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FRACTIONED SATELLITE TO IMPROVE SPACE MISSIONS FLEXIBILITY, MAINTAINABILITY AND PERFORMANCE

Abstract

Space missions are traditionally influenced by time and economic constrains as well as by technical issues. The classical engineering answer to those ties is to settle a single module to serve the orbiting payload in a compact single vehicle provided with redundancies for robustness and reliability. Such a solution, although definitely effective and mature to greatly absolve any kind of mission goals lacks of flexibility and easy maintainability. A possible approach to step forward may be to replace the conventional single vehicle with an assembly of several small semi-independent orbiting vehicles tightly dedicated to a very specific service functionality. A module itself is a single-task designed satellite and can be added, or exchanged, independently from the others, as well as be reused over different missions. Such an architecture is labeled as "fractioned satellites" to highlight the physical distribution of functionalities (e.g. power generation, telecommunication, etc) over a bunch of orbiting elements. The resultant distributed system can be seen as a free-flying payload supported by free-flying service modules. The overall performances of the resultant system shall be equal or possibly better than those achieved by a traditional satellite. Benefits of such a complex architecture lies in an increased efficiency in failure management, a better functionalities exploitation and in orbit flexibility to better fit the whole system performances to the faced, partially-unknown environment. However, fractioned satellites raise several design problems. The design variable space is enlarged - e.g. number of fractions, subsystems to be fractioned - as well as the constraints set to be satisfied – like relative attitude and orbital dynamics-. The paper proposes a method to evaluate the effectiveness of the fractioned satellite solution has in answer a predefined mission objectives, suggesting the best suited functionalities distribution. Comparison with single vehicle solutions is presented too. The proposed approach can perform the evaluation both of the individual fractions and the overall architecture, through the evaluation of costs – taking onto account how the possible failure of the fraction affects the whole architecture in terms of performance downgrade, time/expense for the replacement - estimated service life and reusability of the architecture, that means the residual efficiency of the system after the nominal mission end. A systematic analysis of the benefits/drawbacks of a one-by-one functionality fractioning is firstly presented; secondly the preliminary results of an optimization loop to combine single functionality fractioning to cope with given mission objectives are discussed in details.