Maximum Attainable Drag Limits for Atmospheric Entry via Supersonic Retropropulsion (ABSTRACT)

Noël M. Bakhtian*
Stanford University, Stanford, CA, 94305

Michael J. Aftosmis†
NASA Ames Research Center, Moffett Field, CA, 94035

With manned missions on the horizon for Mars exploration, the ability to decelerate high-mass systems upon arrival at a planet's surface has become a research priority. Supersonic retropropulsion (SRP), the application of jets facing into the freestream, is currently being studied as a candidate enabling technology. A model describing a significant drag augmentation mechanism based on shock manipulation was recently introduced; this proposed method of augmenting decelerative forces without directly relying on escalating thrust offers a deceleration technique independent of fuel use. This work proposes preliminary quantification of the benefits offered by this method of SRP-based flow control. We present an analytical method yielding estimates of maximum drag coefficients attainable through shock manipulation via SRP jets, establishing the feasibility of flow control via SRP as a Mars EDL technology.

The analytical study examines the benefit of maintaining stagnation pressure through cascading oblique shocks as compared to a single strong normal shock. Comparisons with both computational and experimental data of blunt body flows validates the analytic method and shock physics assumptions. A family of C_D-Mach curves and corresponding tables are generated for various shock structures. We then consider real gas effects, analyzing the consequence of varying specific heat ratio, $\gamma = \{1.2 - 1.4\}$, and apply an effective γ value to produce a Mars-specific set of C_D-Mach curves. A theoretical maximum drag coefficient for realizable SRP shock structures is proposed at the conclusion of this study.

By engineering SRP systems optimized for drag augmentation rather than raw thrust, fuel savings allow increased payload thus maximizing landable mass. This paper examines the feasibility of SRP-based flow control for high-mass planetary EDL by quantifying the drag afforded via this technique.

*Ph.D. Candidate, Dept. of Aeronautics and Astronautics, Durand Building, 496 Lomita Mall, Student Member AIAA.
†Aerospace Engineer, NASA Advanced Supercomputing Division, Associate Fellow AIAA.