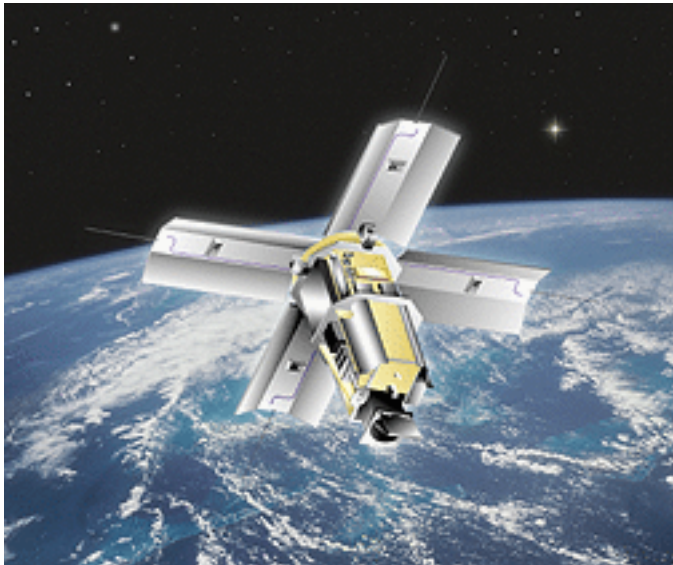


Editor's Note: The Multispectral Thermal Imager (MTI) spacecraft suffered a nearly fatal malfunction in part due to subtle ground command handling issues. This incident teaches several broadly applicable lessons and is recounted below. Details are described in M. Decker, et. al, Proceedings of SPIE, Vol. 4381, p. 184 (2001) and *ibid*, Vol. 5159, p. 102 (2003).

The Loss of MTI Telescope Controller

Background

Developed by the Sandia National Laboratories, the 15-band MTI satellite was launched on March 12, 2000 for Nuclear Nonproliferation Treaty monitoring. A controlling unit operated the aperture door, focusing mirror, and onboard calibration assembly.



The MTI Satellite

Illustration courtesy Sandia National Laboratories

Command Safety Flaw

The ground crew sent commands in two parts: “clear register” followed by “execution.” However, the command checking process would not automatically preclude “execution” in case the “clear” command was not carried out.

Late in 2001, a command was issued when the satellite was near the horizon. The “clear” instruction did not go through, but the “execution” did. Unfortunately, this particular “execution” command, when combined with the register contents left over from a previous command, caused the flight computer to freeze. Several stored command sequences backed up.

Troubleshooting Mistake

During a subsequent contact with the ground station, operators reset the interrupt controller. Right away, all pending commands ran. The telescope aperture door drive and the calibration source motor, intended for operation with a 40-second pause in between, switched on at the same time. The telescope controller, not designed to accommodate the simultaneous mechanism operation, blew a fuse—potentially ending the mission.

Fortunately, MTT’s fail-safe management system automatically sprang the aperture door open and moved the calibration wheel clear. Observations could still be made, and the program subsequently developed a different calibration approach so the mission could be continued.

Lessons Learned.

- Conditional commands (execution of an instruction contingent upon another) must first verify the completion of the preceding command.
- If multiple commands can cause a mechanical or electrical conflict, code in a prevention block (i.e., an exclusive OR).
- Ensure flight computers are restarted in a known mode with only appropriate commands in the queue—always clear pending commands first.

ISO Standard for GEO Disposal Drafted

As part of its new focus on standardizing techniques and best practices for minimizing the creation of space debris, ISO, the International Organization for Standardization, is developing a standard for disposal of satellites operating at geosynchronous altitude. If approved, this International Standard will prescribe requirements for planning and executing maneuvers and operations to remove a space vehicle from geosynchronous orbit at the end of its mission and place it in an orbit for final disposal where it will not pose a future hazard to satellites operating in the geosynchronous ring. Included are requirements related to when the disposal action must be initiated, selecting the final disposal orbit, executing the disposal action successfully, and depleting all energy sources to prevent explosions after disposal. A draft of the standard is available for review and comment. Please contact CORDS@aero.org if you’d like a copy.