brought the virus. It's also possible that the virus was lurking in or around the city for years without being noticed, says Woodall.

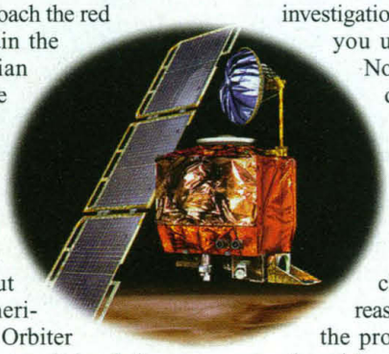
The disease may disappear from view as temperatures drop and mosquitoes die. But it's unknown whether infected eggs might hatch next year, or whether migratory birds might spread the disease to southern U.S. states this fall—a worrying possibility because those states have mosquitoes all year round. Woodall warns: "It could become established in the South if it gets there."

–MARTIN ENSERINK

PLANETARY SCIENCE

More Than Missing Metric Doomed Orbiter

Mission planners have long postulated a martian gremlin who lies in wait for unsuspecting spacecraft that approach the red planet. How else to explain the atrocious record of martian exploration? Humans have launched 28 missions to Mars, but only 9 or 10 could be considered successes. Most of the failures—at least 14 out of 16 attempts—befell Soviet and Russian missions, but last month it was the Americans' turn. Mars Climate Orbiter (MCO) swooped in too low as it headed for Mars orbit, dipped too deeply into the atmosphere, and was never heard from again. Early investigations put the blame on a mismatch of units, with one team of flight engineers reporting measurements in English units that another team assumed were metric.



While that kind of snafu may be as scary as any gremlin, observers are pointing to a variety of problems with MCO. The metric-English confusion was one of them, says an engineer familiar with the MCO navigation operation, "but I think there were other [problems] along the way, and all of them together caused the loss." Whatever the causes, three review panels are rushing to sort them out well before Mars Polar Lander, which may be susceptible to some of the same problems, arrives on 3 December.

The metric-English problem arose between the MCO's navigation team at the Jet Propulsion Laboratory (JPL) in Pasadena, California, and the spacecraft team at Lockheed Martin Astronautics in Denver. The JPL team determined from tracking data where the spacecraft was and how its trajectory should be corrected. The Lockheed Martin team told the spacecraft how to fire its thrusters to make those corrections. Besides nudging the trajectory, the thrusters had to blast once or twice a day to counteract the twisting effects of sunlight hitting the single, off-center solar panel. Inevitably, those adjustments or "momentum dumps" would nudge MCO ever so slightly off course in some random direction. When the Lockheed Martin team told the navigators how much force the thrusters had applied to the spacecraft, they used units of pounds; JPL assumed the data were in newtons, a smaller unit of force. Applying those forces to the tracking data, JPL navigators concluded that MCO was closer to its intended course than it indeed turned out to be.

How such confusion arose is still under investigation. "The general rule is you use metric," concedes Noel Hinners, vice president for flight systems at Lockheed Martin Astronautics in Denver. NASA began to metrify its operations in the 1970s, he notes, and JPL uses metric exclusively, but "for some reason [some companies in] the propulsion industry have continued to use English units." According to sources, the use of metric units for MCO was spelled out in a written agreement between JPL and Lockheed Martin.

Although the use of pounds may have been a fatal error, other factors could have been crucial as well. Momentum dumps occurred frequently for MCO because the spacecraft carried only a single solar panel, placed off center. According to John McNamee, an MCO project manager at JPL, that solar panel arrangement was necessary to give the spacecraft's two instruments, a camera and a radiometer that required wide fields of view, unobstructed looks at Mars. In contrast, the NEAR spacecraft on its way to the asteroid Eros has a symmetrical design and need make no momentum dumps at all.

Once the units errors slipped in, they were difficult to discern in MCO's behavior, navigation specialists note. Tracking data reveals only what the spacecraft is doing in the line of sight between Earth and the spacecraft, so that subtle shifts of the spacecraft in the plane perpendicular to the line of sight, like those imparted by momentum dumps, take time to show up. Only in the last days, as Mars bent MCO's trajectory toward itself, would the changing angle between the line of sight and the trajectory let such subtle changes become more obvious.

In the end, the tracking data did throw up a red flag, indicating that the spacecraft might be coming in below its 140-kilometer target point above the surface. The navigation team recommended raising the low point of the approach—if MCO came in too low, probably around 85 kilometers, atmospheric drag would destroy it—but JPL managers decided against it. "We were considering that," says project manager for operations Richard Cook of JPL, "and we chose not to do that." Cook will be discussing his reasons only with investigators, but some lessons learned are already obvious. The burden of "eternal vigilance" cannot be avoided, says Hinners. "You can never, never take anything for granted." Especially with Mars Polar Lander—and several more missions—getting ready to run the gremlin gauntlet.

–RICHARD A. KERR

NUCLEAR ACCIDENT

Special Treatment Set For Radiation Victim

As life returned to normal this week in Tokaimura, the site of Japan's worst ever nuclear accident, the worker who received the highest dose of radiation was being readied for an experimental procedure using blood stem cells in an attempt to save his life. Meanwhile, government and police investigators were gathering evidence expected to result in charges of criminal negligence

Helping hands. Medics transport plant worker to the hospital after the Tokaimura accident.

CREDITS: (TOP) JPL/NASA; (RIGHT) KYODO NEWS AGENCY/UPI