

Validating Drag and Heating Coefficients for Hollow Reentry Objects in Continuum Flow Using a Mach 7 Ludwig Tube

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ABSTRACT

Drag and heating coefficient databases and models are crucial to destructive reentry simulation. The NASA Orbital Debris Program Office (ODPO) develops, maintains, and performs analysis with the Object Reentry Survival Analysis Tool (ORSAT), which comprises drag and heating models for free molecular, transitional, and continuum flow regimes. These models have, in the past, only included solid, convex, blunt shapes (such as boxes, spheres, and cylinders). Previous work led by ODPO includes the extension of these models to hollow cylinders and square boxes in free molecular and transitional flow using the Direct Simulation Monte Carlo (DSMC) method.

Since 2019, the ODPO has continued its program of DSMC simulations and extended the project to include analyses with the NASA Data Parallel Line Relaxation (DPLR) program on hollow cylinders and boxes (with varying wall thickness-diameter ratio). In fall 2022, the ODPO began a collaboration with the University of Texas San Antonio (UTSA) to use the Mach 7 Ludwig Tube facility to validate the model built using numerical simulations. This facility can replicate (at a scale of approximately 100:1) the conditions seen by reentering objects near typical demise altitudes. We present here the drag and heating coefficients derived from the continued DSMC simulations, the new DPLR simulations, and the 26-test series at UTSA.