



Christopher S. Combs

Dee Howard Faculty Fellow and Assistant Professor
Department of Mechanical Engineering
The University of Texas at San Antonio
One UTSA Circle, EB 3.04.26
San Antonio, TX 78249
ccombs@utsa.edu
210-458-8288

EDUCATION

The University of Texas at Austin, Austin, TX August 2015
Ph.D. Aerospace Engineering

University of Evansville, Evansville, IN May 2010
B.S. Mechanical Engineering

RESEARCH EXPERIENCE

The University of Texas at San Antonio, San Antonio, TX August 2018-*Present*
Associate Professor, Dee Howard Faculty Fellow September 2023-*Present*
Assistant Professor, Dee Howard Faculty Fellow August 2018-August 2023
Director, Center for Advanced Measurements in Extreme Environments (CAMEE) January 2023-*Present*
Aerospace Program Director March 2023-*Present*
Associate Dean for Research Fellow, Klesse College of Engineering & Integrated Design March 2023-*Present*

The University of Tennessee Space Institute, Tullahoma, TN August 2015-August 2018
Research Assistant Professor

The University of Texas at Austin, Austin, TX June 2010-August 2015
Graduate Research Assistant

NASA Langley Research Center, Hampton, VA June 2012-August 2015
Visiting NSTRF Fellow

NASA Ames Research Center, Moffett Field, CA May 2014-August 2015
Visiting NSTRF Fellow

TEACHING EXPERIENCE

The University of Texas at San Antonio, San Antonio, TX
Instructor, Measurements & Instrumentation Fall 2018, Fall 2021, Spring 2023
Instructor, Experimental Methods in Engineering Spring 2019, Fall 2020, Spring 2022, Fall 2022
Instructor, Gas Dynamics Fall 2019
Instructor, Fluid Mechanics Spring 2021

The University of Tennessee Space Institute, Tullahoma, TN Summer 2017
Instructor, Engineering Optics

The University of Texas at Austin, Austin, TX
Instructor, High-Speed Aerodynamics Laboratory Spring 2014, Fall 2014, Spring 2015
Teaching Assistant, High-Speed Aerodynamics Laboratory Fall 2010-Fall 2013
Teaching Assistant, Compressible Flow Spring 2011

HONORS & AWARDS

- Dee Howard Endowed Faculty Fellow, 2018 – *Present*
- NSF CAREER Awardee, 2023
- UTSA College of Engineering & Integrated Design Excellence in Research Award, 2022
- UTSA College of Engineering & Integrated Design E-Week Best Lab Exhibit, 2022
- UTSA Mechanical Engineering Department Highest Research Expenditure Award (Asst. Prof.), 2021
- UTSA Mechanical Engineering Department Highest Graduate Student Support Award, 2021
- Co-author on first place paper at AIAA International Student Conference, 2020
- Finalist for UTSA Presidential Distinguished Achievement Award in Research Achievement, 2020
- UTSA Mechanical Engineering Department Research Achievement Award, 2020
- Air Force Office of Scientific Research Young Investigator Program Awardee, 2019
- AIAA Tennessee Section Special Award for Research Achievement, 2019
- NASA Space Technology Research Fellowship, 2011 - 2015
- Temple Foundation Graduate Fellowship, 2014 - 2015
- AIAA Aerodynamic Measurement Technology Best Paper, January 2013
- John and Mary Wheeler Endowed Graduate Fellowship, 2011 - 2012
- Indiana Space Grant Consortium Scholarship, 2008 – 2010

PROFESSIONAL MEMBERSHIP

- Senior Member of the American Institute of Aeronautics and Astronautics (AIAA)
- Member of the AIAA Aerodynamic Measurement Technology Technical Committee
- Faculty Mentor for AIAA Student Chapter at UTSA
- Member of the American Physical Society (APS)
- Member of the American Society of Mechanical Engineers (ASME)
- Member of the Dee Howard Foundation Board of Directors & Educational Advisory Board
- Member of the San Antonio Chamber of Commerce Aerospace Committee
- Co-Chair of the AIAA AVIATION Aerodynamic Measurement Technology Conference 2019
- Chair of the AIAA SciTech Aerodynamic Measurement Technology Conference 2021
- Organizer of invited special session “Highlighting Women in Aerodynamic Measurement Technology” for the 2021 AIAA SciTech Conference
- Organizer of invited special sessions on High Enthalpy Optical Diagnostics for the 2018 AIAA AVIATION Conference
- Member of 2016 AIAA Ablation Workshop Organizational Committee
- Reviewer for several peer-reviewed publications including Journal of Fluid Mechanics, Experiments in Fluids, Applied Optics, AIAA Journal, Aerospace Science & Technology, and Experimental Thermal & Fluid Science

PUBLICATIONS (*indicates student)

1. Hoffman, E. N. A.,* E. J. LaLonde,* A. Andrade,* I. Chen,* H. Bilbo,* and **C. S. Combs**, “Flow Characterization of the UTSA Hypersonic Ludwig Tube,” *Aerospace*, Vol. 10, No. 5, 2023, p. 463. doi: 10.3390/aerospace10050463
2. Andrade, A.,* E. N. A. Hoffman,* E. J. LaLonde,* **C. S. Combs**, “Velocity Measurements in Hypersonic Flow using Molecular Tagging Velocimetry,” *Optics Express*, Vol. 30, No. 23, 2022, pp. 42199-42213. doi: 10.1364/OE.474841
3. Garcia, M.,* E. N. A. Hoffman,* E. J. LaLonde,* **C. S. Combs**, M. Pohlman, C. Smith, M. Gragston, and J. D. Schmisser, “Effects of Surface Roughness on Shock-Wave/Boundary-Layer Interaction using a Hollow Cylinder Flare Model,” *Fluids*, Vol. 7, No. 9, 2022. doi: 10.3390/fluids7090286

4. Kocher, B. D.,* P. A. Kreth, J. D. Schmisser, E. LaLonde,* and **C. S. Combs**, “Investigation of the Streamwise Development of Distributed Surface Roughness Effects on Supersonic Flows,” *ALAA Journal*, Vol. 60, No. 9, 2022. doi: 10.2514/1.J061623
5. Portillo, D.J,* E. Hoffman,* M. Garcia,* E. LaLonde,* **C. S. Combs**, and R. L. Hood, “The Effects of Compressibility on the Performance and Modal Structures of a Sweeping Jet Emitted from Various Scales of a Fluidic Oscillator,” *Fluids*, Vol. 7, No. 7, 2022. doi: 10.3390/fluids7070251
6. Patel, R. C.,* D. C. Bass,* G. P. Dukuze,* and **C. S. Combs**, “Development of a Small-Scale supercritical Carbon Dioxide (sCO₂) Brayton Cycle,” *Energies*, Vol. 15, No. 10, 2022. doi: 10.3390/en15103580
7. Hoffman, E. N. A.,* J. M. Rodriguez,* S. M. Cottier,* **C. S. Combs**, B. F. Bathel, J. M. Weisberger, S. B. Jones, P. A. Kreth, and J. D. Schmisser, “Modal Analysis of Cylinder-Induced Transitional Shock-Wave/Boundary-Layer Interaction Unsteadiness,” *ALAA Journal*, Vol. 60, No. 5, 2022, pp. 2730-2748. doi: 10.2514/1.J060880
8. Bhanot, K., R. Patel,* and **C. S. Combs**, “Are There Different Shades of Green? – The “Greenium” in Power Generation,” *Journal of Fixed Income*, Feb. 2022. doi: 10.3905/jfi.2022.1.129
9. Murphree, Z. R., **C. S. Combs**, W. M. Yu,* D. S. Dolling, and N. T. Clemens, “Physics of Unsteady Cylinder-Induced Shock-Wave/Transitional Boundary-Layer Interactions,” *Journal of Fluid Mechanics*, Vol. 918, July 2021, A39.
10. Lindörfer, S. A.,* **C. S. Combs**, P. A. Kreth, R. B. Bond, and J. D. Schmisser, “Scaling of cylinder-generated shock-wave/turbulent boundary-layer interactions,” *Shock Waves*, Vol. 30, No. 4, 2020, pp. 395-407.
11. **Combs, C. S.** and N. T. Clemens, “Simultaneous Measurements of Scalar and Velocity using Naphthalene Planar Laser-Induced Fluorescence,” *ALAA Journal*, Vol. 57, No. 11, 2019, pp. 5054-5060.
12. **Combs, C. S.**, J. D. Schmisser, B. F. Bathel, and S. B. Jones, “Unsteady Analysis of Shock-Wave/Boundary-Layer Interaction Experiments at Mach 4.2,” *ALAA Journal*, Vol. 57, No. 11, 2019, pp. 4715-4724.
13. **Combs, C. S.**, E. L. Lash,* P. A. Kreth, and J. D. Schmisser, “Investigating the Unsteady Dynamics of Cylinder-Induced Shock-Wave/Transitional Boundary-Layer Interactions,” *ALAA Journal*, Vol. 56, No. 4, 2018, pp.1588-1599.
14. **Combs, C. S.**, P. A. Kreth, J. D. Schmisser, and E. L. Lash,* “An Image-Based Analysis of Shock Wave-Boundary Layer Interaction Unsteadiness,” *ALAA Journal*, Vol. 56, No. 3, 2018, pp. 1288-1293.
15. **Combs, C. S.**, N. T. Clemens, P. M. Danehy, and S. M. Murman, “Heat Shield Ablation Visualized using Naphthalene Planar Laser-Induced Fluorescence,” *Journal of Spacecraft and Rockets*, Vol. 54, No. 2, 2017, pp. 476-494.
16. **Combs, C. S.**, B. J. Lochman, and N. T. Clemens, “Technique for Studying Ablation-Products Transport in Supersonic Boundary Layers by using PLIF of Naphthalene,” *Experiments in Fluids*, Vol. 57, No. 89, 2016, pp. 1-14.
17. **Combs, C. S.** and N. T. Clemens, “Naphthalene Laser-Induced Fluorescence Measurements at Low Temperature and Pressure,” *Applied Optics*, Vol. 55, No. 13, 2016, pp. 3656-3669.
18. **Combs, C. S.**, N. T. Clemens, P. M. Danehy, B. Bathel, R. Parker, T. Wadhams, M. Holden, and B. Kirk, “Fluorescence Imaging of Reaction Control Jets and Backshell Aeroheating of Orion Capsule,” *Journal of Spacecraft and Rockets*, Vol. 52, 2015, pp. 243-252.

19. Guo, X., H. Zhao, H. Song, E. Zhang, **C. S. Combs**, N. T. Clemens, X. Chen, K. K. Li, Y. K. Zou, and Hua Jiang, "Upconverting Phosphor Thermometry for High Temperature Sensing Applications," *Sensors & Transducers*, Vol. 13, 2011, pp. 124-130.
20. LaLonde, E. J.,* E. N. A. Hoffman,* **C. S. Combs**, B. F. Bathel, J. M. Weisberger, "Characterization and Optimization of a Self-Aligning Focusing Schlieren System," *Optics Express*, in preparation.

CONFERENCE PROCEEDINGS & PRESENTATIONS (*indicates student)

1. Dhanagopal, A.,* C. Williamson,* E. J. LaLonde,* S. Gutierrez,* V. Delgado,* A. Andrade,* and **C. S. Combs**., "High-Speed Pressure Sensitive Paint Measurements of the Initial Concept 3. X Vehicle at Mach 7," AIAA Paper 2023-1179, AIAA SciTech 2023, National Harbor, MD, Jan 23-27, 2023.
2. Hoffman, E. N.,* D. M. Kendhammer,* E. J. LaLonde,* A. Andrade,* and **C. S. Combs**, "Effects of distributed roughness on shock-wave/boundary-layer interactions at Mach 7.2," AIAA Paper 2023-0268, AIAA SciTech 2023, National Harbor, MD, Jan 23-27, 2023.
3. Andrade, A.,* E. J. LaLonde,* E. N. Hoffman,* S. Gutierrez,* and **C. S. Combs**, "Application of Pressure-Sensitive Paint to Investigate Hypersonic Shock-Wave/Boundary-Layer Interactions," AIAA Paper 2023-1178, AIAA SciTech 2023, National Harbor, MD, Jan 23-27, 2023.
4. Hoffman, E. N. A.,* E. J. LaLonde,* M. Garcia,* V. Delgado,* I. Chen,* H. Bilbo,* and **C. S. Combs**, "Characterization of the UTSA Mach 7 Ludwig Tube," AIAA Paper 2022-1600, AIAA SciTech 2022, San Diego, CA, Jan. 3-7, 2022.
5. Bueno, P. C., N. J. Mueschke, E. J. LaLonde,* and **C. S. Combs**, "Spectroscopic Imaging of the Flow Around Hypersonic Vehicles," AIAA Paper 2022-2224, AIAA SciTech 2022, San Diego, CA, Jan. 3-7, 2022.
6. Hoffman, E. N. A.,* J. M. Rodriguez,* M. Garcia,* V. Delgado,* E. LaLonde,* and **C. S. Combs**, "Preliminary Testing of the UTSA Mach 7 Ludwig Tube," AIAA Paper 2021-2979, AIAA AVIATION 2021, Virtual Event, July 26-30, 2021.
7. Portillo, D.J.,* E. Hoffman,* M. Garcia,* E. LaLonde,* E. Hernandez,* **C. S. Combs**, and R. L. Hood, "Modal Analysis of a Sweeping Jet Emitted by a Fluidic Oscillator," AIAA Paper 2021-2835, AIAA AVIATION 2021, Virtual Event, July 26-30, 2021.
8. Hoffman, E. N. A.,* J. M. Rodriguez,* M. Garcia,* V. Delgado,* E. LaLonde,* and **C. S. Combs**, "Update on the construction of the UTSA Mach 7 Ludwig Tube," AIAA SciTech 2021, Virtual Event, Jan. 11-21, 2021. (Invited).
9. Rodriguez, J. M.,* E. N. A. Hoffman,* **C. S. Combs**, B. F. Bathel, J. M. Weisberger, S. B. Jones, P. A. Kreth, and J. D. Schmisser, "Shock-Wave/Boundary-Layer Interaction (SWBLI) Experiments in the Presence of Transition-to-Turbulence on a Flat Plate Model in the NASA LaRC 31-Inch Mach 10 Air Tunnel," AIAA SciTech 2021, Virtual Event, Jan. 11-21, 2021. (Invited).
10. Portillo, D.J.,* I. Bashor,* E. Hoffman,* M. Garcia,* E. Hernandez,* **C. S. Combs**, and R. L. Hood, "Optimizing a Fluidic Oscillator for Organ Preservation," ASME Fluids Engineering Division Summer Meeting, Virtual Event, July 13-15th, 2020.
11. Hoffman, E.,* I. P. Bashor,* and **C. S. Combs**, "Construction of a Mach 7 Ludwig Tube at UTSA," AIAA Paper 2020-2998, AIAA AVIATION 2020, Virtual Event, Jun. 15-19, 2020. (Invited)

12. Bashor, I. P.,* E. Hoffman,* J. Delimont, and **C. S. Combs**, “Developing Non-Intrusive Diagnostics for the Characterization of Direct-Fired sCO₂ Flows,” Paper #48, 7th International Supercritical CO₂ Power Cycles Symposium, San Antonio, TX, Mar. 31-Apr. 2, 2020. (Cancelled due to COVID-19)
13. Cottier, S. M.,* **C. S. Combs**, and L. Vanstone, “Spectral Proper Orthogonal Decomposition Analysis of Shock-Wave/Boundary-Layer Interactions,” AIAA SciTech 2020, Orlando, FL, Jan 6-10, 2020. (Invited)
14. Schmisser, J. S., J. Coder, M. Gragston, R. Glasby, R. Bowersox, and **C. S. Combs**, “Low-Frequency Unsteadiness in Transitional Shock/Boundary Layer Interactions,” AIAA SciTech 2020, Orlando, FL, Jan 6-10, 2020. (Invited)
15. Cottier, S. M.,* **C. S. Combs**, and L. Vanstone, “Spectral Proper Orthogonal Decomposition Analysis of Shock-Wave/Boundary-Layer Interactions,” AIAA Paper 2019-3331, AIAA AVIATION 2019, Dallas, TX, Jun. 17-21, 2019.
16. Bashor, I. P.,* E. Hoffman,* G. Gonzalez,* and **C. S. Combs**, “Design and Preliminary Calibration of the UTSA Mach 7 Hypersonic Ludwig Tube,” AIAA Paper 2019-2859, AIAA AVIATION 2019, Dallas, TX, Jun. 17-21, 2019.
17. Bathel, B. F., S. B. Jones, A. N. Watkins, S. Berry, K. Goodman, **C. S. Combs**, J. D. Schmisser, “Shockwave/Boundary-Layer Interaction Studies Performed in the NASA Langley 20-Inch Mach 6 Air Tunnel,” AIAA Paper 2019-2904, AIAA AVIATION 2019, Dallas, TX, Jun. 17-21, 2019.
18. **Combs, C. S.**, John D. Schmisser, Brett F. Bathel, and Stephen B. Jones, “Analysis of Shock-Wave/Boundary-Layer Interaction Experiments at Mach 1.8 and Mach 4.2,” AIAA Paper 2019-0344, AIAA SciTech 2019, San Diego, CA, Jan. 7-11, 2019.
19. Ogg, D. R., B. E. Rice, S. J. Peltier, J. T. Staines, S. L. Claucherty, and **C. S. Combs**, “Simultaneous Stereo Digital Image Correlation and Pressure-Sensitive Paint Measurements of a Compliant Panel in a Mach 2 Wind Tunnel,” AIAA Paper 2018-3869, 2018 AIAA Fluid Dynamics Conference, Atlanta, GA, Jun. 25-29, 2018.
20. Kocher, B. D.,* **C. S. Combs**, P. A. Kreth, and J. D. Schmisser, “Investigation of the Streamwise Development of Distributed Surface Roughness Effects on Supersonic Flows,” AIAA Paper 2018-4047, 2018 AIAA Fluid Dynamics Conference, Atlanta, GA, Jun. 25-29, 2018.
21. Tester, B. W.,* J. G. Coder, **C. S. Combs**, and J. D. Schmisser, “Hybrid RANS/LES Simulation of Transitional Shockwave/Boundary-Layer Interaction,” AIAA Paper 2018-3224, 2018 AIAA Fluid Dynamics Conference, Atlanta, GA, Jun. 25-29, 2018.
22. Rice, B. E., J. A. McKenzie, S. J. Peltier, **C. S. Combs**, B. S. Thurow, C. J. Clifford, and K. Johnson, “Comparison of 4-camera Tomographic PIV and Single-camera Plenoptic PIV,” AIAA Paper 2018-2036, 56th AIAA Aerospace Sciences Meeting and Exhibit, Orlando, FL, Jan. 8-12, 2018.
23. Harris, A. J.,* P. A. Kreth, **C. S. Combs**, and J. D. Schmisser, “Laser Differential Interferometry and Schlieren as an Approach to Characterizing Freestream Disturbance Levels,” AIAA Paper 2018-1100, 56th AIAA Aerospace Sciences Meeting and Exhibit, Orlando, FL, Jan. 8-12, 2018.
24. Sweetland, K.,* **C. S. Combs**, J. D. Schmisser, R. Rhodes, F.-Y. Zhang, T. M. Moeller, D. H. Plemmons, “Development of MIR TLAS System with Applications to Reacting Hot Gas Flows,” AIAA Paper 2018-1023, 56th AIAA Aerospace Sciences Meeting and Exhibit, Orlando, FL, Jan. 8-12, 2018.

25. Lindörfer, S. A.,* **C. S. Combs**, R. B. Bond, and J. D. Schmisser, “The Role of Boundary-Layer Thickness on Cylinder-Generated Shock-Wave/Turbulent Boundary-Layer Interactions, Part I: Computations,” AIAA Paper 2018-0380, 56th AIAA Aerospace Sciences Meeting and Exhibit, Orlando, FL, Jan. 8-12, 2018.
26. **Combs, C. S.**, S. A. Lindörfer,* P. A. Kreth, and J. D. Schmisser, “The Role of Boundary-Layer Thickness on Cylinder-Generated Shock-Wave/Turbulent Boundary-Layer Interactions, Part II: Experiments,” AIAA Paper 2018-0824, 56th AIAA Aerospace Sciences Meeting and Exhibit, Orlando, FL, Jan. 8-12, 2018.
27. Kocher, B. D.,* **C. S. Combs**, P. A. Kreth, J. D. Schmisser, and S. J. Peltier, “Investigation of the Effects of Distributed Surface Roughness on Supersonic Flows,” AIAA Paper 2017-4313, 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference, Denver, CO, Jun. 5-9, 2017.
28. Lash, E. L.,* **C. S. Combs**, P. A. Kreth, and J. D. Schmisser, “Study of the Dynamics of Transitional Shock Wave-Boundary Layer Interactions using Optical Diagnostics,” AIAA Paper 2017-3123, 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference, Denver, CO, Jun. 5-9, 2017.
29. Tester, B. W.,* J. G. Coder, **C. S. Combs**, and J. D. Schmisser, “Simulation of Transitional Shockwave/Boundary-Layer Interaction Using Advanced RANS-based Modeling,” AIAA Paper 2017-4315, 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference, Denver, CO, Jun. 5-9, 2017.
30. Lindörfer, S. A.,* **C. S. Combs**, P. A. Kreth, and J. D. Schmisser, “Limiting Cases for Cylinder-Induced Shock Wave/Boundary Layer Interactions,” AIAA Paper 2017-4311, 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference, Denver, CO, Jun. 5-9, 2017.
31. Lash, E. L.,* **C. S. Combs**, P. A. Kreth, and J. D. Schmisser, “Experimental Investigation of a Cylinder-Induced Transitional Shock Wave-Boundary Layer Interaction,” AIAA Paper 2017-0760, 55th AIAA Aerospace Sciences Meeting and Exhibit, Grapevine, TX, Jan. 9-13, 2017.
32. Lindörfer, S. A.,* **C. S. Combs**, P. A. Kreth, and J. D. Schmisser, “Numerical Simulations of a Cylinder-Induced Shock Wave/Boundary Layer Interaction,” AIAA Paper 2017-0534, 55th AIAA Aerospace Sciences Meeting and Exhibit, Grapevine, TX, Jan. 9-13, 2017.
33. **Combs, C. S.**, J. D. Schmisser, and J. C. Margiotta, “Update on DARPA’s Materials Development for Platforms Program,” 8th AIAA Ablation Workshop, Tucson, AZ, Oct. 5-6, 2016.
34. **Combs, C. S.**, E. L. Lash,* and J. D. Schmisser, “Investigation of a Cylinder-Induced Transitional Shock Wave-Boundary Layer Interaction using Laser Diagnostics,” AIAA Paper 2016-4321, 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference, Washington, D.C., Jun. 13-17, 2016.
35. Lash, E. L.,* **C. S. Combs**, J. D. Schmisser, P. A. Kreth, and E. A. Beckman, “Developing an Image-Based Analysis of the Dynamics of Transitional Shock Wave-Boundary Layer Interactions,” AIAA Paper 2016-4320, 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference, Washington, D.C., Jun. 13-17, 2016.
36. Lindörfer, S. A.,* P. Anusonti-Inthra, J. D. Schmisser, and **C. S. Combs**, “An Investigation of the Role of an Upstream Burst Diaphragm on Flow Quality within a Ludwieg Tube using RANS,” AIAA Paper 2016-3801, 46th AIAA Fluid Dynamics Conference, Washington, D.C., Jun. 13-17, 2016.
37. **Combs, C. S.** and N. T. Clemens, “Simultaneous Measurements of Scalar and Velocity in a Mach 5 Turbulent Boundary Layer using Naphthalene PLIF and PIV,” AIAA Paper 2016- 1761, 54th AIAA Aerospace Sciences Meeting and Exhibit, San Diego, CA, Jan. 4-8, 2016.

38. **Combs, C. S.** and N. T. Clemens, “Quantitative Measurements of Ablation-Products Transport in a Mach 5 Boundary Layer using Naphthalene PLIF,” 7th AIAA Ablation Workshop, Tullahoma, TN, Oct. 21-22, 2015.
39. **Combs, C. S.** and N. T. Clemens, “Quantitative Measurements of Ablation-Products Transport in a Supersonic Turbulent Boundary Layer using Simultaneous PIV and Naphthalene PLIF,” Ninth International Symposium on Turbulence and Shear Flow Phenomena, Melbourne, Australia, June 30-July 3, 2015.
40. **Combs, C. S.** and N. T. Clemens, “Measurements of Ablation-Products Transport in a Mach 5 Turbulent Boundary Layer using Naphthalene PLIF,” AIAA Paper 2015-1912, 53rd AIAA Aerospace Sciences Meeting and Exhibit, Kissimmee, FL, Jan. 5-9, 2015.
41. **Combs, C. S.** and N. T. Clemens, “Development of Naphthalene PLIF for Making Quantitative Measurements of Ablation Products Transport in Supersonic Flows,” 67th Annual Meeting of the APS Division of Fluid Dynamics, San Francisco, CA, Nov. 23-25, 2014.
42. **Combs, C. S.**, N. T. Clemens, and P. M. Danehy, “Visualization of Capsule Reentry Vehicle Heat Shield Ablation using Naphthalene PLIF,” 17th Int’l Symp. on Applications of Laser Techniques to Fluid Mechanics, Lisbon, Portugal, July 7-10, 2014.
43. **Combs, C. S.**, N. T. Clemens, and P. M. Danehy, “Development of Naphthalene PLIF for Visualizing Ablation Products from a Space Capsule Heat Shield,” AIAA Paper 2014-1152, 52nd AIAA Aerospace Sciences Meeting and Exhibit, National Harbor, MD, Jan. 13-17, 2014.
44. **Combs, C. S.**, N. T. Clemens, and P. M. Danehy, “Naphthalene Planar Laser-Induced Fluorescence Imaging of Orion Multi-Purpose Crew Vehicle Heat Shield Ablation Products,” 66th Annual Meeting of the APS Division of Fluid Dynamics, Pittsburgh, PA, Nov. 24-26, 2013.
45. Burns, R. J., **C. S. Combs**, and N. T. Clemens, “Development of Krypton Planar Laser-Induced Fluorescence for Supersonic Flow Environments,” 66th Annual Meeting of the APS Division of Fluid Dynamics, Pittsburgh, PA, Nov. 24-26, 2013.
46. **Combs, C. S.**, N. T. Clemens, P. M. Danehy, B. Bathel, R. Parker, T. Wadhams, M. Holden, and B. Kirk, “NO PLIF Visualizations of the Orion Capsule in LENS-I” AIAA Paper 2013-0033, 51st AIAA Aerospace Sciences Meeting and Exhibit, Grapevine, TX, Jan. 7-10, 2013.
47. **Combs, C. S.**, N. T. Clemens, and P. M. Danehy, “Visualization of Capsule Reentry Vehicle Heat Shield Ablation using Naphthalene Planar Laser-Induced Fluorescence Imaging,” 65th Annual Meeting of the APS Division of Fluid Dynamics, San Diego, CA, Nov. 18-20, 2012.
48. **Combs, C. S.**, N. T. Clemens, X. Guo, H. Song, H. Zhao, K. K. Li, Y. K. Zou, and H. Jiang, “High-Temperature Surface Thermometry Technique based on Upconversion Nano-Phosphors,” 64th Annual Meeting of the APS Division of Fluid Dynamics, Baltimore, MD, Nov. 20-22, 2011.
49. Guo, X., H. Zhao, H. Song, Q. Chen, K.K. Li, Y.K. Zou, H. Jiang, **C. S. Combs**, V. Narayanaswamy, and N. T. Clemens, “Upconverting Nanophosphors for High Temperature Sensing Applications,” Nanotech 2011, Vol. 1, 2011, pp. 429-433.

INVITED PRESENTATIONS

1. UTEP Advanced Modeling & Simulations Research Seminar, El Paso, TX (*virtual*), “Recent advances in optical diagnostics for hypersonic flows at UTSA,” Mar. 2023.
2. NASA Ames Research Center Entry Systems Technology Division Seminar, Moffett Field, CA (*virtual*), “Hypersonic test capabilities & workforce development at UTSA,” Jan. 2023
3. NASA Langley Research Center Contractor Steering Council, Hampton, VA (*virtual*), “Hypersonic test capabilities & workforce development at UTSA,” Oct. 2022
4. Joint Army-Navy-NASA-Air Force (JANNAF) Summer Meeting, Hampton, VA, “The New Hypersonic Wind Tunnel Facility and Experimental Research at UTSA,” Jun. 2022.
5. National Summit on Hypersonic Weapon Systems, Washington, D.C., “Advancements in High-Enthalpy Testing & Software Simulation,” Apr. 2022.
6. NASA In Your Neighborhood: X-59 Event, Arlington, TX, “Aerospace Engineering at UTSA,” Apr. 2022.
7. Universidad de Santiago de Chile, Santiago, Chile, “High-Speed Aerodynamics Research at UTSA,” Oct. 2020.
8. The University of Texas at Austin, Austin, TX, “Investigations of Cylinder-Generated Shock-Wave/Boundary-Layer Interactions,” Dec. 2019.
9. SpaceATX Forum, Austin, TX, “Hypersonics and the New Space Race,” Nov. 2019.
10. Texas A&M University, College Station, TX, “Design considerations and analysis of Ludwig tube wind tunnels,” Feb. 2019.
11. Air Force Institute of Technology, Wright-Patterson AFB, OH, “Investigations of Cylinder-Generated Shock-Wave/Boundary-Layer Interactions,” Apr. 2018.
12. Arizona State University, Tempe, AZ, “Investigations of Cylinder-Generated Shock-Wave/Boundary-Layer Interactions,” Mar. 2018.
13. University of Colorado Boulder, Boulder, CO, “Investigations of Cylinder-Generated Shock-Wave/Boundary-Layer Interactions,” Mar. 2018.
14. The University of Texas at San Antonio, San Antonio, TX, “Investigations of Cylinder-Generated Shock-Wave/Boundary-Layer Interactions,” Jan. 2018.
15. AIAA Aerodynamic Measurement Technology Technical Committee Meeting, Kissimmee, FL, “UTSI HORIZON Group Diagnostics Expertise,” Jan. 2018.
16. University of Southern California, Los Angeles, CA, “Advancement of Non-Intrusive Optical Diagnostics for the Study of Supersonic Aerothermodynamics,” Feb. 2017.
17. University of Central Florida, Orlando, FL, “Advancement of Non-Intrusive Optical Diagnostics for the Study of Supersonic Aerothermodynamics,” Nov. 2016.
18. Aerospace Corp., El Segundo, CA, “Quantitative Measurements of Ablation-Products Transport in Supersonic Turbulent Flows Using Planar Laser-Induced Fluorescence,” May 2015.

19. The University of Tennessee Space Institute, Tullahoma, TN, “Quantitative Measurements of Ablation-Products Transport in Supersonic Turbulent Flows Using Planar Laser-Induced Fluorescence,” Apr. 2015.
20. NASA Ames Research Center, Moffett Field, CA, “Development of Naphthalene PLIF for Visualizing Ablation Products from a Space Capsule Heat Shield,” May 2014.
21. NASA Langley Research Center, Hampton, VA, “Quantitative Measurements of Ablation-Products Transport for Turbulence Model Validation,” Jul. 2013.
22. The University of Texas at Austin, Austin, TX, “NO PLIF Visualization of the Orion capsule in LENS-I,” Apr. 2013.
23. NASA Langley Research Center, Hampton, VA, “Quantitative Measurements of Ablation-Products Transport for Turbulence Model Validation,” Jul. 2012.
24. The University of Texas at Austin, Austin, TX, “High Temperature Surface Thermometry Technique based on Upconversion Nano-Phosphors,” Feb. 2012.

RESEARCH FUNDING

Total **\$16.6M** career research funding, including **\$7.4M PI-share**

1. “Novel Architected Materials for Drag Reduction and Flow Control in Hypersonic Vehicles,” DoD HBCU/MI Research Program, \$799,999, (Co-PI, 25%), 6/1/23-5/30/2027
Exploring application of architected materials for hypersonic flow control
2. “Novel Non-Intrusive Velocimetry Approaches with Minimized Seeding Impacts,” AFRL, \$183,073, (PI, 100%), 5/1/23-7/30/2025
Development of non-persistent tracer particles for particle image velocimetry applications
3. “CAREER: Experimental Investigation into the Impact of Incoming Boundary Layer State on the Unsteady Dynamics of a Transverse Jet in a Hypersonic Crossflow,” NSF, \$617,941, (PI, 100%), 5/1/23-4/30/2028
Investigation of unsteady dynamics of jets injected into hypersonic flows with additional educational outreach
4. “Validation Quality Experimental Data and Workforce Development for Hypersonic Systems,” Oak Ridge National Laboratory, \$400,000, (PI, 100%), 10/1/22-9/30/2025
Student training and wind tunnel testing in support of ORNL simulation efforts
5. “NASA ODPO Validation Testing,” NASA (Jacobs), \$24,664, (PI, 100%), 9/20/22-1/19/2023
Wind tunnel testing at UTSA in support of NASA atmospheric entry prediction validation
6. “Planning Grant: Development of Hypersonics Research Collaborations,” NSF, \$99,945 (PI, 34%), 8/1/22-7/31/2023
Planning grant to develop hypersonic research collaboration between UTSA, MIT, & Howard University
7. “Enabling Four-Dimensional Laser-Induced Fluorescence Measurements of Hypersonic Aerodynamic Phenomena,” DoD HBCU/MI Research Program, \$525,866 (PI, 50%), 8/1/22-7/31/2023
Purchase of pulse-burst laser upgrade and optical parametric oscillator for hypersonic flowfield measurements
8. “Integrating hybrid learning and aerospace testing into the CEID curriculum,” UTSA Academic Innovation, \$5,000 (PI, 100%), 12/1/21-12/31/2022
Novel new hybrid/remote learning activities using the new hypersonic wind tunnel facility at UTSA

9. "Incorporating In-Demand Technical and Professional Aerospace Skills into CEID's Curriculum," UTSA CEID, \$1,000 (PI, 100%), 12/1/21-12/31/2022
Development of new live lab modules for aerospace courses at UTSA using the hypersonic wind tunnel facility
10. "Modeling and Experimental Measurements of Hypersonic Separation Events," JHTO, \$1,499,000 (UTSA PI, 100%), 10/4/21-9/30/2024
Core UCAH project to study aerodynamics of separating vehicle structures during hypersonic flight
11. "M-STTR Planning Grant: Towards Enabling Advanced Non-Intrusive Measurements of Hypersonic Air-Breathing Propulsion Systems," NASA, \$42,422 (UTSA PI, 100%), 9/1/21-12/31/2021
NASA planning grant to develop competitive STTR proposals with small-business partner Spectral Energies, LLC
12. "DURIP: High-Speed Cameras for High-Speed Imaging in Hypersonic, High-Temperature and Supersonic Flows," AFOSR, \$242,884 (UTSA PI, 100%), 2/1/21-1/31/2022
Purchase of high-speed cameras and image intensifiers for hypersonic flowfield measurements
13. "FAST: Full Airframe Sensing Technology for Hypersonic Aerodynamics Measurements," NASA/AFOSR (sub-award from UT-Austin), \$305,000 (UTSA PI, 100%), 12/1/20-11/30/2023
Development of AI/ML-based methods to infer hypersonic experimental data from sparse data sets
14. "City-based Integrated Engineering Training Alliance to Engage, Educate, and Transform, the Next Generation STEM Workforce," NASA, \$50,000 (Co-PI, 20%), 8/1/20-12/31/2020
Support to develop concept paper for a San Antonio STEM workforce initiative
15. "Development of Optical Diagnostic Techniques for the Thermochemical Characterization of Hypersonic Free-Flight Ground Testing," UTSA VPREDKE Office, \$125,000 (PI, 40%), 9/1/20-8/31/2021
Program with Southwest Research to develop non-intrusive measurements for light-gas-gun applications
16. "(YIP) Investigation of the effects of ablation-induced distributed roughness on shock-wave/boundary-layer interactions," AFOSR, \$449,778 (PI, 100%), 4/1/20-3/31/2023
Investigation into the impact of realistic hypersonic material surfaces on shock-wave behavior and dynamics
17. "NASA Center for Advanced Measurements in Extreme Environments (CAMEE)," NASA, \$4,999,999 (PI, 20%), 10/1/19-9/30/2024
Center targeting measurements in a variety of extreme environments, from arctic ice to hypersonics
18. "Supercritical carbon dioxide (sCO₂) power generation for renewable energy extraction," CPS Energy, \$800,000 (PI, 50%), 9/1/19-8/31/2021
Effort to develop a new Brayton cycle engine using sCO₂ as the working fluid
19. "Non-Intrusive Measurements and Simulations of Reacting sCO₂ Turbine Flows for Low-Emission Renewable Energy Generation," UTSA VPREDKE Office, \$125,000 (PI, 40%), 9/1/19-8/31/2020
Development of non-intrusive flow measurement techniques for high-pressure sCO₂ applications
20. "Burst-mode laser system for temporally and spatially resolved non-intrusive laser diagnostics in supersonic flows," ONR, \$729,000 (Co-PI, 50%), 6/15/18-6/14/2019
Equipment grant to purchase a high-speed, high-power burst-mode laser for supersonic flow measurements
21. "Ultra-high speed schlieren for quantitative measurements of hypersonic flows," AFOSR, \$163,411 (Co-PI, 20%), 6/15/18-6/14/2019
Equipment grant to purchase high-speed cameras for supersonic flow measurements
22. "Arnold Diagnostics Summit," AFOSR, \$205,906 (PI, 50%), 9/30/17-5/29/2021
Research into potential experiments in rotating detonation engines and detonation tubes
23. "Reusable Hypersonic Vehicle Structures," UDRI, \$2,265,504 (Co-PI, 15%), 9/1/17-8/31/2020
Effort aimed at understanding the complexities of incorporating real-world materials into hypersonic vehicle design

24. “Experimental characterization and analysis of the acoustic field and dynamic pressure loads generated by current and developmental suppressor systems,” TN RevV, \$108,500 (Co-PI, 30%), 8/1/17-7/31/2018
Program to study methods to reduce high-pressure loads generated by 0.50-caliber rifles
25. “AFRL/RQHXC Corner Flow Experimental Support,” AFRL, \$474,891 (Co-PI, 20%), 4/5/17-4/4/2019
Velocity measurements to characterize supersonic flow through streamwise corners
26. “SBIR Topic AF151-188 Parametric Inlet Bleed,” Innoveering, Inc., \$11,997 (PI, 100%), 2/1/17-5/31/2017
Experimental support and wind tunnel operation for small-business research and technology demonstration
27. “T&E Workforce Development,” AEDC, \$488,473 (Co-PI, 10%), 1/16/17-9/30/2021
Initial pilot program for the development of the US hypersonic workforce
28. “AFRL REACH Support Project,” AFRL, \$400,724 (Co-PI, 25%), 10/1/15-9/30/2016
Experimental support to AFRL for potential reusable hypersonic vehicle platforms research
29. “DARPA MDP Technical Working Group T&E,” IQM, \$157,206 (Co-PI, 50%), 9/1/15-8/31/2017
Consulting on aerodynamic and testing considerations for hypersonic system material development

INTELLECTUAL PROPERTY (*indicates student)

1. Combs, C. S., Patel, R., Bass, D., Dukuze, G. P., Kaialau, D., Bhaganagar, K., Ahmed, S., *Supercritical Carbon Dioxide Brayton Cycle for Power Generation*, Invention Disclosure, Disclosure ID: 2022-015, 2021.
2. Bunegin, L., Portillo, D.,* Hood, R.L., Fallon, Z., **Combs, C. S.**, *Tunable, Pulsatile, and 3-Dimensional Fluidic Oscillator*, Provisional Patent: 63/066,050, 2020
3. Portillo, D.,* Bunegin, L., Hood, R.L., Fallon, Z., **Combs, C. S.**, *A no-moving-parts fluidic oscillator that delivers single pulses at a tunable frequency*, Invention Disclosure, Disclosure ID: 2020-019, 2019
4. Portillo, D.,* Bunegin, L., Hood, R.L., Fallon, Z., **Combs, C. S.**, *Fluidic Oscillator with Single-pulse Outlet Flow*, Invention Disclosure, Disclosure ID: 2020-018, 2019
5. Portillo, D.,* **Combs, C. S.**, Hood, R.L., *No-moving-parts fluidic oscillator with tunable oscillation frequency*, Invention Disclosure, Disclosure ID: 2020-013, 2019

MEDIA

- Combs, C. S., “10 Biggest Myths in (High-Speed) Aerodynamics,” *Hush-Kit Aviation*, Feb. 17, 2022, <<https://hushkit.net/2022/02/17/10-biggest-myths-in-high-speed-aerodynamics/>>.
- Opinion: Combs, C. S., “Other close encounters to watch for,” *San Antonio Express-News*, Nov. 23, 2021, <<https://www.expressnews.com/opinion/commentary/article/Other-close-encounters-to-watch-for-16646040.php>>.
- Opinion: Combs, C. S., “At the heart of aerospace: San Antonio, TX,” *Aerospace Industries Association*, Oct. 7, 2019, <<https://www.aia-aerospace.org/san-antonio-utsa/>>.
- Guest on several podcasts and news programs: *CNN*, *BBC Newsday*, *Airplane Geeks*, *Cosmic Controversy*, *Engineered Mind*
- Featured in over 50 media releases, news articles, and feature stories online (list [here](#))
- Active and popular educational social media presence on Twitter, with over 25,000 followers ([@DrChrisCombs](#))