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APPLICATION OF DESIGN TRADES TO THE DEVELOPMENT OF THE PROPELLANT TANK FOR A WATER MICRO-RESISTOJET

Abstract

The purpose of this paper is to explain the design process of the pressurised propellant tank for a water micro-resistojet, with application on nanosatellites. The motivation of this propulsion system is its use on future nanosatellite missions of the Delft University of Technology, following the legacy of Delfi C3 and Delfi-n3Xt. The water-based micro-resistojet targets thrust levels in the 0.5-10 mN range by employing MEMS technology in the heating chamber. In order to store the water (propellant), the pressurised tank shall withstand 10 bar as MEOP and have a capacity of 200 ml with a mass limit of 200 g. The design of the propellant tank is tackled following the Design Trades: a systems engineering approach to the decision-making process. This 10-step methodology begins by framing the decision to be made and outlining the design objectives. Subsequently, the design alternatives are created and analysed via trade-off evaluations, considering the previously-defined objectives. From this analysis, it is possible to draw conclusions that will eventually drive the decision. However, the uncertainty of the trade-off process needs to be assessed, as well as its impact on the final decision. An improved set of design alternatives is developed and new trade-offs are performed, following an iterative process. Finally, an undisputed winning design alternative is achieved and selected, closing the decision process. Regarding the propellant tank, the main objectives of the design are the minimization of cost and risk, with maximum performance and design simplicity. An initial set of characteristics of the design is considered: material, manufacturing process, shape and configuration of the propellant tank. Through table trade-off analyses, the different design alternatives are assessed, and sensitivity analyses are conducted to show the impact of the trade-off weights on the outcome. After a decision on the general characteristics, the lid-tank and tank-bus structure interfaces are evaluated. With the help of Design Option Trees, 5 conceptual designs are modelled in 3D to better understand each design solution. Through an advantages-disadvantages table, the interface characteristics are assessed, and the conceptual designs are refined into a single preliminary design, ready for future structural analysis. In conclusion, a successful implementation of the methodology is achieved. The complete process is documented in order to allow traceability of the decisions taken, facilitating design iterations. Furthermore, a set of recommendations for future work is developed, which include a close relation with the manufacturer from the start and parametrisation of designs.