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MONTE CARLO SIMULATION OF RELIABILITY GROWTH OF SMALL-SCALE SATELLITES THROUGH TESTING

Abstract

There is increasing demand of small-scale satellite (a micro/nano/pico satellite seeking low-cost and fast-delivery) development worldwide. The advantages of small-scale satellite are low-cost and fast-delivery. The success rate of small-scale satellite is, however, much lower than traditional satellites. The satellite reliability can be modeled by Weibull statistics. A satellite goes through a series of tests. The tests may detect various defects in design, material, workmanship, etc. Once a defect is detected, it is corrected and the test resumes or the development process goes back to an earlier phase. The failure rate decreases due to improvement and keeps decreasing as the testing continues until it becomes a steady value indicating the shift to the random failure mode. The purpose of the present paper is to study how the reliability is improved by testing. We discuss the testing strategy to optimize the cost (or schedule) against the reliability. This study is carried out as a part of studies to formulate a testing standard suitable for small-scale satellites that aims at improving the satellite reliability, mostly infant mortality, while keeping the low-cost and fast-delivery characteristics. We carry out a Monte Carlo Simulation to simulate the stochastic process where a defect is detected by testing. A satellite system made of 10 sub-systems was assumed. Each sub-system is given an initial failure rate made of a time-dependent part according to a Weibull distribution and a constant part. At each phase of testing, whether a defect is detected or not is judged by a random number for each sub-system. If the defect is detected, either the same test phase is repeated or the test phase goes back to the previous stage, but both with the reduced failure rate. The overall test time is calculated and compared to the final reliability that depends on how many of latent defect remain undetected. Two step testing, i.e. AT (acceptance test) and QT (qualification test) was assumed as well as one step testing, i.e. PFT (proto-flight test). There are various parameters involved in the simulation. From parametric study, it was found that repeating short cycles of testing is effective to achieve relative high reliability with less testing time. This finding agrees with experience felt during actual satellite test that if a failure occurs it occurs early in the test.