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Physics

## Are Units Important? The Sad Tale of the Mars Climate Orbiter



News release by NASA's Jet Propulsion Laboratory <http://mars.jpl.nasa.gov> on Sept 23 1999:

### NASA'S MARS CLIMATE ORBITER BELIEVED TO BE LOST

NASA's Mars Climate Orbiter is believed to be lost due to a suspected navigation error.

Early this morning at about 2 a.m. Pacific Daylight Time the orbiter fired its main engine to go into orbit around the planet. All the information coming from the spacecraft leading up to that point looked normal. The engine burn began as planned five minutes before the spacecraft passed behind the planet as seen from Earth. Flight controllers did not detect a signal when the spacecraft was expected to come out from behind the planet.

"We had planned to approach the planet at an altitude of about 150 kilometers (93 miles). We thought we were doing that, but upon review of the last six to eight hours of data leading up to arrival, we saw indications that the actual approach altitude had been much lower. It appears that the actual altitude was about 60 kilometers (37 miles). We are still trying to figure out why that happened," said Richard Cook, project manager for the Mars Surveyor Operations Project at NASA's Jet Propulsion Laboratory. "We believe that the minimum survivable altitude for the spacecraft would have been 85 kilometers (53 miles)."

Flight controllers at NASA's Jet Propulsion Laboratory in Pasadena, CA and Lockheed Martin Astronautics in Denver, CO will continue their efforts to locate the spacecraft through the Deep Space Network during the next several hours. A special investigation team has been formed by JPL to further assess the situation.

Mars Climate Orbiter is one of a series of missions in a long-term program of Mars exploration known as the Mars Surveyor Program that is managed by the Jet Propulsion Laboratory for NASA's Office of Space Science, Washington, DC. JPL is a division of the California Institute of Technology, Pasadena, CA.

News release by NASA's Jet Propulsion Laboratory <http://mars.jpl.nasa.gov> on Sept 30 1999:

### MARS CLIMATE ORBITER TEAM FINDS LIKELY CAUSE OF LOSS

A failure to recognize and correct an error in a transfer of information between the Mars Climate Orbiter spacecraft team in Colorado and the mission navigation team in California led to the loss of the spacecraft last week, preliminary findings by NASA's Jet Propulsion Laboratory internal peer review indicate. "People sometimes make errors," said Dr. Edward Weiler, NASA's Associate Administrator for Space Science. "The problem here was not the error, it was the failure of NASA's systems engineering, and the checks and balances in our processes to detect the error. That's why we lost the spacecraft."

The peer review preliminary findings indicate that one team used English units (e.g., inches, feet and pounds) while the other used metric units for a key spacecraft operation. This information was critical to the maneuvers required to place the spacecraft in the proper Mars orbit.

"Our inability to recognize and correct this simple error has had major implications," said Dr. Edward Stone, director of the Jet Propulsion Laboratory. "We have underway a thorough investigation to understand this issue."

Two separate review committees have already been formed to investigate the loss of Mars Climate Orbiter: an internal JPL peer group and a special review board of JPL and outside experts. An independent NASA failure review board will be formed shortly.

"Our clear short-term goal is to maximize the likelihood of a successful landing of the Mars Polar Lander on December 3," said Weiler. "The lessons from these reviews will be applied across the board in the future."

Mars Climate Orbiter was one of a series of missions in a long-term program of Mars exploration managed by the Jet Propulsion Laboratory for NASA's Office of Space Science, Washington, DC. JPL's industrial partner is Lockheed Martin Astronautics, Denver, CO. JPL is a division of the California Institute of Technology, Pasadena, CA.