

IMPROVEMENT OF FAST CONCEPTUAL ROCKET DESIGN AND TRAJECTORY OPTIMIZATION FRAMEWORK WITH HYBRID ENGINE MODEL

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Keywords: multidisciplinary design optimization, multidisciplinary design feasible, sounding rocket, engine model, single-stage rocket

Abstract. *The extreme operating conditions, highly demanding mission requirements and intricate and tightly coupled nature of the underlying physical phenomena represent only a few of the challenges engineers must address in the development of aerospace technological solutions. In such an unforgiving domain, the optimization of resources is absolutely vital to extract the best performance with minimal cost and time. To that end, a multidisciplinary design with trajectory optimization framework geared for the preliminary design of rockets optimization, comprised of six low-fidelity disciplinary models -- models of mass and sizing, flight dynamics, aerodynamics, solid-propellant propulsion, structural, and atmosphere -- coupled using a Multidisciplinary Design Feasible (MDF) architecture, had been previously developed and demonstrated. The design optimization algorithm is gradient-based for reduced computational cost and the trajectory optimization uses a Gauss-Lobatto pseudo-spectral method due to its efficiency in solving continuous nonlinear constrained optimal control problems, high accuracy and low computational cost. In order to further expand the capabilities of the integrated design framework, this work focuses on development of a new propulsion model to handle hybrid liquid-solid propellant engines. The new capability is demonstrated in the design of a sounding rocket, considering two engine cases -- solid propellant engine and hybrid engine. The resulting distinct designs for a set of different mission requirements, comprising variations of peak altitude and payload mass, are compared and discussed in terms of overall rocket sizing. The results show the framework's potential to efficiently handle complex rocket design problems with different engine solutions, while offering valuable design insight in terms of mission requirement at a relatively low computational cost at early development stages. Given the design framework modularity, continued effort for the expansion of its capabilities are expected to further extend its applicability to other aerospace solutions, such as multi-stage configurations or other propulsion systems.*