

## Multidisciplinary Design Optimization of high energy hybrid upper stage

The Institute of Aeronautics and the Space and German Aerospace Center are developing the Micro Satellite Launcher known as VLM based on the design of a previous Brazilian Launcher. The current VLM configuration consists of a 4-stage solid propellant launcher and the introduction of a high energy upper is being considered as an alternative for performance improvement. A pressure fed hybrid upper stage with smart design can reach a much higher specific impulse performance when compared to solid propellant motors. The propulsion team at University of Brasilia has a vast experience in designing and testing hybrid propellant motors. In recent years this research group has proposed a multidisciplinary design optimization methodology for hybrid motor. This article describes a preliminary design of both a replacement for VLM's 4th stage and, for VLM's 3rd and 4th stages with hybrid propellant systems. Several technological alternatives are considered and adapted to Brazil's fabrication capabilities, design tradeoffs are accounted for, and at the end a detailed performance prediction model is implemented. The optimization process is built by using a Hybrid Algorithm with an initial multi-objective evolutionary algorithm for consistent exploration of the design space and in the second phase a gradient based single objective algorithm for refinement of the solution.