhang, S. Lukachko, and I. A. Waitz, *GT-2002-30082*, Proceedings of ASME Turbo Expo, Amsterdam, The Netherlands, June 2002. *Journal of Engineering for Gas Turbines and Power*, Vol. 125, July 2003.

"Development of a Catalytic Silicon Micro-Combustor for Hydrocarbon-fueled Power MEMS," C. M. Spadaccini, X. Zhang, C. P. Cadou, N. Miki, and I. A. Waitz, *Sensors and Actuators A* 103 (2003) 219–224.

"Igniters and temperature sensors for a micro-scale combustion system," Xin Zhang, Amit Mehra, Arturo A. Ayo'n, Ian A. Waitz, *Sensors and Actuators A* 103 (2003) 253–262

"Centimeter-Diameter Gas Turbine Generators for Compact Power," A.H. Epstein, S.A. Jacobson, Y. Gong, R. Khanna, J. Lang, H. Li, L. Liu, C. Livermore, H.-S. Moon, J. Protz, N. Savoulides, M. Schmidt, C. Spadaccini, M. Spearing, C.J. Teo, I. Waitz, D. Ward, *Proceedings of the 2003 Power & Energy Collaborative Technology Alliance Symposium*.

"Development of Polysilicon Igniters and Temperature Sensors for a Micro Gas Turbine Engine," X. Zhang, A. Mehra, A. A. Ayon, and I. A. Waitz, IEEE 15th International Micro Electro Mechanical Systems Conference, Las Vegas, Nevada, January 20-24, 2002.

"A 6-Wafer Combustion System for a Silicon Micro Gas Turbine Engine," Mehra, A., Zhang, X., Ayon, A., Waitz, I., and Schmidt, M., Spadaccini, C., *Journal of Microelectromechanical Systems*, Volume 9, Number 4, December 2000, pp.517-527.

"A Through-Wafer Electrical Interconnect for Multi-Level MEMS Devices," Mehra, A., Zhang, X., Ayon, A., Waitz, I., and Schmidt, M., *Journal of Vacuum Science & Technology B*, Volume 18, No. 5, September/October 2000.

"Combustion Tests in the Static Structure of a 6-Wafer Micro Gas Turbine Engine," A. Mehra, I. A. Waitz and M. A. Schmidt, 1999 Solid State Sensor and Actuator Workshop, June 2-4, 1999.

"Microfabrication of High-Temperature Silicon Devices Using Wafer Bonding and Deep Reactive Ion Etching," A. Mehra, A. A. Ayón, I. A. Waitz, and M. A. Schmidt, *Journal of Microelectromechanical Systems*, pp. 152-160, Volume 8, Number 2, June 1999.

"Development of a Hydrogen Combustor for a Microfabricated Gas Turbine Engine," A. Mehra and I. A. Waitz, 1998 Solid State Sensor and Actuator Workshop, Hilton Head Transducers Conference, June 2-4, 1998.

"Combustors for a Micro Gas Turbine Engines," I. A. Waitz, G. Gautam, Y.-S. Tzeng, (Invited paper) International Symposium on Micro-Electro-Mechanical Systems (MEMS), ASME 1996 International Engineering Congress and Exposition, 17-22 November, Atlanta, Georgia, 1996, *ASME Journal of Fluids Engineering*, Volume 120, March 1998.

"Power MEMS and Microengines", Epstein *et al.*, IEEE Transducers '97 Conference, Chicago, IL, June 1997.

"Micro-Heat Engines, Gas Turbines, and Rocket Engines - The MIT Microengine Project," Epstein *et al.*, AIAA Paper 97-1773, 28th AIAA Fluid Dynamics Conference, Snowmass, CO, June 29-July 2, 1997.

IAN A. WAITZ

Other Publications

“Integrated Teaching of Experimental and Communication Skills to Undergraduate Aerospace Engineering Students,” I. A. Waitz and E. C. Barrett, presented at the 1996 ASEE Annual Conference and Exposition, June 1996, *ASEE Journal of Engineering Education* July 1997.

"Experimental Investigation of Wing/Fuselage Integration Geometries",
M. Maughmer, D. Hallman, R. Ruszkowski, G. Chappel, and I. Waitz, *Journal of Aircraft*, Vol. 26, no. 6, August, 1989.

"Rotating Disk Transition Due to Isolated Roughness with Intense Acoustic Irradiation",
I. Waitz and S. Wilkinson, AIAA 88-3761, presented at the First National Fluid Dynamics Congress, Cincinnati, Ohio, July 24-28, 1988.

Patents:

“Reduction of Turbomachinery Noise”

I. A. Waitz, J. M. Brookfield, J. Sell, K. U. Ingard, and B. J. Hayden
U. S. Patent #6,004,095 issued December 21, 1999.

“Microturbomachinery”

A. H. Epstein, S. D. Senturia, I. A. Waitz, J. H. Lang, S. Jacobson, F. F. Ehrich,
M. A. Schmidt, G. K. Ananthasuresh, M. S. Spearing, K. S. Breuer, S. F. Nagle.
U. S. Patent #5,932,940 issued August 3, 1999.

"Microturbomachinery"

A. H. Epstein, S. D. Senturia, I. A. Waitz, J. H. Lang, S. Jacobson, F. F. Ehrich, M. A.
Schmidt, G. K. Ananthasuresh, M. S. Spearing, K. S. Breuer, and S. F. Nagle.
U. S. Patent #6,392,313 issued May 21, 2002.