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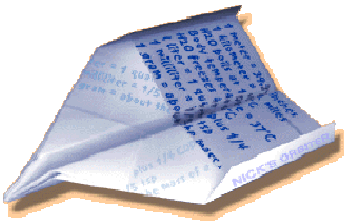
String of Missteps Doomed Orbiter

The Mars Climate Orbiter never made it to Mars. Inattention, miscommunication and overconfidence at the Jet Propulsion Laboratory (JPL) were among the management problems that added up to a fatal error in math and doomed the $125-million Mars Climate Orbiter earlier this year. In its formal report, the NASA accident review board confirmed that JPL and its subcontractors confused English and metric units in a series of miscalculations that led to the orbiter's disappearance Sept. 23, 1999, as it began to circle Mars.

The internal NASA investigation, published Nov. 10, 1999, blamed the loss on these factors:

- Inadequate computer models of the rockets.
- Poor team communication.
- Navigation failures (the team did not know the spacecraft's position and orientation!).
- Inadequate checking of mission components.
- Overwork of the two-member navigation team.
- Confusion over metric and English units.



It's that last problem that really pinches. In a world dominated by the metric system, the United States stands out for its reliance on the English system, which rests on such constants of nature as the length of a king's thumb. The English system is so awkward that even the English have dumped it.

Instead of using the simple metric system, where about all you need to know is how to move a decimal point, American children, especially those contemplating scientific careers, must learn English, metric, and the mystifying math for converting them.

Deadly confusion

What exactly happened with Mars Climate Orbiter? From the best we can make out, when the spacecraft was slowing to enter Mars orbit Sept. 23, the rockets were fired using data from Lockheed Martin, the prime contractor. Sadly, Lockheed had been talking in pounds (an English unit), while the contract specified newtons (both units measure rocket thrust, incidentally).

Noel Hinners, vice president for flight systems at Lockheed Martin's space systems group, said that the company was responsible for assuring that critical measures of the Mars Orbiter's performance were delivered to JPL in metric units. But Lockheed engineers prepared computer files in English units instead because they forgot to check the technical specifications, he said. "To be very blunt, it was overlooked," Hinners said.

"As devastating as the report is, it raises as many questions as it answered," said Pike. "All of these problems are symptomatic of too much work and not enough people. They are all symptomatic of an underfunded program."

Foresight – A gram of prevention worth a kilo of cure?

After years of lofting spacecraft that cost billions, NASA is now trying to do the job "faster, cheaper and better." But the disappearance of Mars Polar Lander ($165 million) and Climate Orbiter ($125 million) raised the question of whether the cut-rate missions are hitting the mark.

Does faster and cheaper equal lesser? A variety of space experts told the New York Times that NASA was simply trying to do too much with too little. "We've all seen this," said John Pike of the Federation of American Scientists. "Anybody who has tried to do too much work without enough people immediately recognizes the symptoms. Stuff doesn't get done. Things fail."

In a recent review of five JPL projects, the NASA auditors were especially troubled by a staffing pattern of too few people at the onset of a project when key engineering decisions are being made and too many later on to catch up with slipping schedules. This contributed to poor workmanship and ineffective engineering designs, they said.

To make up for its initial understaffing of the Mars '98 project, Lockheed's staffing for the last two-thirds of the project was 80% more than planned, the auditors found. To make up for lost time, engineers and technicians were required to work 70 hours a week or more.

"Rushing to meet milestones could … result in engineering decisions being made based on schedule need instead of the need to reduce risk of failure," NASA auditors had warned JPL in their report, delivered just a few days before the orbiter vanished in space.

The project problems were so serious that even before the Mars Orbiter disappeared, JPL had moved to slash Lockheed's performance award from $12.5 million to $3.5 million. Even so, the auditors concluded, JPL managers too often let contractors police themselves.

Preventing the kind of losses that are plaguing NASA is the job of risk management experts. These fault-obsessed folks try to anticipate what could go wrong and devise changes to hardware, software or procedures before launch. It's kind of like the post-mortem investigation now being done on Polar Lander.

Doin' the pre-mortem

Michael Frank, president of Safety Factor Associates, Encinitas, Calif., has done risk assessment for the Cassini and Sojourner spacecraft, says he constructs "fault trees" that try to anticipate every significant malfunction before launch.

For Sojourner, the scientific breadbox that rolled across the Mars landscape in 1997, he started by "looking at a day in the life of the lander. I asked what it is supposed to do, minute by minute." Using a database of failures for the various motors, circuits and other components, he searched for weak links -- components that could bollix the whole mission.

The work focused on the modem Sojourner used to communicate with the lander. "They were spending a lot on software that would make sophisticated, semi-autonomous decisions, but I suggested that they spend a little more on the modem, which was a non-redundant weak link," Frank says. JPL made changes, Frank says, and the little lander worked 'til the end of its 30-day mission.

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String of Missteps Doomed Orbiter – Reading Comprehension Sheet

Read the article "String of Missteps Doomed Orbiter" and answer the following questions **in complete sentence**s. Please underline, highlight, and/or jot down notes in the margins of the article to help you remember key information as you are reading.

1. What major error led to the disappearance of the Mars Climate Orbiter?

2. Why is it more difficult for American students to learn measurement compared to students in any other country?

3. What was the specific error made by the employees of Lockheed Martin?

4. What does the following expression mean to you: "A gram of prevention worth a kilo of cure"?

5. What does the article suggest is a potential explanation for how the measurement conversion could have been overlooked?

6. How does Michael Frank perform risk management assessments?

7. Based on the context of the following sentence, what is the meaning of the word "bollix": "Using a database of failures for the various motors, circuits and other components, he searched for weak links -- components that could bollix the whole mission."?

8. How did Michael Frank's risk assessment aid the Sojourner lander?