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STEAM PUNKED

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"…2 months to **15 days…**"

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Multi-degree-of-freedom Flexible-Arm Robot for Space Applications

Researchers produced a high-fidelity real-time simulation of a 15-dof flexible-arm robotic platform for training and task planning.

"…1 month to **3 days…**"

Analysis of Engine Vibration in Diesel Engine

Engineer analyzed lumped-parameter model to identify and address conditions that produced severe vibrations on engine shut-down, without resorting to FE analysis.

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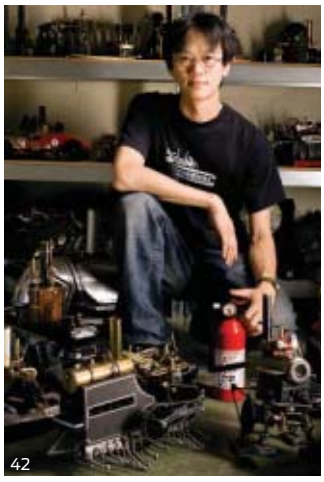

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SPARKS FLY: Engineers build community and more at TechShop [top left]; strange steam-powered critters inhabit I-Wei Huang's garage [top right]; and solar panels on a U.S. Air Force base harvest energy from the sun [bottom].

COVER: JONATHAN SPRAGUE/ REDUX

THIS PAGE, CLOCKWISE FROM TOP LEFT: TIMOTHY ARCHIBALD; JONATHAN SPRAGUE/REDUX; MMA RENEWABLE VENTURES

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Do-it-yourself enthusiasts are drawing on the aesthetics of the 19th-century Victorian era to create fantastic brass-adorned, steam-driven machines. All hail the steampunk subculture. *By Erico Guizzo*

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One of the world's most profligate users of energy, the U.S. military, is turning to renewable sources on a grand scale. *By Sandra Upson*

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A flaw in the Internet's infrastructure makes it easy for scammers to lure people to fake Web sites. *By David Schneider*

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Bomb disposal has gone high-tech, as our reporter saw firsthand when his convoy encountered an IED north of Tikrit, in Iraq. *By Glenn Zorpette*

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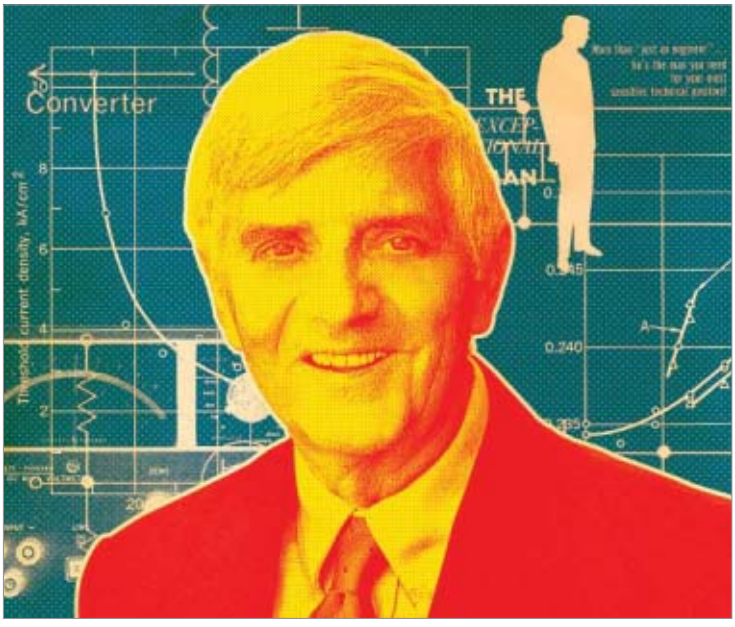

TOP: SEAN MCCABE; BOTTOM: RUTH FREMSON/ THE NEW YORK TIMES

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AVAILABLE 1 OCTOBER ON SPECTRUM ONLINE

BEST OF LUCKY

Fifteen years ago, a book compendium of Robert W. Lucky's column, Reflections, was published as *Lucky Strikes...Again*. Today, through the miracle of the Web, we can publish a compendium whenever we want. So we asked Bob [above] to pick his 10 favorites from his column since then. "Does the list have the one with Brutus, the telephone-answering computer that accidentally discloses the owner's extramarital affair?" asked staffer Nancy Hantman (who arrived at *IEEE Spectrum* in 1981, just months before the column's debut). Sorry, Nancy, that one didn't make the list—but just imagine what did. Let us know if Bob left out your favorite as well. Thanks to the Web, we can do this again, whenever the mood strikes...again.

ONLINE FEATURES:

ROBOTIC DINOSAURS GET BIG: In an exclusive video, two lucky kids get a sneak peek at Kota, a plush triceratops big enough to ride.

NASA SPENT US $650 MILLION and four decades developing *Gravity Probe B* to test Einstein's equations, but the data came back noisy. Cosmologist Paul S. Wesson explains what went wrong and how to save the experiment.

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CONFERENCE LOOKS AT PATTERN RECOGNITION

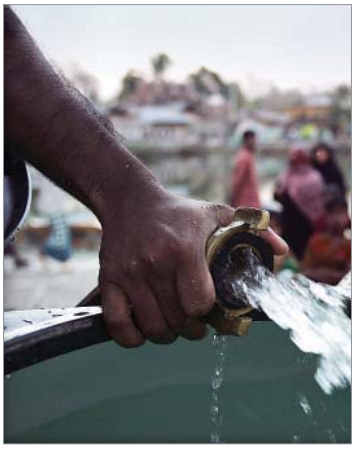
Read up on the latest advances in the fields of computer vision, pattern recognition, speech and signal analysis, and biometrics. These topics and more will be discussed at the 2008 International Conference on Pattern Recognition, scheduled from 8 to 11 December in Tampa, Fla.

IEEE MERCHANDISE AVAILABLE

The new IEEE online store opens its doors this month with its shelves stocked full of T-shirts, caps, umbrellas, and briefcases emblazoned with the IEEE logo.

COMMITTEE TAKES ON CLEAN DRINKING WATER

The IEEE Committee on Earth Observation has been working on a "Water for the World" project aimed at creating pilot programs to provide clean, safe drinking water in areas where there is none.



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back story

Beer, Not Bombs

Executive Editor Glenn Zorpette traveled to Iraq this past January with a secret wish: that he would at some point get close enough to a roadside bomb to see it with his own eyes.

Little could he know that not only was he going to see a bomb, he was also going to help two U.S. Navy bomb-disposal specialists blow it up. One of them snapped a picture [above] just as Zorpette [at right] pulled the pin on an igniter that blew up a charge placed on the bomb by a robot.

Zorpette admits that his aspiration "may seem odd. But I was in Iraq to report on how the military is dealing with roadside bombs, and I've always believed that the best journalism comes from people doing and seeing things firsthand."

He spent much of his time in Iraq embedded with U.S. military specialists trained in explosive ordnance disposal, or EOD. They search for, disable, and destroy roadside bombs. "EOD teams are not only among the best-trained military units I've encountered, they're also the funniest and most irreverent," Zorpette says.

Arriving at the tactical operations center of one EOD team he had been assigned to, he noticed a whiteboard in the room and, in one corner of it, a terse message heralding his arrival: "Today's forecast: sucking up to a reporter. Talking s—t when people are not around."

The humor and bravado are a mechanism for coping with some of the most stressful duties in the war zone, Zorpette says. They're also a kind of social glue that helps draw superbly capable people into trusting, close-knit teams.

The rites can even apply to embedded journalists. "After we blew up that IED, the EOD team leader turned to me and said that according to Navy EOD tradition, I owed him a case of beer," Zorpette explains. "Now if he'll just tell me where to send it, I'll be happy to discharge my debt." ❑

CITING ARTICLES IN IEEE SPECTRUM

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 first Update page is in *IEEE Spectrum,* Vol. 45, no. 10 (INT), October 2008, p. 9, or in *IEEE Spectrum*, Vol. 45, no. 10 (NA), October 2008, p. 13.

COURTESY OF GLENN ZORPETTE

contributors

MARK ANDERSON does double duty in this issue. With the U.S. presidential elections looming, he looks into the long-running battle for secure electronic voting in "Open-Source Voting" [p. 9]. He also reviews Michael Brian Schiffer's book on the history of electrical engineering prior to Edison [p. 20]. "It's filling in a gap that many people, including me, didn't know existed," says Anderson.

JOHN BLAU, who lives in Düsseldorf, Germany, has been contributing to *IEEE Spectrum* for nearly 20 years. Though he's written for us about such diverse topics as low-power processors, peer-to-peer TV, and robotics, his article, "Car Talk" [p. 12], about vehicle-to-vehicle communications schemes, is a natural fit. "I'm based in a country whose economy is highly dependent on car manufacturing," he points out.

VIKTOR KOEN portrays entrapment in his illustrations for "Fresh Phish" [p. 28], which describes a recently discovered flaw in the Internet's Domain Name System. "The multiplicity of the hooks" in his underwater scene "gives it a dramatic effect," he says. Born in Thessaloníki, Greece, Koen is on the faculty of the Parsons School of Design, in New York City. His award-winning images have been exhibited worldwide in museums, galleries, and private collections.

PAUL McFEDRIES has been writing the Technically Speaking column since June 2002. He says he knew it was time for this month's "E-cycling E-waste" [p. 15] when he saw the term *e-waste* in *The New York Times*. McFedries has written numerous books, including *The Complete Idiot's Guide to Weird Word Origins*, which was published this past August. He also runs Wordspy, a Web site that tracks emerging words and phrases.

NATHAN PERKEL was aiming for "a mix of old-fashioned taste with modern technology" in the photo of Jake von Slatt in our cover story, "Steampunk Contraptors" [p. 42]. Enthusiasts like von Slatt (né Sean Slattery) envision a 19th-century world that might have been. To add to the historical effect, Perkel shot the portrait with a traditional large-format 4-by-5-inch film camera instead of the digital camera he used for his other photos in the article.

JONATHAN SPRAGUE wanted to capture the craftsmanship of steampunk artists I-Wei "Crab Fu" Huang and Richard "Datamancer" Nagy [p. 42]. Sprague says he focused on the intricacies of the gears and parts in such creations as the laptop computer disguised as a music box. A first-time contributor to *Spectrum*, Sprague has also shot for *Travel & Leisure*, *Fortune*, and *Men's Journal*.

CLOCKWISE FROM TOP LEFT: PENNY LEVERITT; KAREN HAMMOND; NATHAN PERKEL; KATE POWERS; VIKTOR KOEN; SIGRID BLAU

spectral lines

Digital Dilemma

Converting to digital television is supposed to be simple. It's not

When the U.S. Congress voted in 2006 to stop over-the-air broadcasts of analog television on 17 February 2009, it assured the public that going digital would be cheap and painless. It allocated US $1.5 billion to help fund the purchase of converter boxes for what was supposedly the tiny minority of U.S. households that don't subscribe to a cable or satellite television service. But if my experience is typical, the coupons are just the first step in a conversion that will be neither painless nor, in the long run, cheap.

I ordered two coupon cards back in January. They arrived in April, and in June I purchased a $50 RCA converter box at Wal-Mart. A different brand at Radio Shack was sold out.

The television's built-in analog tuner had gotten great reception on all the major networks, a local nonaffiliated television station, and a Spanish-language channel—all in the VHF band—and six fuzzy but watchable UHF channels.

Using the RCA converter box, I got great reception on one PBS-affiliate channel. This gave me four choices of programming, because the affiliate broadcasts multiple standard-definition programs instead of one high-definition program. Unfortunately, the PBS station was KTEH, out of San Jose, Calif., instead of San Francisco's award-winning KQED. In addition, I got reasonable reception on four Spanish- and Chinese-language channels. But ABC and NBC, two of the three major U.S. networks, broke up constantly and were unwatchable, while CBS went missing entirely.

BRYAN MULLENNIX/GETTY IMAGES

I went back to Radio Shack with my remaining coupon and ended up with a $60 Digital Stream converter. The connection process was the same as for the RCA box. The on-screen graphics are a little nicer, but I never found a comprehensive program guide, which made channel selection difficult. And the digital reception? No better.

Like most people who watch broadcast television, I get my signals through an ancient antenna on my roof—a bent, cobwebbed, aluminum monstrosity that is, it turns out, optimized for VHF signals. Most digital channels come in on the UHF band. So I next installed a $60 indoor RCA Flat Antenna. No improvement.

I convinced my husband to climb up on the roof and replace the VHF antenna with an $80 C2 UHF antenna from Antennas Direct, in Eureka, Mo. This improved reception on my second-floor Sony television. It now gets most of the broadcasts I got with analog reception, along with CW and Ion (two secondary U.S. networks), plus the Spanish and Chinese stations.

The new antenna didn't do as much for the TV in the family room; I am picking up NBC now, but I still can't get most local network affiliates. The local terrain may be responsible, says Ernest Neumann, KQED's director of broadcast operations; UHF doesn't propagate through hills and other obstacles. Or my problem might stem from multipath interference. In urban environments, a strong digital signal can bounce around, and many tuners can't sort out the information.

But, given that I have better reception upstairs, a more likely culprit is the cable from the antenna to the television. Richard Schneider, president of Antennas Direct, says, "Eighty percent of the calls we get about reception problems turn out to be in the signal distribution between the antenna and the tuner."

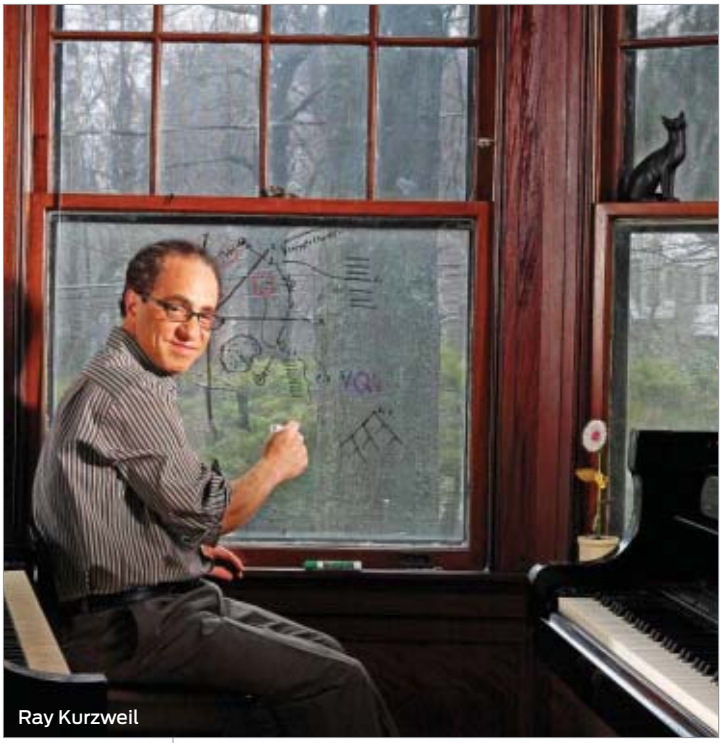
Our antenna cables were installed before we lived in this house. I try to imagine what's going on inside the walls. A splitter probably sends a line into the bedroom—giving the upstairs TV half the original signal—before continuing down the wall, dropping under the house, and splitting into three to five other lines. If that's the case, the family room gets 10 to 15 percent of the original signal.

Yet that was fine for analog VHF television. "The lower VHF frequencies," Schneider says, "tend to be more forgiving of long cable runs and splitters. UHF signals are more prone to loss." With 30 meters of typical coaxial cable, a 50-megahertz VHF signal loses about 2.8 decibels; a 500-mHz UHF signal loses about 8.5 dB. A couple of bites from a mouse along the way can increase that loss dramatically.

If I can find one of the splitters, I can put a preamp on it for about $60. Alternatively, I can rewire. And I'm not alone. "People living more than 10 miles [16 kilometers] away from the transmitter are mainly going to have to start over," Neumann says. Or I can spend about $60 a month for cable or satellite service—just the thing the digital television converters are supposed to help me do without. —Tekla S. Perry

A version of this column appeared in IEEE Spectrum Online's Tech Talk blog on 16 July.

forum


Ray Kurzweil

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THE SINGULARITY: THE LAST WORD

I COMMEND *IEEE Spectrum* for devoting an issue to the varied faces of the singularity ["The Singularity: A Special Report," June]. There were a number of thoughtful essays, such as those by Christof Koch and Giulio Tononi, by Rodney Brooks, and by Vernor Vinge. It is sensible for you to have also included critics, but it would have been useful to assign skeptics who do their homework. John Horgan ["The Consciousness Conundrum"], for example, cites my books, but it seems that he has not read them. He makes no mention of their principal arguments, and many descriptions in your issue are incorrect. You state that I predict the singularity "will occur in about 15 years," yet I clearly state 2045 as my projection—see page 136 of my book [*The Singularity Is Near: When Humans Transcend Biology*, Viking, 2005]. One of my arguments is that progress is exponential. If you think linearly, as Horgan seems to, then human-level intelligence will seem far away. Take 30 linear steps and you get to 30. Take 30 exponential steps (2, 4, 8,...) and you get to a billion, which is one reason that the next several decades will see far more progress than is intuitively obvious. Your constant citing of Moore's Law in every "expert view" is misleading. In my book, I spend several chapters explaining why Moore's Law is just one example of exponential growth and, like all such paradigms, it will come to an end. It was not the first approach to bring exponential growth to the price-performance of computing; it was the fifth such paradigm, and it won't be the last. Smooth—and predictable—exponential growth started over a century ago, decades before Gordon Moore was even born. And it applies to information technologies that go beyond mere computation, such as brain reverse engineering and genetic sequencing. Another argument that Horgan and your other skeptics don't mention is that the design of the human brain, while not simple, is nonetheless a billion times simpler than it appears, due to massive redundancy. Biological systems such as the brain are probabilistic fractals, which give them their messy, unpredictable quality. The design of the human brain is in the genome, and I show that there are only about 50 million bytes of design information (after lossless compression) in the genome (including the epigenetic information in the reproductive machinery), which is a level of complexity we can handle. And indeed, we are making exponential gains in modeling and simulating extensive regions of the human brain, including the cerebral cortex. Horgan's argument is basically "The notions of the singularity are ridiculous. Therefore it won't happen. QED." I respond in detail to this seductive argument in the section "The Criticism From Incredulity" in chapter 9 of my book. In fact, I respond in detail to all of the skeptical arguments in your issue in chapter 9 and in my 2005 book in general, and it would have been useful if your skeptics had gone beyond using de novo arguments as if nothing had ever been written about this subject.

RAY KURZWEIL
IEEE Affiliate Member
Newton Highlands, Mass.

Editor's clarification: The statement "This singularity will occur in about 15 years" appears in the table "Who's Who in the Singularity," which was not written by John Horgan.

CORRECTIONS

In "Earth-Size Radio Telescope Opens Its Eye" [Update, August], the accompanying photo caption should have stated that the radio telescope near Arecibo, Puerto Rico, has a diameter of 305 meters, or roughly 1000 feet.

In "A Computer for the Clouds" [Update, August], the correct average power efficiency for the top 10 supercomputers is 248 million floating-point operations per second per watt.

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update

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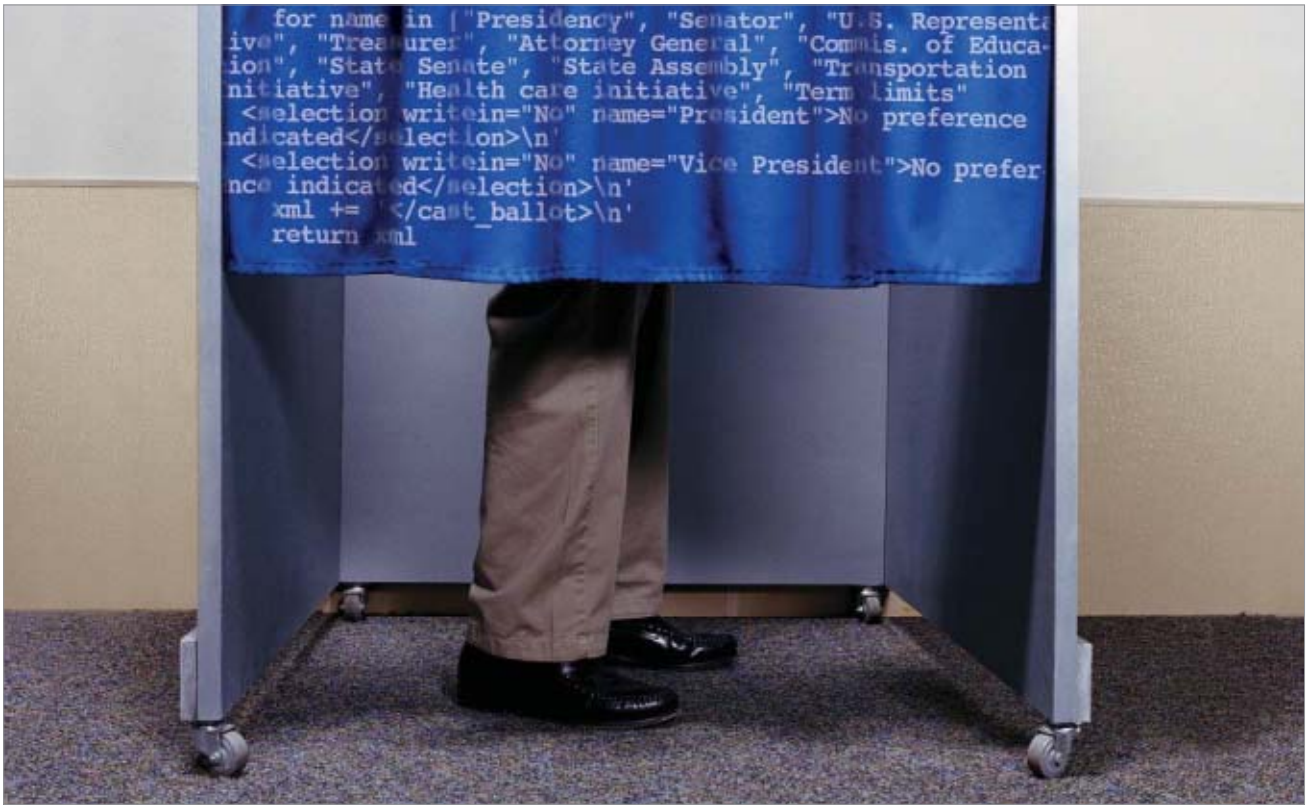


Open-Source Voting

Its proponents could put pressure on voting-machine makers, but critics say it's not a cure-all

PRIVACY, PLEASE: Is open-source voting the solution to the United States' election issues?

PHOTO: DIGITAL VISION/ GETTY IMAGES

IN THE AFTERMATH of the Florida recount debacle of the 2000 presidential election, the U.S. Congress appropriated billions of dollars for state and local governments to buy electronic voting systems. But in the years since, a string of problematic elections has led much of the voting public to join early critics in concluding that available machines are buggy, easily subverted, and impossible to accurately audit.

So perhaps it was only a matter of time before members of the open-source movement would enter the fray, with the claim that their kind of technology can guarantee free and democratic elections. Already, two bellwether states, California and New York, have taken notice. This spring, California's state assembly considered a bill mandating that new voting systems be based on open-source software. The bill didn't pass, despite support from the California secretary of state, whose office certifies voting systems. But at least one major (and for now undisclosed) California city is considering open-source voting. So the issue is likely to come up again. Meanwhile, New York's state board of elections decided late last year to waive certification fees for open-source voting systems.

The catalyst for open-source voting is the Open Voting Consortium, based in Sacramento, Calif., which demonstrated its electronic balloting software in August at LinuxWorld in San Francisco, using it to take a straw poll for the presidential election and also to determine the conference's best-in-show award. According to OVC president Alan Dechert, the vote tallied 816 ballots over 16 polling stations, using ballots that had to be created on the fly after the best-in-show finalists had been chosen.

Dechert admits it's a long way from a straw poll to a state—

update

or even a town—election. But, he says, open-source machines already have much of the functionality of closed-source ones, are more trustworthy, and are one-tenth the cost. A comparable closed-source voting machine costs US $4000, he says, "and it does its job stupidly. With ours, the hardware costs $400 and the software is free." The greatest advantage of open-source voting software, Dechert says, is that anyone who can read computer code can inspect an OVC system to ensure its security.

In the OVC system a voter chooses candidates on a touch screen and then prints a ballot, which shows those selections in bar-code form. The printout would be stored in a ballot box until the polls close. Then, with election monitors observing, the ballots would be hand-scanned using a bar-code reader. Proprietary systems by manufacturers like Diebold, Election Systems & Software, Sequoia Voting Systems, and Hart InterCivic typically tally votes as soon as the voters make their selections. This runs contrary to the OVC's philosophy, which in Dechert's words is "You cast your vote in private, but it's counted in public."

The problem with the OVC model, says Rebecca Mercuri, owner of computer security firm Notable Software, in Philadelphia, is that while OVC may be more secure than today's proprietary systems, it is no more secure than electronically scanning paper ballots.

Moreover, Mercuri says, there are problems that OVC wouldn't necessarily solve. "In poorer precincts or in precincts where there is some deliberate disenfranchisement going on, we find that the machines aren't quite working properly," resulting in long lines at the polls, says Mercuri, who has been called in as an expert in a number of elections.

Earlier this year, Mercuri taught a class at the University of Pennsylvania that built an OVC system from material available on OVC's Web site and ran a mock election. The vote-counting database was buggy, she says. And OVC's software for designing ballots was so complex that even her Ph.D. students were scratching their heads. Of course, as with any open-source product, the solution may be to simply enlist more developers to refine the code. However, Mercuri thinks the open-source model of continual refinement might not fit with a government certification process that takes months and hundreds of thousands of dollars.

Those problems aside, if open-source voting gains in popularity, says Mercuri, it could pressure proprietary voting-machine companies to open their systems to greater scrutiny. "The viability of a real open-source product out there in the market would now kick open the door of the vendors who are saying we're never giving out our source code," she says. —Mark Anderson

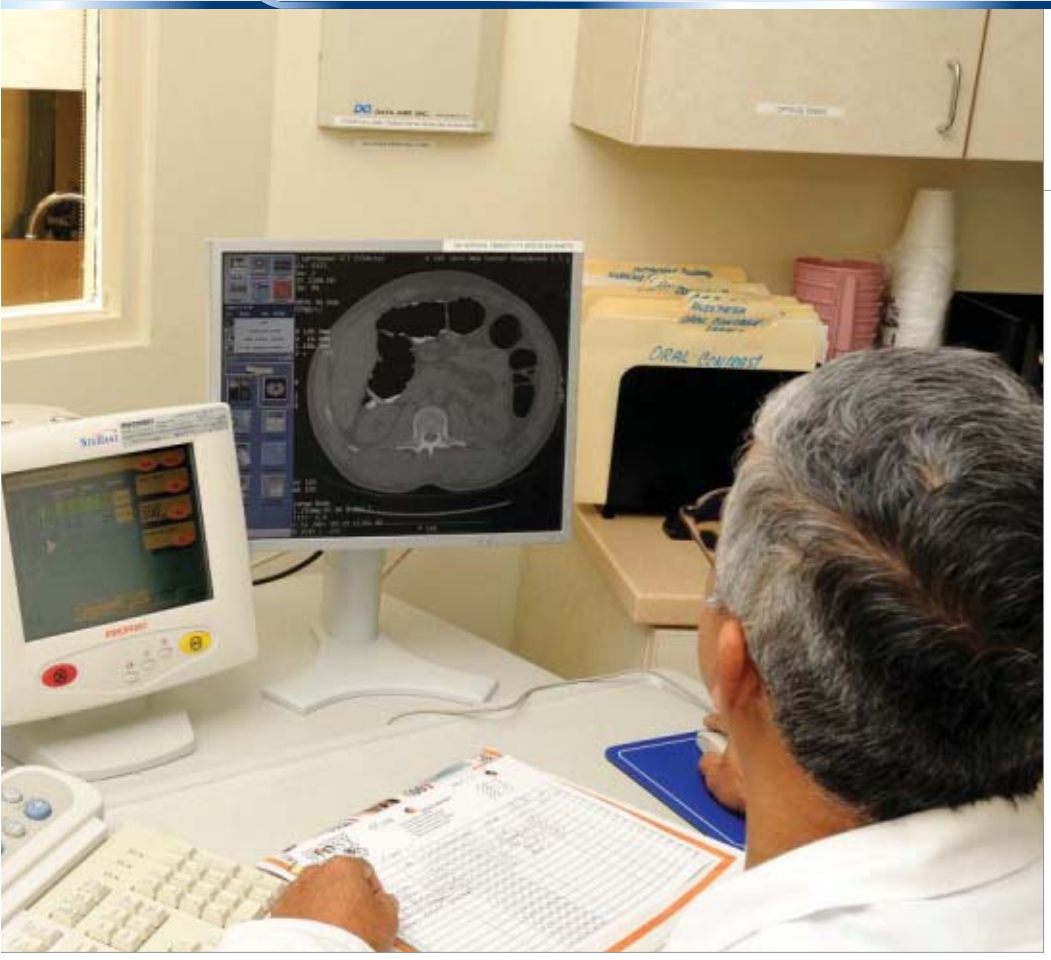
Colon Cancer Screening, The Easy Way

Radiology researchers devise a workaround for a nasty problem

A new software program promises to make one of medicine's more grimace-inducing check-ups significantly simpler. By devising a way to digitally clean up three-dimensional X-ray images of the colon, a group of researchers at the State University of New York at Stony Brook hope to encourage more patients to receive their recommended colon cancer screenings.

Colorectal cancer kills close to 700 000 people each year worldwide—a staggering number considering that most of these victims are done in by a tumor that ticks like a time bomb for as long as 15 years before erupting. This easily foiled killer creeps up on so many people because the gold standard in colorectal cancer detection, the colonoscopy, is tremendously unpopular. The prescreening regimen requires ingesting nothing but liquids for 24 hours, including a diarrhea-inducing concoction that forces a patient to stay near the bathroom for hours. Then there's the test itself: a camera attached to a fiber-optic cable is inserted into a patient's rear and snaked through the colon. This allows a doctor to visually inspect the walls of the gut for the presence of polyps that could turn cancerous.

For the past few years, the option of a virtual colonoscopy



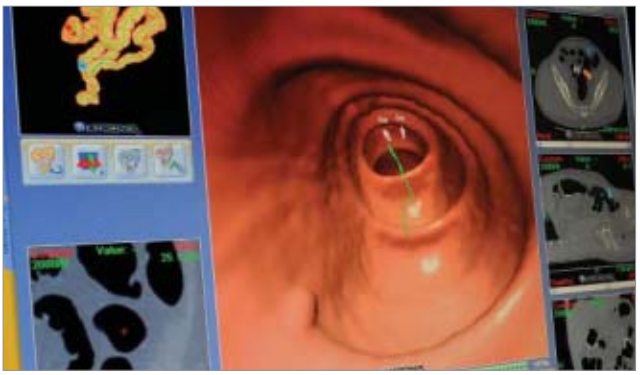
INSIDE OUT: Radiologists in New York have invented a technology that screens for colon cancer without discomfort. *PHOTO: ZHENGRONG LIANG*

has offered patients a partial reprieve by doing away with the inserted camera. Instead, a computed tomography (CT) scan renders a 3-D image of the colon, enabling doctors to perform noninvasive virtual fly-throughs of patients' digestive tracts. But recipients have still had to deal with the discomforting effects of the prescreening potion and diet. Now these researchers hope their method—partial volume segmentation, described in an upcoming article in *IEEE Transactions in Biomedical Engineering*—will banish that as well.

Their algorithm, an improvement on a technique developed in 2002, analyzes the CT scans and discriminates between the pixels that represent colon walls and those showing fluids and fecal matter. This allows doctors to remove the unwanted bits from the image of the colon the way a tourist would use Photoshop to erase strangers from vacation photos.

"Prepless virtual colonoscopy, meaning no laxatives or diet modification, is the holy grail that doctors have been looking for," says Andrew Milano, a clinical professor of gastroenterology who performs virtual colonoscopy at New York University but was not involved in the Stony Brook study. Research shows that only about half of people older than 50 in the United States get their recommended screening for colorectal cancer, primarily due to the invasive nature of the standard colonoscopy, Milano points out.

For electronic colon cleansing to work, each patient has to ingest three shot-glass-size servings of a barium solution that attaches to the stool, making it easily detectable by the CT scanner, and a shot of iodine to make the stool softer and more uniform. This uniformity is important, says Jerome Zhengrong Liang, a radiology professor at Stony Brook's medical school and a member of the team that developed the technique. The software separates the colon from everything else, based on the difference between its density and that of stool and fluid; these differences are indicated by variations in image intensity on the CT scan. Big variations in the stool's consistency might cause the software to mistake fecal matter for part of the colon wall.



FANTASTIC VOYAGE: Physicians can erase the colon's contents and perform a virtual fly-through of the organ. *PHOTO: ZHENGRONG LIANG*

Reliably setting the boundary of the colon wall, says Liang, was the team's greatest technical challenge. The software had to screen out artifacts introduced by the CT scan, in particular one known as the partial volume effect. This effect renders extra layers at the places where, say, air and stool meet. "The scanner generates values at these points, which might suggest that there's tissue there," says Liang. "That might make you think, because of the shape [a lump where the rest of the colon wall is smooth], that you're looking at a polyp when you're not."

But the new software does an even better job of seeing past the artifacts than technology Liang and his colleagues previously patented, reducing the number of false positives by 50 percent. In 2000 the group founded Viatronix, in Stony Brook, to develop an earlier version of prepless virtual colonoscopy. The university is now in talks with several large manufacturers of medical imagers about licensing the new version. —Willie D. Jones

update

LOOK OUT! Vehicle-to-vehicle communication could prevent accidents.
PHOTO: GENERAL MOTORS

Car Talk

Europe begins testing vehicle-to-vehicle and vehicle-to-infrastructure communications systems

UNDER PRESSURE to improve safety and reduce traffic congestion, fuel consumption, and carbon dioxide emissions, the European Union has spawned a batch of projects to give cars the ability to communicate wirelessly with the road and among themselves. The effort, similar to some in Japan and the United States, has reached a major milestone following a June EU ruling that set aside RF spectrum for vehicle-to-vehicle communication. Those developing car- and road-communications systems will begin testing their wares this fall ahead of large-scale road trials at six sites in Europe, which will begin in early 2009. Experts expect the technologies to begin commercial deployment as soon as 2011.

There's been no shortage of ideas. A car might share data with other vehicles over a distance of 20 to 200 meters, giving the driver enough time to intervene and avoid a crash or, if a crash is inevitable, to provide data that optimizes usage of air bags, motorized seat-belt pretensioners, and extendable bumpers. Or a vehicle could communicate directly with others and with roadside infrastructure, using a dynamic local map to help the driver quickly respond to warnings of congestion and make better decisions about his or her route. Now these and other concepts are being tested at the Lindholmen Science Park, in Göteborg, Sweden.

"In some respects, we're guessing what early winner applications and services could be," says Paul Kompfner, head of development at ERTICO-ITS Europe, a public-private partnership that includes major carmakers, IT vendors, and telecommunications service providers focused on developing and deploying intelligent transportation systems and services. "These are intended to be good examples of the spread of systems that could be deployed in the first wave."

One of them could be the Cooperative Vehicle-Infrastructure Systems (CVIS) project. Led by ERTICO, CVIS has been developing software and hardware for onboard and roadside units for use in 10 different applications, including monitoring speed and hazardous goods.

CVIS collaborates closely with the Safespot Integrated Project, another EU-funded initiative, which is focused largely on preventing accidents through intelligent car and road communications systems. Both projects aim to provide a proof of concept for all their tested systems in 2009.

In an important step toward getting these systems on the road, the European Commission agreed to an EU-wide frequency band, 5.9 gigahertz, and allocated 30 megahertz of spectrum for vehicle and roadside infrastructure communications. The frequency is to be used mostly but not exclusively for road safety applications, according to Kompfner.

Both CVIS and Safespot use the 5.9-GHz frequency and are based on IEEE 802.11p wireless technology, says CVIS project manager Peter Christ. The proposed standard is a flavor of Wi-Fi, specially designed for data exchange among moving vehicles and road infrastructure.

Though they'll use the same band, vehicle-to-vehicle and vehicle-to-infrastructure applications have different needs. "One of the big differences between the various applications being tested in both groups is Safespot's need for very low latency and short response times" because it must be able to prevent accidents, says Christ. And because for many of its applications CVIS requires more bandwidth than the 30 MHz allotted by the EU, ERTICO is proposing to use the 5.4-GHz band in addition, he says.

Several other research initiatives hope to contribute their work as well. The EU anticipates that by supporting multiple projects and allocating frequency, it will accelerate deployment of an EU-wide system. —JOHN BLAU

LUBE JOB: The Casimir effect makes MEMS get stuck.

IMAGES: SANDIA NATIONAL LABORATORIES

Unsticking MEMS

Exotic materials could combat the Casimir effect, a kind of quantum-mechanical stickiness

Researchers at Los Alamos National Laboratory, in New Mexico, think they may have the answer to a vexing problem called stiction, which causes ultrasmall components of microelectromechanical systems (MEMS) to stick together. This impediment to micromovement is caused by the Casimir effect (after the Dutch theoretical physicist Hendrik Casimir), an odd attractive force that influences only objects that are very close together. As MEMS components are shrunk to a scale of hundreds of nanometers or less, many engineers predict that the Casimir effect will become more of a problem.

"The Casimir force is the ultimate cause of friction in the nanoworld," says Ulf Leonhardt, a theoretical physicist at the University of St. Andrews, in Scotland. "Micro- or nanomachines could run smoother and with less or no friction at all if one can manipulate the Casimir force."

To understand the Casimir effect, recall that a vacuum only *seems* to be empty space but is actually full of virtual particles and their antiparticle equivalents, which flit into existence and then annihilate one another so fast that they cannot be detected. In 1948, Casimir theorized that these fleeting particles would draw two uncharged metal plates together if the plates were placed very close to each other.

Virtual photons exert pressure as they bounce off the plates. Only photons of a wavelength shorter than the separation between the plates can form there. But in the region surrounding the plates, many more photons with longer wavelengths will be formed as well. The net effect is that there are more photons bouncing off the outside of the plates than between them, and the excess pressure pushes the plates closer together. As the plates grow closer, this effect grows stronger, because even fewer photons are able to form.

Now Felipe da Rosa, Diego Dalvit, and Peter Milonni of the theoretical division of Los Alamos National Laboratory are saying that the Casimir effect, which is normally attractive between two surfaces, could actually be made repulsive—and thus reduce stiction—if those surfaces had a layer of metallic-based metamaterials. Metamaterials are specifically engineered to have properties that do not occur naturally, such as the ability to bend light the wrong way. The method proposed by the Los Alamos team for generating this repulsive effect has yet to be tested experimentally, but experts say it is promising.

The Los Alamos theory is based on an idea of Timothy H. Boyer's, professor of physics at the City University of New York, who theorized in a 1975 paper that magnetic materials with special properties would turn the Casimir force on its head. That's because the virtual photons would induce electromagnetic fields in the plates. With the right material between the plates or perhaps coating them, the induced fields would push the plates apart so strongly that they would overwhelm the pressure of virtual photons squeezing the plates together. Recently, Harvard University professor Federico Capasso and his graduate student Jeremy Munday showed that ethanol between two gold plates would produce some of that effect, reducing the Casimir attraction by 80 percent. But for actual repulsion, simple ethanol won't do.

"You need a strong magnetic material, with unique magnetic effects," explains Dalvit. "There's no hope with standard, naturally existing materials. But with the new metamaterials, we've found that you can have the famous Casimir repulsion."

Dalvit and his colleagues have performed detailed calculations on metamaterials and found that they should fight stiction. He says that experiments to prove it are already under way.

—Saswato R. Das

DEEP-SEA DIVER

This underwater robot, called *Sentry*, can dive up to 5000 meters below the surface and autonomously map the seafloor for 18 hours at a time. On its first voyages, in July and August, it mapped an area off the coast of the northwestern United States to scout ideal locations for underwater laboratories [see "Neptune Rising," *IEEE Spectrum*, November 2005].

PHOTO: UNIVERSITY OF WASHINGTON

"We could potentially put a bioactive silk film in every bag of spinach, and it could give the consumer a readout of whether or not *E. coli* bacteria were in the bag" —David Kaplan, professor of biomedical engineering at Tufts University, in Medford, Mass., on a new edible optical sensor

Home Fuel Cells to Sell in Japan

The outlook is iffy for cost reductions and consumer dividends

After a number of false starts in the United States and elsewhere, fuel cells scaled to home heating and electrical needs may be nearing a commercial debut—at least in Japan. During the last four years the Japanese government has spent more than US $100 million on a program to demonstrate such systems, supporting the work of five companies, including Toyota and Toshiba. Now Matsushita Electric plans to start mass production of the system it developed in the program, with an admittedly modest sales target of 1000 units in 2009. Two other participants, Ebara Corp. and Eneos Celltech, are also reportedly preparing for full-scale manufacturing and marketing in 2009.

Fuel cells are environmentally friendly electrochemical devices that combine hydrogen and oxygen to produce electricity, leaving heat and water as by-products. (Typically, they can generate hydrogen from natural gas, propane, or kerosene.) Each cell has two electrodes, separated by an electrolyte. Hydrogen gas reacts at the anode, releasing hydrogen ions and electrons. The ions pass through the electrolyte to the cathode, while the electrons, blocked by the electrolyte, flow to an external circuit after an inverter converts them to alternating current.

The companies participating in Japan's program from 2004 to 2008 all concentrated on proton-exchange membrane fuel cells, in which a polymer serves as electrolyte. The advantages are compactness and low operating temperature, but their reliance on a costly platinum catalyst is a disadvantage.

Matsushita bills the 1-kilowatt fuel cell it is commercializing as a cogeneration system to provide both heat and power, boasting that the system can generate electricity with a record-setting efficiency of 39 percent. In practice, however, the system is so small and produces so little power that initially it will be used primarily for water heating. Matsushita expects that in the usual household it would be operated once daily, to heat a 200-liter hot water tank. Nevertheless, scaled-up and improved versions may someday supplement the home's electricity significantly and even provide surplus energy that can be sold back to the grid.

HYDROGEN AT HOME: Matsushita will start selling home fuel cells in 2009. *PHOTO: KO SASAKI/THE NEW YORK TIMES/REDUX*

Matsushita has yet to set prices for its fuel cells, which are sold to power companies that then lease to consumers, but to judge from Japan's experience with the proton-exchange systems so far, they will be a pricey way to warm water. According to Atsushi Yamamoto, a deputy director with the Ministry of Economy, Trade and Industry (METI), distributors of the fuel cell systems were given a subsidy of roughly $55 000 for each unit installed in 2005, the first year of the project. The amount has subsequently decreased each year and is now about one-third that figure. "With commercialization beginning next year, we are entering a new phase, so how best to continue subsidizing is under discussion," says Yamamoto. "But it will be less than the current subsidy."

Even at the present level of subsidies, a Matsushita system might pay for itself only in 10 years or so. So for home sales of fuel cells to really take off, costs must come down rather sharply. The project's road map calls for a price tag of around $9000 by 2010 or 2011; Matsushita says it hopes to get its selling price to energy companies down to approximately $5500 by 2015.

So far, Japan's regional energy suppliers have installed just 3700 units for field testing in the METI program. By 2010 METI expects from 20 000 to 100 000 systems to be installed, but Yamamoto concedes that, due primarily to higher-than-expected costs, those targets are much lower than original predictions. He thinks that Kyocera may have a better chance of reducing costs in a solid-oxide fuel cell it's been developing, also with METI support, because that system does not use platinum.

—John Boyd

technically speaking

BY PAUL McFEDRIES

E-cycling E-waste

Recycling old words to reprocess old electronics

AUTOMAKERS have long given their best designers free rein to come up with "concept cars"—prototypes that highlight some new design or high-tech feature but aren't meant for the production line. Back in February, mobile-phone maker Nokia borrowed this idea and unveiled a **concept phone** called the Remade. The hook? It was made almost entirely of recycled materials, such as aluminum cans, plastic bottles, and even old car tires.

The Remade is an example of **upcycling**, a form of recycling that takes used or recycled materials and creates a new product with a quality or value higher than that of the original materials. Materials that are designed to be **upcycled** are called **technical nutrients**. Traditional recycling is sometimes described as **downcycling** because the quality of the material degrades with each life cycle. Recycled paper isn't as nice as newly printed paper; recycled steel isn't as strong as newly forged steel. (The in-between form—where the recycled material is basically the same as the original material—is called **closed-loop recycling**.)

Six billion humans generate an awful lot of **e-waste** (or for the hyphen-averse, **ewaste**) in the form of discarded computers, monitors, cellphones, and other electronic gewgaws. The process of recycling their components or metals is called **e-cycling** (or often **ecycling**), and it's been getting a lot of press lately—and generating a lot of new lingo. Indeed, **e-scrap** has the dubious honor of being the fastest growing segment of the garbage system.

The sheer quantity of all this **WEEE** (waste electrical and electronic equipment) is bad enough, but then there are all its toxic heavy metals, such as lead, cadmium, and mercury, which leach out, harming nearby ecosystems. That's why many municipalities around the world now mandate that old electronic appliances must be e-cycled. (According to *Discover* magazine, a new British law explicitly includes sex toys as an example of e-waste that must *not* be tossed out.)

NOKIA'S APTLY NAMED PHONE, the Remade, is an example of "upcycling"—it's made of aluminum cans and other recycled materials. PHOTO: NOKIA

It's no wonder we're starting to see lots of **reclaimers**, which are firms that process so-called **brown goods**—obsolete electronic products such as radios and televisions. Reclaimers divide brown goods into **historic scrap** (or **historic waste**), which refers to obsolete electronics manufactured by a company that's still in business, and **orphan scrap** (or **orphan waste**), obsolete items made by a firm that's gone out of business.

Reclaimers reclaim as much as they can, not only from computers and cellphones (which contain millions of dollars worth of copper, gold, silver, and other precious metals) but also an increasingly wide range of electronic goods, including VCRs, CD players, calculators, radios, stereos, CB radios, fax machines, and answering machines.

The reclaimers sell what they can to manufacturers who **upcycle** the materials into new goods. What's left requires **certified destruction**, in which an e-scrap item such as a computer is carefully and completely dismantled so that it poses no danger to the environment.

The hidden riches in cellphones and other electronic gear have been called **green gold** because they're realized only through e-cycling programs. Large companies handle most of this, but some individuals want a slice of the pie too. These **urban miners** prize discarded electronics but also scour cities for scrap metal. This **aboveground mining** is usually aboveboard, but some underhanded individuals have taken to cutting down bronze statues, tearing down iron fences, and even stealing manhole covers, committing a crime known as **materials theft**.

Consumers are getting hip to the recycling problems inherent in electronics and are starting to **precycle**, or choose gadgets based on how recyclable they are. Some manufacturers take responsibility for their products **cradle to cradle**, extending a product's life cycle to include recycling it into something new. If the manufacturer also handles these recycling duties, it's called an **extended producer**. Most such manufacturers also offer voluntary **take-back programs**, in which consumers can return **end-of-life** devices at no charge.

Of course, you could also follow the lead of a nut-orchard owner in Australia, who wanted to attract birds that would eat pests. His solution? Convert the shells of old Macintosh computers into birdhouses! ❑

hands on

The Innovators Club

Interest in TechShop's neighborhood workshops is growing

You don't need your own exercise equipment to get fit, so why do you need your own machine tools to build something cool?

Such thinking led Jim Newton to found the first TechShop, a high-tech workshop open to anyone who pays a modest membership fee. Think of it as a health club for geeks. Instead of treadmills and elliptical trainers, you'll find laser and plasma cutters, milling machines and lathes, oscilloscopes and frequency generators. What's more, you'll run into like-minded folk who can give you tips on everything from tungsten inert-gas welding to computer-aided design, either through organized classes or informal coaching.

That first TechShop opened its doors in Menlo Park, Calif., in October 2006. Now it's branching out. Two new facilities, one in Durham, N.C., and another in Portland, Ore., are opening soon, and more are in the planning stages [see sidebar, "A New Crop of Shops"].

Newton, who used to be the science advisor to the popular television program "Mythbusters," created TechShop to have such a workspace at his disposal for building what he describes as his own "crazy inventions." At the start, it wasn't clear to him how to support such a facility other than by doing lots of dreary job-shop work. Then Newton conceived of making it a community-supported resource. But that model came with its own shortcomings. Wouldn't klutzy people maim themselves and then sue the business into bankruptcy? Wouldn't insurers refuse to provide coverage for that very reason?

As it turned out, Newton got his liability insurance. One reason was the emphasis he has put on safety instruction. His latest system for allowing only trained members to use the more dangerous pieces of equipment is a very sweet hack, appropriate to the whole TechShop philosophy. Each tool has a pair of safety lights, one of which shines red unless the member using it (identified by an RFID badge) has been instructed on the safety and basic operation of the tool, in which case a database is updated and the other light shines green. "If we catch you using that machine with the red light on," Newton says, "you're gone—you're out." But the badge system has proved to be almost unneeded for safety, because of a basic human quality: "People," he says, "have a very strong sense of self-preservation."

Even if ensuring safety isn't a problem, doesn't a shared shop necessarily suffer the tragedy of the commons? Don't people abuse the tools or even walk off with ones that aren't bolted down? Newton says you have to expect that things like end-mill cutters will get dulled but that those members wanting sharper tooling are free to bring their own. And he has found that stuff hasn't been lost to theft—just the reverse, in fact. "We actually have the opposite problem," he says. Because of spontaneous donations, the number of tools on the shelves has grown with time.

The number of participants is growing too.

SPARKS FLY—literally and figuratively—at TechShop, a community workshop in Menlo Park, Calif., founded by Jim Newton [foreground].
PHOTO: TIMOTHY ARCHIBALD

A NEW CROP OF SHOPS

The Durham, N.C., TechShop is slated to open in December, spearheaded by Scott Saxon in partnership with Jim Newton. Saxon had just returned from a year of piloting autonomous aerial vehicles in Afghanistan—a skill he picked up flying radio-controlled model airplanes—when a chance meeting with Newton sparked the idea of duplicating the Silicon Valley experiment in Saxon's hometown. A similar encounter with Newton motivated Denney Cole, a former Intel employee who now works part-time for the Portland Group, to launch a TechShop in his part of the Pacific Northwest.

The Durham site boasts almost twice the square footage of the Menlo Park TechShop and will be outfitted with mostly brand-new equipment. (Much of the gear in Menlo Park was donated or bought used.) Other TechShops are in preliminary planning stages in Los Angeles, Sacramento, San Diego, San Francisco, and Sunnyvale, Calif., and in Seattle, Austin, Texas, and Orlando, Fla.

Saxon hopes to open several locations before he's through. He believes that any place with 100 000 people within a half-hour's drive can support such a community workshop. If he's correct, TechShop franchises may be springing up in many other cities as well. Move over, Dunkin' Donuts—geeks want a better place to hang at night. —*D.S.*

There are currently some 400 individual members, the more ardent of whom have to be thrown out when the shop closes down at midnight. Once membership reaches its planned limit of 500, Newton will keep it open 24/7. "You can live here if you want," he says, jokingly.

TechShop also boasts a few dozen corporate members. Some are small companies that need access to equipment they can't afford. But they also include such California heavyweights as NASA's Ames Research Center in San Jose, PDI DreamWorks in Redwood City, and Frog Design in Palo Alto, an industrial-design consultancy well known for its work on some of the early Apple and Sun computers. That such enterprises have signed on to TechShop, when they surely have access to other machine shops, shows that its real value lies in the rich community it offers.

That community raises a potential problem, though: inventors may see a risk in doing prototype work at TechShop—having their ideas stolen. And even if nothing scurrilous takes place, using TechShop could conceivably compromise an inventor's ability to obtain a patent.

Newton is sensitive to these worries and plans to incorporate a blanket nondisclosure agreement into the membership documents. That way, no one demonstrating a cool new gizmo to other TechShoppers could be viewed as putting the invention to public use.

TechShop indeed caters to budding entrepreneurs. It hosts "inventors-alliance meetings" and, Newton hopes, may eventually be able to offer them seed money to get their businesses launched. "As a frustrated inventor," Newton says, "I know I would like to see that." —David Schneider

careers

mini-profile

HIGH-TECH HAUNTING

If your lab is haunted, you can call an engineer instead of a psychic. Even celebrity medium James Van Praagh seems to think so. Though he claims also to be "clairsentient," able to intuit messages from "the beyond," Van Praagh says that even those not so gifted can sense spiritual entities with the help of a little technology. His new best seller, *Ghosts Among Us: Uncovering the Truth About the Other Side* (HarperCollins, 2008), offers a list of electromagnetic field readers, Geiger counters, digital video and audio recorders, thermometers, infrared thermal scanners, and audio amplifiers. "These devices," he says, "pick up temperature drops and spikes in electromagnetic charges that often signify the presence of ghosts." Talk about spectral efficiency!

—Susan Karlin

Generation GPS

Sam Altman wanted to track his friends 24/7. Now he's making a business of it

A SUTURE KIT became a permanent fixture in the Altman household around the time Sam's mom, a doctor, came home to find her son surrounded by the parts of what was once the family TV.

"She was pretty good-natured about that," he says. "I was one of those losers who hung out in the basement building things. I'd be ripping out circuit boards, and in the process I would cut or shock myself. She stitched me up on the kitchen table more than once."

Years later, those battle scars are paying dividends. At the ripe old age of 23—and on sanctioned leave from Stanford University—Sam Altman and Nick Sivo, his best friend from freshman computer class, also 23, are the creators of Loopt, software for cellphones that figures out where users are and displays photos of their friends moving around on a map.

Verizon Communications and Sprint Nextel are already clients. Loopt charges users $3 to $4 a month for the service and is considering selling local ads. It is also integrating the service with Facebook and other social networking sites.

Needless to say, software that tracks people 24 hours a day draws its share of controversy, even though the service applies only to networks of friends who also buy it, is closed to children under 14, and reminds new users that they are being tracked.

"The tracking gets a knee-jerk reaction," says Altman. "A year into the company, we had to hire a chief privacy officer." Loopt has added privacy features, such as letting users temporarily block the tracking of their movements or even enter fake locations.

Altman has a passion for GPS technology. In 2004, he spent the summer after his freshman year in a research project that built the first autonomous navigation system for helicopters—"like an autopilot, but one that can dodge buildings," he says.

Back in school that fall, Altman had an epiphany when he noticed his fellow students constantly on their cellphones. The moment class ended, he says, they were calling their friends. "People were relying on their cellphones more and more. It got me thinking about how powerful location-based advertising could be."

The following summer, with US $6000 in funding from Y Combinator, a venture capital firm that helps launch young engineers with great ideas but no business savvy, he and Sivo put together a prototype that could pinpoint the position of any participant's cellphone and display the information on every other participant's cellphone. If the phone doesn't have GPS built in, the service analyzes the exchange of signals between the phone and cell towers to locate a user. Altman committed himself full-time. "I went to the first two weeks of classes and my head wasn't in it," he says. "I thought, 'This could be a huge deal if I do it right.' "

Armed with parental blessings and strategic guidance from Stanford's computer science department and the Business Association of Stanford Entrepreneurial Students, which helps students commercialize technological ideas, he and Sivo took leaves of absence and set about badgering venture capitalists.

They raised $5 million and signed deals with BlackBerry, Verizon, Sprint, and its youth brand, Boost Mobile. They are talking to other carriers, both foreign and domestic.

So far the technology has come more easily than the corporate mentality. "My age helps because I am in the target demographic," says Altman. "I'm basically building a service for me and my friends. But when I go meet with a senior person at a carrier, I get comments about my age. One of my first hires was someone in his 40s that could talk to the grown-ups."

At some point, Altman needs to return to Stanford for his degree. "I'm hoping the company can count toward my senior project."

—SUSAN KARLIN

LEFT: MARK HOOPER/GETTY IMAGES; RIGHT: ROBYN TWOMEY/CONTOUR BY GETTY IMAGES

Humor Dos and Don'ts

Optimist: The glass is half full.
Pessimist: The glass is half empty.
Engineer: The glass needs to be redesigned.

I'VE TOLD THAT JOKE at parties many times and have always gotten a laugh. Tell it to a group of senior engineers who have heard it a hundred times, though, and you'll get a polite, stony silence at best. Your ability to use humor can play a positive role in your career, but judgment is called for. Here are a few dos and don'ts.

Back in 1997, I met baseball legend Henry "Hank" Aaron. He had arrived early for a meeting at my office. We were alone, and he seemed uncomfortable. Sensing this, I had the New York brashness to tease him about the recent World Series in which the Yankees beat his former team, the Braves. We had a good laugh. *Use humor to break the ice.*

In those days, one of my co-workers regularly fell asleep in the afternoon while reading. One day our supervisor beckoned us to Andy's cubicle, where he gently placed a note on his reading material that said, "We're all watching you!" Andy woke up, saw the note, and looked around sheepishly. We were in hysterics. A bonding experience! *Playful stunts can lighten the mood, so long as they don't offend.*

The safer strategy is to tell jokes about yourself and your own foibles. For example, in person, I can implicitly refer to my own appearance. I'm 5 feet 5 inches [1.65 meters] tall and bald. So when others complain they're having "a bad hair day," I say, "Every day is a bad hair day for me." If a program is running late and the moderator asks me to be short, I say, "I'm always short." *Develop your sense of self-deprecating humor.*

Those jokes rely on my physical presence, where people can also see me smile. Humor frequently doesn't convey itself in e-mail. The slightest sarcasm can come across as mean. Using emoticons, such as a ☺ or a "wink" ;-), can help. *Ensure your messages are taken in the spirit you intended.*

Even a joke that is guaranteed to be funny can get you a bad workplace reputation with people who might be put off by these trivial spamlike messages. *Don't mindlessly forward e-mail jokes at work.*

On the other hand, you can send free e-cards for many situations, such as thank-yous, congratulations, and other sentiments. They can be a refreshing change. Just make sure they're appropriate for a business communication. There's more to humor than telling jokes. *Find ways to add a lighter touch to all your communications.*

PHILLIP TOLEDANO/GETTY IMAGES

Rarely are we engineers called upon to entertain, but we often make presentations where humor can hold the audience's interest and reinforce our points. I was on the engineering panel at a middle school career day recently, and while I didn't tell any actual jokes, the principal later thanked me for "being so funny." For example, when I had the students calculate the minimum required "red time" interval at a street intersection, I pretended to be a slow-moving older pedestrian crossing the street. My overacted role-playing was effective and lighthearted. *Integrate humor into your talks.*

You've probably seen cartoons in presentations where the caption is too small to be read, or you just don't get the point of it. On the other hand, popular comic strips like *Dilbert* and *Peanuts* can be useful. I've used a *Peanuts* cartoon to illustrate stress: the first three panels show Charlie Brown lying wide awake all through the night; the last panel shows him standing on the pitcher's mound, thinking, "Before a big game, there shouldn't have to be a night before." *Humorous slides must relate to the content. Cartoons must be clear.*

There's a diverse audience out there, and different people find different things funny, or even offensive, so be careful and err on the side of caution. Hank Aaron and I come from disparate worlds—enough so that insulting his team was a bit risky. *Be careful of cultural differences.*

Humor can be an important facet of your work—and personal—life. Use it wisely. —CARL SELINGER

books

BRINGING POWER TO THE PEOPLE

A new book rescues the lost history of electrical engineering

On 20 August 1842 an explosion on the Potomac River pulverized an old clam boat and sent its "millions of fragments 500 feet into the air," in full view of U.S. President John Tyler and 8000 other spectators. The explosion was triggered by remote control, when Samuel Colt, the famous revolver maker, threw an electric switch some 8 kilometers downstream. A clearly awed Congress later gave Colt US $15 000 to pursue his research into what he called "submarine batteries"—today's mines and torpedoes.

A new book by technology historian Michael Brian Schiffer vividly recounts this and other little-known tales of the pioneers who first tamed "galvanism" and mastered magnetism. These early innovators contended with such hidebound experts as pioneering scientist and founding Smithsonian director Joseph Henry, who, despite his discovery of inductance, impeded the practical application of this still-pure electrical science. Back stories, like the first sketches for a 1753 telegraph and a faxlike machine from 1853, emerge like long-neglected ghosts.

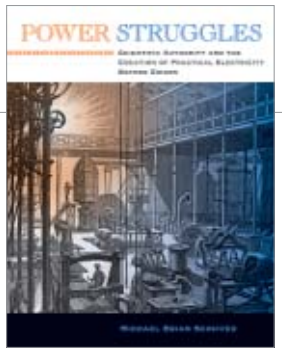
Coaxing these tales out of *Power Struggles: Scientific Authority and the Creation of Practical Electricity Before Edison*, however, requires some patience. Schiffer—who is, of all things, an anthropology professor at the University of Arizona at Tucson—meticulously researched his book, packing it with 1100 endnotes.

A preface confesses the author's childhood determination to become an electrical engineer, and one senses in him a childlike wonderment, as if these ancient inventions were the world's newest marvels. Gadget geeks will appreciate this gear-centric focus, a steampunk Consumer Electronics Show in book form.

However, scholarship comes first here, storytelling second. The narrative, such as it is, moves back and forth in time telegraphically. For instance, a scrappy kid named Charles Brush is, four paragraphs later, an industrial tycoon whose electrical arc lights have illuminated two continents and proudly crowned the new Statue of Liberty.

Now that Schiffer has compellingly mapped the neglected half century before Edison commercialized electricity, here's hoping that someone will take these materials and concentrate on a single unifying thread or, better yet, threads, weaving them into one historical strand. Every journey—even that of a transatlantic telegraph message—must have a beginning, a middle, and an end.

—Mark Anderson



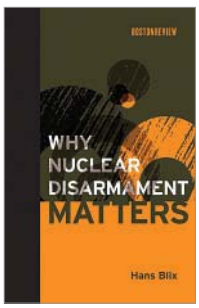
POWER STRUGGLES: SCIENTIFIC AUTHORITY AND THE CREATION OF PRACTICAL ELECTRICITY BEFORE EDISON
By Michael Brian Schiffer; MIT Press, 2008; 440 pp.; US $38
ISBN: 978-0-262-19582-9

A DISARMING ARGUMENT

Hans Blix wants the United States to restart nuclear disarmament talks

If you admire efforts by Henry Kissinger to revive nuclear disarmament negotiations, and yet you also respected Hans Blix for standing up to President George W. Bush in the run-up to the second Iraq war, then this little book about nuclear disarmament is for you. *Why Nuclear Disarmament Matters* is the latest—and one of the best—in an uneven but ambitious series of short and accessible introductions to various weighty subjects, from global poverty to capital punishment.

"Since World War II there has been a tremendous consolidation and expansion of international law," Blix observes. "Customary law has been codified [at the global level]." He lists trade, finance, communications, space, nuclear energy, and human rights as areas newly subject to such codification.



WHY NUCLEAR DISARMAMENT MATTERS
By Hans Blix; Boston Review/MIT Press, 2008; 112 pp.; US $14.95;
ISBN: 978-0-262-02644-4

It's Blix's belief that the continued consolidation of law—most significantly, nuclear disarmament treaty law—is the best way of heading off catastrophic violence. (Blix did concede, however, in a talk he gave earlier this year in New York, that some problems will remain intractable and make the use of force unavoidable. He mentioned a new international doctrine that's been gaining ground—the "responsibility to protect." Perhaps in time that principle will be enshrined in our international code of conduct alongside the duty to answer aggression, so that there is a comprehensive standard for legitimate military action.)

Though Blix may minimize as inconveniences problems like Islamic extremism and ethnic hatred, there is no more eloquent or informed spokesperson for the view that talking with adversaries and enemies is essential. There are obvious dangers in that attitude, which is why policy toward Iran and Russia are major issues in the U.S. presidential contest. Do the merits of talking outweigh the dangers? In this concise book, Blix makes the case that they do.

—William Sweet

A Less Well-Oiled War Machine

The high cost of petroleum is forcing the U.S. military to turn to solar, geothermal, and wind energy *By Sandra Upson*

IN THE MIDDLE OF THE MOJAVE DESERT, a nondescript two-story building behind a gated fence houses an unlikely group of geologists. Their lineage is strong: several generations of prospectors have been drawn to dig in this dry corner. Within 100 kilometers of the geologists' base near China Lake, Calif., 19th-century gold diggers stumbled on riches, and later oilmen got lucky in the same inhospitable soil. Now these earth-minded fellows have grand ambitions of their own. Their aim is to turn the U.S. Department of Defense into one of the world's largest users of geothermal energy.

Their vision isn't all a pipe dream. The rising cost of fuel has the Pentagon pressuring the four branches of the armed services to cut their energy bills wherever they can. It's easy to see why—every US $10 increase in the price of a barrel of oil costs the Air Force, for example, an extra $600 million. The Army, Navy, and Marines, too, are tearing through their budgets. In response, energy managers at bases across the country are reevaluating how they light, insulate, heat, and cool their buildings. The most ambitious of these managers have begun aggressively adopting renewable-energy technologies. Together they have emerged as a distributed network of clean-energy advocates. The irony, of course, is that these military men and women should form such a group at the heart of one of the most energy-intensive operations on the planet.

Among them are these desert geologists. Employed by the Navy, they are responsible for one of the largest geothermal power plants in the United States, a 270-megawatt generation facility at Coso Hot Springs, at China Lake. In the next few years, these scientists hope to figure prominently in a Department of Defense plan to generate 25 percent of its electricity from renewable sources by 2025.

For an organization that spent $13 billion on energy in 2007 and has a War on Terror to finance, whittling away at domestic electricity bills, which account for only one-fourth of that

FERTILE LAND: The U.S. military is using some of its vast quantities of land to generate power, as it did for this 270-megawatt geothermal power plant [left] and a 14-megawatt photovoltaic array [previous pages and above], both located in the Mojave Desert.

PHOTOS: LEFT, USN-GPO, CHINA LAKE, CALIF.; PREVIOUS PAGES AND RIGHT, MMA RENEWABLE VENTURES

figure, may seem like a silly exercise. The scale of the projects and the savings, though, prove that the military is not merely indulging in a public-relations ploy. Not counting the geothermal power plant, the Defense Department says that in fiscal year 2007 it had produced or bought enough renewable energy to cover 11.9 percent of its electricity needs, which amounts to about 1.3 trillion kilojoules a year.

"There's been a shift in the last five years, where more people are actively trying to do the right thing inside the agencies, and I don't believe it's simply because of high energy costs," says John Archibald, a former deputy director of the U.S. Department of Energy's Federal Energy Management Program. "Many are aware of the global-warming issue, and quite a few have signed on that this is something we need to address." Until recently, military planning and environmental stewardship rarely overlapped, except when it came to cleaning up toxic-waste sites and managing "the bugs and bunnies," as some government officials refer to habitat-conservation projects on federal land.

That attitude has begun to change. Many defense staffers cite specific legislation—the Energy Policy Act of 2005, which set clean-energy milestones for the federal government, and the Energy Independence and Security Act of 2007, which adopted the 2025 benchmark as a goal for the whole country. But the language surrounding the goal is weak and provides no direction. To Thomas Morehouse, a consultant for the Institute for Defense Analyses, a think tank in Alexandria, Va., the energy legislation alone doesn't explain the DOD's greenish inclinations. "There is no energy policy. There is no coordinated Defense Department program for renewable-energy deployment and no single office in the Pentagon that tracks it," he says. "The projects so far happened largely because you get a particular base commander somewhere who's enthusiastic about doing this and puts in the effort to make it happen."

Indeed, bolstered by edicts from the upper echelons of government, energy managers at individual bases have begun to act on a conviction that climate change and a constricted energy supply could make for an ugly future. What has emerged is a patchwork of energy-sustainability projects. Some of them have been record setting, others are barely noticeable, but together they attest to a growing concern about the DOD's annual consumption of some 912 terajoules, almost 1 percent of U.S. energy use.

As Don Juhasz, chief of energy and utilities for the U.S. Army, puts it, "There are enough of us deep within the DOD who see that, long term, if we're going to be here 50 years from now, we need to be leaders and drive the country towards the future we want. We need to set the example."

The Naval Air Weapons Station, in China Lake, Calif., sits on a hilly plot of arid land about 240 km east of Los Angeles. The California wildfires recently smoldered down from the mountains to the west, but a sudden downpour this past July briefly painted the Joshua trees and ankle-high brush a perky green. From the Geothermal Program Office, manager Andrew Sabin dispatches his crew to check out promising geothermal spots across the Southwest. This summer, they were investigating California's Chocolate Mountains, where the Navy and Marines test aerial weapons. "It's probably one of the hottest spots on Earth, literally and figuratively," Sabin says. In theory, this region could produce more than 600 MW, an enormous figure given that the total geothermal electric power generation in the United States today adds up to about 3000 MW, according to the Geothermal Energy Association.

Simply put, a geothermal power plant generates electricity through wells that can reach thousands of meters into the Earth. The wells bring heat to the surface by drawing hot water or steam from high-temperature cracks in the Earth with fluid flowing through them. That water or steam then drives turbine generators. Finding the best spots to drill those deep wells, however, can be tricky and expensive.

SUNNY OUTLOOK: The U.S. Navy's geothermal program, run by Andrew Sabin, is on the verge of developing a new power plant.

PHOTO: FRED PROUSER/REUTERS

Initially, geologists exploring a site look for the most obvious beacons, such as the bubbling mud puddles and fumaroles that send up clouds of steam in the hillside around the Navy's China Lake base. Even a quick scan through Google Earth images can reveal some promising linear features that could turn out to be faults. Once a site is chosen, the geologists analyze the rocks, inspect soil densities, and study the chemical characteristics of subsurface water. This past summer, they were gathering data on variations in the area's magnetic and gravitational fields. The flow of liquid along a fault over time can alter the mineral makeup of the rocks, changing the local magnetic field. An unexpected magnetometer reading suggests the presence of a flowing fluid in the rock, and therefore also points to a well-defined fault.

But none of those data are enough to positively identify a geothermal hot spot. "Until we drill a hole in the ground, I know as much about this rock as you do," says Steven Bjornstad, the senior geologist on staff at the Geothermal Program Office, adding, "Some day I hope I can stop saying that." After decades of research on ways to rely less on drilling, the office has just begun experimenting with lidar imagery, which should add more certainty to the site selections. The office has commissioned an aircraft to fly over a long north-south valley west of the Chocolate Mountains to generate maps from a laser scanner that sends trillions of photons down to Earth and measures the length of time before they are reflected back. "We know there's high heat flow and fluid, and now we're looking for active faults," Sabin explains. "Any structures would be very, very subtle, but we're hoping that with lidar they'll jump right out at us." Coupled with a digital model of the area's elevation, certain lidar patterns can seem, to the trained eye, distinctly like a fault.

Though lidar has been around for some time, only recently has the image resolution—and interest—been high enough to make it worth pursuing. "Ten years ago when we went knocking on doors, we got no response. Now when we come calling, the base commanders are interested and we can have a conversation," Sabin says. But geothermal development always starts small; the inscrutability of this deep-seated resource tends to make developers shy. A contractor has agreed to install a 30-MW power plant at Naval Air Station Fallon, in Nevada, even though the production capacity of the field could be as much as 160 MW. The leadership at another Nevada base, Hawthorne Army Depot, has also welcomed exploration on its base.

Sabin, Bjornstad, and their crew of eight others are arguably the most organized and well-funded entity promoting geothermal development within the United States. Their office's operation is underwritten entirely by what the Navy earns from its agreement with the power plant's operators—about $14.7 million a year. A third of that goes to the geothermal office, and the rest pays for energy projects within the Navy that might otherwise struggle for support.

One of those projects is a set of studies assessing the feasibility of wind turbines. At Naval Air Station Corpus Christi, in Texas, anemometers 30 meters up in the air measure daily wind speeds around the base. "This bay is the windsurfing capital of the world—it's always windy. But even knowing that, there can still be risk for an energy-services contractor to put up a turbine," says Chris Tindal, the deputy director of the Navy's Shore Energy Program. "But if we've already collected the wind data, it'll lower their risk and lower the price, and that's the big key for us."

If the Navy follows through, these commercial-scale wind turbines will be its first in the continental United States. Up to now, the Navy has used them only at offshore locations like San Clemente Island, a naval base 126 km west of San Diego, and Guantánamo Bay, Cuba, where four 950-kilowatt wind turbines have been spinning since 2005. Because Cuba provides no electricity to the base, a 3.8-MW hybrid wind and diesel-generator plant saves the service $1.2 million a year in the form of fuel that no longer needs to be transported to the island.

Back in the Mojave desert, far from Guantánamo, a different renewable-energy project demonstrates the surprising economics that can come into play. A 14-MW photovoltaic array—the largest in the Americas—has been generating electricity for almost a year. To a pilot's eye, the rows of black rectangles form dotted lines on the rocky beige landscape on which Nellis Air Force Base sprawls, about 15 km northeast of the Las Vegas strip.

Every few minutes, hundreds of half-horsepower motors purr as the 72 416 panels tilt a few centimeters to the west. Balanced on stout little concrete feet, 56 hectares (140 acres) of panels follow the sun like worshipful robots. But as dusk

approaches, the solar panels change their course: they start to tilt backward, to the east, their black faces leaning away from the sun. The engineers on the project, from SunPower Corp., based in San Jose, Calif., found that if the panels turn westward as dusk approaches, the shadows cast by some panels onto others lead to a greater loss of efficiency than if the solar cells soaked up rays while lying more or less flat, at an oblique angle to the descending sun.

Dictating those finely plotted movements are computer-controlled trackers designed by SunPower (which also manufactured some of the solar cells, along with Evergreen Solar, Sanyo, and Suntech Power). The panels, fixed at a 20-degree southward tilt, rotate from east to west in response to the trackers' cues. Each string of a few dozen solar pods has its own motor and a controller. The controller feeds data to an inverter, which is remotely monitored in the system's control room. On a hillier section of the installation, the strings are programmed to move along paths that take the terrain into account. "It's a funny sight when something does go wrong, because one row will point in a completely different direction from everything else around it," says Michelle Price, Nellis's energy manager.

To check on the system's performance, weather stations throughout the site record air temperatures, wind speeds, and solar radiation. A monitoring algorithm uses those environmental measurements to calculate how much electricity the system should be generating at any given time. "It was the first time we installed this tracker in the United States and the first time that we did a tilted tracker," says Julie Blunden, SunPower's vice president for public policy and corporate communications. The tilting and tracking, Blunden says, allow the field to generate 30 percent more energy than if the panels were fixed in place.

But the cost of all those trackers, inverters, cells, and concrete pedestals adds up—to more than $100 million, in this case—and breaking even on such a system could take half a century. That's where Nevada's renewable-energy laws come into play, in particular the one that requires the state's utilities to increase the amount of electricity generated from renewable sources by 3 percent every two years. That legislation created a big incentive for Nevada Power, the local utility, to see that the Nellis solar field came into existence.

121 000 km²

LAND OWNED BY THE DOD, ABOUT EQUAL IN SIZE TO NORTH KOREA

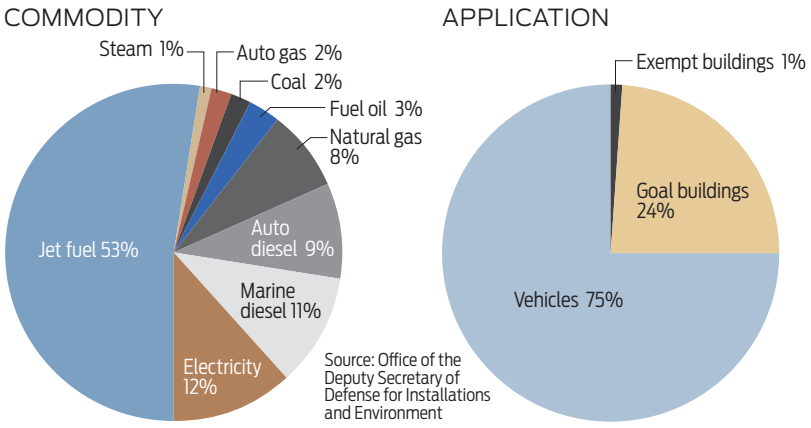
The project started with a voice-mail pitch left on Steve Dumont's phone by a solar-energy developer, in 2004. Dumont, the energy program manager for Air Combat Command, initially ignored the proposal. But then, he says, "I did a back-of-the-envelope calculation, and pretty quickly I saw that this could work." From there, it was a matter of convincing others in the Air Force to submit a proposal for the project to Nevada Power. "It took two years of telling people that it was a great idea, that we think the economics are there, and that we might even be able to get a good deal out of it," Dumont says.

Nellis's energy staff moved ahead. First, they combed through project proposals that they'd solicited and then zeroed in on the SunPower system. The base agreed to lease out the land for the project at a nominal fee. A financing company, MMA Renewable Ventures, was brought in to pay the up-front costs; it now owns the equipment and sells the power to the base. MMA then sold the renewable-energy certificates it acquired for the installation—each certificate usually represents the "green attributes" of 1 megawatt-hour—to Nevada Power. As a result, only the utility can claim credit for the solar energy that, technically, MMA provides and Nellis consumes.

The outcome of these business negotiations was more dramatic than anyone at Nellis had expected. The base agreed to pay 2.2 cents per kilowatt-hour, down from about 7 cents, which is what it had originally paid, for the next 20 years. "I've received hundreds of phone calls from people asking me about 'the Nellis model,' " says Price, the energy manager. The conditions may be hard to duplicate, but that won't stop people from trying—Price has hosted visits from mayors, senators, and even representatives of the Walt Disney Co. David Felix, a senior manager at MMA, predicts a second wave of solar projects on military lands in the near future. "You can see the other requests for proposals that have been issued since. Davis-Monthan, Fallon, Edwards, and many others have expressed interest in following suit," notes Felix, ticking off the bases that could become future clients.

Dumont also expects to develop more solar energy projects, starting with Davis-Monthan Air Force Base, in Arizona. "The more we put these big ones in, the more we help the industry to reach its prime."

WHERE IT ALL GOES: Of the US $13 billion the military spent on energy in fiscal year 2007, more than half went to jet fuel, which is used by aircraft, some battle tanks, and the occasional generator. The DOD's 577 000 buildings account for one-fourth of its energy use.



One man closely watching the Nellis saga unfold is Chris Archer, the deputy base civil engineer at McGuire Air Force Base, in New Jersey. On a recent summer morning, Archer surveyed his turf with a keen eye for flat roofs and unobstructed empty fields. Every few minutes, a C-17 cargo aircraft took off on a delivery run and another came in for landing at the base's active airfield. "They've cracked the code on how to do big solar, and that makes it easier for us," Archer says of the Nellis installation. *Continued on page 50*


Google

FRESH PHISH

How a recently discovered flaw in the Internet's Domain Name System makes it easy for scammers to lure you to fake Web sites By David Schneider

WHEN YOU DIRECT your browser to www.google.com, you take it for granted that the Web page that appears will indeed come from Google and not from some shadowy Internet scammer pretending to be Google. But your faith is misplaced. It turns out to be easy for a malicious computer hacker to trick your browser into steering you anywhere he wants and then to pilfer sensitive information, like your user name, password, and credit card number.

Dan Kaminsky, of the Seattle-based computer-security firm IOActive, stumbled onto the problem in February while examining the functioning of the Domain Name System, or DNS, the database that computers use to find their way around the Internet. At the time, it was still just a theoretical vulnerability; he had not actually observed anyone taking advantage of it. But he knew that clever criminals would eventually uncover the flaw, at which point all kinds of damage could be done. "I realized the scope of this pretty quickly," he recalls.

He then alerted other security experts and the makers of network equipment and worked with them behind the scenes to get software patches written. The various vendors released their new code in a coordinated move on 8 July. At that point the existence of the threat became common knowledge, at least among computer types, but the details of how the flaw could be exploited were still shrouded in mystery. To give network administrators time to install the new software, Kaminsky had planned to wait 30 days before publicly describing the vulnerability. But things soon spiraled out of his control.

By looking at the patch, others guessed what Kaminsky had found, and soon some had posted their ideas on the Internet. The cat slipped fully out of the bag when a blogger at the computer-security firm Matasano Security confirmed some of these speculations. The blog post was taken down quickly, but not quickly enough to prevent it from being copied and widely disseminated.

Within days, code to exploit the newfound weakness in the DNS had been posted on the Web site of the "computer

VIKTOR KOEN

academic underground" (http://www.caughq.org)—precisely the kind of thing Kaminsky had hoped to forestall.

Whereas some network administrators may initially have been reluctant to patch their systems, fearing that the upgrade itself might cause problems, most of them now seem to have made the change. No definitive tally is available, but Kaminsky has created a tool on his personal Web site (http://www.doxpara.com) that allows visitors to check whether the server they are using has been patched. He reports that as of 9 July, about 85 percent of the name servers being tested were vulnerable. But by 6 August, the proportion had dropped to 30 percent.

But even those who have taken the appropriate steps are not exactly breathing easy. The patch is not a perfect countermeasure, as Kaminsky has emphasized on his blog: "This is just a stopgap—we're still in trouble with DNS, just less."

If you follow computing at all, you know that security experts routinely uncover software glitches and vulnerabilities and then issue software patches and upgrades. What Kaminsky has found, however, is much bigger and much scarier.

To understand why, you need to know the basics of how the DNS works. The Domain Name System is essentially the Internet's phone book. It's a huge database containing the 32-bit numeric codes that identify every single site on the Internet. These are known as Internet Protocol addresses, or IP addresses for short. Amazingly, this database is distributed over some 12 million computers worldwide, known as DNS name servers.

When you type "www.google.com" into your browser, it must translate that human-readable text into an IP address before it can access the site. To do so, your computer sends a request to a name server upstream, probably one maintained by your Internet service provider.

Then, if your ISP's name server has the IP address for the requested site stored—or "cached"—it returns this information to your computer pronto. If not, it goes through what may be an elaborate process querying other name servers to find the address.

Kaminsky has discovered a way for a hacker to insert a false IP address into the cache of a name server. The hacker could, for example, change the name server's entry for "www.paypal.com," thus blocking access to PayPal, or worse, duping people into going to a site that mimics PayPal's. From there, it would be relatively simple to harvest user names, passwords, and other valuable data.

Such an attack would work much like the many "phishing" scams now plaguing the Internet, but in this case the victims wouldn't need to click on a link in a shady e-mail message. They could type the correct name, "www.paypal.com," directly into a browser and still get sent to the wrong place. (The real PayPal would upgrade the security of the connection from http to https, but the victim may easily fail to notice when this doesn't happen on the scammer's simulated site.)

The attacker could also use this tactic to redirect e-mail. By replacing the IP address of, say, a corporate mail server with the IP address of a mail server that he controlled, he could inspect incoming correspondence before passing it on to the targeted company's mail server. Even more troubling, he could add his own malicious code to e-mail attachments, which from the recipient's point of view might appear to come from known and trusted sources.

Security experts had long been aware of two general ways that a hacker could carry out such a "cache poisoning" attack on a name server. But both had been rendered ineffective years ago with changes to DNS software. Kaminsky, however, has found a way for a hacker to circumvent these fixes—and to combine the two exploits in a way that makes an attack especially potent.

The first kind of attack causes the targeted name server to query a second name server, one that the bad guy controls. That turns out to be incredibly easy to do, even if the name server to be poisoned is behind a corporate firewall or otherwise protected from outside access.

Suppose this hypothetical villain creates a Web page that contains a description of Mother Teresa—perhaps an eBay ad for a copy of her definitive biography. Unbeknownst to you, the page includes an embedded image that is hosted on a machine in the hacker's evil domain, BadGuysAreUs.com. So when you access that eBay page seeking to purchase a book about Mother Teresa, your browser sends out a DNS query to look up the IP address of BadGuysAreUs.com.

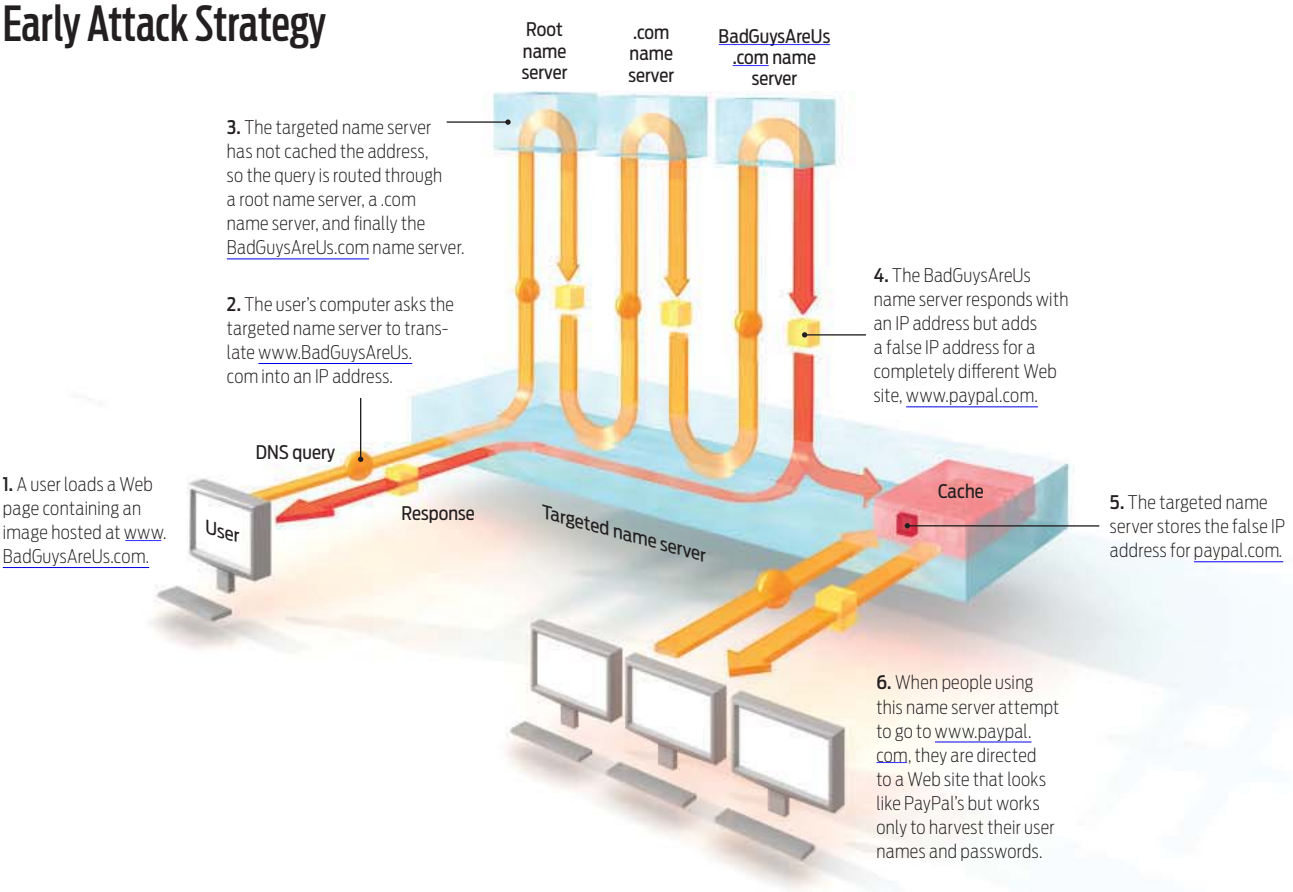
Assuming the hacker doesn't try this too often, the address won't be in your name server's cache, so it will issue a series of queries to other name servers. Eventually, your name server will be referred to the bad guy's name server, which responds by supplying the requested IP address. Now here's where it gets ugly: the Domain Name System allows the answer to include additional information. The bad guy's name server could thus be programmed to send a false IP address for any other site—such as Citibank (http://www.citibank.com)—along with the requested IP address. The fake address would then take the place of the bank's real IP address in your name server's cache, where it would act to redirect traffic from anyone trying to use that server to reach www.citibank.com.

The ability to tack on additional information in a DNS response was considered a valuable feature when the Internet was first set up—it was designed to provide the IP addresses of name servers referenced in the main part of the response. At that time, which predates the Web by many years, nobody thought much about the possibility of scammers using this mechanism to take advantage of folks purchasing things through an Internet auction or doing their banking online.

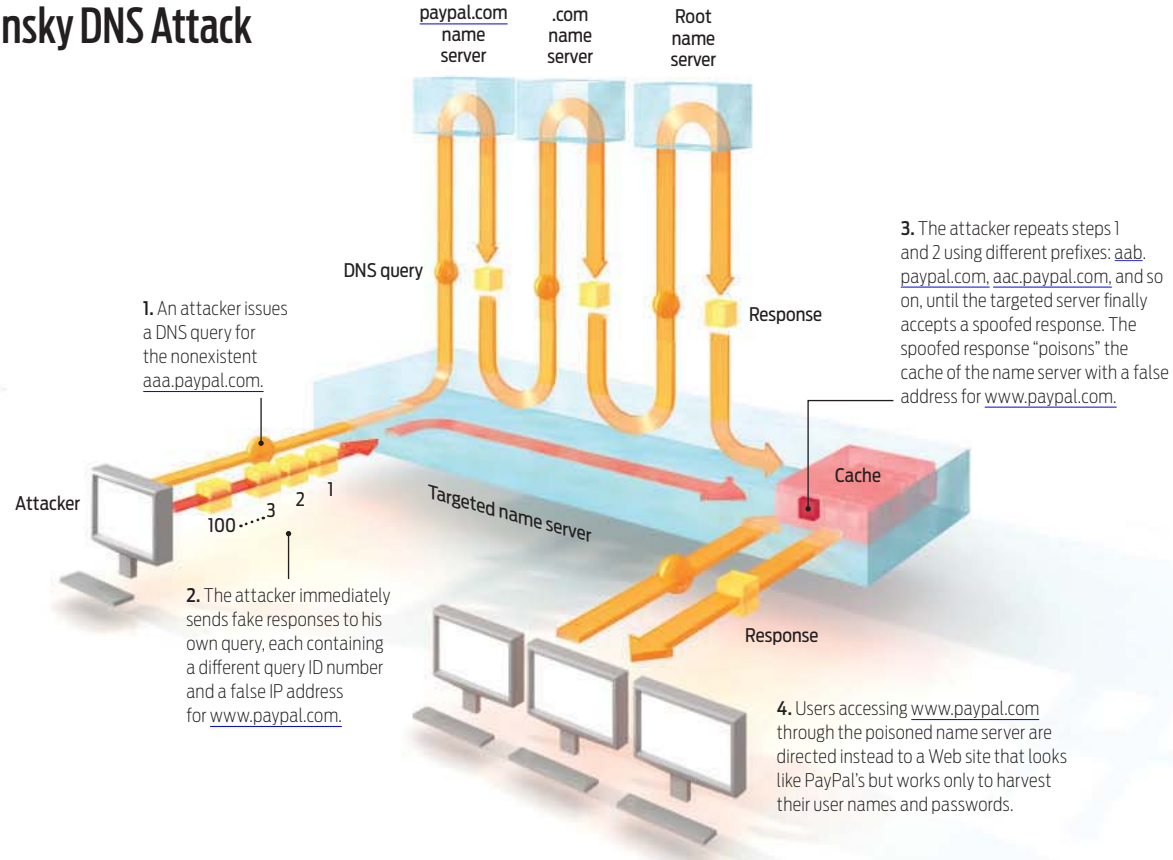
To counter such mischief, DNS software was changed about a decade ago to do what is called bailiwick checking. With that, any extra information added to a DNS response is ignored if it pertains to a domain that is different from the one that was asked about in the first place. So your name server would disregard an IP address said to be for www.citibank.com if the original query was about BadGuysAreUs.com.

The second way an attacker can poison a name server's cache relies on the fact that the conversation your computer has with the name server upstream—or the conversation between two name servers involved in answering your query—is fundamentally insecure. One computer sends out a request to another and then waits for an answer from it. But the

Early Attack Strategy



Kaminsky DNS Attack



BRYAN CHRISTIE DESIGN

answer could, in fact, come from any machine, anywhere.

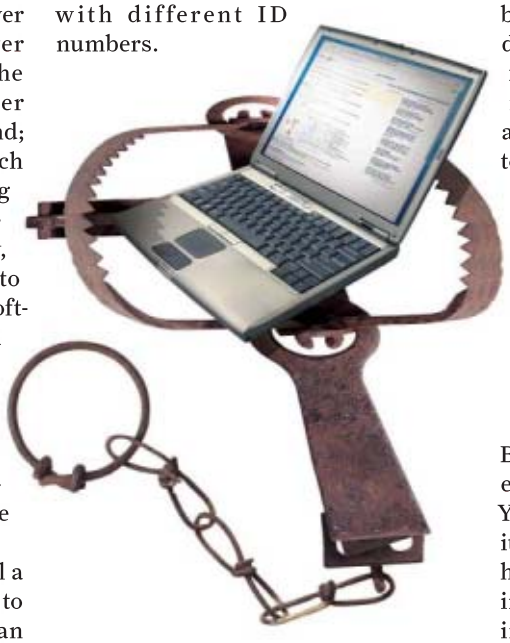
Well, almost—a few systems work differently. Anyone accessing sites in Sweden's .se domain, for example, can use a secure extension to DNS called DNSSEC (for Domain Name System Security Extensions) to carry out DNS lookups. But DNSSEC hasn't really caught on, in part because it is cumbersome for name-server administrators to manage. That attitude now seems due for an adjustment. "There certainly was a spike in interest in DNSSEC" after Kaminsky made his discovery known, says Cricket Liu, a DNS expert at Infoblox, a Santa Clara, Calif., provider of DNS hardware and software.

Still, most communication between name servers continues to take place over an insecure channel. The receiver does check the origin of an answer using a numeric tag attached to the request. But this query ID number wasn't designed with security in mind; it was intended originally just to match up outgoing requests with incoming answers. Early on, DNS software assigned those numbers sequentially, which made it easy for an attacker to guess them. Since about 1997, DNS software has been configured to assign those ID numbers randomly to make such attacks harder. But the ID number has only 16 bits, which translates to 65 536 possible values—few enough to give an attacker a reasonable chance of guessing right if he can try thousands of times.

And that, it turns out, is easy. All a hacker needs to do is send a request to the name server asking it to look up an IP address it doesn't have cached. Then he immediately bombards the server with answers, each containing a different query ID number. Many of the fake replies will beat the real answer back to the name server seeking the address. One of them, the attacker hopes, will contain the correct query ID. More sophisticated versions of this second type of attack don't have such long odds: one scheme, for example, takes advantage of the fact that nominally "random" query IDs can to some extent be predicted.

Up until now, guess-the-query-ID attacks hadn't been considered much of a menace, because the hacker would very likely fail on the first attempt, and the name server would then store the correct IP address in its cache, typically for a day or so. Thus, if the first such attack failed, the hacker would have to wait a day or more to try again. If he had to attempt this hundreds of times before achieving success, it could take years to poison the name server's cache.

Kaminsky's insight reveals how an attacker could sidestep that problem. Imagine that a hacker asked your ISP's name server to look up a nonexistent address within the paypal.com domain—for instance, aaa.paypal.com. This nonsensical name would, of course, not be cached in your ISP's name server, so it would pass the request up the line, eventually asking the real PayPal's name server for the corresponding IP address. While all that was going on, the attacker would send your ISP's name server a lot of spoofed answers with different ID numbers.



Because the hacker has a head start in the race, many of his simulated DNS responses will beat the real one back to your name server. If, for example, 100 fake answers arrive before the real one, the attacker's chances of having one of his bogus responses accepted improve, from 1 in 65 536 to a more worrisome 1 in 655. Even if all 100 spoofed answers fail to get the ID number right, there's nothing preventing him from repeating this attack as many times as he wants, asking about different nonexistent addresses each time: aab.paypal.com, aac.paypal.com, and so forth. Eventually—typically in about 10 seconds by Kaminsky's estimation—a false answer will be accepted.

What's so scary about someone giving your name server an IP address for, say, pdq.paypal.com? Nothing, of course. But remember that the attacker can add some devastating additional information to his spoofed DNS response—namely, a false IP address for www.paypal.com. Such fakery will pass the bailiwick checks because the extra information is for the same domain as the bogus name that was being looked up in the first place. So the bad address will go into the cache, taking the place of the previous entry for www.paypal.com if one had been stored there.

The 8 July patch makes such an attack much more difficult—though not impossible. It works by randomly varying not just the query ID but also the port number in use, which you can think of as being like the suite number on a postal address. To defeat this defense, a hacker must guess both the 16-bit query ID and the 16-bit port number—32 bits in all—requiring, on average, some 4 billion spoofed replies to be received. Such a colossal amount of traffic would be hard to conceal from network administrators.

SECURITY professionals are taking Kaminsky's attack scenario very seriously, and hackers appear to be testing the waters.

Computer-security expert Steven M. Bellovin, a professor of computer science at Columbia University, in New York City, says, "I've seen reports that it's started to happen in the wild." But he believes that DNS cache poisoning will ultimately affect few people—in contrast to what can happen with certain computer viruses and worms—given that system administrators are now taking appropriate steps. He nevertheless cautions, "It's one of the more serious problems we've seen, because it's going after the infrastructure. The hard-core bad guys are starting to wake up." ❑

TO PROBE FURTHER *Paul Vixie's pioneering report "DNS and BIND Security Issues," which warned that the Domain Name System was vulnerable to attack, appeared in* Proceedings of the Fifth USENIX UNIX Security Symposium, *Salt Lake City, June 1995.*

A full description of how the Domain Name System works is available in DNS and BIND, *Fifth Edition, by Cricket Liu and Paul Albitz, O'Reilly, 2006.*

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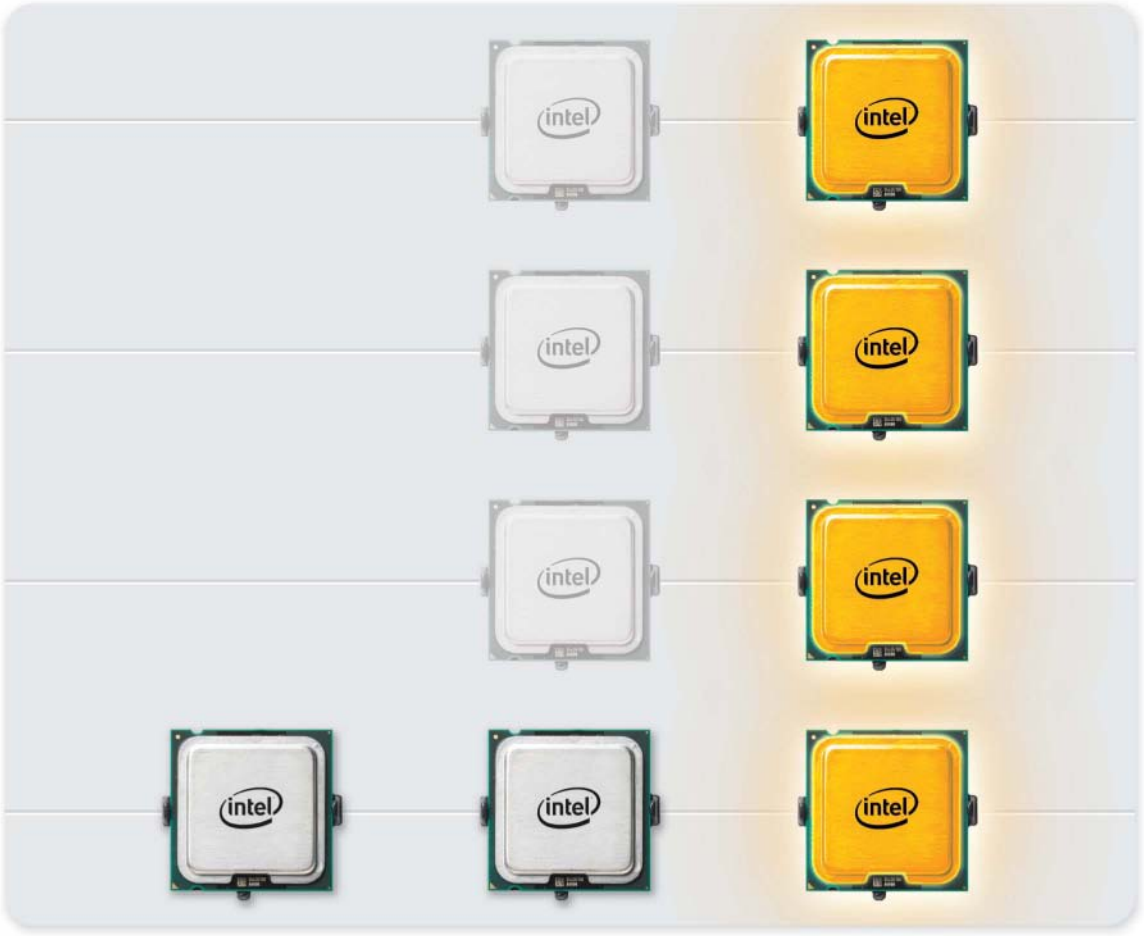

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A high-tech form of bomb disposal has evolved on the streets of Iraq and Afghanistan. It may be coming to a city near you

COUNTERING IEDs: PART TWO By Glenn Zorpette

It's late January, about 3:00 on a cloudy, humid, windless afternoon. We're on the edge of the city of Tikrit. A couple donkeys stand in the muddy median nearby. Half a dozen similarly priced and armored U.S. Army vehicles are scattered around us, pulling security and blocking traffic. A military supply convoy stretches behind us, followed by a motionless queue of cars and trucks kilometers long, with some very irritated Iraqis inside them.

In front of us, 125 meters away, there is only one thing: an improvised explosive device.

We're going to blow it up.

"Hey, this is your day," says the Navy tech who's driving the truck and leading our little three-man crew. He grins at me behind dark aviator glasses and a thick mop of wavy black hair. "How many reporters get to go back to New York and say, 'I blew up an IED?' "

Humming a Suzanne Vega tune, the other Navy man, in the back of the truck, peers at the IED through the optics of a remotely controlled robot called a Talon, which costs almost exactly as much as an Aston Martin DB9 roadster. He's prodding the object with the Talon's manipulator arm.

The IED, which cost its builder less than the price of a couple of Aston Martin wheel rims, looks like a big burlap bag with two oversize sandbags inside. Working the joysticks of his briefcase-size remote, the tech grabs one of the bags with the Talon's arm. "I can't pull 'em or push 'em," he reports. "They're heavy."

In fact, they might actually be sandbags. This thing might be a fake IED, put here to distract us from a real one nearby. Or it might have been placed here just to let hidden insurgents watch and learn from how we deal with it.

Then again, the bags might be filled with explosives. Supporting that possibility are a few other objects in the burlap bag coming into view on the briefcase monitor in the truck, courtesy of the Talon's video camera. These objects could be an artillery round or two, and maybe some control electronics. A pair of shiny, shellacked copper wires leads away from the bag in the general direction of a small, single-story concrete building about a kilometer away.

Enough already. There's one surefire way to find out if the IED is real: detonate a charge on it. The robot operator summons the Talon back to the truck, and the driver hands it some blocks of C-4 explosive attached to a reel of shock tube. He hands me the reel. The robot whirs back to the IED, spinning the reel in my lap. The robot drops the C-4 between the two bags.

The driver hands me the igniter. I grip it tightly in my left hand while inserting my right middle finger into the ring at the end of its firing pin.

"Stand by for fire in the hole in 15 seconds," the driver says over the truck's public-address system. "Fire in the hole in 10, 9, 8, 7, 6..."

EXPLOSIVE ORDNANCE DISPOSAL has come a long way since the London Blitz. Over eight months in 1940 and '41, hundreds of thousands of bombs rained down on British cities, killing an estimated 43 000 people and leaving 1.4 million homeless. Roughly 10 percent of the bombs did not explode, and the job of defusing them fell mostly to army but also to a few navy units. Assigned to one of these was an American named Draper L. Kauffman.

PREVIOUS SPREAD, FROM LEFT: GLENN ZORPETTE; DANFUNG DENNIS/WPN; GLENN ZORPETTE; DANFUNG DENNIS/WPN

PREVIOUS PAGES: A remotely controlled Talon robot reaches for a mortar round [left page]. The Talon is controlled by a console in the Joint EOD Rapid Response Vehicle (JERRV) behind it. On the right page, from left: EOD tech Edward Hart operates a Talon from inside a JERRV; a JERRV parked near Tikrit, Iraq; a U.S. Navy EOD tech investigates an unexploded rocket north of Tikrit on 25 July 2007.

THESE PAGES: On 28 January 2008, near Tikrit, two U.S. soldiers [left] pause before a route-clearance mission to hunt for improvised explosive devices. That mission included a Buffalo vehicle [above, background] and also an RG-31 [foreground]. The cages shield the vehicles from rocket-propelled grenades. On a 2007 mission, Scott Crawford [right] taped together two blocks of C-4 to blow up an IED.

After the United States entered the war, the U.S. Navy gave Kauffman the task of creating a school for bomb-disposal technicians, which survives to this day. For more than 60 years, trainees have learned to dispose of unexploded bombs, locate and destroy mines on land and underwater, demolish underwater obstacles to beach and harbor assaults, move ammunition stores, and clean up after munitions accidents.

Those tasks kept explosive ordnance disposal (EOD) techs busy until about six years ago, when the wars in Afghanistan and Iraq started generating wave upon wave of IEDs. The tide started in Afghanistan in 2002 but gained enormous momentum months later in Iraq, where vast ammunition caches set up by Saddam Hussein in the 1970s and 1980s provided insurgents with an estimated million tons of artillery rounds and other explosives. Early on, the standard IED was one or more artillery rounds rigged to a radio-based detonator such as a cellphone or a garage-door opener.

Coalition EOD teams did their best to keep up. Unfortunately, their techniques, tactics, and technology had been developed for fundamentally different problems. Before Iraq and Afghanistan, a bomb in the road was usually a mine. Any trained EOD technician could identify its type, and therefore its inner workings, on sight. An IED, unlike a mine, can be detonated at the push of a cellphone button by a man peering through a pair of binoculars at the EOD tech grappling with it.

Five years ago, EOD teams were traveling the roads of Iraq in unarmored Humvees. When they approached IEDs, they sometimes wore heavy bomb suits, which offered limited protection to vital organs but were cumbersome and stifling in the Iraqi heat, despite their whirring ventilator fans. Most techs pre-

Editor's note: To minimize the possibility that information in this article could endanger coalition personnel in Iraq or Afghanistan, a draft of this article was reviewed by current and former officials of the Joint IED Defeat Organization, a U.S. Defense Department agency. In response to those reviews, *IEEE Spectrum* voluntarily eliminated some details concerning the mission recounted in this article.

THIS SPREAD, FROM LEFT: GLENN ZORPETTE (2); MICHAEL ZELTKALNS/U.S. NAVY

ferred to take their chances without them, and many of them were killed—more than 50 over the next four years, according to the EOD Memorial Web site (http://www.eodmemorial.org).

In the end, new tactics and techniques emerged based on small, maneuverable robots, gyroscopically stabilized optics, exotic systems to detect buried wires and metal, electronic jammers to defeat radio-controlled IEDs, and blast-resistant vehicles. Meanwhile, for the first time EOD techs were routinely integrated into combat and covert missions, to deal with IEDs encountered while moving through hostile areas.

"The American military has invented, in about three or four years, a way of warfare that didn't exist before," says Daniel Gouré, vice president of the Lexington Institute, a Washington, D.C., think tank. "That's lightning speed."

Today EOD techs have other responsibilities, like postblast and forensic analysis at IED attack sites. The information they gather helps flesh out dossiers on bomb makers, bomb-making cells, and the social, financial, and logistical networks that supply and sustain them.

Regardless of what happens in Iraq and Afghanistan, the new technologies and tactics will endure. Long after the conflicts in those places have subsided, IEDs, including car and suicide bombs, will continue to wreak bloody havoc. Outside of Iraq and Afghanistan, there are more than 200 IED attacks every month around the world, according to the British counter-IED consulting firm Hazard Management Solutions.

"We will be fighting an irregular war for the next 20 or 30 years," says Lt. Gen. Thomas F. Metz, the director of the U.S. military's Joint IED Defeat Organization (JIEDDO), in an interview. "The enemy doesn't want to fight us at sea, or in the air, or in a pitched land battle. The enemy is going to fight us in an electromagnetic environment," using IEDs.

THE DAY BEGAN at Contingency Operating Base Speicher with a predawn briefing and a prayer. Nineteen of us stand around in a circle in the light thrown by our huge armored vehicles. The two Navy EOD specialists—the team leader–driver and the robot operator—and I will be in a Joint EOD Rapid Response Vehicle, or JERRV. We'll be part of a convoy with more than a dozen Army specialists riding in several of these vehicles, all equipped with high-end optics and other systems to help spot and manipulate IEDs.

Most of the soldiers are shouting and joking and laughing; they look like teenagers. By contrast the Navy EOD techs seem subdued and world-weary. They're both in their mid-20s. I'm old enough to be their father.

Two of the Army vehicles are encased in steel cages, to deflect or destroy rocket-propelled grenades. One of them has a giant robotic arm to paw through trash and whatever turns up. Mounted to the front of one of the other vehicles is the same air blower used to dry the track at Nascar races; here it'll blow away trash heaps, which sometimes conceal IEDs.

The briefing covers intelligence on local insurgents and procedures to follow if we find IEDs, come under attack, or need medical evacuation by helicopter. We get our call sign: "trip wire." Then a soldier says a prayer out loud.

After leaving Speicher, we'll travel north on Iraq's main north-south thoroughfare, Highway 1, which the U.S. military calls Main Supply Route Tampa. At some point we'll turn around and drop in for lunch at Forward Operating Base (FOB) Summerall, north of Bayji. If all goes well, we'll be back at Speicher in time for dinner.

This IED-hunting exercise is called route clearance. It keeps the roads open for supply convoys transporting fuel, mail, spare parts, ammunition, computers, soap, video-game consoles, lightbulbs, furniture. And food, of course.

Anyone who has ever spent time in a war zone understands the importance of food. In Iraq, the quantity, quality, and variety of comestibles in the dozens of far-flung U.S. dining facilities result from multiple logistical wonders that occur every day. ("Ice cream!" an EOD veteran had blurted out to me over dinner the night before, laughing so hard he was red in the face. "You've got guys risking their lives so that some far-off FOB can have Baskin-Robbins. Think about it, man!")

The sky is just starting to lighten as we roll out. We pull up to a huge pit, and the Navy techs let me test-fire the JERRV's .50-caliber machine gun into it, provoking amused radio commentary from the soldiers in the vehicles lined up behind us. Then we rumble and bounce through the gates, and the driver flips on the US $80 000 electronic jammer. It puts out signals powerful enough to swamp the receivers of any radio-controlled IEDs that we might encounter [see Web-only sidebar, "The Electromagnetic Struggle," at http://www.spectrum.ieee.org/oct08/eodextra].

We listen to pulsating rock music on an iPod plugged into an excellent sound system, an unofficial "aftermarket" addition to the JERRV, which costs a little over $1 million, nicely equipped. I sit in the "death" seat next to the driver, wearing headphones that let me talk to the Navy techs and also with the other vehicles in the convoy. Outside the thick Lexan windows flows an overcast tableau of scrubby, rocky, littered desert and the occasional cluster of decrepit concrete houses, villas, and abandoned gasoline stations.

An hour later we're skirting the city of Bayji. Occasionally, we pass men sitting in chairs drinking tea, or working on a car. Five little boys playing near the side of the road wave to us, and the robot operator throws them a handful of lollipops.

After 40 minutes a spotter in one of the vehicles ahead of us sees something in the road and we all stop. It turns out to be a big metal box with two bricks in it and some wires attached—your basic fake IED. Word comes back over the radio and we wait while the Army specialists search for other devices.

Insurgents place dummy IEDs for any of several reasons: to videotape how a route-clearance team deals with an IED so they can refine their methods of attack, for example, or to halt the teams so they can fire rocket-propelled grenades at the vehicles.

A while later we hear over the radio that just after we left, Iraqi Police stopped a car and detained the five men inside it. They had the standard trappings of IED emplacers: long-range cordless phones (used to trigger the bombs), AK-47 assault rifles, and a digital video camera. It's likely we had been videotaped.

We continue on at a pace that seems excruciatingly slow. I ask the team leader what he thinks of the "concerned local citizens," the U.S. military term for the Sunni Iraqis, also known as Awakening members, who are paid modestly to help capture insurgents and disrupt bomb-making networks. "It's the best thing we've got going," the team leader says. "It's not controlled by the IA or the IP"—the Iraqi Army or the Iraqi Police.

"It's probably why this route clearance is so routine," the robot operator chimes in from the back of the truck.

A few minutes later, the team leader, who is on his third deployment, talks about some of his previous missions. "You see weird stuff on route clearance," he says. "I've seen 12 or 15 vehicles get blown up in front of me. You'll see people pop up and squirt out of buildings running. I've dealt with postblast where there were

MAN, MACHINE: Thayer Jones, a U.S. Navy EOD tech, rests in a JERRV during a route-clearance mission on 24 July 2007.

deaths or body parts. On my last deployment, we got blown up twice, both times because an officer ran over a pressure plate."

Maybe that's why he seemed so much older than the Army specialists on their first deployment.

We turn left onto a route that loops around Bayji rather than going through it; the Americans call this the Hershey Bypass. At 9:40 a.m., we stop to answer nature's call.

"Get a good look around before you hop out," the team leader advises. "And close the door after you go out."

Later, the robot operator, a Navy lieutenant who is less experienced than the team leader, comments on the lack of action so far. "The way I feel is, I'm here; I'm away from my wife. There is s—t out there to be taken care of. If I'm here and I'm not finding it, I feel like I'm wasting my time."

The team leader shrugs wearily. "I've seen enough IEDs in my life. I really don't care if I never see one again."

The radio hisses: "Just before the overpass. There's a hole in the left side...a wire beside it. It doesn't look like the wire goes in the hole." Another false alarm. On we go.

We get to the top of our route around midday. We turn around, drive for 45 minutes or so, and pull in to FOB Summerall a little after noon. We stop by the EOD tactical operations center to drop off a coffee machine we'd brought with us from Speicher. A team leader there tells us that last night a raid in the desert nearby yielded 140 fifty-kilogram bags of homemade explosive. The pathway leading to the operations center is a line of captured 130-millimeter brass artillery shell cases, laid side by side, gleaming yellow in the brown dirt.

EVERY WAR HAS ITS ICONIC VEHICLES. World War II had the Jeep; Vietnam had Huey helicopters; the first Gulf War had the Humvee. Iraq has "mine resistant, ambush protected" vehicles, including the JERRV.

The U.S. government's approach to countering IEDs has been criticized as being overly reliant on technology and overly preoccupied with finding and disabling IEDs already on the roads. The JERRV is the apotheosis of that approach; still, there's no arguing with its success. Hundreds of EOD techs have gone on thousands of missions since the first JERRVs arrived in late 2005, and so far only two men have been killed by an IED while in a JERRV: Chief Petty Officer Patrick L. Wade and Petty Officer 1st Class Jeffrey L. Chaney.

They lost their lives on 17 July 2007, after an IED packed in a culvert underneath a road in northern Iraq threw their 26-ton vehicle several tens of meters. The equivalent weight of the explosive was later estimated to be many hundreds of kilograms of TNT. The blast crater was about 100 cubic meters.

It's hard not to love a JERRV when you're inside one, in Iraq, far from any base, cocooned within its armor and technology and massive, purpose-built utilitarianism. Its soft red lighting is easy on the eyes at night. The doors are of a composite material, the better to withstand attacks from rocket-propelled grenades and explosively formed penetrators, a particularly lethal form of IED. Steel plates protect the engine compartment. The machine gun on top fires armor-piercing incendiary rounds.

In racks in the cabin and behind the dashboard may be installed several hundred thousand dollars' worth of electronics: the jammer; a gyroscopically stabilized optical system called a Gyrocam; frequency-hopping VHF radios; and a blue-force tracker, which shows the truck's position, tracks it relative to other "friendlies," and allows them all to communicate.

On a previous route-clearance mission, Master Chief Michael Perdun had marveled at the improvement in transport. "One day you're flying around the country with canvas doors on your Hummer, and the next day you're in this," he said, with a wave to indicate the diesel-driven vault we were riding in.

Of course, JERRVs also carry the tools of the bomb-disposal trade: a big cabinet stocked with C-4 and other explosives, reels of shock tube, igniters—and the robots, usually Talons, which let the EOD techs do most of what they need to do while sitting inside the truck.

DANFUNG DENNIS/WPN

RIGHT AT BOOM: U.S. Navy bomb-disposal specialists came across an improvised explosive device north of Tikrit on Iraq's Highway 1, on 28 July 2007. As they blew it up, Chief Butler, an EOD technician, snapped a picture through the windshield of their Joint EOD Rapid Response Vehicle.

The Talon robot is produced by Foster-Miller Technologies, a U.S. subsidiary of the British defense company QinetiQ, and it costs about $160 000. It is typically controlled by radio and it moves on tracks, like a tiny tank, with an amusingly jaunty whir. There are more than 2000 of them in Iraq and several hundred in Afghanistan. In a typical configuration it weighs about 52 kg, can keep pace with a person who is jogging briskly, and has video cameras that can be switched between visible, thermal, and night vision. There's also a version that can be outfitted with a .30-caliber machine gun or a .50-caliber rifle. And Talons don't leave other Talons on the battlefield: if an IED blast damages a Talon, another one is dispatched to drag the broken one back to the JERRV (which is why JERRVs always carry more than one Talon).

The Pentagon's goal for future EOD robots is to give them more intelligence and, therefore, autonomy. An Advanced EOD Robot System (AEODRS) is to be deployed in the next five years. The lead organization for the project, which has not yet been formally approved, will be the Naval Explosive Ordnance Disposal Technology Division, in Indian Head, Md.

The division declined my request to visit but agreed to answer written questions. What will the new robot be able to do that the existing ones can't? I asked. "AEODRS is envisioned to have significant autonomy as appropriate for the EOD mission, scalability/family of systems, modularity/plug&play and EM [electromagnetic] environment capability," came the e-mail response.

And what exactly does "significant autonomy" mean? It conjures a vision of a tech crouched in an armored truck, peering at the scene from his robot's video cam on the display of a tablet computer and using a stylus to circle an IED. With no more direction, the robot makes its way to the bomb on its own.

But if that's one of the capabilities the Navy envisions for its future bomb-disposal robots, it isn't ready to say so yet. "NAVEODTECHDIV is currently working with the EOD users to determine what types of autonomy are 'right' for EOD missions" is all they would tell me.

It was an appointment near Samarra. And it was a prime example of why, six months later, as this article was being written, IED attacks had fallen off in Iraq.

On 8 January, U.S. soldiers from the 101st Airborne Division, along with Navy EOD techs, crept toward a cluster of buildings and tents believed to be a camp of al-Qaeda in Iraq, the main foreign insurgent group. The mission was dubbed Operation Fulton Harvest, and it began with a tip from a local source. The area, in the desert southwest of Samarra, is dotted with sparse clusters of small dwellings. The EOD team was there to use various technologies to detect any IEDs or other booby traps.

Two of the first three buildings the raiders came upon had been used as a place to mix ammonium nitrate fertilizer with diesel fuel or urea to make bulk explosive and also to dry the resulting product. The third building was an IED-production house. It was clear that the facilities were in active use, said Maj. Kelly Kendrick, the operations officer of the 101st Airborne, in an interview at Speicher two weeks after the raid.

Spotters on helicopters found a footpath near the third building leading through some tall grass to a living and cooking area that included several tents. The soldiers had gotten about 5 meters into the tall grass when they were attacked.

There was an all-out firefight with 15 to 20 insurgents. For 15 minutes the air buzzed and roared with bullets, grenades, rocket-propelled grenades, and even mortars, all at close range. Three soldiers were killed and two wounded; three insurgents were killed and three captured. The rest of the insurgents escaped.

Over the next few days the EOD and other specialists uncovered a network of underground bunkers and tunnels underneath the tent area, including an al-Qaeda command-and-control center and another underground chamber that had been booby-trapped with a grenade.

They found enough raw materials to make 4000 kg of homemade explosive and, in a nearby house, 1500 kg of finished product. There was a dump-truck-size vehicle being turned into a vehicle-borne IED, with 1000 kg of explosive, Kendrick said. There were four other smaller vehicles also being con-

DANFUNG DENNIS/WPN

verted to VBIEDs, and nine other big IEDs being built with "victim-operated" triggers, such as pressure plates.

The investigators also found weapons and armaments, electronics training manuals in Arabic, $16 800 in $100 bills, some Sudanese money, and lots of ball bearings, which insurgents pack around an IED's main charge to maximize death and destruction. There were also personal computers and simple video-production facilities to make and mass-produce grisly propaganda video discs, which the team found stacked by the thousands in one of the underground chambers.

It was a standard insurgent camp. During the several weeks I spent north of Baghdad, raids like that one occurred at a rate of several a week within a 75-km radius of Tikrit. Virtually all of them began in the same way, with a tip from a local resident or a former insurgent who was fed up with al-Qaeda or other foreign fighters.

The cumulative effect of those and countless other raids, several months later, was a steep decrease in the rate of IED attacks in Iraq. The tip-offs and raids did what billions of dollars spent developing technologies, some exotic, apparently could not. Can it be that old-fashioned community relations and police work are all that matter and that the technological solutions the U.S. military has been chasing are a mirage?

It's a tempting argument, at least superficially, but it overlooks the many factors and chores beyond tips and firefights that are necessary to take apart an IED network. Also, it underestimates what technology does, because much of the technology is classified. U.S. military officials will say only that technology-based forensics from captured IEDs, postblast analysis, and other sources are helping them to understand networks and even identify individual bomb makers. "They're tracking those guys a lot better than they were a couple years ago," said Lt. j.g. Scott Bryant, a Navy EOD tech at Forward Operating Base Falcon, south of Baghdad, in an interview a few weeks after the Fulton Harvest raid.

Even a straightforward raid on an insurgent camp involves technology: the mission often begins with overhead reconnaissance and surveillance, often from pilotless drone aircraft. And as far as I could tell from my interviews in Iraq, no commanders would think of raiding a camp without taking along EOD techs trained in the use of classified technologies to sweep the roads and footpaths for IEDs.

"We absolutely need science and technology," says Col. Kevin Lutz, the commander of Combined Joint Task Force Troy, the U.S. military organization that oversees EOD and related activities in Iraq. "It's not a panacea, but we cannot do without it."

"I HAD A COW ON MY LAST DEPLOYMENT," the team leader reminisces. Insurgents have often concealed IEDs in dead (and occasionally live) animals. So EOD operators generally blow up any animal carcass they come across. "We put four blocks of C-4 in its ass."

We're about 8 hours into the mission and we're getting a little bored.

At 2:33 p.m., with Led Zeppelin's "Black Dog" playing on the sound system, the radio hisses the words that suddenly make life interesting: "Possible IED on southbound lane. Wires running west."

"Well, we're gonna get to blow something up," the team leader says. He says it the way a farmer might say, "It looks like we're gonna get a little rain."

Ten minutes later we see the IED, or fake IED, in the road. "I think I see our present up here," the team leader says.

"Yeah, that's cute," replies the robot operator.

We pull up near the two donkeys, next to a soldier who is holding an M-16 across his chest. The team leader leans out the door and asks, "What's going on?"

The soldier says the thing looks like two 120-mm artillery rounds in a burlap bag with wires coming out of it.

The robot operator sends out the Talon. He finds bags inside the burlap that are too heavy to push or pull with the robot's arm. "That's UBE or sand," he says. "We'll find out when we blow it." (UBE means "unidentified bulk explosive.")

"WHERE DO YOU TURN OFF YOUR AGGRESSION LEVEL?" the team leader muses.

He steers the robot back to the JERRV. The team leader ties a big knot in some shock tube and tapes it up with a blasting cap and two blocks of C-4 plastic explosive. Shock tube is plastic hose a few millimeters in diameter, lined inside with a dusting of HMX explosive and fine aluminum powder. One end of the tube is attached to an igniter, and the other to a blasting cap wrapped up in some blocks of C-4. The igniter, a tube 12 centimeters long with a pin in one end, starts a shock wave that travels down the tube at 2000 meters per second, sustained by the explosive inner lining. The shock wave triggers the blasting cap, which detonates the C-4.

"Stand by for fire in the hole in 15 seconds," the team leader announces. "Fire in the hole in 10, 9, 8, 7, 6, 5, 4, 3, 2, 1."

I pull the pin on the igniter. There's an orange fireball, maybe 12 meters in diameter. I feel a thump like a punch in the chest. The igniter sparks and sizzles in my hand. A cloud of black smoke drifts toward us.

"Yep, that was definitely some s—t," the team leader says. He keys the iPod and blasts "Play That Funky Music" while he and the robot operator play air drums.

There's frag in the road around the blast site, which means that in among the bags of UBE there was also almost certainly an artillery shell or two, to create shrapnel.

We gather up the IED's command wires, enamel-covered copper. They clearly lead to a one-story building, about 25 meters square, a kilometer or so away. The team leader and the robot operator debate about what they should do. "Whoever was there, dude, they're gone now," the team leader says. "I guarantee it."

"Still, we could find s—t. Make the house go away."

In the end, they decide to let the house stand. "My experience with command wire," the team leader tells me, "is that when you trace it out, there's rarely anything at the end of it except a power source and a switch."

"Where do you turn off your aggression level?" he muses. He's been in situations where there was also a combat team, whose commander was "basing his decision on what you say—whether they destroy a house or knock down a building."

We do some postblast analysis and then drive back to Speicher. At the EOD tactical operations center, we learn that five U.S. soldiers in a Humvee have just been killed in an IED attack and coordinated ambush from a mosque in Mosul, north of where we were. No one says anything for a minute or two.

The buzz from having blown up a bomb is gone. ❑

THE STEAMPUNK CONTRAPTORS

HARDWARE HACKERS ARE CREATING FANTASTICAL MACHINES FROM A VICTORIAN AGE THAT NEVER WAS

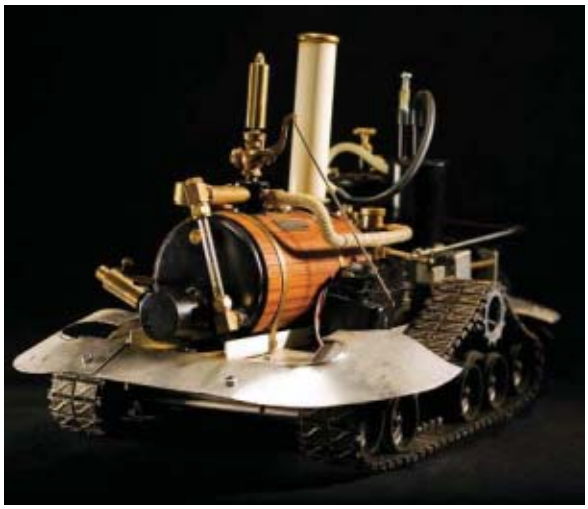
By Erico Guizzo

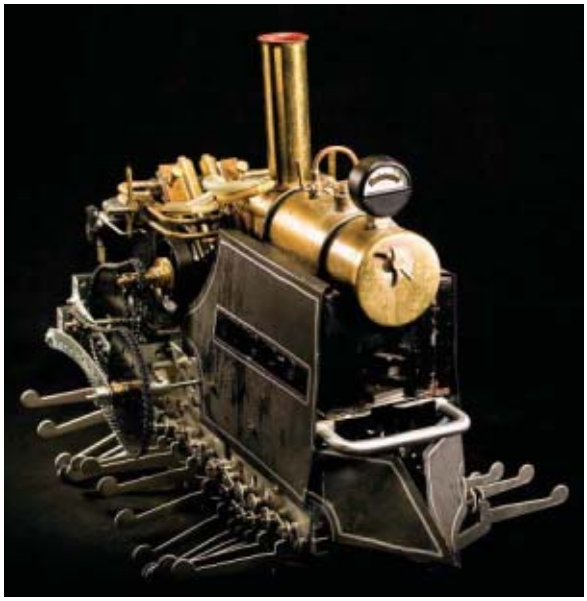
TOP-HATTED TINKERER: Sean Slattery, whose steampunk persona is that of a 19th-century inventor named Jake von Slatt, holds one of his creations, a telegraph sounder that clacks out text feeds from the Web. He's also built a Wimshurst high-voltage generator [opposite] using parts bought at Home Depot.

PHOTOS: NATHAN PERKEL

RETRO RIDE: Sean Slattery (aka Jake von Slatt) plans to convert his faux 1929 Mercedes into an anachronistic steam-powered Victorian vehicle. *PHOTO: NATHAN PERKEL*

SEAN SLATTERY puts on his goggles and starts up the engine of his Frankenstein's monster of a car, its fiberglass body imitating that of a 1929 Mercedes SSK, its chassis taken from a 1972 Volkswagen Beetle. He bought it on eBay for US $1500, and after major repairs he is now ready to add his own hack. He plans to paint the machine black with gold filigree, mount brass headlights and a slanted grille, and install a compact boiler to drive the vehicle with the fiery might of steam. Call it the Steampunk Car.





AUTOMATON ANIMATOR

In a small garage in Dixon, Calif., artist I-Wei Huang, known as Crab Fu, has brought to life a legion of remote-controlled steaming creatures. He built them out of scale-model tanks and boats, electronics kits, and "a bunch of junk parts I've collected." The Trilobite [top] uses a miniature steam boiler and the engine from a model boat to turn its metal tracks. The Centipede [center] crawls using 32 legs driven by a steam-powered system of sprockets and chains. The Lobster [bottom] has the chassis of a 1/16-scale toy tank fitted with an aluminum carapace and a small steam engine.

PHOTOS: JONATHAN SPRAGUE/REDUX

Steampunk is a burgeoning subculture that draws on the elaborate aesthetics and romantic worldview of 19th-century England to envision how things might have looked had a few key technologies been developed further. It conjures a gaslit cityscape filled with steam-powered robots, mechanical computers, ray-gun-toting aeronauts, and monocled mad scientists.

Steampunk diehards talk and dress as if they lived in such a world. Some stay in character all the time—whether at a steampunk gathering or the supermarket. Slattery, 46, takes things a bit more casually. Most of the time he's a regular guy: a Linux system administrator, married, with two daughters. It's when he walks into his garage, crammed with metalworking tools and hunks of brass he's found at the town dump, that he becomes Jake von Slatt, proprietor of the Steampunk Workshop.

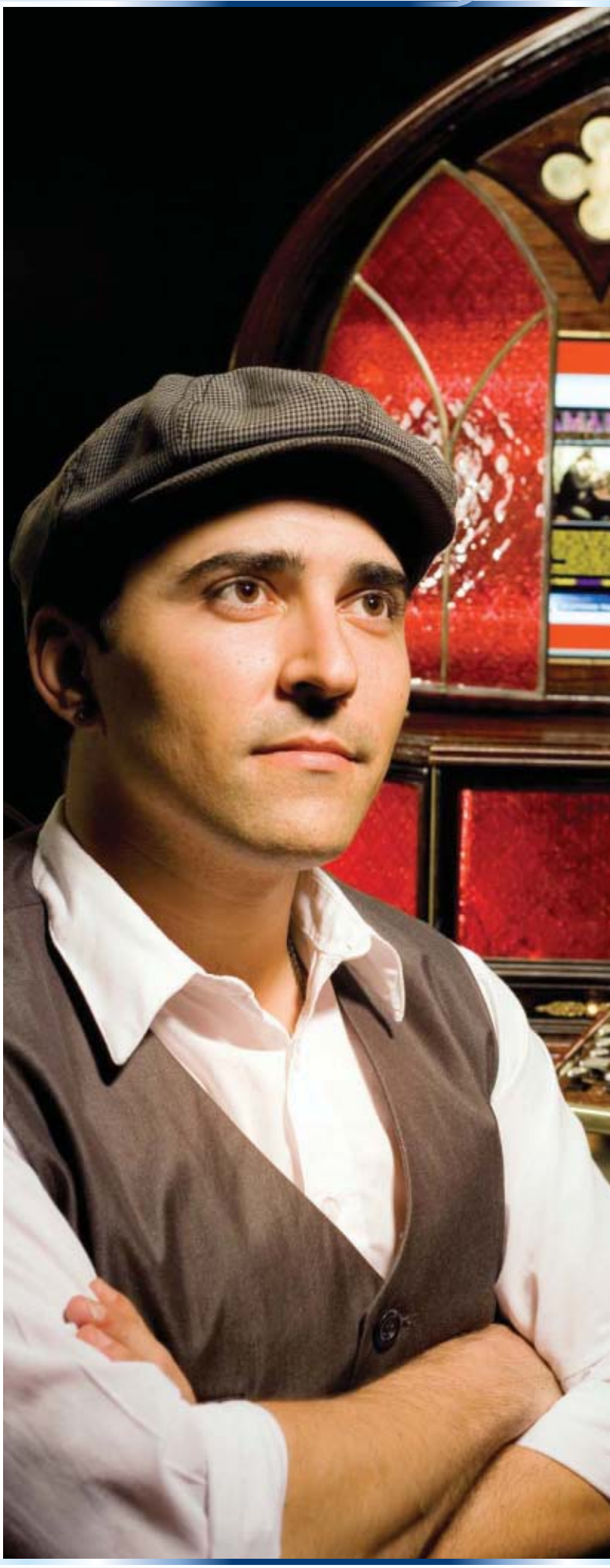
On a recent summer afternoon, he parks the Steampunk Car at his home in Littleton, Mass., and guides a visitor through the property. In the backyard sits a school bus converted into a fully equipped Victorian-style recreational vehicle. On his office desk, he keeps a brass-adorned PC "fit for the office of Queen Victoria herself."

"I've always been fascinated at this blend of the old and the new," he says, "particularly when there's an element of anachronism—something out of time."

Steampunk has its roots in the 1980s as a type of speculative fiction, its name a tongue-in-cheek derivation from another literary subgenre, cyberpunk. But in the past few years, the movement has been "steamrolling," as Slattery puts it, with the emergence of steampunk fashion, music, and design.

Feeding this growth are the pipes of the Internet. If the computer hackers of the 1980s had hobbyist clubs, the steampunk community has Facebook, YouTube, and online forums like Brass Goggles, where they philosophize about their lifestyles, discuss novels like *The Warlord of the Air* (1971), by Michael Moorcock, and *Lord Kelvin's Machine* (1992), by James Blaylock, and share photos of their handmade prop weapons ("This is Chekhov, the newest darling in my personal arsenal, a rotary-dial gun").

"It's about a society that is learning to bubble up on networks," says sci-fi writer Bruce Sterling, coauthor with William Gibson of *The Difference Engine*,



ANTIQUE ARTIFICER

California artist Richard "Datamancer" Nagy calls his latest creation the Archbishop [left], a Gothic-themed wooden frame with stained glass and brass embellishments that houses a high-powered PC and a liquid-crystal display. It comes with a brass keyboard [top], a drawing tablet disguised as an antique book, and a curious back story: in July, a 5.8-Richter-scale earthquake almost knocked the Archbishop to the ground, but Nagy jumped over a worktable and saved it. His steampunk portfolio also includes a handcrafted wooden case that looks like a Victorian music box but is actually a laptop computer [middle and bottom]. It has a copper keyboard, leather wrist pads, and a clock-winding key to boot it up.

PHOTOS: JONATHAN SPRAGUE/REDUX

a 1990 novel that many steampunk fans cite as a big inspiration. "That's the part that's really weird and new and remarkable about steampunk—not the brass, top hats, and whalebone but that it's digital and rootless and headless."

THE DESIRE TO MAKE THINGS is an integral part of the steampunk movement. Drawing inspiration from fantastical works like Jules Verne's *Les Voyages Extraordinaires* and H. G. Wells's *The Time Machine*, steampunk adherents embrace the do-it-yourself ethic, and they prize unique, intricate designs over disposable, bland creations.

"It's part art and part just tinkering with stuff, trying to create something that no one has really tried to do before," says I-Wei Huang, known as Crab Fu, an artist and animator based in Dixon, Calif., who has built a collection of steam-powered mechanical critters.

Another artist, Richard "Datamancer" Nagy, is even trying to make a living out of it. He recently relocated from New Jersey to California to be at the "fabrication headquarters of the U.S.," he says. His most famous creations are a laptop computer disguised as a music box and retro-futuristic keyboards.

Von Slatt, Crab Fu, and Datamancer are among the most prolific steampunk contraptors. But they're far from alone. Countless steampunk artifacts—a Jules Vernian water-cooled PC with brass pipes and a porthole, a time machine named Dihemispheric Chronaether Agitator "capable of traveling forward in time at exactly 1 SPS [second per second]"—have appeared on the Internet. Jacob "Jake of All Trades" Hildebrandt, a student at Michigan Technological University, is currently building a steam-powered TV in his dorm room and documenting the process in his blog.

Recently, steampunk appears to have reached an ebullient point. Brass and clockwork items labeled "steampunk" are proliferating on eBay and Etsy. Already, there's a steampunk interior design blog, a steampunk cookbook, and a soon-to-open steampunk boutique in New York City. Media coverage in outlets from *The Wall Street Journal* to *Maxim Russia*—and this magazine among them—have helped disseminate steampunk even further. It doesn't come as a surprise that the result was a bit of a backlash.

One Polish steampunk purist took issue with those who think that "imitating 19th-century upper class is rebellious or revolutionary." A poseur posted a mocking video—"Keep it brassy!"—on his blog. And *Design Observer* published a harsh critique by one Randy Nakamura, who called steampunk fabricators "mediocre hobbyists" and characterized the movement as "closer to Disney than punk or sci-fi."

Steampunk fans regarded the criticism as pointless. What's wrong, they asked, with some Victorian-era fans who enjoy building stuff, adding that the movement does strive to find a deeper ideology. "If you can imagine another world, it can allow you to creatively confront the challenges of the present," says John "Manyjohns" Shamberg, a member of Kinetic Steam Works, a San Francisco Bay Area arts group, whose creations include a 10-meter-high steampunk tree house. "This is where steampunk gets its depth, by combining a recognition of a rather dystopic past/present with a utopic imperative."

As steampunk grows, the discussion will probably continue. The question is how the movement can remain true to its DIY and anticonsumerist principles. Will steampunk evolve into something lasting—or will it disappear like thin vapor?

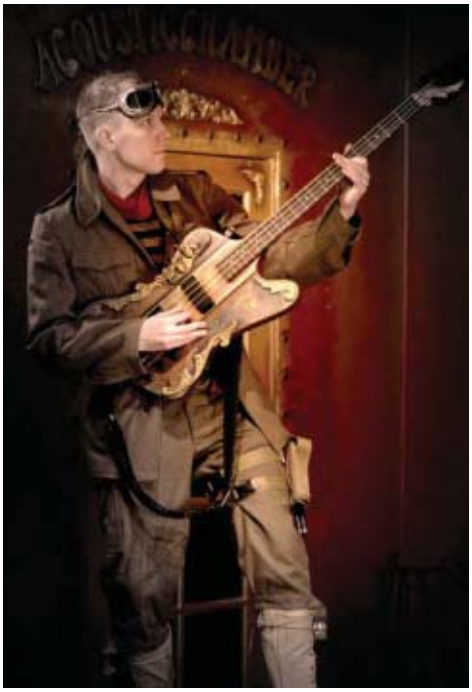
BACK AT THE STEAMPUNK Workshop, Slattery is not concerned about where things are heading. He's having too much fun, he says, creating things and meeting like-minded people. For him, the challenge has been finding time for all his steampunk activities, which lately include finishing the steam-powered car, building a furnace that uses a BMW fuel injector to melt metal, and maybe steampunking a bulldozer he saw on Craigslist.

"My wife has been extremely tolerant," he says, "even on a few occasions when I found myself signing e-mails to her as 'Jake von Slatt.' " ❑

TO PROBE FURTHER Learn more about steampunk at Aether Emporium (http://etheremporium.pbwiki.com) and Brass Goggles (http://www.brassgoggles.co.uk).

To see more steampunk artifacts, visit the Web sites of Sean Slattery (http://www.steampunkworkshop.com), I-Wei Huang (http://www.crabfu.com), Richard Nagy (http://www.datamancer.net), and Kinetic Steam Works (http://www.kineticsteamworks.org).

The first California Steampunk Convention (http://www.steampunkconvention.com) takes place later this month in Sunnyvale.



STEAMING SUBCULTURE

Born as a literary subgenre two decades ago, steampunk has now materialized in the creations of a growing number of enthusiasts. Early this year, a strange apparatus named the Telectroscope [top left] connected New York City and London using a video link—or, if you ask the imaginative artists who created it, using a transatlantic tunnel conceived by "an eccentric Victorian engineer." California artist Tom Sepe shows off his Whirlygig Emoto [top right], a "steam-electric hybrid motorcycle," at this year's Maker Faire in San Mateo, Calif. Hats, goggles, and ray-gun props are among the steampunk accessories handcrafted by artists like Molly "Porkshanks" Friedrich of Seattle [middle left]. Special effects and film-prop company Weta Workshop in New Zealand—best known for its work on the *Lord of the Rings* film trilogy—offers collectibles like the limited-edition Unnatural Selector ray gun [middle right]. A self-propelled three-story Victorian house on wheels, the Neverwas Haul [bottom left] is a collaborative project of San Francisco Bay Area artists and fabricators. Seattle band Abney Park incorporates steampunk not only into its lyrics but also its instruments, which include a clockwork-adorned guitar, a flintlock bass hybrid [bottom right], and a "Tesla-powered keyboard."

PHOTOS, CLOCKWISE FROM TOP LEFT: MARY ALTAFFER/AP PHOTO; LISA MEKIS; STEVE UNWIN/WETA WORKSHOP; ROBERT BROWN; LIBBY BULLOFF (2)

A Less Well-Oiled War Machine

Continued from page 27

He has a big job on his hands—to make McGuire, 24 km outside Trenton, able to go completely off-grid by 2015. McGuire is one of two model energy bases chosen by the Air Force last year to explore energy efficiency to the fullest extent economically possible. A base in New Jersey is a logical starting point: between the state's generous renewable-energy credits and a relatively high electricity price (13 cents per kilowatt-hour, compared with a national average of 9 cents), the Air Force stands to gain from easing its draw. In the year since he began his mission, Archer has replaced a poorly insulated 2-hectare (5-acre) roof on a warehouse and begun installing smart meters on large buildings to track their energy use.

In that one year, electricity use dropped by 14 percent. "We've been addressing all the low-hanging fruit," Archer says with a modest shrug. His task list now includes putting 100 kilowatts' worth of solar panels on several warehouse roofs, replacing 1970s-era lighting, and dismantling the central heating plant by installing more-efficient furnaces in some buildings and ground-source heat pumps underneath others. Those units use the thermal stability of the Earth to transfer heat to a building from the ground through geothermal wells dug about 120 meters deep.

"At first I think the Air Force and McGuire struggled with what this model-energy idea means," says Joseph Bogdan, McGuire's energy manager. Now that the team of civil and electrical engineers has gained momentum, he and Archer think they'll be able to halve the electricity consumed at McGuire from its 2003 level by 2011. They are also in the beginning stages of developing solar and biomass power plants.

Specifically, they want to install a 2-MW solar array in an empty field between a dormitory and two day-care centers on the base. Archer periodically checks out the location, just a minute's drive from his office on base. "Can you imagine?" he says, hands on his hips as he scans the field on a recent visit. "These children will grow up playing right next to all these solar panels, and to them it'll look completely normal." He's optimistic that a 6-MW solar installation on a brownfield on the edge of the base won't be far behind. "I think we're going to be able to carve out a deal, maybe even better than what Nellis did," he says. To meet McGuire's routine electrical demand of 12 MW, they'll need something on that scale.

But not every base has access to renewable-energy incentive programs or giant naturally occurring geothermal resources. The Army has a similar goal of five net-zero-energy bases by 2015, where, over the course of a year, the base or buildings would produce more energy on site than they consume from the grid or from other fossil sources. In states that lack strong support for renewable energy, keeping it affordable can be challenging.

That was William Stein's experience during his decade as the energy manager at Fort Huachuca, in Arizona. Using a combination of third-party financing and small sums from the Army, he trimmed electricity use by 1 percent at a time when the base and its population were expanding. In addition to replacing inefficient lighting *Continued on page 52*

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A Less Well-Oiled War Machine

Continued from page 50

and repairing a broken solar-heated pool, Stein procured several rooftop solar panels, installed a 10-kW wind turbine, and put in two of the military's first solar-collector walls. Here, the sun's radiation warms a heat-collecting panel installed parallel to a building's exterior, most commonly several centimeters away from its south-facing side. Fans draw the heat into an air cavity between the panel and the building, and that air in turn provides heat and ventilation for the occupants of the building. Such solar-heating systems have since become a hit on Army bases—this past spring, Fort Drum, in New York, finished installing 50 solar walls made by Toronto-based Conserval Engineering.

"We're trying to be leading edge, bleeding edge, but the problem is we get a lot of resistance," Stein says. "It's not all doom and gloom, but we've got to turn the ship very, very slowly." His work won him the title of energy champion and got his face on a poster in Army offices in Washington, D.C. He now manages the national program for the Army's net-zero-energy bases, which his boss, Don Juhasz, hopes will be the service's main contribution to meeting the Defense Department's mandate of 25 percent renewable energy by 2025—once they figure out how to do it.

Some military employees hope that the arguments for renewable energy are compounding in their favor. This past February, a report released by a Defense Science Board task force on energy strategy concluded that the vulnerability of the national electric grid to attack or failure could compromise the ability of domestic bases to carry out their missions. Though each base has backup diesel generators to power critical buildings, well-placed renewable-energy technologies could stretch a base's supply of diesel fuel, if not replace it, in an emergency.

The reasons to deploy renewable-energy technologies are compelling, but Brad Hancock, the DOD's associate director for energy and utilities, sees a gap between what the bases want to do and what they can do on their own. "We're mostly looking in the 100-kW to the little-smaller-than-a-megawatt range, to have security of energy and to lock in electricity prices," he says of the projects that the department chooses to fund internally. "We want to produce enough renewable energy, but we're still struggling with the life-cycle cost issues."

Chris Tindal, the Navy's shore-energy manager, sums up the military's operating philosophy succinctly. "If we can buy more ships, more planes, more bullets, that's what we'd rather do than put our money into infrastructure," he says. In other words, that's why military dollars are always in short supply for domestic energy projects. But that position also explains, in light of an uncertain energy future and a handful of stunning economic successes, why some individuals are inching the military toward a cleaner, more sustainable stance on power. Their work is really paying off, too: as Hancock sees it, the military is "more than on track" to fulfill its vision for 2025. With some bases supplying their own electricity and vast empty stretches of military land being used to produce power, the U.S. military, at least at home, is at the forefront of an energy revolution. ❑

Washington University in St. Louis
School of Engineering & Applied Science

Washington University in St. Louis, Department of Electrical and Systems Engineering.
The Department of Electrical and Systems Engineering (ESE) invites applications for faculty positions at the levels of assistant, associate, or endowed full professor. The ESE department is the result of a recent merger between the Department of Electrical Engineering and the Department of Systems Science and Mathematics, and is under new leadership. New faculty members will have the opportunity to participate in building the department and in moving it forward in exciting new directions. Candidates should have a doctorate in Electrical Engineering, Systems Engineering, or related fields. The department is interested in candidates with a strong commitment to pursuing externally-funded research, and to teaching at both the undergraduate and graduate levels. Exceptionally strong applicants in all areas of electrical and systems engineering will be considered. Technical areas of interest include, but are not limited to, telecommunications, applied physics, energy, nanoelectronics and integrated circuits, systems and control theory, robotics, mechatronics, systems biology, mathematical and physical modeling, imaging, sensor networks, and security technologies.

Washington University in St. Louis is a medium-sized private university of approximately 7000 undergraduate and 6000 graduate and professional students, which enjoys high academic standing and a strong and growing national reputation. The ESE department presently has 17 full-time tenured and tenure-track and 4 senior faculty. There are approximately 80 undergraduate students, 80 full-time graduate students and 30 part-time graduate students. The department offers separate undergraduate and graduate degrees in Electrical Engineering and in Systems Science and Engineering. The University is located in a semi-urban area, adjacent to Forest Park, with many cultural and recreational activities.

More information on the department is available at
www.ese.wustl.edu.

Applications will be accepted immediately, and interviews will begin after January 1, 2009. Applicants should send a letter of interest, curriculum vitae, a list of at least 5 academic or professional references, and a statement of vision for research and teaching in electronic form (PDF) to ***facsearch@ese.wustl.edu***.

Washington University in St. Louis is an Equal Opportunity and Affirmative Action employer, and invites applications from all qualified candidates.

The Hong Kong Polytechnic University
香港理工大學

DEPARTMENT OF COMPUTING

The Department invites applications for Professors/Associate Professors/Assistant Professors in Database and Information Systems/Biometrics, Computer Graphics and Multimedia/Software Engineering and Systems/Networking, Parallel and Distributed Systems. Applicants should have a PhD degree in Computing or closely related fields, a strong commitment to excellence in teaching and research as well as a good research publication record. Applicants with extensive experience and a high level of achievement may be considered for the post of Professor/Associate Professor.

Please visit the website at ***http://www.comp.polyu.ed.hk*** for more information about the Department. Salary offered will be commensurate with qualifications and experience. Initial appointments will be made on a fixed-term gratuity-bearing contract. Re-engagement thereafter is subject to mutual agreement. Remuneration package will be highly competitive. Applicants should state their current and expected salary in the application. Please submit your application via email to ***hrstaff@polyu.edu.hk***. Application forms can be downloaded from ***http://www.polyu.edu.hk/hro/job.htm***. **Recruitment will continue until the positions are filled.**

Details of the University's Personal Information Collection Statement for recruitment can be found at ***http://www.polyu.edu.hk/hro/jobpics.htm***.

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tf

C A U
Christian-Albrechts-Universität zu Kiel
Technische Fakultät

The Institute of Electrical & Information Engineering, Faculty of Engineering (TF) at Christian-Albrechts-Universität zu Kiel (CAU) in Kiel, Germany, invites applications for a

FULL PROFESSOR (W3)
Digital Signal Processing and System Theory
(to succeed Prof. Dr.-Ing. U. Heute) for the winter semester 2009.

We are seeking an outstanding scientist with exceptional teaching and organizational abilities and a track record of excellence in dedicated research and teaching.

You will have wide-ranging expertise in a number of relevant areas of signal processing and system theory, including:

- **Signal processing algorithms**
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- **Signal processing in biological and medical applications.**

Your teaching obligations will include the delivery of courses in electrical engineering and information engineering at both undergraduate and post-graduate level and provision of interdisciplinary courses and teaching within and outside the Faculty of Engineering, specifically in Signals and Systems, System Theory and Signal Processing.

You will be willing to undertake research collaborations with other departments of the Faculty of Engineering and CAU as a whole, particularly in the field of Information Engineering. You will also demonstrate experience in acquiring and conducting research projects and/or bring relevant project experience from your own field of industrial expertise.

CAU is seeking to increase its roll of female professors and therefore specifically requests suitably qualified women candidates to apply for this position. Priority will be given to applications from women who demonstrate equal abilities, competence and professional qualifications. The university actively encourages applications from severely disabled candidates and will give preference to such applicants who meet the professional criteria.

Please also refer to § 61 and § 63 Clause 1 of the Hochschulgesetz des Landes Schleswig-Holstein (Schleswig Holstein Higher Education Act).

Send your application by 31st October 2008 together with a curriculum vitae, list of publications, details of your professional and scientific track record and teaching experience, and a resume of your research interests to

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der Christian-Albrechts-Universität zu Kiel
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Faculty Position Announcement

The School of Electrical & Electronic Engineering of Yonsei University invites applications of outstanding candidates for tenure and non-tenure track international faculty positions in all areas of electrical engineering. The position is a joint appointment with Underwood International College.

Yonsei University has the longest tradition and is acknowledged as one of the best universities in Korea. Please visit ***http://ee.yonsei.ac.kr*** and ***http://uic.yonsei.ac.kr*** for more information.

Successful applicants must have a doctoral degree in electrical engineering or a related discipline, and a commitment to excellence in teaching. The international faculty positions require for all educational degrees to be completed from institutes outside the Republic of Korea (ROK) and the applicant must not be a ROK citizen.

Review of applications will commence in September of 2008 and continue until positions are filled. Applications should include, in a single PDF file in this order: cover letter, statement of research objectives, probable instructing lectures, CV, and publication list. Also, two letters of recommendation should be sent separately to the address below. Application material should be submitted by E-mail to:

Prof. Young Joong Yoon, Chairman
School of Electrical & Electronic Engineering
Yonsei University
262 Seongsanno, Seodaemun-gu
Seoul, 120-749, Republic of Korea
E-mail: ***yjyoon@yonsei.ac.kr***

THE HONG KONG POLYTECHNIC UNIVERSITY
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The Hong Kong Polytechnic University is the largest government-funded tertiary institution in Hong Kong, with a total student headcount of about 27,200, of which 13,500 are full-time students, 11,400 are part-time students, and 2,300 are mixed-mode students. It offers programmes at Doctorate, Master's, Bachelor's degrees and Higher Diploma levels. The University has 27 academic departments and units grouped under six faculties, as well as 2 independent schools and 2 independent research institutes. It has a full-time academic staff strength of around 1,250. The total consolidated expenditure budget of the University is in excess of HK$4 billion per year.

DEPARTMENT OF ELECTRONIC AND INFORMATION ENGINEERING

Professor / Associate Professor / Assistant Professor in Bioinformatics and Biomedical Circuits and Systems / Photonics and Optoelectronics / Electronic Circuit Design (three posts) [tenable from October 2008]

Since its inception in 1974, the Department of Electronic and Information Engineering has enjoyed a distinguished history of providing outstanding engineering education to students in Hong Kong. Currently, it has around 35 full-time academic staff in the areas of Communications, Circuits and Microelectronics, Computer Engineering and Information Technology. In addition, leading scholars regularly visit the Department for research collaboration and enhance the Department's research profile. The Department has extensive resources to support a wide variety of research interests and activities. Please visit the website at http://www.eie.polyu.edu.hk for more information about the Department.

The appointees will be required to (a) teach at undergraduate and graduate levels in one or more of the following areas: Bioinformatics and Biomedical Circuits and Systems / Photonics and Optoelectronics / Electronic Circuit Design; (b) conduct research that leads to publications in top-tier refereed journals and awards of research grants; (c) supervise student projects and theses; (d) engage in scholarly research/consultancy in their area of expertise; and (e) contribute to departmental activities. Those appointed at Professor/Associate Professor level will be expected to provide leadership in research, programme/curriculum development, administration, etc. Candidates who demonstrate potential in making significant contributions to emerging technologies will also be considered.

Applicants should (a) have a PhD degree in a relevant discipline; (b) have a publication record or strong potential to publish in top-tier refereed journals; (c) be able to demonstrate evidence of effective classroom teaching skills; and (d) have excellent communication skills (the medium of instruction is English). Those with excellent teaching and publication records will be considered for appointment at the level of Professor/Associate Professor.

REMUNERATION AND CONDITIONS OF SERVICE

Salary offered will be commensurate with qualifications and experience. Initial appointments will be made on a fixed-term gratuity-bearing contract. Re-engagement thereafter is subject to mutual agreement. Remuneration package will be highly competitive. Applicants should state their current and expected salary in the application.

APPLICATION

Please submit application form via email to hrstaff@polyu.edu.hk; by fax at (852) 2764 3374; or by mail to **Human Resources Office, 13/F, Li Ka Shing Tower, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong**. Application forms can be obtained via the above channels or downloaded from http://www.polyu.edu.hk/hro/job.htm. Recruitment will continue until the positions are filled. Details of the University's Personal Information Collection Statement for recruitment can be found at http://www.polyu.edu.hk/hro/jobpics.htm.

AUS
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College of Engineering

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American University of Sharjah (AUS) is a not-for-profit, coeducational institution of higher education formed on the American model. AUS is licensed in the United Arab Emirates and is incorporated in the State of Delaware in the United States. It is accredited by the Commission on Higher Education of the Middle States Association of Colleges and Schools, Philadelphia, Pennsylvania. All College of Engineering undergraduate degree programs are accredited by ABET.

The Department of Electrical Engineering and the Department of Computer Science and Engineering have vacancies for permanent and visiting faculty positions in the following areas:

Electrical Engineering: Faculty positions preferably at the assistant professor rank in the following areas: digital signal processing, electromagnetics, microelectronics and other emerging areas in electrical engineering.

Computer Science and Engineering: Faculty positions at the assistant, associate or full professor rank in the following areas: artificial intelligence, enterprise computing, computer graphics and animation, human-computer interaction and programming language design.

Qualifications

Strong preference is given to candidates with degrees (BS, MS, PhD) from a Western-style university that is ABET (or equivalent) accredited. Teaching experience in an American model of higher education and work experience in North American industry are highly desirable. English is the language of instruction at AUS.

Please visit the AUS employment website at:

www.aus.edu/employment/faculty_engr.php for more information.

THE CHINESE UNIVERSITY OF HONG KONG

Dean of the Faculty of Engineering

The Chinese University of Hong Kong, founded in 1963, aspires to be acknowledged regionally and internationally as a first-class comprehensive research university. The University offers a broad spectrum of programmes up to PhD level in various disciplines organized under eight (8) Faculties (viz. Arts, Business Administration, Education, Engineering, Law, Medicine, Science and Social Science), with a team of over 2,000 full-time teaching and research staff. In 2007-08, undergraduate and postgraduate enrolment in publicly-funded programmes stands close to 10,700 and 3,400 respectively (*http://www.cuhk.edu.hk*).

The Faculty of Engineering comprises the Departments of Computer Science and Engineering, Electronic Engineering, Information Engineering, Mechanical and Automation Engineering, and Systems Engineering and Engineering Management. The Faculty has about 250 full-time teaching and research staff, 1,550 undergraduate and 430 postgraduate research students. Detailed information on the Faculty is available at *http://www.erg.cuhk.edu.hk/*.

The Dean of Faculty will be a member of the University senior management team reporting to the University Council via the Vice-Chancellor/President or the Provost. As the academic and executive head of the Faculty, the Dean will provide academic leadership and discharge administrative responsibilities in respect of academic, staff, financial and student matters.

Candidates should be academics with established scholarship appropriate for appointment at professor level in an academic department, with an appreciation of the breadth of research and educational developments in the fields relevant to the Faculty. They should have demonstrated capability for academic leadership and management at an appropriate level in higher education institutions, long-term vision for the development of the Faculty, and excellent interpersonal and communication skills.

Salary and fringe benefits for the post will be highly competitive, commensurate with qualifications and experience.

Please send applications/nominations under confidential cover, to the Search Committee for the Dean of the Faculty of Engineering, c/o Office of the Vice-Chancellor/President, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong [fax: (852) 2603 5230; e-mail: *SCDeanship@cuhk.edu.hk*]. All applications/nominations will be treated in strict confidence. The Personal Information Collection Statement will be provided upon request.

Consideration of applications/nominations will begin in August 2008 and will continue until the post is filled. The University reserves the right to fill the post by invitation.

UNIVERSITY OF ALBERTA
EDMONTON, ALBERTA, CANADA

www.careers.ualberta.ca

Faculty Positions, Electrical and Computer Engineering

The Department of Electrical and Computer Engineering invites applications for several tenure-track and tenured faculty positions at the Assistant, Associate and Full Professor level. Exceptional candidates are being sought in all areas of Electrical Engineering, Computer Engineering, and Engineering Physics. Areas of special interest include:

(i) Biomedical Engineering: including DNA sequencing and molecular diagnosis of diseases, nanoscale bioengineering, analysis and control of biomedical processes, biomedical signal and image processing, biophotonics, biosensors, drug delivery systems, systems biology and medical robotics.

(ii) Information and Communications Technologies: including high speed and low power integrated circuit design, FPGA systems, embedded systems, RF/microwave circuits, metamaterials, spintronic devices, multimedia digital signal and image processing and robotics.

(iii) Nanotechnology: including micro and nano electromechanical systems (MEMS and NEMS), nanophotonics, BioMEMS, solid state electronics, nanoscale, plasmonic, quantum devices and control of nano-scale devices.

(iv) Energy Systems: including photovoltaic devices, renewable energy systems, magnetic and electric energy conversion methods and devices.

Candidates must have earned (or expect) a PhD in electrical and computer engineering or a closely related area, a solid publication record and have a strong commitment to research and teaching. Postdoctoral and/or industrial experience will be considered an asset. Successful candidates will be expected to develop a significant independent research program with external funding, supervise graduate students in their field of interest, and teach postgraduate and undergraduate courses in electrical and computer engineering. Regardless of their educational background, all successful candidates will be required in due course to become licensed professional engineers in the Province of Alberta.

Founded in 1908, the University of Alberta is one of Canada's foremost research-intensive universities. The campus is situated on the south bank of the North Saskatchewan River, with quick and convenient access to the city centre. The greater Edmonton area has a population of over a million people and offers a diverse array of cultural and sporting activities year round. The Department of Electrical and Computer Engineering is undergoing a major expansion and is committed to securing a position among the leading schools in North America. With a present complement of 59 faculty members, research in the Department is vigorous and covers all major areas of Electrical and Computer Engineering and Engineering Physics. Our graduate program attracts outstanding students from the best schools worldwide and presently has an enrollment of over 370 students, including approximately 180 PhD candidates. The undergraduate programs in Electrical Engineering (which includes options in biomedical engineering and nanoengineering), Computer Engineering (which includes options in software engineering and nanoscale systems design), and Engineering Physics (with an option in nanoengineering), enroll over 600 students.

Research and teaching needs are served by two new buildings with a total area of 340,000 square feet. Facilities include a state of the art machine shop, and a unique world-class nano and microfabrication facility. Located nearby, the National Institute for Nanotechnology (NINT) offers unique opportunities for collaboration with faculty, industry and government. The undergraduate and graduate laboratories are generously equipped with state of the art equipment and excellent computing facilities are available. Extensive funding opportunities are available through a variety of national and provincial sources. Further information about the Department can be found at www.ece.ualberta.ca.

Applicants are invited to submit their curriculum vitae including employment history, a statement outlining research and teaching interests, a brief description of major contributions, reprints of at least two representative research papers, and the names of at least three referees.

The review of applications will begin on November 1, 2008. The competition will remain open until all positions are filled.

Interested applicants may apply to:

Dr. H. J. Marquez, Chair
Department of Electrical and Computer Engineering
University of Alberta
Edmonton, Alberta, Canada T6G 2V4
Email: marquez@ece.ualberta.ca

All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority. If suitable Canadian citizens and permanent residents cannot be found, other individuals will be considered. The University of Alberta hires on the basis of merit. We are committed to the principle of equity in employment. We welcome diversity and encourage applications from all qualified women and men, including persons with disabilities, members of visible minorities, and Aboriginal persons.

china eu india japan korea russia usa

ITER is the joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power. It is now under construction alongside the Cadarache site in Provence, south-east France.

The partners in the project are the European Union, Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the USA.

Further information on **ITER** is available on its website **www.iter.org**.

Applications, from nationals of the partners, are sought for the position of:

Leader of the Coil Power Supply Section

Within the Electrical Engineering Division, the appointee will lead the Section responsible for detailed design, layout, technical specifications, procurement, testing, integration and start-up of the magnet coil power supplies,

Qualifications

- PhD or MSc in Electrical or Power Electronics Engineering.

Experience

- At least 10 years in design, construction and operation of high voltage substations, large step-down transformers, pulsed power distribution systems, AC/DC power conversion plant and reactive power compensation systems.
- Knowledge of power supply systems for Tokamak fusion devices, large science facilities and/or fast discharge systems for the quench protection of large superconducting magnets would be advantageous.
- The ITER team is multinational and multi-cultural; the appointee must perform effectively in this environment. Excellent communication skills in the working language of English will be required.

Application

- The application procedure and applicant requirements are published at **www.iter.org/a/index_jobs.htm**.
- The reference for this position is **CEP-025**.
- Closing date is Friday 31 October 2008.

Further opportunities for positions at **ITER** will become available during 2009 and be published on its website. Interested persons are encouraged to visit the site regularly.

microfab University of Utah

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Fraunhofer Institut Zuverlässigkeit und Mikrointegration IZM Branch Lab at The University of Utah

USTAR

The Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, seeks applications to fill at least two tenure-track positions at the assistant, associate or full professor level for an interdisciplinary research cluster in ***Micro and Nanosystem Integration and Packaging***.

We are particularly interested in candidates with background in electronic micro/nano-system integration and packaging, biocompatible materials and packaging, solid state devices, reliability, testing, and micro/nano system modeling and simulation. Information on department research activities and curricula may be found on the web at **www.ece.utah.edu**. The web site also has information on five more positions available in the department, including a Chair search. Information on the College of Engineering can be found at **www.coe.utah.edu**. Successful candidates will conduct research with tenure track appointments in the Department of Electrical and Computer Engineering, but may also be appointed in other departments such as Materials Science, Bioengineering or Mechanical Engineering. Suitable candidates may be considered for joint appointments with the College of Science or the Medical School at the University of Utah.

These positions are part of the Utah Science, Technology and Research Initiative (USTAR), which was funded by the Utah State Legislature to attract focused teams of outstanding researchers who have the potential to help build major research programs and create new technology that can ultimately lead to commercial products and/or new industries for Utah. The USTAR initiative is also supporting a new interdisciplinary building which will house a new nanofabrication laboratory and characterization facilities that will cater to solid state devices, MEMS, sensor and packaging research and development, as well as the handling of biomedical samples. The building will facilitate communication for researchers such as the ones hired under this solicitation, from engineering, sciences and the medical school, as well as offering lab access for selected industrial stake holders. Information on the USTAR initiative can be found under **www.ustar.utah.gov**. Candidates for this initiative should have a demonstrated track record of successful, funded projects and an interest or track record in technology commercialization, entrepreneurial or industrial experience.

The positions are also associated with and partially supported by the **Fraunhofer Institute for Reliability and Microintegration IZM**, and leverage a strong collaborative and international research program with a Fraunhofer IZM branch laboratory in Utah. Fraunhofer support includes in-house access to Fraunhofer infrastructure, know-how, and resources. Selected positions may be associated with joint Fraunhofer appointments, possibly at a center director's or co-director's level.

Résumés with names, contact information for at least three references, and statements for research and teaching goals should be sent to Ms. Debbie Sparks, USTAR Faculty Search Committee, University of Utah, Electrical and Computer Engineering Department, 50 South Central Campus Drive, Room 3280, Salt Lake City, UT 84112-9206. Email applications are accepted at **dsparks@ece.utah.edu**. Applications will be reviewed starting September 1, 2008, and will be accepted until the positions are filled.

Faculty responsibilities include developing and maintaining an internationally recognized research program, effective classroom teaching at the undergraduate and graduate levels, and professional service. Applicants must hold a Ph.D. by the time of appointment. The University of Utah values candidates who have experience working in settings with students from diverse backgrounds and possess a strong commitment to improving access to higher education for historically underrepresented students. The University is an AA/EO employer, encourages applications from women and minorities, and provides reasonable accommodations for known disabilities of applicants and employees.

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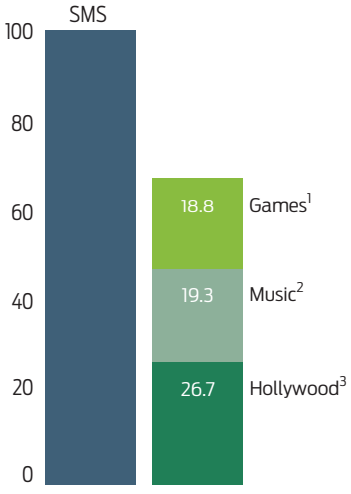
$100 BILLION. THAT'S an estimate of how much the world's 3.3 billion cellphone users spent to send 1.7 trillion text messages last year—more than Hollywood's worldwide box-office receipts, global music sales, and U.S. video-game and PC-game sales combined.

In fact, those movie, music, and gaming revenues will come to only about half the US $130 billion that short message service (SMS) will bring in this year, according to the market research firm Informa Telecoms & Media.

The United States came late to the SMS revolution, but with a fourfold increase in the past two years, its total texting now puts it second only to China. But the country second to none in its fervor to text is the Philippines. Last year, Filipinos sent 155 billion messages. That's more than four messages per day for every man, woman, child, and baby. Filipinos embraced messaging during the political protests of the late 1990s, because it was then the only unmonitored form of communication.

Acision, an SMS service provider in the Netherlands that handles about two-thirds of the world's text messages each year, has noticed a generally "eastward wave of adoption from the UK to Scandinavia to Western Europe, then Eastern Europe, Asia, and finally the Americas. Europe SMS traffic has peaked, Asia is near its peak, and America will be peaking in a couple of years." —STEVEN CHERRY

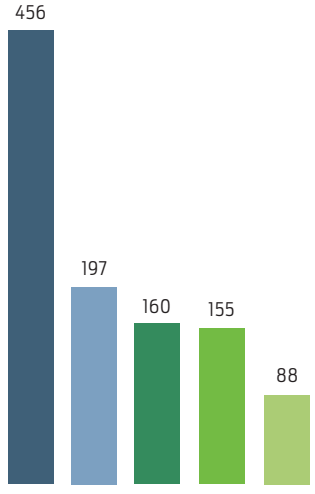
Revenue, 2007
(U.S. $, billions)



[1] U.S. video-game and PC-game sales
[2] Global music sales
[3] Global Hollywood box-office receipts

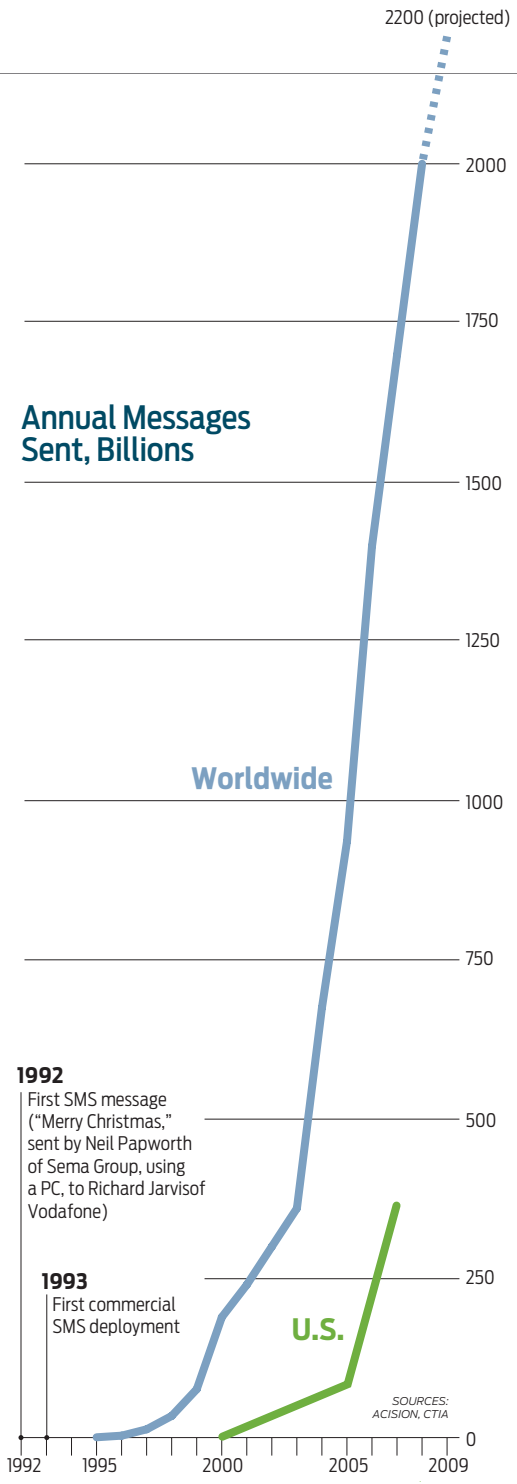
SOURCES: IFPI, RIAA, MPAA

Top Five Texters, 2007
(Billions of messages)



SOURCES: OVUM, QUANTIFICA

Annual Messages Sent, Billions



43 000 000 000
Number of text messages sent, New Year's, 2007–2008
SOURCES: ACISION, ITU

1707
Number of text messages, per person, sent by Filipinos in 2007
SOURCE: OVUM