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AGILE-SYSTEMS ENGINEERING FOR SUB-CUBESAT SCALE SPACECRAFT

Abstract

Space systems miniaturization has been increasingly popular for the past decades, with over 1600 CubeSats and 300 sub-CubeSat sized spacecraft estimated to have been launched since 1998. This trend towards decreasing size enables the execution of unprecedented missions in terms of quantity, cost and development time, allowing for massively distributed satellite networks, and rapid prototyping of space equipment. Pocket-sized spacecraft can be designed from scratch in less than a year and can reach weights of less than 10g, taking away the considerable costs and requirements typically associated with orbital flight. However, while Systems Engineering methodologies have been proposed for missions down to CubeSat size, there is still a gap regarding design approaches for picosatellites and smaller spacecraft, which can exploit their potential for iterative and accelerated development. In this paper, we propose a Systems Engineering methodology that abstains from the classic waterfall-like approach in favor of agile practices, focusing on available capabilities, delivery of features and design "sprints". This methodology originates from the software engineering discipline and shifts away from the typical system-subsystem-component model, suggesting instead to specify desired capabilities which are directly linked to one or more components. To account for the decrease in reliability due to the more "relaxed" nature of this approach, we also explore the degree of reliability and value added by simultaneously launching identical designs, different designs, or a combination of both. This methodology allows quick adaptation to imposed constraints, changes to requirements and unexpected events (e.g. chip shortages or delays), by making the design flexible to well-defined modifications. 2 femtosatellite missions, currently under development and due to be launched in 2023, are used as case studies for our approach, showing how miniature spacecraft can be designed, developed and qualified from scratch in 6 months or less. Both missions involve the attachment of a chip-sized satellite ("ChipSat") into a larger spacecraft, either relying on their host for communications and power or being completely independent. The proposed methodology has applications in Earth orbits and beyond, bringing well-established design practices into the domain of aerospace engineering and providing a well-structured approach to the creation of small-sized spacecraft, which benefits from quick integration of past lessons learned with new technologies.