

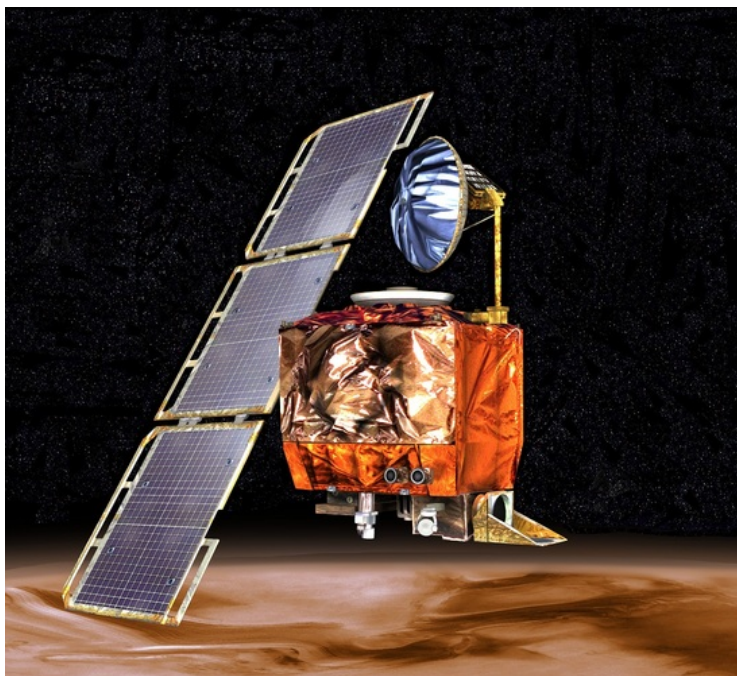
Case Studies: Metric/English Conversion Errors

To learn more about systems of measurement, visit the [SI Unit page](#) and the [Non-SI Unit page](#). As the four examples below can attest, small errors in these unit systems can harbor massive ramifications.

1. The Mars Climate Orbiter: A Multimillion Dollar Mistake
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The Mars Climate Orbiter: A Multimillion Dollar Mistake

Although NASA declared the metric system as its official unit system in the 1980s, conversion factors remain an issue. The Mars Climate Orbiter, meant to help relay information back to Earth, is one notable example of the unit system struggle. The orbiter was part of the Mars Surveyor '98 program, which aimed to better understand the climate of Mars. As the spacecraft journeyed into space on September 1998, it should have entered orbit at an altitude of 140-150km above Mars, but instead went as close as 57km. This navigation error occurred because the software that controlled the rotation of the craft's thrusters was not calibrated in SI units. The spacecraft expected newtons, while the computer, which was inadequately tested, worked in pound forces; one pound force is equal to about 4.45 newtons. Unfortunately, friction and other atmospheric forces destroyed the Mars Climate Orbiter. The project cost \$327.6 million in total. Tom Gavin, an administrator for NASA's Jet Propulsion Laboratory in Pasadena, stated, "This is an end-to-end process problem. A single error like this should not have caused the loss of Climate Orbiter. Something went wrong in our system processes in checks and balances that we have that should have caught this and fixed it."



NASA's Constellation Program: A Possible Casualty of Metric/English Conversions

Another NASA-related conversion concern involves the Constellation project, which is focused mainly on manned spaceflight. Established in 2005, it includes plans for another moon landing. The Constellation project is partially based upon decades-old projects such as the Areas rocket and the Orion crew capsule. These figures and plans are entirely in English units, and converting this work into metric units would cost approximately \$370 million. Despite receiving \$400 million of the \$1 billion of stimulus money given to NASA, the Constellation program struggled financially. When President Obama unveiled his planned budget in January 2010, funds for Constellation were drastically cut, virtually dismantling the program.



Work on the Constellation Project, image courtesy NASA/Kim Shiflett



Disneyland Tokyo: A Bumpy Blunder

Tokyo Disneyland's Space Mountain roller coaster came to a sudden halt just before the end of a ride on December 5, 2003. This startling incident was due a broken axle. The axle in question fractured because it was smaller than the design's requirement; because of the incorrect size, the gap between the bearing and the axle was over 1mm – when it should have been a mere 0.2mm (to picture this, imagine that the gap is the thickness of a dime, compared to what it's supposed to be, the thickness of two sheets of common printer paper.) The accumulation of excess vibration and stress eventually caused it to break. Though the coaster derailed, there were no injuries. Once again, unit systems caused the accident. In September 1995, the specifications for the coaster's axles and bearings were changed to metric units. In August 2002, however, the English unit plans prior to 1995 were used to order 44.14mm axels instead of the needed 45mm axels.

Air Canada Flight 143: Unit-Caused Fuel Shortage

A Boeing 767 airplane flying for Air Canada on July 23, 1983 diminished its fuel supply only an hour into its flight. It was headed to Edmonton from Montreal, but it received low fuel pressure warnings in both fuel pumps at an altitude of 41,000 feet; engine failures followed soon after. Fortunately, the captain was an experienced glider pilot and the first officer knew of an unused air force base about 20 kilometers away. Together, they landed the plan on the runway, and only a few passengers sustained minor injuries. This incident was due partially to the airplane's fuel indication system, which had been malfunctioning. Maintenance workers resorted to manual calculations in order to fuel the craft. They knew that 22,300kg of fuel was needed, and they wanted to know how much in liters should be pumped. They used 1.77 as their density ratio in performing their calculations. However, 1.77 was given in pounds per liter, not kilograms per liter. The correct number should have been 0.80 kilograms/liter; thus, their final figure accounted for less than half of the necessary fuel.



The Air Canada craft, image courtesy Akradecki

