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JPL Machinists Off Kilter in a Metric Universe

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His touch is lost, the one that built parts for Galileo's flight to Jupiter, the one that knows instantly when a spacecraft rod is off by a thousandth of an inch--one-third the thickness of a piece of paper.

Until recently, machinist Antonio M. Fonseca worked in the Jet Propulsion Laboratory's "back shop" by feel, with what he calls a craftsman's touch. But today he picks up a spacecraft beam and his instinct escapes him. He can't think in inches anymore. His whole thought process has been thrown off kilter. Engineers are shipping him blueprints in the strange new world of millimeters, a measurement that he cannot picture in his head.

"I don't trust that (metric) system," grouses Fonseca, 54, a Burbank man with 30 years' experience in machine shops. "I trust what I know."

In La Canada Flintridge, Fonseca and 45 other JPL machinists are building the Mars Pathfinder, NASA's first attempt at an all-metric spacecraft. With few exceptions, all Pathfinder's parts are metric sized, from its nuts and bolts to its 10-kilogram (22-pound) robotic rover, which will scurry across the bumpy Mars terrain to study soil and rocks.

What is happening to the machinists will slowly happen to many Americans as the metric system inexorably creeps into new areas of life. The change is sluggish because the United States remains the only industrialized nation in the world yet to adopt the system; the government's push in the 1970s for a national conversion fizzled long ago. Still, metric conversion is spreading into sectors of the economy that depend on

international standards--and, as a result, uncertainty is spreading into work that experienced professionals such as Fonseca once did without pause.

Consider the dilemma of Werner Schwarz, 36, a 15-year JPL machinist.

Before Pathfinder, Schwarz, a big man from Saugus with a ponytail, didn't hesitate when he had to punch a row of holes in an aluminum plate, each an inch apart. He put the plate on the worktable of a milling machine and turned a crank to move the drill bit to the next hole. He didn't have to watch the digital readout that tells how far the drill bit moves; he knew in his head how far an inch is.

He demonstrates how he used to do it, spinning the crank without looking. Bam. Crank to the next hole. Bam, bam, bam.

Afterward, he checks the digital readout to see how accurately he had moved from hole to hole. He is off by six thousandths of an inch, the thickness of a strand of hair sliced four times.

Metric holes throw him off. For metric jobs, when he turns the crank, he has no idea how far he's going unless he checks the digital readout, which switches to metric with a push of a button. That slows him down, strips away his sense of mastery.

"If you give me a metric dimension, I'll sit here for about 15 seconds (and watch the readout), and I'll get it right, but that's 15 seconds vs. nothing," Schwarz said.

He's going to have to get used to it. After Pathfinder is launched next year, every JPL-built spacecraft will be made with metric parts. Officials at JPL, NASA's leading center for solar system exploration, say the switch is necessary to keep up with international space agencies.

The machinists who are building Pathfinder get no share of the media spotlight that shines on the space agency's gravity-defying astronauts and sober mission control room. Their windowless warehouse reeks of oil and shakes from monstrous machines, hissing, clanging, whirring. In steel-toed boots, dozens of men--no

women--work on their feet all day in a room so loud that it is impossible to talk without shouting. Their step is cushioned by a soft, scruffy linoleum floor littered with shaved aluminum bits and gravel to sop up spilled oil.

JPL scientists and engineers are weaned on the metric system. But it's the boys in the back shop who have to retool 20 years or more of gut feeling in the English system of inches. Most of them have no more than a high school education, and make an annual salary of about $40,000 to $50,000. Yet they are the elite in their field, able to etch the fine grooves on a part, work that can save a spacecraft from stress fracture.

The work is punishing. Their hands are disfigured by scratches and scars, their fingerprints nearly rubbed out. But they find time to play darts during breaks and rib each other with nicknames.

For these men the switch to metrics is not simply about numbers. They are used to complex trigonometry formulas in their work; they can understand that a millimeter is about the thickness of a dime. This, they explain, is about a loss of control, of having to operate in a new language with the awkwardness and imprecision of translation.

"A lot of the work that gets done isn't so scientific," said Richard E. Fleischner, a design engineer for Mars Pathfinder. "It's (instinctive judgments made by) these guys with tons of experience--in English (inch) units."

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Back in Gerald Ford's presidency, the federal government threw its weight behind a grand notion: America would join the rest of the world in converting to metrics. Federal agencies would convert, and then private enterprise would follow. Citizens would learn to drive 90 kilometers per hour. Sportswriters would learn to describe towering 120-meter home runs.

The dream died in the 1980s, however, largely because metric conversion came to be viewed as just another regulatory burden. Scattered private industry conversion occurred as a consequence of international trade.

In 1988, Congress mandated that all major federal agencies switch to metric by 1992. But efforts slowed when the Reagan Administration cut back funds for metric conversion and eliminated a national metric board that was overseeing the switch.

Most of the 39 federal agencies are making strides toward metric conversion, according to Gerard C. Iannelli, director of the metric program for the U.S. Department of Commerce. For example, all federal highway construction will be done in metrics by September, 1996. However, no agency has completely converted, Iannelli said.

In addition to JPL, only one other NASA agency, Goddard Space Flight Center in Greenbelt, Md., is making major strides toward the metric system. Goddard is building a Tropical Rainfall Measuring Mission spacecraft that is half-metric and half-English sized, according to Richard Weinstein, NASA's manager of engineering standards, who coordinates metric efforts.

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Give Antonio Fonseca that small spacecraft beam that inserts into a larger one and he'll put the two parts together and shake them, testing for tightness and a telltale rattle. He knows if the fit is off by a thousandth of an inch. A "lead man," or shop supervisor, Fonseca is a die-hard inch man.

"It's a feel," said Fonseca, a native of Colombia who is prone to theatrical gestures and pacing. "I describe it as a *gusto,* a taste. . . . It's not a (literal) taste, but in Spanish, we say *gusto,* something that you come with."

Until now, JPL has made only a few metric parts for spacecraft built by Russia, France and other countries. For those parts, JPL either made do with their English tools, bought metric equipment or got help from outside contractors. The complete

switch to metric is expected to cost JPL more than $9 million over five years for new equipment, computer software, manuals and training.

Work on Pathfinder started only two months ago, so nobody is in a hurry to master metric. Only 10% of the machinists' work is for Pathfinder, not enough for the unfamiliar metric numbers to sink in. The rest of their work is for another spacecraft and a high-tech camera, both made with conventional measurements.

To learn metrics, most of the machinists took a four-hour introductory class. Others learned on the job. The younger machinists picked it up quickly; the older ones tended to stumble. All were told to try to start thinking in metric, not to look at blueprints and convert millimeters to inches. Some cheat.

The switch to metrics has not led to noticeable delays or extra overtime costs, nor are mistakes likely to slip through an elaborate testing process, JPL officials say. Nevertheless, complexities abound.

For one thing, there aren't enough metric tools, so a machinist tries to make do with his English ones. Instead of making a metric part, he makes the closest--but not exact--inch-sized equivalent. He figures out that equivalent by rounding the number up or down. But he runs into problems when he makes two pieces that are supposed to fit together and he can't remember which piece he rounded up and which he rounded down.

Or a machinist may misread a Pathfinder blueprint, half of which include both metric and English numbers. He can glance at a blueprint's English number and mistake it for a metric one.

Or he can put the decimal point in the wrong place. Most English numbers the machinists deal with take three decimal places, while metric numbers--which measure smaller lengths--tend to have two.

Most machinists use their own tools. The veterans own toolboxes five feet high, brimming with trusty English-sized equipment from 20 or 30 years back. They don't

want to buy new tools. Only three of them even own a metric ruler.

Machinist Patrick Olagues, 43, keeps his worn micrometer in its own pine case. A micrometer is a standard tool, used to measure small diameters. It's an old Brown and Sharpe model, with a funky clamp. To use it, he has to twist a knob and jiggle the clamp until it feels just so, in increments of one-hundredth of an inch. It's the first tool he ever owned, a gift from his first machine shop supervisor in 1970, and engraved with the nickname "Patty."

Soon, Olagues knows he'll take the old micrometer home to Fontana and replace it with a new one that measures in increments of 2 millimeters--which he has no feel for.

The tool crib's metric supply is meager. Only 2% of its 23,000 tools and parts are metric. Tools are costly, so JPL waits to replace worn ones with metric ones, rather than buying a whole new set.

"I wish we could just buy them all tools. I wish we were Ford or GM or something," lamented Linda S. Robeck, JPL's metric manager, the trouble-shooter for the metric transition.

On a recent afternoon, a machinist approaches the tool crib counter to check out equipment from attendant Daniel Hernandez, 48. The machinist knows the drill size he needed in inches but not in millimeters. "Drill No. 29, let's see, how much is that in metric?" he asks Hernandez, scribbling on a pad to figure the conversion.

Hernandez is just as lost.

One day, Hernandez talked with Robeck about the confusion. Hernandez, a barrel-chested man, wore a blue cotton work shirt with a name patch that said, "Daniel," and a pocket protector bulging with pens and pencils. Robeck, 31, a petite woman with waist-length blonde hair, wore a headband and dangling mother-of-pearl earrings.

The workers, he complained, are saying, “I need it in metric. What’s the closest thing to a half inch?”

Robeck rolled her eyes. “So, they’re having *you* do (the conversion)? Great,” she moaned sarcastically.

“And I *don’t know* “ the answer, Hernandez countered with dismay.

She suggested that more poster-sized conversion charts would help. Hernandez has only one, behind the locked gate of his tool crib so it doesn’t get stolen.

Some machinists are skeptical that JPL will ever go all metric. For years, they say, managers have talked about switching to metric.

“I was hoping they’d wait two more years until I retire--then I wouldn’t have to change,” joked Bernie Hartman, a 63-year-old Mission Hills resident with 32 years of experience.

They say they’ll adopt to the new way--when they have to.

They remember how far they’ve come, from starting off in tiny shops shaving down screws to building spacecraft. Launch days are big deals in the back shop. They dim the fluorescent lights, and on overhead TVs watch their handiwork fly into outer space.

Werner Schwarz used to make plastic molds. Now, he makes one-of-a-kind spacecraft parts, and he’ll do it metric or otherwise.

“Here, your fingerprints are in space,” he marveled. “You don’t get that in plastics.”

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