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SPACE SYSTEM CONCEPT DESIGN: A VALUE-CENTRIC ARCHITECTURE BASED ON SYSTEM CHARACTERISTIC SPACE

Abstract

"Smaller, faster, and cheaper" is a commonly touted mantra for spacecraft and space mission design. This plus other influencing factors has resulted in a number emerging design concepts such as miniaturisation, modularity, and commercialisation, leading to the rapid development of small and inexpensive platforms, e.g., cubesats and nanosats, stimulating an upcoming revolution in space design and development.

However, the current requirement-centric design philosophy and corresponding labour-intensive and customised development and production process typically spends considerable time and money on the integration and testing of large and complex systems, which does not inherently fit with modular and miniaturised concepts and technologies. Therefore, there is a significant potential benefit in establishing and adopting a new design architecture for space mission analysis. This paper proposes a new categorisation, characterisation and value-centric design architecture to address this need.

In order to identify key characteristics and system properties, various space systems are investigated and then categorised into four basic types, namely monolithic spacecraft, constellations of identical spacecraft, fractionated spacecraft and combined spacecraft.

After that, system characteristic space, comprised of duplication, fractionation, and derivation, is proposed to capture the overall system configuration characteristics of each of the classifications and the potential for hybridised designs. To some extent, different values of these three dimensions can be regarded as a representative of certain design type, or even a guideline of system concept design.

Mapping relations can be established between the system characteristic space and system properties, e.g. reliability, lifetime cost, etc. Applications of such mapping relations are dual: on one hand, the impacts of the system characteristic space on the system properties can be quantitatively analysed; on the other hand, system architecture can be optimised in the system characteristic space. In conclusion, the value-centric architecture based on system characteristic space serves as an effective approach for space system concept design.