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A SYSTEMS ENGINEERING APPROACH FOR ACCOMMODATING DISRUPTIVE SPACE TECHNOLOGIES

Abstract

In the history of space activities, efforts have been made to achieve breakthroughs in space applications and capabilities through what are known as disruptive or game-changing technologies. Reusable rockets and spacecraft, reconfigurable satellites, and in-situ resource utilization are examples of some well-known subjects of interest causing disruption. Linking the subjects of interest to application scenarios makes it possible to map the relation between such scenarios and the intrinsic information and functions. However, identifying this flow of information and functions is not enough to enable a breakthrough if there is no understanding of how a disruptive process is inserted in these relations. Thus, being able to identify, measure and model how the disruptive process interacts with the current Systems Engineering framework and system modeling tools represents the first step to achieve the desired innovation. This paper proposes a method to identify and measure the disruptive process, integrating it with the Systems Engineering framework for space missions. First, a definition of disruption is presented, considering the case of space activities and how this could be compared with disruption in other technology areas. Then, taking examples of current disruptive trends in the space industry, a parametric analysis is proposed. This considers some of the basic relations from space mission design, like cost-mass-performance, margins and tolerances, robustness and flexibility. Finally, the relation between disruption parameters and systems engineering parameters is outlined, and appropriate ways to integrate such relations into a model for mission design is discussed. As examples, two cases are presented considering scenarios of space sustainability and on-orbit servicing. In the first case, a commercial asteroid mining mission illustrates the disruption effect of a mission as a whole. In the second study, an observation mission demanding specific breakthroughs in lifetime and architecture is analyzed and the link between the disruption and on-orbit servicing applications is discussed.