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A Simulation Study of the Flow Over a Roughness Element IAN J. SYSYN, PATRICK H. BONNER, FRANK G. JACOBITZ, University of San Diego — A design focus of transportation systems is the reduction of aerodynamic drag forces in order to increase overall energy efficiency. An important component of such work is the transition of laminar to turbulent flows in a boundary layer. While laminar flows generally result in higher energy efficiencies, turbulent boundary layers can improve the stability of lift forces. This laminar to turbulent transition can be tripped by surface roughness, imperfections, or protrusions. The current study considers the flow around a cylindrical roughness element under laminar inflow conditions. The simulations aim to reproduce experiments (J. Lemarechal et al., 2018) visualizing the flow structure through the use of temperature-sensitive paint (TSP) applied to a heated surface. Both the experiments and simulations show the transition of the laminar boundary layer ahead of the roughness element to a more vortical flow state in its wake. Using Ansys CFD, the development of a horseshoe-shaped vortical structure as well as a recirculation zone directly downstream of the element is observed and the simulations qualitatively reproduce the experimental observations. The simulation results are also used to quantify the impact of the roughness element on the overall drag force and drag coefficient.

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