

English-Metric mix-up is blamed for loss of Mars Orbiter

by Robert Lee Hotz
Los Angeles Times

NASA lost its \$125 million *Mars Climate Orbiter* because spacecraft engineers failed to convert from English to metric measurements when exchanging vital data before the craft was launched, space agency officials said Thursday, September 30th.

A navigation team at the Jet Propulsion Laboratory in Pasadena, Calif., used the metric system of millimeters and meters in its calculations while Lockheed Martin Astronautics in Denver, which designed and built the spacecraft, provided crucial acceleration data in the English system of inches, feet and pounds.

As a result, JPL engineers mistook acceleration readings measured in English units of pound-seconds for a metric measure of force called newton-seconds.

In a sense, the spacecraft was lost in translation.

"That is so dumb," said John Logsdon, director of George Washington University's Space Policy Institute. "There seems to have emerged over the past couple of years a systematic problem in the space community of insufficient attention to detail."

The loss of the Mars probe was the latest in a series of major spaceflight failures this year that destroyed billions of dollars worth of research, military and communications satellite or left them spinning in useless orbits. Earlier last month, an independent national security review concluded that many of those failures stemmed from an overemphasis on cost-cutting, mis-

management, and poor quality control at Lockheed Martin, which manufactured several of the malfunctioning rockets.

But National Aeronautics and Space Administration officials and Lockheed executives said it was too soon to apportion blame for the most recent mishap. Accident review panels convened by JPL and NASA are still investigating why no one detected the error.

"It was launched that way," said Noel Hinners, vice president for flight systems at Lockheed Martin's space systems group. "We were transmitting English units and they were expecting metric units. The normal thing is to use metric and to specify that."

None of JPL's rigorous quality control procedures caught the error in the nine months it took the spacecraft to make its 461 million-mile flight to Mars. Over the course of the journey, the miscalculations were enough to throw the spacecraft so far off track that it flew too deeply into the Martian atmosphere and was destroyed when it entered its initial orbit around Mars last week.

John Pike, space policy director at the Federation of American Scientists, said that it was embarrassing to lose a spacecraft to such a simple math error. "It is very difficult for me to imagine how such a fundamental, basic discrepancy could have remained in the system for so long," he said.

"I can't think of another example of this kind of large loss due to English vs. metric confusion," Pike said. "It is going to be the cautionary tale until the end of time."

At the Jet Propulsion Lab, which

owns its international reputation for the unerring accuracy it has displayed in guiding spacecraft across the shoals of space, officials did not flinch from acknowledging their role in the mistake.

"We know this error is the cause," said Thomas R. Gavin, deputy director of JPL's space and Earth science directorate, which is responsible for the JPL Mars program. "And our failure to detect it in the mission caused the unfortunate loss of Mars Climate Orbiter."

"When it was introduced and how it was introduced we don't know yet," Gavin said.

NASA officials in Washington, D.C., were reluctant to blame either Lockheed Martin or JPL solely for the problem, saying the error arose from a broader quality control failure.

"People make mistakes all the time," said Carl Pilcher, the agency's science director for solar system exploration. "I think the problem was that our systems designed to recognize and correct human error failed us."

"We don't see any connection between this failure and anything else going on at Lockheed Martin," Pilcher said. "This was not a failure of Lockheed Martin. It was systematic failure to recognize and correct an error that should have been caught."

In any event, scientists are anxious that the conversion error does not affect a second spacecraft, the *Mars Polar Lander*, now approaching the red planet for a landing on Dec. 3. The radio orbiter would have served as a last relay for the lander before beginning its own two-year survey of the Martian atmosphere and seasonal

Martian atmosphere and seasonal weather.

Data exchanges for the *Global Surveyor*, which has been orbiting Mars since 1997, have been conducted exclusively in the metric system, Hinners said. Mission controllers expect to use the *Surveyor* as a relay station in place of the lost orbiter.

If found formally at fault by an accident review board, Lockheed will face financial penalties. But it was not certain Thursday whether Lockheed's contract with JPL actually specified the system of measurements to be used, as many aerospace agreements now often do.

Whatever the contractual consequences for the aerospace company, the loss of the Mars orbiter might have a lasting effect on public confidence in NASA, space analysts said.

Earlier this year, for example, NASA faced public concerns about its Cassini probe as it swung within a celestial hairsbreadth of Earth with an onboard cache of plutonium. The agency's matchless skill in navigating space helped defuse fears of a potentially lethal collision between Earth and the Cassini probe.

Now that skill will be more open to question, analysts said Thursday.

"It is ironic," Logsdon said, "that we can cooperate in space with the Russians and the Japanese and the French but we have trouble cooperating across parts of the United States. Fundamentally, you have partners in this enterprise speaking different languages."

ABKHAZIA



PHOTO BY YURI KOZYREV

Russian paratroopers patrol the beaches of the Black Sea in Abkhazia as part of a peacekeeping mission.

Nuclear technicians employed illegal operations manual

by Sonni Efron and Valerie Reitman
Los Angeles Times

TOKYO -- The uranium processing plant where Japan's worst nuclear accident occurred was using an illegal operations manual that directed workers to save time by mixing a uranium solution in stainless steel buckets, and workers had been performing that procedure -- cited as one of the causes of Thursday's nuclear fission reaction -- for four or five years, company officials admitted Saturday.

The revelations shocked Japan Sunday.

"This is completely unforgivable. I have nothing else to say," said Masaru Hashimoto, governor of Ibaraki prefecture, where the accident in the town of Tokaimura irradiated 49 people. "This is outrageous, or rather it's insulting." "Unbelievable!" declared a Sunday morning television talk show.

Plant owner JCO Co.'s head of manufacturing, Hiroyuki Ogawa, held a news conference Saturday at which he disclosed the existence of the manual, which had been revised in 1997 and had never been submitted for the required government approval. Ogawa said company officials were well aware that the illicit procedure, in which uranium oxide was dissolved in a solution in stainless steel buckets, produced toxic emissions.

"This is a safety problem," Ogawa said. "We knew if we asked for formal approval, we would not get it."

The Science and Technology Agency called the manual "illegal."

The manual reportedly ordered workers to "prepare three clean stainless steel buckets," and Ogawa said he had witnessed workers using such buckets to mix the uranium solution for four or five years. The procedure bypassed the factory's elaborate system of preparing the uranium slowly, using a system of four different tanks connected by pipes with metering devices attached to ensure that dangerous concentrations of uranium could not occur.

Ogawa said the bucket method was used as a timesaver because it took just 30 minutes compared with the three hours needed to pipe the chemicals through the vats in the proper procedure.

One of the workers seriously injured in the blast, Yutaka Yokokawa, 54, told police in an interview from his hospital bed Friday that the bucket procedure was used frequently, according to Japanese news reports.

Hospital officials disclosed for the first time Saturday that two other workers, Hisashi Ouchi and Masato Shinohara, had received more than lethal doses of radiation. Ouchi received 17 sieverts of radiation, Shinohara received 10 sieverts, and Yokokawa was exposed to 3 sieverts. Seven sieverts is considered a lethal dose, and the exposure standard for ordinary Japanese citizens is 0.001 sievert at a time, according to Japanese news reports.

Ouchi, 35, was transferred to Tokyo University Hospital on Saturday to receive a blood transfusion taken from a newborn's umbilical cord, in a procedure that doctors hoped would compensate for his deteriorating ability to produce blood. Shinohara, 39, was also listed in critical condition.

The Tokaimura accident is being considered the third worst in history,

after the Chernobyl and Three Mile Island nuclear disasters. However, on Saturday, Japanese officials permitted the last evacuees within a quarter-mile radius of the uranium processing plant to return to their homes and declared that the area around the plant is safe and that local crops, livestock and fish pose no health hazards.

Other troubling details of how the accident could have occurred continued to emerge this weekend, as a host of other design and safety procedural violations were disclosed that altered the initial perception that irresponsible workers alone were to blame.

Among other factors, the workers Thursday were handling an unusually high-grade and potentially dangerous kind of uranium without special training or safety procedures. They also allegedly violated even the company's secret, timesaving procedures by dumping the uranium solution from the buckets into a precipitation tank that held a large quantity of uranium from a day earlier, triggering the reaction.

Moreover, once the accident occurred, officials did not immediately report the radiation leakage, so that three firefighters who were sent to the plant arrived without protective gear and were also contaminated, the *Asahi* newspaper reported Sunday. It was not known how much radiation they received.

JCO officials were slow to respond to the nuclear fission reaction once it began, in part because all three of the factory's alarm bells began to ring simultaneously, making it impossible to immediately determine in what part of the plant the accident had occurred, the *Asahi* said. The plant reported the ac-

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head of manufacturing

cident by fax to Tokaimura officials at 11:54 a.m., 61 minutes after the accident occurred, instead of telephoning authorities.

Even as the nuclear reaction was taking place, officials reportedly spent the extra time preparing a document in order to comply with a regulation that all nuclear accidents be reported in writing, the newspaper said.

The accident has highlighted how loosely regulated the uranium processing plant was.

The three workers now hospitalized with radiation poisoning had not been licensed by the government to deal with nuclear fuel. Nor were they required to be. Apparently only a single individual in a company that handles nuclear material is required to obtain certification from the Science and Technology Agency. The men did have lower-level licenses that allowed them to work with dangerous, though non-nuclear, materials.

CIA unable to precisely track Russian nuclear testing

by Roberto Suro
The Washington Post

WASHINGTON -- In a new assessment of its capabilities, the Central Intelligence Agency has concluded that it cannot monitor low-level nuclear tests by Russia precisely enough to ensure compliance with the Comprehensive Test Ban Treaty, which the Senate will begin debating this week, senior officials said Saturday.

Twice last month the Russians carried out what might have been nuclear explosions at their Novaya Zemlya testing site in the Arctic. But the CIA found that data from seismic sensors and other monitoring equipment were insufficient to allow analysts to reach a firm conclusion about the nature of the events, officials said.

The Russian government has assured the Clinton administration that the tests involved only conventional explosives and that it has not violated its promises to abide by the unratified treaty, which prohibits nuclear tests.

Senior congressional staffers were briefed on the new CIA assessment before Senate Majority Leader Trent Lott, R-Miss., last Thursday abruptly scheduled a vote on the test ban treaty after having refused to bring it to the floor since President Clinton sent it to the Senate for ratification two years ago.

Lott vowed to defeat the treaty because it endangers national security. Clinton has promised an all-out fight for ratification of what he depicts as a landmark arms control pact.

Republicans and Democrats predicted Saturday that the CIA's ability to monitor low-level tests will be a major issue in the debate leading up to a vote that could take place as early as Oct. 12. Senior intelligence officials, including possibly Director of Central Intelligence George J. Tenet, will begin briefing senators on the monitoring issue Monday, sources said.

Ratification of a treaty requires a two-thirds vote in the Senate, and by all accounts the Democrats, who hold 45 seats, are far short of the required 67 votes. The treaty has been signed

by 154 nations, including the United States, but it has been ratified by only 47 countries, most recently Bulgaria on Wednesday. More significantly, the treaty has been ratified by only 23 of the 44 nuclear-capable countries that must confirm it for the treaty to take effect.

Although the U.S. intelligence community has a long-standing concern about the difficulty of gathering data on low-level nuclear tests, the recent Russian tests -- and others like it earlier this year -- prompted the CIA re-evaluation. As a result, the agency formed a new assessment that these

events can be verified, he said.

While the administration argues that the treaty would provide new tools to detect testing that would help remedy the weaknesses in U.S. capabilities, Republican leaders contend that the treaty is worthless unless the United States can ensure compliance on its own, because Russia, China and other nations have a history of denial and deception on nuclear testing.

During a speech to the Senate on Friday declaring his opposition to the treaty, Armed Services Committee Chairman John W. Warner, R-Va., said that the recent history of Russian test-

ing activity had to be taken into account. "There is a body of fact developed over the past 18 months that it will be imperative for every senator to examine before deciding how to vote," Warner said in an interview. That information would be made available to the Senate during briefings and hearings this week, Warner said.

According to a military intelligence assessment that has circulated widely at the Pentagon and in the intelligence community, over the past 18 months Russia has conducted tests in the granite caverns of Novaya Zemlya to develop a low-yield tactical nuclear weapon that is the linchpin of a new military doctrine to counter U.S. superiority in precision guided munitions.

In monitoring Novaya Zemlya, U.S. surveillance satellites have repeatedly observed the kind of activity that usually precedes and then follows a low-level nuclear test; in between, seis-

"Without the treaty, the problem of assessing these kinds of events undoubtedly exists, but the question you have to ask is whether the treaty would leave us better off or worse, and inarguably we would be better off."

-Sandy Berger,
national security adviser

mic data that are gathered have been insufficient to allow a clear assessment of what transpired, officials said.

"We do not have any data that indicates a nuclear explosion during those events," said a senior administration official.

The administration's position is that Russian President Boris Yeltsin has stood by his 1997 promise to conduct only "subcritical" tests, in which conventional explosives are detonated in the presence of nuclear materials as a way of testing existing nuclear weapons without creating a nuclear chain reaction. The United States, which stopped nuclear testing in 1992, also has used subcritical tests to evaluate weapons.

Although some officials at the CIA and other intelligence agencies believe that Russia has repeatedly conducted nuclear tests in violation of Yeltsin's promise, the CIA does not claim to have conclusive data one way or the other. Indeed, it is uncertainty about what is happening rather than an accusation of Russian misbehavior that is the key point of the CIA assessment, officials said.

"Tests at these kinds of levels are difficult to characterize in an exacting manner, and that is a major challenge to the intelligence community," a senior U.S. official said.

The administration is prepared to argue that the difficulty of monitoring low-level tests is a major factor in favor of the treaty and its new global monitoring system, but administration officials are concerned that their message will take longer to get across than the stark suspicions of Russian motives that lie behind many Republican arguments.

"It is unfortunate that after two years of inaction we now get a 12-day rush to judgment," Berger said.

"We don't think this is a good treaty," Lott said Friday. "We think it would put us in a weakened position internationally, but since there have been all these calls and demands for a vote, we have offered to vote."