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SPACE POWER SYMPOSIUM (C3)
Small and Very Small Advanced Space Power Systems (4)

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AN APPROACH FOR THE ROBUST DESIGN OF THE POWER SYSTEMS OF SMALL SATELLITES

Abstract

The paper presents an approach to robust model-based system engineering applied to the design of the power system of a nano-satellite. Nano-satellites are expected to answer to the cheaper, faster and better design philosophy. A proper definition of "better" should include elements of performance and reliability. Reliability standards based on margins added to the system budgets might fail to correctly capture the actual quality of the design, and might lead to oversize the spacecraft or underestimate the impact of uncertainties. The paper presents a simple parametric simulation model for a generic small satellite and a computational approach that provides an optimal design solution under uncertainty. Two types of uncertainties are included: aleatoric and epistemic. The former are irreducible uncertainties and generally well represented with probability distribution describing the frequency of an event. The latter instead are reducible uncertainties due to a lack of knowledge. Epistemic uncertainties are typical in the preliminary design phase, in particular when new ideas and concepts are introduced. Although nano-satellites, like cubesats, follow generally accepted standards, they are often used as test bed for new technologies. The content of epistemic uncertainty is therefore not negligible and needs to be taken into account alongside aleatoric uncertainty. The approach proposed in this paper unifies the treatment of aleatoric and epistemic uncertainty through the theory of Upper and Lower Previsions, and incorporates the quantification of uncertainty into the optimisation of the performance of the power system of the satellite. The result is an optimal compromise between performance and reliability. Few illustrative examples will demonstrate the effectiveness of the proposed methodology.