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## Mystery of Orbiter Crash Solved

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NASA's Mars Climate Orbiter was lost in space last week because engineers failed to make a simple conversion from English units to metric, an embarrassing lapse that sent the \$125 million craft fatally close to the Martian surface, investigators said yesterday.

Officials are scrambling to determine whether a similar error is buried in the computer files of two other spacecraft currently cruising through space: the Mars Polar Lander, scheduled to hit the Martian surface on Dec. 3, and the Stardust craft bound for a comet.

It now appears the error had affected the orbiter mission from its launching almost 10 months and 416 million miles before its Sept. 23 failure. And yet the problem was never caught and corrected by the system of checks and balances at the Jet Propulsion Laboratory (JPL) in California, which manages this and numerous other interplanetary missions for NASA.

As a result, flight controllers believe the spacecraft plowed into the Martian atmosphere, where the stresses crippled it, aborted its insertion into Martian orbit and most likely left it hurtling on through space in an orbit around the sun.

Baffled NASA officials said they were struggling to figure out how this happened, and bracing themselves for an onslaught of derision.

"Our inability to recognize and correct this simple error has had major implications," said JPL director Edward Stone.

The initial error was made by contractor Lockheed Martin Astronautics in Colorado, which, like the rest of the U.S. launch industry, traditionally uses English measurements. The JPL navigation team, on the other hand, uses metric measurements in the complex business of figuring out a spacecraft's position relative to moving planets and keeping it on course. The contractor, by agreement, is supposed to convert its measurements to metrics.

However, officials said, this simple error should not have cost them a spacecraft. Investigators are collecting information about whether concerns were raised by anyone during the mission but ignored, whether proper procedures were followed, and in general how both human and computer monitors failed to detect the problem.

"We are revisiting all the files from day one," said JPL's Charles Elachi, director of space and earth sciences. "We want to get to the bottom of this and fix it."

The initial error occurred in computer files forwarded regularly by Lockheed Martin to JPL navigators, according to Elachi's deputy, Tom Gavin. The wrong numbers referred to tiny thruster firings performed routinely twice a day. The navigators, in turn, performed their analysis of the spacecraft's position in space based on the assumption that the descriptions of these firings were in metric units of force per second (newtons). In fact, the numbers instead represented pounds (of force per second). This led to tiny miscalculations of the spacecraft's course that compounded over time. There were subtle clues in the data that something was off, but no one recognized the cause until yesterday.

Officials said there will likely be no personnel firings over the failure. As one put it, the emphasis will not be in "pointing fingers and dealing out punishment," but in "figuring out how the process failed and fixing it." Two separate panels are looking into the failure, including an internal JPL group and a review board consisting of both JPL and outside experts. An independent NASA group will be formed shortly.

The orbiter was one in a series of missions being dispatched to Mars every two years, under NASA's recently adopted "faster, smaller, cheaper" philosophy. NASA officials rejected suggestions that the failure reflects badly on that approach. Historical failure rates for billion-dollar missions of the past, and the smaller, more frequent missions of today, are similar -- about 10 percent, they said.

Under the discarded system of flying huge and complex missions only once in a decade or so, a loss was more devastating, officials said. In this case, they have the surveyor in Martian orbit and the lander on its way.

This eases the sting of the talk show jokes that are bound to fly concerning the foolishness of the mistake, said Carl Pilcher, NASA's chief of solar system exploration. "Oh, God, there's nothing we can do about that. We'll live through it. . . . Then we'll wow them again."

The orbiter's main mission was to monitor the Red Planet's atmosphere, surface and polar caps for one Martian year, or 687 days. First, however, the craft was to have served as a communications relay link for the lander. Managers said backup plans will allow the lander instead to transmit data either directly to Earth, through the global Deep Space Network of antennas, or through the orbiting Mars Global Surveyor.

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