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A NEW RELIABILITY EVALUATION METHOD OF SOLAR ARRAY UNFOLDING MECHANICS BASED ON TEST DATA ON GROUND AND ON-ORBIT FLIGHT DATA

Abstract

As one of critical units on the spacecraft, the unfolding reliability of spacecraft solar array unfolding mechanics directly affects the spacecraft's flight mission success. Duo to unable to be backed up, the solar array unfolding mechanics are required to be designed with super high reliability index, while it usually has extra-small samples. Then, the verification of reliability requirement becomes an awkward problem. The unfolding of solar array mechanics usually can be considered as one-shot event. The reliability evaluation of one-shot products generally needs a considerable large amount of experiment samples. However, the test data gathered via on-site experiments would be barely adequate due to the limitations of cost, time and other factors. Therefore, the traditional verification test of unfolding reliability of solar array unfolding mechanics based on statistical testing is not feasible for very high reliability index requirement because of limited test samples, test cost and test condition restriction on the ground. Thus a new reliability analysis method is presented for quantitative reliability analysis of solar array unfolding mechanics with limited test data. This method makes full use of the data obtained development process to extend the information quantum and then carry out the reliability evaluation of one-shot product. Firstly, according to the results of FMEA (fault mode and effect analysis), the unfolding mechanics is divided into several weak links. Then, the system reliability models of unfolding unit are built under these weak links. Considering the limited reliability test data on ground, the other test data are used to assess the reliability. These data include impact test data, simulation test data, function test and component-level performance test data, and so on. The method fuses all kinds of useful test data and simulation data for components reliability assessment. At last, the previous similar product on-bit flight data are integrated with the component-level analysis results to implement the whole unfolding mechanics reliability evaluation. The method provides a feasible way to evaluate and verify the high reliability of solar array unfolding mechanics with extra-small samples, and this method can also be extended to other space mechanics with similar characteristic.