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MODULAR ARCHITECTURE DESIGN AND EVALUATION OF LARGE SPACECRAFT

Abstract

Spacecraft in orbit usually encounter problems such as high maintenance costs, the aging of infrastructures, and fuel limitation. How to ensure that the spacecraft runs sustainably and stably in orbit has become a research hotspot in the field of space technology. After entering orbit, various states of spacecraft are solidified, and the costs of maintenance are greatly increased. Such spacecraft generally neither have an on-orbit service interface nor the ability to accept on-orbit services after being in orbit. The modular design of the spacecraft is an effective mean which could improve the spacecraft's ability to accept on-orbit maintenance. Modular spacecraft usually require standard and uniform mechanical and electronic interfaces between the modules. These modules are replaceable, easy to operate, and have plug-and-play function. The current satellite quality in orbit is generally large, and the components are complex, so that the cost is high. Modular design for large satellites and in-orbit maintenance have very important and realistic research value. Firstly, the characteristics of traditional satellites are summarized. The satellite subsystems are divided into two types: structural subsystems and functional subsystems. Then, the working characteristics of each functional system are analyzed, including components classification, installation location, spatial directivity requirements, and volume ratio. At the same time, the bearing characteristics and structure categories of the structural subsystem are analyzed. Modular satellite design requirements include structural requirements, such as shape, volume, strength requirements; self-expandable requirements; power supply, information, thermal control bus integration requirements; on-orbit operation requirements. According to the setting of structural modules and functional modules, there are two alternatives of modular spacecraft's configuration: separate configuration and unified configuration. The structural module and functional module are separately designed in the separate configuration scheme. In unified configuration scheme, each module is a unit of structure module and function module. After selecting geometric model and analying special components, such as solar sails and engines which are difficult to integrate, the modular satellite would adopt an axial polyhedral stacking configuration. Combined with engineering application requirements, the whole function module is divided. The module division rules and evaluation criteria are formulated, and the quantitative model is established for evaluation. Standard interface are designed and interface standards that meet common requirements are developed. Moreover, the power supply, communication, and thermal control topology schemes are designed. Finally, architecture design are carried out in combination with specific engineering data.