NASA HESSI VIBRATION TEST FAILURE

The primary mission of the High Energy Solar Spectroscopic Imager (HESSI) is to explore the basic physics of particle acceleration and explosive energy release in solar flares.

The HESSI spacecraft was subjected to a vibration test on March 21, 2000, at NASA's Jet Propulsion Laboratory, Pasadena, CA.

A failure of the shaker table caused an overtest condition. The shaker applied an excessive base acceleration to the spacecraft.

As a result, the spacecraft's structure was damaged; and three of the four solar arrays were severely damaged.

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BOARD FINDS CAUSE OF HESSI MISHAP

The HESSI Mishap Board released its final report today saying that the High Energy Solar Spectroscopic Imager (HESSI) spacecraft was damaged March 21 during pre-flight vibration tests because of a malfunction in the vibration test system at NASA's Jet Propulsion Laboratory in Pasadena, CA. (The vibration tests simulate the stresses that the spacecraft experiences during the rollout, release and flight to orbit aboard the Pegasus launch vehicle.)

The damage was caused when the test device, called a "shaker," delivered approximately 20 G's, ten times the appropriate level for the test, to the spacecraft. (A G is a unit of force equal to the gravity exerted on a body at rest.) As a result, the spacecraft's structure was damaged and three of the four solar arrays were severely damaged. Satellites are routinely subjected to vibration testing as part of preparing them for flight.

Mishap Board Chairman Denny Kross, Manager, Engineering Systems at NASA's Marshall Space Flight Center, Huntsville, AL, said a misalignment between two pieces of the test stand led to an abnormally high level of static friction (what engineers call "stiction"). The computer used to control the test then tried to compensate and induced too large a shock into the satellite. "It's similar to what happens when you are trying to close a sticky, wooden window that's just a little out of kilter in the frame," Kross said. "As soon as the window starts to stick, your brain says, 'push down harder.' And if you are not careful, you can push so hard that, when the window does break free, its slams down onto the bottom of the window sill."

To prepare for the test, the satellite is mounted on a device called a slip table, which attaches atop a large slab of granite mounted to the floor. A thin layer of oil is continuously pumped between the slip table and the granite slab to allow the slip table to move freely when stimulated by the "shaker." A computer controls how hard the spacecraft is shaken, and accelerometers measure the response of the spacecraft to the shaking.

Engineers found that the shaker mechanism had shifted on its mounting base, due to a failed support bearing. The problem was not discovered until after the accident. The broken bearing shifted the position of the shaker mechanism causing the misalignment between the slip table and the granite mass, and this misalignment in turn created friction between the two pieces of hardware. The computer, sensing this friction, calculated an inappropriate drive signal and the resulting pulse was significantly higher that expected, damaging the satellite.

Two primary factors contributed to the accident, Kross said. One was the absence of a scheduled maintenance program requiring periodic inspections of the shake table. The other was the lack of a procedure requiring the test team to look for any shaker performance problems in the pre-test data. "Had either of these procedures been in place, this incident could have been avoided," Kross said.

The Board has made a number of recommendations in its report for changing processes and procedures used by NASA for vibration tests. "The JPL test team responded magnificently in the wake of this incident," he said. "They are revamping their inspection program so the test fixture is physically and visually inspected at regular intervals. They are adding steps in the testing procedure so that results of earlier tests are reviewed and analyzed to look for early indications of stiction before the final tests are conducted."

Kross said other recommendations, such as refurbishing the shaker and implementing over-test protection methods, also are underway at JPL. As a result of the Board's work, new procedures were put in place at NASA's Goddard Space Flight Center, Greenbelt, MD, where similar testing is done, and alerts have been sent to other sites in the U.S. and overseas where satellites undergo vibration checks.

The HESSI satellite will be repaired and re-assembled at the University of California, Berkeley, which is serving as the prime contractor on the project and is home to the principal investigator. HESSI will be returned to JPL for continued spacecraft testing after re-assembly. Launch plans will be announced when available.

NASA's development cost for the HESSI spacecraft was budgeted at $40 million. Development, launch vehicle and mission operations costs bring the total mission value to $75 million. HESSI is a Small Explorer mission and is managed by Goddard under the Explorer Program. The science team includes co-investigators from Switzerland, Scotland, Japan, France and The Netherlands. More information on the mission can be found at:

http://hesperia.gsfc.nasa.gov/hessi/
http://hessi.ssl.berkeley.edu

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