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Air Layer Drag Reduction STEVEN CECCIO, BRIAN ELBING, ERIC WINKEL, DAVID DOWLING, MARC PERLIN, University of Michigan — A set of experiments have been conducted at the US Navy's Large Cavitation Channel to investigate skin-friction drag reduction with the injection of air into a high Reynolds number turbulent boundary layer. Testing was performed on a 12.9 m long flat-plate test model with the surface hydraulically smooth and fully rough at downstream-distance-based Reynolds numbers to 220 million and at speeds to 20 m/s. Local skin-friction, near-wall bulk void fraction, and near-wall bubble imaging were monitored along the length of the model. The instrument suite was used to access the requirements necessary to achieve air layer drag reduction (ALDR). Injection of air over a wide range of air fluxes showed that three drag reduction regimes exist when injecting air; (1) bubble drag reduction that has poor downstream persistence, (2) a transitional regime with a steep rise in drag reduction, and (3) ALDR regime where the drag reduction plateaus at 90% $\pm$ 10% over the entire model length with large void fractions in the near-wall region. These investigations revealed several requirements for ALDR including; sufficient volumetric air fluxes that increase approximately with the square of the free-stream speed, slightly higher air fluxes are needed when the surface tension is reduced, higher air fluxes are required for rough surfaces, and the formation of ALDR is sensitive to the inlet condition.

Brian Elbing
University of Michigan

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