DEPARTMENT OF MECHANICAL & AEROSPACE ENGINEERING
WILLIAM MAXWELL REED SEMINAR SERIES

"Compressibility considerations in hybrid modeling of hypersonic turbulent boundary layers"

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Abstract:
Hybrid turbulence models offer an attractive prospect for accurate and affordable turbulence simulations, blending Reynolds-averaged Navier-Stokes (RANS) and Large Eddy Simulation (LES) formulations to mitigate grid requirements compared to Direct Numerical Simulation (DNS) and wall-resolved LES. While it holds great potential, hybrid modeling of hypersonic turbulent boundary layers (TBLs), especially with strong wall cooling, demands particular attention for two key reasons. Firstly, the RANS components of hybrid models were primarily developed for incompressible flows and have been validated for subsonic or moderately supersonic flows without significant wall heat transfer. Secondly, the success of a hybrid model hinges on a seamless transition from the RANS mode to the LES mode in the near-wall region, where hypersonic TBLs differ significantly from their incompressible counterparts. This necessitates a meticulous adaptation of hybrid models to respect the near-wall characteristics of hypersonic TBLs. To that end, we will first show how the popular k-ω RANS model fails dramatically in hypersonic TBLs with cold walls. Subsequently, we will introduce a compressibility correction strategy that remarkably improves its accuracy. With an improved RANS model, we will then analyze a hybrid RANS/LES model designed for incompressible flows in a hypersonic context, identifying the reasons behind its increased sensitivity to compressibility effects and varying grid levels. Finally, these insights are incorporated into a novel hybrid RANS/LES model along with a new heat flux closure, exhibiting minimal sensitivity to compressibility and grid size in hypersonic TBLs, with or without strong wall cooling.

Speaker Bio:
Dr. Mustafa Engin Danis is a Postdoctoral Research Associate at Los Alamos National Laboratory. He earned his bachelor's degree in Mechanical Engineering and Physics, followed by a master's degree in Mechanical Engineering from Bogazici University in Istanbul, Turkey. After four years of hands-on experience in developing an in-house integrated flow, heat transfer, and combustion design software as a software engineer at General Electric Aviation, he pursued his doctoral studies in Applied Mathematics and Aerospace Engineering at Iowa State University, culminating in the successful completion of his Ph.D. in 2023. His research expertise encompasses numerical analysis, turbulence modeling and simulation, hypersonic flows, and high-performance scientific computing. His present focus involves dedicated efforts towards advancing next-generation numerical methods and expanding the boundaries of current simulation capabilities in computational fluid dynamics, with the ultimate goal of enhancing accessibility to large-scale real-life turbulent flow simulations. Dr. Danis has been recognized with prestigious awards, including the 2015 Rising Star Award from GE Aviation, the 2022 Mathematics Research Excellence Award, and the 2023 Robert J. Lambert Applied Mathematics Award from the Department of Mathematics at ISU. Additionally, he received the ISU Research Excellence Award from the ISU Graduate College in 2023. Beyond his academic pursuits, Dr. Danis enjoys playing the guitar, following European soccer, and exploring the scenic trails of New Mexico during his free time.

Date: Monday, January 22, 2024
Time: 3:00 PM EST
Place: Whitehall Classroom Building 110
Contact: Dr. Jonathan Wenk

Attendance open to all interested persons

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