SPACE SYSTEMS SYMPOSIUM (D1)
System Engineering Tools, Processes & Training (I) (3)

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COSTS AND RISK ANALYSIS TOOL FOR CONCEPTUAL LAUNCH VEHICLE MDO

Abstract

Recently the design philosophy in the aerospace field has smoothly shifted from the classical "design-to-performance" towards the "design-to-cost" and "design-to-reliability" approaches. As far as the space transportation industry is concerned, the launch vehicles design is often driven by cost minimization, taking into account constraints of system reliability, safety assurance and pure technical performance. On the other hand, the well known Multidisciplinary Design Optimization (MDO) methodologies are nowadays becoming of interest within the space community too, mainly exploited to deal with the conceptual and early preliminary design of complex aerospace systems. Therefore a simple and reliable cost and risk assessment model for space transportation systems is needed; in particular, the model should be capable to provide – on the basis of high-level design specification only - estimates of program life cycle costs and vehicles reliability, appropriate for a Pre-Phase A or early Phase A projects. To this end, a cost and reliability model for expendable launch vehicles is here proposed, originally conceived as a part of a MDO framework currently under development at Politecnico di Milano and Universität Bremen under a dedicated ESA program. A statistical model has been developed for costs, based on Koelle's "TRANSCOST 7.2" (TCS - 2007) and integrated with ESA data. It consists of mass-based cost estimating relationships, and additional correction factors which consider aspects such as team experience, learning factor and technical complexity. Such approach allows to estimate development, production and operations costs, and to produce a high level Cost Breakdown Structure. A "reliability vs. time" philosophy has been selected to model risks. Every component has been characterized by a failure rate, which determines the related exponential reliability function. These functions are appropriately combined for each mission phase from pre-launch storage to payload injection, to obtain an overall reliability vs. time history and hence the final mission success probability. A breakdown structure is available for risks too. This life cycle costs estimation and launch reliability tool has been validated against several launcher actual designs and foreseen concepts in the European scenario, with the support of the ESA costs and risks sections. Results are going to be discussed in the paper. The aforementioned validation campaign turned out a 15-20% accuracy. Moreover, the models seem particularly suited to fairly and quickly compare different design solutions. Those features make the proposed tool well-suited for integration in a MDO framework for conceptual and early preliminary design.