more important for the improvements it will make to transparency and for its simplified verification procedures, compared with its predecessor. "This is a treaty on training wheels to get us back in the treaty business," he says. "It's about showing we and the Russians can work together on something complex and contentious."

Although further reductions in the US stockpile are likely, the US must plan them carefully to ensure that a credible deterrent force is maintained, cautioned Stephen Younger, a former senior associate director at Los Alamos. In remarks at an NNSA-sponsored conference, Younger said that at some level—perhaps 100 warheads—an enemy might be tempted to launch a preemptive attack, calculating that it can "ride out" whatever retaliatory strike the US can muster with its remaining strategic weapons. Younger, currently president of the contractor that operates the NNSA's Nevada Test Site, said a litany of technological challenges will first have to be met to ensure compliance with a global ban. And then there's the diplomatic challenge of persuading unwilling nuclear weapons nations to disarm.

### A nuclear summit

Just days after the New START treaty signing in Prague, Obama hosted a nuclear security summit that brought a record number of world leaders to Washington in a show of support for his vision to secure within four years all of the estimated 2000 tons of separated plutonium and highly enriched uranium (HEU) scattered around the world. Nearly all the 47 leaders participating at the summit brought with them a recent accomplishment or commitment to lock up fissile materials. Chile, Kazakhstan, Mexico, and Vietnam promised or reiterated previous pledges to send the HEU that fuels their research reactors back to the nation of origin—the US, Russia, or China—and trade it in for low-enriched uranium.

Other countries agreed to install radiation monitors at ports to help detect nuclear smuggling. Russia used the occasion to officially shut down for good its last plutonium production reactor, which doubled as an electrical generating station. The US touted a recently completed HEU materials facility at Oak Ridge that consolidates under one roof the US stockpile of HEU that had been spread around the site in a number of World War II–era warehouses.

Gary Samore, White House coordinator for weapons of mass destruction, counterterrorism, and arms control, told reporters at the summit's conclusion to expect more remarkable achievements to be announced at a second summit in Buenos Aires, Argentina, this fall. "Physical protection is something that governments and industry know how to do if they invest the resources," Samore said. Progress continues in the meantime: On 9 June, the NNSA announced a new agreement with the government of Croatia to equip the Balkan nation's seaports, airports, and border crossings with radiation detectors and to train operators to use and maintain them.

**David Kramer**

# Airport checkpoint technologies take off

**From bench-top instruments to full-body scanners, the US government is testing new equipment to screen humans for explosives.**

**In the wake** of the failed attempt in December 2009 to bring down a Northwest Airlines flight with powder explosives, the US Transportation Security Administration (TSA) has accelerated the revamp of its airport screening technologies. Armed with funds from the 2009 American Recovery and Reinvestment Act, TSA is spending \$50 million on trace-explosives detection systems, \$22 million on liquid-explosives scanners (see story on page 28), and \$73 million on controversial full-body scanners, which might have revealed the explosives knitted to the December suspect's underwear.

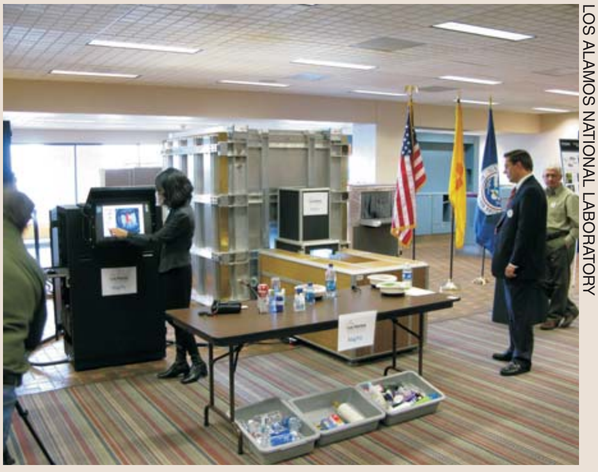
So far, TSA has installed more than 95 full-body scanners, at about \$160 000 each, in 31 US airports; it plans to deploy up to 450 by the end of the year and 500 more next year. Among the primary suppliers are California-based Rapiscan Systems, whose system generates images from backscattered x-ray radiation, and New York–based L-3 Communications, whose scanners generate images from reflected or scattered millimeter waves. Both systems take less than 10 seconds to screen one person, not including the time it takes a TSA agent to analyze the image.

The agency has been evaluating both technologies in airports since 2007. And their use and development date back

## Liquid-explosives scanners stand trial in airports

Air passengers may once more be allowed to pack beverages, lotions, and hair spray in their carry-on luggage, if imaging technologies to detect liquid explosives can prove their worth. Several competing systems, including multi-energy x-ray systems and a low-field magnetic resonance imaging (MRI) scanner, are undergoing field tests at some airports worldwide.

The evaluations are part of a move by some governments to relax restrictions on the transport of liquids, gels, and aerosols through security checkpoints; they also figure in the overhaul of airport security technologies for detecting trace and bulk explosives (see accompanying story). Since the foiled plot four years ago to bomb several transatlantic flights with hydrogen peroxide–based explosives, security regulations have restricted passengers in the US and more than 60 other countries to transparent 100-ml containers that can fit into a small plastic bag.



LOS ALAMOS NATIONAL LABORATORY

A new x-ray scanner developed by UK-based Kromek Ltd can analyze up to 2 liters of liquid regardless of the container's wall thickness or opacity. The company grew out of the physics department's efforts at the University of Durham in 2003 to commercialize a vapor-phase process of fabricating cadmium telluride single crystals, which are used as a solid-state detector for x rays and gamma rays. But Kromek cofounder Arnab Basu quickly saw the opportunity to use the crystals for digital x-ray systems in security applications. Baggage screening requires up to 1 MeV, says Basu, but x-ray baggage screening systems traditionally use silicon detectors, and "most high-energy radiation above 20 keV goes straight through [them]." The denser CdTe detector is more sensitive and can identify classes of chemicals by performing multispectral x-ray analysis; in contrast, conventional x-ray systems measure only density and atomic number, which are not enough to distinguish liquids. Kromek's liquid scanners are already being evaluated in several airports around Europe.

"Why would you use an old-fashioned x-ray machine that just gives you a picture when you're looking for explosives?" says Dolan Falconer Jr, CEO of Atlanta-based ScanTech Holdings, whose dual-energy x-ray checkpoint baggage system is being considered by the Department of Homeland Security's (DHS's) Transportation Security Administration. In dual-energy x-ray systems, metals absorb the lower-energy radiation; organics and lighter materials such as narcotics and explosive compounds in liquids and powders absorb the higher-energy x rays. ScanTech's technology, which was recently selected for installation at Abu Dhabi International Airport in the United Arab Emirates, also uses multiple planes and angles and an advanced detection algorithm to strip out the clutter around objects of interest, says Falconer.

Development of another liquid-scanning technology is being funded by the DHS. Conceived at Los Alamos National Laboratory to map the brain's neuronal activity, MagViz uses an applied low-field (50 µT) MRI to spot liquid explosives and other potentially dangerous materials that may be masked by liquids. "White matter and gray matter in the brain are essentially the same thing to an x-ray machine, but look quite different" on a magnetic resonance image, says MagViz project leader Michelle Espy. An airport-ready model of the system (gray crate and black box in photo) was tested at New Mexico's Albuquerque International Sunport in December 2008.

At low magnetic fields, MagViz does not have the ability to determine the "chemical shift" of resonant frequencies from a reference frequency, which is how MRIs and nuclear magnetic resonance spectrometers determine a material's identity, says Espy. Instead of looking for frequency shifts, the machine gauges chemical differences by measuring spin relaxation times. Espy is pursuing alternatives to the extremely sensitive superconducting quantum interference device (SQUID) detectors, which are needed to pick up the weak magnetic signal, but require bulky cryogenic equipment. Despite that constraint, the technology has attracted several suitors looking to commercialize it.

Even though the liquid embargo remains in place for the foreseeable future, Espy says she's a witness to how quickly, in response to new threats, the government identifies new technologies. "After the [August 2006] terrorist plot, we had DHS in our lab in September looking at our instrument," she says. "It was that fast."

**Jermey N. A. Matthews**

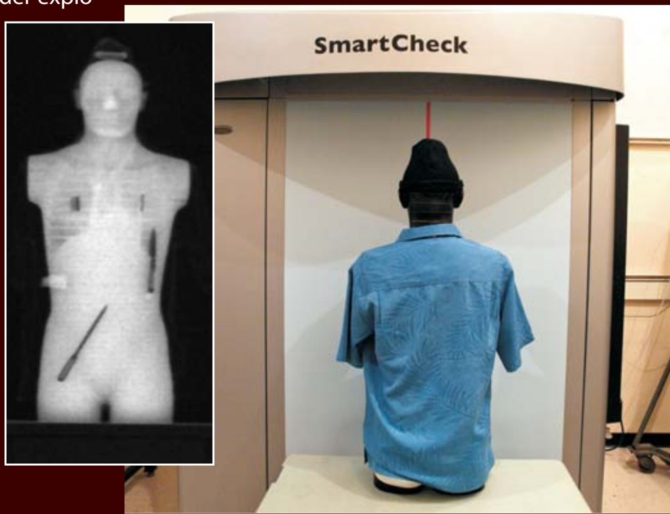
even further, says Michael Gray, director of radiologic compliance and safety at Rapiscan. "Our scanners have been used in courthouses, prisons, and even in battlefield zones for many years."

Millimeter-wave systems come with a tradeoff between penetration and spatial resolution, says Erich Grossman, who has developed superconducting detectors for millimeter-wave scanners at NIST in Boulder, Colorado. "As you increase frequency, clothing becomes progressively more opaque, but spatial resolution becomes better." Another challenge is that the reflected waves often return depolarized or otherwise distorted. Terahertz (submillimeter) technology is in its early stages of addressing those issues, "just like radar technology had to," says Edwin Heilweil, who works on terahertz imaging and spectroscopy systems at NIST headquarters in Gaithersburg, Maryland. The initial goal was that "we'd be able to see and analyze things inside packaged goods, or envelopes, as in the case of the anthrax scare in 2002."

### Virtual pat-down

To address critics' privacy concerns, manufacturers of x-ray and millimeter-wave scanners are incorporating technologies that blur the scanned person's face or present an outline. L-3's new millimeter-wave scanner uses software to automatically identify potential threats and alerts a human screener only if a threat is spotted; the scanner was recently installed at Amsterdam's Schiphol international airport, where the December suspect boarded. Arguing in favor of body scans, Gray says, "I travel extensively, and I'm always amazed at the lack of consistency of pat-downs."

Other critics worry that the x-ray backscatter machines could cause cancer, although they are limited to a radiation dose of 0.25 microsieverts per screening. Mahesh Mahadevappa, chief physicist at the Johns Hopkins University Hospital in Baltimore, Maryland,




**Backscattered x-ray radiation** off a clothed phantom made of real human bones reveals in the scanned image a razor blade (right chest), a ceramic knife (left abdomen), powder explosives (right abdomen), and other potentially dangerous items. NIST is evaluating this full-body scanner, manufactured by American Science and Engineering, and others for use at airport security checkpoints. NIST

says, "A person would have to go through [an x-ray backscatter scanner] 1000 to 2500 times in a year to equal the dosage of one chest x ray." NIST scientist Bert Coursey, who develops performance and safety standards for the Department of Homeland Security, says that the x-ray backscatter systems meet national health and safety standards drafted by the American National Standards Institute (ANSI) and the Health Physics Society and that DHS has contributed to a similar set of standards to be released by the International Electrotechnical Commission next month.

Manufacturers don't always report dosage values that are comparable, says radiation physicist Lawrence Hudson, who is developing performance tests for x-ray backscatter systems at NIST headquarters. "When trying to measure very small exposure from rapidly moving narrow x-ray beams, one must carefully account for various factors," he says. To evaluate a scanner's image quality, NIST uses ANSI standards to develop test kits that contain materials with differing physical and chemical properties to measure various image-quality metrics, such as resolution and materials discrimination. Using specific threat objects to test systems, as TSA does, is important, says Hudson, "but quantitative standard artifact testing is more scientific."

## Multimodal screening

In another section of NIST's Gaithersburg campus, similar quantitative standard artifact testing is being conducted with spectrometers and gas and ion chromatographs that detect trace explosives. After TSA agents swipe a passenger's hands, shoes, or luggage, they place the swipe material into a machine that desorbs the particles by heating, then aerodynamically transfers them to an analysis chamber, says NIST research chemist Greg Gillen. "We [develop] the best practices for collecting samples," says Gillen, such as applying the appropriate force when swiping. Gillen's labs are also studying the thermal, electrostatic, and aerodynamic effects of particle desorption.

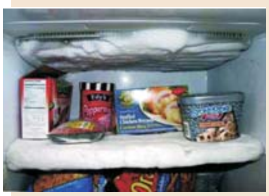
Future airport screening technologies will be multimodal, says James Tuttle, explosives division director at DHS. "Advanced and automated imaging systems integrated with a trace-explosives detection portal are an example of the kind of technology that might be in the airports five to eight years from now."

**Jermey N. A. Matthews** ■

## web watch

**To suggest topics or sites for Web Watch, please visit http://www.physicstoday.org/suggestwebwatch.html. Compiled and edited by Charles Day**

**http://psufoodscience.typepad.com/psu_food_science**



From the food science department of the Pennsylvania State University comes the informative and entertaining blog **The Science of Food**. The blog has a food physics category, where you can find posts about freezer burn, an aggregation phenomenon known as the Cheerio Effect, and other topics. The blog is noteworthy for providing links to the scientific papers it mentions.

**http://www.cifarnbq.ca**

The Canadian Institute for Advanced Research is sponsoring a series of public debates and discussions designed to engage the public in setting the nation's research priorities. Under the title the **Next Big Question**, the debates tackle problems such as Can we build a brain? and Where can quantum computing carry us? and What is the fate of the universe? Besides summarizing the debates, the series website also provides a means to vote for your favorite question.

**http://www.nsf.gov/eyesonthesky**

At NSF's website **Eyes on the Sky** you can find descriptions and images of the ground-based observatories that NSF supports. The site also describes the astrophysical and cosmological questions that the observatories were built to tackle.