Metric Mishap Caused Loss of NASA Orbiter
* By Kathy Sawyer & Robin Lloyd (Washington Post Staff Writer & CNN Interactive Senior Writer)

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.

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 other interplanetary missions for NASA.

On approach to Mars it appears the engine fired late causing the spacecraft to come within 60 km (36 miles) of the planet -- about 100 km closer than planned and about 25 km (15 miles) beneath the level at which the rocket could function properly.

As a result the spacecraft's propulsion system overheated and was disabled as Climate Orbiter dipped deeply into the atmosphere, JPL spokesman Frank O'Donnell said.

That probably stopped the engine from completing its burn, causing Climate Orbiter to plowed through the atmosphere, moving past Mars and in an orbit around the sun.

The inability to recognize and correct this simple error has had major implications and has caused NASA to start to prepare for the onslaught of derision from the public.

The initial error was made by U.S. contractor Lockheed Martin Astronautics, 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 is supposed to convert its measurements to metrics before delivery to NASA. (NASA has been using the metric system predominantly since at least 1990).

"This is an end-to-end process problem," he said. "A single error like this should not have caused the loss of Climate Orbiter. Something went wrong in our system of checks and balances that we use that should have caught this and fixed it."

The initial error occurred in the files that were sent daily by Lockheed to JPL navigators. The wrong measurements were used to power the daily thruster firings. The navigators were performing their daily analysis of the spacecraft's position in space based on the assumption that the firings were in metric units of force per second (newtons). 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 now.

"We are going to look at how the data transferred," Gavin said. "How did it originally get into our system in English units? When we were doing navigation and Doppler checks, how come we didn't realize it was not the metric calculations being used?" Going forward the emphasis will not be in "pointing fingers and dealing out punishment," but in "figuring out how the process failed and fixing it."

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.

The orbiter's main mission was to monitor the Red Planet's atmosphere, surface and polar caps for one Martian year, or 687 days. The craft was to have served as a communications relay link for the lander. The Polar Lander was to relay information to the Mars Climate Orbiter to help scientists understand Mars' water history and the potential for life in the planet's past. There is strong evidence that Mars was once awash with water, but scientists have no clear answers to where the water went and what drove it away.

**Error points to nation's conversion lag**

Lorelle Young, president of the U.S. Metric Association, said the loss of Climate Orbiter brings up the "untenable" position of the United States in relation to most other countries, which rely on the metric system for measurement. She was not surprised at the error that arose.

"In this day and age when the metric system is the measurement language of all sophisticated science, two measurements systems should **not** be used," Young said.

"Only the metric system should be used because that is the system science uses," she said.

She put blame at the feet of Congress that she said has squeezed NASA's budget to the point that it has no funds to completely convert its operations to metric.

"This should be a loud wake-up call to Congress that being first in technology requires funding," she said, "and it's a very important area for the country."