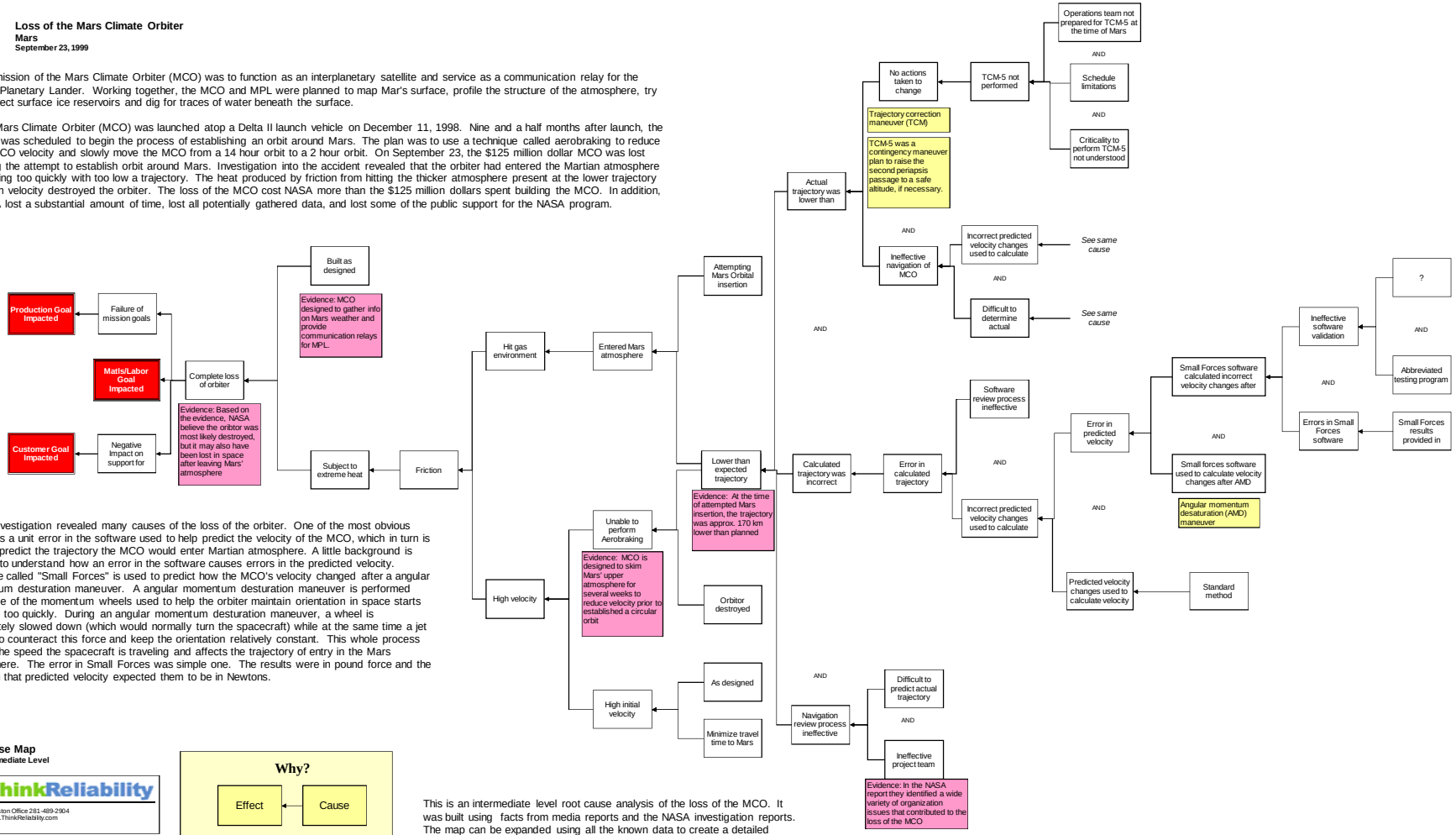
Loss of the Mars Climate Orbiter
Mars
September 23, 1999

The mission of the Mars Climate Orbiter (MCO) was to function as an interplanetary satellite and service as a communication relay for the Mars Planetary Lander. Working together, the MCO and MPL were planned to map Mar's surface, profile the structure of the atmosphere, try to detect surface ice reservoirs and dig for traces of water beneath the surface.

The Mars Climate Orbiter (MCO) was launched atop a Delta II launch vehicle on December 11, 1998. Nine and a half months after launch, the MCO was scheduled to begin the process of establishing an orbit around Mars. The plan was to use a technique called aerobraking to reduce the MCO velocity and slowly move the MCO from a 14 hour orbit to a 2 hour orbit. On September 23, the $125 million dollar MCO was lost during the attempt to establish orbit around Mars. Investigation into the accident revealed that the orbiter had entered the Martian atmosphere traveling too quickly with too low a trajectory. The heat produced by friction from hitting the thicker atmosphere present at the lower trajectory at high velocity destroyed the orbiter. The loss of the MCO cost NASA more than the $125 million dollars spent building the MCO. In addition, NASA lost a substantial amount of time, lost all potentially gathered data, and lost some of the public support for the NASA program.



NASA investigation revealed many causes of the loss of the orbiter. One of the most obvious causes is a unit error in the software used to help predict the velocity of the MCO, which in turn is used to predict the trajectory the MCO would enter Martian atmosphere. A little background is needed to understand how an error in the software causes errors in the predicted velocity. Software called "Small Forces" is used to predict how the MCO's velocity changed after a angular momentum desturation maneuver. A angular momentum desturation maneuver is performed when one of the momentum wheels used to help the orbiter maintain orientation in space starts spinning too quickly. During an angular momentum desturation maneuver, a wheel is deliberately slowed down (which would normally turn the spacecraft) while at the same time a jet is fired to counteract this force and keep the orientation relatively constant. This whole process affects the speed the spacecraft is traveling and affects the trajectory of entry in the Mars atmosphere. The error in Small Forces was simple one. The results were in pound force and the program that predicted velocity expected them to be in Newtons.

Cause Map
Intermediate Level

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Why?

Effect ← Cause

NOTE: Read the Cause Map from left to right with the phrase "Was Caused By" in place of each arrow.

This is an intermediate level root cause analysis of the loss of the MCO. It was built using facts from media reports and the NASA investigation reports. The map can be expanded using all the known data to create a detailed Cause Map.