A STRUCTURAL CONCEPT STUDY FOR FUTURE PLANETARY PROBES AND SAMPLE RETURN VEHICLES S. V. Perino[1] and J. Bayandor[2], [1]Crashworthiness for Aerospace Structures and Hybrids (CRASH) Lab, Virginia Tech, 100 Randolph Hall, Blacksburg, VA 24061, svp@vt.edu, [2]Crashworthiness for Aerospace Structures and Hybrids (CRASH) Lab, Virginia Tech, 100 Randolph Hall, Blacksburg, VA 24061, bayandor@vt.edu

Introduction: A parametric structural investigation of Atmospheric Entry Vehicle (AEV) concepts for future planetary probes and sample return vehicles was conducted. The AEV concept was first developed for the Mars Sample Return (MSR) mission as an Earth Entry Vehicle (EEV) for delivering Martian samples back to the Earth's surface [1,2]. The parametric vehicle concept is however 'multi-mission' and is equally applicable for delivering payloads and probes to other planetary bodies with sufficient atmospheres such as Mars, Venus, and others. The AEV concept has a simple configuration with an aerodynamically stable and passive reentry design. The vehicle is thus without a parachute system and relies entirely on aerodynamic drag during atmospheric entry to reduce vehicle velocity; if surface landing or sample return missions are required, an impact absorbing sphere is used to protect the payload. During launch and reentry, depending on the mission, the vehicle may experience large structural loads. To enable rapid assessment of multiple potential vehicle configurations for different missions, we created a parametric and automated structural dynamics analysis methodology [3]. The methodology enables rapid modification to all aspects of a model including: geometry, material properties, load and boundary conditions, mesh grids, and analysis controls. Analyses including quasi-static inertial launch loading, vibration frequency response, acoustic loading, and reentry dynamic pressure loading were conducted for preliminary study of the vehicle concept. Several geometry, mass, and material parameters were varied from -50% to +50% of baseline values for the MSR mission [1]. Each vehicle configuration was then analyzed individually. A total of 136 analyses were conducted on 34 unique vehicle configurations. Important and sometimes unexpected vehicle response trends as well as quantitative stress and frequency response data were recorded. Of the parameters investigated, cone angle and vehicle diameter were found to be the most influential on the vehicle's mass and structural response. The highest stress response observed was for an inertial launch analysis conducted on the -50% cone angle model which had 2.7x the baseline stress but only 1.4x the baseline mass. Key aspects of the analysis methodology and important discoveries about the AEV design and tradespace are discussed in the context of planetary exploration missions.

References:

[1] R. Mattingly, L. May, Mars Sample Return as a Campaign, in: IEEE Aerosp. Conf., IEEE, Big Sky, MT, 2011.
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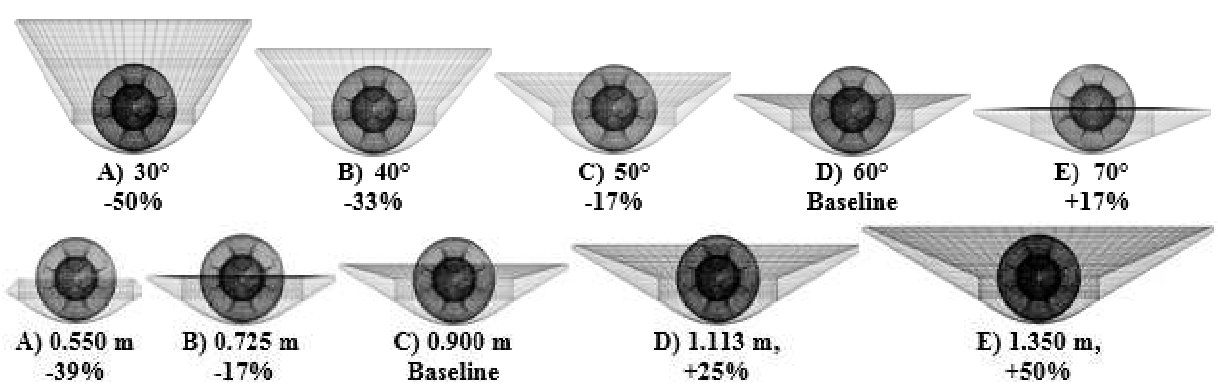
[3] S.V. Perino, J. Bayandor, A. Siddens, A Comprehensive Structural Dynamic Analysis Approach for Multi Mission Earth Entry Vehicle (MMEEV) Development,NASA STI CR-2013-218003, Blacksburg, VA, 2012.



A selection of structural configurations investigated using the developed methodology