

# Pyroshock Environments Characterized for Spacecraft Missions



*EOS spacecraft following shock separation testing at Lockheed Martin Missiles & Space, Valley Forge, Pennsylvania.*

Pyrotechnic shock, or pyroshock, is the transient response of a structure to loading induced by the ignition of pyrotechnic (explosive or propellant activated) devices. These devices are typically used to separate structural systems (e.g., separate a spacecraft from a launch vehicle) and deploy appendages (e.g., solar panels). Pyroshocks are characterized by high peak acceleration, high-frequency content, and short duration. Because of their high acceleration and high-frequency, pyroshocks can cause spaceflight hardware to fail. Verifying by test that spaceflight hardware can withstand the anticipated shock environment is considered essential to mission success.

The Earth Observing System (EOS) AM-1 spacecraft for NASA's Mission to Planet Earth is scheduled to be launched on an Atlas IAS vehicle in 1999, and the NASA Lewis Research Center is the launch vehicle integrator for this NASA Goddard Space Flight Center spacecraft. The EOS spacecraft was subjected to numerous ground shock tests to verify that its scientific instruments and avionics components will withstand the shock-

induced vibration produced when the spacecraft separates from the launch vehicle. Shock test data from these tests represent the third largest available pyroshock database in the United States. Future spacecraft missions will directly benefit from the knowledge gained from these tests.

The payload separation system used for EOS is a new system that operates by firing six separation nuts. This system was tested to verify its functional operation and to characterize the resulting shock levels. The launch vehicle contractor (Lockheed Martin Astronautics) and spacecraft contractor (Lockheed Martin Missiles & Space) completed 16 separation test firings. This resulted in an unusually large amount of pyroshock data. Typically, only one or two pyroshock test firings are performed for a spacecraft mission.

Because of the size of this separation system shock database, engineers were able to perform unique statistical analyses to characterize the distribution of the test data. For example, it was proven that the shock data follow a lognormal distribution, a concept often assumed but rarely proven. The test-to-test repeatability of the shock source level was analyzed, and the effects of various test configurations and separation nut production lots were examined and quantified.

Engineers investigated the change in shock level as the shock traveled from the spacecraft separation interface to the avionics components of the upper stage and analyzed the effects of the structural fidelity (simulator versus real) of the components and their weight on vibrational response. In addition, the shock attenuation with distance and across joints was quantified and compared with concepts originally generated in 1970, and the effects of separation nut preload and firing sequences effects were examined.

Because of this EOS shock testing and the analyses performed at NASA Lewis, a significant amount of new information on pyroshock and its characteristics is now available to the aerospace industry. We hope that this information will help future spacecraft test planners to perform better and cheaper spacecraft separation shock tests and to better understand their test data.

**Find out more about EOS:**

<http://eos-am.gsfc.nasa.gov/spacecraft.html>

<http://eosps0.gsfc.nasa.gov>

<http://www.earth.nasa.gov/>

## **Bibliography**

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