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### Guarding Nuclear Reactors and Material From Terrorists and Thieves

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For decades the United States has sought international standards to ensure that nuclear facilities and materials are physically protected against theft and sabotage. On September 11, the need for such an initiative became strikingly apparent as analysts pondered the other possible targets of a terrorist attack. What would have been the loss of life if, for example, a hijacker had crashed a fuel-laden jetliner into a nuclear reactor, causing a meltdown and dispersing radioactive material?

Indeed, just days after the attacks, Mohamed ElBaradei, the head of the International Atomic Energy Agency (IAEA), made it clear that the attack had dramatic implications for the nuclear industry and for non-proliferation: "The tragic terrorist attacks on the United States were a wake-up call to us all. We cannot be complacent. We have to and will increase our efforts on all fronts—from combating illicit trafficking to ensuring the protection of nuclear materials—from nuclear installation design to withstand attacks to improving how we respond to nuclear emergencies."

Spencer Abraham, the U.S. secretary of energy, appeared before the IAEA to urge "maintaining the highest levels of security over nuclear materials." "We need to strengthen international commitments and cooperation on the physical protection of nuclear materials, particularly those that can readily be converted to weapons use," he said.

If terrorists were willing to kill thousands of innocent people in suicidal attacks against buildings symbolizing America's economic and military power, they would probably not hesitate to use truck bombs made of conventional explosives to attack nuclear reactors in order to create clouds of radioactivity like those produced by the 1986 disaster at Chernobyl. They would have little trouble acquiring anti-tank weapons that could blow up the heavy canisters in which radioactive spent fuel from nuclear reactors is transported through populated areas. It is even possible that they could acquire fissile material from one of the poorly guarded nuclear facilities around the world and find scientists willing to make nuclear weapons.

Current international agreements do not require that nuclear material and facilities in domestic use be guarded against thieves or saboteurs, including terrorists. This is a dangerous gap in the global barrier against proliferation. The IAEA has taken the first steps toward requiring measures to physically protect nuclear materials, but it is essential that this effort be pursued expeditiously and that countries take all reasonable steps to ensure that nuclear material is not part of the next terrorist attack.

#### Safeguards Do Not Protect

The 1968 nuclear Non-Proliferation Treaty (NPT) requires non-nuclear-weapon states to accept safeguards administered by the IAEA on all their nuclear activities. But, when the NPT was drafted, nuclear terrorism was not perceived as a significant threat, and the safeguards consist of monitoring and accounting measures designed to prevent non-nuclear-weapon states from diverting nuclear material from peaceful nuclear activities to weapons programs. The safeguards are not intended to prevent theft of nuclear material by outsiders or the bombing of reactors and spent fuel by terrorists.

Today there are threats not foreseen in 1968 that are unlikely to be deterred by NPT requirements: terrorists who want to blow up nuclear reactors with high explosives to kill civilians and create chaos, thieves who want to steal weapons-usable nuclear material to sell to states or terrorists seeking nuclear weapons, and disgruntled employees who want to steal material and sell it on the black market.<sup>1</sup>

The threat that a terrorist might try to blow up a U.S. nuclear facility is frighteningly plausible. Even before the September 11 attacks, conventional high-explosive bombs delivered by car, truck, or boat had been used in numerous terrorist attacks on U.S. facilities: a U.S. Marine barracks in Lebanon in 1983, the World Trade Center in New York City in 1993, the Federal Building in Oklahoma City in 1995, a U.S. military housing complex in Saudi Arabia in 1996, two American embassies in Africa in 1998, and a U.S. naval vessel in a port in Yemen in 2000.

If such an attack against a nuclear plant were successful, the number of casualties could be extremely high because of the resulting spread of radioactive material. In 1981, an environmental impact statement prepared by the U.S. Nuclear Regulatory Commission (NRC) estimated that a large truck bomb used against a nuclear reactor in a highly populated area could produce 130,000 fatalities.<sup>2</sup> In effect, a simple conventional explosive used against a nuclear facility would serve as a large radiological weapon. The possibility of terrorist attacks on nuclear reactors is, of course, not limited to those in the United States. Attempts to blow up or penetrate nuclear reactors have been reported in Western Europe, Russia, South Africa, Argentina, and South Korea.<sup>3</sup>

Despite the danger, no multilateral treaty requires that nuclear material and facilities be protected from such attacks. The IAEA recommends, but does not require, general provisions to protect reactors against sabotage, and IAEA inspectors do not check whether these recommendations are observed. The Nuclear Suppliers Group asks that the recipients of nuclear exports take into account IAEA recommendations, but it does not make them mandatory.<sup>4</sup>

The NRC's rules do contain explicit requirements for protection of licensed civilian reactors, and in 1993—after the World Trade Center bombing and after a car that could have contained a bomb crashed through the fences around Pennsylvania's Three Mile Island reactor—the commission adopted new standards for protecting U.S. civilian power reactors from truck bombers. However, even before the attacks of September 11, those standards were criticized as being too weak,<sup>5</sup> and on September 19 an IAEA statement acknowledged that most nuclear power plants are not strong enough to withstand attack by "a large jumbo jet full of fuel" without dispersion of large amounts of radioactive material.<sup>6</sup>

It is also difficult to ascertain whether the U.S. departments of Defense and Energy require similar standards for comparable government facilities because many of their rules on protection are classified. Some Department of Energy nuclear facilities appear vulnerable to terrorist attack. A 1999 Energy report states, "Recent tests have shown that barriers and vault systems used by the U.S. Department of Energy are not as robust as once thought.... Although many approaches have been investigated, a promising technological alternative has not yet been identified."<sup>7</sup>

Although the danger that hostile states or terrorists will acquire and use nuclear weapons seems smaller than the threat that terrorists will use conventional explosives to destroy nuclear facilities, the consequences could be far greater.

There is clearly a market for weapons-usable nuclear material, and inadequately protected nuclear material threatens everyone. It is not just states like Iran, Iraq, Libya, and North Korea that may be seeking nuclear weapons; the Aum Shinrikyo sect and Osama bin Laden's al Qaeda group have also

tried to acquire nuclear material for weapons.<sup>8</sup> If hostile states or terrorists were to obtain enough highly enriched uranium (HEU) from civilian facilities, the manufacture of a simple Hiroshima-type bomb would be within their ability.<sup>9</sup>

The IAEA safeguards required by the NPT would eventually detect the absence of the stolen material from safeguarded facilities, but thieves, who intend to steal material and disappear, would not likely be deterred by the fact that the theft would be discovered after they had departed. If significant quantities of weapons-usable material became readily available on the nuclear black market, the other actions taken to prevent the spread of nuclear weapons (such as IAEA inspections, export controls, and NPT conferences) would be futile.

A great deal of fissile material exists in civilian facilities around the world, and experience has shown that some of it is vulnerable to theft. According to August 2000 IAEA estimates, a total of more than 1,306 kilograms of highly enriched uranium exists in research reactors in 27 countries, sometimes in quantities large enough to make a bomb.<sup>10</sup> Twenty percent of these reactors are in Asia and the Middle East. Plutonium is often better protected than HEU, but 12 countries possess a total of 180,000 kilograms of civilian plutonium, and the amount is growing rapidly.

As of September 1999, the IAEA had recorded 139 reports of illicit trafficking of nuclear material,<sup>11</sup> most of which have come from Europe—although it is unclear whether this is the result of more trafficking there or simply more effective police work. Much of the nuclear material in these cases has probably come from Russia or other former Soviet republics. For example, several kilograms of HEU from Russia were seized in Prague from a gang with members in Belarus, the Czech Republic, Germany, and Russia. European security authorities are currently investigating alleged arrangements for the sale of Russian radioactive material by a prominent member of a Russian crime organization to representatives of al Qaeda. But Russia's troubled nuclear infrastructure is not the only source of at-risk fissile material: HEU stolen from a research reactor in the Congo was apprehended by police in Italy and Belgium in 1998.<sup>12</sup> Earlier this year, 600 grams of HEU of unknown origin was seized in Colombia.<sup>13</sup>

### Addressing the Gap

The IAEA refers to securing nuclear facilities against thieves and saboteurs as "physical protection" to distinguish it from the monitoring and accounting "safeguards" required by the NPT. "Physical protection" means providing walls, fences, human guards, sensors, and alarm systems that will detect, warn against, and ultimately help prevent the unauthorized movement of humans, vehicles, or radioactive substances within a protected area.

Many countries provide some form of physical protection for their nuclear material, but because there is no international standard or requirement for physical protection of civilian nuclear material (as there is for safeguards), countries' protections vary widely and are often inadequate. For example, of 19 countries with nuclear facilities covered by a 1997 survey, only 11 reported that they had designed their physical protection facilities to deal with terrorism.<sup>14</sup>

Just as the NPT's requirement that non-nuclear-weapon states have safeguards is essential to prevent the spread of nuclear weapons, so is the requirement that all countries with nuclear material have physical protection for nuclear material. If terrorists can crash large planes into the Pentagon, they can certainly find a way to attack nuclear reactors. And if thieves can steal weapons-usable material in Russia, the Congo, Colombia, or elsewhere, they can use it to make nuclear weapons or sell it to someone who will.

There is one treaty that provides for physical protection of civilian nuclear material: the 1980 Convention on the Physical Protection of Nuclear Material. But it only applies to the protection from theft of material in international transit—for example, reprocessed plutonium being shipped from England back to Japan. The original draft of the treaty, proposed by the United States, was designed to cover both international transport and domestic transport, use, and storage. However, during the negotiations, important potential parties objected to domestic requirements, and in the end the treaty protected civilian nuclear material only against theft in international transport. It now has 69 parties, including most countries with major nuclear programs.

The convention divides nuclear materials into categories, which receive different levels of protection depending on the amount of material in question and how useful that material would be in making weapons. For example, more than two kilograms of unirradiated plutonium and more than five kilograms of unirradiated uranium (containing more than 20 percent of the isotope U<sup>235</sup>) are in Category I, which receives the highest protection. The convention requires that Category I material in storage related to international transport be located within a "protected area" with access restricted to "persons whose trustworthiness has been determined," and it requires surveillance of the material by guards in close communication with response forces.

In 1997, the United States and the IAEA began to consider amending the convention to make it applicable to nuclear material in domestic use, and in 1999 the director-general of the IAEA convened a group of experts to recommend a course of action.<sup>15</sup>

Experts in the IAEA working group did not have a lot of information on current country practices for domestic protection because there is no treaty that requires providing that information, which most countries regard as confidential. To compensate, the experts relied in part on a few general observations.

First, they noted that all of the nuclear material involved in the many incidents of illicit trafficking known to the IAEA seemed to have come from domestic use, storage, and transport—not from the international transport covered by the convention. Therefore, they concluded that amending the convention to require domestic protection could help reduce illicit trafficking.

Second, experts in the working group from developing countries reported that they had difficulty persuading their legislatures and other authorities to adopt physical protection statutes and regulations because there was no multilateral treaty requiring standards for domestic protection. This meant that passing legislation and appropriations at home for adequate physical protection was often difficult.

Finally, the experts saw that the amount of nuclear material in peaceful nuclear programs under IAEA safeguards was rapidly increasing—six-fold since the convention was negotiated in the late 1970s. This meant that, without major efforts to provide new funds for physical protection in each country needing improvements—funds that legislatures were reluctant to provide without an international requirement—the risks of theft and sabotage of nuclear material were likely to increase.<sup>16</sup>

The experts concluded that the IAEA director-general should convene a group to draw up the text of an amendment to the convention. They specifically recommended that the amendment make the existing convention applicable to domestic use, storage, and transport of nuclear material. They further recommended that the convention be expanded to require protection against sabotage, not just theft; that the convention clearly state the objectives of physical protection; and that information about how a particular facility is protected be kept confidential.

However, the experts opposed amendments that would mandate any international oversight, reporting requirements, or peer review of how states implemented physical protection measures. Instead, the experts explicitly placed the onus of ensuring physical protection on the national governments. In a set of 12 fundamental principles that they approved in addition to their recommendations for amendments, the experts said that the country with nuclear material should be "responsible for establishing and maintaining a legislative and regulatory framework to govern physical protection" and that that country should provide inspections of physical protection under its authority. Clearly, the experts wanted to avoid international verification of how states would implement the amended convention's requirements.

The experts also opposed amendments that would permit more changes in protection standards at a later date without once again going through the arduous amendment process, apparently not wanting to make it too easy to raise standards again.

It may seem surprising that some experts opposed principles or amendments that would support some sort of international verification, which would

help ensure that agreed-upon measures were actually being implemented. Perhaps the nuclear industries in important developed countries were resistant to changes that would cost them more money. Perhaps some of the European Union countries, which had earlier contributed to improvements in safeguards and physical protection in Russia, could not believe that nuclear material stolen in the Congo or Colombia could threaten them. Perhaps China and Russia feared inspections or a requirement that reports on their physical protection practices be submitted to other countries.

In the end, U.S. experts, who supported verification provisions, could not overcome opposition to any measure requiring any type of international oversight over national protection practices. If the experts' recommendations are the basis for the negotiation of a treaty amendment, there will be no required international verification and no required reports from parties providing significant information on physical protection practices. This weakens the convention and makes it more difficult to standardize protection procedures internationally.

#### What Next?

The IAEA's Board of Governors and the IAEA's General Conference welcomed the experts' report on amending the convention, the Board meeting just before and the Conference meeting just after the September 11 attacks. The General Conference accepted the Board's approval of the experts' fundamental principles, which state that responsibility for regulation of a system for physical protection "rests entirely within" the state having the system. It commended the IAEA's programs of training, guidance, and technical assistance to assist states in establishing or improving systems of physical protection. Finally, it requested the IAEA to strengthen all of its work "relevant to preventing acts of terrorism involving nuclear materials and other radioactive materials," and it urged IAEA members to support all of these programs.

Most importantly, the General Conference unanimously supported the decision by Director-General ElBaradei to convene a meeting of experts to draft an amendment to the convention on physical protection. That meeting is scheduled for December 2001. Given the new concerns about physical protection after September 11, there could be a new effort in the drafting meetings to add some sort of international verification or reporting requirement. Or perhaps an amendment could simply require that each country's national implementing legislation be reported to the IAEA. This would allow the IAEA to verify whether states-parties had in fact adopted national standards and whether their application is subject to national inspection.

However, even if it does not include provisions for international verification, an amendment to the convention making its requirements for physical protection applicable domestically and adding provisions on sabotage is essential. Physical protection practices vary a great deal from country to country, and the threat from terrorists, thieves, and saboteurs is all too real.

Adoption of stronger physical protection standards against these threats is essential, and the sooner the better. Unfortunately, putting an amendment into effect will probably take several years. In the meantime, the Board-approved principles for physical protection and the IAEA-recommended standards for physical protection, both of which deal with sabotage as well as theft, should be applied immediately.

If adequately funded, the IAEA can provide guidance, training, advisory services, and technical assistance to help countries improve their protection practices and to implement the new principles and recommendations. For countries that accept an IAEA advisory team and cannot afford the protection that that team recommends, financial assistance could be provided as it already has been to Russia, some former Soviet republics, and a few East and Central European countries. This could be an inducement to the states given assistance not only to provide the protections but to join the convention if they have not yet done so.

The United States and the international community can no longer postpone taking stronger measures to ensure the physical protection of nuclear facilities and nuclear material. Weapons-usable material must be kept out of the hands of states and terrorists trying to make nuclear weapons, and nuclear reactors and spent fuel must be protected from sabotage, lest an attack spread radioactive debris over a large area, killing many and injuring more. Now is the time for the United States and the IAEA to take the lead in securing the world's vulnerable nuclear infrastructure.

#### NOTES

1. A survey for Gosatomnadzor, the Russian nuclear regulatory agency, showed that every nuclear theft from the Russian facilities it regulated during 1990-95 involved an insider (though outsiders were often involved) and none were detected by the existing Russian safeguards and protection systems then in effect. I. Koupriyanova, "Russian Perspectives on Insider Threats," Proceedings of the 40th Annual Meeting of the Institute for Nuclear Materials Management, July 1999.
2. Nuclear Regulatory Commission, "Supplement to Draft Environmental Statement Related to the Operation of San Onofre Nuclear Generating Station, Units 2 & 3," NUREG-0490, January 1981. See also Sandia National Laboratories, "An Analysis of Truck Bomb Threats to Nuclear Facilities," 1984; Sandia National Laboratories, "Summary Report of Workshop on Sabotage Protection in Nuclear Power Plant Design," February 1977.
3. Oleg Bukharin, "Problems of Nuclear Terrorism," *The Monitor: Nonproliferation, Demilitarization and Arms Control*, Spring 1997, p. 8; Oleg Bukharin, "Upgrading Security at Nuclear Power Plants in the Newly Independent States," *The Nonproliferation Review*, Winter 1997, p. 28; Three Mile Island Alert Security Committee, [www.tmia.com/sabter.html](http://www.tmia.com/sabter.html).
4. The IAEA recommendations are in IAEA Information Circular 225, Rev.4 (1999). The suggestion from the suppliers that these recommendations "are a useful basis" for physical protection practices appears in Annex C to Nuclear Suppliers' Guidelines, IAEA Information Circular 254 (1999).
5. Testimony of Paul Leventhal, president of the Nuclear Control Institute, to the U.S. Nuclear Regulatory Commission, May 5, 1999.
6. See William J. Cole, "Global Atomic Agency Confesses Little Can Be Done to Safeguard Nuclear Plants," Associated Press, September 19, 2001.
7. U.S. Department of Energy, DOE Research and Development Portfolio: National Security, 1999, p. 87.
8. George J. Tenet, testimony before the Senate Select Committee on Intelligence, February 2, 2000; "U.S. Indictment: 'Detonated and Explosive Device,'" *The New York Times*, November 5, 1998; Gavin Cameron, "Multi-Track Micro-Proliferation: Lessons from Aum Shinrikyo," *Studies in Conflict and Terrorism*, October-December 1999.
9. J. Carson Mark, Theodore Taylor, Eugene Eyster, William Maraman, and Jacob Wechsler, "Can Terrorists Build Nuclear Weapons?" in Paul Leventhal and Yonah Alexander, eds. *Preventing Nuclear Terrorism*, (Lexington Books, 1987), pp. 55-65; U.S. Department of Energy, *Nonproliferation and Arms Control Assessment of Weapons-Usable Material Storage and Excess Plutonium Alternatives*, 1997, p. 35-39.
10. IAEA, "Nuclear Research Reactors in the World," IAEA-RDS-3, September 2000.
11. IAEA Director-General Mohamed ElBaradei, statement to the General Conference, September 1999.
12. See Fritz Steinhausler and Lyudmila Zaitseva, *Database on Nuclear Smuggling, Diversion and Orphan Radiation Sources*, Stanford Institute for International Studies, 2001.
13. *Ibid.*
14. Kevin J. Harrington, *Physical Protection of Nuclear Material: National Comparisons*, Sandia National Laboratories in cooperation with Stanford University Center for International Security and Cooperation, 1999.
15. See George Bunn, "Raising International Standards for Protecting Nuclear Materials from Theft and Sabotage," *The Nonproliferation Review*, Summer 2000, p. 146, 152.
16. M. Gregoric, "Ongoing Efforts to Strengthen the International Physical Protection Regime," IAEA International Conference on Security of Material, Stockholm, May 7-11, 2001, Paper IAEA-CN-86. (Gregoric was the chairman of the experts working group, and he gave a report on its work at this Stockholm Meeting.)

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Once nuclear material is acquired, could terrorists make a nuclear weapon? Yes U.S. Office of Technology Assessment (1977): "A small group of people, none of whom have ever had access to the classified literature, could design and build a crude nuclear explosive device [O]nly modest machine-shop facilities that could be contracted for without arousing suspicion would be required." No country that has nuclear weapons (and Iran is not one of these) would want terrorists to get their hands on a nuclear weapon for fear that it would actually be used right there, on that country. So security, background checks, and so on are all very secure when it comes to access to these weapons. So no, terrorists cannot get their hands on one. The Nuclear Security Summit, started by President Obama in 2010, aims to address this problem by encouraging governments to secure and eliminate weapons-usable nuclear materials. The fourth of these meetings begins Thursday in Washington, with more than 50 world leaders, including President Xi Jinping of China, expected to attend, though not President Vladimir Putin of Russia. Experts say that many officials do not believe that nuclear terrorism is a serious threat. Even if the chances are small that terrorists will acquire a nuclear weapon, the fact that the potential consequences are devastating should propel summit participants to aggressively plug security gaps. Another effort to focus attention on nuclear threats is more quixotic but still valuable. When it comes to domestic nuclear terrorism—a subject that has been touched recently by highly speculative journalism—making that distinction requires knowing some nuclear fundamentals. Radioactive fly ash, a coal byproduct used in building and paving materials, contributes an additional dose. Coal pollutants are estimated to cause about 15,000 premature deaths annually in the United States. Nuclear power: 0.02 millirem (0.05 in the United States). Could terrorists make a nuclear weapon from commercial U.S. reactor fuel? Not easily. It is enriched with uranium-235 but not nearly enough to make it weapons-grade.