

## **Brian M. Argrow**

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Director, Integrated Remote & In-Situ Sensing Systems Program (IRISS)

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### **RESEARCH**

Unmanned Aircraft Systems (UAS) design, operations, and applications; high-speed aerodynamics and gas dynamics

### **EDUCATION**

Ph.D., Aerospace Engineering, University of Oklahoma, 1989, NSF Fellow, GEM Fellow

M.S., Mechanical Engineering, University of Oklahoma, 1986

B.S. with distinction, Aerospace Engineering, University of Oklahoma, 1983

### **PROFESSIONAL EXPERIENCE**

- Schaden Leadership Professor and Chair, Ann and H.J. Smead Aerospace Engineering Sciences, 2017-present
  - Our students and faculty are pushing the limits of aeronautics and astronautics research, designing and building next generation unmanned aircraft, expanding the possibilities of remote sensing, and building space instruments and satellites for orbit around Earth and beyond. We are home to 58-tenure track, research, and instructional faculty, over 500 graduate students and 1000 undergraduates.
- Director, Integrated Remote & In Situ Sensing Initiative (IRISS), 2015-present
  - Along with Earth Lab, IRISS is a “co-pillar” of the CU Grand Challenges’ Our Space. Our Future. IRISS is leading the development of new sensing systems and strategies to gather previously unobtainable data that feeds science discovery.
- Co-Director Unmanned Aircraft System & Severe Storms Research Group (USSRG), 2014-present
  - USSRG is a consortium of public and private sector collaborators led by the University of Nebraska–Lincoln and the University of Colorado Boulder. USSRG aims to bring together collaborators from universities, federal laboratories, the private sector, and others who share a vision of bringing UAS to bear on the study of severe storms
- Associate Dean for Education, College of Engineering and Applied Science, 8/07-2/12
  - Provided vision and leadership for advancing the College at the forefront of engineering education with curriculum modernization, student programs, enhanced-learning initiatives, and program assessment
- Alfred and Betty Look Professor of Engineering, Department of Aerospace Engineering Sciences, University of Colorado, 7/06-6/12

- Founding Director (Emeritus), Research and Engineering Center for Unmanned Vehicles (RECUV), 1/04-6/12
  - RECUV is a university/government/industry partnership dedicated to the development and application of unmanned vehicle systems
- Associate Chair, Department of Aerospace Engineering Science, University of Colorado, 8/01-8/04
  - Led re-design of the AES senior projects courses, the final major revision for the AES Curriculum 2000. Created the annual AES Curriculum and Teaching Workshop
- Associate Professor, Aerospace Engineering Sciences, University of Colorado, 4/99-8/06
  - Named a 2000 President's Teaching Scholar, with lifetime guild appointment
- Assistant Professor, Aerospace Engineering Sciences, University of Colorado, 8/92-4/99
  - Co-led AES Curriculum 2000 development and implementation; introduced the Proactive Teaching and Learning model adopted for classroom teaching
- AFOSR Summer Faculty Researcher, Wright Lab, Wright-Patterson AFB, OH, 5/92-7/92
- Assistant Professor, School of Aerospace and Mechanical Engineering, University of Oklahoma, 5/89-8/92
- Instructor, School of Aerospace and Mechanical Engineering, University of Oklahoma, 8/86-5/89
- Tutor/Counselor, Minority Engineering Programs, University of Oklahoma, 8/82-8/88
- Member of the Technical Staff, Summer Intern, Fluid Mechanics Dept., The Aerospace Corp., El Segundo, CA, 1983 and 1984

## **REVIEW BOARDS AND PANELS**

- Defense Innovation Board Space Advisory Committee (2020-pres)
- National Academies of Sciences, Engineering, and Medicine Aeronautics and Space Engineering Board (2016-pres)
  - Executive Committee (2017-pres)
  - Committee on Assessing the Risks of Unmanned Aircraft Systems Integration (2017-18)
  - Committee on Aviation Safety Assurance (2017)
- ASTM Committee F38 on UAS; F38.02 Flight Operations (2014-2016)
- Chair, AIAA Unmanned Systems Program Committee (2009-2013)
- National Research Council Research Associates Review Panel (2012)
- NASA Advisory Council, Aeronautics Committee, UAS Subcommittee (2011-2013)
- NOAA ISETCSC Advisory Committee (2007-2010)
- USAF Scientific Advisory Board (2005-2009)
- NASA Academy of Program and Project Leadership, Management Operations Working Group (2003-2005)
- USAF Scientific Advisory Board (ad hoc member), UAV Study, Vehicles Panel (2003)

- NASA LaRC Peer Review Panel (Jan. 2003)
- Defense Science Study Group (IDA, DARPA) (1999–2001)
- NASA Advisory Council, Aeronautics and Space Transportation Technology Advisory Committee, Airframe Systems Subcommittee (1997-2000)
- Manufacturing Technology & Aerospace Proposal Review Panel, Texas Advanced Research/Advanced Technology Programs, Texas Higher Education Coordinating Board (1995-1997)

## **AWARDS**

2016 AIAA Fellow

2014 Center for STEM Learning Fellow

2011-12 University of Colorado Boulder Faculty Assembly Excellence in Service Award

2009 Department of the Air Force Exemplary Civilian Service Award

2007 University of Colorado Best Should Teach Award

2006 University of Colorado College of Engineering & Applied Science Max Peters Faculty Service Award

2003 University of Colorado Marinus Smith Award

2003 Subaru Teaching Spotlight Award

2000 University of Colorado President’s Teaching Scholar (lifetime guild appointment)

1996-1997 University of Colorado Boulder Faculty Assembly Excellence in Teaching Award

1996 University of Colorado College of Engineering & Applied Science Charles A. Hutchinson Teaching Award

1995 W. M. Keck Foundation’s Engineering Teaching Excellence Award

## **INDUSTRY BOARDS**

Founding Board of Directors, UAS Colorado (2014)

Founding Board of Directors, Rocky Mountain UAS, LLC (2013)

## **CONFERENCES AND WORKSHOP ORGANIZATION**

- Session Chair, Autonomous UAS Operations in High-Density Low-Altitude Urban Environments, AIAA Science and Technology Forum (SciTech), San Diego (Jan 7-11 2019).
- Chair, 3<sup>rd</sup> AUVSI/AIAA Workshop on Civilian Applications of Unmanned Aircraft Systems, AUVSI XPONENTIAL, Dallas, TX (May 2017).
- Organizing Committee and presenter for the NCAR / EOL Community Workshop on Unmanned Aircraft Systems for Atmospheric Research, 21-24 Feb 2017.
- Panel Organizer/Moderator, Integrated Remote & In Situ Sensing (IRISS) Initiative, CU’s “Our Space. Our Future.” Grand Challenges Event, Denver Museum of Nature and Science, Denver, CO (Sep 2015)
- Panel Organizer/Moderator, Small UAS in the Academic Setting, NASA UAS Traffic Management (UTM) Convention, NASA Ames Research Center, Moffett Field, CA (July 2015)

- Panel Organizer/Moderator, UAS Policy Issues, International Society for Atmospheric Research Using Remotely Piloted Aircraft (ISARRA), University of Oklahoma, Norman, OK, 2015 (May 2015)
- ISARRA 2015 Organizing Committee (May 2015)
- Chair and Panel Moderator, AUVSI/AIAA Second Workshop on Civilian Applications of Unmanned Aircraft Systems, Orlando, FL (May 2014)
- AUVSI Unmanned Systems 2014 Technical Committee (May 2014)
- Executive Steering Committee, AIAA AVIATION 2013 Conf., Los Angeles, CA (Aug 2013)
- Panel Organizer, Creating an Developing the Market for UAS, AIAA AVIATION 2013 Conf., Los Angeles, CA (Aug 2013)
- Technical Events Chair, 2012 AIAA Infotech@Aerospace Conf., St. Louis, Missouri (Jun 2012)
- Technical Events Chair, 2011 AIAA Infotech@Aerospace Conf., St. Louis, Missouri (Mar 2011)
- Moderator, Unmanned Air Systems: The Next Generations,” 48<sup>th</sup> AIAA Aerospace Sciences Meeting New Horizons Forum, Orlando, FL, Jan 2010.
- Chair IDGA UAV Workshop, Vienna, VA., (Apr 2010)
- Co-Chair, AUVSI/FAA Workshop on Best Practices for UAS Integration into the National Air Space, AUVSI North America Conference, Washington, D.C. (Aug 2009)
- Co-Chair, UAS Research Directions for the National Airspace System, Unmanned Unlimited Conference and Exhibit, Seattle, WA (Apr 2009)
- Co-Chair, NSF/AUVSI/FAA/DHS Workshop on UAS Research Directions for the National Air Space, AUVSI North America Conference, San Diego, CA (Jun 2008)
- Conference Co-Chair, Civilian Applications of Unmanned Aircraft Systems, Boulder, CO (Oct 2007)
- Technical Program Committee Infotech@Aerospace Conference, Washington, DC (2005)
- Technical Program Committee, Unmanned Unlimited Conference, Workshop, and Exhibit, Chicago (2004)
- Technical Program Co-Chair, 2<sup>nd</sup> Unmanned Unlimited Conference Systems Technologies, and Operations—Aerospace, Land, and Sea Conference, Workshop, and Exhibit, San Diego (2003)
- Technical Program Co-Chair, 1<sup>st</sup> Unmanned Aerospace Vehicles, Systems, Technologies, and Operations Conference and Workshop, Portsmouth, VA (2002)

## **PUBLICATIONS**

### **1. Archival Journal**

- 1.1. Roseman, C.A., Argrow, B.M., “Low-Speed DSMC Simulations of Hotwire Anemometers at High-Altitude Conditions,” *Fluids*, Vol. 6, 20.  
<https://doi.org/10.3390/fluids6010020> (2021).
- 1.2. Gijs de Boer; Constantin Diehl; Jamey Jacob; Adam Houston; Suzanne W. Smith; Phillip Chilson; David G. Schmale, III; Janet Intrieri; James Pinto; Jack Elston David

- Brus; Osku Kemppinen; Alex Clark; Dale Lawrence; Sean C. C. Bailey; Michael P. Sama; Amy Frazier; Christopher Crick; Victoria Natalie; Elizabeth Pillar-Little; Petra Klein; Sean Waugh; Julie K. Lundquist; Lindsay Barbieri; Stephan T. Kral; Anders A. Jensen; Cory Dixon; Steven Borenstein; Daniel Hesselius; Kathleen Human; Philip Hall; Brian Argrow; Troy Thornberry; Randy Wright; Jason T. Kelly, “Development of Community, Capabilities, and Understanding through Unmanned Aircraft-Based Atmospheric Research: The LAPSE-RATE Campaign,” *Bull. Amer. Meteor. Soc.* Vol. 101 (5), pp. E684–E699, <https://doi.org/10.1175/BAMS-D-19-0050.1> (2020).
- 1.3. Roseman, C. A. and Argrow, B. M., “Weather Hazard Risk Quantification for sUAS Safety Risk Management,” *Journal of Oceanic and Atmospheric Technology*, Vol. 37, pp. 1251-1268, <https://doi.org/10.1175/JTECH-D-20-0009.1> (2020).
  - 1.4. Eric W. Frew, Brian Argrow, Steve Borenstein, Sara Swenson, C. Alexander Hirst, Henno Havenga, Adam Houston, “Field observation of tornadic supercells by multiple autonomous fixed-wing unmanned aircraft,” *Journal of Field Robotics*, Vol. 37, pp. 1077-0193 <https://doi.org/10.1002/rob.21947> (2020).
  - 1.5. Nicholas S. Campbell and Brian M. Argrow, “Unsteady Heat Transfer for Pressure Vessels in Atmospheric Flight at Orbital Velocities,” *Journal of Thermophysics and Heat Transfer*; <https://doi.org/10.2514/1.T5767>, 25 Jul (2019).
  - 1.6. Gijs de Boer, Brian Argrow, John Cassano, Joseph Cione, Eric Frew, Dale Lawrence, Gary Wick, and Cory Wolff, “Advancing Unmanned Aerial Capabilities for Atmospheric Research,” *Bulletin of the American Meteorological Society*, Vol. 100, p. ES105-ES108; <https://doi.org/10.1175/BAMS-D-18-0254.1>, 9 Apr (2019).
  - 1.7. Roger Laurence, III and Brian M. Argrow, “Numerical Calibration of a Low-Speed sUAS Flush Air Data System,” *Journal of Oceanic and Atmospheric Technology*, Vol. 36, No. 8, pp. 1577-1590, doi: 10.1175/JTECH-D-18-0208.1 (2019).
  - 1.8. Sara Swenson, Brian Argrow, Eric Frew, Steve Borenstein, and Jason Keeler, “Development and Deployment of Air-Launched Drifters from Small UAS,” *Sensors*, Vol. 19, No. 9, p. 2149, doi: 10.3390/s19092149 (2019).
  - 1.9. Steven E. Koch, Martin Fengler, Phillip B. Chilson, Kimberly L. Elmore, Brian Argrow, David L. Andra Jr., and Todd Lindley, “On the Use of Unmanned Aircraft for Sampling Mesoscale Phenomena in the Preconvective Boundary Layer,” *Journal of Oceanic and Atmospheric Technology*, Vol. 35, No. 11, pp. 2265-2288, doi: 10.1175/JTECH-D-18-0101.1 (2018).
  - 1.10. Gijs de Boer, Mark Ivey, Beat Schmid, Dale Lawrence, Darielle Dexheimer, Fan Mei, John Hubbe, Albert Bendure, Jasper Hardesty, Matthew D. Shupe, Allison McComiskey, Hagen Telg, Carl Schmitt, Sergey Y. Matrosov, Ian Brooks, Jessie Creamean, Amy Solomon, David D. Turner, Christopher Williams, Maximilian Maahn, Brian Argrow, Scott Palo, Charles N. Long, Ru-Shan Gao, and James Mather, “A Bird’s-Eye View: Development of an Operational ARM Unmanned Aerial Capability for Atmospheric Research in Arctic Alaska,” *Bulletin of the American Meteorological Society*, Vol. 99, No. 6, pp. 1197-1212, doi:10.1175/BAMS-D-17-0156.1 (2018).
  - 1.11. Roger Laurence, III and Brian M. Argrow, “Development and Flight Test Results of a Small UAS Distributed Flush Airdata System,” *Journal of Atmospheric and Oceanic Technology*, Vol. 35, No. 5, pp. 1127-1120, doi: 10.1175/JTECH-D-17-0192.1 (2018).

- 1.12. Laurence III, R.J., Argrow, B.M., and Frew, E.W., “Wind Tunnel Results for a Distributed Flush Airdata System,” *Journal of Oceanic and Atmospheric Technology*, Vol. 34, No. 7, pp. 1519-1528, doi: 10.1175/JTECH-D-16-0242.1 (2017).
- 1.13. Houston, A.L., Laurence III, R.J., Nichols, T.W., Waugh, S., Argrow, B., and Ziegler, C.L., “Intercomparison of Unmanned Aircraftborne and Mobile Mesonet Atmospheric Sensors,” *Journal of Oceanic and Atmospheric Technology*, Vol. 33, pp. 1569-1582, doi: 10.1175/JTECH-D-15-0178.1 (2016).
- 1.14. de Boer, G., S. Palo, B. Argrow, G. LoDolce, J. Mack, R.-S. Gao, H. Telg, C. Trussel, J. Fromm, C.N. Long, G. Bland, J. Maslanik, B. Schmid, and T. Hock: “The Pilatus Unmanned Aircraft System for Lower Atmospheric Research,” *Atmospheric Measurement Techniques*, Vol. 9, 1845-1857, doi:10.5194/amt-9-1845-2016 (2016).
- 1.15. Jung, T. P., Starkey, R. P., and Argrow, B., “Modified Linear Theory Sonic Booms Compared to Experimental and Numerical Results,” *Journal of Aircraft*, Vol. 52, No. 6, pp. 1821-1837, doi: 10.2514/1.C033088 (2015).
- 1.16. Turansky, C. P., and Argrow, B. M., “Volumetric geometry for DSMC and the Voldipar code,” *Computers & Fluids*, Vol. 121, No. 8, pp. 114-132, doi: 10.1016/j.compfluid.2015.08.009 (2015).
- 1.17. Elston, J., Argrow, B., Stachura, M., Weibel, D., Lawrence, D., and Pope, D., “Overview of Small Fixed-Wing Unmanned Aircraft for Meteorological Sampling,” *Journal of Oceanic and Atmospheric Technology*, Vol. 32, 1, pp. 97-115, doi: 10.1175/JTECH-D-13-00236.1 (2015).
- 1.18. Turansky, C. P. and Argrow, B. M., “Nonlinear Dynamics of Objects in Transition Flow During Atmospheric Entry,” *Journal of Spacecraft and Rockets*, Vol. 51, No. 3, pp. 855-872, doi: 10.2514/1.A32604 (2014).
- 1.19. Turansky, C. P. and Argrow, B. M., “Rigid-Body Dynamics in Free-Molecular and Transition Flow,” *Journal of Spacecraft and Rockets*, Vol. 51, No. 1, pp. 239-252, doi: 10.2514/1.A32441 (2014).
- 1.20. Pilinski, M. D. and Argrow, B. M., “Aerodynamic Analysis Based on Challenging Minisatellite Payload Satellite Lift-to-Drag Measurements,” *Journal of Spacecraft and Rockets*, Vol. 50, No. 6, pp. 1162-1170, doi: 10.2514/1.A32394 (2013).
- 1.21. Pilinski, M. D., Argrow B. M., Palo, S. E., and Bowman, B. R., “Semi-Empirical Satellite Accommodation Model for Spherical and Randomly Tumbling Objects,” *Journal of Spacecraft and Rockets*, Vol. 50, 556-571, doi: 10.2514/1.A32348 (2013).
- 1.22. Jung, T. P., Starkey, R. P., and Argrow, B., “Lobe Balancing Design Method to Create Frozen Sonic Booms Using Aircraft Components,” *Journal of Aircraft*, Vol. 49, No. 6, pp. 1878-1893 (2012).
- 1.23. Roadman, J., Elston, J., Argrow, B., and Frew, E., “Mission Performance of the Tempest Unmanned Aircraft System in Supercell Storms,” *Journal of Aircraft*, Vol. 49, No. 6, pp. 1821-1830 (2012).
- 1.24. Jung, T. P., Starkey, R. P., and Argrow, B., “Methodology for Conducting Scaled Sonic Boom Flight Tests using Unmanned Aircraft Systems,” *Journal of Aircraft*, Vol. 49, No. 5, pp. 1234-1244 (2012).

- 1.25. Frew, E. W., Elston, J., Argrow, B., Houston, A, and Rasmussen, E., “Sampling Severe Local Storms and Related Phenomena,” *IEEE Robotics & Automation Magazine*, Vol. 19, 1, pp. 85-95 (2012).
- 1.26. Houston, A.L., Argrow, B., Elston, J., Lahowetz, J., Frew, E.W., and Kennedy, P. C., “The Collaborative Colorado–Nebraska Unmanned Aircraft System Experiment,” *Bulletin of the American Meteorological Society*, Vol. 93, No. 1, pp. 39-54 (2012). (cover article)
- 1.27. Elston, J., Argrow, B., Frew, E., Houston, A., and Straka, J., “Evaluation of Unmanned Aircraft Systems for Severe Storm Sampling using Hardware-in-the-Loop Simulations,” *Journal of Aerospace Computing, Information, and Communication*, **8**, No. 9, pp. 269-294 (2011).
- 1.28. Elston, J., Roadman, J., Stachura, M., Argrow, B., Houston, A., and Frew, E., “The Tempest Unmanned Aircraft System for In Situ Observations of Tornadoic Supercells: Design and VORTEX2 Flight Results,” *Journal of Field Robotics*, Vol. 28, No. 4, pp. 461-483 (2011).
- 1.29. Pilinski, M. D., K. Moe, Argrow B., Palo, S. E., “Measuring Absolute Thermospheric Densities and Accommodation Coefficients using Paddlewheel Satellites: Past Findings, Present Uses, and Future Mission Concepts,” *Advances in the Astronautical Sciences*, Vol. 58, No. 3, Jul-Sep, pp.531-549 (2011).
- 1.30. Pilinski, M., Argrow, B., and Palo, S., “Drag Coefficients of Satellites with Concave Geometries: Comparing Models and Observations,” *Journal of Spacecraft and Rockets*, **48**, No. 2, pp. 312-325 (2011).
- 1.31. Pilinski, M., Argrow, B., and Palo, S., “A Semi-Empirical Model for Satellite Energy-Accommodation Coefficients,” *Journal of Spacecraft and Rockets*, **47**, No. 6, pp. 266-272 (2010).
- 1.32. Argrow, B., Maute, K., Farhat, C., Nikbay, M., “F-function lobe balancing for sonic boom minimization,” *Computational Fluid Dynamics Journal*, **17**, No. 4, pp. 221-234 (2009).
- 1.33. Murphy, R. and Argrow, B., “UAS in the National Airspace System: Research Directions,” *Unmanned Systems*, **27**, No. 6, pp. 23-28 (2009).
- 1.34. Elston, J., Frew, E., Lawrence, D., Gray, P., and Argrow, B., “Net-Centric Communication and Control for a Heterogeneous Unmanned Aircraft System,” *Journal of Intelligent and Robotic Systems*, **56**, No. 1-2, pp. 199-232 (2009).
- 1.35. Argrow, B., Weatherhead, E., and Frew, E. W., “Real-Time Participant Feedback from the Symposium for Civilian Applications of Unmanned Aircraft Systems,” *Journal of Intelligent and Robotic Systems*, **54**, No. 1-3, pp. 87-103 (2009).
- 1.36. Maute, K., Farhat, C., Argrow, B., and Nikbay, M., “Sonic boom mitigation via shape optimization using an adjoint method and application to a supersonic jet aircraft,” *European Journal of Computational Mechanics*, **17**, 1-2, pp.217-243 (2008).
- 1.37. Frew, E., Dixon, C., Elston, J., Argrow, B., Brown, T., “Networked Communication, Command, and Control of an Unmanned Aircraft System,” *Journal of Aerospace Computing, Information, and Communication*, **5**, No. 4, pp 84-107 (2008).

- 1.38. Farhat, C., Maute, K., Argrow, B., and Nikbay, M., "Shape Optimization Methodology for Reducing the Sonic Boom Initial Pressure Rise," *AIAA Journal*, **45**, No. 5, 1007 (2007).
- 1.39. Guardone, A., Argrow, B., "Nonclassical gasdynamic region of selected fluorocarbons," *Physics of Fluids*, **17**, 116102 (2005).
- 1.40. Farhat, C., Argrow, B., Nikbay, M, and Maute, K., "Shape Optimization with F-Function Balancing for Reducing the Sonic Boom Initial Shock Pressure Rise," *International Journal of Aeroacoustics*, **3**, 361-378 (2004).
- 1.41. Guardone, A., Vigevano, L., and Argrow, B., "Assessment of thermodynamic models for dense gas dynamics," *Physics of Fluids*, **16**, 3878 (2004).
- 1.42. Ferguson, S., Guardone, A., and Argrow, B., "Construction and Validation of a Dense Gas Shock Tube," *J. Thermophysics and Heat Transfer*. **17**, 326 (2003).
- 1.43. Ferguson, S. H., Ho, T. L., Argrow, B. M., and Emanuel, G., "Theory for Producing a Single-Phase Rarefaction Shock Wave in a Shock Tube," *Journal Fluid Mechanics*, **445**, 37 (2001).
- 1.44. Brown, B. P. and Argrow, B. M., "Application of Bethe-Zel'dovich-Thompson Fluids in Organic Rankine Cycle Engines," *Journal of Propulsion and Power*, **16**, 1118 (2000).
- 1.45. Graves, R. E. and Argrow, B. M., "Bulk Viscosity: Past to Present," *J. Thermophysics and Heat Transfer*, **13**, 337 (1999).
- 1.46. Brown, B. P. and Argrow, B. M., "Characteristic Calculation of Equilibrium Flow in Minimum Length Nozzles," *Inverse Problems in Engineering*, **7**, 65 (1999).
- 1.47. Brown, B. P. and Argrow, B. M., "Nonclassical Dense Gas Flows for Simple Geometries," *AIAA Journal*, **36**, 1842 (1998).
- 1.48. Brown, B. P. and Argrow, B. M., "Two-Dimensional Shock Tube Flow for Dense Gases," *Journal Fluid Mechanics*, **349**, 95 (1997).
- 1.49. Argrow, B. M., "Computational Analysis of Shock Tube Flow for Dense Gases," *Shock Waves*, **6**, 241 (1996).
- 1.50. Aldo, A. C. and Argrow, B. M., "Dense Gas Flow in Minimum Length Nozzles," *Journal of Fluids Engineering*, **117**, 270 (1995).
- 1.51. Rohrs, H. W., Wickham-Jones, T., Ellison, G. B., Berry, D., and Argrow, B. M., "FTIR Absorption Spectroscopy of Jet-Cooled Radicals," *Review of Scientific Instruments*, **66**, 2430 (1995).
- 1.52. Emanuel, G. and Argrow, B. M., "Linear Dependence of Bulk Viscosity on Shock Wave Thickness," *Physics of Fluids*, **6**, 3203 (1994).
- 1.53. Argrow, B. M. and Cox, R. A., "A Quantitative, Second-Law Based Measure of Numerical Accuracy," *Thermodynamics and the Design, Analysis, and Improvement of Energy Systems*, AES-30/HTD-266, ASME, 49 (1993).
- 1.54. Cox, R. A., and Argrow, B. M., "Entropy Production in Finite-Difference Schemes," *AIAA Journal*, **31**, 210 (1993).
- 1.55. Borth, C. J. and Argrow, B. M., "Evaluation of Entropy Production and Numerical Entropy Change in Flowfield Solutions," *Second Law Analysis: Industrial and Environmental Applications*, AES-25/HTD-191, 101 (1991).



- 1.56. Argrow, B. M. and Emanuel, G. “Computational Analysis of the Transonic Flow Field of Two-Dimensional Minimum Length Nozzles,” *Journal of Fluids Engineering*, **113**, 479 (1989).
- 1.57. Argrow, B. M. and Emanuel, G., “Comparison of Minimum Length Nozzles,” *Journal of Fluids Engineering*, **110**, 283 (1988).
- 1.58. Argrow, B. M., Emanuel, G., and Rasmussen, M. L., “Entropy Production in General Nonsteady Coordinates,” *AIAA Journal*, **25**, 1629 (1987) (Errata, **27**, 986 (1989)).
- 2. Book Chapter, Encyclopedia, Editorial, and Review Articles**
- 2.1. Argrow, B. M., Educating Aerospace Leaders in the Ann and H.J. Smead Department of Aerospace Engineering Sciences,” *Colorado Business Review*, **87**, No. 2, pp. 11-13 (2021).
- 2.2. Argrow, B. M., “Opinion: The Hypersonics Workforce Puzzle,” *Aviation Week and Space Technology*, Jan 9, 2019 (<https://aviationweek.com/defense/opinion-hypersonics-workforce-puzzle>).
- 2.3. Argrow, B., “Chap. 9: Unmanned Aircraft System Design,” in **Introduction to Unmanned Aircraft Systems, 2<sup>nd</sup> Ed.**, Douglas M. Marshall, Richard K. Barnhart, Stephen B. Hottman, Eric Shappee, and Michael T. Most, Eds. CRC Press (2016).
- 2.4. Elston, J., Stachura, M., Dixon, C., Argrow, B., and Frew, E.W., “Chap. 34: A Layered Approach to Networked Command and Control of Complex UAS,” in **Handbook of Unmanned Aerial Vehicles**, Kimon P. Valavanis and George J. Vachtsevanos, Eds. Springer-Verlag, 2013.
- 2.5. Stachura, M., Elston, J., Argrow, B., Frew, E.W., and Dixon, C., “Chap. 90: Certification Strategy for Small Unmanned Aircraft Performing Nomadic Missions in the U.S. National Airspace System,” in **Handbook of Unmanned Aerial Vehicles**, Kimon P. Valavanis and George J. Vachtsevanos, Eds. Springer-Verlag, (2013).
- 2.6. Argrow, B., “Unmanned Aircraft Systems Operations in US Airspace,” in **Encyclopedia of Aerospace Engineering**, Eds. R. Blockley and W. Shyy, John Wiley: Chichester. DOI: 10.1002/9780470686652.eae460, Dec (2012).
- 2.7. Argrow, B., and Unmanned Systems Program Committee, “Year in Review: Unmanned Systems,” *Aerospace America*, **49**, No. 11, p. 74 (2011).
- 2.8. Argrow, B., Christiansen, R., Francis, M., “Year in Review: Unmanned Systems,” *Aerospace America*, **27**, No. 11, p. 73 (2009).
- 2.9. Brown, T., Argrow, B., Frew, E., Dixon, C., Hinkle, D., Elston, J., Gates, H., “Experiments Using Small Unmanned Aircraft to Augment a Mobile Ad Hoc Network,” **Emerging Technologies in Wireless LANs: Theory, Design, and Deployment**, Ed. B. Bing, Cambridge University Press, Chap. 33, pp. 695-717, (2008).
- 2.10. Argrow, B. M., “A Survey of Facilities for High-Temperature, High-Pressure Fluids Experiments,” Special Feature, *Measurement Science and Technology*, **16** (2005).

### 3. Conference Proceedings and Presentations

- 3.1. Christopher A. Roseman, Joseph L. Pointer, Brian M. Argrow and Dale A. Lawrence, "Experimental and Numerical Calibration of Hotwire Anemometers for the Study of Stratospheric Turbulence," AIAA Paper AIAA Scitech 2021 Forum, Virtual Event, Jan 2021.
- 3.2. Pol Mesalles Ripoll, Nicholas S. Campbell and Brian M. Argrow, "Aerothermodynamic Uncertainty in Lifting and Boost-Glide Entry Trajectories," AIAA Paper 2021-0934, Virtual Event, Jan 2021.
- 3.3. Argrow, B. M., "Nomadic Unmanned Aircraft Systems: A New Entrant into the National Airspace," AA&S 2020 Virtual Conference, Aug 2020 (presentation).
- 3.4. Mahon, A., Pointer, J. L., Lawrence, D., and Argrow, B., "A calibration system for low-velocity flows at stratospheric conditions," AIAA Paper 2020-2210, AIAA Aerospace Sciences Meeting, AIAA Scitech 2020 Forum, Orlando, FL, Jan 2020.
- 3.5. Gupta, A., Argrow, B., "Analytical Approach for Aero-Optical and Atmospheric Effects in Supersonic Flow Fields," AIAA Paper 2020-0684, AIAA Aerospace Sciences Meeting, AIAA Scitech 2020 Forum, Orlando, FL, Jan 2020.
- 3.6. Israelsen, B., Ahmed, N., Frew, E., Lawrence, D., Argrow, B., "Machine Self-confidence in Autonomous Systems via Meta-analysis of Decision Processes." ADVANCES IN ARTIFICIAL INTELLIGENCE, SOFTWARE AND SYSTEMS ENGINEERING (10th Int Conf on Appl Human Factors and Ergon (AHFE) / AHFE Int Conf Human Factors in Artificial Intelligence and Social Comp / AHFE Int Conf on Human Factors, Software, Serv and Syst Engn / AHFE Int Conf of Human Factors in Energy, July 24, 2019 - July 28, 2019). Ed.Ahram T: SPRINGER INTERNATIONAL PUBLISHING AG, January 01, 2020. 213-223.
- 3.7. Argrow, B. M., Frew, E., Borenstein, S., Houston, A., "In Situ Sensing in Tornadoic Supercells Using Small UAS," 2019 AGU Fall Meeting, San Francisco, Dec 2019. (presentation)
- 3.8. Thornberry, T. D., Gao, R., Watts, L. A., Ciciora, S. J., McLaughlin, R. J., Hepler Rosenlof, K., Argrow, B. M., Hesselius, D., Kochanski, A., Mandel, J., "The NightFOX Project: A Small UAS System for Wildfire Observations," 2019 AGU Fall Meeting, San Francisco, Dec 2019. (presentation)
- 3.9. Ranquist, E., Humbert, J., Argrow, B., "Distributed Acceleration Sensing for Small UAS Wind Gust Estimation." 99th Annual American Meteorological Society Meeting, Phoenix, AZ, January 20, 2019.
- 3.10. de Boer, G. J., Houston, A. L., Jacob, J. D., Pinto, J. O., Argrow, B., Chilson, P. B., Diehl, C., Elston, J., Intrieri, J., Lawrence, D. A., Lundquist, J. K., and Smith, Suzanne, "Lower Atmosphere Process Studies at Elevation: A Remotely Piloted Aircraft Team Experiment (LAPSE-RATE)," 99th American Meteorological Society Annual Meeting (poster)
- 3.11. Roseman, C. A., Argrow, B. M., and Pinto, J. O., "Targeted Weather Forecasts for Small Unmanned Aircraft Systems," 99th American Meteorological Society Annual

Meeting, 19th Conference on Aviation, Range, and Aerospace Meteorology, Phoenix, AZ, Jan 2019.

- 3.12. Lawrence III, R., Dunbar, G., Farnsworth, J., and Argrow, B., "Aircraft Geometry Effects on a Distributed Flush Airdata System, 2018 AIAA Aerospace Sciences Meeting, Kissimmee, FL, Jan 2018.
- 3.13. Koch, S., Chilson, P., Argrow, B., Fengler, M., Lindley, T., "On the Use of UAS for Prediction of Severe Convective Storm Initiation," 19th Symposium on Meteorological Observation and Instrumentation, Austin, TX, Jan 2018.
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- 3.17. Frew, E. W., Argrow, B., Houston, A., and Weiss, C. "Toward an Autonomous Airborne Scientist for Studying Severe Local Storms," AIAA Paper 2016-3580, AIAA Paper 8<sup>th</sup> AIAA Atmospheric and Space Environment Conference, AIAA AVIATION 2016, Washington, DC, Jun 2016.
- 3.18. Laurence, R. J., Argrow, B., Frew, E. W., "In-Situ Wind Sensing from Small UAS with Distributed Pressure Sensors, AIAA Paper 2016-4199, 8<sup>th</sup> AIAA Atmospheric and Space Environment Conference, AIAA AVIATION 2016, Washington, DC, Jun 2016.
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- 3.20. Lillard, A., Frew, E., Argrow, B., and Lawrence, D., "Assurances for Enhanced Trust in Autonomous Systems, AAAI Fall Symposium on Self-Confidence in Autonomous Systems, Arlington, VA, Nov 2015.
- 3.21. Laurence III, R.J., Elston, J.S., and Argrow, B.M., "Probeless Wind Sensing with Distributed Pressure Sensors," International Society for Atmospheric Research Using Remotely Piloted Aircraft (ISARRA), Norman, OK, May 2015.
- 3.22. Pope, D., Argrow, B., and Lawrence, D.A., "Optical Flow Techniques for Wind-Velocity Sensing on a Small Unmanned Aircraft System," AIAA SciTech Conference, Kissimmee, FL, Jan 2015.
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- 3.25. Nichols, T.W., Elston, J.S. and Argrow, B., "Analysis of the Accuracy of MEMS Magnetometers in Small UAS for use in State Estimation," AIAA SciTech Conference, Kissimmee, FL, Jan 2015.
- 3.26. Houston, A., Argrow, B., Frew, E., and Weiss, C., "The Application of UAS Towards Tornado Research and Forecasting," AGU Fall Meeting, San Francisco, CA, Dec 2014.
- 3.27. Frew, E., Argrow, B., Houston, A., and Weiss, C., "Initial Results from an Energy-Aware Airborne Dynamic, Data-Driven Application System Performing Sampling in Coherent Boundary-Layer Structures," AGU Fall Meeting, San Francisco, CA, Dec 2014.
- 3.28. Argrow, B., Frew, E., Houston, A., and Weiss, C., "Recent Advances in the Tempest UAS for In-Situ Measurements in Highly-Dynamic Environments," AGU Fall Meeting, San Francisco, CA, Dec 2014.
- 3.29. Laurence III, R., Nichols, T., Elston, J., and Argrow, B., "Validation of Supercell Wind and Thermodynamic Measurements from the Tempest UAS and a Mobile Mesonet," Proceedings of the AUUVSI Unmanned Systems 2014 Conference, Orlando, FL, May 2014.
- 3.30. Elston, J., Argrow, B., "Energy Efficient UAS Flight Planning for Characterizing Features of Supercell Thunderstorms," ICRA 2014 IEEE International Conference on Robotics and Automation, Jun 2014.
- 3.31. Chilson, P., Bonin, T., Meyer, N., Mack, J., Argrow, B. Newman, J., Muschinski, A., Root, L., Tichkule, S., Klein, P., Oncley, S., and Wolfe, D., "The role of UAS operations and data collection during an atmospheric boundary layer experiment in Colorado: Perspectives from the ground up, 2<sup>nd</sup> ISARRA Conference, Odense, Denmark, May 2014.
- 3.32. Elston, J. S., Argrow, B. M., and Stachura, M., "Covariance Analysis of Sensors for Wind Field Estimation by Small Unmanned Aircraft," 2<sup>nd</sup> ISARRA Conference, Odense, Denmark, May 2014.
- 3.33. Turansky, C.P. and Argrow, B.M., "Feasibility of Semi-Passive Surface Accommodation Control in Rarefied Flows," AIAA Paper 2013-4681, AIAA Atmospheric Flight Mechanics Conference, Boston, MA, Aug 2013.
- 3.34. Frew, E.W., Argrow, B., Lawrence, D., Elston, J., Stachura, M., "Unmanned Aircraft Systems for Communication and Atmospheric Sensing Missions," 2013 American Control Conference, Jun 2013.
- 3.35. Frew, E.W., Argrow, B., Houston, A., Weiss, C., and Elston, J., "An Energy-Aware Airborne Dynamic Data-Driven Application System for Persistent Sampling and Surveillance," International Conference on Computer Science, Jun 2013.
- 3.36. Stachura, M., Elston, J., Frew, E.W., Argrow, B., Brown, T.X., and Dixon, C., "Multi-UAS Testbed for Wireless Communication Experiments, ICRA 2013 Workshop

Towards Fully Decentralized Multi-Robot Systems: Hardware, Software and Integration,” May 2013.

- 3.37. Argrow, B.M., Louie, Knight, D.W, Canney, N.E., Brown, S., Blanford, A.J., Gibson, C.L., and Kenney, E.D., “Introduction to Engineering: Preparing First-year Students for an Informed Major Choice,” 119<sup>th</sup> ASEE Annual Conference & Expo, San Antonio, TX, Jun 2012.
- 3.38. Jung, T. P., Starkey, R. P., and Argrow, B. M., “Comparison of Sonic Booms from Modified Linear Theory to Flight Test Data,” 50<sup>th</sup> AIAA Aerospace Sciences Meeting, Nashville, TN, Jan 2012.
- 3.39. Starkey, R. P., Argrow, B. M., and Krevor, Z. C. “Design and Flight Testing of a 15% Dynamically Scaled HL-20 Vehicle Model,” 49<sup>th</sup> AIAA Aerospace Sciences Meeting, Nashville, TN, Jan 2012.
- 3.40. Argrow, B., Frew, E., Elston, J., Stachura, M., Roadman, J., Houston, A., and Lahowetz, J., “The Tempest UAS: The VORTEX2 Supercell Thunderstorm Penetrator,” Infotech@Aerospace 2011, St. Louis, MO, Mar 2011.
- 3.41. Elston, J., Stachura, M., Argrow, B., Frew, E., and Dixon, C., “Guidelines and Best Practices for FAA Certificate of Authorization Applications for Small Unmanned Aircraft,” Infotech@Aerospace 2011, St. Louis, MO, Mar 2011.
- 3.42. Jung, T., Starkey, R., and Argrow, B., “Survey Paper on Acoustic Advance Applied to Sonic Booms,” 4<sup>th</sup> AIAA Aerospace Sciences Meeting, Orlando, FL, Jan 2011.
- 3.43. Jung, T., Starkey, R., and Argrow, B., “Design Methods to Create Frozen Sonic Booms via Lobe Balancing using Aircraft Components,” 17<sup>th</sup> AIAA/CEAS Aeroacoustic Conference, Portland, OR, Jun 2011.
- 3.44. Jung, T., Starkey, R., and Argrow, B., “Feasibility Study of using a Small-Scale UAS for Sonic Boom Minimization Research, 49<sup>th</sup> AIAA Aerospace Sciences Meeting, Orlando, FL, Jan 2011.
- 3.45. Elston, J., Argrow, B., Houston, A., and Frew, E., “Design and Validation of a System for Targeted Observations of Pre-Tornadic Supercells Using Unmanned Aircraft,” In 2010 IEEE/RSJ International Conference on Intelligent Robots and Systems, Taipei, Taiwan, pp. 101-106, Oct 2010.
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- 3.48. Frew, E. W. and Argrow, B. M., “Embedded Reasoning for Atmospheric Science Using Unmanned Aircraft Systems.” In AAAI 2010 Spring Symposium on Embedded Reasoning: Intelligence in Embedded Systems, Palo Alto, CA, Mar 2010.

- 3.49. Elston, J., Argrow, B., Houston, A., and Lahowetz, J., "Distributed Atmospheric Sensing using Small UAS and Doppler Radar," AIAA Paper 2009-2023, Infotech@Aerospace & Unmanned Unlimited Conference, Seattle, WA, Apr 2009.
- 3.50. Houston, A., Argrow, B., Elston, J., and Lahowetz, J., "Unmanned Aircraft Observations of Airmass Boundaries: The Collaborative Colorado-Nebraska Unmanned Aircraft System Experiment," American Meteorological Society 24th Conference on Severe Local Storms, Savannah, GA, Oct 2008.
- 3.51. Argrow, B., Weatherhead, E., Frew, E., "Real-Time Participant Feedback from the Symposium for Civilian Applications of Unmanned Aircraft Systems, International Symposium on Unmanned Aerial Vehicles, Orlando, FL, Jun 2008.
- 3.52. Argrow, B., Houston, A., "UAS for In Situ Sensing of an Atmospheric Airmass Boundary," AIAA Infotech@Aerospace Conference and Exhibit, Rohnert Park, CA, May 2007.
- 3.53. Bateman, T., Nelson, J., Argrow, B., "A Low-Cost, Rapid Construction UA Design," AIAA Infotech @ Aerospace Conference and Exhibit, Rohnert Park, CA, May 2007.
- 3.54. Elston, J., Frew, E. W., and Argrow, B., "Networked UAV Communication, Command, and Control," AIAA Guidance, Navigation, and Control Conference, Keystone, CO, Aug 2006.
- 3.55. Argrow, B., "Cooperative Mobile Sensing Systems for In Situ Measurements in Hazardous Environments," AGU Fall Meeting, San Francisco, 5-9 Dec 2005. (Invited)
- 3.56. Elston, J., Argrow, B., and Frew, E., "A Distributed Avionics Package for Small UAVs," AIAA Paper 2005-6984, Infotech@Aerospace, Sep 2005.
- 3.57. Cory Dixon, Eric W. Frew, Brian Argrow. "Electronic Leashing of an Unmanned Aircraft to a Radio Source," 44th IEEE Conference on Decision and Control, Seville, Spain, pp. 3560-3565, Dec 2005.
- 3.58. Dixon, C., Frew, E., and Argrow, B., "Radio Leashing of an Unmanned Aircraft," AIAA Paper 2005-7030, Infotech@Aerospace, Sep 2005. (Invited)
- 3.59. Frew, E., Dixon, C., Argrow, B., and Brown, T., "Radio Source Location by a Cooperating UAV Team," AIAA Paper 2005-6903, Sep 2005.
- 3.60. Argrow, B., Rasmussen, E., and Lawrence, D., "UAV Systems for Sensor Dispersal, Telemetry, and Visualization in Hazardous Environments," AIAA Paper 2005-1237, 43<sup>rd</sup> AIAA Aerospace Sciences Meeting and Exhibit, Jan 2005.
- 3.61. Bateman, T., Argrow, B., Sheek, M., Hanft, J., Dean, A., and Blakeley, B., "USAS, A Stability Augmentation System," AIAA Paper 2004-6587, AIAA 3<sup>rd</sup> Unmanned Unlimited Technical Conference, Workshop and Exhibit, Sep 2004.
- 3.62. Brown, T., Argrow, B., Dixon, C., and Doshi, S., "Ad Hoc UAV Ground Network (AUGNet)," AIAA Paper 2004-6321, AIAA 3<sup>rd</sup> Unmanned Unlimited Technical Conference, Workshop and Exhibit, Sep 2004.

- 3.63. Argrow, B, Farhat, C., Maute, K., and Nikbay, M., "Linear-Theory-Based Shape Optimization for Sonic Boom Minimization," IUTAM Symposium Transsonicum IV, Göttingen, Germany, Sep 2002. (Invited)
- 3.64. Farhat, C., Argrow, B., Maute, K., and Nikbay, M., "A Shape Optimization Methodology with F-Function Lobe Balancing for Mitigating the Sonic Boom," AIAA Paper 2002-5551, 9th AIAA/ISSMO Symposium and Exhibit on Multidisciplinary Analysis and Optimization, Atlanta, GA, Sep 2002.
- 3.65. Argrow, B. M., "Proactive Teaching and Learning in the Aerospace Engineering Curriculum 2000," Proceedings of the ASEE Annual Conference and Exposition, Montreal, Jun 2002.
- 3.66. Argrow, B. and Curry, J., "Integration of UAV Senior Projects into the Curriculum 2000," AIAA Paper 2002-3485, 1<sup>st</sup> AIAA Unmanned Aerospace Vehicles, Systems, Technologies, and Operations Conference and Workshop, Portsmouth, VA, May 2002.
- 3.67. Dixon, C., Eheim, C., Argrow, B., and Palo, S., "Tornado Chaser: A Remotely Piloted UAV for In Situ Meteorological Measurements," AIAA Paper 2002-3479, 1<sup>st</sup> AIAA Unmanned Aerospace Vehicles, Systems, Technologies, and Operations Conference and Workshop, Portsmouth, VA, May 2002.
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- 3.69. Ferguson, S. H. and Argrow, B. M., "Simulation and Experimental Verification of Rarefaction Shock Waves in a Single-Phase Vapor," 23<sup>rd</sup> International Symposium on Shock Waves, Ft. Worth, TX, Jul 2001.
- 3.70. Ferguson, S. H. and Argrow, B. M., "Simulations of Nonclassical Dense Gas Dynamics," AIAA Paper 2001-2752, 35<sup>th</sup> AIAA Thermophysics Conference, Anaheim, CA, Jun 2001. (Invited).
- 3.71. Graves, R. E. and Argrow, B. M., "Aerodynamic Performance of an Osculating-Cones Waverider at High Altitudes," AIAA Paper 2001-2960, 35<sup>th</sup> AIAA Thermophysics Conference, Anaheim, CA, Jun 2001.
- 3.72. Brown, B. P. and Argrow, B. M., "Application of Bethe-Zel'dovich-Thompson Fluids in Organic Rankine Cycle Engines," AIAA Paper 99-0462, 37<sup>th</sup> AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan 1999.
- 3.73. Brown, B. P. and Argrow, B. M., "Nonclassical Dense Gas Flows for Simple Geometries," AIAA Paper 97-1881.
- 3.74. Seebass, A. R. and Argrow, B. M., "Sonic Boom Minimization Revisited," AIAA Paper 98-2956, 2<sup>nd</sup> AIAA Theoretical Fluid Mechanics Meeting, Albuquerque, NM, June 1998.
- 3.75. Graves, R. E. and Argrow, B. M., "Bulk Viscosity: Past to Present," AIAA Paper 98-2576, 7<sup>th</sup> AIAA/ASME Joint Thermophysics and Heat Transfer Conference, Albuquerque, NM, Jun 1998.

- 3.76. Miller, R. W., Argrow, B. M., Center, K. B., Brauckmann, G. J., and Rhode, M. N., “Experimental Verification of the Osculating Cones Method for Two Waverider Forebodies at Mach 4 and 6,” AIAA Paper 98-0682, 36<sup>th</sup> Aerospace Sciences Meeting & Exhibit, Reno, NV, Jan 1998.
- 3.77. Miller, R. W. and Argrow, B. M., “Subsonic Aerodynamics of an Osculating Cones Waverider,” AIAA Paper 97-0189, 35<sup>th</sup> Aerospace Science Meeting & Exhibit, Reno, NV, Jan 1997.
- 3.78. Aldo, A. C. and Argrow, B. M., “Dense Gas Flow in Minimum Length Nozzles,” NASA CP-10122, 1995.
- 3.79. Argrow, B. M. and Emanuel, G. “Computational Analysis of the Transonic Flow Field of Two-Dimensional Minimum Length Nozzles,” AIAA Paper 89-1822, 1989.

#### 4. Special Reports

- 4.1. National Academies of Sciences, Engineering, and Medicine, (contributing author). “Assessing the Risks of Integrating Unmanned Aircraft Systems (UAS) into the National Airspace System,” The National Academies Press, Washington, DC, <https://doi.org/10.17226/25143>, 2018.
- 4.2. National Academies of Sciences, Engineering and Medicine, Committee on Aviation Safety Assurance (contributing author). “In-Time Aviation Safety Management,” The National Academies Press, Washington DC, <https://doi.org/10.17226/24962>, 2018.
- 4.3. USAF Scientific Advisory Board (contributing author), “Virtual Training Technologies,” SAB-TR-09-XX, Aug 2009.
- 4.4. USAF Scientific Advisory Board (contributing author), “Implications of Spectrum Management for the Air Force,” SAB-TR-08-03, Aug. 2008.
- 4.5. USAF Scientific Advisory Board (contributing author), “Thermal Management Technology Solutions,” SAB-TR-07-05, Sep. 2007.
- 4.6. USAF Scientific Advisory Board (contributing author), “Air Defense Against Unmanned Aerial Vehicles, Vol. 2,” SAB-TR-06-01, Sep. 2006.
- 4.7. USAF Scientific Advisory Board (contributing author), “Unmanned Aerial Vehicles in Perspective: Effects, Capabilities, and Technologies, Vol. 1,” SAB-TR-03-01, Sep. 2003.
- 4.8. Argrow, B. M., “Assessment of the Impact of Low-Cost Robotic Aircraft to National Security,” IDA Paper-3704, Institute for Defense Analysis, Defense Science Study Group, Feb. 2002, pp.79-101.

#### FUNDED RESEARCH

- PI: “Hypersonic Glider Detection Satellite,” ASTRA, LLC, DoD STTR Phase-1, 3/1/2021-5/31/2021.
- Co-PI: “Measurements of TRACER Pre-Convective Conditions and Mesoscale Circulations Using Small Unmanned Aircraft Systems (sUAS),” DOE, 10/1/2020-9/30/2021.
- Co-PI: “Collaborative Research: Targeted Observation by Radars and UAS (Unmanned Aircraft Systems) of Supercells (TORUS),” NSF, 9/1/2018-8/31/2020.



- PI: MURI: “Integrated Measurement and Modeling Characterization of Stratospheric Turbulence,” AFOSR Multidisciplinary University Research Initiative (MURI), 7/1/2017-6/30/2022.
- Co-PI: “Nighttime Fire Observations eXperiment (NightFOX) - UAS wildfire measurements in support of FIREX and fire weather forecasting,” NOAA/ESRL Chemical Sciences Division, 8/1/2017-8/31/2019.
- PI: Aerobraking with ACES,” United Launch Alliance, 9/1/2016-8/31/2017.
- Co-PI: “Coordinated Persistent Airborne Information Gathering: Cloud Robotics in the Clouds DDDAS,” 1/01/2016 - 12/31/2018, Eric Frew (PI).
- PI: “Low-Altitude Operations of Small UAS under Part 107,” NSF-I/UCRC Center for Unmanned Aircraft Systems, 9/1/2016-8/31/2017.
- Co-PI: “Adaptive Assurances for Enhancing Trust,” NSF-I/UCRC Center for Unmanned Aircraft Systems, 9/1/2015-8/31/2017.
- Co-PI: “Convection Initiation Experiments at Oklahoma Mesonet Sites,” NOAA/NSSL, 10/1/2016-9/30/2018.
- PI: “Task Allocation Simulation for Controlled Emergency Response,” Aerospace Corporation, 8/1/2015-6/30/2016.
- PI: “Integrated Remote & In-Situ Sensing Program,” University of Colorado Boulder, 9/1/2015-pres.
- Co-PI: “NRI: Collaborative Research: Targeted Observation of Severe Local Storms Using Aerial Robots,” NSF National Robotics Initiative, 1/1/2016-12/31/2018.
- Co-PI: “Assured Autonomy,” NSF-I/UCRC Center for Unmanned Aircraft Systems, 9/1/2014-8/31/2015.
- PI: “TTwistor Advanced Small Unmanned Aircraft System,” Colorado Advanced Industries Accelerator Program, 6/1/2014 - 5/31/2016.
- PI: “Upgrading the Tempest UAS for Nomadic Deployments & Integration of a Lightning Detection Instrument,” Jonathan Merga Foundation, “8/1/2014-10/31/2015.
- PI: “RAPID: Support for Multi-sUAS Evaluation of Techniques for Measurement of Atmospheric Properties (MET MAP),” 8/1/2014-7/31/2015.
- PI: NASA SBIR, Phase I: Advanced Technologies for Coordinated In Situ Atmospheric Sensing, Black Swift Technologies, 6/1/2014 - 11/31/2014.
- Co-PI: “Energy-Aware Aerial Systems for Persistent Sampling and Surveillance,” AFOSR, 9/1/2012-8/31-2015.
- Co-PI: “Emerging sUAS In-Situ Sensing Technologies,” NSF-I/UCRC Center for Unmanned Aircraft Systems, 9/1/2012-8/31/2016.
- Co-PI: “I/UCRC Phase I: Center for Unmanned Aircraft Systems,” NSF, 9/1/2012-8/31/2013
- PI: “Wind Data System for the Tempest Unmanned Aircraft,” NOAA National Severe Storms Lab, 9/1/2012-8/31/2013.
- Co-PI: “Investigations of Spatial and Temporal Variability of Ocean and Ice Conditions In and Near the Marginal Ice Zone (aka the Marginal Ice Zone Observations and Processes Experiment [MIZOPEX]), NASA, 9/1/11-8/31/14.

- PI: “Forge Aeronautics Flight Operations Testing,” Forge Aeronautics, LLC, 10/22/10-3/31/11.
- Co-PI: “Collaborative Research: Planning Grant: I/UCRC for Unmanned Aircraft Systems,” NSF, 2/15/2010-2/15/2011.
- Co-PI: “Dream Chaser Dynamically Scaled Model,” Sierra Nevada Corp., 3/1/10-12/31/10.
- PI: “Collaborative Research: Development of Unmanned Aircraft System for Research in a Severe Storm Environment and Deployment within the VORTEX2,” NSF, 5/10/10-1/31/11.
- PI: “Collaborative Research: Development of Unmanned Aircraft System for Research in a Severe Storm Environment and Deployment within the VORTEX2,” NSF, 2/1/09-1/31/11.
- Co-PI: “UAS Research Directions for the National Air Space,” NSF, 5/2/08-2/28/09.
- Co-PI: “I3: Towards a Center for STEM Education,” NSF, 9/22/08-9/21-11.
- Co-PI: “One Day’s Pay: Educating K-16 Engineers to Create Affordable Innovations,” NSF, 9/1/08-8/31/11.
- Co-PI: “Networked Systems Test Bed Integration, Phase 1,” L3 Communications, 10/1/07-11/30/08.
- PI: SGER: Collaborative Research: UAS for In-Situ Sensing along Atmospheric Airmass Boundaries, NSF, 9/15/07-8/31/08.
- PI: Remote Operation of UAS and Technologies for Command, Control, Communications, and Computers, Dept. Transportation (FAA), total award, 8/22/07-8/21/08.
- PI: Wing-Integrated Antennas for Unmanned Aircraft, USAF SBIR, Phase 2, with First RF Corp., 6/07-5/09.
- Co-I: Atmospheric Neutral Density Prediction, AFOSR MURI, 5/07-4/12.
- Co-PI: UAV Sensor Data Collection Phase 4, L-3 Communications, 8/1/06-8/30/07.
- PI: Small UA Prototype Construction and Test Project, EIM Corp., 9/06-3/07.
- PI: Design, Fabrication, and Test of a Wing-Integrated Antenna, USAF SBIR, Phase 1, with First RF Corp., 9/06-12/06.
- Co-PI: UAV Sensor Data Collection, L3 Communications, 1/06-6/06, \$258.
- Co-PI: Sea Ice Freeboard, Roughness and Topography from UAV Laser Profilometry, Satellite and Surface Observations: Relationships to Ice Dynamical and Thermodynamical Properties, NSF, 10/05-4/08.
- PI: SNC Spartan UAV Prototype: Design, Fabrication, Assembly, and Test, Sierra Nevada Corp., 6/05-12/05.
- Co-PI: Ad Hoc UAV-Ground Networking (AUGnet) Project and Networked UAV C3: Integration, Deployment, and Test Plan, L3Communications, 7/03-6/05.
- Co-PI: Supersonic Aircraft Shaping Technology for a Constrained Shock Pressure Rise, NASA, 10/1/02-9/30/03.
- PI: Vertical Integration in the Aerospace Engineering Curriculum 2000, Lockheed Martin, 6/1/2002-5/31/2005.
- Co-PI: Shape Optimization for Sonic Boom Minimization, DARPA, 1/1/01-12/31/01.
- PI: Supplemental Equipment for a Dense Gas Shock Tube, NSF, 3/15/00.

- Co-PI: Applications of Aerosondes to Long Term Measurements of the Atmosphere and Sea Ice Surface in the Beaufort/Chukchi Sector of the Arctic Ocean, NSF, 6/99-5/04.
- PI: Experimental Investigation of Dense Gas Dynamics, NSF, 6/99-6/02.
- Co-PI: A Workshop on Dense Gas Dynamics, NSF, 2/99-1/00.
- Co-PI: Optimization and Analysis of a Waverider Vehicle for Global Spaceplane Trajectories, AFOSR, 1/98-12/98.
- PI: Engineering Applications of Dense Gases, Phase 1: Advanced Computational Methods, NSF, 7/96-6/97.
- PI: Subsonic and Supersonic Testing of Osculating-Cones Derived Waveriders, NASA, 7/96-6/98.
- Co-PI: Measurements of Vertical Air Velocities from Radar (ARMAR) and DC-8 Aircraft, NASA, 7/94-6/95.
- PI: Numerical Entropy Production in Navier-Stokes Solutions, EPSCoR/NSF.

### **SELECTED INVITED PUBLIC SEMINARS, TALKS, INTERVIEWS**

- “Supercells to Supersonics: Enabling Severe Weather Research with Aerospace Engineering” University of Washington, Nov 2019.
- “Supercells to Supersonics: Enabling Severe Weather Research with Aerospace Engineering” Pennsylvania State University, Mar 2019.
- “A Career of Constrasts: Tornadoes to Hypersonics,” NASA NIAC Annual Meeting, Denver CO, Sep 2017.
- “Dr. Drone,” Coloradan Alumni Magazine, Sep 2017.
- “The Changing Face of Aerospace: The Impact of UAS on Aviation,” AIAA AVIATION 2016, Washington, DC.
- “UAS for Weather Research at the University of Colorado Boulder, 2016 Oklahoma UAS Summit, 9 Aug 2016.
- “Storm Chasing with Drones on the Great Plains,” Boulder Kiwanas Club, Boulder, CO, 18 Jan 2016.
- “Storm Chasing with Drones on the Great Plains,” Boulder Flatirons Rotary Club, Boulder, CO, 2 Dec 2015.
- “Storm Chasing with Drones on the Great Plains,” Boulder Rotary Club, Boulder, CO, 7 Aug 2015.
- “Drones in Colorado: Are the Risks Worth the Rewards?” Colorado Joint Legislative Lunch Presentation, Colorado State Capitol, Denver, CO, 20 April 2015.
- “Why Senate Bill 059 Overreaches Regarding UAS Technologies,” Testimony to the Colorado State Senate Judiciary Committee, Colorado State Capitol, Denver, CO, 24 Feb 2015.
- “Weather Drones,” How on Earth? The KGNU Science Show, 17 Dec 2014 (<http://howonearthradio.org/archives/4455>).
- “In-Situ Meteorological Measurements Using Small Unmanned Aircraft Systems,” National Weather Center Colloquium, Norman, OK, 18 Nov 2014.

- “Unmanned Unplugged: UAS Education Campaign,” AUVSI Unmanned Systems 2014, May 2014 (<http://increasinghumanpotential.org/news/unmanned-unplugged/brian-argrow/>).
- “Unmanned Aerial Vehicles (drones),” Panel Discussion, Colorado Photonics Industry Association, Louisville, CO, 19 Feb. 2014.
- “Civilian Applications of Small UAS,” Salida Business Incubator, Salida, CO, 12 Feb 2014 ([http://www.themountainmail.com/free\\_content/article\\_51fb03a8-9591-11e3-bde9-0017a43b2370.html](http://www.themountainmail.com/free_content/article_51fb03a8-9591-11e3-bde9-0017a43b2370.html)).
- “UAS in Colorado,” Testimony for the Colorado Senate Transportation Committee, Colorado State Capitol, Denver, CO, 28 Jan 2014.
- “Already a testing ground for drones, Colo. wants contract to expand,” Colorado Public Radio, 16 Dec 2013 (<http://www.cpr.org/news/story/already-testing-ground-drones-colo-wants-contract-expand#sthash.F43YzMe1.dpuf>).
- “How will thousands of drones impact already crowded skies?” PBS NewsHour, 14 Dec 2013 ([http://www.pbs.org/newshour/bb/science/july-dec13/drones\\_12-14.html](http://www.pbs.org/newshour/bb/science/july-dec13/drones_12-14.html)).
- “Good Drones—Good Idea!” Denver Café Scientifique, Denver, CO, 10 Sep 2013.
- “Tornado Tech: How Drones Can Help With Twister Science,” NPR All Tech Considered, 16 Aug 2013 (<http://www.npr.org/blogs/alltechconsidered/2013/08/16/212262909/tornado-tech-how-drones-can-help-with-twister-science>).
- “In Situ Sensing in Convective Storms and Air Masses with Small Unmanned Aircraft Systems,” Oklahoma AUVSI UAS Summit, Norman, OK, 26 March 2013.
- “In Situ Sensing in Convective Storms and Air Masses with Small Unmanned Aircraft Systems,” 16th Conference on Aviation, Range, and Aerospace Meteorology, 93<sup>rd</sup> American Meteorological Society Annual Meeting, Austin, TX, 6-10 Jan 2013 (co-authors, Eric Frew, Adam Houston, Christopher Weiss, Conrad Ziegler).
- “Cooperative Mobile Sensing Systems,” University of Oklahoma, 16 May 2012.
- “NetUASC3: An Unmanned Systems Command, Control, Communication, and Sensing Architecture,” Multi-Vehicle Cooperative Control Panel, University of Southern California, 30 Mar 2012.
- “Tempest UAS: VORTEX2 Supercell Thunderstorm Penetrator,” National Weather Center and National Severe Storms Laboratory, Norman, OK, Oct 2011 (co-authors: Jack Elston, Eric Frew, Adam Houston, Jamie Lahowetz)
- “NSF Hazards Research Showcase,” US Senate Hart Office Building, invited by Nevada Senator Harry Reid, Florida Senator Ben Nelson, and NSF Director Subra Suresh, Sep 6-7, 2011 (co-authors: Jack Elston, Eric Frew, Adam Houston, Jamie Lahowetz)
- “NetUASC3: An Unmanned Systems Command, Control, Communication, and Sensing Architecture,” Phoenix AIAA/SAE Annual Meeting, Phoenix, AZ, Feb. 2011 (co-authors: Jack Elston, Eric Frew, Cory Dixon)
- “NetUASC3: An Unmanned Systems Command, Control, Communication, and Sensing Architecture,” IEEE Globecom Workshop on Wireless Networking for Unmanned Aerial Vehicles, Miami, FL, Dec. 2010 (co-authors: Jack Elston, Eric Frew, Cory Dixon)
- “Unmanned Aircraft in VORTEX2,” AMS Severe Local Storms Conference, Denver, CO, Oct 2010 (Presented by Adam Houston, Eric Frew Co-author).

- “VORTEX2 Unmanned Aircraft System,” AUVSI Unmanned Systems North America 2010, Denver, CO, Aug. 2010 (Adam Houston, Eric Frew Co-authors).
- “Refinements in the Semi-Empirical Accommodation Coefficient Model for Satellites,” 38<sup>th</sup> COSPAR Scientific Assembly, Bremen, Germany, July 2010 (presented by PhD Candidate M. Pilinski, S. Palo Co-author).
- “Capstone Projects in the College of Engineering and Applied Science,” 2010 Capstone Design Conference, Boulder, CO, June 2010.
- “Small Satellite Approaches to Measuring Neutral Winds and Density,” CNOFS Science Meeting, Breckenridge, CO, May 2010 (presented by PhD Candidate M. Pilinski, J. Forbes, Scott Palo Co-authors).
- “Research Directions and Best Practices for UAS in the NAS,” IDGA UAV Workshop, Vienna, VA., Apr 2010.
- “UAS in VORTEX2: Goals and Challenges,” 5<sup>th</sup> FAA UAS Conference, San Diego, CA, Feb 2010.
- “Supercell Thunderstorm Penetration by UAS in VORTEX 2,” Ball Aerospace Corp., Boulder, CO, Feb 2010.
- “Supercell Thunderstorm Penetration by UAS in VORTEX 2,” NOAA Earth Systems Research Laboratory, Boulder, CO, Jan 2010.
- “Unmanned Air Systems: The Next Generations,” 48<sup>th</sup> AIAA Aerospace Sciences Meeting New Horizons Forum, Orlando, FL, Jan 2010.
- “UAS in VORTEX 2,” FAA UAS Staff Meeting, San Diego, CA, Jul 2009.
- “Preparing for the Future Perspective of Academia II,” AUVSI 2008 Unmanned Systems Program Review,” Washington, D.C., Feb 2008.
- NOAA: *Cooperative Mobile Sensing Systems for In Situ Measurements in Hazardous Environments*,” Dec. 2005
- Lockheed Martin: *Ad Hoc UAV Ground Network (AUGNet)*, Lockheed Martin, Nov. 2004
- Dept. Aerospace Engineering and Mechanics, University of Minnesota *Research and Engineering Center for Unmanned Vehicles*, May 2004
- DARPA 2003 QSP Technology Exchange Meeting: *Linear Theory Based Optimization for Sonic Boom Minimization*, Nov. 2003
- University of Colorado Faculty Teaching Excellence Program Symposia on Teaching and Learning: *Pro-Active Teaching & Learning*, Sept. 1999, Feb. 2003
- Computer Science Dept., Colorado State University *Pro-Active Teaching & Learning*, June 2001
- DARPA QSP Kickoff Meeting: *Supersonic Aircraft Shaping Technology for Constrained Shock Pressure Rise*, Dec. 2000
- University of Colorado, College of Engineering and Applied Sciences Excellence in Teaching Series: *Pro-Active Teaching & Learning in the AES Curriculum 2000*, Feb. 1999

## **COURSES TAUGHT (at Univ. Colorado since 1997)**

### Undergraduate

GEEN 1300 Introduction to Engineering Computing

GEEN 1500 Introduction to Engineering

ASEN 2002 Introduction to Thermodynamics and Aerodynamics

ASEN 2004 Aerospace Vehicle Design and Performance

ASEN 3111 Aerodynamics

ASEN 3128 Aircraft Dynamics

ASEN 4018 Senior Projects: Design Synthesis

ASEN 4028 Senior Projects: Design Practicum

### Graduate

ASEN 5051 Introduction to Fluid Mechanics

ASEN 5061 Real Gas Dynamics

ASEN 5151 High-Speed Aerodynamics

ASEN 5227 Aerospace Math

ASEN 5519 UAS in the National Airspace System

ASEN 6519 Rarefied Gas Dynamics

ASEN 6061 Molecular Gas Dynamics & DSMC

## **GRADUATE STUDENTS, POSTDOCS**

### Postdoc

John Bird (2019-) RECUV/IRISS

Nicholas Campbell (2019-) RECUV

Roger Laurence III (2017-2018) CEAS/IRISS

Jack Elston (2012-2014) NSF GEO Directorate

Craig Turansky (2013-2014) AES/RECUV

### Ph.D. Dissertation

Alberto Roper Pol (2020) *Generation of Gravitational Waves due to Magnetohydrodynamic Turbulence in the Early Universe*

Nicholas Campbell (2019) *Analysis Methods for Reusable Spacecraft Undergoing Aeroassist Maneuvers*

Tevis Nichols (2017) *Particle Streak Anemometry: A New Method for Proximal Flow Sensing from Aircraft*

Roger Laurence (2017) *sUAS Wind Sensing with Computational Fluid Dynamics and a Distributed Flush Airdata System*

Craig Turansky (2012) *High-fidelity dynamic modeling of spacecraft in the continuum–rarefied transition regime*

Marcin Pilinski (2011) *Dynamic gas-surface interaction modeling for satellite aerodynamic computations*

Vivek Kaila (2010) *A study of meshless and finite element approaches for aeroelastic analysis on interacting surfaces*

Stephen Ferguson (2001) *Dense gas shock tube : Design and analysis*

Rick Graves (1999) *Aerodynamic performance of osculating-cones waveriders at high altitudes*

Brady Brown (1997) *Two-dimensional dense gas dynamics*

Current Ph.D candidates:

Christopher Roseman

Sara Swenson

Joseph Pointer

Robert Sasse

M.S. theses supervised:

Pol Mesalles Ripoll (2020) *Assessment of Spacecraft Aerodynamics Under Uncertainty Toward the Optimization of Atmospheric Entry Trajectories*

Anubhav Gupta (2020) *Analytical Theory of Aero-Optical and Atmospheric Effects in Supersonic and Hypersonic Flows*

Rolf Miller (1998) *Experimental aerodynamics of osculating cones waveriders*

Brady Brown (1994) *Design and analysis of a minimum length nozzle with equilibrium flow*

Charles Aldo (1993) *Supersonic flow in minimum length nozzles for dense van der Waals gases*

Alok Gautam (1992) *A computational analysis of the viscous transonic flow field of axisymmetric minimum length nozzles*

Cynthia Borth (1991) *Evaluation of Numerical Entropy Production in Flowfield Solutions.*

**PROFESSIONAL MEMBERSHIPS**

Fellow, American Institute of Aeronautics and Astronautics

American Physical Society

American Society for Engineering Education

**CONSULTING**

- DLVR, LLC, Limited Partner (2018-pres)
- Chaffee County, CO, “Airworthiness Statement and Safety Risk Analysis for a Small UAS (2014)
- ITT Industries, Systems Division “Architecture for Unmanned Aircraft Transport of Scientific Data from the South Pole to McMurdo Station” (2010)
- Lockheed Martin, “Aerocapture Inflatable Decelerator” (2004)

- Williams Professional Services, LLC (2002)
  - “Kaiser-Hill Independent Safety Assessment,” Contract No. WPS-SUB02-003
  - “Evaluation of DOE Standard 3013-2000,” Contract No. DE-AT01-01EW07005
- ITT Industries, Systems Division, “High Altitude Scoping,” Contract No. DASG6098-C-0099 (1999-2000)
- Krispin Technologies, Inc., “Innovative Organic Rankine Cycle Engines,” National Science Foundation SBIR Contract No. 9860391 (1998)