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Technical Management Processes: Trade-off Analysis And Cost Estimation For Innovative Space Systems

By

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Declaration

I hereby declare that, the contents and organization of this dissertation constitute my own original work and does not compromise in any way the rights of third parties, including those relating to the security of personal data.

Giuseppe Governale
2023

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Technical Management Processes: Trade-off Analysis And Cost Estimation For Innovative Space Systems

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In an evolving space industry that includes an increasing number of commercial actors, rapid evaluation of innovative space systems is crucial. This PhD thesis addresses the need for effective technical management processes, specifically trade-off analysis and cost estimation, in the context of the evolving space industry. The research focuses on the evaluation of microlaunchers, the development of inflatable heatshields, and the design of human landing systems for lunar exploration. By developing and applying methodologies and processes, this thesis aims to contribute to the understanding of these innovative space systems.

The evaluation of microlaunchers, which are predominantly commercial in nature, presents unique challenges. This research identifies the considerations necessary for evaluating microlaunchers, such as selecting concepts proposed by commercial companies and estimating their costs. As the space sector experiences an influx of commercial entities, it becomes crucial to develop methodologies that effectively assess and compare these new launch systems.

Sustainability is a critical aspect of space exploration, and this research focuses on the development of inflatable heatshields. These heatshields enable the recovery of launchers' upper stages and enhance missions to Mars by enabling the landing of larger payloads at higher altitudes. The research explores trade-off methodologies for making critical design decisions regarding inflatable heatshields and investigates cost estimation techniques to support informed decision-making in their implementation.

Lunar exploration has gained significant attention, and the development of human landing systems has become a priority. Fast prototyping capabilities and accurate cost estimation are essential, particularly when evaluating similar systems proposed by multiple commercial actors with limited available data. The research addresses these challenges and contributes to the effective design and evaluation of human landing systems for lunar missions.

Through a mix of methods and models, expert consultations, and hardware tests, the developed methodologies and processes are validated, confirming their validity and flexibility for different case studies of innovative space systems. The research

outcomes provide valuable insights, methodologies, and tools for engineers and decision-makers involved in the design and evaluation of space systems, enabling them to navigate the complexities of the evolving space industry.

This PhD thesis extensively addresses the research question of how technical management processes, including trade-off analysis and cost estimation, can be developed and applied to meet the needs of the evolving space industry, particularly in the context of innovative space systems involving commercial actors. The thesis includes validated case studies that effectively address the research question, contributing to the body of knowledge in space engineering.

The methodologies developed for the evaluated applications offer a systematic approach to assessing trade-offs and estimating costs, empowering systems engineers in the development of similar innovative systems. The positive feedback received from industries and agencies underscores the practical relevance and utility of the developed methodologies, with industry stakeholders expressing keen interest in adopting these tools during the early conceptual phases of mission design.

This research has practical implications for academia and industry, enhancing decision-making, optimizing resource allocation, and contributing to the advancement of the space industry. By addressing the challenges posed by the evolving commercial landscape of space applications, this research provides valuable insights and tools for systems engineers, enabling them to make informed decisions and contribute to the progress of the space industry.