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MODULARITY IN THE LIFE CYCLE OF SATELLITE SYSTEMS: A REVIEW OF BARRIERS, DRIVERS, AND IMPACTS

Abstract

Modularity is a design concept that fostered flexibility, changeability, and cost-effectiveness in complex product systems (e.g., airplanes, oil and gas plants,) over the past few decades. Yet, in the context of satellite systems, this concept is far less leveraged, though the literature emphasizes several potential advantages. Given the emerging trend towards New Space, exploring modularity may unfold new opportunities for reducing time-to-market, making the design and development processes more efficient, or delivering higher value to clients. Leveraging modularity would push the space industry to enhance its design and production practices.

Understanding the fundamental challenges, pre-conditions, and motivations involved in adopting modular approaches at different levels (i.e. design/production; single/multiple satellite systems) can provide valuable insights into improving the satellite system architecture while revealing the benefits these approaches offer. To this end, we reviewed the literature on modularity in complex product systems and critically compared it to current practices in the satellite domain through interviews with space actors. Based on the findings, we identified barriers to implementing modularity in satellites at different levels, including technical and organizational ones. We also discussed the pre-conditions (e.g. advances in technology) and motivations (e.g. market pressures) that drive the modularization process in the satellite domain. Finally, we analyzed the potential impacts that different levels of modularity in satellite systems might have on space companies' objectives, such as new services and revenue streams or higher development costs.

This paper sets a foundation for further investigation of the benefits and challenges of adopting modularity in satellite systems. By shedding light on the barriers, drivers, and impacts, this paper aims to unveil the added value of modularity and its potential to enhance satellite systems' performance, reliability, and sustainability. The results are intended for both researchers and practitioners engaged in the design and development of satellite systems.