

*Editor's Note: Contact to the Solar and Heliospheric Observatory (SOHO) was lost in June 1998 due to ground controller errors, and control was not regained until three months later. In this issue we recount the events that led to the mishap; in the next issue we will discuss SOHO's dramatic rescue.*

## SOHO in Trouble

**Background.** SOHO is a joint program between ESA and NASA. Launched in April 1996 to the Sun-Earth L1 point (almost a million miles from the Earth), SOHO has collected spectacular images of the Sun that have helped revolutionize solar science.

### SOHO Attitude Control.

SOHO uses three gyros:

- Gyro A, to control the safe mode;
- Gyro B, to detect faults; and
- Gyro C, for normal attitude control.

**Erroneous Software Patch.** Gyro A should be programmed to automatically spin up whenever SOHO enters safe mode. During a revision of several stored command sequences, a new feature was added to enable gyro deactivation (spin down). The engineer lacked system knowledge and neglected to add instruction to spin up Gyro A. A sloppy control change process failed to catch the error—the change was not properly communicated, nor was the macro's name altered to highlight the change.

**Prelude to Failure.** After a routine momentum management maneuver in which all gyros were turned on, Gyro A was commanded off, using the flawed sub-routine, to conserve its life. Coincidentally, Gyro B was improperly set, causing a false reading. The on-board computer detected the fault in Gyro B and put SOHO in safe mode. The error on Gyro B was corrected, but control shifted from Gyro C to A, which now was off.

**Confusion.** Readings from Gyro B (working) and Gyro A (despun) diverged, causing the thruster to fire and try null the apparent roll error, which did not in fact exist. SOHO entered safe mode again two hours later.

**Rash Judgments.** SOHO was designed to survive in safe mode for at least 48 hours. However, instead of using this time to analyze why one anomaly followed on the heel of another, the overloaded staff commenced recovery efforts immediately, ignoring the operations script that required the stored telemetry to be checked. Had this step been followed, the erroneous status of Gyro A would have been obvious.

**Ancillary Indicators Ignored.** In the rush to recover from safe mode, other indicators of Gyro A misbehavior were ignored. For example, thruster firing results did not match Sun sensor data. And Gyro A should not have continued to read zero after the thruster firings.

**Misdiagnoses.** During previous safe modes, SOHO's roll rate had been close to zero. Now, Gyro A read zero and Gyro B was variable, indicating non-zero roll rates. Based on past safe modes, the operators regarded Gyro B as at fault, and turned it off. With no functional gyro, control of SOHO was lost.

### Lessons Learned.

- Software patches should be checked as thoroughly as the original software.
- Operators should be trained to recognize failure signatures and follow contingency procedures.
- The system should be designed to quickly identify discrepancies with potential catastrophic impact, either autonomously or with good telemetry displays.



*SOHO weighs about two tons and with its solar panels extended stands about 25 feet across. It was launched in December, 1995. SOHO will continue operating well past the next solar maximum in 2001.*

*Images courtesy SOHO (ESA & NASA)*

