Paper ID: 16675
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SPACE SYSTEMS SYMPOSIUM (D1)
Poster Session (P)

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NANO-SATELLITE MISSION DESIGN BY PARAMETRIC THROUGH-LIFE SYSTEM MODELLING

Abstract

For decades we have approached Space mission design in a relatively consistent manner, with developments such as concurrent engineering facilities streamlining the process in recent years. These methods continue to be effective for large, bespoke platforms where mission requirements are relatively open-ended, however for small, resource-limited systems, a new approach to mission design is presented which lays emphasis on parametric mathematical modelling, flexibility and generalised design solutions.

The primary objective of the approach described is to exploit the standardised nature of the 'CubeSat' platform by modelling behaviour of potential sub-systems and inter-linking them to create a complete parametric satellite model. In addition, supporting elements including the design and development phase, ground segment, LEOP phase and de-orbiting are modelled, making this a uniquely 'through-life' methodology. These models are used by the Systems engineers to conduct trade studies over a range of mission options and optimise the overall configuration, with the aim of decreasing overall design time and cost whilst increasing performance metrics (for example coverage frequency, image resolution or lifetime).

The model exists at two fundamental levels; Mission and Platform. At the 'Mission' level, steady-state analytical models of the space, ground and launch segments are analysed against industry-accepted cost models. Multi-objective optimisation is incorporated to maximise system performance (metric dependent on mission requirements) and minimise cost. At the 'Platform' level, dynamic properties of the Space segment (fed by outputs from the Mission-level) are examined in detail through application of numerical simulation. Typical satellite behaviour over orbit time-scales, such as ground station visibility, power profiles and short-term attitude perturbations are analysed.

Results of a case study are presented, showing design and simulated operation of the UKube1 Nanosatellite. Performance of the satellite over a typical orbit is presented as well as long-term propagation analysis to show predicted long-term and end-of-life activity.