The former Soviet Union's stockpile of fissile material remains dangerously vulnerable, yet the Bush Administration has proposed cutting funds for safeguarding it

Nuclear Trafficking: 'A Real And Dangerous Threat'

STOCKHOLM—At the dusty, windswept Dostyk checkpoint on the border of Kazakhstan and China, it takes several hours to prepare the Soviet-era trains for the continuing journey eastward. Each wagon must be winched up so engineers can replace the undercarriage with one that fits the narrower gauge Chinese rails. As passengers gape at the brute-force procedure, Kazakh border guards sweep the idled train for smuggled goods, sniffing around mainly for opium or other narcotics. On 6 April, they uncovered a potentially more sinister shipment: two satchel-sized lead-coated containers packed with a radioactive substance. Kazakh officials have yet to divulge the results of an investigation to determine whether the contraband is the stuff of nuclear nightmares—highly enriched uranium (HEU) or plutonium that might be fashioned into a bomb—and if so, who the intended recipient was. A U.S. official who requested anonymity believes that the material was bound for North Korea.

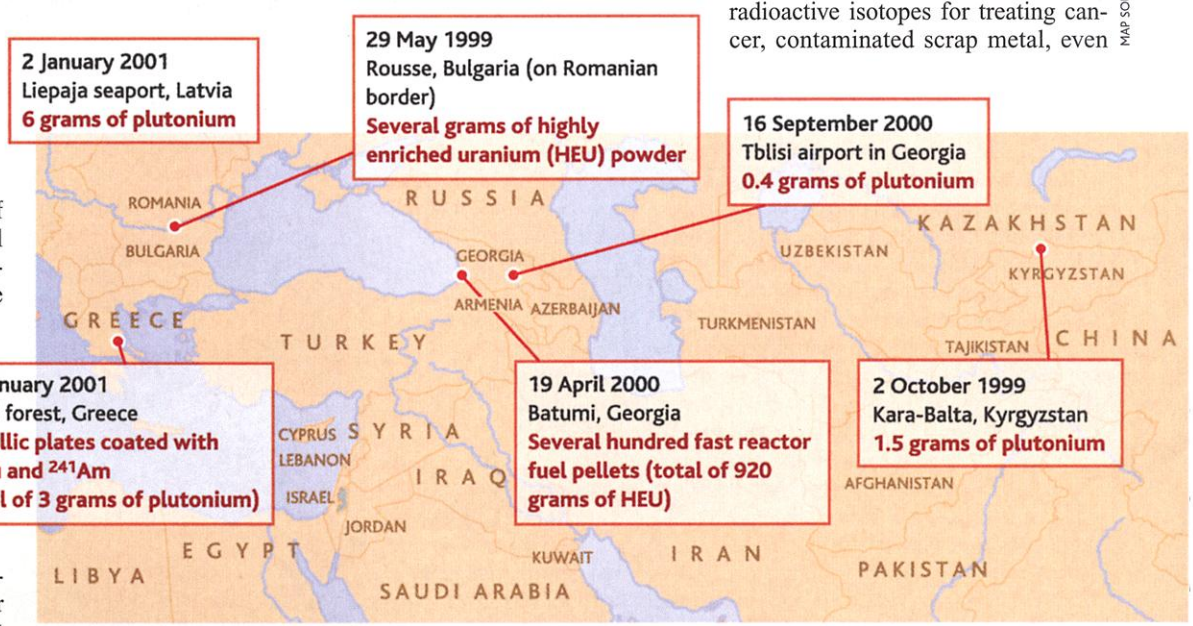
The seizure is both a triumph and a warning for the security officers and scientists engaged in a mostly cloak-and-dagger battle to keep the Soviet nuclear genie bottled up. Although the Kazakh police have on several occasions seized nuclear material, including 150 kilograms of uranium fuel pellets smuggled out of the Ulbinsk uranium-fuel processing facility in Ust-Kamenogorsk in 1995, the Dostyk bust was their first at a border crossing. The triumph is that the contraband was detected at all: The remote checkpoint lacked radiation monitors until the U.S. Department of Defense (DOD) paid for equipment for it early last year. The warning is one echoed by similar incidents across Central Asia and Eastern Europe: A decade-long effort to lock down about 600 tons of Soviet-era HEU and plutonium that is considered especially vulnerable—enough raw material for about 40,000 bombs—has far to go.

"We are in a serious situation now—things have deteriorated," Rolf Ekéus, chair of the Stockholm International Peace Research Institute, said last month at a meeting here on nuclear trafficking sponsored by the International Atomic Energy Agency (IAEA). Indeed, the world is at a critical juncture in its efforts to safeguard nuclear materials. In April, the Bush Administration proposed cutting $100 million from a raft of programs run by the U.S. Department of Energy (DOE) to improve nuclear security in Russia, and the White House National Security Council (NSC) is completing a sweeping review of U.S. defense and nonproliferation policy. A major battle is shaping up in Congress over the fate of these programs, some of which have drawn sharp criticisms in the past few years. "There have to be a number of changes in how we provide assistance," says Harlan Strauss, director of the DOD's International Counterproliferation Program. Meanwhile, several countries, including Russia, are discussing ways to beef up international efforts to counteract nuclear terrorism.

The stakes are enormous. Either "we can spend resources today to eliminate the threat at its source, or we will be forced to spend much more tomorrow to defend ourselves from weapons and technology after they have proliferated," says Senator Richard Lugar (R–IN), an architect of DOD's much-lauded nonproliferation program; it, too, is under NSC scrutiny.

A nuclear Silk Road

Nuclear trafficking is an insidious consequence of the end of the Cold War. "It has emerged as a real and dangerous threat," says Anita Nilsson, head of IAEA's Office of Physical Protection and Material Security. At the Stockholm meeting, her agency released new statistics indicating that there have been more than 550 reported incidents of illicit trafficking worldwide since 1993. The majority involve substances that cannot be turned into atomic bombs: for instance, radioactive isotopes for treating cancer, contaminated scrap metal, even



MAP SOURCE: IAEA

Southern trade route. After a 3-year hiatus, institutions over the past 2 years have reported six seizures of weapons-grade nuclear materials. Although the amounts were not nearly enough for an atomic bomb, DOD's Harlan Strauss says "we're seeing only a small portion of the problem."

New Effort Puts Radiation Sentinels at the Borders

VIENNA—Travelers and luggage passing through customs here at the international airport face more than a collection of surveillance cameras and x-ray machines: For the last several months, they also have been scanned by a neutron and gamma ray detector. So far the focus has been on the detector's performance. But the stakes will go up this summer, when officials begin to search any baggage that triggers the radiation sentinel in an effort to catch nuclear smugglers.

A rise in trafficking of radioactive materials has been one of the most chilling consequences of the breakup of the Soviet Union (see main text). Only recently, however, have European governments begun to crack down on smuggling. A priority is tightening porous borders.

Leading these efforts is the Illicit Trafficking Radiation Detection Assessment Program. Sponsored by the Austrian government and run by scientists from the Austrian Research Centers in Seibersdorf, the program first tested detectors at the Nickelsdorf border crossing between Austria and Hungary. In a 6-month period last year at Nickelsdorf, the detectors revealed a mind-boggling array of radioactive materials crossing the border. Some 13 trucks a day, out of 900 that cross the border, set off the alarms; the rate was lower, but still startling, for passenger vehicles, at one alarm every other day. Border guards discovered everything from contaminated scrap metal to blueberries mysteriously tainted with radioactive cesium. No weapons-grade nuclear materials were intercepted, but such a coup would have been a long shot: "We did not expect to find smugglers," says the project's manager, Peter Beck, a health physics researcher at the Austrian Research Centers, which heavily promoted the study.

The detectors tested at Nickelsdorf aren't foolproof, however. The devices record collisions between gamma rays and neutrons and sodium iodine or plastic scintillation detectors, producing flashes noted by a photomultiplier and registered by a counter. But such detectors can miss the isotopic signature of smuggled material hidden inside a large shipment of legally transportable isotopes or inside a shielded container, says Rolf Arlt of the International Atomic Energy Agency's Safeguards program. "If several isotopes are present," he says, "the current generation of isotope identifiers cannot sort them out properly." Instead, the counters display only the strongest energy peak.

Pointing the way. Fiber optics are being incorporated into experimental radiation detectors. Ionizing radiation interacts with the scintillating fibers and produces light, which is converted to an electrical signal.

Arlt and other scientists are now testing a new generation of portable detectors, with a cadmium-zinc-tellurium semiconductor that sheds electrons when irradiated by gamma rays or neutrons. These detectors "cannot do miracles," says Arlt, but their sharper resolution makes them better than the scintillation detectors at distinguishing isotopes.

—SUSAN LADIKA

Susan Ladika is a freelance writer in Vienna.

gold bars tainted with iodine-131 or U.S. dollars sprayed with zirconium-95. But on at least 16 occasions, police in Europe and Asia have seized HEU or plutonium.

The most high-profile incident occurred in 1994, when a German lab traced 363 grams of plutonium powder back to Russia (see sidebar on p. 1634). "That case helped us realize there was a problem," says Nikolai Kravchenko, chief of nuclear interdiction at Moscow's Sheremetyevo airport. "We had no knowledge, no idea what equipment was needed." However, it wasn't until April 1996, at the Nuclear Safety Summit in Moscow, that Russia officially acknowledged the threat of nuclear smuggling along its 20,000-kilometer border with 14 countries, says Paula Knepper of Los Alamos National Laboratory in New Mexico.

In the wake of that meeting, increased vigilance on the borders and beefed-up security were credited with the fact that no seizures of fissile material were reported to the IAEA between 1996 and 1998. But in late 1998, Russia's Federal Security Service foiled an attempt by insiders to spirit 18.5 kilograms of HEU from a weapons lab in the Ural Mountains, potentially enough for a workable atomic bomb. (It's unclear where the material was headed.) "That's the case I'm most worried about," says analyst Scott Parrish of the Center for Nonproliferation Studies in Monterey, California. He points out that insider conspiracies, which can defeat even modern security measures, pose a continuing threat. And in the past 2 years, six incidents have been reported, including the April 2000 seizure of nearly a kilogram of HEU in the form of fast reactor fuel pellets in the Republic of Georgia (see map). These incidents are alarming enough, but "we're seeing only a small portion of the problem," argues Strauss. "We really are on the edge of the unknown."

Russia's nuclear arsenal of about 20,000 strategic and tactical warheads poses some risks, but the warheads are not the main problem, experts say; they are relatively well secured, and their fissile material is hard to remove. The real threat comes from the world's largest stockpile of HEU and plutonium—about 600 metric tons—that's not already incorporated into warheads. This nuclear legacy is stored at weapons labs, civilian research centers, and naval shipyards. As the case in the Urals indicates, much of the material is vulnerable to inside jobs, because many Cold War–era safeguards still in place—guards, guns, and gates—"were designed with spies in mind," says Alexander Schmid of the United Nations Terrorism Prevention Branch in Vienna.

Interpol and domestic intelligence agencies have shared sketchy information about organizations that may be involved in nuclear trafficking and about their motives. Most worrisome are the aspirations of nations that can accrue the expertise necessary to process uranium and plutonium into warheads. Take Iran, for example. Russia has provided assistance and equipment for Iran's nuclear power industry and had cut a deal to sell Iran laser isotope separation technology that could be used to enrich uranium; the deal was scuppered after U.S. objections. "I think this relationship with Iran has been a conduit for all kinds of nuclear material we don't know about," worries Rensselaer Lee, a senior fellow at the Foreign Policy Research Institute in Philadelphia.

"There's an undeniable trend toward proliferation [by] states. If this trend spills over into nonstate actors, we're in real trouble," says Schmid. The U.S. Central Intelligence Agency has drawn up a list of a dozen terrorist groups known to be attempting to acquire weapons of mass destruction, including Osama bin Laden's Al Qaeda. Whereas some groups

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hope to develop makeshift warheads, says Roberto Maroto of Interpol's General Secretariat in Lyon, France, intelligence reports suggest that others would settle for "radiological bombs"—conventional devices that could disperse hazardous material over a wide area. "Such devices are easy to make," he notes.

In the early 1990s, the worst hemorrhaging of former Soviet nuclear materials seemed to be into Eastern Europe. Over the past few years, however, concern has shifted to Central Asia and the Caucasus. "This is much more sensible from the traffickers' perspective—lower risks and nearer to potential end users" like bin Laden, says Phil Williams, director of the Matthew B. Ridgway Center for International Security Studies at the University of Pittsburgh.

One emerging transit route, says Sergey Chetvergov of Kazakhstan's Atomic Energy Committee, is south from Kazakhstan through Uzbekistan and Turkmenistan into Iran, Afghanistan, and perhaps on to Pakistan. And according to Aysun Yücel of the Turkish Atomic Energy Authority, Turkey has become another major route for traffickers. Police investigations of seizures inside Turkey, she says, indicate that material is making its way westward from former Soviet countries—particularly Kazakhstan—over the Caspian Sea, across the Caucasus, and into Turkey, with potential intended destinations being Syria, Iran, and Iraq. "Fortunately, the illicit trafficking incidents involved amateurs" who were not well organized, Yücel says. To step up vigilance at the borders, she says, Turkey and the United States last year signed an agreement to install radiation detectors along Turkey's eastern frontier.

Border check. Stepped-up use of radiation detectors is being urged along sensitive borders.

CREDITS: (TOP TO BOTTOM) P. BECK/AUSTRIAN RESEARCH CENTER SEIBERSDORF; SOURCE: DOE AND THE CENTER FOR NONPROLIFERATION STUDIES

U.S. policy: at a crossroads

Since 1993, DOE has spent more than $550 million to safeguard Russia's HEU and plutonium stockpiles. But its Material Protection, Control, and Accounting (MPC&A) program has paid for full security systems for only 86 tons and partial protection for a further 106 tons—in all, about a third of the total that DOE considers most vulnerable. Security measures range from the simple—placing 1-ton concrete blocks over containers holding plutonium at the Mayak Production Association in the Urals—to the complex—using electronic barriers to limit access to sensitive rooms at Moscow region's Obninsk nuclear facility, the origin of 2.7 kilograms of HEU seized in Prague in December 1994. DOE expects it will take another decade and at least $1.7 billion more to deal with the rest, by either securing it or converting it to a form that can't be used for weapons.

The Bush budget would cut the MPC&A program from $170 million this year to $139 million in 2002—$87 million less than DOE requested. These cuts would come "just when the program is gathering momentum," says Russian nuclear expert Matthew Bunn of Harvard University's Belfer Center for Science and International Affairs. He notes that the program has enjoyed consistent bipartisan support, however, and predicts that Congress will restore MPC&A's budget to at least 2001 levels.

The future looks far grimmer for another DOE program, this one designed to help Russia find peaceful work for its nuclear weapons scientists. Russia's atomic energy ministry, Minatom, is downsizing its nuclear weapons complex and has asked DOE for help in creating at least 1500 civilian jobs each year for former weapons scientists in 10 closed, and once top-secret, cities that form the core of this complex (*Science*, 8 January 1999, p. 160). DOE agreed. In late 1998, it launched the Nuclear Cities Initiative (NCI), with ambitious hopes to spend $600 million over 5 years on projects in all 10 cities. In its first 2 years, however, Congress approved just $22.5 million for projects in three closed cities: two weapons design centers—Sarov and Snezhinsk—and Zheleznogorsk, a production facility. Many of the 370 workers NCI supports work on part-time contracts for the U.S. national labs. NCI won an increase to $26.6 million in 2001, but the Bush Administration has proposed a 75% cut for 2002, to $6.6 million.

The Administration's antipathy toward the program was bolstered by a report released last month by the congressional General Accounting Office. It pointed out that only 30% of NCI funds were spent on projects and activities in Russia; the vast majority was eaten up mainly by travel costs and salaries of U.S. national labs staff members who manage NCI projects and by overhead charges. (DOE officials characterize the expenditures in the U.S. labs as "start-up costs.") The Russians have not helped NCI's cause, either. Officials in Zheleznogorsk, for example, recently torpedoed a project by refusing to allow technology for a luminescent tube recycling project to be moved outside the city's restricted zone—a fundamental NCI requirement. And on more than two dozen occasions over the past 2 years, the Russian government has denied visa requests from U.S. personnel planning to visit the three NCI-supported cities. These actions have slowed projects and, in a big embarrassment for the program, scotched a U.S.–Russian NCI oversight meeting last

U.S. NUCLEAR NONPROLIFERATION SPENDING*

Program	FY 2001 Appropriation ($ thousands)	FY 2002 Request to Congress ($ thousands)	FY 2002 vs. FY 2001 ($ thousands) (%)
Nonproliferation and Verification R&D	244,515	206,102	–38,413 (–15.7)
Arms Control	148,588	101,500	–47,088 (–31.7)
Material Protection, Control, and Accounting (MPC&A)	169,707	138,800	–30,907 (–18.2)
HEU Transparency Implementation	14,592	13,950	–642 (–4.4)
International Nuclear Safety	19,401	13,800	–5,601 (–28.9)
Fissile Materials Disposition	226,148	290,089	+63,941 (+28.3)
Program Direction	51,459	51,459	0 (0)
Subtotal, Defense Nuclear Nonproliferation	874,410	815,700	–58,710 (–6.7)
Use of prior year's balances	-526	-42,000	–41,474 (–7885)
Total budget for Defense Nuclear Nonproliferation	873,884	773,700	–100,184 (–11.5)

* Does not include Nuclear Cities Initiative.

November. "They've promised us more cooperation only if NCI spends more money in Russia," grouses one DOE official.

At the proposed level of funding, "it will be very difficult, if not impossible, to sustain a viable program," says William Hoehn III, director of the Washington, D.C., office of the Russian-American Nuclear Security Advisory Council, a bilateral think tank. He and other observers hope, however, that a fledgling European initiative can pick up some of the slack. This Italian-led effort, which will focus on environmental and energy-efficiency projects, has just started raising funds from European nations.

The NCI is not the only imperiled part of DOE's year-old long-term Russian nonproliferation initiative. The Administration's proposed cuts would, among other things, eviscerate DOE's efforts to help manage Russia's 30 tons of plutonium extracted for fuel at civilian power plants and shelve research on a geological repository for spent fuel—a Russian version of Yucca Mountain. The cuts would also eliminate an effort to set up an unclassified database of Russia's plutonium stockpile. "The consequences of these cuts are quite substantial," asserts Bunn. Adds Hoehn, "It sends a signal to me that these efforts are simply not going to be a priority security issue for the Bush Administration."

Some experts argue, however, that the money for programs like MPC&A and NCI would be better spent "disrupting nuclear deals in the making where possible," as Lee puts it. He advocates stepping up intelligence gathering on so-called rogue nations like Iraq and North Korea and increasing border surveillance, while ending the economic and diplomatic isolation of these states "to undercut the strategic rationale" for developing weapons of mass destruction. Many other experts concur that intelligence operations must be strengthened. "We need to know in more detail what kind of actors are doing what," says Lars van Dassen, director of the nuclear nonproliferation program at the Swedish Nuclear Power Inspectorate. Others argue that although both kinds of activities are urgently needed, "the best hope is to secure the materials so they are never stolen in the first place," says Bunn.

Diplomacy: the missing voice

While the United States debates the future of its nonproliferation efforts, other countries are looking for ways to strengthen international treaties and programs. Experts are now discussing how to tighten accounting under the Convention on the Physical Protection of Nuclear Material, which binds signatories to track exports and imports of weapons-grade uranium and plutonium. The United Nations is weighing new ideas and might consider a Russian antiterrorism measure that would ask states to improve physical controls on all nuclear materials. Another far-reaching scheme is taking shape within IAEA. Physicist Moustafa Bahran, chair of the National Atomic Energy Commission of the Republic of Yemen, is lining up support for a voluntary program to tag and track high-risk materials. He intends to propose it at the next IAEA general conference in September.

Over the next few months, however, the focus will be on the United States. The Administration's defense and nonproliferation policy is expected early this month, and Congress will debate the budget proposals throughout the summer. Provoking the most concern, perhaps, is the apparent rudderlessness of the U.S. nonproliferation strategy. "There's nobody in charge at the moment," says Bunn. What's needed, he argues, is someone who would report directly to the president and oversee nonproliferation efforts across the government. "I'm absolutely convinced that if the president went to Congress with a plan, we'd see substantial funds for nonproliferation efforts," Bunn says. Without such a plan and the money to implement it, the cat-and-mouse game between nuclear traffickers and border guards at Dostyk and other remote corners of the world may shift in favor of the smugglers—leaving the world a far riskier place. **–RICHARD STONE**

MEETING LANGUAGE, BRAIN, AND COGNITIVE DEVELOPMENT

What Makes the Mind Dance and Count

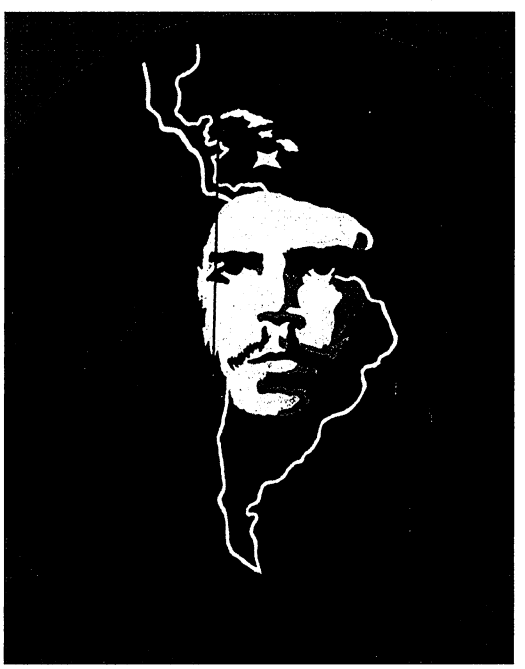
PARIS—Four dozen leading cognitive neuroscientists met here at the Collège de France from 3 to 5 May to share their latest data on topics such as amusia—an inability to perceive music—and number sense in infants. The "Language, Brain, and Cognitive Development" gathering was held in honor of Jacques Mehler, founder of the journal *Cognition*, who will soon retire from CNRS.

Wired for Sound, Not Music

Che Guevara was widely recognized as a man of many talents. Yet one talent the 1960s revolutionary lacked was the ability to hear music, a shortcoming he was acutely aware of. According to one account, Guevara was at a party one evening when he spotted a nurse he wanted to dance with. He asked a friend to give him a nudge when the orchestra struck up a tango. But the friend got the signal mixed up, sending Guevara out on the dance floor to dip and swirl his partner absurdly to the tune of a soft Brazilian samba.

Guevara suffered from congenital amusia, a nearly total tone deafness that turns music into mere noise. Although 5% or more of some populations suffer from this syndrome, it has not been widely studied. At the meeting, Isabelle Peretz of the University of Montreal reported preliminary results with amusical subjects that may support the hypothesis that the brain contains specific neural pathways for music.

Peretz studied 11 amusical adults who had a high level of education, didn't have any loss of hearing or other obvious neurological impairments, and had tried to take music lessons when children and thus had been exposed to music from an early age. These individuals, along with 67 control subjects, were given a battery of tests for musical ability and other cognitive skills, such as language ability. Most members of the amusical cohort were unable to detect when a tune, such as "Happy Birthday," was played with pitch alterations that made it clunk in the ears of the



Too tone-deaf to tango. Che Guevara.

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