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Nuclear Terrorism – Threat or Not?

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Abstract. A terrorist attack using nuclear or radiological materials is a low-probability event, but if executed, would lead to unprecedented socio-economic, material, and psychological disruption and damage. This chapter seeks to provide a sound assessment of the scope and nature of the threat by examining the different types of nuclear terrorism, each of which poses different risks, involves different barriers to success, and requires different terrorist capabilities. In addition, the chapter aims to provide an overview of the sources and nature of terrorists' motivations to employ a nuclear attack.

INTRODUCTION

Nuclear terrorism is a low probability, high consequence threat. That is, the probability that a terrorist organization would utilize a nuclear strategy is far lower than the probability of many other types of terrorist attacks, but the risk posed by nuclear terrorism – the probability multiplied by the immense consequences of such an event – is unacceptably high. Indeed, former US President Barack Obama has stated that the danger of a terrorist group obtaining and using a nuclear weapon is "one of the greatest threats to global security."[1] Given the potentially catastrophic consequences of nuclear terrorism, scholars and policymakers have justifiably focused substantial efforts and resources on understanding and attempting to prevent the threat.

Although nuclear terrorism as a threat entered the international discourse in the mid-1970s with the negotiation of the Convention on the Physical Protection of Nuclear Materials (CPPNM) and the development by the IAEA of the first set of international guidelines for physical protection, contemporary concerns about nuclear terrorism came to the fore after the collapse of the Soviet Union left 35,000 nuclear warheads and thousands of tons of nuclear material spread across Russia, Ukraine, Kazakhstan and Belarus.[2] The events of September 11, 2001 caused purported restraints on terrorist violence to be re-examined, and gave credence to the idea that a capable terrorist organization motivated by the desire to cause mass casualties might succeed in mounting a nuclear attack. Thus, in the years following 9/11, there was an explosion of US and international initiatives designed to combat the threat of nuclear terrorism. In recent years, the rise and global reach of powerful and well-funded terrorist groups such as the Islamic State of Iraq and Syria (ISIS), combined with the spread of civilian nuclear energy to new countries across the globe, has yet again placed nuclear terrorism high on the political agenda of many states.

But what exactly is the nature of the threat of nuclear terrorism? Fortunately, there have been no instances in which non-state actors have used nuclear weapons, and the historical record of pursuit by terrorists of intact nuclear weapons, compared to other weapons and tactics, is sparse. However, as this chapter will demonstrate, nuclear terrorism can occur in a variety of ways, and may be achieved by terrorist groups through numerous pathways. At the same time, the execution of nuclear terrorism involves significant technical, financial, political, and security-related hurdles that organizations must overcome to break the nuclear threshold. Moreover, it is not sufficient to assume that all terrorists who have the opportunity or capability to carry out an act of nuclear terrorism will automatically do so. It is necessary to consider how well nuclear terrorism fits in with an organization's ideology, goals, and strategic and organizational objectives.

This chapter will proceed in three main sections. First, it will take stock of some of the challenges and limitations inherent in scholarly attempts to assess the threat of nuclear terrorism. Second, it will review in detail the three scenarios of nuclear terrorism that experts consider most likely: radiological terrorism, the attack or sabotage of a nuclear facility, and the detonation of a nuclear device, and also provide insights from the historical record. Finally, this chapter will review the oft-neglected "demand side" of nuclear terrorism, that is, the sources and nature of terrorists' motivation to engage in nuclear terrorism.

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THE LIMITS AND CHALLENGES OF ASSESSMENT

Before reviewing the substance of nuclear terrorism in the proceeding sections, it is necessary to acknowledge several challenges in assessing the scope and nature of the threat. First, the small sample size of prior nuclear and radiological events and the (fortunate) absence of catastrophic events makes a sound analysis of nuclear terrorism extremely difficult. Secondly, empirical evidence of nuclear terrorism is often limited to proxy evidence, or analyses of frequently-examined cases such as the Japanese doomsday cult Aum Shinrikyo, Al Qaeda, or rebel factions in Chechnya.[3] Moreover, the details of even these cases are often sketchy and ambiguous, complicating a rigorous assessment of the threat.[4]

Compounding these problems is a general lack of information on the subject due to secrecy on the part of both the terrorist organizations and national governments. Secrecy and stealth complicate valid threat assessments.[5] Terrorist organizations, in an effort to evade national counterterrorism efforts, rely heavily on secrecy. Thus, there is a notable lack of reliable evidence in the public domain on the capabilities and intentions of the terrorists themselves. Another barrier that scholars face in their analysis is the fact that, as Micah Zenko notes, "Nuclear terrorism lies at the nexus of three areas the US government treats with supreme secrecy – intelligence, nuclear weapons, and terrorism." [6] As a result, it is more than likely that all of the relevant information is not available for scholarly consumption. Finally, military and security officials often downplay the seriousness of, for example, incidents at nuclear energy or weapons facilities, or do not report breaches or vulnerabilities. Even in the US, which has been much more open about its security vulnerabilities, many historical cases have only recently become known.[7] In the absence of the above information, it is difficult for scholars to provide accurate and complete threat assessments. With these challenges in mind, the next section of this chapter will provide a detailed overview of what experts see as the three key threats involving nuclear or radiological weapons and non-state actors.

SCENARIOS OF NUCLEAR TERRORISM

Experts have typically divided nuclear terrorism dangers into three categories: (1) radioactive dispersal devices (RDDs, which include conventional explosives that disperse radioactive materials, known as dirty bombs) or radioactive emission devices (REDs, or fixed radiological sources that expose potential victims to radiation); (2) attacks or sabotage of nuclear facilities; and (3) terrorist acquisition and detonation of a nuclear device. Each type of nuclear terrorism poses different risks and requires different capabilities from terrorist organizations. The following sections will analyze each type of nuclear terrorism in turn while providing examples from the empirical record.

Radiological Terrorism

Of the three types of nuclear terrorism, an act of radiological terrorism would likely cause the lowest scale of destruction, and would not lead to catastrophic levels of death and injury on the scale of a nuclear weapons detonation. The largest impact of most dirty bomb events would be economic, for example, the substantial costs involved in the evacuation, relocation, and cleanup of areas contaminated by radiation.[8] Radiological terrorism could also cause significant short- and long-term health problems for people in the area exposed to the radiation, and would undoubtedly engender widespread distress and panic. This mode of nuclear terrorism would be the easiest for a terrorist organization to execute due to the ubiquitous nature of radiological materials and the relatively less complex technical demands of such an undertaking.

Radiological devices as weapons of mass disruption

Radiological terrorism could take several forms. The two most commonly cited scenarios include the use of a radiological dispersal device (RDD), or a radiological exposure device (RED). The use of an RDD would involve the intentional dispersal of radioactive material, either by using conventional explosives (a.k.a. a "dirty bomb") or spreading the material actively (e.g. using a sprayer) or passively (i.e. without the assistance of a powered mechanical device).[9] Despite media and other reports to the contrary, a dirty bomb is in no way similar to a nuclear bomb. A nuclear bomb creates an explosion that is millions of times more powerful than that of a dirty bomb. The cloud of radiation from a nuclear bomb could spread tens to hundreds of square miles, whereas a dirty bomb's radiation would be dispersed only within a few blocks or miles of the explosion.[10] RDDs are considered "weapons of mass disruption" because they are not expected to kill large amounts of people but instead destabilize the economy and functioning of a society through panic, the destructive force of the blast, and the spread of radiation

and radioactive materials. On the other hand, a RED emits radiation without spreading radioactive material itself. This distinguishes a RED from a passive RDD because the passive RDD still requires the dispersal of radioactive material over an area.[11] For example, a terrorist organization could place a concealed radioactive source in a highly-trafficked location such as a train station, sports arena, or concert hall.

However, as James Acton, Brook Rogers, and Peter Zimmerman note in a 2007 study, exposure to radioactive materials by the "inhalation, ingestion, or immersion" is another, largely overlooked, mechanism of radiological terrorism that may be attractive to terrorist organizations.[12] If administered in this manner, radioactive materials can be lethal in tiny quantities. For example, the murder of Alexander Litvinenko, a former Russian spy, in November 2006 by polonium-210 ingestion was likely the first provable act of radiological terror.[13] Relatively simpler versions of these attacks are likely within the skillset of reasonably technically competent terrorists.

Incidents such as the inadvertent dispersal of cesium-chloride in Goiânia, Brazil in 1987 illustrate the scale of damage that could be caused by radiological terrorism. On September 13, 1987 scavengers broke into an abandoned cancer clinic and took a metal canister from a radioteletherapy machine, which contained 1,375 curies of cesium-137. Without realizing what it was, they broke open that canister and gave the material to friends and family, eventually giving it to a junkyard. The junk dealer opened the canister, causing the Cs-137 powder to disperse, which spread further as a result of runoff and wind. The Brazilian National Nuclear Energy Commission (CNEN) found that 200 people had been contaminated, of those 200 people four died, one individual had an arm amputated, and 28 suffered radiation burns. Other direct consequences of the incident included a massive clean-up of contaminated land, at a cost of US$20 million, while indirect costs included an estimated millions of dollars of lost tourism.[14] This incident, in addition to the attempted theft of cobalt-60 in Chechnya in 1999 which led to three deaths, and the hijacking of a truck carrying cobalt-60 in Mexico City, Mexico in 2013, illustrate the potential dangers that might occur should terrorists obtain and use radiological materials to physically or economically damage or intimidate a population.[15]

Radiological materials are widespread and often vulnerable

It would not be too difficult for terrorist organizations to obtain radioactive materials for use in a plot. According to the International Atomic Energy Agency (IAEA), millions of radioactive sources have been distributed worldwide over the past fifty years, with hundreds of thousands currently being used, stored, and produced in familiar locations like hospitals and universities.[16] According to one estimate, radiological sources large enough to pose a serious danger exist in over 13,000 buildings in more than 100 countries.[17] Radioactive materials are used widely for numerous applications covering various sectors such as medicine (e.g., teletherapy, radiography, and blood-irradiation), industry (e.g. level, dredger, conveyor, and well-logging gauges), and sterilization (e.g., medical instruments and food). Some of these sources use high-risk radiological materials – radioactive materials that are extremely dangerous (Category 1), very dangerous (Category 2), or dangerous (Category 3) to people not shielded properly – that could result in serious injury or death if misused.

Moreover, the quality of both regulatory and physical security arrangements for radiological sources is highly variable by country, state, or even institution. Many medical, commercial and industrial groups that handle radiological materials are ill-equipped to secure them, and a lack of national regulatory controls in many countries has led to thousands of missing or stolen radiological sources. Indeed, even in the US, a country with stricter regulatory guidelines, it is estimated that every day one radioactive source is "orphaned," in other words, it falls outside of an institution's accounting system.[18] In the developing world, such controls are generally far weaker, particularly in Central Asia and the Caucasus area, unstable regions that inherited many radioactive sources following the collapse of the Soviet Union.

Attack or Sabotage of a Nuclear Facility

Nuclear power plants have long been recognized by experts as potential targets for terrorists. As Bennett Ramberg noted in his 1980 book, *Nuclear Power Plants as Weapons for the Enemy*, "Nuclear power plants turn conventionally armed enemies into nuclear enemies."[19] Indeed, one need not look further than recent events in Belgium to understand the potential dangers posed by the confluence of a violent non-state actor and nuclear facilities. In 2012, two employees at Belgium's Doel-4 nuclear power station left their jobs to become fighters in Syria.[20] In August 2014, an employee at the same nuclear reactor intentionally drained the lubricant for the reactor turbine, causing it to overheat and shut down for five months.[21] The perpetrator and the motive still remain unknown to Belgian authorities. And finally, in 2015, Belgian police discovered that the perpetrators of the Paris terror attacks

monitored and surveilled an official at multiple Belgian nuclear research sites, which housed a wide range of nuclear and radiological materials, including highly-enriched uranium.[22]

Terrorists are indeed interested in nuclear facilities, which exist in numerous locations worldwide. According to the IAEA, there are 440 power reactors in operation (with 60 under construction) around the globe, along with 218 operational research reactors, which are used to produce medical isotopes and train nuclear scientists.[23] The global nuclear industry also includes hundreds of plants that enrich uranium and fabricate fuel for reactors.[24] The security measures at these facilities can vary widely, as there are no binding global standards for physical protection at civilian nuclear facilities. The IAEA recommends general provisions to protect reactors against attack or sabotage, for example, INFCIRC 225, but IAEA inspectors do not verify whether these measures have actually been implemented at sites. Rather, each country adopts its own domestic laws and regulations which operators are supposed to implement at their facilities. The following sections will describe several possible scenarios in which an attack or sabotage of a nuclear facility could occur, and provide examples from the empirical record.

Attacking a nuclear facility to steal nuclear or radiological material

Since non-state actors cannot currently manufacture their own nuclear material, attacking a facility where highly enriched uranium (HEU) or plutonium (Pu) is housed is a potential means to obtain the materials necessary to build a nuclear device. Nuclear facilities also often store large amounts of radioactive material, spent fuel, and other nuclear waste products that terrorists could use in a dirty bomb. As Gary Ackerman correctly notes, although non-state actors may be the ultimate recipient of the nuclear material, the perpetrators of the theft at the facility could be experienced, profit-driven criminal groups who would then sell the material to a violent non-state customer.[25]

The disappearance of nuclear material from a reactor in Kinshasa is one of the few cases where a perpetrator was successful in actually stealing substantial amounts of nuclear material. During the late 1970s, unknown perpetrators stole two fuel rods, which contained small amounts of uranium enriched to twenty percent, from a small research reactor at the University of Kinshasa's Kinshasa Nuclear Research Center in what is now the Democratic Republic of the Congo (then, Zaire).[26] While twenty-percent low-enriched uranium isn't particularly useful for either an actual nuclear weapon or a dirty bomb, this case symbolizes potential intent or terrorist to acquire more dangerous material. At the time, the theft raised no alarms at the facility, and the rods were only noticed to be missing during a routine inventory check.[27] The reactor was said to be poorly guarded by a token fence and small group of security guards.[28] It is worth noting that the fuel rods used in the reactor were provided to Zaire by the US with almost no security stipulations as part of the Atoms for Peace Program. The fuel rods remained unaccounted for over the next two decades until the late 1990s, when an Italian smuggling ring obtained one of the rods and sold it to an Italian police sting operation whom they believed to be a Middle Eastern buyer. While the Kinshasa case is considered to be uniquely significant in that the perpetrators managed to steal a significant amount of nuclear material, according to the Nuclear Facilities Attack Database (NuFAD) at the National Consortium for the Study of Terrorism and Responses to Terrorism (START), there have been seventeen successful incidents of nuclear or radiological theft (along with two unsuccessful attempts) at nuclear facilities from 1961 to 2014.[29]

Sabotaging a nuclear facility to disperse radioactive material

A second way in which terrorists might target a nuclear facility for malicious purposes is by causing harm to the facility itself, in other words, by sabotaging the normal operations of the facility with the intention of causing a meltdown of the reactor core and releasing radioactivity into the environment. This scenario would be attractive to terrorists seeking to cause considerable damage. As John Holdren notes, a successful attack on a nuclear power reactor could, "destroy the facility itself, worth hundreds of millions to billions of dollars; produce tens to hundreds or even thousands of early fatalities and tens of thousands of delayed cancer deaths; and severely contaminate hundreds to thousands of square miles of land, requiring removal of much of it from habitation, commerce and agriculture for periods ranging from months to many decades."[30] The disaster at the Fukushima Daiichi nuclear plant in 2011 underscores the vulnerability of nuclear power plants and demonstrates the terror, disruption, and massive costs that could be caused by a major nuclear accident.[31] Although it took an extraordinary natural disaster to take out both the normal and emergency cooling at the plant, this type of event could also be caused by the intentional sabotage of a power reactor by a motivated terrorist group. An attack on a nuclear power plant would also play on the public's fear of radiation exposure if the attack released radioactive material into the environment.

There are several kinds of nuclear sabotage that are discussed in the public domain. First, as the attacks of September 11, 2001 underscored, terrorists could use an airliner or plane packed with explosives as a guided missile to crash into a nuclear power plant, specifically a number of potential targets: the reactor core or the reactor's spent-

fuel storage pool would be the most dangerous targets, but a mixed-oxide fuel fabrication plant, a dry-cask spent-fuel storage facility, or a nuclear waste-repository also represent targets.[32] It is worth noting that only as recently as 2009 has the US Nuclear Regulatory Commission (NRC) required all new nuclear power plants to incorporate design features that would ensure that, in the event of a crash by a commercial airliner, the plant's reactor core would remain cooled or the reactor containment would remain intact, and radioactive releases would not occur from spent fuel storage pools.[33] The fact that these guidelines are only beginning to take shape at nuclear power plants in the US, whose nuclear power plants are widely considered to be the best guarded in the world, does not bode well for the security of plants in other nuclear power states, particularly those just beginning to develop nuclear power.

In addition to the threat posed by aircraft, more recently, government officials have also been forced to take into account the emerging threat of small drones. In 2014, thirteen nuclear power plants in France were plagued by around twenty unexplained drone overflights, while a similar unmanned aircraft was spotted flying over Belgium's Doel-4 nuclear site that same year. [34] Terrorist groups could harness drones as an intelligence-gathering tool in order to capture precise images of nuclear plants for use in a future breach attempt, or could be packed with explosives to cause immediate damage to the plant.

Second, terrorists could attack a nuclear facility by land using mortars, rockets, or other emplaced explosives.[35] One of the most recent manifestations of this type of attack occurred in 2014 during the conflict between Hamas and Israel. On one day of the conflict, Hamas fired seventy-four rockets from the Gaza Strip into Israel's territory, at least three of which targeted the Negev Nuclear Research Facility, which houses an operational nuclear reactor.[36] Israel's Iron Dome anti-missile system intercepted one of the missiles before it could land, while the other two landed in open areas. While Hamas has been thought to target the reactor in the past, this incident represents the first time that the group explicitly stated that it had been attempting to strike the reactor.[37] According to Gary Ackerman and James Halverson, "Although the attack caused no damage, this incident represents perhaps the most significant instance of a non-state actor attacking a nuclear facility in either a genuinely airborne or "standoff" capacity."[38] This scenario is particularly concerning given its feasibility: Mortars and rockets are relatively low cost, unsophisticated weapons already possessed by many non-state actors. Moreover, most nuclear facilities around the world are not protected by expensive missile defense systems like Iron Dome. One could imagine such an attack being carried out on one of South Korea's twenty-five nuclear power plants by North Korea, which is rapidly developing and expanding its ballistic missile arsenal. This scenario is all the more concerning as a recent report by South Korea's operator, the Korea Hydro and Nuclear Power Company (KHNP), revealed that the outer protective walls of South Korean reactors were never meant to withstand a missile strike or other forms of concerted attack.[39] Again, while the IAEA recommends in its nuclear security guidance that countries "protect targets against stand-off attacks consistent with their design basis threat (DBT)," this recommendation is not required and few states have encoded it in their domestic legal framework.[40]

A third mode of sabotage terrorists could carry out on a nuclear power plant is a ground assault by a commando team. This commando-style attack could be mounted using a small armed force, whose members are potentially familiar with the plant layout or possibly aided by accomplices inside the plant, to gain entry to a facility in order to use explosives or other means in an attempt to release radioactivity into the area.[41] In 2007, eight men, split into two four-man teams, simultaneously attacked the outer security perimeter of the Pelindaba Nuclear Facility in South Africa, where hundreds of kilograms of weapons-grade uranium is stored. One of the teams breached the outer perimeter and exchanged gunfire with a guard until they were eventually chased away, but the other team disabled the electrified outer fence and proceeded to disable the alarm while raising no alarms.[42] Once inside, the intruders disabled the security cameras and entered the emergency control center where they shot a guard in the chest.[43] The four intruders spent a total of forty-five minutes within the facility's security perimeter without being apprehended by security forces, and then escaped the same way through which they arrived. Although the perpetrators did not set off explosives inside or steal material, it is a reminder of the highly capable adversaries that nuclear security measures must be designed to prevent, detain, and deter. In the US, prior to the September 11, 2001 attacks, the NRC included in the national DBT the possibility of a small commando-style attack. However, governmental and nongovernmental experts raised concerns that the commando force in the DBT was too small, as compared to the nineteen attackers during the 9/11 attacks.[44] The revised US DBT may require defense against larger commando groups, but the NRC has not published the new DBT due to security sensitivities.

Attackers could also potentially use trucks, vans, or other vehicles filled with explosives against a nuclear power plant. This type of weapon produced devastating effects on military bases, embassies, other government buildings, and commercial buildings throughout the 1990s.[45] Alternatively, terrorists could mount a waterborne attack on a nuclear facility, as many power plants are accessible by sea, lake, or river.[46]

Finally, cyber-attacks are an emerging vulnerability for nuclear power plants. Several notable cyberattacks have already occurred at nuclear facilities, including the Stuxnet virus that damaged Iran's Natanz centrifuge facility, the

placement of a virus into the computers of the Ignalia nuclear power plant in Lithuania in 1992, and the hacking of the computer systems of KHNP, South Korea's nuclear operator by presumably North Korea.[47] Attackers could use cyber techniques to undermine security at nuclear reactors to facilitate, on one end of the spectrum, the theft of confidential or proprietary information, or the release of radiation on the other. According to a 2015 report published by Chatham House, "An adversary with sufficient technical knowledge and adequate resources could mount an attack on a nuclear power plant that could trigger the release of ionizing radiation. All nuclear power plants need offsite power to operate safely and all have a standby generator which is designed to be activated when a loss of main power occurs. Attacks on the offsite power supply and on the on-site backup system could create some of the effects that occurred following the 2011 earthquake and tsunami at Fukushima Daiichi, although multiple failures of the many safety features at modern nuclear power plants could also need to occur at the same time as that loss to offsite power and the disruption of standby generators."[48] While the concern of radiation release is remote, even a small-scale cyber incident at a nuclear facility would likely have a disproportionate effect on the public's opinion of nuclear energy and nuclear industry. Although terrorists are not currently believed to possess an advanced cyber capability, groups like the Islamic State of Iraq and Syria (ISIS) have developed a sophisticated strategy of online recruitment, which utilizes not only Facebook and Twitter but also encrypted platforms on mobile devices.[49] Moreover, it is not implausible that a group's desire to cause damage at a nuclear facility could lead them to develop the necessary skills or employ a profit-motivated cyber-criminal group to do this.[50] Cyber defense of nuclear power plants requires a significant financial and intellectual investment on the part of states. According to the NTI Nuclear Security Index, many countries require virtually no cyber security measures at nuclear facilities and do not have a legal framework for these requirements.[51]

Sabotaging a nuclear facility to disrupt the operation of the facility

A third category of non-state motivation for attacking a nuclear facility may be to disrupt the operations of the facility or shut the facility down. For example, non-state actors might wish to disrupt or eliminate the energy source for a particular area. There are a number of vulnerable components at power reactors whose destruction could disrupt energy production for weeks or even months including the main turbine generator, the electric generator, conductors, transformers, circuit breakers and switches.[52] This action might be linked to a broader political struggle, for example, an ethno-nationalist group shutting down a civil power reactor to disrupt electricity supplies to a local population in an attempt to extract loyalty or other concessions.[53] This mode of attack could also be carried out by anti-nuclear groups who oppose the use of nuclear energy and, ironically, hope to stop the operations of a reactor in order to prevent the harm caused by nuclear materials.

Intrusion as a form of protest

The intrusion of a nuclear power plant as a form of protest, while not necessarily an act of attack or sabotage on a nuclear facility, is nonetheless included in this discussion because the intrusion of protestors or activists into a nuclear facility highlights the vulnerabilities that could be exploited by individuals or groups with violent or malicious intentions. In these scenarios, the perpetrators are usually anti-nuclear or environmental activists and do not intend to acquire material, shut down a facility, or even cause serious harm to the facility. Rather, they seek to draw attention to their cause, which often times includes pointing out the deficiencies in security at nuclear plants.[54] Greenpeace activists have broken into nuclear facilities around the globe numerous times. In October 2012, Greenpeace activists entered two nuclear power plants in Sweden by breaking open a gate and scaling fences without being interdicted by security guards. Four of the activists hid on the roof of one reactor overnight before being discovered by guards and surrendering the next morning.[55] In 2014, Greenpeace activists broke into the Fessenheim nuclear plant near the German border and hung a banner from the reactor building.[56]

One of the most serious and well-known cases of protestor intrusion at a nuclear power plant was the 2012 break-in at the Y-12 National Security complex in the US. This incident is of particular interest because Y-12 is ostensibly one of the most stringently guarded nuclear facilities in the world, as it houses the main US repository of weapons-grade uranium. Indeed, according to Matthew Bunn, before the intrusion, nuclear security managers at the US Department of Energy (DOE) would have pointed to the security program at Y-12 as one of the strongest at DOE.[57] Nevertheless, an 82-year-old nun along with two other activists breached the outer layer of security at the complex, with little more than a pair of bolt-cutters, and succeeded in getting to the building where thousands of bombs' worth of HEU was stored.[58] The activists evaded multiple cameras, alarms, and other sensors. The activists proceeded to vandalize the building, using their own blood and sledgehammers, for two hours before being detected and arrested by a single security guard.[59] Stunningly, because the facility had experienced hundreds of false alarms

in months leading up to the break-in, security guards heard the alarms but did not act upon them because they thought they were not real.[60] Similarly, the guards heard the protestors hammering on the building's wall but assumed that the sounds were being made by maintenance workers.[61] While their intent was not to cause serious harm to the facility, the protestors revealed major weaknesses in the complex's nuclear security and highlighted the damage that could easily be done by adversaries with more nefarious intents.

High-level observations

The Nuclear Facilities Attack Database (NuFAD), a database complied by the University of Maryland's National Consortium for the Study of Terrorism and Responses to Terrorism (START), examines all incidents of assaults, sabotage, and breaches of nuclear facilities from 1961 to 2014. The database points to some interesting high-level observations about the scenarios discussed above. First, there are eighty cases of attacks, sabotage, or breaches against nuclear facilities in the empiric record, a sizeable number compared to the general perception of the frequency of these events. While many of the notable and reported cases were discussed above, there are many more cases that have not received the same level of media attention. Second, according to the database, at least sixty percent of the attempted attacks on nuclear facilities were deemed "successful," that is they met the defined or ostensible goals of the perpetrator.[62] Third, in one-third of all cases examined, the perpetrators penetrated structures where nuclear or radiological materials were actually housed. Finally, in more than seventy-five percent of the cases examined, the perpetrators managed to breach the outer defenses of the facility. Fortunately, for now, the most successful types of perpetrators appear to be criminals and anti-nuclear or environmental activists. However, the empirical record demonstrates that successful attacks, sabotage, and breaches of nuclear facilities are indeed possible. Combined with a historic interest by violent non-state groups in nuclear weapons, which will be discussed in a later section of this chapter, it may simply be luck that these two forces have not yet coincided.

Detonation of a Nuclear Device

The final scenario of nuclear terrorism that will be discussed in this chapter is the detonation of a nuclear device. Although this is the most devastating type of nuclear terrorism, it is the least likely to occur, given the significant technical and security-related challenges involved. To accomplish the detonation of a nuclear device, terrorists could either acquire a ready-made nuclear weapon from a state's arsenal through theft, purchase, or gift, or they could construct a crude or improvised nuclear device using weapons-grade nuclear material acquired through theft or diversion. These two scenarios, along with their associated challenges and limitations, will be discussed in the below sections.

Terrorists could steal or buy a nuclear weapon

The existing arsenals of the nine nuclear-weapons states represent the most obvious means by which terrorist groups could acquire an intact nuclear weapon. The global stock of nuclear weapons is estimated to be 14,900 warheads.[63] Precise information about the security of nuclear weapons is highly classified in nuclear-weapons states, but experts agree that stealing an intact nuclear weapon, and then detonating that weapon, could be extremely difficult, if not nearly impossible. A terrorist group would need considerable financial and technical resources, as well as a high degree of organizational, military, and technical competency, to mount an attack on a weapons storage facility, transfer the weapon to a target without being discovered by the authorities, and finally overcome safeguard measures on the weapons designed to prevent unauthorized detonation.[64] Indeed, because nuclear weapons are considered to be the "crown jewels" of many countries, they are necessarily protected with every means at the state's disposal.[65] Moreover, as alluded to above, even if the terrorist group managed to steal a fully assembled nuclear weapon, they might not be able to detonate it. Many modern nuclear weapons are equipped with safety features, what are known as "permissive action links," or PALs, which require an authorized code before detonation. Many nuclear weapons are also equipped with features that are designed to prevent the weapon from detonating unless it has completed the expected flight to its target.[66] As Charles Ferguson explains, "You'd have to run it [the nuclear weapon] through a specific sequence of events, including changes in temperature, pressure and environmental conditions before the weapon would allow itself to be armed, for the fuses to fall into place and then for it to allow itself to be fired. You don't get it off the shelf, enter a code and have it go off."[67]

The "new" nuclear-armed states perhaps represent the most alarming possibilities for the theft of a nuclear weapon by a terrorist group. History demonstrates that political turmoil, government instability and crisis situations

put the security and control of nuclear weapons at risk.[68] Elena Sokova notes that these incidents include the 1961 coup in Algeria when a French nuclear site and a nuclear device were at the center of a battle for competing loyalties; the internal power struggle within the Chinese nuclear research and development program and within the Chinese strategic missile forces during the Cultural Revolution in 1966; and the storming by anti-Moscow rebels of an army base with nuclear weapons in Azerbaijan in 1990.[69] More recently, during an attempted coup against Turkish President Recep Erdogan in 2016, the US temporarily lost access to the Incirlik Air Base in Turkey, located sixty-eight miles from the Syrian border. Incirlik is home to fifty American B61 gravity bombs. During the coup, Turkish forces loyal to Erdogan surrounded the base and cut off power for days.[70]

In particular, the regional instability and ongoing terrorist activity in South Asia, as well as the potential for collapse in North Korea, present concerns for the security of nuclear weapons. For example, Pakistan is the most oft-cited example where a "loose nuke" scenario could occur. Public statements from the US and Pakistani officials express confidence in the security of Pakistan's nuclear arsenal, but there is evidence that these statements may have less merit than it appears. In 2013, the *Washington Post* reported that secret documents provided by National Security Agency whistle blower Edward Snowden revealed that then Director of National Intelligence James Clapper had warned that "knowledge of the security of Pakistan's nuclear weapons and associated material encompasses one of the most critical sets of…intelligence gaps," which was concerning "given the political instability terrorist threat, and expanding inventory [of nuclear weapons] in that country."[71] Other experts note that the Pakistani authorities have a dismal record thwarting insider threats – the AQ Khan network operated under the noses of the Pakistani establishment for years – and that the greatest risk of a loose nuke stems from insiders in the Pakistani nuclear establishment working with outside Islamist militants.[72] Moreover, the divide within the Pakistan's military, particularly the fact that senior military officials have been found to have proven ties to religious extremists, make safeguarding its nuclear weapons much more difficult.[73]

Terrorists could construct a crude nuclear bomb

Instead of acquiring an intact nuclear weapon from another state's arsenal, terrorists could construct what is known as an "improvised nuclear device." The most difficult part of making a nuclear bomb is acquiring the nuclear material. The production of fissile material, whether by enriching uranium or producing plutonium in a reactor and separating it from spent fuel, is a technically complex and expensive feat for even advanced states, and as such is well beyond the plausible capabilities of terrorist groups. [74] Thus, obtaining fissile material for a bomb through purchase or theft, though still exceedingly difficult, is the most realistic option for terrorists. However, as mentioned in this chapter's section on the attack or sabotage of nuclear facilities, the essential ingredients for nuclear weapons are housed in facilities whose security measures range from excellent to dismal. According to Matthew Bunn, the highest risks of nuclear theft by non-state actors today appear to be in Pakistan, in Russia and at HEU-fueled research reactors (many of which are located on relatively insecure university campuses) around the world.[75] Moreover, since the end of the Cold War, there have been approximately twenty documented cases of theft and smuggling of plutonium or HEU.[76] Fortunately, none of the known incidents have come close to the quantity of material necessary for a nuclear device. For example, in an incident reported in 2007, 79.5 grams of uranium enriched to eighty-nine percent were seized in Georgia.[77] While the enrichment level of this material is alarmingly high, the amount is still far short of what would be required for a nuclear device.

Should terrorists get hold of the fissile material necessary, they would then need to fashion a nuclear explosive device that could be delivered to a target. While constructing such a working device from these materials is by no means a trivial task, numerous and repeated assessments by the US government, other governments, and nongovernmental organizations confirm that it is indeed plausible that an advanced terrorist group, with technical assistance and sufficient resources, could make a primitive device if it acquired enough HEU or Pu.[78] Terrorists could plausibly fashion two types of crude nuclear devices. The simplest type of nuclear bomb terrorists could make, a gun-type bomb, is similar to the *Little Boy* bomb the US dropped on Hiroshima during World War Two. A gun-type bomb essentially involves slamming two pieces of HEU together at an extremely high speed. Building such a bomb would require "some ability to cast and machine uranium, a reasonable knowledge of the nuclear physics involved, and a good understanding of cannons and ballistics."[79] Knowledge of chemical processing may also be needed, but often times these processes are no more advanced that those undertaken by certain criminal groups in the illegal drug industry.[80] A second albeit more difficult device for terrorists to construct is an "implosion-type" bomb, in which "precisely arranged explosives crush nuclear material to a much higher density, setting off a chain reaction."[81]

The chances for success of these efforts would certainly be improved by the addition of experts with direct experience in a national nuclear weapons program. Nevertheless, a study from the now-defunct congressional Office

of Technology Assessment found: "A small group of people, none of whom have ever had access to the classified literature, could possibly design and build a crude nuclear explosive device…Only modest machine-shop facilities that could be contracted for without arousing suspicion would be required."[82] Critically, this assessment was reached in 1977, before the age of the internet, which made troves of relevant information on nuclear weapons more widely accessible. Moreover, this crude bomb would not need to be a safe, secure, reliable weapon that could be delivered by a ballistic missile, like those nuclear weapons found in states' arsenals. The bomb, likely of an uncertain and unreliable yield, could be transported to its target by truck, boat, or land. Particularly with regard to land transportation, many countries have poorly-guarded borders, so this feat would not necessarily be very difficult to accomplish.

IDENTIFYING THE ADVERSARY

The above sections reviewed the various scenarios in which terrorists could theoretically deploy a nuclear strategy, in other words, the supply side of the equation. However, to materialize in practice, these scenarios would require a perpetrator with the intent to engage in this particular type of violence. As Gary Ackerman notes, "One all too often comes across the unquestioned assumption that any terrorist capable of employing a nuclear weapon would automatically want to do so...the history of terrorism reveals, however, that not every terrorist group has sought to maximize its killing power; indeed, the vast majority of terrorists have purposefully curtailed the scale of their violence."[83] Terrorist interest in nuclear weapons is typically seen as lacking because of (1) the technical and material difficulties associated with executing a nuclear attack (2) fears of reprisal, and (3) political constraints on overwhelming violence from a terrorist organization's base. Nevertheless, with the increase in the number of terrorist groups who have expressed the desire to inflict violence on a large scale, the traditional restraints on terrorists might be breaking down. The following sections will consider the other side of the equation, the demand side, that is, the motivational dynamics and decision-making processes of terrorist organizations contemplating one of these nuclear options, and review the universe of non-state actors that might wish to acquire and use nuclear weapons.

Why might terrorist organizations pursue a nuclear strategy?

There are a variety of factors that might induce a terrorist organization to pursue a nuclear strategy. A nuclear strategy might appear attractive to terrorist organizations for a number of reasons. For example, the most obvious reason for terrorists to pursue this strategy would be to inflict massive casualties upon their perceived enemies. Other reasons include the disproportionate psychological impact that nuclear weapons cause, the prestige of nuclear weapons, the ideology of a particular terrorist group, atomic fetishism, and more.[84]

However, in general, if one is to look at terrorist organizations as rational actors, the use of nuclear weapons must serve specific objectives for which conventional or other weapons are less suited.[85] An organization's leaders would ask themselves, "Will a nuclear weapon help us achieve our objectives faster or more effectively than other means? Will the possession or use of such a weapon bring us a considerable amount of prestige or power to intimidate our enemies?" As noted above, the strategic deliberations of most terrorist organizations have steered them away from nuclear weapons. Especially before 9/11, many terrorism scholars observed that there were few strategic benefits a group could derive from the detonation of a nuclear device or the sabotage of a nuclear facility compared to other less extreme measures. Brian Jenkins' well-known maxim that "Terrorists want a lot of people watching, not a lot of people dead" from the 1970s sums up this point.[86] Importantly, a terrorist group might consider whether a nuclear attack would be counter-productive by generating, for example, condemnation among the group's base and their potential supporters. By crossing the nuclear threshold, the group could undermine its popular support, "encouraging a perception of the group as deranged mass murderers, rather than righteous vanguards of a movement."[87] Finally, a nuclear attack may be counterproductive for a group seeking to influence the political process by provoking a government to expand its efforts to destroy the group.

Terrorist organizations, to be sure, are not always driven by strictly strategic motivations.[88] Groups may be motivated by organizational factors, such as expanding their size, influence, or wealth, fending off intervention by authorities, and destroying competing groups. Groups whose behavior is influenced by organizational politics might find that employing a nuclear strategy furthers (or hinders) their organizational goals. For example, the group "Avenging Israel's Blood," a group of Holocaust survivors determined to avenge the murder of six million Jews, was determined—against all political and strategic considerations— to poison Nazi SS storm troopers with Zyklon

B.[89] In this case, a leader's obsession with a particular class of weapons led to the employment of that weapon becoming the overriding group objective.

One of the most prominent explanations for why some terrorist organizations may choose to utilize a nuclear strategy while others will not, focuses on the "type" of organization in question. When examining the spectrum of terrorist groups, scholars have differentiated between types of organizations that are supposedly more constrained from committing acts of mass destruction and those that might be less inhibited, and indeed, might find incentives to commit such acts. According to this theory, each terrorist type has a different ideology, psychology, and motivation that can explain its propensity to use or avoid nuclear weapons. Jerrold Post identifies a diverse typing of sub-state terrorist groups—social-revolutionary terrorism, nationalist-separatist terrorism, religious extremist terrorism, right-wing terrorism, and single-issue terrorism—and analyzes the motivations and goals of each type in order to determine the constraints against or incentives to use a nuclear strategy.[90] For example, Post argues that the goal of social-revolutionary and nationalist-separatist terrorist groups is to establish a new socio-political order or state. In so far as these groups are seeking to influence and change their societies, they are significantly constrained from indiscriminate acts of violence that cause mass causalities among their own countrymen or cause negative reaction in international audiences. Thus, they would be less likely to use nuclear weapons.

In contrast, scholars have asserted that terrorist group types that are the most conducive to the pursuit of a nuclear strategy are those that reflect either an apocalyptic millenarian or religious fundamentalist character, a threat that has come to the fore since 9/11. For example, religious fundamentalist groups act to attain the greatest possible benefits for themselves and their coreligionists only. Violence is a "sacramental act or divine duty executed in response to some theological demand or imperative," which is said to eliminate the group's ambivalence about indiscriminate killing.[91] Bruce Hoffman takes up a similar line of argument in his analysis of the "traditional" terrorist versus the "new" terrorist. Hoffman argues that in contrast to traditional terrorism, which is practiced by a collection of individuals belonging to an organization with a defined set of political, social or economic objectives, new terrorism is motivated in whole or in part by religious imperatives and has led to more intense acts of violence that have produced considerably higher levels of fatalities.[92] In sum, certain groups but not others may seek to use nuclear weapons due to the nature of their particular ideology, psychology, motivations, and goals.

Who are the most likely candidates?

Aum Shinrikyo was the first terrorist organization to make genuine efforts to acquire a nuclear capability. The group ultimately settled for the pursuit of chemical weapons, culminating in its successful release of sarin gas in the Tokyo subway system in 1995. Aum, a well-resourced apocalyptic millenarian organization that was highly active in the 1990s in Japan, attempted on numerous occasions to purchase, produce, or otherwise acquire a nuclear capability. Aum tried to buy nuclear weapons from Russia and purchased land in Australia that contained uranium. A combination of the group's apocalyptic ideology, vast resources, impressive persistence in the face of failure, and lax Japanese law enforcement enabled it to undertake a concerted, if unsuccessful, effort to acquire nuclear weapons.[93] While analysts at the time believed that this confluence of factors was unlikely to be repeated, the rise of Al Qaeda and other transnationalist jihadi movements challenged this conventional wisdom.

At the present, the universe of non-state actors that might seek to acquire and use nuclear weapons is largely confined to jihadists and far-right groups. These two groups of terrorist organizations have the longest and most documented interest in nuclear and radiological, as well as chemical and biological, weapons. Each group will be discussed in turn below.

Efforts by Al Qaeda, the diffuse network of jihadists responsible for many of the deadliest, mass-casualty terrorist attacks in the past decade, to acquire nuclear weapons have been well-documented. Indeed, Al Qaeda's willingness to inflict mass casualties, its repeated efforts to attain weapons of mass destruction (WMD), and its stated intention to use WMD have been enough to convince many policymakers and academics that it is only a matter of time before Al Qaeda will indeed employ WMD. In various statements and videos, Al Qaeda has asserted its "right" to kill four million Americans in retaliation for the deaths of innocent civilians in the Muslim world, for which it holds the US and Israel primarily responsible.[94] Al Qaeda's former leader, Obama bin Laden, stated in 1998 that it is a "religious duty" to acquire and use WMD, and repeated this promise to use "massive weapons" in a 2007 video.[95] Bin Laden also sought and was granted a fatwa, or religious edict, from a Saudi cleric in 2003 authorizing the use of nuclear weapons.[96] Al Qaeda has sought nuclear material in Sudan and southern Africa, technical documentation on radiological and nuclear weapons have been found in Al Qaeda's possession, and on at least one occasion (the Jose Padilla case) a plot to detonate a dirty bomb in the US was actively contemplated but scrapped on feasibility grounds.[97] Al Qaeda in the past also reportedly contacted the AQ Khan network for assistance with its weapons program, although the Khan network rejected them for unknown reasons.[98] Finally, Al Qaeda's attempts to

obtain nuclear weapons included a well-known case in which two extremist Pakistani nuclear weapons scientists met with bin Laden and his deputy, Ayman al-Zawahiri, in 2001 to discuss nuclear weapons, which reportedly included the scientists handing over a design for a nuclear bomb.[99]

While the evidence with respect to Chechen jihadists is much sparser compared to that of Al Qaeda, this variety of terrorist group has also been shown to have an interest in nuclear weapons. Chechen terrorists have repeatedly threatened to sabotage nuclear facilities or to carry out dirty bomb attacks.[100] Moreover, Russian officials have confirmed two cases of Chechen groups conducting reconnaissance activities at two nuclear weapons storage sites, and the Russian state newspaper reported two additional cases of terrorist reconnaissance of trains transporting nuclear weapons.[101]

The Islamic State of Iraq and Syria (ISIS), a global jihadist group which rose to prominence in 2014, has not been as outspoken or as clear about their intentions with regards to nuclear weapons as Al Qaeda. Only one article in the group's English-language magazine, *Dabiq*, mentions a hypothetical scenario in which ISIS acquires a nuclear weapon and smuggles it into the US for detonation.[102] Nevertheless, the idea that ISIS could take advantage of chaos and weak governance in Iraq and Syria to acquire dangerous materials has prompted officials to take precautions to protect against the threat of a nuclear or radiological ISIS. For example, the US is providing Iraq with training and equipment that will enhance Iraq's capability to "locate, identify, characterize, and recover orphaned or disused radioactive sources in Iraq thereby reducing the risk of terrorists acquiring these dangerous materials."[103] Moreover, many scholars have assumed that due to the similarity in the groups' ideologies, and the fact that ISIS continues to hold Osama bin Laden in high esteem, ISIS can be assumed to share Al Qaeda's general views on nuclear and other weapons of mass destruction.

However, as noted by Thomas Hegghammer and Andreas Hoelstad Daehli in their comprehensive survey of jihadi writings, chemical, biological, radiological and nuclear (CBRN)-related texts make up a relatively small proportion of jihadi texts on tactics and weapons. Moreover, nuclear and radiological weapons make up the minority of the CBRN texts.[104] In fact, bin Laden never stated that nuclear or radiological weapons were necessarily his WMD of choice, and all of his statements speak about nuclear weapons alongside chemical and biological weapons.[105] In sum, the doctrine and writings of jihadi groups point to a clear interest in mass casualty terrorism, with nuclear and radiological weapons being only one means to this end, with Al Qaeda writing more on radiological and nuclear terrorism than most other terrorist organizations.

In addition to jihadi groups, far-right militant groups have repeatedly demonstrated a desire and willingness to inflict mass casualties and an interest in nuclear weapons and other WMD. Interestingly, according to Peter Bergen, between 2001 and 2013, individuals with connections to far-right ideologies or groups were responsible for thirteen incidents involving either chemical, biological, or radiological weapons, while during the same timeframe in the US jihadists were responsible for zero.[106] The worldview of far-right individuals and groups points to nuclear intent. For example, the manifesto of Anders Behring Breivik, the Norwegian terrorist who bombed a government building and carried out a shooting spree on a Labour party youth summer camp, included a one hundred-page section on musings about CBRN weapons. Breivik endorses the use of these weapons, calling small nuclear weapons "ideal for annihilating concentrations of category A and B traitors" (though he does not advocate for nuclear weapons for surface detonation above .2 kilotons as they would cause too many civilian casualties), and recommends sabotaging nuclear reactors in order to cause "Chernobyl-style damage" to the enemy."[107] Interestingly Breivik's manifesto also contains detailed instructions for how to sabotage a nuclear reactor, and included among other things, six different assault strategies that would-be terrorists could utilize. Breivik apparently also called for taking radioactive sources from hospitals, which led Norway to decide to convert all its blood irradiators from cesium chloride (radioactive) to x-rays (non-isotopic).[108] Other far-right groups have documented an interest in nuclear weapons as well; for example, in the mid-1990s an American group called the Aryan Republic Army produced a video in which it claimed to have a bomb containing "yellowcake plutonium residue." While this was probably an empty threat, it shows that far right groups are indeed interested in using nuclear weapons.

Beyond jihadi and far-right groups, scholars have noted that the Basque ETA, the South African ANC, and Northern Ireland's IRA have been linked to actual attempts at radiological or nuclear terrorism.[109] This subset of groups does not include groups that have only considered this option.

CONCLUSION

This chapter has attempted to provide a sound assessment of the threat of nuclear terrorism. The chapter detailed the various ways in which a terrorist organization could carry out an act of nuclear terrorism – through the use of an RDD or RED, an attack or sabotage against a nuclear facility, or the detonation of a stolen intact nuclear weapon or

terrorist-made crude nuclear device – while carefully considering the substantial hurdles any terrorist organization would face in this pursuit. In addition, this chapter has sought to take stock of terrorist motivations for carrying out an act of nuclear terrorism, as well as identify how well nuclear terrorism fits in with various organizations' ideologies, goals, and strategic and organizational objectives.

Without exaggerating the threat, or signaling that a large-scale nuclear terror attack by non-state actors is likely or imminent, this chapter suggests that the international community should take the threat of nuclear terrorism seriously. Fortunately, while nuclear terrorism remains a low-probability event and a significant act of nuclear or radiological terrorism has yet to occur, scholars and the policy community should not minimize the threat due to the disastrous consequences of such an event, and a clear, well-documented interest by non-state groups in nuclear matters.

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