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THE UNTHINKABLE

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Can the United States be made safe from nuclear terrorism?

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In October, 2005, a radiation sensor at the Port of Colombo, in Sri Lanka, signalled that the contents of an outbound shipping container included radioactive material. The port's surveillance system, installed with func from the National Nuclear Security Administration, an agency within the Department of Energy, wasn't yet ir place, so the container was loaded and sent to sea before it could be identified. After American and Sri Lanka inspectors hurriedly checked camera images at the port, they concluded that the suspect crate might be on any one of five ships—two of which were steaming toward New York.

Sri Lanka is a locus of guerrilla war and arms smuggling. It is not far from Pakistan, which possesses nuclear arms, is a haven for Al Qaeda, and has a poor record of nuclear security. The radiation-emitting container presented at least the theoretical danger of a "pariah ship," Vayl Oxford, the director of the Domestic Nuclear Detection Office, which is part of the Department of Homeland Security, said. It seemed plausible, if unlikely that Al Qaeda or rogue Pakistani generals might load a bomb onto a cargo vessel. Within days, American satellites located the five suspect ships and intelligence analysts scrutinized their manifests; a team at the National Security Council took charge. One ship, it learned, was bound for Canada, and another for Hamburg Germany. The White House decided to call in its atomic-bomb squad, known as NEST, the Nuclear Emergency Support Team—scientists who are trained to search for nuclear weapons. One team flew to Canada and a second to Europe, where it intercepted one of the ships at sea before it could reach Hamburg. They found nothing.

The United States Coast Guard stopped the two New York-bound ships in territorial waters, about ten miles offshore; from that distance, if there was a nuclear weapon on board a detonation would cause relatively little harm. Scientists boarded the vessels, shouldering diagnostic equipment, but these ships, too, turned out to be clean; as it happened, the offending vessel was on an Asian route, and its cargo was scrap metal mixed with radioactive materials that had been dumped improperly. The entire episode, which was not disclosed to the public, lasted about two weeks.

This sometimes nerve-racking exercise resulted in no more than the disposal of some radioactive waste. It wa also the first major defensive maneuver triggered by a shield that the United States is attempting to build as a defense against a clandestine nuclear attack. The idea, in essence, is to envelop the country in rings of radiatic detectors and connect these sensors to military and police command centers, which would then respond to unexplained movements of nuclear material. The project, comparable in ambition to ballistic-missile defense, the first of its kind in the atomic age. The plan has already attracted criticism from some scientists and defens strategists, primarily because, as with missile defense, the project promises to be expensive and would require leaps of ingenuity to overcome technical problems presented by the laws of physics.

Still, with little public discussion this "layered defense," as it is described by its proponents, is being deployec The federal government has distributed more than fifteen hundred radiation detectors to overseas ports and border crossings, as well as to America's northern and southern borders, domestic seaports, Coast Guard ship airports, railways, mail facilities, and even some highway truck stops. More detectors are being distributed ea month. NEST and the Federal Bureau of Investigation maintain a permanent team to respond to events in Washington and along the Northeast Corridor; a second team trained to dismantle nuclear weapons is based ir Albuquerque, and eight other teams able to diagnose radioactive materials operate on continuous alert elsewhere in the country. Since the terrorist attacks of September 11, 2001, NEST teams have been deployed about twice a year because of specific threats reported by intelligence agencies, including at least two instances, apart from the Sri Lankan episode, where they boarded a ship approaching the United States. NEST units also discreetly screen vehicles, buildings, and people at designated events such as political conventions and the recent N.B.A. All-Star Game, in Las Vegas. In the United States alone, the sensors generate more than a thousand radiation alarms on an average day, all of which must be investigated.

The world, it turns out, is awash in uncontrolled radioactive materials. Most are harmless, but a few are dangerous, and many detectors are still too crude to distinguish among different types of radiation; they ring just as loudly if they locate nuclear-bomb material or contaminated steel or, for that matter, bananas, which emit radiation from the isotope potassium-40. So far, the result has been a cacophony of false alarms, which, in most cases, are caused by naturally occurring radiation that has found its way from soil or rock into manufactured products such as ceramic tiles. In addition, people who have recently received medical treatments with radioactive isotopes such as thorium can set off the detectors. At baseball's All-Star Game in Detroit in 2005, unobserved NEST scientists screened tens of thousands of fans entering the stadium, and their sensors rang just once—reacting to the former Secretary of Energy Spencer Abraham, who was radioactive from a recent doctor's visit.

Detritus from nuclear commerce that has slipped through American and international regulatory systems is another periodic source of alarms, and one that has proved to be a greater cause of concern. Virtually none of the loose material detected so far would be useful to a terrorist seeking to build a fission weapon—a bomb of the sort that was dropped on Hiroshima. A disquieting fraction of it, however, might be useful for what the American defense bureaucracy calls a "radioactive dispersal device," more commonly known as a dirty bomb. There is recent evidence, too, that Al Qaeda-inspired radicals are pursuing such a weapon.

The term "dirty bomb" can refer to a wide variety of devices, but generally it describes one that would use a conventional explosive such as dynamite to release radioactive material into the air. The initial explosion and its subsequent plume might kill or sicken a dozen or perhaps as many as a few hundred people, depending on such factors as wind and the bomb-maker's skill. If the weapon was particularly well made, employing one of the most potent and long-lived types of radioactive materials that are used in medicine and in the food industry, it might also cause considerable economic damage—perhaps rendering a number of city blocks uninhabitable. Radioactive ground contamination cannot easily be scrubbed away, so it might be necessary to tear down scores of buildings and cart the rubble to disposal sites. It's easy to imagine what the impact of such an attack would be if the contaminated area was, say, a quarter of the East Village, or the Seventh Arrondissement of Paris.

Charles Ferguson is a former nuclear submarine officer trained in physics; he left the Navy for a career in security studies and is currently a senior fellow at the Council on Foreign Relations. In 2003, he co-wrote an unclassified report titled "Commercial Radioactive Sources: Surveying the Security Risks." About two years later, F.B.I. agents working on an international terrorism case asked to meet with him. They brought a document showing that some of his report had been downloaded onto the computer of a British citizen named Dhiren Barot, a Hindu who had converted to Islam. Barot, it turned out, had been communicating with Al Qaeda about a plan to detonate a dirty bomb in Britain, and he had used a highlighting pen on a printout of Ferguson's study while conducting his research.

The report described how large amounts of certain commercial radioactive materials might pose a danger to a terrorist who tried to handle them. "This seems to have worried him," Ferguson told me, referring to Barot, "so he decided to look at smoke detectors." Some detectors contain slivers of americium-241; the isotope's constant emission of radiation creates a chemical process that screens for smoke. Barot informed his Al Qaeda handlers that he was thinking about buying ten thousand smoke detectors to make his bomb. In fact, to make a device that would be even remotely effective, Ferguson said, he would have had to buy more than a million. "Either his reading comprehension was poor or he was evading the assignment," Ferguson told me. In Britain, last October, Barot pleaded guilty to terrorism-related charges.

Barot appears to have been only marginally more competent than Jose Padilla, the hapless American convert to Islam who travelled to Pakistan, met with Al Qaeda leaders, and then flew to the United States, where he was arrested amid great fanfare, in June 2002. John Ashcroft, then the Attorney General, held a press conference in which he accused Padilla of "exploring a plan" to build a dirty bomb, charges that were later omitted from an indictment against him.

The Barot and Padilla cases raise a strategic question—whether it is worth setting up an expensive, imperfect system whose effectiveness would be greatest against slow-witted terrorists. The Bush Administration is now spending about four hundred million dollars annually on radiation-detector research, but nuclear physicists who have studied the technology disagree about how discriminating these sensors might become. One point on which everyone agrees, however, is that, of all the potentially dangerous radioactive isotopes, it will always be most difficult to detect highly enriched uranium-235, one of the two materials, along with plutonium, used to make fission weapons. Unless it is being compressed to explode, highly enriched uranium is a low-energy isotope that does not emit much radioactivity—it is "dull," in the lexicon employed by scientists in the field. This makes it relatively easy to shield inside lead casing, or to mask by surrounding it with brighter isotopes. Plutonium, by comparison, is fairly bright, and many of the most dangerous isotopes that could be used in dirty bombs, such as cesium 137 and cobalt 60, are brighter still. Radiation sensors, then, will always be more effective against a Dhiren Barot than against, say, the Pakistani nuclear scientist Abdul Qadeer Khan, a metallurgist who has spent many years studying fission weapons and highly enriched uranium, as well as the challenges of international smuggling.

It is common, in defense studies, to evaluate an adversary on the basis of capability and intent. Pakistan has a nuclear-weapons capability, but its government, however fragile it may be, is presumed to have no hostile intentions toward the United States. Al Qaeda, on the other hand, has demonstrated hostile intentions but has little known nuclear capability. Osama bin Laden has declared that the acquisition of nuclear weapons is a religious duty, and it is well documented that he tried to buy uranium during the mid-nineteen-nineties while he was living in Sudan. (Like many other would-be purchasers of black-market nuclear material, he apparently fell victim to a scam.) After September 11th, bin Laden met with Pakistani nuclear scientists to discuss weapons issues. More recently, Al Qaeda-inspired radicals have sought nuclear materials. "We know they have a significant appetite and they have been searching for different materials, in different venues, for the past several years," Vahid Majidi, an assistant director of the F.B.I., who is in charge of the bureau's newly formed weapons-of-mass-destruction directorate, told me. "The question becomes our vigilance and their ability to execute."

Last September, the Nuclear Threat Initiative posted a translation of a message that appeared on the Web and was attributed to Abu Ayyub al-Masri, the leader of Al Qaeda in Iraq. The speaker called for experts in "chemistry, physics, electronics, media and all other sciences, especially nuclear scientists and explosives experts." He continued, "We are in dire need of you.… The field of jihad can satisfy your scientific ambitions, and the large American bases are good places to test your unconventional weapons, whether biological or dirty, as they call them."

The available evidence, then, suggests that while jihadi leaders might like to acquire a proper fission weapon, their pragmatic plans seem to run to dirty bombs—a more plausible ambition. Among other things, the international nuclear black market holds more promise for dirty-bomb builders than for those who are interested in fission weapons. In all the cases of nuclear smuggling reported to the International Atomic Energy Agency since the collapse of the Soviet Union, none have involved significant amounts of fissionable materials. (There have been at least two cases in which a seller possessing small amounts of highly enriched uranium promised that he could get much more but was arrested before the claim could be tested; the most recent of these occurred in the former Soviet republic of Georgia, in 2006.) By comparison, the I.A.E.A. has recorded about three dozen black-market smuggling incidents through 2004 involving radiological isotopes in quantities that would be useful for a destructive dirty bomb, according to European diplomats who have analyzed the records. It would not be simple to build a damaging device with these materials. Still, Peter Zimmerman, who served as the chief scientist of the Senate Foreign Relations Committee from 2001 to 2003, said, “I think there are Al Qaeda people who, given finely divided material, could think of very creative and malicious ways to use it. Why hasn’t it happened? The answer is we’ve been lucky.”

The Bush Administration has not assigned the same urgency to the dirty-bomb threat that it has to the threat of a terrorist attack using a fission weapon. Fred Iklé, who served as the Under-Secretary of Defense for Policy in the Reagan Administration and has consulted on homeland-defense matters for the Bush Administration, told me that he and his colleagues have been considerably more concerned about a full-blown nuclear-weapons conspiracy, which would have the potential to trigger a worldwide economic depression and force millions of Americans to flee major cities. By contrast, even the worst dirty-bomb event, Iklé said, would be less than “a Katrina.”

Last year, analysts at the Department of Homeland Security divided the threat of a weapon-of-mass-destruction attack against the United States into two categories, “catastrophic” and “limited,” according to Maureen I. McCarthy, a senior adviser in the department’s intelligence and analysis office. A catastrophic attack, in this taxonomy, would cause ten thousand or more casualties and fifty billion to a hundred billion dollars in economic damage, and would produce a “major global policy shift,” McCarthy said last November, at an intelligence symposium. A limited attack might produce a hundred to a thousand casualties and would be confined to a single region, although it might also have “global political consequences.” The D.H.S. intelligence analysts placed a fission-weapon attack, the use of some biological agents, and an outbreak of hoof-and-mouth disease in the catastrophic category (the latter in part because it might require the closure of national borders for up to ninety days). Dirty bombs fell into the limited category. From the very beginning, fear of a fission bomb and its consequences has influenced American thinking about the costs and benefits of possible defenses against nuclear terrorism.

The Washington office of Los Alamos National Laboratory is in a modern building on the south side of the Mall, near a busy hotel. Richard Wagner has a spacious office on the second floor, which he has filled with color photographs of nature scenes. He is seventy years old, a trim man with a white mustache and a calm, precise demeanor. Wagner is a physicist who entered the field of nuclear weapons during the nineteen-sixties. He rose to become the deputy director of Lawrence Livermore National Laboratory and, for five years during the Reagan Administration, served as the Pentagon’s principal civilian adviser on nuclear weapons. He chaired an intelligence advisory board at the Pentagon during the Clinton years. At that time, he undertook the first of three studies on how the United States might erect a defense against a nuclear sneak attack. As much as anyone, Wagner is convinced of the need to employ radiation sensors in a national shield.

Wagner recalled, when I visited him on a recent wintry afternoon, that his interest in nuclear terrorism began during the early nineteen-seventies, when an F.B.I. agent arrived at Livermore carrying an extortion note. The F.B.I. man wanted to know if the threat, which involved a plan to blow up a nuclear device, was plausible. It was not, as it happened, but the incident, and several others like it during that period, got Wagner and a colleague at Livermore, Bill Nelson, thinking about what they would have done if they ever faced a serious case.

The subject had received remarkably little attention. In 1946, Robert Oppenheimer, the physicist who supervised the building of the first atom bombs, told Congress that three or four men “could destroy New York” by sneaking a nuclear weapon into the city. When a senator asked how such a weapon, smuggled in a crate or a suitcase, could be detected, Oppenheimer replied, “With a screwdriver.” It was not until the early seventies that the issue was revived inside the defense bureaucracy—stimulated, in part, by the publication of John McPhee’s “The Curve of Binding Energy,” which drew on interviews with the theoretical physicist Theodore B. Taylor, an innovator in nuclear-weapons design. Taylor spoke about the possibility that an individual, perhaps an American citizen, could build a fission bomb. In one striking passage, he holds a sliver of metallic uranium-235 in his hands as he speculates, “If ten per cent of this were fissioned, it would be enough to knock down the World Trade Center.” As a result of these warnings, Wagner recalled, "the government was getting more sensitive to the possibility that this might happen."

At the time, the dominant fear was that a bomb-builder would issue an extortion demand; the government would then have to find him in a hurry and dismantle his weapon. "Our job was to search, and then, if we ever found anything, do something safe with it," Wagner said. "It was the threat object that was fixed, and we were moving. And the idea of it being the other way around, the threat object moving toward the U.S. or around the U.S., and the detectors being fixed, which is part of the current paradigm—I don't remember that as being much in our thinking." To address such possibilities, Wagner helped to create NEST.

Wagner returned to the subject as part of a 1996 Summer Study sponsored by the Pentagon. The Soviet Union had collapsed, and black-market smuggling of nuclear materials had become an acute concern in the Clinton Administration. This time, Wagner was influenced by Fred Iklé, who has adapted some of Ted Taylor's concerns during the post-Cold War period. (In 2006, Iklé published a book entitled "Annihilation from Within: The Ultimate Threat to Nations.") Iklé's work, Wagner said, made him aware that a plausible attacker might be a terrorist group or a nation-state acting by covert means; the threat now, therefore, "was not just a nut, but it was part of a strategic sea change."

Wagner presented his ideas for a national-defense system to Defense Secretary William Cohen. He proposed an approach based on linked, computerized, intelligent radiation sensors—a system that would involve a very large number of detectors. A version of this concept had been secretly tested in North Las Vegas, where scientists drove through webs of linked sensors with a radioactive device; each time one pinged, the computers would analyze an accumulating portrait of the trajectory of the radioactive device. Cohen said he feared that the system would run afoul of the Posse Comitatus Act, which limits the military's intervention in domestic security. Jamie Gorelick, a former deputy attorney general who had become a Pentagon adviser, disagreed, but Cohen replied, as Wagner recalled it, " 'Well, it may not be illegal, but, man, it would be bad politics for D.O.D. to be seen to be getting ready to go out there and mess around in the U.S., in the states.' And Jamie said, 'Think what the politics would be like the morning after the explosion.' And, literally, Bill Cohen—I mean, good guy, I thought, a good Secretary of Defense—just couldn't say anything more.… And so nothing happened." An aide to Cohen said that he did not recall the discussion.

In March of 2002, Wagner was appointed to lead a new Defense Department task force on the same subject. Its members interviewed more than seventy scientists and analysts at the C.I.A., the Defense Intelligence Agency, and the national nuclear-weapons laboratories. Wagner and his colleagues chose "to concentrate almost exclusively on the nuclear-explosive threat," treating dirty bombs as a "lesser-included case," according to the final report, which was published in June of 2004. "A very rough estimate for civil detector deployments for all layers in the United States and overseas—along roads, at ports and airports, around and within cities, etc.—is one hundred thousand to four hundred thousand detectors," the report states. Depending on the model chosen, the cost of that many detectors would easily exceed ten billion dollars.

Wagner recommended an ambitious research program to address the problem of detecting highly enriched uranium; he foresaw a system that would be close to foolproof against a sophisticated attacker, perhaps one who had access to the resources of a hostile government. The task force acknowledged that even the best radiation-sensor system imaginable would be vulnerable to creative enemies, but added that "over the course of history, defenses that are far from perfect have played vital strategic roles."

Wagner told me that his faith in radiation-detection technology derives in part from the progress that has been made in cosmic-ray and particle physics. "Today, if you're looking for a neutrino from a pulsar in the next galaxy," he said, a scientist "can detect one event per year and reject the millions of background events." The goal of new defense research, he continued, should be to bring "advanced technologies out of the academic community" and learn how to apply them at border posts and truck stops.

It should be possible, Wagner said, by way of example, to detect the dull signature of highly enriched uranium by spraying out other kinds of radiation, perhaps from an aircraft, and then search for an echo, roughly the way sonar works—an approach that's likely to create health problems for civilian populations. Even if that difficulty could not be overcome, he continued, such technology could be useful in enemy territory if it was necessary to do a quick search for hidden nuclear bombs. Indeed, Fred Iklé told me that the Pentagon is now conducting this sort of research.

Wagner presented his grand plan to Donald Rumsfeld, then the Secretary of Defense, in early June, 2004. Ronald Reagan, the political father of ballistic-missile defense, had just died, and Rumsfeld, who was enthusiastic about Wagner's ideas, said that he would begin discussing the plan with Cabinet members when he saw them at Reagan's funeral. With support from Vice-President Dick Cheney, five months later the White House approved the idea, and the Department of Homeland Security decided to roll out detectors immediately, even though research into the more difficult problems of radiation sensing had barely begun. Because there was nothing else available, the department initially bought commercial machines of the type used, for example, by American steel mills to prevent contaminated scrap from entering their facilities. To Wagner's disappointment, the number and sophistication of these sensors fell considerably short of what had been envisioned.

From Hadrian's Wall to the Maginot Line to ballistic-missile defense, Emperors and Presidents have often preferred dramatic defensive innovations, even implausible ones, to incremental improvements. Radiation sensing is, of course, a passive defense, similar to a fence. Missile defense, by contrast, may be destabilizing, because it encourages states that hold missiles to improve their arsenals. Widespread radiation detection might prompt terrorists and criminals to improve their smuggling techniques, but it cannot, in itself, change the military balance.

Jeffrey Lewis, a nonproliferation specialist at the New America Foundation, said that radiation sensors had probably attracted support within the Bush Administration because they appeal to the instincts of defense thinkers who want to act boldly in the world but are also, at heart, isolationists. "You don't have to go mess with the difficult diplomacy of getting the Pakistanis to secure their material if you can ring the country with interceptors, or ring the country with detectors," he said. "Even if it's ineffective, it's something that we can do entirely ourselves—that's just really appealing to these guys."

Critics of Wagner's ideas say that he is too optimistic about the long-term potential of sensor technology, and that heavy spending on detectors will divert resources from the more important work of securing or eliminating dangerous nuclear materials—plutonium, highly enriched uranium, and dirty-bomb components. There are, for example, roughly a hundred and thirty-five civilian research reactors worldwide, including a number in the United States, that continue to use highly enriched uranium; some of these facilities have worrisome security. Sensors will never be effective enough against smuggled highly enriched uranium to justify the cost, Thomas Cochran, the director of the nuclear program at the Natural Resources Defense Council, argues. And while detectors might be more effective against dirty-bomb isotopes, Cochran says, the risks don't justify the expenditures. "That's not to say you should do nothing, but most of these things are going to be caught by good intelligence and not by the borders," Cochran said. He believes that the country would be much safer much faster if the federal government would concentrate on the painstaking challenge of reducing the number of nuclear weapons and materials at home and abroad.

Bush Administration officials I spoke with said that they are already spending more than one billion dollars each year to secure nuclear materials in Russia and elsewhere. "Obviously, the very first thing you want to do is make sure that nuclear warheads and special nuclear material within known facilities is secure," William Tobey, who oversees nonproliferation programs at the National Nuclear Security Administration, said. "But work is either under way or complete at all such facilities that we've been allowed access to in Russia. So, then, once you've got that work under way, you want to make sure that if, for some reason, your systems are not perfect—and our systems are human, so they're likely not to be perfect—that you've got another way of managing the problem. And that becomes detection at borders."

The defense bureaucracy that George W. Bush and Dick Cheney have built seems to gravitate toward military men and others who share Cheney's sense that the terrorist attacks of September 11th were transformational. Joseph Krol, who oversees NEST, for example, is a retired rear admiral who was in charge of Navy operations at the Pentagon when American Airlines Flight 77 struck the building; twenty-eight men and women under his command died that day. "The idea of a nuclear event is a low-probability event, but we have taken it seriously, to the extent that we have developed a real capability," he told me. "You could look at it and say, 'Well, maybe you're spending a little too much money on this low-probability event.' But the outcomes of such an event are so disastrous that it's worth our attention."

On September 9, 2004, a division of Halliburton dispatched from Russia to Houston, via air freight, a diagnostic tool used in oil fields which contained eighteen and a half curies of americium-241. (A curie is a measure of radioactivity.) That much americium, a Department of Energy official said, "would make a pretty nasty dirty bomb." The tool passed through Amsterdam and Luxembourg and then cleared Customs at John F. Kennedy International Airport on October 9th, where it was supposed to be picked up by a freight company and sent on to Houston. But the shipment disappeared. Nobody at Halliburton, which relied in part on outside shipping contractors, noticed that it was missing until February 7th. Halliburton's Radiation Safety officer contacted the Nuclear Regulatory Commission's operations center the following day. The F.B.I. immediately sent agents to search for the missing tool, according to documents and statements later obtained by the staff of Representative Edward J. Markey, of Massachusetts. By using surveillance-camera footage at Kennedy, the agents tracked the shipment to a warehouse outside Boston, where the americium had been trucked by mistake and set aside. A subsequent N.R.C. inspection of Halliburton found that workers in the company's shipping department were "often unaware of the specifics of the routing of each shipment" of radioactive materials.

The Bush Administration's fixation on radiation sensors has not been accompanied by a comparably ambitious drive to fund, for example, increased inspections of companies that hold commercial nuclear material that could be used to build dirty bombs, and, as a result, the country's regulatory system in this area remains strikingly weak. For decades, the purpose of government regulation of trade in portable nuclear materials was to protect workers and the public from the effects of accidental exposure to radiation; much of the day-to-day responsibility rested on compliance by private businesses. Until September 11th, the possibility that a terrorist might mount an attack using commercial radioactive isotopes received very little attention. In 2002, after it had become clear that Al Qaeda or its followers might be seeking radioactive material, the N.R.C. and the Department of Energy formed a task force of physicists and engineers to study precisely what kinds, in what amounts, might be used effectively for dirty bombs. The I.A.E.A. conducted a similar study. The scientists who participated struggled with questions of bomb engineering and malicious intent which they had never before considered; among other things, they had to decide what level of skill could reasonably be attributed to an attacker. Edward McGaffigan, a commissioner at the N.R.C., said they assumed that they would be dealing with someone who knew some science— "Not super-smart, but certainly well above Jose Padilla." The result, in 2003, was a new system for identifying which materials were truly dangerous.

The final official list contains only fifteen risky isotopes. (Other commercial isotopes, such as polonium, which was employed in London last autumn to murder the former Russian spy Alexander Litvinenko, can kill individuals or small groups but cannot cause damaging long-term ground contamination; these materials are not classified as a security risk.) Because of their widespread availability and their potency, the isotopes of greatest concern are cesium, cobalt, and americium. There are, for example, several hundred irradiation machines in the United States that employ large amounts of cobalt and cesium, and thousands more of these machines are scattered around the world under light control—Ethiopia has at least one, and Ukraine has at least a hundred. Investigators in Markey's office, searching the Web, found one such machine, with its entire stockpile of cobalt, available for free, provided that a customer would haul the material away; the machine was in Lebanon.

In the United States, between 1994 and 2005, the N.R.C. recorded sixty-one domestic cases of stolen or lost isotopes in amounts that would clearly be useful to someone making a dirty bomb, although the majority of these involved iridium-192, which loses its potency fairly quickly. It is not clear whether the commission's records describe all or even most of the problem cases. Among other things, the N.R.C.'s records of materials that entered the American marketplace before 1994 are generally unreliable. Problematic batches from earlier eras are missing. Some are associated with the bizarre case of the Gammator, a nineteen-sixties-era research contraption filled with dangerous amounts of cesium that was distributed by the Atomic Energy Commission to schools, hospitals, and private firms to promote nuclear understanding. Several Gammators sent to New York and New Jersey, as well as other places, have never been found.

There is continued demand for isotopes that can attack cancer cells, sterilize medical or industrial instruments, or efficiently detect cracks in critical metal structures, such as oil pipelines, in remote locations. In the United States, there are now about fifty-four thousand licensed batches of radioactive materials that could be used in a dirty bomb, according to the N.R.C. The N.R.C. recently issued classified orders to American licensees—hospitals, clinics, universities, and corporations—instructing them to improve on-site security, but the commission lacks the budget to follow up with frequent inspections. Most of the N.R.C.'s revenue comes from fees extracted from nuclear utilities and businesses, not from Congress, and the nuclear industry lobbies heavily to keep its payments down.

Under the country's patchwork system of state and federal regulation, most companies that hold dangerous commercial materials are inspected not by the N.R.C. but by thirty-four "Agreement" states, which have varying priorities and often inadequate resources. In December, 2005, investigators with the Government Accountability Office, who were testing the reliability of the country's radiation-detector system, successfully imported at simultaneous crossings on the Canadian and Mexican borders a dangerous quantity of dirty-bomb material by using false license and freight documents. Radiation sensors rang, but Customs officials did not question the validity of the import papers and, acting on their own discretion, allowed the material to go through. Even today, some of the states that are supposed to help Customs check such license records do not staff their operations centers around the clock.

Companies and hospitals with large amounts of cobalt and cesium have no easy way to dispose of these substances if they cut back on a line of research or go out of business. "There is absolutely no way to dispose of that material commercially—I think that's a real problem," said Julia Whitworth, who leads a project at Los Alamos National Laboratory to recover and secure these "orphaned sources." In the past three years, Los Alamos has collected about five hundred large batches of cobalt, an indication of how many unwanted units of this substance are around. Licenses granted each year by the N.R.C. only exacerbate the problem, because the federal government has never built adequate disposal sites. Some companies just dump this material illegally or inadvertently. So much discarded radioactive material courses through the country's scrap-metal piles that steel companies face a serious risk of contaminating their plants and workers by accidentally melting hot junk. There have been thirty-five such accidents in the United States since 1982; cleanup costs can run as high as twenty-four million dollars per event, according to John Wittenborn, an attorney who represents the steel industry.

The rules governing commercial materials make up the small print in the *Federal Register*. In America since September 11th, the political rewards and the big budgets have gone not to those who want to emphasize stricter regulations but to those who promise to catch terrorists in the act.

The Domestic Nuclear Detection Office has a new-car smell. Its growing staff—about two hundred scientists, F.B.I. agents, military officers, and other officials—recently moved to larger quarters, a granite-and-glass building six blocks from the White House. Vayl Oxford, the director, who was appointed by President Bush, is a 1974 graduate of West Point. He is a mandarin in the national-security bureaucracy who wields influence by accumulating knowledge about complex, classified government operations, but whose role is largely invisible to the public. Oxford retired from the military in 1992; since then he has worked in the nuclear-weapons field, in such fictional-sounding divisions of the Pentagon as the Defense Special Weapons Agency. For a time, he studied the blast effects of nuclear bombs, and later, during the Clinton Administration, he worked on what he described as "the offensive aspects of counter-proliferation," meaning that he helped to evaluate weapons that could destroy an adversary's chemical, biological, or nuclear facilities.

Oxford speaks in the clipped vernacular of his specialty; he refers to fission bombs and dirty bombs together as “rad-nuke,” and to the problem of chemical and biological weapons as “chem-bio.” Explaining his thinking after September 11th, he said, “We always thought that the rad-nuke issue was a prevention issue, as opposed to chem-bio, which is a lot about how fast and how effectively you can respond to an attack.”

We met recently in his office, where the model of a jet fighter on which he once worked is prominently displayed. He told me that his mandate from the White House has been “to develop what we called ‘a global nuclear-detection architecture.’ ” Oxford said that he sees threats from varied enemies, actual and hypothetical. “You’ve got the influence of A. Q. Khan—that, in my mind, is pretty devastating,” he said. “I worry about the fragility of a government in Pakistan. What happens to its arsenal? I worry about weird uses of North Korean weapons, as opposed to a ballistic-missile attack that is easily attributable.… A lot of people think that at D.H.S. all we’re focussed on is Al Qaeda. That’s not here. This is looking at the nuclear threat from a broader perspective, and trying to figure out how to deal with it.”

To confront the threat of a dirty-bomb attack, Oxford favors an improved system for real-time tracking of all commercial nuclear materials in the United States, perhaps using tags that can be monitored by satellite. His office is urging manufacturers of large commercial sources to fortify their machines against attack, and he would like to see some materials replaced with less risky alternatives. Such campaigning has added a new degree of urgency to the Bush Administration’s assessment of the threat. Later this year, the federal government will hold its annual, classified exercise involving top officials (known as TOP-OFF), in which these officials rehearse responses to a major disaster scenario. This year’s scenario, an official familiar with the planning told me, will posit three simultaneous dirty-bomb explosions.

Radiation detectors paid for by the Domestic Nuclear Detection Office currently screen about ninety per cent of cargo entering the United States from Canada and Mexico, as well as a similar percentage of private cars and trucks; they are also used to check about ninety per cent of incoming shipping containers. Oxford said that he plans to oversee the installation of enough detectors to screen ninety-eight per cent of imported maritime cargo by the end of the year. Creative terrorists, like drug smugglers, might then try to enter with small boats, or sneak across the land border, he said. Therefore, he is also trying to develop a more mobile system of radiation sensors on Coast Guard vessels, and at interior locations such as weigh stations, bridges, and tunnels.

Oxford is promoting the next generation of sensor, called the Advanced Spectroscopic Portal, which has been undergoing tests in New York and at the Nevada Test Site. This machine can distinguish bananas from cesium, but it will be no more sensitive than current detectors in its ability to locate highly enriched uranium, a Department of Energy official involved with the detection program said.

Finding highly enriched uranium is “a really hard problem,” Oxford conceded. Customs inspectors already use imaging equipment to scan for unusual shielding inside some shipping containers, but his office is supporting research to investigate more mobile and effective systems. “We agree that solving this through passive systems alone is not sufficient,” Oxford said. He compared the challenge to that undertaken during fifty years of research to support anti-submarine warfare during the Cold War. There, too, the challenge, he said, was to “extract unique signatures out of a very cluttered environment. It’s not just the detector itself but the software algorithm and the signals-processing” that make such a system more or less effective.

Even crude or faulty sensor systems might expose a sophisticated attacker, Oxford said. “I don’t think it’s ever possible to provide a hundred-per-cent shield; I don’t think ballistic-missile defense ever believed that they would be able to do that. I think that every step and every defensive layer that we put in complicates an adversary’s plan to be able to do this, and gives us other opportunities, to use other means…to try to identify that something may be planned.”

Fifteen years ago, many feared that a nuclear weapon might be bought or stolen by terrorists in the former Soviet Union. The country had large stockpiles of fission weapons and highly enriched uranium that were, in some cases, so poorly inventoried that nobody could say for sure how much material existed. Although Russia's resurgent security police and years of investment in nuclear security by the United States and other countries have reduced the dangers, international organized-crime networks still thrive in Russia and the smaller countries on its southern rim. The A. Q. Khan case has led some in the American defense bureaucracy to conclude that Pakistan is now a greater problem than Russia. India has large amounts of fissile material at civilian facilities and is a site of recurring, violent terrorist conspiracies. North Korea's dictator, Kim Jong Il, has a record of kidnapping and other erratic acts. A gloomy mind can readily devise plausible scenarios for nuclear terrorism in which any of these places might be a source of weapons or materials. As for potential targets, Al Qaeda's long-standing interest in New York, and its status as the largest seaport on the East Coast, has made the city, along with Washington, D.C., the focus of continual attention by the federal government since September 11th.

Building a fission weapon, or even detonating a stolen one, would be a challenging task for conspirators who didn't have a government's budget and infrastructure behind them, but people who are knowledgeable about nuclear weapons believe that it can be done. The most difficult aspect of such a project is acquiring a sufficient amount of highly enriched uranium or plutonium; the engineering work required to make a crude bomb could likely be mastered by a group of scientists—perhaps as few as a dozen. To prove the point, in a recent article in *Foreign Policy* Jeffrey Lewis and Peter Zimmerman described a hypothetical terrorist plan to build a basic fission weapon on a hundred-and-fifty-acre ranch in a remote area of the United States. Their imaginary budget was ten million dollars, their team would consist of nineteen people, and they found that they could buy many of the parts required over the Internet. Their scheme was inspired by the more ambitious plans of the Japanese terrorist cult Aum Shinrikyo, which explored uranium mining in Australia during the nineteen-nineties before mounting a sarin-gas attack on the Tokyo subway. Any of these cases, however, would require a successful plan to move contraband nuclear materials across international borders; as with the movement of terrorists themselves, borders offer a relatively uncomplicated chance of detection. This ancient principle of defense, more than faith in the technology of radiation sensing, may explain the support that the Bush Administration's detector program has attracted so far.

In the meantime, America's radiation-sensing system is, at least for now, detecting radioactive briefcase clasps, manhole covers, and chafing dishes. These are among the contaminated products caught by detectors recently at border crossings; in New York's seaports alone, there have been twenty such cases. On a recent morning when I visited a sensor outpost at the Port of Newark, four young Customs officers with pistols strapped to their belts huddled in a booth filled with computers as trucks rumbled through a line of radiation portals, which are shaped like metallic archways. The officers had joined Customs thinking that they would mainly battle narcotics traffickers; now they spend most of their time on terrorism issues, and they know more about isotopes than some high-school physics teachers do. Each time an alert in their booth sounds, a polite, calm computer voice speaks to them, as it did when I stopped by: "Gamma alert, lane six." This happens more than two hundred times per day at the Port of New York and New Jersey.

The officers checked the driver's papers, scanned the truck's sides with a handheld isotope identifier, consulted their computer screens, and within minutes announced their conclusion: denture cleaners, potassium-40. They spoke in the bored, slightly sardonic tone common among police officers, as if they were reviewing a burglar's jimmying techniques.

At some point, perhaps after the expenditure of a great amount of money, it will probably be cops like these, and not scientists or defense theorists, who decide where radiation detection should rank on the long and diverse list of counterterrorism techniques. The Department of Homeland Security recently announced an initiative to experiment with the installation of radiation detection at some bridges, tunnels, roadways, and waterways leading into Manhattan; later, the department hopes to surround other cities. The N.Y.P.D. fears that the sensors might prove to be too costly and would generate too many false alarms. Nearly three hundred thousand cars and trucks cross the George Washington Bridge in both directions on an average day; without an efficient way to process radiation alerts, a single convoy of banana trucks could jam up traffic for hours. "There are a lot of possible concerns that could surface with it," Raymond Kelly, the N.Y.P.D.'s commissioner, told me. Yet, he said, "we see this as something certainly worth trying." Kelly wants to deploy rings of sensors fifty miles or more from New York, so there would be a better chance of spotting an incoming device. In February, he held talks with his counterparts in Connecticut and New Jersey. Still, Kelly said, the entire project remains "very conceptual in nature." ♦