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Small Launchers: Concepts and Operations (7)

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MICRO LAUNCHER OPTIMUM DESIGN USING THE SOLID ROCKET MOTOR S-50

Abstract

The market of small satellites has experienced substantial growth in the last decade due to the high level of miniaturization in its components, allowing missions that only a decade ago were the exclusive domain of much larger satellites. This tendency has opened a new field for the development of low cost small/micro launchers (Light Launcher Vehicles - LLVs) to act on this specific market, mostly private-led initiatives, called nowadays as NewSpace Launch Systems. This new approach has the advantage to fulfill with high quality the mission requirements, once these launchers are dedicated to supporting specifically small, micro, and nano-satellite LEO missions. In the design of launchers, the use of optimization methods to maximize the payload mass and the propellant storability, as well as minimize the structural mass for a given mission or range of missions is mandatory. During the optimization process, a method to maximize the overall vehicle performance, in general, expressed by the payload capability, is handling a combination of different propulsion systems to form the vehicle stages in association with an optimum trajectory analysis. Sometimes, manipulation of the propulsion system characteristics is also required, which results in modifications to the original motor design. In this work, the focus will be put on the Solid Rocket Motor (SRM) S-50, which will be used as a reference for the analyzes. The S-50 composes the first and second stages of the Brazilian Micro-satellite Launch Vehicle (VLM) and the first stage of the Suborbital Rocket VS-50, and it was designed to burn 12 tons of solid propellant during 80 seconds in a composite (CFRP) motor case, presenting an attractive structural ratio. This paper addresses the stage optimization problem by using gradient methods and genetic algorithms focusing on the reference SRM S-50 as the first stage combined with successive stages derived from the S-50's original design through the proposed optimization methodology. In the procedures to find the optimum solution for the proposed problem, concepts of optimal trajectory, maximum payload capability, structure optimization, and properly flight dynamics and control analysis are applied. The obtained results will be compared with reference missions for consistency checking.