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THE MAGAZINE OF TECHNOLOGY INSIDERS



**What Really Happened
at Fukushima
and What It Means
for Nuclear Power**



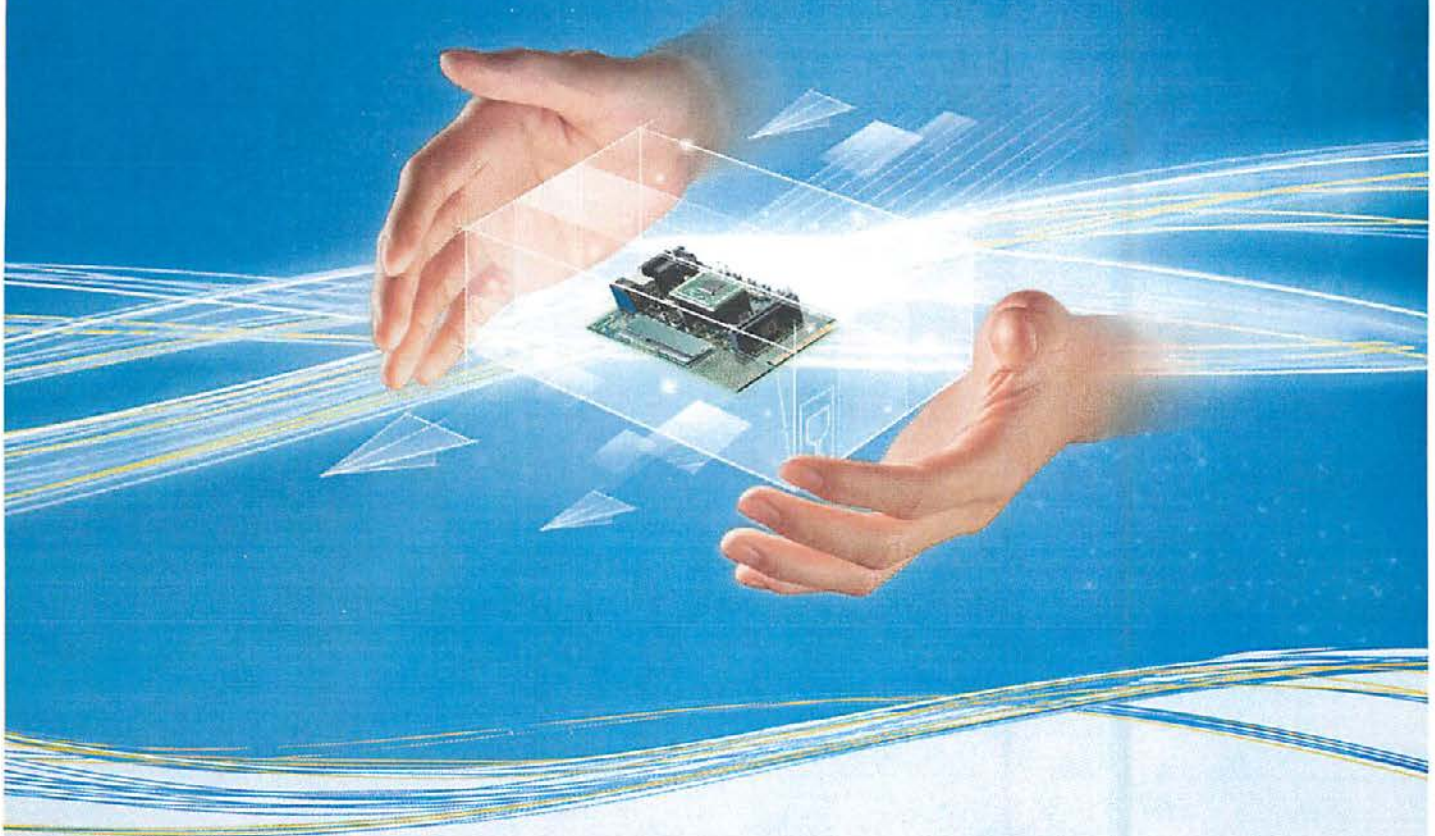
**ON 11 MARCH,
A MONSTER TSUNAMI
SWAMPED A 40-YEAR-OLD
JAPANESE NUCLEAR
POWER PLANT,
CAUSING THE
FIRST TRIPLE-CORE
MELTDOWN
IN HISTORY**

**An IEEE
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**Investigative
Report**



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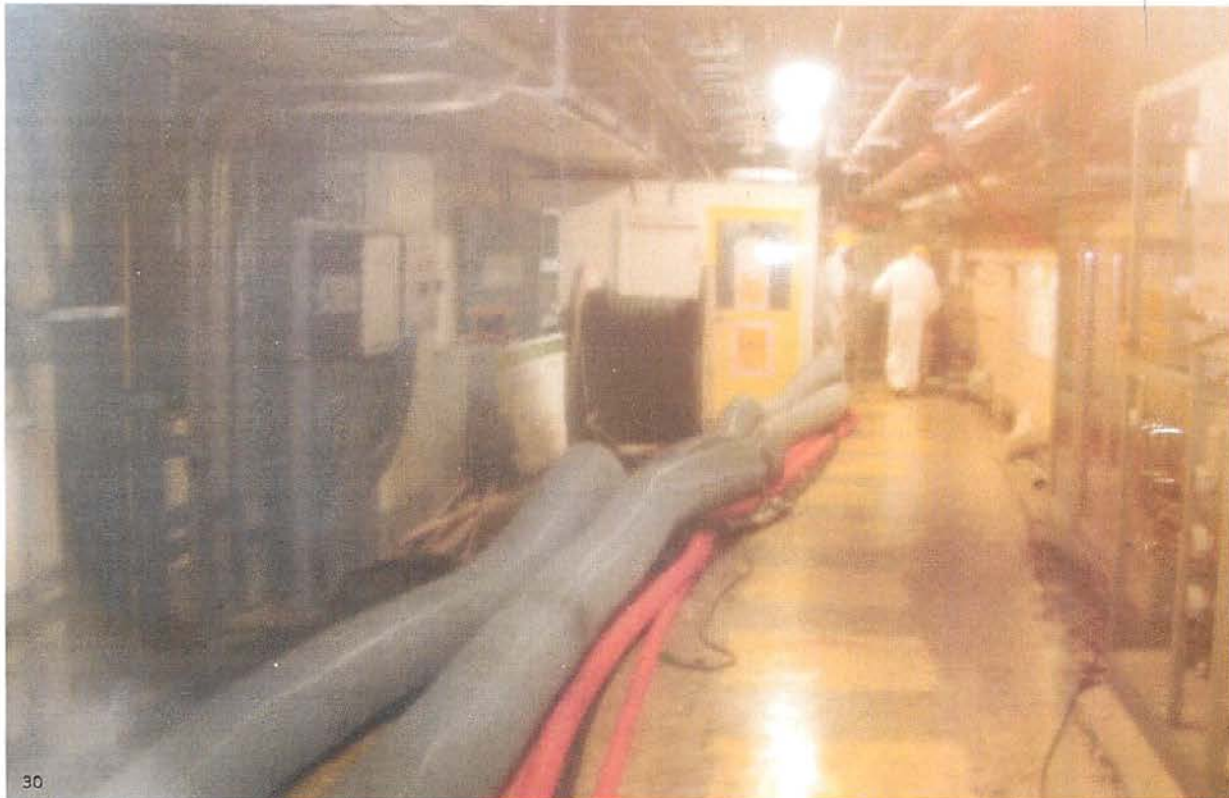
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COPING WITH CATASTROPHE:
Workers inside the Fukushima Dai-ichi nuclear power station labor to stabilize the ruined reactors.

COVER: CARL DeTORRES

THIS PAGE: CLOCKWISE FROM TOP: TERCO; DAVID PLUNKERT; ROLFE HORN

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On the first day of the Fukushima Dai-ichi nuclear accident, workers struggled mightily to prevent disaster—and ultimately failed. *By Eliza Strickland*

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Governments are reassessing nuclear policies in the wake of the accident. *By Ritchie S. King*

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Berlin vows to end its nuclear program by 2022. *By Peter Fairley*

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Rival schemes emerge in the struggle to keep Moore's Law alive. *By Khaled Ahmed & Klaus Schuegraf*



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Designing a clock to last 10 000 years poses a challenge for our speed-obsessed age: How do you build something for the distant future and get people to care about it today? *By David Kushner*



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AVAILABLE 1 NOVEMBER

Fukushima: Measuring the Impact

The radiation released by Japan's nuclear disaster caused the government to evacuate towns and impose bans on fishing and agricultural exports. For an interactive map of the government's response, as well as a peek into the future of the Fukushima Dai-ichi site, go to <http://spectrum.ieee.org/fukushima>.



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SATELLITE SERVICE EARNS MILESTONE

The world's first direct broadcast satellite service, which became available in 1984, is being honored with an IEEE Milestone this month. This service was the culmination of 18 years of research, which included the development of an inexpensive low-noise receiver and investigations of rain attenuation in the 12-gigahertz band.

FINANCING ENGINEERING EDUCATION

As most parents and students know, tuition at top engineering schools is not cheap. To help ease the financial burden, IEEE offers dozens of scholarships, fellowships, travel grants, and internships to engineering undergrads and grad students.

SIGNAL PROCESSING CONFERENCE

The IEEE International Conference on Emerging Signal Processing Applications, to be held from 12 to 14 January in Las Vegas, will cover 3-D technology for gaming, telepresence, gesture recognition for games and natural user interfaces, and more.

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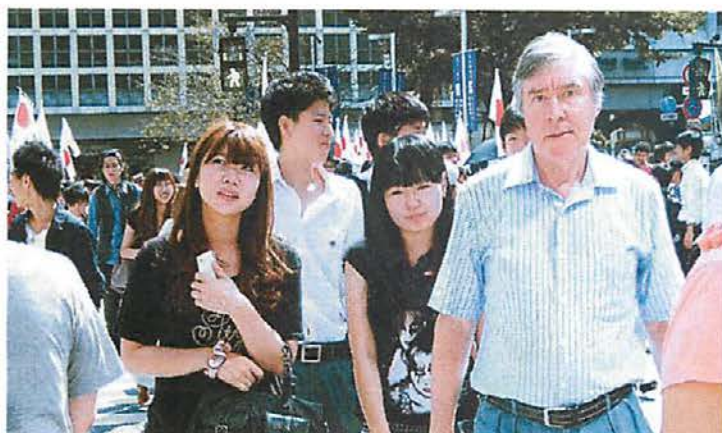


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back story



Assignment: Fukushima

IF YOU'RE a habitué of IEEE Spectrum's website, then you've noticed that we've posted rather a lot of stories and updates on the disaster at the Fukushima Dai-ichi nuclear plant. Although nearly every Spectrum staffer has contributed to our coverage, it has been John Boyd [above], our man in Japan, whose reports have enabled us to break as many stories as we have.

You'll find his latest article on the effort to bring the Fukushima Dai-ichi reactors under control in the Update section of this issue. And behind that article are the more than 50 online reports he has filed since the crisis began on 11 March.

Born in England, Boyd arrived in Japan in 1972 during what was supposed to be an around-the-world hitchhike. He never left. Living in Japan for the past four decades has inured him to earthquakes. But he could tell that the one this past March was different.

"At first I thought it was a huge windstorm because the power lines were swinging so much," he says. The buildings in his

neighborhood of greater Tokyo were shaking so violently that some people sought safety in a nearby field, only to discover that the field itself was bucking and heaving.

Amazingly, Boyd's apartment building withstood it all. After searching for a friend, he plunked down in front of the TV just in time to see a tsunami devour the northeast coast.

Although his own city was spared the tsunami's ravages, life was no picnic. "The first few weeks it was tough because there was a run on food, and bottled water wasn't available because of panic over radiation," he says. Train service was halted, aftershocks rattled coastal areas, and rolling blackouts stifled Tokyo. "But news was coming in all the time," Boyd marvels.

He says he wasn't immediately aware of the scope of this story. But when he filed his first report, he already seemed to know the direction it was going to take. It was prefaced by a note that "things are likely to get worse"—a true British understatement if ever there was one. □

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IEEE Spectrum publishes two editions. In the International edition, the abbreviation INT appears at the foot of each page. The North American edition is identified with the letters NA. Both have the same editorial content, but because of differences in advertising, page numbers may differ. In citations, you should include the issue designation. For example, The Data is in IEEE Spectrum, Vol. 48, no. 11 (INT), November 2011, p. 64 or in IEEE Spectrum, Vol. 48, no. 11 (NA), November 2011, p. 92.

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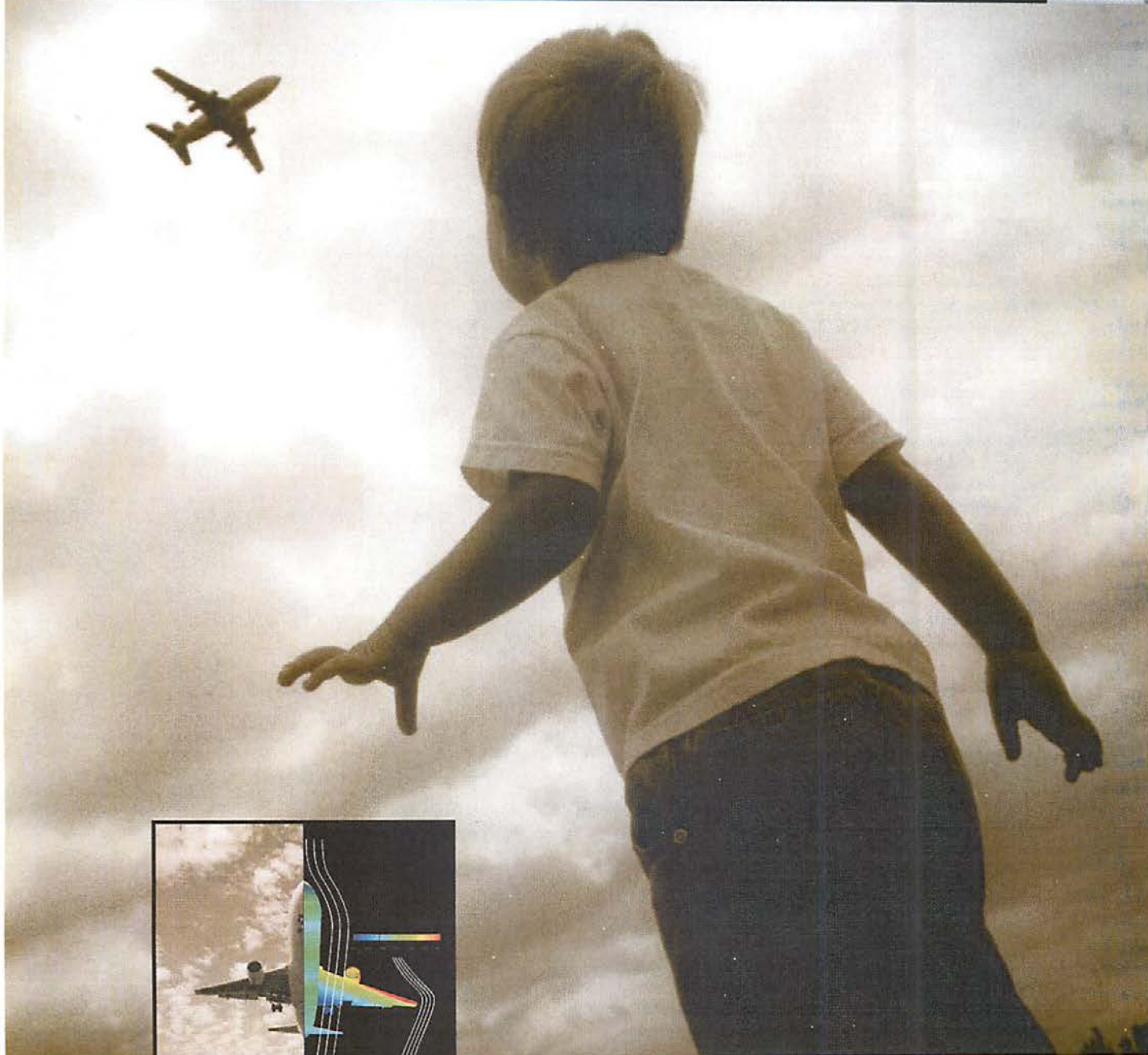
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contributors

KHALED AHMED and **KLAUS SCHUEGRAF** write about the coming competition between thin-channel 3-D and 2-D transistors in "Transistor Wars" [p. 50]. Ahmed is an IEEE senior member and a technology strategist in the Silicon Systems Group at Applied Materials, where Schuegraf is chief technology officer. After years of working on ways to manufacture smaller and smaller bulk silicon transistors, both are excited about the rapid development of the new, thin-channel alternatives. "From a device physics perspective, thin is definitely in," Ahmed says.



PETER FAIRLEY writes about energy as a contributing editor for *IEEE Spectrum*. Fairley,

a world traveler who divides his time between Vancouver Island and Paris, has the international perspective *Spectrum* needed for articles about China's nuclear-powered future [p. 46] and Germany's nuclear-free future [p. 47]. "When it comes to energy, every country has its own unique set of political restraints and cultural hang-ups," he says. "That's what makes it interesting."



DAVID KUSHNER wrote "Ticking to Eternity" [p. 54], about the effort to build a monumental clock that will tell time for 10 000 years. He wonders how people will view the clock millennia from now: "I keep picturing the Neanderthals in 2001: *A Space Odyssey* discovering the monolith, stumbling on to this amazing thing."

A *Spectrum* contributing editor, Kushner has written three books, including *Levittown: Two Families, One Tycoon, and the Fight for Civil Rights in America's Legendary Suburb*.



DAVE LEVITAN, a freelance journalist in New York City, is a contributor to

Spectrum's EnergyWise blog. He wrote "Prospects for an Artificial Leaf Are Growing" [p. 15] because "some of the best ideas for energy are already out there in nature," he says. "We just have to adapt what exists." A companion piece on how engineers are taking cues from whales and fish in designing wind farms is at <http://spectrum.ieee.org/levitan0911>.



HARRY TEASLEY has been developing video games for more than 20 years, and many of his

games, like the massively multiplayer *Lord of the Rings* online, are supported by hyperspecialized computer mice. "I could open a museum of input devices, and most of them are total failures," says Teasley, who writes about the Microsoft Touch Mouse in "Gestures Creep Into Mouse Interfaces" [p. 26]. But when you find a mouse that works well with a game, he says, "it's a revelation."



PAUL WALLICH took to his basement workshop in Vermont to test out a MakerBot

3-D printer for "Absolutely Fab" [p. 22]. There, he made a number of small plastic doodads, including a SpongeBob SquarePants figurine for his 6-year-old son. His 3-year-old isn't so lucky, at least for now. "He's being kept far away from this thing," says Wallich, "considering that it's squirting out plastic at 220 °C."



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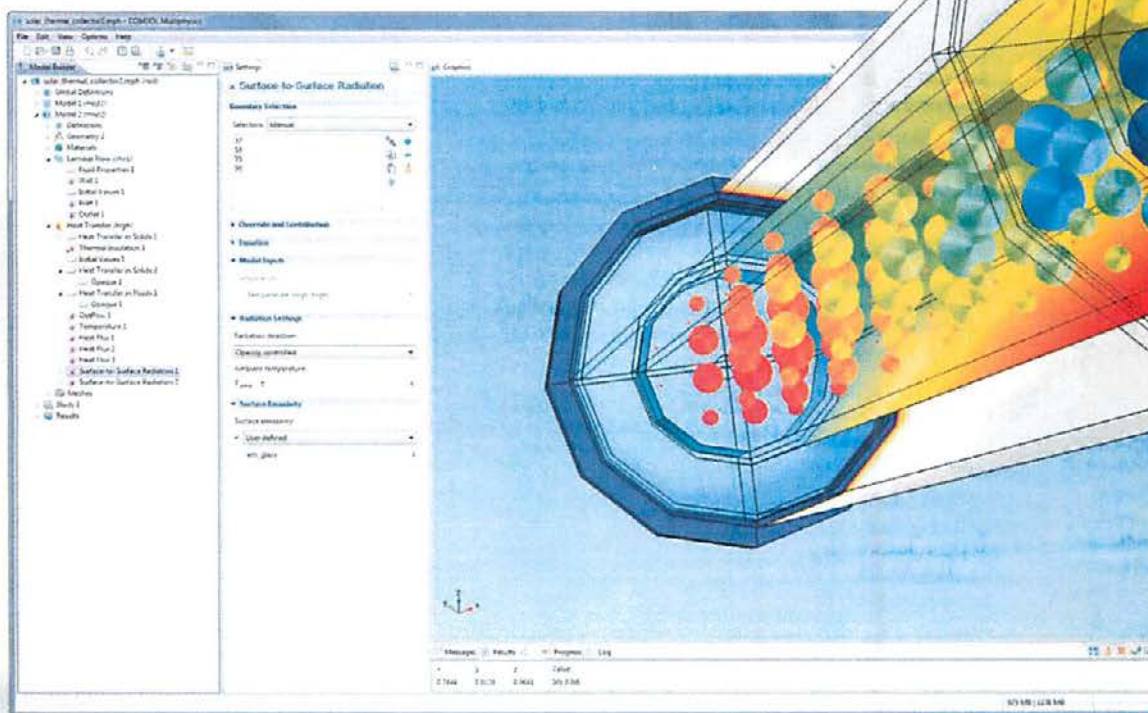
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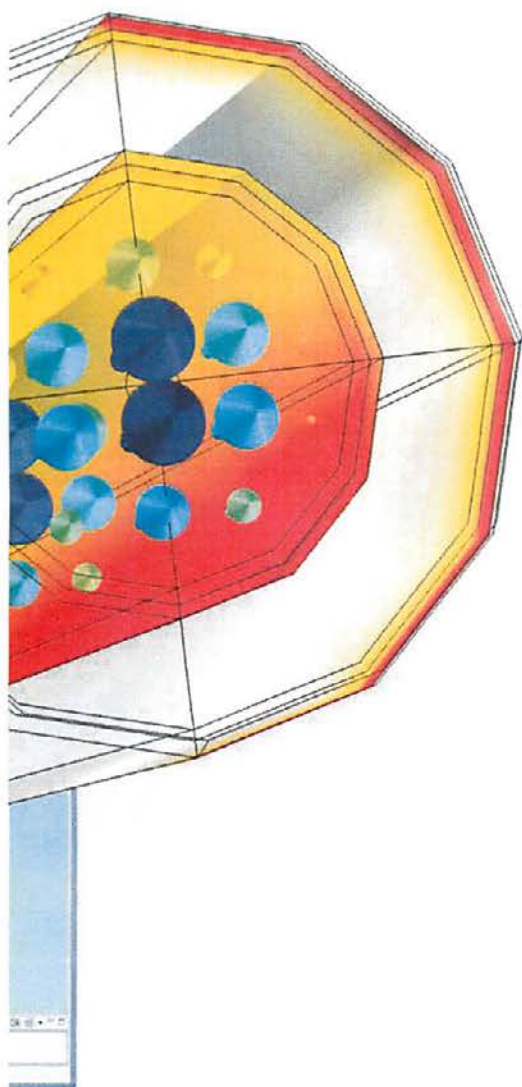


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From left: Iwao Hyakutake, Eiki Hotta, and Tsuneo Futami

Covering Fukushima With a Little Help From Our Friends

JOURNALISM is about access—to people, places, documents, and other things. And here's why good journalism is hard: When a journalist most needs access to something is often the exact time it's hardest to get that access. The reason, of course, is that lots of journalists are all flocking to the same person or place, in response to the same news-making event. For example, everyone wants to talk to the cabinet minister the day after he resigns amid scandal.

And so it was with the Tokyo Electric Power Co., whose Fukushima Dai-ichi nuclear power plant suffered core meltdowns in three reactors in the days after an enormous tsunami inundated the plant. The world's journalists besieged TEPCO, which behaved in an all-too-predictable fashion: It hunkered down and gave terse and

essentially useless updates about the unfolding disaster.

For us, perfunctory coverage of this calamity wasn't an option. IEEE members expect us to give them authoritative insights into engineering-related events. And the bigger the event, the greater the expectations. Besides, we had a reputation to live up to: *IEEE Spectrum* won its first National Magazine Award—the highest honor in U.S. magazine publishing—for a report published in 1979 on the Three Mile Island nuclear accident in Pennsylvania.

Immediately after the news of trouble at Fukushima broke, our Japan correspondent, John Boyd, began filing blog posts [see Back Story, this issue]. But we also needed a staffer in our New York City office to anchor our output, which was being directed by Samuel K. Moore, *Spectrum's*

news editor. Associate Editor Eliza Strickland accepted the challenge.

We had hired her to be our Asia editor, a newly created position, and her first day of work at *Spectrum* was Wednesday, 9 March. The Fukushima disaster began not quite two days later. For a true journalist, there's a kind of thrill, a mix of butterflies and fervor, that you feel when something huge occurs in your beat area. Strickland had never written on nuclear technology before, but she was well prepared to do so: She came to *Spectrum* from *Discover* magazine, where she had been a Web editor specializing in energy and environmental issues.

Over the next month she wrote or edited dozens of posts and stories, including ones on worst-case scenarios and a buoy-based tsunami warning system. She soon found that, in the endless quest for access, she had something important on her side: the global reach of IEEE. Strickland contacted Professor Eiki Hotta, chair of the Japan chapter of the IEEE Nuclear & Plasma Sciences Society (NPSS). He put her in touch with Professor Tsuneo Futami of the Tokyo Institute of Technology, who is a former superintendent of the Fukushima Dai-ichi plant. Professor Futami became Strickland's guide and champion, patiently answering her questions for two days at his Tokyo office and securing for her an exclusive interview at TEPCO headquarters.

Although the executives at TEPCO didn't reveal much during the interview, the scene there was memorable.

With summer coming on, the utility had embarked on a stringent energy conservation regime. So Strickland was startled on arriving to find TEPCO's senior management in suits and ties, rushing around dark, hot hallways as they grappled with the repercussions of the second-worst nuclear power plant accident in history. It was thanks to Professor Futami, too, that Strickland secured an interview with the officials at Japan's Nuclear and Industrial Safety Agency who oversaw the response to the Fukushima crisis. The vice-chair of the NPSS, Hiroshi Akatsuka, accompanied her to that interview.

IEEE's dynamic Japan organization helped at every turn. Just before Strickland left Tokyo to travel to the city of Aizu-Wakamatsu, she learned that her interpreter wouldn't be able to meet her there. The head of the IEEE Japan office, Iwao Hyakutake, wheeled into action and arranged for a replacement. In an empty school in Aizu-Wakamatsu, where Strickland interviewed the mayor of an evacuated town, she was touched by the sight of corridors lined with strings of paper cranes, sent by well-wishers from around the world.

We would like to thank Professor Futami, Professor Hotta, Professor Akatsuka, Mr. Hyakutake, and the many others who helped us with our report on Fukushima. By believing in what we do and by being generous with their time, they enabled us to start a discussion about exactly what happened at Fukushima and what it all means.

—SUSAN HASSLER

FROM LEFT: IWAO HYAKUTAKE, EIKI HOTTA, TSUNEO FUTAMI

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