SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Space Technology and System Management Practices and Tools (4)

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AN EFFECTIVE METHOD FOR ANALYZING STOCHASTIC MISSIONCYCLE COST OF FRACTIONATED SPACECRAFT

Abstract

With the rapid development of computational capability, sensor technology and communication technology, the traditional monolithic spacecraft tends to be coordinated and controlled by multiple spacecraft whose control center is network. In order to solve the personal, technical, environmental, launch, demand and funding uncertainties etc, Charlotte Mathieu and Annalisa Weigel from the Massachusetts Institute of Technology came up with a completely new concept of fractionated spacecraft in 2005. To fully understand the impact of various uncertainties on its development, launch and in-orbit operation, we use the stochastic missioncycle cost to comprehensively evaluate the survivability, flexibility, reliability and economy of the ways of dividing the various modules of the different configurations of fractionated spacecraft. In order to more fully compare the advantages and disadvantage of different configurations, the most important thing is to establish the space mission cost model that considers the impact of uncertainties within the whole missioncycle, that is to say the lifecycle cost of the fractionated spacecraft should consider the missioncycle costs of development, launch, deployment, operation, maintenance, replacement and so on, obtaining the comprehensive evaluation results through their distribution characteristics. The essential work here is to establish the cost model of the fractionated spacecraft. We systematically describe its concept and then analyze its evaluation and optimal design method that exists during recent years and propose the stochastic missioncycle cost for comprehensive evaluation. We also establish the models of the costs such as module development, launch and deployment and the impacts of their uncertainties respectively. We treat all these uncertainties as stochastic variables and model them with the probability method. Finally, we carry out the Monte Carlo simulation of the complete missioncycle costs of various configurations of the fractionated spacecraft under various uncertainties and give and compare the probability density distribution and statistical characteristics of its stochastic missioncycle cost, using the two strategies of timing module replacement and non-timing module replacement. The simulation results verify the effectiveness of the comprehensive evaluation method and show that our evaluation method can comprehensively evaluate the adaptability of the fractionated spacecraft under different technical and mission conditions.