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COST ESTIMATION METHODOLOGY AND TOOL FOR FUTURE REUSABLE ACCESS TO SPACE SYSTEMS

Abstract

In the last decades, the integration of costs analysis into conceptual design activities has proven to be a central tool to address the multifaceted features of innovative systems: this capability seems now essential to assess the viability of reusable launchers in the near-term future. Currently, the path towards a fully reusable access to space vehicle is still hampered by some technological developments as well as by the uncertainties of their economic success. Therefore, the integration of a Life Cycle Cost (LCC) algorithm at conceptual design stage could play a fundamental role in guiding engineers towards the selection of most economically sustainable concepts. In this context, Politecnico di Torino has already proposed a LCC methodology and tool called "HyCost 1.0" specifically tailored to air-breathing high-speed transportation systems. This paper discloses the enhancement of HyCost 1.0, i.e. "HyCost 2.0" methodology, which includes future Reusable Access to Space Vehicles within the methodology and tool capabilities. The main novelty of the proposed approach is that, basing on the heritage of previous LCC estimation activities carried out at Politecnico di Torino, it provides a complete framework supporting cost estimation of both high-speed transportation systems and Reusable Access to Space Vehicles, thus covering a wide spectrum of concepts and design solutions. The new approach is based on the classical costs' subdivision proposed in TransCost, i.e. Research, Development, Test and Evaluation, Theoretical First Unit Production Cost and Ground and Flight Operations Cost. In turn, the first two cost categories are split between Airframe (i.e. structures and on-board systems excluding engines) and Engines components, while Ground and Flight Operations Cost are made up by Direct Operating Cost, Refurbishment and Spares Cost and Indirect Operating Cost. The main goal of this research activity is to evaluate the applicability of already existing parametric cost estimation relationships (CER) to the peculiarities of Reusable Access to Space Vehicles and if necessary, to define new equations. Specifically, this new set of equations shall be able to capture the impact of different vehicle configurations (e.g. staging strategy, staging Mach number, parallel or series configuration, etc...) onto costs as well as the impact of the most promising propulsive solutions, ranging from Scramjet and Combined Cycle engines to rocket engines. Eventually, this new methodology and implemented routines are applied and validated using the SpaceX Starship case study.