Development Of FIAT-Based Parametric Thermal Protection System Mass Estimating Relationships For NASA's Multi-Mission Earth Entry Concept.

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An integrated tool called the "Multi Mission System Analysis for Planetary Entry Descent and Landing" (M-SAPE) is being developed as part of NASA's In-Space Propulsion Technology (ISPT) program. Part of M-SAPE's development requires the formulation of mass estimating relationships (MERs) to determine the vehicle's Thermal Protection System (TPS) material and required thickness for safe Earth entry. The objective of this study was to develop MERs using simple correlations that were non-ITAR and matched as accurately as possible NASA's high-fidelity ablation modeling tool, the Fully Implicit Ablation and Thermal Analysis Program (FIAT[i]). These MERs would be a first-estimate for feasibility studies; it is understood that higher-fidelity modeling like FIAT would be necessary once a proposed trajectory was down-selected. The trajectory space for these MERS consisted of 840 different trajectories, and a material's heating limit was the main constraint for an allowable trajectory. MERs for the vehicle fore body included the ablating materials Phenolic Impregnated Carbon Ablator (PICA[ii]) and Carbon Phenolic[iii] atop Advanced Carbon-Carbon. For the backshell the materials were Silicone Impregnated Reusable Ceramic Ablator (SIRCA[iv]), Acusil[v] II, SLA-561V[vi], and LI-900. The MER/FIAT ratio indicates MERs are accurate to within 9% (at one standard deviation) of FIAT prediction, and the most any MER can under-predict TPS thickness is 17% of FIAT prediction. This paper focuses on the development of these MERs, the resulting equations, model limitations, and model accuracy.

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