Paper ID: 38873
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SPACE SYSTEMS SYMPOSIUM (D1)
Space Systems Architectures (2)

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ECONOMIC VALUE PROPOSITION FOR MODULAR ARCHITECTURES

Abstract

Modular assemblies now represent the edge of feasibility for nanosatellites. These innovative concept are enabled by the availability of relatively low-cost, standardized components of cubesat derivation. Modular assemblies are based on a fundamentally different system architecture which shows the premises of both unprecedented operational flexibility and enhanced risk mitigation capabilities. These features are, however, hard to objectively quantify against more technical specification. Proving the benefits of an architecture to be greater than those of another is therefore highly dependent on the choice of metric (e.g. mass minimization, cost minimization or weight parameter based hybrid criteria).

In this paper, we propose to seek maximization of economic value, defined as projected profits at the time of design. We hold this guiding metric as a reasonable compromise between the industry's drive towards economic success, the technical capabilities of the system and a reasonably simple mathematical formulation. The merits of this choice are showcased in the conceptual study of modular vs monolithic architectures, which aims to highlight the mission requirements which have a predominant role in the architectural choice. Such driving parameters have been identified as the level of uncertainties on revenues-per-performance models (e.g. dollars-per-bps-rates) and in the scalability of component technology. High levels of uncertainty in future revenues will favour more agile and reconfigurable solutions, which more effectively capitalize on short terms fluctuations of real market demands. Components characterized by performance figures directly related to their size, such as optical arrays or radio antennas may penalize modular assemblies, which are inherently characterized by smaller platforms.

To determine the cases in which modular architecture is preferable, worst case scenario is identified as everything that advantages the monolithic option. To estimate revenues, it is therefore assumed that market demand is constant over the entire mission and known beforehand; under this assumption, even the monolithic/unchanging architecture can maximizes revenues. This defies the purpose of reconfigurability through modularity, which is indeed superfluous. Revenues are however equal in both cases. If we prove that, for a specific mission, the cost of the modular architecture is not greater than that of the monolithic one, we have equal value. Then, by removing the hypothesis of perfect knowledge of constant demand, we show that a modular architecture provides comparable costs and greater projected revenues, therefore higher value.

We test the proposed method on case studies of historical commercial relevance, namely Earth resource monitoring, Earth observation and telecommunications.