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REVISITING THE SHAPES OF SPACECRAFT STRUCTURES ACCORDING TO 3D ADDITIVE MANUFACTURING

Abstract

The objective of this study is to investigate how and when structural topology optimization (TO), within the pre-processing phase of the 3D additive manufacturing (AM) techniques, should be applied in the spacecraft structures design process. 3D AM techniques while still evolving, are projected to exert a profound impact on manufacturing, swiftly progressing from rapid prototyping to the production of end-use products, giving to industry new design flexibility, reducing energy use and shortening time to market. Interest in these new additive techniques has grown as applications of 3D AM offer solutions that may be revolutionary if applied to the space field, with the possibility of enabling large scale space manufacturing standing out as one of the most appealing one. The capability of guaranteeing independence of the component cost from its geometrical complexity, reducing weight and production times and improving its structural performances, makes AM the perfect candidate to enable volume production for space applications (e.g. for very large constellations of small satellites). In this framework, the pre-processing phase of 3D AM techniques is crucial to take full benefit of its capabilities. The first step in the 3D AM design process is to develop a 3D model using a computer modeling software (CAD) and a TO software converting the model into a standard AM file format, changing the size, location, or other properties of the model. Implementing TO in the concept stage of spacecraft structures requires a close and a careful interaction between the design phase and the structural/system analysis to create the correct design domain. The purpose of TO is to find the optimum distribution of material, varying the density of the material in the model and removing it from regions where it is not necessary to sustain the applied loads, with the result of generating the input for the design phase in an iterative scheme. The final configuration

of a spacecraft, characterized by the presence of various subsystems, is a compromise among different requirements: current 3D AM design tools therefore need to be adapted to encompass specific features and design rules typical of space systems.