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Small Launchers: Concepts and Operations (7)

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MULTI-CRITERIA DECISION MAKING FOR SMALL LAUNCHER CONCEPTS

Abstract

A three-staged launcher weighing 200 tons at liftoff, capable of transporting 1.5 ton payload from the NARO space center to 700 km Sun-Synchronous Orbit is under development, success of which greatly relies on the performance and reliability of newly-developed Lox/Kerosene engines with 7-ton and 75-ton thrust forces. Both engines successfully passed qualification phase. As part of this Korean Space Launch Vehicle program, the second stage was modified into a single-staged test vehicle with a 75-ton engine, and the engine performance was flight-proven in 2018.

This study will be an exploratory research, in which various concepts of the upper stage are combined with the test vehicle and a multidisciplinary design approach is used to examine their technical validity. The goal is to come up with small launcher concepts that can carry 500 kg to 500 km in an economic way in order to provide more flight opportunities for the growing sector of small satellites. In this article, however, we will focus on stakeholder analyses, multi-criteria decision-making process and inter-criteria weighting factors and technical validation of vehicle concepts on a two-staged launcher consisting of a highly capable upper stage and an extended test vehicle stage. A systematic approach is devised to evaluate launcher concepts in terms of development and production cost, technical innovation and maturity as well as vehicle performance and reliability. These conflicting attributes of different concepts are weighted according to various scenarios of the stakeholder analyses in order to clearly describe the decision rationale behind the chosen concept.

Even though frequent and interactive iterations are required among different disciplines including trajectory, propulsion, aerodynamics, control and structures, these trade-off studies in the conceptual design phase often suffer from a divisive culture of organization. As a remedy for this non-technical bottleneck, vehicle system engineers have been trying to establish an efficient and effective launcher staging optimization framework based on the multi-disciplinary design optimization software. The key elements required for the design framework are the rapid configuration modeling, autonomous load and strength analysis that can update the component mass of load-bearing structure. With given configuration and mass, the trajectory optimization is used to satisfy both mission requirements and flight safety constraints. In the full paper, we will elaborate on the mission requirements, flight safety constraints and select design variables as well as the aerodynamic and propulsion characteristics, load profiles, material properties for metal and composite components, structural-sizing results and mass estimates in details.