Title: New Developments in Retropropulsion Testing for Mars Entry, Descent and Landing
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Abstract: NASA's plans for landing human-scale payloads on Mars in the next decade require that retrorockets be used to decelerate the atmospheric entry vehicle continuously from supersonic conditions through soft touchdown. Conventional Mars entry vehicle architectures that include a single parachute for supersonic-to-subsonic descent are not scalable to the sizes needed to land humans on Mars (~20 metric tons). The major aerosciences risks are the uncertainties in predicting aerodynamic stability and performance during powered free-flight and landing. These risks are influenced partially by current limitations in relevant data and testing methods. Consequently, trajectory simulations currently depend on unvalidated powered descent and landing aerodynamics models. NASA engineers have identified gaps in testing methods that, if addressed, would improve the ability to validate these models.

There are gaps in capabilities to test multi-engine hot-gas retropropulsion systems in US wind tunnels. This is partially due to the successful use of parachutes as decelerators for human spaceflight at Earth and for the entire Mars lander program to date. Retropulsion test data historically and to this day are limited to using high pressure air jets, at comparatively low temperatures, as engine plume simulants on subscale wind tunnel models. Additionally, the ability to directly measure aerodynamic interference force and moments is limited by existing flow-through balance capabilities. This paper briefly covers historical and recent test data, and identifies new ground test techniques as a means to provide more relevant test data for powered flight and landing aerodynamic model validation. These techniques include using heated inert gases as a substitute for combustion products, additively manufactured 6-component flow-through force and moment balances, and off-body quantitative diagnostic measurements.