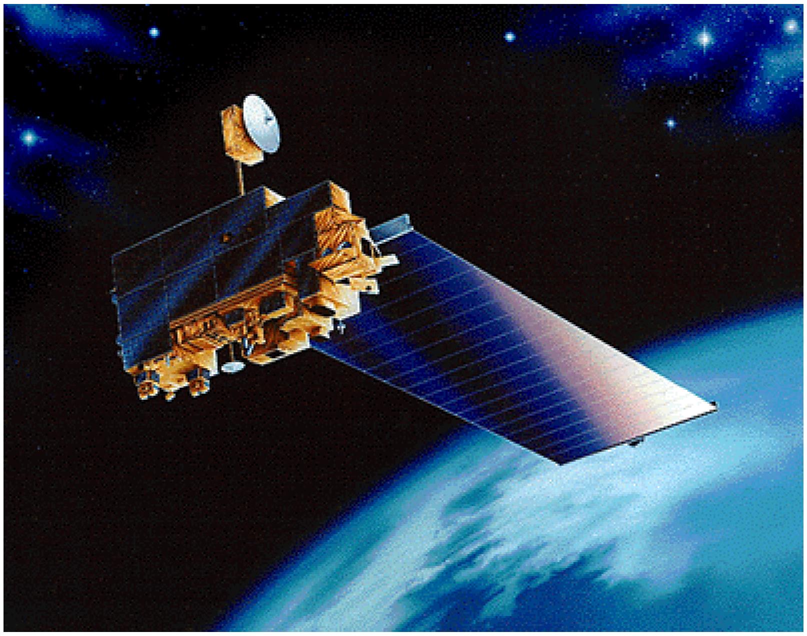
Statistical Treatment of Earth Observing System Pyroshock Separation Test Data



EOS spacecraft.

The Earth Observing System (EOS) AM-1 spacecraft for NASA's Mission to Planet Earth is scheduled to be launched on an Atlas IIAS vehicle in June of 1998. One concern is that the instruments on the EOS spacecraft are sensitive to the shock-induced vibration produced when the spacecraft separates from the launch vehicle. By employing unique statistical analysis to the available ground test shock data, the NASA Lewis Research Center found that shock-induced vibrations would not be as great as the previously specified levels of Lockheed Martin.

The EOS pyroshock separation testing, which was completed in 1997, produced a large quantity of accelerometer data to characterize the shock response levels at the launch vehicle/spacecraft interface. Thirteen pyroshock separation firings of the EOS and payload adapter configuration yielded 78 total measurements at the interface. The multiple firings were necessary to qualify the newly developed Lockheed Martin six-hardpoint separation system.

Because of the unusually large amount of data acquired, Lewis developed a statistical methodology to predict the maximum expected shock levels at the interface between the EOS spacecraft and the launch vehicle. Then, this methodology, which is based on six shear plate accelerometer measurements per test firing at the spacecraft/launch vehicle interface, was used to determine the shock endurance specification for EOS.

Each pyroshock separation test of the EOS spacecraft simulator produced its own set of interface accelerometer data. Probability distributions, histograms, the median, and higher order moments (skew and kurtosis) were analyzed. The data were found to be lognormally distributed, which is consistent with NASA pyroshock standards. Each set of lognormally transformed test data produced was analyzed to determine if the data should be combined statistically. Statistical testing of the data's standard deviations and means (*F* and *t* testing, respectively) determined if data sets were significantly different at a 95-percent confidence level. If two data sets were found to be significantly different, these families of data were not combined for statistical purposes.

This methodology produced three separate statistical data families of shear plate data. For each population, a P99.1/50 (probability/confidence) per-separation-nut firing level was calculated. By using the binomial distribution, Lewis researchers determined that this per-nut firing level was equivalent to a P95/50 per-flight confidence level. The overall envelope of the per-flight P95/50 levels led to Lewis' recommended EOS interface shock endurance specification. A similar methodology was used to develop Lewis' recommended EOS mission assurance levels.

The available test data for the EOS mission are significantly larger than for a normal mission, thus increasing the confidence level in the calculated expected shock environment. Lewis significantly affected the EOS mission by properly employing statistical analysis to the data. This analysis prevented a costly requalification of the spacecraft's instruments, which otherwise would have been exposed to significantly higher test levels.

Bibliography

Hughes, W.O.; and McNelis, A.M.: Statistical Analysis of a Large Sample Size Pyroshock Test Data Set. Proceedings of the 68th Shock and Vibration Symposium, Hunt Valley, MD, Nov. 6, 1997.

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