Cost-effective and sustainable scenarios for future reusable space transportation and re-entry systems

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The Dissertation proposes a comprehensive methodology aimed at supporting preliminary and conceptual design activities by determining the Cost-Effectiveness and the technological sustainability of advanced Reusable Launch Vehicle (RLV) concepts. This is performed through the development of three key Modules specifically tailored for future RLVs analysis, i.e., a Cost Model (Module 1), an Effectiveness Model (Module 2) and a Methodology for Technology Roadmapping (Module 3). Results from Module 1 and Module 2 are properly merged to suggest the most cost-effective solution among competing options. Moreover, the integration of Module 1 and Module 3 is extensively studied with the purpose to exploit the outcomes from cost estimation to determine the technological sustainability of future reusable concepts. Selected Case Studies are also introduced to verify and test each Module. At the beginning, a through literature review on previous efforts on RLVs development is presented, highlighting the major technological challenges encountered in past activities. Then, benefitting of the historical overview, a discussion about the most promising design options is provided, selecting proper Case Studies to be used to test developed models. Subsequently, a Cost Model is proposed basing on main identified gaps of state-of-the-art cost methodologies. In this context, special attention is devoted in developing a dedicated set of Cost Estimation Relationships (CERs) for the most promising RLV configurations previously identified, suggesting a structured mathematical approach to be followed for new CERs derivation. The proposed Cost Model is also tested with the selected Case Studies, comparing obtained results with previous estimations from independent sources. Moreover, in support of technological sustainability assessment, an enhanced version of a state-of-the-art methodology for Technology Roadmapping (called TRIS) is presented. The enhanced TRIS is applied to a noteworthy Case Study among those previously identified, providing a practical example of technological sustainability assessment. To support the roadmapping process, a thorough revision of an already existing database (HyDat) able to store data required for Technology Roadmapping is also performed. Then, after introducing suitable approaches to perform Cost-Effectiveness assessment, an Effectiveness Model specific for RLVs and based on trade-off analysis is proposed, providing guidelines towards Cost-Effectiveness assessment and

results evaluation. Ultimately, the Cost-Effectiveness comparison of Case Studies is provided, suggesting the most cost-effective option.