Viewpoint

Relearning the ABCs: Terrorists and "Weapons of Mass Destruction"

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Concern continues to mount over potential new "superterrorists" with evil intentions and capacities. However, there is still uncertainty about the likelihood of future terrorist use of so-called "weapons of mass destruction" (WMD), or more precisely, atomic,[2] biological, or chemical (ABC) weapons, and also about how terrorists are most likely to use these materials. The potential consequences of such acts of violence *could* be extremely severe, with projections ranging from thousands to hundreds of thousands of casualties. Such scenarios, long a favorite plot of both written and cinematic fiction, became a reality with the 1995 sarin attack on the Tokyo subway during the morning rush hour. The Aum Shinrikyo cult broke a long-standing "taboo" by applying an ABC weapon in a large-scale terrorist attack. Until then, the use of non-conventional means on a larger scale had been reserved for states, and the incident had a tremendous impact on national security concerns and priorities (especially in the United States).

Unfortunately, current images of emerging terrorist threats and imminent doomsday could make it harder to evaluate accurately the relative threats from these weapons. Perhaps more disturbingly, such images could lead to a blurring of meaningful distinctions between the weapon types when policymakers and others try to understand and defeat these threats. Official statements certainly present a frightening picture. For example, in November 1997, US Defense Secretary William Cohen stated during a TV interview that a supply of anthrax the size of a five-pound bag of sugar would kill half the population of Washington, DC.

In a 1999 article, Tucker and Sands argue that alarmist biological and chemical terror scenarios and their predicted catastrophic consequences have been based on the potential vulnerability of urban centers to such attacks and the growing availability of relevant technology and materials, and that these scenarios have not drawn on a careful assessment of terrorist motivations and patterns of behavior.[3] The authors are, rightfully, concerned by the fact that "chemical and biological terrorism has come to occupy such a high position on the worry list of top US government officials when so little is known about the actual threats."[4]

This threat perception could be based partly on certain inherent advantages of biological weapons over other weapons. Biological weapons are cheap and easy to produce, and difficult to detect once they are created.[5] The consequences, both in terms of casualties and economic damage due to ruined crops or paralyzed city centers, could be huge. Moreover, future developments in biotechnology could create unprecedented opportunities for new forms of violence, coercion, or subjugation.[6] But, despite several "advantages," one should question whether biological and chemical weapons are the non-conventional weapons of first choice for terrorist groups for large-scale violence. Conventional weapons are still the most important terrorist instruments. However, *if* terrorists choose to pursue ABC weapons, there are important inherent differences among the ABC weapon types that will affect the way terrorists would apply such means.

In this context, the terrorist potential of nuclear weapons does not receive adequate recognition in the current debate. It has been claimed that while "chemical, biological, or radiological terrorism is likely to occur in the United States, nuclear terrorism is unlikely to do so, as it is too difficult."[7] According to such views, both the acquisition of fissile materials and the construction of a viable weapon supposedly are beyond the capacities of terrorist groups.

On the contrary, this viewpoint argues that excluding nuclear terrorism could be a dangerous and oversimplified approach to understanding the low-probability, but still potential, non-conventional terror threat. The current US fixation on biological and chemical terrorism, apparently rooted in both fictional representations and factual misinterpretations, is at risk of overshadowing the persistent proliferation and security risks of the Cold War nuclear legacy. By discussing the advantages and drawbacks of different ABC means from the point of view of terrorists, this viewpoint explains why the diversion of weapons-usable fissile materials represents a continued and possibly bigger threat to international security than Cohen's bag of sugar.[8]

This viewpoint presents a set of "lessons," starting with discussions of the inherent problems of the "WMD" concept and of the likelihood of large-scale terror attacks. As the risk of such terror cannot be ruled out, the viewpoint then explains how terrorists could acquire and deploy non-conventional weaponry, in particular crude nuclear weapons. The next sections discuss the probable effects of chemical, biological, and nuclear terrorism. The viewpoint then offers some concluding lessons on the overall ABC threat and the importance for future threat assessments of understanding the potentials of the respective weapons.

DEFINING THE KEY CONCEPTS

The problems of understanding terrorism start with the search for a definition. Several definitions for "terrorism" have been proposed, yet without universal adherence to any. In fact, the giraffe has been introduced as a somewhat exotic metaphor for terrorism: "It is hard to describe, but everybody knows it when they see it." As a result, up to 120 different definitions have been recorded for the term "terrorism."[9]

Given the problems defining conventional terrorism, no wonder there are different opinions about what "WMD" terrorism is. In fact, one of the biggest problems in assessing the likelihood or the possible impact of mass-destructive terrorism within the United States is the very basic, but surprisingly difficult question of designing a workable definition of weapons of mass destruction.[10] Commonly, WMD are defined and understood as weapons capable of causing mass casualties. However, while today's powerful conventional firepower, capable of inflicting large-scale killings, immediately challenges this type of definition, a more pressing problem is the failure to discriminate between non-conventional weaponry within the category of "WMD."

The collective grouping of atomic (nuclear), biological, and chemical weapons in the category assumes a degree of similarity in the projected death rates from each weapon type. However, the three classes of weapons differ greatly in lethality, destructive power, the feasibility of protection and defense, and their potential missions.[11] The ultimate weapons of mass *destruction* are nuclear weapons, which have enormous destructive powers. A single nuclear warhead can destroy a large city. One hundred warheads are estimated to have the capacity to destroy the United States and civilization as we know it.[12] While biological weapons still have to be proven efficient on a larger scale, these weapons *could* possess lethality comparable to a single nuclear weapon. Chemical weapons, however, are clearly far below nuclear weapons in their destructive capacity.

Inclusion of biological and chemical weapons in the "WMD" group blurs the distinctions between the weapons, their effects, and consequently our understanding of the threats they pose and how to meet these. Accordingly, the phrase "WMD" is generally avoided in this text, and the more precise term of the 1950s and 1960s, "ABC weapons," is dusted off and brought back into the limelight.[13]

USE OF ABC WEAPONS

Undoubtedly, the possession of non-conventional weapons leads to new opportunities for terrorists to move from basically a physiological level of violence to acts of severe physical impact and large-scale killing. These changes could be so profound that it has been claimed that much of what has been thought about terrorism, including some of our basic assumptions, must be reconsidered.[14] But whether terrorists would cause mass casualties by using non-conventional weapons remains an open question. Neither past nor more recent trends support such an assumption, despite the serious incident in Japan.

While the number of casualties caused by terrorism has increased, and the violence has become more indiscriminate, conventional means are still the instruments of choice for terrorists. Smaller and more conventional instruments of destruction are still quite lethal and can have a strong effect on the targeted individual, corporation, government, or what is often the ultimate target: public opinion. Even terrorist groups or individuals seeking to cause extensive casualties have tended to use conventional means to achieve their objectives.[15]

A number of authors have pointed out that the groups most likely to engage in non-conventional terrorism in the United States are the most unlikely to succeed in doing so using chemical, radiological, or biological weapons, due to these groups' small sizes and lack of resources.[16] The "Database of Incidents Involving Chemical, Biological, Radiological, or Nuclear Materials, 1900-Present" maintained by the Center for Nonproliferation Studies at the Monterey Institute of International Studies, contains 329 incidents, most of them biologically or chemically related, with an apparent terrorist motivation.[17] The overwhelming majority of incidents, however, do not reflect any significant escalation of the mass-destruction threat, but rather a growing interest in non-conventional weaponry among politically and religiously motivated groups and individuals.[18] Moreover, an analysis of the incidents reveals that many of them were hoaxes and that most of the rest resulted in no or few fatalities.

However, the validity of trend analysis as a basis for future terror predictions is questionable, and the mere interest of some terrorist groups in ABC weapons justifies efforts to understand this potential threat.[19] One approach is to consider the assessments likely to be performed by the terrorists themselves prior to any large-scale act of violence.

If and when terrorists do think about ABC weapons, they may perform *strategic* assessments of such weapons' impact and the possibilities of massive retaliation in response. Consequently, different cost/benefit calculations and even moral constraints could limit their actions. Large-scale violence could stigmatize the group and hamper possible political aspirations. Committing mass murder may lead to estrangement between the terrorists and their supporters. Besides, typically terrorists do not perceive themselves as psychotic madmen and killers, but merely as political or military units.[20] Killing many thousands of people might not be consistent with the terrorists' perceptions of themselves as liberators or freedom fighters. Only the most extreme and least rational groups, or those motivated not by distinct political aims but by apocalyptic visions or by some pan-destructive beliefs, are likely to employ ABC weapons.[21]

Furthermore, a group's interest in ABC weaponry is not the same as obtaining such capabilities. Before any decision to deploy either conventional or non-conventional weapons, a terrorist group will have to judge its competence to use the weapon effectively. This will involve practical assessments of the level of training, skills, and technical and logistical capabilities required. Terrorists are dependent on success, as failure could threaten the cohesiveness or the very existence of the group. This creates an environment of risk aversion where known and proven tactics will be preferred. Surely, if the stakes are high, terrorists, as others, can accept further risks. But there have always been enormous gaps between the potential of a weapon and the abilities and/or will to employ it by terrorists.[22] Most terrorist groups, even those pursuing suicidal ends, protect their resources. Wasting personnel and money will inevitably harm the group and its long-term goals. Consequently, new means and methods of violence with unknown outcomes would be less appealing.

However, a terrorist's acquisition of ABC weapons may be governed by opportunistic approaches. Instead of relying on long-term planning, preparation, and finally weapons acquisition, groups might simply choose the means that readily become available. Indeed, such opportunism characterizes the efforts to acquire nuclear weapons by both Aum Shinrikyo and Al Qaida, the group of Osama bin Laden.[23]

The combination of practical and strategic obstacles could make the road to ABC capabilities a long and cumbersome one. But, if terrorists, after making their assessments, choose to seek ABC weapons, how easily could such means be acquired?

PRODUCTION OF ABC WEAPONS

While recipes for biological material production are widely available today on the Internet, experts' opinions differ on the ease with which biological weapons can be produced. According to some, biological weapons can be made in a garage or a kitchen, as preparing growth medium for bacteria is no more complicated than brewing beer.[24] Others, however, believe that engaging even in the most primitive level of biological warfare requires scientific skills and training. These experts tend to dismiss the "kitchen table" argument and believe that access to a microbiological laboratory is crucial.[25]

A striking parallel can be seen in the discussion surrounding crude nuclear weapons production and whether sub-national groups will succeed in producing them. Unsuccessful state nuclear programs (e.g., the Iraqi's) are often cited as evidence of the difficulties of establishing reliable nuclear weapons programs. Unfortunately, this line of reasoning may lead to underestimating the threat from nuclear terrorists. It is important to recognize the technical opportunities available and the limited skills required for the successful production of a crude nuclear explosive device. In fact, there is a good deal of misunderstanding about the ease with which a sub-national group could fabricate a nuclear explosive.[26]

As with biological weapons, no basic research is required to construct a nuclear weapon. Luis W. Alvarez, a prominent nuclear weapons scientist in the Manhattan Project, has argued that it is not difficult to set off an explosion using highly enriched uranium (HEU):[27]

> With modern weapons-grade uranium, the background neutron rate is so low that terrorists, if they have such materials, would have a good chance of setting off a high-yield explosion simply by dropping one half of the material onto the other half. Most people seem unaware that if separated HEU is at hand it's a trivial job to set off a nuclear explosion... [and] even a high school kid could make a bomb in short order.

Not all weapons scientists would go so far as to argue that a high school student could make a bomb, but the technical capabilities to set off an explosion using nuclear materials should certainly be considered as within reach for some terrorists. Moreover, terrorists may also be attracted to a crude nuclear weapons option due to the low radiation levels associated with HEU. In contrast to biological materials for weapons, fresh (unirradiated) uranium material can be handled unshielded without protective measures. HEU thus provides a convenient material for weapons production for groups with limited resources and no access to advanced laboratories.

Uranium was indeed the material of choice for both the Hiroshima bomb and the South African nuclear weapons program. "Little Boy," the HEU bomb the United States dropped on Hiroshima in 1945, was triggered by a simple "gun" mechanism. A small, slug-shaped piece of uranium was fired down a barrel into a larger, cup-shaped piece of HEU.[28] This elementary design generated a destructive force of about 15 kilotons (kt)—the equivalent of 15,000 tons of TNT. South Africa produced six nuclear devices based on the simple uranium gun-type principle[29] while under the constraints of an international embargo, and thus having to rely on its own resources.

The nuclear weapons produced more than 50 years ago represented sophisticated technology and science at that time. Today these weapons are not only old, they are primitive. Their designs are well known from the scientific literature.[30] Even lectures that were given to the physicists of the Manhattan Project at its commencement have now been published.[31] Likewise, within the information swamp of the Internet, potential nuclear weapons producers can find some useful sites.[32]

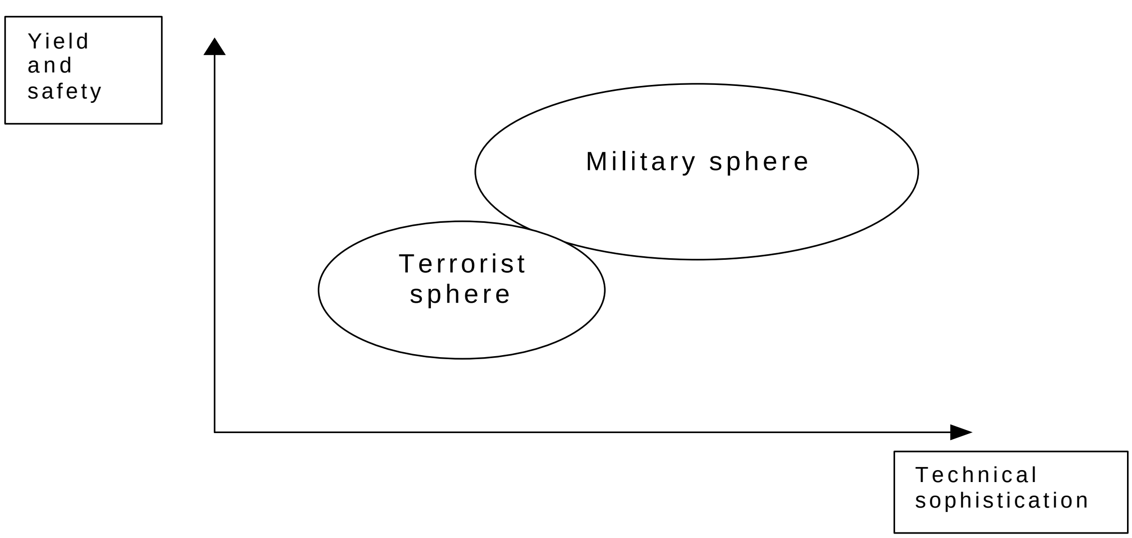
The detailed weapons descriptions remain classified; however, Frank Barnaby has argued that a competent group of physicists and engineers, given adequate resources and access to literature, would have little difficulty in designing a fission weapon from scratch. They would not need to access any classified information.[33] Indeed, to reveal the potential of clandestine nuclear bomb production, nuclear scientists have presented technical outlines of crude gun-type weapons based on readily available commercial equipment and explosives. For example, one design that is about one-meter long and weighs no more than 300 kilograms would lead to a nuclear explosive. Such a crude uranium weapon is likely to explode with a yield equivalent to that of several hundred to a few thousand tons of TNT.[34]

Such a weapon would probably be good enough by terrorist standards. Although covert attackers desire predictable results from weapons, less precision is required than for military purposes. Terrorists would not have to meet the extremely tight specifications and tolerance standards for weapons production.[35] Military weapons must, to a much larger extent than terrorist weapons, be both safe and reliable. That is, when the weapons are used, they must produce optimal yields with a minimal impact from possible detonation effects due to aging or heat. And during long-term storage, military weapons must remain safe and secure, protected from either unintended and/or unauthorized detonation. The differences are outlined in Figure 1, which shows the respective spheres of activity of military and terrorist weapons designers. Because terrorists can operate with lower technical constraints, they can potentially produce a lower, but still "significant" yield.

While there are distinct differences between terrorists' and states' nuclear devices, the two types overlap somewhat, both in terms of technical levels and yields. To maintain high confidence in the workability and yield of its untested nuclear stockpile, a proliferant state with limited access to sophisticated technology might well choose to remain with the simpler designs. The South African and Pakistani nuclear weapons program are examples, representing the lower-end of state military nuclear weapons production. Moreover, many of the modernization programs for nuclear weapons aim at producing smaller weapons with lower yields (and a higher efficiency). The advancement of nuclear weaponry since 1945 can be seen at an unclassified level by comparing the size and weight of "Little Boy" with the far smaller, lighter, and more powerful weapons carried by modern ballistic missiles.

In fact, the most important constraints for a state designing a nuclear device are the weight capacity of the delivery vehicle and the space available to carry the weapon (the diameter and length of a nosecone or the length and width of a bomb bay). Crude nuclear weapons, however, due to their limited size and weight, will easily fit into a van, or even automobiles, for the possible subsequent detonation in densely populated areas. Other non-military means of delivery could be trucks or ships in harbors. Knowing the precise yields of their nuclear explosive devices may be superfluous for terrorists. But the effects of nuclear weapons are widely known after two wartime explosions and more than 2,000 peacetime tests.[36] Based on declassified information and scientific literature,[37] terrorists could perform rough calculations on destruction as a function of the nuclear yield or again turn to the Internet for estimates.[38]

Figure 1: Terrorist and Military Nuclear Weapons Compared



Thus, the production and use of crude nuclear weapons should be regarded as within the capacities of terrorists groups. But despite the "ease" with which workable nuclear explosive devices can be made, the acquisition of fissile material in sufficient quantity is a prerequisite and possibly the most formidable obstacle to the production of nuclear weapons.[39] The next section examines just how difficult it is.

FISSILE MATERIALS ACQUISITION

The primary technical barrier against all types of terrorism, conventional or non-conventional, is lack of access to weapons or other credible means of destruction. In particular, access to HEU or plutonium, the essential components of nuclear weapons, determines whether or not nuclear weapons production is feasible. State nuclear weapons programs are supported by large and costly infrastructures for enrichment and/or reprocessing of fissile weapons material. Sub-national groups, however, are more likely to rely on externally acquired or supplied weapons-usable materials, eliminating the need for complex, large-scale production facilities.

The probability of a successful detonation increases as the mass of fissile materials increases. Ideally therefore, terrorists should possess up to 50 kilograms of HEU for a gun-type device or approximately half this mass for an implosion-type weapon.[40] Alternatively, a nuclear explosive could be created by reducing the required critical mass, which can be done by keeping the neutrons at the edge of the mass from straying and redirecting them back into the chain reaction. This process calls for a "tamper," a thick casing of a dense metal such as naturally occurring uranium. In this case, amounts as low as three to four kilograms of weapons-grade plutonium and eight to 12 kilograms of HEU, depending on the technical design of the device, could be sufficient.[41]

The gathering of sufficient nuclear materials still is regarded as "extremely difficult" by some scholars, who observe that "only a hand-full of cases involving weapons-significant materials are known, and date to the early 1990s."[42] However, other factors suggest that the proliferation risk of nuclear materials is indeed real. The vast production of fissile materials during the Cold War has left the world with a staggering legacy of three million kilograms of weapons-usable material.[43] More than half of the overall production of weapons-usable materials is in excess of national security needs.[44] Furthermore, recently declassified US documents reveal that a significant nuclear yield can be accomplished by utilizing reactor-grade plutonium in the nuclear explosive, so terrorists may not even need to get their hands on military-purpose nuclear materials.[45]

This sudden jump in the potential supply of fissile materials may fundamentally alter the prerequisites for nuclear terrorism and the practical assessments made by terrorist groups prior to such acts. Indeed, bin Laden's group has been trying to penetrate this new nuclear market, most probably unsuccessfully, as arrests have been made on at least two occasions.[46]

While the risk of nuclear theft is a global problem, a critical part of the problem remains within the former Soviet Union, as evidenced by the geographical pattern of seizures to date. The huge quantities of fissile materials and the numerous reports of lax security for and accounting of nuclear materials in the Newly Independent States (NIS) raise concerns over the possibility of a successful diversion of significant quantities of weapons-usable materials.[47] There have been multiple seizures of kilogram quantities of stolen weapons-usable uranium, and one seizure of hundreds of grams of weapons-usable plutonium.[48]

Russia and the other NIS are thought to possess roughly 1,350 metric tons (Mt) of weapons-usable material, of which some 700 Mt are in nuclear weapons, and 650 Mt are in a variety of other forms. About 50 Mt of the weapons-usable material outside nuclear weapons, or about seven percent, had been secured with US assistance by the end of 1999.[49] According to high-ranking US Department of Energy (DOE) officials, the seven percent figure refers only to those sites where upgrades have been completed, and rapid security upgrades have also been performed at a number of additional sites.[50] When all the ongoing security upgrades are completed in 2006, some 400 tons, or approximately 60 percent of the total weapons-usable material stock, will be adequately secured.[51]

However, Russia's Ministry of Atomic Energy has been reluctant to grant US representatives access to buildings in the nuclear weapons complex because of Russian national security concerns. Thus, little progress has been made in installing nuclear security systems in Russia's nuclear weapons complex, where over 90 percent of all the nuclear material in Russia and the NIS is located.[52] Thus, the threat remains. Despite the ongoing US assistance, US Secretary of Energy Bill Richardson stated in March 1999 that, given the current political instability and degenerating economic conditions prevailing in Russia, there is a very real threat that nuclear weapons materials could be stolen or diverted into the hands of terrorists or non-nuclear nations.[53]

Today, the threat of diversion by *insiders* may pose the greatest risk in Russia. While trying to reap profits on an obscure black market for fissile materials, insiders, normally criminal novices, are often involved in the diversion of materials, even from the most sensitive facilities.[54] They know both what to steal and possibly how to steal it. This type of threat is a function of both inadequate physical security and the remnants of the Soviet approach to material control, which emphasized centrally planned production targets and personal responsibility, rather than facility-specific inventory accounting.[55]

Analysis of confirmed cases of HEU and plutonium theft or diversions reveals some interesting patterns. For example, although the number of proliferation-significant instances remains small, the quantity of nuclear material offered for sale increased during the mid-1990s.[56] As of mid-April 2000, the "Illicit Trafficking Database" of the International Atomic Energy Agency (IAEA) contained 299 incidents confirmed by member states involving either nuclear materials, radioactive sources, or both.[57] An additional 88 cases have yet to be confirmed. Of the confirmed incidents, almost half of the seizures involved radioactive sources, six percent involved either plutonium or HEU, and the rest low-enriched or natural uranium.

Some 18 confirmed attempts of smuggling of weapons-usable materials have been stopped since 1993, when the IAEA registrations started; thus, the confirmed cases alone represent more than just "a handful." Moreover, the real figures are not known, so some accumulation of materials cannot be ruled out. If border guards do not have modern radiation-detection equipment, or the equipment is not turned on or in functioning order, fissile materials might be smuggled out without detection. Just one "successful" diversion of significant quantities of plutonium or uranium could be enough for terrorists to build a crude nuclear weapon.

A close call took place in December 1998. The Russian Federal Security Services intercepted an attempt to divert 18.5 kilograms of "radioactive materials that might have been used in the production of nuclear weapons."[58] Russian officials confirmed this attempt in November 1999, stating that the perpetrators "could have done serious damage to the Russian state." While the Russian government has not revealed the specific type of material involved, one can infer, based on the descriptions of the material, the quantities involved, the sensitive facility where the diversion took place, and the potential consequences of a successful diversion, that it was either HEU or plutonium. This makes this case the largest documented attempt to steal weapons-usable materials in the former Soviet Union, and a confirmed case that apparently involved a conspiracy to steal enough materials for a bomb at a single stroke.[59]

There are thus reasons to believe that terrorists could potentially gain access to the needed quantities of fissile materials. If so, the next issues they must address are the weaponization and deployment of ABC devices.

DEPLOYMENT OF ABC WEAPONS

Acquisition of nuclear, biological, or chemical materials is necessary but not sufficient for acts of ABC terrorism. Weaponization of the materials is essential. Nuclear materials have to be introduced into nuclear bomb assemblies, and biological and chemical materials have to be made more resistant and dispersible to cause disease and death in a target population or be used to attack the food supply.

Biological agents are naturally occurring microorganisms (bacteria, viruses, fungi) or toxins and are therefore readily available.[60] But even after producing a weaponized bacteria or virus, effective dissemination of these may pose huge obstacles to the possessors. Efficient deployment of the infectious agents has been the challenge of biological weapons designers since the dawn of biological warfare. In fact, biological weapons were used very infrequently in the past, most likely because they turned out to be very impractical weapons, producing relatively few casualties against armed forces.[61]

Biological agents, with some notable exceptions (e.g., the hardy anthrax spore), are affected by changes in temperature, and the efficiency of a biological attack depends strongly on having a stable and favorable wind direction and particle (aerosol) distribution. The fact that many biological agents are killed by sunlight and moisture further complicates effective delivery and dissemination.

For nuclear weapons, the situation is different. As explained above, a nuclear terrorist with access to sufficient amounts of HEU or plutonium will have a good chance of setting off a nuclear explosion by achieving a critical mass. The successful launching of such attacks will, moreover, not be affected by meteorological or environmental conditions. Past experience suggests that crude HEU nuclear weapons can be made to function without any prior testing and with a limited risk of pre-ignition. At least two types of nuclear weapons can be built and fielded without any kind of yield test, and the possessors could have reasonable confidence in the performance of those weapons.[62]

The risk of limited yields increases in a more poorly assembled device, as the chain reaction will be aborted as the system rapidly expands. However, even if pre-ignition in a simple nuclear device occurs at the worst possible moment—that is, when the materials first become compressed enough to sustain a chain reaction—the explosive yield is still on the order of one or a few kilotons.[63] Although this is referred to as a "fizzle yield," even a one-kt bomb would have a radius of destruction roughly one-third of that of the Hiroshima weapon, making it a potentially fearsome explosive. As a comparison, the most powerful conventional bomb ever used, the "Earthquake" bomb (also known as the "Grand Slam") had a yield of 10 tons, which is 100 times lower.[64]

Likewise, a bioterrorist need not engage in experimental tests to investigate the lethality of the weaponized agent. But if a biological weapon is untested there may still be questions about its effectiveness and the best ways of utilizing the weapon. Biological terrorists may also encounter difficulties in controlling the agent and preventing self-infection. While conventional explosives, nuclear devices, or even chemical agents affect a definite space in a definite time with definite damages,[65] biological agents are unpredictable: they can easily get out of control (e.g., contagious agents such as smallpox and pneumonic plague), backfire, or simply have no effect at all.

Low-quality agents and crude dissemination methods would make biological attack less technically challenging, but also less effective. Aum Shinrikyo had extensive financial resources and expertise and years of research into chemical and biological weapons.[66] Nevertheless, it was unable to carry out a successful mass casualty attack.[67] To improve their weapons' performance, biological terrorists will need detailed knowledge about dissemination techniques and the optimal particle-sizes of the agents.

Thus, while access to technology is likely to increase the effectiveness of all types of weaponry, crude biological terrorist weapons may remain less reliable than crude nuclear terrorist weapons. The latter are still likely to produce significant "minimum" yields even at the lower end of the technological scale.

ABC EFFECTS AND COUNTERMEASURES

While a wide range of agents, scenarios, and modes of operation are possible for biological or chemical attacks, countermeasures are available for some of these. Defenses range from vaccines to gas masks and other protective clothing, and from containment to decontamination. However, early detection and warning as well as adequate preparation are essential for most of these countermeasures to be effective. Moreover, an almost immediate shortage of antidotes and equipment is probable. Stockpiling vaccines is unrealistic as they only apply to specific agents. Even with extensive preparation, a society could succumb to novel biological agents or genetically engineered organisms. Remedial actions for an unprepared population in the event of a major biological weapons attack are thus limited.

But while chemical and biological weapons have yet to be proven efficient for causing mass casualties, there is no defense against the thermal effects, pressure, and radiation caused by the detonation of a nuclear weapon. Within less than a millionth of a second after detonation, the extremely hot weapon residues radiate large amounts of energy.[68] While the fireball is still luminous, the temperature is so high that all weapon material is in the form of vapor, absorbing surrounding materials. Moreover, a fraction of a second after the nuclear explosion, a high-pressure shock wave develops and moves outward from the fireball. The physical effects are devastating. As a terrorist nuclear weapon is likely to be detonated at ground level, the radioactive cloud would be much more heavily loaded with radioactive debris than an airburst cloud. The fallout from a terrorist bomb may therefore result in particularly severe radioactive contamination.

For terrorists, the targets are usually instrumental; they are targeted in an attempt to achieve certain consequences beyond the specific act of violence. Thus, how the terrorism is perceived could be of high importance.

An evaluation of the demonstration effects of different ABC weapons is given in the following section.

PERCEPTIONS OF ABC THREATS

Another poorly understood dimension of possible ABC terrorism is the demonstration effects associated with different types of incidents. Studies of risk perception show that the public has a greater fear of consequences that are catastrophic, not well understood by them, and from a confirmed event.[69] Corroboration of the attacks is normally therefore of importance for terrorists, as the immediate affirmation of the violence will be central in attracting attention. Most terrorists want showy attacks that produce a great deal of noise.[70] Moreover, nuclear weapons could have a special attraction, as the prestige associated with acquiring a nuclear capability is unmatched by chemical and biological weapons. A nuclear device would set a terrorist organization apart from any other group, and would compel governments to take the terrorists seriously.[71]

Biological weapons, however, are “silent killers”—many of them do not lead to a sudden and definite confirmation of a serious act of violence. The effects of infectious biological materials will not become apparent until days or weeks have passed, due to the incubation period. The victims may be widely dispersed, so there are no geographically concentrated effects or casualties. Delayed, limited, or even total lack of public attention could be the result, as it was for many of the activities of the Aum Shinrikyo. The cult made nine attacks with biological and chemical weapons before and then two attempts after the major subway incident.[72] Some of the chemical attacks were lethal, but none of the attempts initially were recognized as terror incidents by the media, the public, or the law enforcement authorities.

Also, nature itself produces lethal agents, and natural outbreaks of infectious diseases therefore occur regularly.[73] These outbreaks can be mistaken for covert biological terror actions, and vice versa. Rapid detection of the causative agent and its source can be more than challenging for the responding authorities. The confusion arising after a total of seven fatal human cases and concomitant mortality in birds caused by a virus outbreak in New York City in late August and September 1999, demonstrates this uncertainty. The virus, West Nile, had never before been seen in the Western hemisphere.[74] It remains unknown how the virus was introduced in the United States and the length of time it had been in the country. The extent of its geographic distribution in the United States is still a mystery. No similar ambiguity of cause and consequences would exist in the aftermath of a terrorist nuclear explosion.

Moreover, the incubation periods after biological exposures may further complicate the epidemiological investigation. Terrorists could take advantage of the resulting “vacuum of knowledge,” and fuel the uncertainty by releasing threatening statements to the media, and of course, by escaping from the scene of the crime without leaving traces. However, the lack of “proof” may also undermine the biological terrorists’ intentions in situations of extortion or blackmail, and could cause less psychological impact than confirmed acts of atomic terrorism.

Indeed, the increasing awareness of the dangers of biological terror due to both cinematic fiction and the introduction of governmental response programs will inevitably raise the psychological impacts of such acts of terror. Both biological and chemical attacks are likely to cause panic and fear if and when the malicious effects produced by the agents become apparent. However, the dramatic and well-known effects of atomic bombs and previous nuclear accidents are already firmly embedded in the minds of the public.[75] In the mid-1990s, nuclear power plants became the technological hazard that the public perceived as having the most negative and most problematic constellation of traits.[76]

Limited public understanding and knowledge of radiation and the human inability to sense potential exposures have cultivated highly negative perceptions of radiation. Terrorists who capitalize on this fear of radiation are likely to get attention and to have a strong psychological impact on the public as well as governments. The ability to cause substantial panic, fear, and insecurity would help terrorists fulfill the intentions behind their violence, again making crude nuclear weapons a potentially tempting option.

In this regard, the use of radiological weapons may also prove to be a feasible ABC option.[77] Radioactive substances could be intentionally scattered—e.g., by the use of conventional explosives (“dirty bombs”)—to expose populations and the environment to radiation.[78] Like biological and chemical weapons, radiological weapons have the potential of intimidation, due to their power to paralyze city centers and leave areas uninhabitable. Radioactive substances can be handled by terrorists with the proper protective shielding and a minimum of skill. Moreover, the radioactive materials could be used to create credible nuclear *hoaxes*, likely to produce a high level of unrest. So-called "nuclear placebo bombs," a combination of powerful high explosives and fission products, may give the impression of a nuclear detonation (prior to analysis of the fission products) and thus create a strong physiological impact.

CONCLUSION: ABC LESSONS

While focusing primarily on the risks of nuclear terrorism, this viewpoint by no means suggests we should disregard biological and chemical terrorism per se. Rather, its goal has been to point out some of the distinctive features of the different types of non-conventional terrorism, and to correct some of the misperceptions surrounding the complexity of building and using crude nuclear weapons.

The practical and strategic assessments likely to be considered by terrorists make it probable that guns and conventional bombs will remain the weapons of choice for most terrorist groups. However, the risk of atomic, biological, or chemical terrorism, while small and uncertain, cannot be neglected. To understand this possibly emerging threat, both the motives of the terrorists and their capabilities must be carefully evaluated, together with any contextual (political, moral, or practical) constraints the terrorists may be facing.

The threat of terrorist deployment or use of biological weapons depends on successful delivery and control of the substances. As long as the "poor man's atomic bomb" remains unreliable and unpredictable, biological weapons can have limited applicability even for terrorists. Depending on its effectiveness and the available targeting opportunities, biological terrorism may come to constitute an option in the future for groups with more strategic goals.

Today, due to their inherent features and demonstration effects, crude nuclear weapons may prove to be a more reliable, tempting, and prestigious option than crude biological weapons for aspiring large-scale terrorists. Crude uranium weapons can be easily built and fielded without any type of test, and their possessors can be confident in their performance. The difficulty of acquiring fissile material in sufficient quantities is therefore the most daunting obstacle to the production of crude nuclear weapons. But, the enormous existing volume of materials and persistent incidents of illicit nuclear trafficking make successful diversion of significant amounts of high-quality fissile materials probable.

For decades, non-conventional weaponry was reserved for states. The risk of terrorism resulting in mass casualties can therefore appear overwhelming and frightening. Resources to combat terrorism have increased in terms of both budgets and programs. However, the possible emergence of new and more "attractive" threats should not allow us to lose track of lingering post-Cold War nuclear challenges. Today, the US DOE budget for nuclear nonproliferation, which includes the funds for physical protection and disposition of fissile materials as well as efforts to prevent brain drain, is some half a billion dollars less than the $1.4 billion the United States spends annually to safeguard American citizens from biological and chemical terrorism.[79]

Understanding a threat or a challenge often starts with the concept used for describing the phenomenon. Thus, while relearning the ABCs, the concept of "weapons of mass destruction" should, as an important start, be carefully examined to comprehend the inherent differences and meanings of the respective weapons. Indeed, nuclear weapons may have become less of a concern since the end of the Cold War, but their potential for devastating effects remains due to both existing state nuclear arsenals and the difficulty of fully protecting the stocks of excess fissile materials. Therefore, nuclear weapons should not be treated as anachronisms, but as continued threats to global security.

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[2] Atomic weapons include both nuclear and radiological weapons.

[3] Jonathan B. Tucker and Amy Sands, "An Unlikely Threat," *Bulletin of the Atomic Scientists* 55 (July/August 1999), p. 47.

[4] Ibid, p. 46.

[5] Biological toxins are among the most lethal agents known. A single microbe can, because it reproduces, theoretically produce the desired detrimental outcome in a target host. That is, a single smallpox virus or plague bacillus can grow and produce disease—with fatal outcomes. However, it usually takes more than a single organism to establish an infection.
[6] E.g., by using genetically engineered organisms acting directly at the cells. From J.P. Robinson, quoted in Lois R. Ember, "A Double-Edged Sword," *Chemical & Engineering News,* December 6, 1999, p. 110.
[7] Gavin Cameron, "WMD Terrorism in the United States: The Threat and Possible Countermeasures," *The Nonproliferation Review* 7 (Spring 2000), p. 172.
[8] The major comparisons throughout the text will be made between nuclear and biological weapons, being the potentially most lethal ABC weapons.
[9] See J. Miller, "Terrorism around the Mediterranean," paper presented to the 29th Annual Conference of the International Institute for Strategic Studies, Barcelona, Spain, 1987.
[10] Cameron, "WMD Terrorism in the United States," p.163.
[11] Wolfgang K.H. Panofsky, "Dismantling the Concept of 'Weapons of Mass Destruction'," *Arms Control Today* 28 (April 1998), p. 3.
[12] Steve Fetter, "The Future of Nuclear Arms Control," *Physics and Society* 28 (October 1999), p. 8.
[13] While the FBI defines WMD as those involving chemical, biological, or nuclear weapons, others, like Richard A. Falkenrath, Robert D. Newman, and Bradley A. Thayer, in *America's Achilles' Heel: Nuclear, Biological, and Chemical Terrorism and Covert Attack* (Cambridge, MA: BCSIA Studies In International Security, The MIT Press, 1998), discuss NBC (nuclear, biological and chemical) weapons instead. For a useful discussion of the problems of defining WMD terrorism, see Cameron, "WMD Terrorism in the United States," pp.163-164.
[14] Walter Laqueur, *The New Terrorism: Fanatics and the Arms of Mass Destruction* (New York and Oxford: Oxford University Press, 1999), p. 7.
[15] Cameron, "WMD Terrorism in the United States," p.164.
[16] Ibid., p.173.
[17] Ibid., p.165. These are the numbers as of December 1999. For a description of 55 of the terrorist incidents in the database, see "Terrorism in the U.S.A. Involving Weapons of Mass Destruction," Chemical and Biological Weapons Nonproliferation Project, Center for Nonproliferation Studies, Monterey Institute for International Studies, January 1, 1999.
[18] Cameron, "WMD Terrorism in the United States," p.165.
[19] Trend analyses inevitably involve inaccuracies due to the divergent definitions and categories of terrorism, which create biases in all statistics on terrorism. The statistical figures can be incomplete due to a lack of international observers or journalists or because of a high frequency of terrorism in a region (and thus a lack of newsworthiness), or reflect a political agenda, governed by the strategic or national goals of a government that reports on terrorist incidents.
[20] Bruce Hoffman, *Inside Terrorism* (London: Victor Gollancz, 1998), p. 29.
[21] Laqueur, *The New Terrorism*, p. 70.
[22] David Rapoport, "Terrorism and Weapons of the Apocalypse," *National Security Studies Quarterly* 5 (Summer 1999), p. 51.
[23] For an interesting comparison of the efforts of these two highly different groups to acquire weapons of mass destruction, see Gavin Cameron, "Multi-track Micro-proliferation: Lessons From Aum Shinrikyo & Al Qaida," *Studies in Conflict and Terrorism* 22 (October-December 1999). The nuclear weapons program of Aum Shinrikyo was abandoned for biological and chemical weapon programs. Using a track normally pursued by states, the Aum Shinrikyo tried to acquire and then enrich the fissile materials for their nuclear weapons from natural uranium mined at the cult's premises in Australia. However, such an approach, which requires extensive equipment, would be a more feasible method for state nuclear weapons production. This may be why the cult abandoned that approach to follow a more opportunistic path.
[24] Laqueur, *The New Terrorism*, p. 65.
[25] Ibid.
[26] [Editor's note: In order not to make it easier for unwanted actors to find information about how to build a nuclear bomb, the specific reference provided by the author has been removed from this endnote.]
[27] Luis W. Alvarez, *The Adventures of a Physicist* (New York: Basic Books Inc., 1987), p. 125.
[28] "Fat Man," the plutonium bomb used against Nagasaki, had the same design as the bomb used in the Trinity test on July 6, 1945 in New Mexico.
[29] Rodney W. Jones et al., *Tracking Nuclear Proliferation: A Guide in Maps and Charts, 1998* (Washington, DC: Carnegie Endowment for Peace), p. 243.
[30] The technical literature is flooded with relevant information. [Editor's note: In order not to make it easier for unwanted actors to find information about how to build a nuclear bomb, the specific references provided by the author have been removed from this endnote.]
[31] The lectures were delivered by Robert Oppenheimer's theoretical lieutenant. [Editor's note: In order not to make it easier for unwanted actors to find information about how to build a nuclear bomb, the individual's name and specific references provided by the author have been removed from this endnote.]
[32] [Editor's note: In order not to make it easier for unwanted actors to find information about how to build a nuclear bomb, the specific websites provided by the author have been removed from this endnote.]
[33] Frank Barnaby, *How Nuclear Weapons Spread: Nuclear Weapon Proliferation in the 1990s* (New York: Routledge,1993), p. 37.
[34] [Editor's note: In order not to make it easier for unwanted actors to find information about how to build a nuclear bomb, the specific reference provided by the author has been removed from this endnote.]
[35] J. Carson Mark, Theodore Taylor, Eugene Eyster, William Maraman, and Jacob Wechsler, "Can Terrorists Build Nuclear Weapons?" in Paul Leventhal and Yonah Alexander, eds., *Preventing Nuclear Terrorism: The Report and Papers of the International Task Force on Prevention of Nuclear Terrorism* (Lexington, MA: The Nuclear Control Institute and Lexington Books, 1987), p. 63, and Falkenrath et al., *America's Achilles' Heel,* p. 100.
[36] A total of 2,050 nuclear tests have been carried out by seven nuclear weapons states. Center for Defense Information, *The Defense Monitor* 28 (1999).
[37] E.g., the classic book of Samuel Glasstone and Philip J. Dolan, *The Effects of Nuclear Weapons,* third edition (Washington, DC: United States Department of Defense and the Energy Research and Development Administration, 1977). The book was first published in 1950.
[38] A wide range of Internet sites offer both graphical and visual demonstrations of the powers of nuclear weapons, often by comparing them with the effects of conventional explosives. See e.g., <http://www.atomicarchive.com/Example/Example1.shtml>.
[39] Military Critical Technologies website, "Part II: Weapons of Mass Destruction Technologies" (1997, updated December 1999), p. II-5-1, <http://www.dtic.mil/mctl/>.
[40] The bare critical mass of HEU metal enriched to 94 percent U-235 is 52 kg. Mark et al., "Can Terrorists Build Nuclear Weapons?" p. 63.
[41] These are the amounts required for a reasonably well-designed implosion bomb. The figures for a gun-type design weapon will be higher. See Matthew Bunn, *The Next Wave: Urgently Needed Steps to Control Warheads and Fissile Materials* (Washington, DC: Carnegie Endowment for International Peace, 2000), p. 9, and Thomas B. Cochran and Christopher E. Paine, "The Amount of Plutonium and Highly-Enriched Uranium Needed for Pure Fission Nuclear Weapons" (New York: Natural Resources Defense Council), revised, April 13, 1995, p. 9. The minimum quantities given by these authors contrast with the "significant quantities" of the International Atomic Energy Agency of 8 kg of plutonium and 25 kg of highly enriched uranium, respectively.
[42] Quotes in Gavin Cameron, "Nuclear Terrorism Reconsidered," *Current History* (April 2000), p. 154.
[43] Two-thirds of these materials are produced for military purposes. David Albright and Kevin O'Neill, eds., *The Challenges of Fissile Material Control* (Washington, DC: Institute for Science and International Security, ISIS Reports, 1999), p. 6.
[44] David Albright, Frans Berkhout, and William Walker, *Plutonium and Highly Enriched Uranium, 1996: World Inventories, Capabilities and Policies* (London: Stockholm International Peace Research Institute and Oxford University Press, 1997), pp. 441-443.

[45] A test was carried out in 1962 with reactor plutonium provided by the United Kingdom (US Department of Energy, "Additional Information Concerning Underground Nuclear Weapons Tests of Reactor-Grade Plutonium," undated factsheet). The isotopic composition of the material is classified, but may have had some weapons-grade qualities. Generally reactor-grade plutonium is significantly more radioactive than weapons-grade plutonium. This complicates the design, manufacture, and stockpiling of the weapons. Moreover, due to the high neutron background in reactor-grade plutonium, the material is less controllable. An increased risk of pre-ignitions and fizzle yields will be the result. But, this will also ease the detonation of the nuclear weapons. The ever-increasing quantities of plutonium from civilian nuclear power plants could thus make reactor-grade plutonium a more appealing option to terrorists. Reactor-grade plutonium is considered by the International Atomic Energy Agency as a direct-use, i.e., weapons-usable, material.

[46] See, e.g., *Washington Post*, September 26, 1998, p. A19, or P. Mann, "Nuclear Risks Mount in Besieged Russia," *Aviation Week and Space Technology* (September 1998).

[47] See, e.g., Graham T. Allison, Owen R. Cote, Jr., Richard A. Falkenrath, and Steven E. Miller, *Avoiding Nuclear Anarchy: Containing the Threat of Loose Russian Nuclear Weapons and Fissile Material* (Cambridge, MA: CSIA Studies in International Security no.12, MIT Press, 1996).

[48] For documented thefts of weapons-usable fissile materials and an important and timely update on the proliferation challenges and steps to be taken to minimize the risk of nuclear proliferation from the Former Soviet Union, see Bunn, *The Next Wave.*

[49] United States General Accounting Office (GAO), *Nuclear Nonproliferation: Limited Progress in Improving Nuclear Material Security in Russia and the Newly Independent States,* Report to Congressional Requesters, GAO/RCED/NSIAD-00-82, March 2000, p. 7.

[50] These rapid upgrades are referred to as "quick fixes." They involve steps such as fortifying entrance and exit points, placing one-ton concrete blocks on material storage areas, or even just bricking up windows to secure these sites against terrorist or outside attack. The next level of protection includes material tracking and accounting systems to protect against insiders siphoning off these fissile materials. Both layers of protection are needed to secure materials well into the future. Statement of Rose Gottemoeller, Deputy Administrator for Defense Nuclear Nonproliferation (Acting), US Department of Energy, before the Subcommittee on Energy and Water Development, Committee on Appropriations, United States Senate, March 28, 2000, <www.nn.doe.gov/sawtest.htm>.

[51] GAO *Nuclear Nonproliferation*, p. 8.

[52] Ibid., p. 7.

[53] Statement by US Secretary of Energy Bill Richardson before the Committee on Armed Services Subcommittee on Military Procurement, US House of Representatives, March 4, 1999, <http://www.doe.gov/news/testimon/cas3499.htm>.

[54] J.L. Ford, R.C. Schuller, and William Potter, "Defining the Nuclear Smuggling Pathways," paper presented at the International Conference on Non-Proliferation and Safeguards of Nuclear Materials in Russia, Moscow, May 14 –17, 1996.

[55] William Potter, "Before the Deluge? Assessing the Threat of Nuclear Leakage from the Post-Soviet States," *Arms Control Today* 25 (October 1995).

[56] Ibid.

[57] Personal communication with A. Eveleens, IAEA Illicit Trafficking Database Office, April 17, 2000.

[58] For a description of the case, see Bunn, *The Next Wave*, p. 17, or Scott Parrish and Tamara Robinson, "Efforts to Strengthen Export Controls and Combat Illicit Trafficking and Brain Drain," *The Nonproliferation Review* 7 (Spring 2000), p. 112.

[59] Bunn, *The Next Wave*, p. 17.

[60] E.g., from soil samples and infected rodents. In addition to naturally occurring organisms, genetically modified organisms may be used as biological agents in the future.

[61] Rapoport, "Terrorism and Weapons of the Apocalypse," p. 54.

[62] Military Critical Technologies, "Weapons of Mass Destruction Technologies," p. II-5-1.

[63] National Academy of Sciences, *Management and Disposition of Excess Weapons Plutonium* (Washington, DC: Committee on International Security and Arms Control, National Academy Press, 1994), p. 33.

[64] For details, see <www.danshistory.com/ww2/bombs.html>.

[65] In addition, long-term effects of radiation (e.g., increased cancer and possibly genetic changes) will occur.

[66] Aum contained some 20 scientists with graduate degrees, and its laboratories were so good that the chief chemist said he left the university because Aum's facilities were better. Murray Sayle, "Nerve Gas and Four Noble Truths," *The New Yorker,* April 1, 1996.

[67] Mistakenly, the Tokyo subway incident often is quoted as a biological attack. It was, however, carried out with sarin, a chemical nerve agent.

[68] Glasstone and Dolan, *The Effects of Nuclear Weapons*, p. 27.

[69] See, e.g., P. Slovic, "Perception of Risk," *Science* 236 (1987), pp. 280-285. For the importance of radiation exposures being "confirmed" to cause psychological impact, see Morten B. Maerli, "The Norwegian Public's Perception of Risk from Electromagnetic Fields," *Radiation Protection Dosimetry* 68, nos. 3/4 (1996), pp. 235-238.

[70] Laqueur, *The New Terrorism*, p. 70.

[71] Cameron, "Nuclear Terrorism Reconsidered," p. 155.

[72] Rapoport, "Terrorism and Weapons of the Apocalypse," p. 56.

[73] Terrorists might go to an outbreak area to try to obtain infectious agents with proven lethality. In fact, members of Aum Shinrikyo went to Africa to attempt getting the Ebola virus for later terrorist acts, but without success.

[74] R.S. Lanciotti et al. "Origin of the West Nile Virus Responsible for an Outbreak of Encephalitis in the Northeastern United States," *Science* 286 (December 17, 1999), pp. 2333-2337.

[75] K.R. Smith, quoted in P. Slovic, "Perception of Risk and the Future of Nuclear Power," *Physics and Society* 23 (January 1994), <http://www.physics.wm.edu/~sher/ajan94.html>.

[76] Ibid.

[77] Normally, the number of acute casualties will be low during acts of radiological terrorism, but their potential psychological impact could be strong. The most spectacular performance with radiological weapons so far was given by Chechen leaders in 1995. At that time, they threatened to turn Moscow into a "desert" by using armed and buried containers of cesium. After they gave notification to a television company, one container was, under heavy media coverage and publicity, found in the Izmailovskii Park of Moscow. The Moscow incident was more of a warning and an act of blackmail than anything else, as the actual radiation effects probably would have been limited.

[78] Radioactive isotopes suitable for use as weapons include cesium-137, cobalt-60, iodine-131, and other short-lived, relatively easy-to-produce fission products. The most readily available source for the materials of radiological weapons is spent fuel from nuclear reactors; indeed, the spent fuel rods themselves are sufficiently "hot" to be used directly, although chopping or pulverizing them could increase the effects. Medical isotopes are another readily available source of radioactive material in quantities suitable for spreading terror. Several hundred radioactive sources get lost every year in the United States.

[79] Figures for biological and chemical preparation are taken from John T. Finn and Tessa L. Walters, "Preparing for Bioterrorism and the Flu," unpublished manuscript. These figures are compared with the overall request for $906 million for the fiscal year 2001 DOE budget on nuclear nonproliferation. Figures taken from the Statement of Rose Gottemoeller before the Senate Subcommittee on Energy and Water Development, March 28, 2000.