Abstract Submitted
for the DFD10 Meeting of
The American Physical Society

Mean profile of a high-Reynolds-number smooth-flat-plate turbulent boundary layer DAVID R. DOWLING, Univ. of Mich., GHANEM F. OWEIS, Am. Univ. of Beirut, ERIC S. WINKEL, Design Research Engineering, JAMES M. CUTBIRTH, Mainstream Engineering Corp., STEVEN L. CECCIO, MARC PERLIN, Univ. of Mich. — Although smooth-flat-plate turbulent boundary layers (TBLs) have been studied for nearly a century, measurements at Reynolds numbers typical of marine & aerospace transportation systems are scarce. Experimental results at momentum-thickness Reynolds numbers (Re) up to 150,000 from the US Navy W.B. Morgan Large Cavitation Channel using a polished 12.9-m-long flat-plate test model at water flow speeds up to 20 m/s are presented. Mean velocity profiles were measured 10.7 m from the leading edge of the model over a wall-normal range from less than one wall unit to more than twice the nominal boundary layer thickness using particle-tracking and laser-Doppler velocimetry. Static pressure and average skin-friction were measured independently. A mild favorable pressure gradient led to a flow speed increase of 2.5% over the test surface. The measurements span a factor of three in Re and were fitted to within experimental uncertainty using one set of constants and modern empirical inner- and outer-profile forms based on traditional TBL asymptotics. The fitted profiles satisfy the von-Karman momentum integral to within 1%, and show distinct differences from equivalent zero pressure gradient results. [Supported by DARPA & ONR]

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Date submitted: 03 Aug 2010 Electronic form version 1.4