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THERMO-MECHANICAL CONCEPT FOR A MODULAR ON-ORBIT-SERVICEABLE SATELLITE SYSTEM

Abstract

Within the iBOSS project (intelligent Building Blocks for On-Orbit Satellite Servicing), a research program funded by the German Federal Ministry for Economic Affairs and Energy and managed by the German Aerospace Center, a full modular and serviceable satellite architecture is being developed. This architecture combines a spacecraft's modularization with On-Orbit-Servicing capability. The modules are able to detach autonomously in space and can be maintained by a servicer satellite. Assembly, disassembly, upgrade and repowering of satellite systems in space can be carried out by means of robotic manipulation, thus an enhancement of lifetime can be attained. The building block architecture facilitates the development and integration of new satellite systems and may reduce production costs and time.

The modularization is achieved by subdividing a satellite bus on component level and subsequent integration of the components into independent building blocks. By connecting these blocks with a multifunctional interface, also developed within the iBOSS project, a mission specific satellite can be initially assembled and launched into orbit. The preliminary design of the module's primary structure considers different aspects like weight, complexity and classification. It focuses on problems like structural stability, load-introduction and thermo-mechanical aspects. Two different concepts, a frame based and a monocoque structure made of CFRP (Carbon Fiber Reinforced Plastics), are investigated and compared regarding their structural and thermo- mechanical performance.

With respect to the reconfiguration and rearrangement of building blocks in orbit the blocks' surfaces cannot act distinctly as radiator or isolator. Moreover, the thermal deformations have to be kept in small margins. As a consequence of this required high level of flexibility, the satellite's building blocks do not possess a predominant orientation. This challenges the thermal control and the structure's thermo-mechanical design. In order to realize a multi-functional lightweight structure, the composite design takes advantage of the anisotropic properties of CFRP, like high stiffness, high thermal conductivity and low thermal expansion. The thermo-mechanical concept intends to distribute the heat energy even around the module, towards the module's interfaces. This paper investigates the block's structure capability to spread the necessary amount of heat energy along specific paths and past structure joints, without the extensive use of additional thermal conductive elements.