

## CURRICULUM VITAE

### IAIN D. BOYD

H.T. Sears Memorial Professor of Aerospace Engineering Sciences  
Faculty Director of National Security  
University of Colorado  
Boulder, CO 80303.

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Web page: <https://aero.engin.umich.edu/people/iain-d-boyd>

#### EDUCATION

- |       |   |
|-------|---|
| 12/88 | Ph. D. in Aeronautics and Astronautics,<br>University of Southampton, England |
| 7/85  | B. Sc. (with honors) in Mathematics,<br>University of Southampton, England    |

#### EMPLOYMENT HISTORY

- |                 |  |
|-----------------|--|
| 08/19 – present | Faculty Director of National Security<br>University of Colorado, Boulder, CO                         |
| 08/19 – present | H.T. Sears Memorial Professor of Aerospace Engineering,<br>University of Colorado, Boulder, CO       |
| 10/10 – 08/19   | James E. Knott Professor of Aerospace Engineering,<br>University of Michigan, Ann Arbor, Michigan    |
| 07/17 – 06/19   | Faculty Director of Government Relations<br>University of Michigan, Washington, DC                   |
| 8/02 – 9/10     | Professor of Aerospace Engineering,<br>University of Michigan, Ann Arbor, Michigan                   |
| 6/99 - 8/02     | Associate Professor<br>Aerospace Engineering,<br>University of Michigan, Ann Arbor, Michigan         |
| 11/95 - 5/99    | Associate Professor<br>Mechanical and Aerospace Engineering,<br>Cornell University, Ithaca, New York |

- 1/93 - 10/95      Assistant Professor  
Mechanical and Aerospace Engineering,  
Cornell University, Ithaca, New York
- 1/89 - 12/92      Research Scientist  
Eloret Institute, NASA Ames Research Center,  
Moffett Field, California

## HONORS AND AWARDS

- 06/2019      AIAA Thermophysics Best Paper Award  
06/2018      AIAA Thermophysics Award  
10/2017      Fellow, Royal Aeronautical Society  
07/2017      Chief of Staff of the Air Force Award  
                    for Exceptional Public Service  
10/2014      Fellow, American Physical Society  
06/2012      AIAA Thermophysics Best Student Paper Award  
06/2011      AIAA Thermophysics Best Paper Award  
05/2011      Fellow, American Institute of Aeronautics & Astronautics  
10/2009      James E. Knott Professor of Engineering  
06/2009      Paper selected by *Physics of Plasmas* as one of its most  
                    significant publications in 50 years  
03/2009      UM Monroe-Brown Foundation Research Excellence Award  
09/2006      CTR Senior Fellow (Stanford University)  
06/2005      AIAA Thermophysics Best Student Paper Award  
03/2004      UM Aerospace Outstanding Achievement Award  
01/1998      AIAA Lawrence Sperry Award  
09/1997      Cornell Engineering College Teaching Award  
07/1997      AIAA Electric Propulsion Best Paper Award

## ACADEMIC EXPERIENCE

### A. Courses Taught

- Hypersonic Aerothermodynamics* (graduate; 2003, 2004, 2007; Michigan)  
*Molecular Gas Dynamics* (graduate; 2003-2006, 2008-2016; Michigan)  
*Gas Kinetic Theory* (graduate; 2000, 2001; Michigan)  
*Introduction to Gas Dynamics* (undergraduate; 2000-2002, 2005; 2009-2015;  
Michigan)  
*Spacecraft Engineering* (undergraduate; 1997, 1998; Cornell)  
*Compressible Fluid Flow* (graduate; 1996, 1997, 1998; Cornell)  
*Physics of Fluids* (graduate; 1994-1996, 1999; Cornell)  
*Introduction to Aeronautics* (undergraduate; 1993-1995; Cornell)  
*Computational Aerodynamics* (graduate; 1993; Cornell)

**B. Graduate Students/Visitors**

Current Students:	Tim Aiken	(CU)
	Michele Anderson	(CU)
	Amin Taziny	(CU)
	Austin Brenner	(UM)
	Sam Chen	(UM)
	David Dang	(UM)
	Kaelan Hansson	(UM)
	Michael Holloway	(UM)
	Candice Kaplan	(UM)
	Thomas Marks	(UM)
	Mackenzie Meyer	(UM)
	Astrid Raisanen	(UM)
	Pawel Sawicki	(UM)
	Alex Vaszonyi	(UM)
Graduated Students:	Lauren Mackey <i>Williams International</i>	(PhD, Michigan, 2019)
	Horatiu Dragnea <i>Aerospace Corporation</i>	(PhD, Michigan, 2018)
	Peter Cross <i>Naval Air Weapons Center</i>	(PhD, Michigan, 2017)
	Kyle Hanquist <i>University of Arizona</i>	(PhD, Michigan, 2017)
	Kevin Neitzel <i>Sierra Nevada Corporation</i>	(PhD, Michigan, 2017)
	Maria Choi <i>NASA Glenn Research Center</i>	(PhD, Michigan, 2016)
	Brandon Smith <i>Spectral Sciences, Inc.</i>	(PhD, Michigan, 2015)
	Kentaro Hara <i>Texas A &amp; M University</i>	(PhD, Michigan, 2015)
	Ashley Verhoff <i>Blue Origin</i>	(PhD, Michigan, 2015)

Jon Wiebenga <i>Williams International</i>	(PhD, Michigan, 2014)
Cyril Galitzine <i>Northeastern University</i>	(PhD, Michigan, 2014)
Anna Abhilasha <i>CD-adapco</i>	(PhD, Michigan, 2013)
Andrew Crow <i>Lockheed-Martin</i>	(PhD, Michigan, 2013)
Adam Irvine <i>Onyx Aerospace</i>	(PhD, Michigan, 2013)
Paul Giuliano <i>NASA Jet Propulsion Laboratory</i>	(PhD, Michigan, 2013)
Eunji Jun <i>University of Hawaii</i>	(PhD, Michigan, 2012)
Hicham Alkandry <i>Applied Physics Laboratory</i>	(PhD, Michigan, 2012)
Tyler Huismann <i>University of Colorado</i>	(PhD, Michigan, 2011)
Tim Deschenes <i>Spectral Sciences, Inc.</i>	(PhD, Michigan, 2011)
Erin Farbar <i>Chrysler, Canada</i>	(PhD, Michigan, 2010)
Tim Holman <i>Naval Research Laboratory</i>	(PhD, Michigan, 2010)
Nick Bisek <i>Air Force Research Laboratory</i>	(PhD, Michigan, 2010)
Minkwan Kim <i>University of Southampton, United Kingdom</i>	(PhD, Michigan, 2009)
Andrew Porwitzky <i>Sandia National Laboratory</i>	(PhD, Michigan, 2008)
Jeremy Boerner	(PhD, Michigan, 2008)

*Sandia National Laboratory*

Yongjun Choi (PhD, Michigan, 2008)  
*Michigan State University*

John Yim (PhD, Michigan, 2008)  
*NASA Glenn Research Center*

Jose Padilla (PhD, Michigan, 2007)  
*NASA Langley Research Center*

Andrew Lofthouse (PhD, Michigan, 2007)  
*United States Air Force Academy*

Leonardo Scalabrin (PhD, Michigan, 2007)  
*Embraer, Brazil*

Tom Schwartzentruber (PhD, Michigan, 2007)  
*University of Minnesota*

Matt McNenly (PhD, Michigan, 2006)  
*Lawrence Livermore National Laboratory*

Michael Martin (PhD, Michigan, 2006)  
*National Renewable Energy Laboratory*

Jon Burt (PhD, Michigan, 2006)  
*NASA Glenn Research Center*

Anton VanderWyst (PhD, Michigan, 2006)  
*Northrop-Grumman Corporation*

Chunpei Cai (PhD, Michigan, 2005)  
*Michigan Technical University*

Jerry Emhoff (PhD, Michigan, 2005)  
*Applied Physics Laboratory*

Justin Koo (PhD, Michigan, 2005)  
*Air Force Research Laboratory*

Wen-Lan Wang (PhD, Michigan, 2004)  
*Foxconn Technology Group*

Quanhua Sun (PhD, Michigan, 2003)  
*Chinese Academy of Sciences*

Jitendra Balakrishnan (PhD, Cornell, 2001)  
*Corning*

Jyothish George (PhD, Cornell, 2000)

Douglas VanGilder (PhD, Cornell, 2000)  
*CRAFT Technology*

Daniel Karipides (PhD, Cornell, 1999)  
*Tech-X Corporation*

Gang Chen (PhD, Cornell, 1998)  
*Brion Technologies*

Keith Kannenberg (PhD, Cornell, 1998)  
*Lockheed-Martin*

Research Staff:

Ross Chaudhry (Postdoc: 2018 – present)  
Savio Poovathingal (Postdoc: 2018 – present)  
Kyle Hanquist (Postdoc: 2017 – 2019)  
Sinan Eyi (Visitor from Turkey: 2017-2018)  
Brandon Smith (Research Scientist: 2015 – 2018)  
Daniil Andrienko (Postdoc: 2014 – 2017)  
Andrew Weaver (Postdoc: 2015 – 2017)  
Michael Logue (Postdoc: 2015 – 2016)  
Anna Abhilasha (Postdoc: 2013 – 2015)  
Kelly Stephani (Postdoc: 2012-2014)  
Hicham Alkandry (Postdoc: 2012-2014)  
Erin Farbar (Research Scientist: 2010-2016)  
Jaegang Kim (Postdoc: 2010-2014)  
Tom Scanlon (Visitor from Strathclyde Univ.: 2012)  
Alexandre Martin (Postdoc: 2007-2010)  
Minkwan Kim (Postdoc: 2009-2010)  
Jon Burt (Postdoc: 2006-2010)  
Michael Keidar (Research Scientist: 1998-2005)  
Quanhua Sun (Postdoc: 2003-2005)  
Andrew Christlieb (Postdoc: 2001-2002)  
Jing Fan (Postdoc: 1998-2000)  
Laurent Garrigues (Postdoc: 2000)  
Sergey Gimelshein (Postdoc: 1998)  
Savino Longo (from University of Bari: 1997-1998)  
Stefan Stefanov (Visitor from Sofia, Bulgaria: 1997)  
Koffi Kossi (Postdoc: 1996-1998)  
Gabriel Font (Postdoc: 1995-1997)  
Stefan Dietrich (Postdoc: 1993-1995)

### **C. University of Michigan Service**

Faculty Director of Government Relations, Washington, DC (2017-2019)  
Member, Executive Committee, Michigan Institute for Plasma Science & Engineering (2012-2017)  
Member, Aerospace Engineering Internal Review Committee (2013)  
Member, Executive Committee, Michigan Institute for Computational & Discovery Engineering (2013-2014)  
Chair, Aerospace Department Head Search Committee (2010-2011)  
Chair, College of Engineering Honors & Awards Committee (2010)  
Member, College of Engineering Research Computing Committee (2010-2011)  
Member, College of Engineering Honors & Awards Committee (2009)  
Member, Aerospace Engineering Graduate Committee (2008-present)  
Member, Aerospace Engineering Undergraduate Committee (2000-2002)  
Member, Aerospace Engineering Faculty Search Committee (2008-2009)  
College of Engineering freshmen advisor (2007-2008)  
Faculty Advisor, Michigan Rocket Engineering Association (2007-2012)  
Chair, Aerospace Engineering Faculty Search Committee (2005-2006)  
Member, Aerospace Department Head Search Committee (2004-2005)  
Faculty Advisor, Student Chapter of AIAA (2002-2005)  
Undergraduate Program Advisor in Aerospace Engineering (2000-2003)  
Chair, Aerospace Engineering Curriculum Committee (2003-2005)  
Member, College of Engineering Faculty Phase of the Anniversary Campaign (2002-2005)  
Member, College of Engineering Nominating Committee (2002-2003)  
Member, University of Michigan Senate Assembly (2002-2005)  
Director, W.M. Keck Computational Fluid Dynamics Laboratory (2002-2011)

### **D. Software Licensing**

#### MONACO:

- ESI Group (2011)
- Boeing Space & Intelligence Systems (2013)
- Space Exploration Company (2016)
- Blue Origin (2016)
- NASA Glenn Research Center (2017)
- Naval Research Laboratory (2017)

#### LeMANS:

- Virtual EM Inc., Ann Arbor, MI (2013)
- Corvid Technologies (2013)
- Active Cooling Technologies, Inc. (2015)
- Raytheon Missile Systems (2016)

- Naval Research Laboratory (2017)
- L3-Harris Corporation (2019)

MOPAR-MD:

- Southwest Research Institute (2016)
- Raytheon Missile Systems (2016)
- Naval Research Laboratory (2017)

## EXTERNAL PROFESSIONAL ACTIVITIES

### A. Journal Editorships and Reviewing

Editorial Board, *Physical Review Fluids*, (2016-present)

Associate Editor, *Journal of Thermophysics and Heat Transfer*, (2016-present)

Editorial Board, *Physics of Fluids*, (2014-2015)

Associate Editor, *Journal of Spacecraft and Rockets*, (1994-2015)

Editorial Board, *International Journal of Aerospace Engineering*, (2010-2013)

Editorial Advisory Board, *The Open Aerospace Engineering Journal*, (2009-2011)

Manuscript reviewer for more than 50 different journals spanning engineering, physics, chemistry, and scientific computation.

Proposal reviewer for NASA, NSF, AFOSR, ARO.

### B. Board, Committee, and Panel Activities

Member, Strategic Advisory Group on Counter Hypersonics, Northrop-Grumman Corporation (2019 – present)

Member, AIAA Public Policy Committee, Key Issues Co-Chair, (2019 – present)

Member, IDA DSSG Alumni Outreach Group, (2018 – present)

Member, IDA Hypersonics Working Group, (2018 – present)

Member, AIAA Fellows Selection Committee (2017 – present)

Member, National Academies Intelligence Science & Technology Expert Group (2016 – present)

Panelist, University Hypersonic Research Partnerships, Hypersonic Capabilities Conference, Purdue, IN (2019)

Panelist, Materials for Hypersonics, Defense Strategies Institute, Alexandria, VA (2019)

Member, National Academies Panel for Assessment of the Army Research Laboratory (2019)

Member, National Academies Panel for Assessment of Independent Research at the Army's Research and Development Centers (2018)

Member, IDA Forum on Emerging Areas of Science & Technology Policy (2018)

Panelist, Hypersonics 101, AIAA, U.S. Capitol Building, Washington, DC (2018)

Member and Vice Chair, Air Force Scientific Advisory Board (2010-2017)

Member, Review Board for DOE Exascale Computing Requirements (2016)



Member, Board of Directors, Space United (2013 – 2014)  
 Member, Panel on USAF R&D, AFA Symposium, Langley AFB (2015)  
 Member, Review Board for AFRL High Speed Strike Weapons Program (2015)  
 Member, Scientific Committee, 5<sup>th</sup> International Workshop, Radiation of High Temperature Gases in Atmospheric Entry, Barcelona, Spain (2012)  
 Member, NATO RTO-AVT, Catalytic Gas-Surface Interactions (2011-2012)  
 Member, NSF Proposal Review Panel on Combustion & Plasmas (2010)  
 Member, Scientific Committee, 4<sup>th</sup> International Workshop, Radiation of High Temperature Gases in Atmospheric Entry, Paris, France (2010)  
 Member, Defense Science Study Group (2008-2009)  
 Member, Board of Honor of Rarefied Gas Dynamics (2008 – present)  
 Member, National Research Council Panel on Assessment of NASA Aeronautics Program (2007-2008)  
 Member, Review Board on Aerothermodynamics for NASA Mars Science Laboratory (2007)  
 Co-Lead for Aerothermodynamics, Hypersonics Education Initiative (2007)  
 Member, AIAA Electric Propulsion & Power Technical Committee (1997-2007)  
 Member, NSF Proposal Review Panel on Plasma Science (2006)  
 Member, Organizing Committee of 2002 Rarefied Gas Dynamics Symposium  
 Member, Organizing Committee of 2001 AIAA Joint Propulsion Conference

### **C. Membership of Professional Societies**

Fellow, American Institute of Aeronautics and Astronautics (AIAA), 2011  
 Fellow, American Physical Society (APS), 2014  
 Fellow, Royal Aeronautical Society (RAeS), 2017  
 Member, American Society of Mechanical Engineers (ASME)  
 Member, American Association for the Advancement of Science (AAAS)

### **D. Experience In Science & Technology Policy**

Air Force Scientific Advisory Board (AFSAB): 2010 – 2017.

Vice Chair: Study topic development, member selection (2014 – 2016)

Study Chair: *Maturity of Directed Energy for Airborne Applications* (2016)  
 Briefed to: Secretary and Chief of the Air Force, House and Senate Committees, Air Force Major Commands, White House, DARPA

*Technology Readiness of Hypersonic Vehicles* (2014)  
 Briefed to: Secretary and Chief of the Air Force, Air Force Major Commands, Asst. Sec. Def, Navy, White House, DARPA, NASA

Study Member: *Test and Evaluation for Emerging USAF Needs* (2017)  
*Utility of Quantum Systems to the Air Force* (2015)  
*Microsatellite Mission Applications* (2013)  
*Extended Use of Space Sensors* (2012)  
*Munitions for the 2025+ Environment* (2011)

Air Force Research Laboratory Reviews:

Propulsion Directorate (2010)  
Air Vehicles Directorate (2011)  
Aerospace Systems Directorate (2012; 2013-Chair)  
Space Vehicles Directorate (2013, 2015)  
Office of Scientific Research (2014)  
Directed Energy Directorate (2014, 2016-Vice Chair)  
Munitions Directorate (2016)  
Materials & Manufacturing Directorate (2016)

Institute for Defense Analyses, Alexandria, VA

Consultant, Science & Technology Policy Institute (STPI), 2016 – present  
Multiple studies commissioned by OSTP, NASA, OSD, ODNI  
Member, Defense Science Study Group (DSSG), 2008-2009  
Member, DSSG Alumni Outreach Group, 2019-present

National Academies of Science, Engineering, & Medicine

Member, Intelligence Science & Technology Expert Group, 2016-present  
Member, Review Panel for Army Research & Development Centers, 2018

**E. Consulting**

CFDRC (2012, 2019 - present)  
Science & Technology Policy Institute (2015 – present)  
Ohio Aerospace Institute (2009 - present)  
Orbion, Inc. (2018)  
Microcosm, Inc. (2018)  
Spectral Sciences (2012, 2017 - 2018)  
Craft Technology (2017 - 2018)  
SpaceX (2016, 2018)  
IQM Research Institute (2015 – 2016)  
Raytheon Missile Systems (2015)  
Seneca Sciences (2014 – 2015)  
The Aerospace Corporation (1997-98, 2001-2004, 2013-2017)  
VirtualEM Inc (2013)  
RockWest (2012-2013)

Cornell Technical Services (2012-2013)  
Ovshinsky Solar (2011-2012)  
Raytheon Professional Services (2010-2011)  
CU Aerospace (2009)  
ZONA Technology (2009-2010)  
MilSys Technologies (2008)  
Naval Research Laboratory (2008)  
Mattson Technology, Inc. (2006-2007)  
Aerospace Testing Alliance (2006)  
Jet Propulsion Laboratory (2006)  
ERC, Inc. (2000-2004, 2006)  
Institute for Defense Analyses (2006, 2008-2009)  
ElectroDynamic Applications (2005-2006)  
QSS, Inc (2005)  
Applied Physics Laboratory (2005)  
Advatech Pacific (2005-2007)  
Aerojet (2004-2005)  
Clear Science, Inc. (2003-2004)  
SAGE Systems (2003)  
Tech-X Corporation (2002)  
Sverdrup Technology, Inc. Corporation (2002)  
Intelsat Global Service Corporation (2002)  
NASA Marshall Space Flight Center (2000)  
Epion Corporation (1999)  
SETI Institute (1999, 2009, 2010)  
Symyx, Inc. (1999)  
Applied Pulsed Power (1999)  
Eaton Corporation (1998)  
Los Alamos National Laboratory (1998)  
Quantum Materials Technology, Inc (1997-98)  
Dutch High Energy Physics Institute (1994)

## **F. Short Courses**

“Introduction to Hypersonic Aerothermodynamics,” National Institute of Aerospace, Hampton, VA, September 2007 (with G. V. Candler).

“Advanced Hypersonic Aerothermodynamics,” National Institute of Aerospace, Hampton, VA, December 2007 (with G. V. Candler).

## G. Public Outreach

Op Ed, "Commercial supersonic aircraft could return to the skies," <https://theconversation.com/commercial-supersonic-aircraft-could-return-to-the-skies-113022>, July 2019.

Op Ed, "Why is the Pentagon interested in UFOs?" <https://theconversation.com/why-is-the-pentagon-interested-in-ufos-116714>, May 2019.

Op Ed, "US, Russia, China race to develop hypersonic weapons," <https://theconversation.com/us-russia-china-race-to-develop-hypersonic-weapons-114694>, May 2019.

Television Interview: "DOD Explores the Use of Hypersonics in National Defense," Government Matters, Arlington, VA, June 2019.

Radio Interview: "Virgin Galactic IPO," Knowledge@Wharton, July 2019.

Radio Interview: "Future of Supersonic Commercial Aircraft," Knowledge@Wharton, April 2019.

Radio Interview: "SpaceX Launch to the ISS," Knowledge@Wharton, March 2019.

Press Interview: "Musk, Branson, and Bezos," The Independent (UK), <https://www.independent.co.uk/news/science/elon-musk-space-jeff-bezos-richard-branson-apollo-11-moon-landing-a9011591.html>, July 2019.

Press Interview: "Hypersonic Missiles Fuel New Global Arms Race," How Stuff Works, <https://science.howstuffworks.com/hypersonic-missiles.htm>, July 2019.

Press Interview: "Why China's Artificial Moon Probably Won't Work," Discovery Magazine, <http://blogs.discovermagazine.com/d-brief/2018/10/26/china-artificial-moon-light-satellite/#.XTjUK1B7IBw>, October 2018.

Press Interview: "Strange Encounters," ASEE Prism, <http://www.asee-prism.org/strange-encounters/>, September 2018.

Press Interview: "Hypersonic Weapons Race," Aerospace America, <https://aerospaceamerica.aiaa.org/features/hypersonic-weapons-race/>, June 2018.

## PRESENTATIONS AND PUBLICATIONS

**A. Invited Talks at Conferences and Workshops**

1. "Hypersonic Signatures Via Particle Simulations," JASON Spring Meeting, Maclean, VA, April 2019.
2. "When Is High Fidelity Aerothermochemistry Modeling Needed?" AIAA Thermophysics Award Lecture, San Diego, CA, January 2019.
3. "Plume Simulations for Micro-Propulsion Devices," 3<sup>rd</sup> International Workshop on Micropropulsion for Cubesats, Washington, DC, July 2018.
4. "Nonequilibrium Processes in Hypersonic Rarefied Flows," 31<sup>st</sup> Symposium on Rarefied Gas Dynamics, Glasgow, United Kingdom, July 2018.
5. "Computation of Hypersonic Flow Using High Fidelity Aerothermochemistry," 7<sup>th</sup> European Conference on Computational Fluid Dynamics, Glasgow, United Kingdom, June 2018.
6. "Computational Modeling of Oxygen Chemistry for Hypersonic Flows," Hypersonic Meteoroid Entry Physics, Erice, Italy, October 2017 (Boyd, I.D., Neitzel, K. and Andrienko, D.)
7. "Modeling of Chemistry Using the Direct Simulation Monte Carlo Method," Graeme A. Bird Keynote Lecture, DSMC Workshop, Santa Fe, NM, August 2017.
8. "A Collaborative Modeling-Experimental Study of Chemical Kinetics for Pyrolyzing Ablators," AIAA Ground Testing Conference, Denver, CO, June 2017.
9. "Nonequilibrium Mechanisms in Rarefied Hypersonic Flow," AIAA Fluid Dynamics Conference, Washington, DC, June 2016.
10. "State Resolved Analyses of High Temperature Energy Transfer Processes in Oxygen," 52<sup>nd</sup> Society of Engineering Science Technical Meeting, College Station, TX, October 2015.
11. "Parallel Computation of Nonequilibrium Gas Flows," 27<sup>th</sup> International Conference on Parallel Computational Fluid Dynamics, Montreal, May 2015.
12. "Challenges for the Direct Simulation Monte Carlo Method," *Workshop on Moment Methods in Kinetic Theory II*, Fields Institute, University of Toronto, October 2014.

13. "Modeling of Radiation in Fluid Flow," *Center for Turbulence Research Summer Program*, Stanford University, July 2014.
14. "Computations of High-Enthalpy Laminar Air Flow Around Double Cone and Cylinder-Flare Geometries," *AIAA Thermophysics Conference*, Atlanta, GA, June 2014 (Alkandry, H., Anna, A., and Boyd, I. D.).
15. "Progress in Coupled Modeling of Flow, Surface Chemistry, and Material Response," *Radiation and Gas-Surface Interaction Phenomena in High-Speed Re-entry*, Urbana-Champaign, IL, April 2014.
16. "Detailed Analyses of Oxygen Thermochemistry Based on State-Resolved Kinetics," *AIAA SciTech Meeting*, National Harbor, MD, January 2014.
17. "Simulation of a Pulsed Atomic Oxygen Beam," *SPIE Optical Engineering & Applications Conference*, San Diego, California, August 2013 (Carron, N., Boyd, I.D., et al.)
18. "Computation of Hypersonic Flow Using the Direct Simulation Monte Carlo Method," *21<sup>st</sup> AIAA CFD Conference*, San Diego, California, June 2013.
19. "Progress and Future Prospects for Particle-Based Simulation of Hypersonic Flow," *43<sup>rd</sup> AIAA Fluid Dynamics Conference*, San Diego, California, June 2013 (Schwartzentruber, T.E. and Boyd, I.D.).
20. "Approaches for Emulating the Boltzmann Equation When Particle Simulation Becomes Inefficient," *Workshop on Issue in Solving the Boltzmann Equation for Aerospace Applications*, Providence, Rhode Island, June 2013.
21. "Status and Challenges for Coupled Modeling of Flow, Surface Chemistry, and Material Response," *Gordon Conference on Atmospheric Re-entry Physics*, Ventura, California, February 2013.
22. "State-resolved Analysis of Thermochemical Nonequilibrium for H<sub>2</sub> and N<sub>2</sub>," *1<sup>st</sup> International Symposium on Hypersonic Aerothermodynamics—Recent Advances*, Bangalore, India, December 2012 (Kim, J.G. and Boyd, I.D.).
23. "Hybrid Particle-Continuum Numerical Methods for Aerospace Applications," *Models and Computational Methods for Rarefied Flows*, Von Karman Institute for Fluid Mechanics, Brussels, Belgium, January 2011 (Boyd, I.D. and Deschenes, T.R.).
24. "Simulation of Electric Propulsion Thrusters," *Models and Computational Methods for Rarefied Flows*, Von Karman Institute for Fluid Mechanics, Brussels, Belgium, January 2011.

25. "Hybrid Particle-Continuum Methods for Nonequilibrium Gas and Plasma Flows," *27<sup>th</sup> International Symposium on Rarefied Gas Dynamics*, Asilomar, CA, July 2010.
26. "Development of Hybrid DSMC-Continuum Methods for Nonequilibrium Gas and Plasma Flows," *Direct Simulation Monte Carlo: Theory, Methods, and Applications*, Santa Fe, NM, September 2009.
27. "Strongly Coupled Computation of Material Response and Nonequilibrium Flow for Hypersonic Ablation," (with Alexandre Martin), *AFOSR/NASA/SNL Technical Interchange Meeting on Ablation Modeling*, Santa Fe, NM, April 2009.
28. "Simulation of Non-Continuum Hypersonic Flows," *NASA Fundamental Aeronautics Program Annual Meeting*, Atlanta, GA, October 2008.
29. "Direct Simulation Monte Carlo for Atmospheric Entry. 1. Theoretical Basis and Physical Models," *Nonequilibrium Hypersonic Flows*, Von Karman Institute for Fluid Mechanics, Brussels, Belgium, September 2008.
30. "Direct Simulation Monte Carlo for Atmospheric Entry. 2. Code Development and Application Results," *Nonequilibrium Hypersonic Flows*, Von Karman Institute for Fluid Mechanics, Brussels, Belgium, September 2008.
31. "Direct Simulation Monte Carlo for Atmospheric Entry," *Shortcourse on Hypersonic Entry and Cruise Vehicles*, Stanford University, CA, July 2008.
32. "Hybrid Computation of Nonequilibrium Gas and Plasma Flows," *3<sup>rd</sup> ASTRONUM Conference*, St. John, Virgin Islands, June 2008.
33. "Flow and Radiation Analyses of Stardust Entry," *3<sup>rd</sup> Reentry Emission Signatures Workshop*, NASA Ames Research Center, CA, May 2008.
34. "Monte Carlo Simulation of Particle Radiation in High Altitude Solid Rocket Plumes," *43<sup>rd</sup> AIAA Joint Propulsion Conference*, Cincinnati, OH, July 2007.
35. "Particle Simulation of Chemical Nonequilibrium in Hypersonic Gas Flows," *232<sup>nd</sup> Meeting of the American Chemical Society*, San Francisco, CA, September 2006.
36. "Multi-Scale Modeling of Hypersonic Flows," *Hypersonics Workshop*, Minneapolis, MN, October 2005.
37. "Lessons Learned from Modeling In-Space Hall Thruster Plume Experiments," *High-Power Electric Propulsion Test Platform User Workshop*, Houston, TX,

May 2005.

38. "Numerical Simulation of Hall Thruster Plasma Plumes," *9<sup>th</sup> Space Charging Technology Conference*, Tokyo, Japan, April 2005.
39. "Sensitivity Analysis of Near Field Simulations of Plasma Plumes," *Mini Conference on Plasma Propulsion*, Division of Plasma Physics 46<sup>th</sup> Annual Meeting, Savannah, Georgia, November 2004.
40. "Review of Micro-Propulsion Ablative Devices," *International Symposium on Energy Conversion Fundamentals*, Istanbul, Turkey, June 2004.
41. "Hybrid Particle-Continuum Computation of Nonequilibrium Hypersonic Flows," *NASA Marshall Spring Fluids Workshop*, Huntsville, Alabama, April 2004.
42. "Hybrid Particle-Continuum Computation of Multi-Scale Nonequilibrium Gas Flows," *Particle-Based Mesoscale Simulation Techniques Symposium*, University of Minneapolis, Minnesota, April 2004.
43. "Direct Simulation Monte Carlo Method: A Particle Method for Nonequilibrium Gas Flows," *Particle-Based Mesoscale Simulation Techniques Symposium*, University of Minneapolis, Minnesota, March 2004.
44. "Hybrid Particle-Continuum Computation of Nonequilibrium Hypersonic Flows," *Workshop on Multi-Algorithm Methods for Multi-Scale Simulations*, Lawrence Livermore National Laboratory, California, January 2004.
45. "Hybrid Particle-Continuum Computation of Nonequilibrium Hypersonic Flows," *American Mathematical Society Southeastern Section Fall Meeting*, Chapel Hill, North Carolina, October 2003.
46. "The Information Preservation Method: A DSMC Variant With Reduced Statistical Fluctuations," *Workshop on "40 Years of the DSMC Method"*, Milan, Italy, June 2003.
47. "Simulation of Micro-Scale Aerodynamics," *41<sup>st</sup> AIAA Aerospace Sciences Meeting*, Reno, Nevada, January 2003.
48. "Predicting Breakdown of the Continuum Equations Under Rarefied Flow Conditions," *23<sup>rd</sup> International Symposium on Rarefied Gas Dynamics*, Whistler, Canada, July 2002.
49. "Particle Methods for Micro-Scale Gas Flows," *32<sup>nd</sup> AIAA Fluid Dynamics Conference*, St. Louis, Missouri, June 2002.
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247. Spanjers, G.G, Antonsen, E.L., Burton, R.L., Keidar, M., Boyd, I.D., and Bushman, S.S., "Advanced Diagnostics for Millimeter-Scale Micro Pulsed Plasma Thrusters," AIAA Paper 2002-2119, May 2002.
248. Boyd, I.D., "Hall Thruster Far Field Plume Modeling and Comparison to Express Flight Data," AIAA paper 2002-0487, January 2002.
249. Candler, G.V., Nompelis, I., Druguet, M.-C., Holden, M.S., Wadhams, T. P., Boyd, I.D., and Wang, W.-L., "CFD Validation for Hypersonic Flight: Hypersonic Double-Cone Flow Simulations," AIAA Paper 2002-0581, January 2002.
250. Wang, W.-L. and Boyd, I.D., "Continuum Breakdown in Hypersonic Viscous Flows," AIAA Paper 2002-0651, January 2002.
251. Keidar, M., Boyd, I. D., Gulczinski, F. S. III, Antonsen, E. L., and Spanjers, G. G., "Analyses of Teflon Surface Charring and Near Field Plume of a Micro-Pulsed Plasma Thruster," IEPC Paper 01-155, October 2001.
252. Keidar, M., Boyd, I. D., and Beilis, I. I., "Analyses of the Plasma Flow and Presheath Structure in Hall Thrusters," IEPC Paper 01-62, October 2001.



253. Koo, J.W., Boyd, I.D., Haas, J.M., and Gallimore, A.D., "Computation of the Interior Flow of a 2 kW-Class Hall Thruster," AIAA Paper 2001-3321, July 2001.
254. Boyd I.D. and Falk, M.L., "A Review of Spacecraft Material Sputtering by Hall Thruster Plumes," AIAA Paper 2001-3353, July 2001.
255. Katz, I. et al., "A Hall Effect Thruster Plume Model Including Large-Angle Elastic Scattering," AIAA Paper 2001-3355, July 2001.
256. Keidar, M. and Boyd, I.D., "Electromagnetic Effects in the Near Field Plume Exhaust of a Pulsed Plasma Thruster," AIAA Paper 2001-3638, July 2001.
257. Boyd, I.D. and Crofton, M.W., "Grid Erosion Analysis of the T5 Ion Thruster," AIAA Paper 2001-3781, July 2001.
258. Crofton, M.W. and Boyd, I.D., "Plume Measurement and Modeling Results for a Hollow Cathode Micro-Thruster," AIAA Paper 2001-3795, July 2001.
259. Keidar, M., Boyd, I.D., Lepsetz, N., Markusic, T.E., Polzin, K., and Choueiri, E.Y., "Performance Study of the Ablative Z-Pinch Pulsed Plasma Thruster," AIAA Paper 2001-3898, July 2001.
260. Sun, Q., Boyd, I.D., and Candler, G.V., "Numerical Simulation of Gas Flow Over Micro-Scale Airfoils," AIAA Paper 2001-3071, June 2001.
261. Wang, W.L., Boyd, I.D., Candler, G.V., and Nompelis, I., "Particle and Continuum Computations of Hypersonic Flows Over Sharp and Blunted Cones," AIAA Paper 2001-2900, June 2001.
262. Martin, M.J., Kurabayashi, K., and Boyd, I.D., "Measurement of Lift and Drag on MEMS Scale Airfoils in Slip Flow," Paper FEDSM2001-18210, *ASME Fluids Engineering Division Summer Meeting*, New Orleans, LA, May 2001.
263. Boyd, I.D. and Wang, W.-L., "Monte Carlo Computations of Hypersonic Interacting Flows," AIAA Paper 2001-1029, January 2001.
264. Boyd, I.D. and Sun, Q., "Particle Simulation of Micro-Scale Gas Flows," (invited) AIAA Paper 2001-0876, January 2001.
265. Keidar, M. and Boyd, I.D., "Device and Plume Model of an Electrothermal Pulsed Plasma Thruster," AIAA Paper 00-3430, July 2000.

266. Boyd, I.D., Garrigues, L., Koo, J., and Keidar, M., "Progress in Development of a Combined Device/Plume Model for Hall Thrusters," AIAA Paper 00-3520, July 2000.
267. Boyd, I.D. and Crofton, M.W., "A Computational Study of Grid Erosion Through Ion Impact," AIAA Paper 00-3664, July 2000.
268. Wysong, I.J., Dressler, R.A., Chiu, Y.H., and Boyd, I.D., "Evaluation of DSMC Dissociation Models Through Comparison To Measured Cross Sections," AIAA Paper 00-2359, June 2000.
269. Boyd, I.D., "A Review of Hall Thruster Plume Modeling," AIAA Paper 00-0466, January 2000.
270. Boyd, I.D., "Computation of Atmospheric Entry Flow Around a Leonid Meteoroid," AIAA Paper 00-0583, January 2000.
271. Gimelshein, S.F., Boyd, I.D., and Ivanov, M.S., "Modeling of Internal Energy Transfer in Plume Flows of Polyatomic Molecules by the DSMC Method," AIAA Paper 99-0738, January 1999.
272. VanGilder, D.B., Keidar, M. and Boyd, I.D., "Modeling Hall Thruster Plumes Using Particle Methods," AIAA Paper 99-2294, June 1999.
273. Boyd, I.D., Keidar, M. and McKeon, W., "Modeling of a Pulsed Plasma Thruster From Plasma Generation to Plume Far Field," AIAA Paper 99-2300, June 1999.
274. Crofton, M.W. and Boyd, I.D., "The Origins of Accelerator Grid Current: Analysis of T5-Grid Test Results," AIAA Paper 99-2443, June 1999.
275. Gimelshein, S.F., Boyd, I.D., Sun, Q., and Ivanov, M., "DSMC Modeling of Vibration-Translation Energy Transfer in Hypersonic Rarefied Flows," AIAA Paper 99-3451, June 1999.
276. George, J.D. and Boyd, I.D., "Simulation of Nozzle Plume Flows Using a Combined CFD-DSMC Approach," AIAA Paper 99-3454, June 1999.
277. Boyd, I.D., "Nonequilibrium Chemistry Modeling in Rarefied Hypersonic Flows," AIAA Paper 99-3634 (invited), June 1999.
278. Cai, C.-P., Fan, J., Boyd, I.D. and Candler, G.V., "Direct Simulation Methods for Micro-Channel Flows," AIAA Paper 99-3801, June 1999.

279. Fan, J., Boyd, I.D., Cai, C.-P., Hennighausen, K. and Candler, G.V., "Computation of Rarefied Gas Flows Around a NACA 0012 Airfoil," AIAA Paper 99-3804, June 1999.
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282. VanGilder, D.B. and Boyd, I.D., "Analysis of Collision Phenomena in Hall Thruster Plumes," IEPC Paper 99-076, October 1999.
283. Garrigues, L., Boyd, I.D., and Boeuf, J.-P., "Computation of Hall Thruster Performance," IEPC Paper 99-098, October 1999.
284. Keidar, M., Boyd, I.D., and Beilis, I.I., "Particulate Interaction with Plasma in a Teflon Pulsed Plasma Thruster," IEPC Paper 99-213, October 1999.
285. Keidar, M., Boyd, I.D., and Beilis, I.I., "A Model of an Electrical Discharge in a Co-Axial Pulsed Plasma Thruster," IEPC Paper 99-214, October 1999.
286. George, J. D. and Boyd, I.D., "Numerical Investigation of Hydrogen Plume Flows Using Unstructured Grids," AIAA Paper 98-2448, June 1998.
287. Kannenberg, K. C. and Boyd, I.D., "Three Dimensional Monte Carlo Simulations of Plume Impingement," AIAA Paper 98-2755, June 1998.
288. Karipides, D.P., Boyd, I.D. and Caledonia, G.E., "Detailed Simulation of Surface Chemistry Leading to Spacecraft Glow," AIAA Paper 98-2848, June 1998.
289. Longo, S. and Boyd, I.D., "Coupled PIC/MCC and State-to-State Continuum Model of a Parallel-Plate RF Hydrogen Discharge," AIAA Paper 98-2984, June 1998.
290. Burton, R.L. et al., "Overview of US Academic Programs in Electric Propulsion," AIAA Paper 98-3182, July 1998.
291. Boyd, I.D., Kannenberg, K.C., Kossi, K. K., Levin, D.A., and Weaver, D.P., "Modeling the Plume Contamination and Emissions of an Ammonia Arcjet," AIAA Paper 98-3505, July 1998.

292. VanGilder, D.B. and Boyd, I.D., "Particle Simulation of the SPT-100 Hall Thruster Plume," AIAA Paper 98-3797, July 1998.
293. Boyd, I.D., "Computation of the Plume of the D55 Hall Thruster Plume," AIAA Paper 98-3798, July 1998.
294. Boyd, I.D., Kossi, K.K., and Levin, D.A., "Direct Simulation of Ultra-Violet Emission From the Hydroxyl Radical," AIAA Paper 97-2527, Atlanta, GA, June 1997.
295. Boyd, I.D., VanGilder, D.B., and Liu, X., "Monte Carlo Simulations of Neutral Xenon Flow of Electric Proplulsion Devices," IEPC Paper 97-20, September 1997.
296. VanGilder, D.B., Font, G.I., and Boyd, I.D., "Hybrid DSMC-PIC Computation of an Ion Thruster Plume," IEPC Paper 97-182, September 1997.
297. Boyd, I.D., Phillips, W.D., and Levin, D.A., "Sensitivity Studies for Prediction of Ultra-Violet Radiation in Nonequilibrium Hypersonic Bow-Shock Waves," AIAA Paper 97-0131, Reno, NV, January 1997.
298. Holden, M.S., Harvey, J.K., Boyd, I.D., George, J., and Horvath, T., "Experimental and Computational Studies of the Flow Over a Sting-Mounted Planetary Probe Configuration," AIAA Paper 97-0768, January 1997.
299. Font, G.I. and Boyd, I.D., "Numerical Study of the Effects of Reactor Geometry on a Chlorine Helicon Plasma Etch Reactor," Paper 96-0591, AIAA Aerospace Sciences Meeting, Reno, NV, January 1996.
300. Boyd, I.D., Bose, D., and Candler, G.V., "Monte Carlo Modeling of Nitric Oxide Formation Based on Quasi-Classical Trajectory Calculations," Paper 96-1845, AIAA Thermophysics Conference, New Orleans, LA, June 1996.
301. Karipides, D.P., Boyd, I.D., and Caledonia, G.E., "Development of a Monte Carlo Overlay Method With Application to Spacecraft Glow," Paper 96-1847, AIAA Thermophysics Conference, New Orleans, LA, June 1996.
302. Kannenberg, K.C. and Boyd, I.D., "Development of a 3D Parallel DSMC Code for Plume Impingement Studies," Paper 96-1848, AIAA Thermophysics Conference, New Orleans, LA, June 1996.
303. Boyd, I.D., "Monte Carlo Simulation of Nonequilibrium Flow in Low Power Hydrogen Arcjets," (invited) Paper 96-2022, AIAA Fluid Dynamics Conference, New Orleans, LA, June 1996.

304. Muntz, E.P., Lutfy, F., and Boyd, I.D., "Study of Reacting, High-Energy Flows Using Pulsed Electron-Beam Fluorescence," AIAA Paper 96-1986, AIAA Fluid Dynamics Conference, New Orleans, LA, June 1996.
305. Wysong, I.J., Pobst, J.A., and Boyd, I.D., "Comparisons of Hydrogen Atom Measurements in an Arcjet Plume With DSMC Predictions," Paper 96-3185, AIAA Joint Propulsion Conference, Orlando, FL, July 1996.
306. Boyd, I.D., "Monte Carlo Simulation of Hydrogen Arcjet Flow Fields," Paper 96-3297, AIAA Joint Propulsion Conference, Orlando, FL, July 1996.
307. Beiting, E.J., Welle, R.P., Boyd, I.D., and VanGilder, D.B., "Specific Impulse Measurements for a Resistojet: Comparison with Monte Carlo Calculations," Paper 96-3307, AIAA Joint Propulsion Conference, Orlando, FL, July 1996.
308. Boyd, I.D., Karipides, D.P., Candler, G.V., and Levin, D.A., "Dissociation Modeling at High Altitude and Application to the Skipper Flight Experiment," Paper 95-0709, AIAA Aerospace Sciences Meeting, Reno, NV, January 1995.
309. Dietrich, S. and Boyd, I.D., "Parallel Implementation on the IBM SP-2 of the Direct Simulation Monte Carlo Method," AIAA Paper 95-2029, 29th AIAA Thermophysics Conference, San Diego, CA, June 1995.
310. Boyd, I.D. and Srinivasan, A., "Design of Thermochemical Nonequilibrium Experiments for the LENS Hypersonic Facility," AIAA Paper 95-2006, 29th AIAA Thermophysics Conference, San Diego, CA, June 1995.
311. Kannenberg, K.C., Dietrich, S., and Boyd, I.D., "Development of an Object-Oriented Parallel DSMC Code for Plume Impingement Studies," AIAA Paper 95-2052, 29th AIAA Thermophysics Conference, San Diego, CA, June 1995.
312. Karipides, D.P., Boyd, I.D., and Levin, D.A., "Prediction of Ultraviolet Emissions in Rarefied Hypersonic Flow," AIAA Paper 95-2091, 29th AIAA Thermophysics Conference, San Diego, CA, June 1995.
313. Chen, G. and Boyd, I.D., "Statistical Error Analysis for the Direct Simulation Monte Carlo Technique," AIAA Paper 95-2316, 26th AIAA Fluid Dynamics Conference, San Diego, CA, June 1995.
314. Beiting, E.J., Garman, L., Boyd, I.D., and VanGilder, D.B., "CARS Velocity and Temperature Measurements in a Hydrogen Resistojet: Comparison with Monte Carlo Calculation," Paper 95-2382, AIAA Joint Propulsion Conference, San Diego, CA, July 1995.

315. Butler, G.W., Boyd, I.D., and Cappelli, M.A., "Nonequilibrium Flow Phenomena in Low Power Hydrogen Arcjets," Paper 95-2819, AIAA Joint Propulsion Conference, San Diego, CA, July 1995.
316. Boyd, I.D., VanGilder, D.B., Beiting, E.J., Cohen, R.B., Pencil, E.J., and Hirsch, S.D., "Numerical and Experimental Studies of Hydrogen and Nitrogen Flows in a Resistojet," Paper 95-20, 24th International Electric Propulsion Conference, Moscow, Russia, September 1995.
317. Levin, D.A., Candler, G.V., Boyd, I.D., et al., "In-Situ Measurements of Transitional and Continuum Flow UV Radiation from Small Satellite Platforms," Paper 94-0248, AIAA Aerospace Sciences Meeting, Reno, NV, January 1994.
318. Dietrich, S. and Boyd, I.D., "A Scalar Optimized Parallel Implementation of the DSMC Technique," Paper 94-0355, AIAA Aerospace Sciences Meeting, Reno, NV, January 1994.
319. Nijhawan S., Candler, G.V. and Boyd, I.D., "Improved Continuum Modeling of Low-Density Hypersonic Flows," Paper 94-1956, AIAA Thermophysics Conference, Colorado Springs, CO, June 1994.
320. Boyd, I.D., Srinivasan, A., Muntz, E.P., Hanson, R.K. and Holden, M.S., "Thermochemical Nonequilibrium Design Calculations for Detailed Hypervelocity Experiments in the LENS Facility," Paper 94-2097, AIAA Thermophysics Conference, Colorado Springs, CO, June 1994.
321. Boyd, I.D., Chen, G. and Candler, G.V., "Predicting Failure of the Continuum Fluid Equations in Transitional Hypersonic Flows," Paper 94-2352, AIAA Fluid Dynamics Conference, Colorado, Springs, CO, June 1994.
322. Muntz, E.P., Boyd, I.D., and Ketsdever, A., "Rarefied Flow Testing in the 1990's: Measuring Those Phenomena That Are Difficult to Compute," Paper 94-2639, AIAA Thermophysics Conference, Colorado Springs, CO, June 1994.
323. Penko, P.F., Boyd, I.D. and Howell, T.G., "Preliminary Experimental and Numerical Studies of Plume Impingement on a 100 Degree Cone," Paper 94-3142, AIAA Joint Propulsion Conference, Indianapolis, IN, June 1994.
324. Kannenberg, K.C. and Boyd, I.D., "Monte Carlo Computation of Rarefied Supersonic Flow Into a Pitot Probe," Paper 94-3301, AIAA Joint Propulsion Conference, Indianapolis, IN, June 1994.
325. Boyd, I.D. and Gokcen, T., "Computation of Axisymmetric and Ionized Flows Using Particle and Continuum Methods," Paper 93-0729, AIAA Aerospace Sciences Meeting, January 1993.

326. Lumpkin, F.E., Boyd, I.D., and Venkatapathy, E., "Comparison of Continuum and Particle Simulations of Expanding Rarefied Flows," Paper 93-0728, AIAA Aerospace Sciences Meeting, January 1993.
327. Candler, G.V., Boyd, I.D., et al., "Continuum and DSMC Analysis of Bow Shock Flight Experiments," Paper 93-0275, AIAA Aerospace Sciences Meeting, January 1993.
328. Boyd, I.D., Cappelli, M.A., and Beattie, D.R., "Monte Carlo Computation of Nozzle and Plume Flows of a Low-Power Hydrogen Arcjet," Paper 93-2529, AIAA Joint Propulsion Conference, Monterey, CA, June 1993.
329. Penko, P.F., Riley, B., Boyd, I.D., "Assessment of Three Numerical Methods for the Computation of a Low-Density Plume Flow," Paper 93-2530, AIAA Joint Propulsion Conference, Monterey, CA, June 1993.
330. Boyd, I.D., Pham-Van-Diep, G.C., and Muntz, E.P., "Monte Carlo Computation of Nonequilibrium Flow in a Hypersonic Iodine Windtunnel," Paper 93-2871, AIAA Thermophysics Conference, Orlando, FL, July 1993.
331. Pham-Van-Diep, G.C., Muntz, E.P., and Boyd, I.D., "Measurement of Vibrational Population Distributions in a Free-Jet Flow of Chemically Reacting Iodine Vapor and Comparisons With Monte Carlo Predictions," Paper 93-2996, AIAA Fluid Dynamics Conference, Orlando, FL, July 1993.
332. Boyd, I.D., Beattie, D.R., and Cappelli, M.A., "Monte Carlo and Experimental Studies of Chamber Effects for a Low-Power Hydrogen Arcjet," International Electric Propulsion Conference, Seattle, WA, September 1993, .
333. Zelesnik, D., Penko, P.F., and Boyd, I.D., "Effects of Nozzle Geometry on Plume Expansion for Small Thrusters," International Electric Propulsion Conference, Seattle, WA, September 1993.
334. Boyd, I.D. and Gokçen, T., "Assessment of Thermochemical Models for Continuum and Particle Simulations of Hypersonic Flow," Paper 92-2954, AIAA Thermophysics Conference, Nashville, TN, July 1992.
335. Boyd, I.D. and Whiting, E.E., "Decoupled Predictions of Radiative Heating in Air Using a Particle Simulation Method," Paper 92-2971, AIAA Plasmadynamics Conference, Nashville, TN, July 1992.
336. Penko, P.F., Boyd, I.D., Meissner, D.L., and DeWitt, K.J., "Analysis and Measurement of a Small Nozzle Plume in Vacuum," Paper 92-3108, AIAA Joint Propulsion Conference, Nashville, TN, July 1992.
337. Jafry, Y.R., Vanden Beukel, J., Boyd, I.D., and DeBra D.B., "Impingement Calculations for Ultra-Low Density Helium Thrusters," 12th IFAC

- Symposium on Automatic Control in Aerospace, Ottobrun, Germany, September 1992.
338. Haas, B.L. and Boyd, I.D., "Models for Vibrationally-Favored Dissociation Applicable to a Particle Simulation," Paper 91-0774, AIAA Aerospace Sciences Conference, Reno, NV, January 1991.
  339. Boyd, I.D., Penko, P.F., and Meissner, D.L., "Numerical and Experimental Investigations of Rarefied Nozzle and Plume Flows of Nitrogen," Paper 91-1363, AIAA Thermophysics Conference, Honolulu, HI, June 1991.
  340. Penko, P.F., Boyd, I.D., Meissner, D.L., and DeWitt, K.J., "Pressure Measurements in a Low-Density, Nozzle Plume for Code Verification," Paper 91-2110, AIAA Joint Propulsion Conference, Sacramento, CA, June 1991.
  341. Boyd, I.D., "Assessment of Chemical Nonequilibrium in Rarefied Hypersonic Flow," Paper 90-0145, AIAA Aerospace Sciences Meeting, January 1990.
  342. Boyd, I.D., Penko, P.F. and Carney, L.M., "Efficient Monte Carlo Simulation of Rarefied Flow in a Small Nozzle," Paper 90-1693, AIAA Thermophysics Conference, Seattle, WA, June 1990.
  343. Boyd, I.D., "Direct Simulation of Rotational and Vibrational Nonequilibrium," Paper 89-1880, AIAA Thermophysics Conference, Buffalo, NY, June 1989.
  344. Boyd, I.D. and Stark, J.P.W., "Modelling of a Small Hydrazine Thruster Plume in the Transition Flow Regime," Paper 88-2631, AIAA Thermophysics Conference, San Antonio, TX, June 1988.

## **F. Research Seminars**

1. Department of Energy, Headquarters, Washington, DC, May 2019.
2. The Aerospace Corporation, Launch, Strike, & Range, El Segundo, CA, May 2019.
3. University of Colorado, Aerospace Engineering, Boulder, CO, January 2019.
4. University of Illinois, Aerospace Engineering, Urbana-Champaign, IL, December 2018.
5. Raytheon Air & Space Systems, Rosslyn, VA, November 2018.



6. Texas A & M University, Aerospace Engineering, College Station, TX, September 2018.
7. Orbital ATK, Dulles, VA, March 2018.
8. University of Maryland, Mechanical Engineering, College Park, MD, February 2018.
9. George Washington University, Mechanical & Aerospace Engineering, Washington, DC, January 2018.
10. Purdue University, Aeronautics & Astronautics, West Lafayette, IN, December 2017.
11. Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, November 2017.
12. Naval Research Laboratory, Space Technology Division, Washington, DC, October 2017.
13. University of Kentucky, Mechanical Engineering, Lexington, KY, October 2017.
14. Future In-Space Operations Tele-Seminar, September 2017.
15. RAND Corporation, Arlington, VA, May 2017.
16. University of Colorado, Aerospace Engineering, Boulder, CO, April 2017.
17. Aerospace Corporation, El Segundo, CA, March 2014.
18. Air Force Research Laboratory, Propulsion Directorate, Wright-Patterson AFB, OH, May 2011.
19. University of Illinois Urbana-Champaign, Aerospace Engineering, IL, September 2010.
20. NASA Ames Research Center, Moffett Field, CA, July 2010.
21. Air Force Research Laboratory, Propulsion Directorate, Wright-Patterson AFB, OH, August 2009.
22. Air Force Research Laboratory, Air Vehicles Directorate, Wright-Patterson AFB, OH, May 2009.
23. Georgia Institute of Technology, Aerospace Engineering, Atlanta, GA, November 2008.

24. Ohio State University, Aerospace Engineering, Columbus, OH, November 2008.
25. Lawrence Berkeley National Laboratory, Scientific Computing, Berkeley, CA, May 2007.
26. NASA Ames Research Center, Moffett Field, CA, May 2007.
27. University of Virginia, Mechanical & Aerospace Engineering, Charlottesville, VA, March 2007.
28. Lawrence Livermore National Laboratory, Applied Scientific Computing, Livermore, CA, February 2007.
29. University of California Los Angeles, Mechanical & Aerospace Engineering, Los Angeles, CA, February 2007.
30. Air Force Research Laboratory, Propulsion Directorate, Edwards Air Force Base, CA, December 2006.
31. NASA Ames Research Center, Moffett Field, CA, November 2006.
32. Stanford University, Mechanical Engineering, CA, October 2006.
33. Princeton University, Mechanical & Aerospace Engineering, Princeton, NJ, February 2006.
34. Michigan Technological University, Mechanical Engineering, Houghton, MI, Dec. 2005.
35. Queen Mary University of London, Department of Engineering, England, April 2005.
36. University of Michigan, Aerospace Engineering, Ann Arbor, MI, October 2004.
37. Virginia Tech, Aerospace & Oceanic Engineering, Blacksburg, VA, October 2004.
38. University of Glasgow, Aerospace Engineering, Scotland, July 2004.
39. NASA Marshall Space Flight Center, Huntsville, AL, April 2004.
40. Aerojet Corporation, Redmond, WA, January 2004.
41. University of Michigan, Aerospace Engineering, September 2003.
42. Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, April 2003.
43. University of Maryland, Aerospace Engineering, College Park, MD, April 2003.

44. University of Michigan, Mathematics, Ann Arbor, MI, January 2003.
45. Air Force Research Laboratory, Propulsion Directorate, Edwards Air Force Base, CA, October 2002.
46. Air Force Research Laboratory, Air Vehicles Directorate, Wright-Patterson AFB, OH, April 2002.
47. Arnold Engineering and Development Center, Arnold AFB, TN, February 2002.
48. Mechanical Engineering, Vanderbilt University, Nashville, TN, September 2001.
49. NASA Marshall Space Flight Center, Advanced Propulsion Center, Huntsville, AL, April 2001.
50. TRW, Propulsion Division, Redondo Beach, CA, January 2001.
51. California Institute of Technology, Aeronautics, Pasadena, CA, October 2000.
52. Jet Propulsion Laboratory, Advanced Propulsion, Pasadena, CA, October 2000.
53. Aerospace Corporation, Los Angeles, CA, October 2000.
54. Ohio State University, Mechanical Engineering, Columbus, OH, April 2000.
55. University of Minnesota, Aerospace Engineering, Minneapolis, MN, April 1999.
56. Air Force Research Laboratory, Space Vehicles Directorate, Hanscom Air Force Base, Boston, MA, March 1999.
57. Universite Paul Sabatier, Plasma Physics, Toulouse, France, January 1999.
58. University of Illinois-Urbana Champaign, Aeronautics & Astronautics, IL, December 1998.
59. NASA Lewis Research Center, Cleveland, OH, November 1998.
60. University of Michigan, Aerospace Engineering, Ann Arbor, MI, October 1998.
61. Worcester Polytechnic Institute, Mechanical Engineering, MA, September 1998.
62. Brown University, Applied Mathematics, Providence, RI, September 1998.
63. CERCA, Montreal, Canada, May 1998.

64. Pennsylvania State University, Aerospace Engineering, State Park, PA, March 1997.
65. Princeton University, Applied Physics, Princeton, NJ, December 1996.
66. NASA Lewis Research Center, Cleveland, OH, September 1996.
67. Stanford University, Mechanical Engineering, CA, April 1996.
68. NASA Ames Research Center, Moffett Field, CA, April 1996.
69. Air Force Research Laboratory, Space Vehicles Directorate, Hanscom Air Force Base, Boston, MA, March 1996.
70. Ohio State University, Mechanical Engineering, Columbus, OH, October 1995.
71. NASA Lewis Research Center, Cleveland, OH, August 1995.
72. Physical Sciences Incorporated, Andover, MA, August 1995.
73. Aerospace Corporation, Los Angeles, CA, July 1995.
74. Air Force Phillips Laboratory, Edwards Air Force Base, CA, July 1995.
75. Massachusetts Institute of Technology, Space Propulsion Group, Cambridge, MA, April 1995.
76. Syracuse University, Mechanical and Aerospace Engineering, NY, December 1994.
77. Science Applications International Corporation, McLean, VA, August 1994.
78. NASA Lewis Research Center, Cleveland, OH, May 1994.
79. NASA Ames Research Center, Moffett Field, CA, March 1994.
80. NASA Langley Research Center, Hampton, VA, January 1994.
81. NASA Lewis Research Center, Cleveland, OH, July 1993.
82. CALSPAN Corporation, Buffalo, NY, July 1993.
83. NASA Ames Research Center, Moffett Field, CA, April 1993.
84. Stanford University, Mechanical Engineering, Stanford, CA, November 1992.
85. University of Southern California, Aerospace Engineering, Los Angeles, CA, November 1992.
86. University of Virginia, Aerospace Engineering, Charlottesville, VA, April 1992.
87. Massachusetts Institute of Technology, Aeronautics and Astronautics, Cambridge, MA, April 1992.

88. University of California San Diego, Applied Mechanics and Engineering Science, San Diego, CA, March 1992.
89. NASA Lewis Research Center, Cleveland, OH, March 1992.
90. Pennsylvania State University, Aerospace Engineering, PA, March 1992.
91. Cornell University, Mechanical and Aerospace Engineering, NY, February 1992.
92. Stanford University, Aeronautics and Astronautics, CA, October 1991.
93. CNRS, Laboratoire D'Aerothermique, Meudon, France, April 1991.
94. NASA Lewis Research Center, Cleveland, OH, March 1991.
95. University of Southern California, Aerospace Engineering, CA, March 1990.
96. University of California, Mechanical Engineering, Berkeley, CA, August 1989.
97. University of Kaiserslautern, Applied Mathematics, Germany, September 1987.