Space Operations Digest

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This is the first edition of the Space Operations Digest, created to share information of interest to satellite operators and others in the space community. This issue reviews the effect of solar activities on satellites, a recent cause for concern.

Understanding Solar Risks

Background. Solar activities threaten satellites in numerous ways. When a coronal mass ejection hits Earth's magnetic field, it may produce magnetic substorms that result in a hot plasma, in turn causing an electrostatic discharge (ESD) on the surface of spacecraft. The radiation belts may also be "pumped up" after the storms, causing high-energy electrons to penetrate satellites and trigger ESD problems inside the spacecraft.

Impact. The Aerospace Corporation's Space Systems Engineering Database (SSED), the largest of its kind in the world, has cataloged more than 160 instances of major on-orbit anomalies caused by ESD and more than 50 other significant events related to solar radiation. The results can be traumatic, as indicated in the table below. Five missions have been lost to ESD alone, far surpassing any other kind of environmentally related satellite anomalies.

Missions Lost to Electrostatic Discharge

Satellite	DSCS II	GOES 4	Feng Yun 1	Marecs A	Insat 2D
Date	02/73	11/82	06/88	03/91	10/97

SSED serves as a national repository of information on various government space programs and makes available a vast amount of general space-related information to serve government policy- and technical decision-makers. One particular area of focus is satellite anomaly data, which includes detailed histories of more than 200 satellites as well as general information on virtually all Western satellites. This information has been critical in efforts to improve the reliability of satellite systems and forms the basis of The Aerospace Corporation's lessons-learned database, which will be presented in future issues of this newsletter.

Another Y2K Scare? Media hype of a "satellite-killer solar storm" has increased significantly because a solar max is looming. In reality, solar hazards do not coincide with solar max; they can take place at any time during a solar cycle. It is beyond today's capability to make accurate day-to-day predictions of space weather. Conditions leading to surface charging, the more serious problem, are not only just marginally correlated to solar max, but also build up so fast that imminent forecast cannot be made. Internal charging caused by radiation increases may be reasonably forewarned but have caused no satellite failures to date. Because satellites cannot maneuver away from a serious threat, they must be designed to withstand extreme space weather events as a matter of course.

Analyzing the Sun's Role in Failure. Satellite operators, builders, and insurers are sometimes mired in disputes over the part solar activity plays in a failure. This analysis is by no means straightforward and can be illustrated with some postmortems in which Aerospace recently participated.

In one case a communication satellite catastrophically failed after a severe magnetic storm caused by a coronal mass ejection, which promptly became the leading suspect in the failure. Space weather involvement was eventually ruled out, and published reports ultimately pinned the loss on faulty materials.

In another case a spacecraft suffered a series of solar-array degradations in an environment manifestly ripe for surface charging. It was also found that the wiring technique used was apt to stress the cables, damage the sleeves, and create a short. The ESD problem although precipitated by the solar storm could have been averted if the manufacturing technique had been optimized.

Summary of Lessons Learned. Although the space environment may seem to have damaged a satellite in a particular instance, only a rigorous investigation can reveal the true root cause and the proper corrective actions. A satellite must be designed to combat solar threats with robust margins—specifically, satellites need to be hardened against ESD. Adherence to the well-established design guidelines on structure, materials, shielding, cable interfaces, and circuits is crucial, as is the ability of materials and components to pass rigorous survivability tests.

Space Lessons Learned

The Aerospace Corporation collects lessons learned from failures in the space industry to avoid the repetition of mishaps. Government contractors can share these lessons by calling (310) 336-8222. Each issue of the digest will summarize such a lesson. This issue examines the importance of venting honeycomb structures.

Venting Honeycomb Structures Reduces Delamination Risk
Conventional honeycomb structures have enclosed cores. This design is apt to fail for space applications because some volatiles will unavoidably be trapped in the cells. During launch the structure will heat rapidly, forcing the volatiles to expand in the confined space and create an overpressure that will break the structure at any weak spot. This problem, which has caused the loss of several satellites, can be mitigated with ventilation. Unvented structures should be used only under exceptional conditions and be supplemented by thorough inspection and proof testing to ensure flight worthiness. The recent X-33 tank failure starkly illustrates the consequence of ignoring this lesson.

The mission of the Center for Orbital and Reentry Debris Studies is to provide state-of-the-art, objective technical analyses and assessments on space debris, collision avoidance, reentry breakup, and related space hazards. For more information, contact Bill Ailor at 310-336-1135, or via email at William.H.Ailor@aero.org, or visit CORDS online at **http://www.aero.org/cords/**.