

Mistakes in Measurement

Read each story below and write your answers to the questions in the spaces provided.

Loss of Mars Climate Orbiter

What happened

Mars Climate Orbiter (MCO) was launched on 11 December 1998 on a mission to orbit Mars as the first interplanetary weather satellite and to provide a communications relay for another spacecraft, the Mars Polar Lander. MCO was lost on 23 September 1999 when it failed to enter an orbit around Mars, instead crashing into the planet, destroying the \$125 million craft, part of a \$328 million mission.

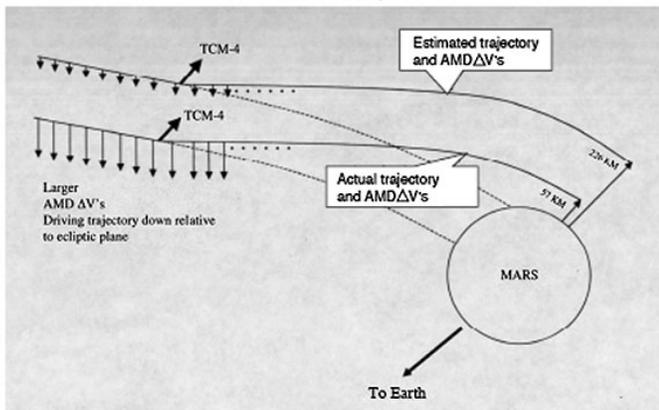
Why it happened

The root cause of the failure was a computer program that was supposed to provide its output in newton seconds (N-s) but instead provided pound-force seconds (lbf-s). From the mishap investigation report:

As a result of the incorrectly computed trajectory, the spacecraft's initial periapsis (low-point in the Martian orbit) was only 57 km; the minimum survivable periapsis was 80 km.

Picture summary

Schematic MCO Encounter Diagram
Not to scale



Analysis Questions

Why did the crash happen?

What is a Trajectory?

World Record Long Jump Lost

What happened

University of Houston sophomore track star Carol Lewis made a record-breaking long jump at the NCAA Men's and Women's Indoor Track Championship, 11-12 March 1983 in Pontiac, MI.

However, her jump did not qualify as an official record.

Why it happened

To be considered as official records, college sports track and field measurements must be metric. However, officials hosting the games refused to use metric tapes. As a result, the non-metric measurements don't qualify as official records. For record-setting purposes, measurements cannot be converted to metric after the event.

[Source: American National Metric Council *Metric Reporter*, May 1983.]

Draw a picture summary here!

Analysis Questions

Why was it important to measure distances in metric?

What type of unit (ft, mi, km, m, etc) should she have used?

Roller Coaster Derailment at Tokyo Disneyland's Space Mountain

What happened

On 5 December 2003, the Space Mountain roller coaster at Tokyo Disneyland derailed when an axle broke just before the end of the ride; there were no injuries.

Why it happened

According to a 21 January 2004 report from Oriental Land Co., which built and operates Tokyo Disneyland, the diameter of the broken axle was found to be smaller than its design specification. As a result, the gap between the axle and its bearing, which should have been about 0.2 mm, was actually over 1 mm, resulting in excessive play that caused more vibration than normal, eventually causing the axle to break.

The broken axle was one of 30 axles received in October 2002, all of which were found to be thinner than the design specification as a result of an error when they were ordered in August 2002.

That error arose from improperly maintaining the design drawings. In September 1995, the design specifications for the axle bearing had been changed to metric units, and the specification for the axles was therefore changed as well. As a result, there were two sets of design drawings. In August 2002, the old drawings were mistakenly used to order 44.14 mm axles instead of the correct, 45 mm parts.

The company confirmed that other orders for axles used the correct dimensions.

Picture summary	Analysis Questions What caused this accident? Millimeters measure what quantity? (mass, length, time, volume, etc.)
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Korean Air MD-11 Crash

What happened

On 15 April 1999, Korean Air flight 6316, an MD-11 freighter on a flight from Shanghai to Seoul, crashed shortly after takeoff from Shanghai Hongqiao Airport. The aircraft was destroyed, its three crew members and five persons on the ground were killed, and 37 on the ground were injured.

Why it happened

The flight was initially cleared to an altitude of 900 meters, then instructed to climb to 1,500 meters. After reaching about 1,400 meters, the crew erroneously concluded that they had misinterpreted the altitude. Having decided that they should be at 1,500 feet, rather than meters, they began a rapid descent.

During the process, they lost control of the aircraft and crashed.

Note that aircraft altitudes are in feet throughout the world, except for China, Mongolia, and the CIS (former Soviet states), which use meters.

Picture summary	Analysis Questions Which is larger, a foot or a meter? What unit would pilots use to measure altitude in Canada?
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Medication dose errors

What happened

In 2004, a baby was given 5 times the prescribed dose of Zantac Syrup, a medication for reducing stomach acid production, until a doctor pointed out the error a month later. Fortunately, the child was not injured, although doctors say there was a risk of seizure or stroke had the incorrect dosing continued.

Why it happened

The doctor prescribed a dose of 0.75 milliliter twice a day, but the pharmacist labeled the bottle, "Give 3/4 teaspoonful twice a day." A teaspoon is about 4.9 mL.

Note that an additional source of error, given a prescription in teaspoons, is that consumers might use teaspoons from the silverware drawer instead of measuring spoons.

Picture summary	Analysis Questions Which is larger, a teaspoon or a milliliter? What would have happened to the baby had this mistake continued?
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Gimli Glider: Boeing 767 Emergency Landing

What happened

On 23 July 1983, Air Canada flight 143, a Boeing 767 flying from Montreal to Edmonton, ran out of fuel about an hour into its flight. At an altitude of 41,000 feet the crew received its first indication of low fuel pressure in one fuel pump, and a few seconds later, in the other fuel pump. An initial decision to divert to Winnipeg had to be abandoned when both engines failed. The partially extended nose gear collapsed on landing, stopping the aircraft before it hit anyone on the ground. Two passengers suffered minor injuries using the emergency slides to evacuate the aircraft.

Why it happened

The aircraft's fuel quantity indication system had begun malfunctioning three weeks before the incident. It failed completely the night before the flight. The crew, seeing the blank gauges, decided to resort to manually calculating the amount of fuel required for the trip back to Edmonton and on to Ottawa.

The maintenance workers performed a test that estimated that 7,682 liters of fuel were in the tank. They knew they needed 22,300 kilograms of fuel for the remaining flight, so the question was, How much fuel, in liters, should be pumped from the fuel truck into the aircraft? They were forced to resort to a manual calculation. However, 1.77 was the density of the fuel in pounds per liter (lb/L), not kilograms per liter (kg/L); the correct figure for kg/L would have been 0.80. As a result, they ended up with less than half of the required amount of fuel on board.

Picture summary	Analysis Questions Why did the crash happen? What is a Trajectory?
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