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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

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CONCEPTUAL DESIGN SYNTHESIS METHODOLOGY APPLICATION FOR AN ORBITAL REENTRY GENERIC WING-BODY CONFIGURATION

Abstract

Goal: In the case of space access vehicles (SAV), the conceptual design phase represents the point where critical decisions are made specifying the geometric configuration, sub-system technologies, and operational requirements. NASA Launch Vehicle Design Process Report states that decisions made during the conceptual design phase account for eighty percent of the total life cycle cost. This research proposes a new approach for developing a state-of-art design synthesis methodology for space access systems. The proof-of-concept is demonstrated for a wing-body configuration spacecraft that executes a lifting reentry from low-earth-orbit and performs a horizontal landing on a runway.

Methodology: The conceptual design assessment of a complicated system like a SAV, is characterized by the multi-disciplinary effects and interactions among involved sub-disciplines—aerodynamics, propulsion, performance, and weights. The current research develops a conceptual design synthesis system for a wing-body lifting reentry vehicle, based on constant mission sizing logic described in Hypersonic Convergence by Paul Czysz. Based on the generic wing-body configuration, the geometry is modeled in terms of major design features. For example, the nose of the craft is defined by the radius, the fuselage is defined by the cross-sectional shape, max diameter, and length and the wings are defined by the leading edge sweep, planform shape, and planform area. Building the vehicle up in this piecewise parametric manner allows for flexibility in the geometry function and a more inclusive evaluation of geometric influences on the design. The onboard propulsion system is similarly executed, with the consideration of pre-selected off-the-shelf upper stage rocket engines as the controlling factor. Once the geometry and propulsion specifications are decided, each case is then a starting point for executing follow-on primary disciplinary analysis in the sequence: aerodynamics, propulsion, performance matching, and weight and volume. The synthesis analysis sizes the vehicle based on total weight and volume convergence logic.

The sizing process is implemented using MATLAB. Each disciplinary method is coded in a separate module. The geometry variables are iterated and combined in NASA OpenVSP to develop a set of unique geometry profiles. Each geometry profile is analyzed and processed until the objective functions converge.

Results: The results demonstrate the influence and importance of primary design drivers–geometry configuration and propulsion–on the complete vehicle system. A design solution space is presented at the end identifying the feasible design points based on operation and technology constraints.