Space Operations Digest

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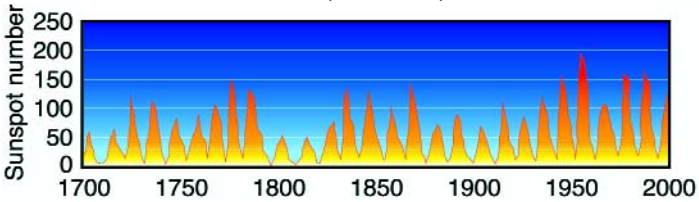
The Aerospace Corporation periodically publishes the Space Operations Digest to share information of interest to satellite operators and others in the space community. This issue summarizes the effect on satellites of the current high level of solar activity known as the solar max.

Solar Cycle 23 in Perspective

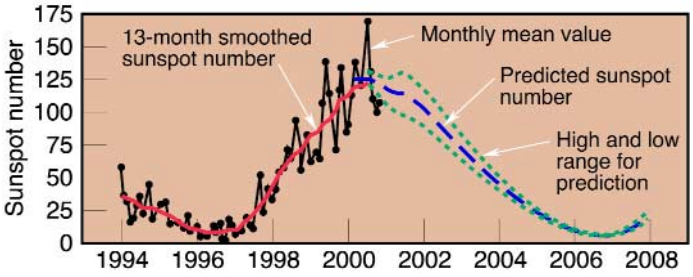
Background. The sun flares up in 11-year cycles. During periods of high activity (solar max) there are more sunspots than usual, accompanied by bigger flares and solar proton events. If Earth is hit by one of these solar proton events, problems with radio communications and satellites can arise.

Solar Cycle History



The latest cycle, the 23rd since record-keeping began, peaked in late 2000 with a maximum sunspot number of about 123.5 (derived from the number of individual spots and sunspot groups, followed by curve smoothing; this is not necessarily an integer). This cycle is comparatively benign—cycle 21 peaked with a sunspot number of 164.5 in December 1979, and cycle 22 peaked with a sunspot number of 158.5 in July 1989. There was, nonetheless, extensive media coverage about the anticipated "satellite-killer storms."

Solar Cycle 23 Sunspot Numbers



Year 2000 Activities—Proton Events. The most dramatic space weather events of 2000 were the solar proton events July 13-23 and November 9-18. Both rank among the four largest of the past 30 years. A variety of single-event upsets, solar-array degradation, increased atmospheric drag, sensor degradation, and false star images on spacecraft ensued.

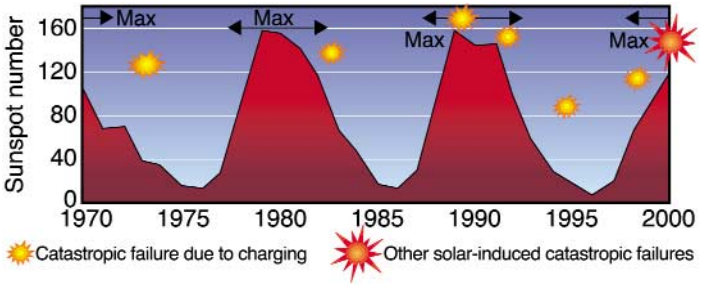
- On July 15, 2000, the Japanese ASCA satellite was lost due to strong atmospheric drag that created a torque on the spacecraft, which could not be corrected by its attitude-control system. This drag was caused by the severe geomagnetic storm that accompanied the solar proton event.
- On November 9, 2000, the WIND spacecraft's attitude-control subsystem, command pulse, star scanner, and magnetic sensors were disabled due to sensor saturation. Operation was later restored.
- Also on November 9, 2000, the star camera on the STARDUST spacecraft showed hundreds of false-star images. Unable to determine its attitude, the spacecraft went into safe-hold mode. It successfully recovered later.

Other Activities. The year 2000 proved to be otherwise quite uneventful. There were two days of "severe" and eight days of "major" geomagnetic storms, events that can lead to intense spacecraft charging and subsequent discharges. Within a comparable phase of the previous solar cycle in 1989, there were five severe and 16 major storm days.

The energetic electron flux in geosynchronous orbit, as measured by the GOES 8 spacecraft, was also relatively benign. The average daily flux of electrons with energies greater than 2 MeV never reached major or severe storm levels and surpassed minor storm levels on only three days.

No Time to Relax. The high point of activity for the current, relatively modest cycle has passed. As shown in the graph below, however, many space weather hazards can occur during the declining phase of a solar cycle.

Space Weather Hazards After Peak Activity



As covered in the first issue of the Space Operations Digest, conditions leading to spacecraft charging, the most onerous on-orbit problem, only marginally correlate to solar events. Troubles can occur at any time during a solar cycle, and satellites need to be hardened against space weather using well-established design guidelines on structure, materials, shielding, cable interfaces, and circuits.

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/**.