The Likelihood of Nuclear Terrorism

by ***Gavin Cameron***

INTRODUCTION

Nuclear terrorism, as a term, has been used in the past to encompass a broad range of possibilities, from trespass actions on reactors by single-issue protest groups to, potentially, the detonation of a nuclear yield device. This article is concerned with the likelihood and implications of the most dangerous of these possibilities: the detonation of a nuclear yield device and radiological terrorism. Since they both have been profoundly affected by the increased opportunities for nuclear proliferation in the past five years, the article will begin by examining the likelihood that sub-state actors may acquire fissile or radiological materials, and what this means for an act of nuclear terrorism. After considering the state of the nuclear "grey" market, the study will assess the ease with which terrorists could build a nuclear-yield weapon. The article argues that, although the technical aspects of building such a device are not insurmountable, the acquisition of sufficient fissile material to do so poses a significant obstacle. Radiological terrorism, an attack using non-fissile material, is then analysed and its potential attraction as an instrument for terrorists is considered. The study concludes with an examination of the non-nuclear options for such groups. It asks whether terrorists are likely to resort to non-conventional weaponry at all and, if they do, whether chemical or biological weapons are not more likely to be used.

Nuclear Terrorism: The Opportunities

Easier access to fissile material is largely a result of the collapse of the Soviet Union and the growth of nuclear trafficking that has stemmed from it. As Graham Allison, former Assistant Secretary of Defense, has noted: "Russia is a state in revolution . . . This revolution is shredding the fabric of a command and control society, in a state that houses a superpower nuclear arsenal and a superpower nuclear enterprise."[1] FBI Chief Louis Freeh, has described the situation as "the greatest long-term threat to the security of the US,"[2] and Allison has stated that "the greatest single threat to the security of America today is the threat from loose nukes from the Soviet Union."[3] Russia, too, acknowledges the danger. As early as 1989, then chairman of the KGB, Vladimir Kryuchkov, said:

The threat of nuclear terrorism is for us very dangerous. The fact is that on the globe several tons of enriched uranium has disappeared from sites where it was produced and stored. It is not technically difficult to make a nuclear device, and this will mean the individual groups can terrorize not only towns, but even entire countries.[4]

While nuclear weapons once were regarded as being held under tight military supervision, now it appears that even these may be less secure than was believed previously. Many nuclear warheads are being stored in facilities intended for conventional weapons "in less than adequate physical security."[5] Warhead disassembly plants at Zarechny, Trekhgorny and Lesnoy have especially lax security. There may have

been at least one case where a fissile material component of a weapon was stolen and then recovered.[6]

Furthermore, there is a huge quantity of nuclear materials, dispersed throughout Russia, that is even less secure. Reliable estimates put the Russian inventory at between 150 and 165 metric tonnes of weapons grade plutonium, and 1000 and 1300 metric tonnes of enriched uranium.[7] However, no one really knows what quantities are involved because, during the Cold War, Soviet facilities were set production targets. When these were exceeded, material was kept aside, rather than declared, so as to compensate for any shortfalls in subsequent targets.[8] Consequently, such facilities were more concerned with producing as much nuclear material as possible, rather than keeping an accurate record of existing stocks. Furthermore, material was counted in ruble value, rather than in weight, and inventories could be off by several tons.[9] Obviously, this poses immense problems of accounting, and the danger is heightened by poor security, especially at nuclear sites, secret cities and research institutes.

The problem stems, at least in part, from the fact that, in the Soviet Union, nuclear security was dependent on it being a closed state, with strict controls over foreign travel by its citizens; internal security within the state was tight, discipline was rigidly enforced when controls were violated, and there was simply no black market for nuclear materials. Personnel were screened and closely supervised by members of the security services. Usually, nuclear material could be accessed only by a three man team: two technicians and a member of the security services.

Clearly, such procedures are no longer feasible in the new Russia and members of the security services are now as likely to be responsible for nuclear diversion as anyone else.[10] Much of the theft is insider crime: staff employed within the industry making the most of their access to nuclear material. Even some former Soviet nuclear scientists are involved in the theft of materials: the man who worked in the secret city of Krasnoyarsk who attempted to smuggle two pounds of dual-use material out of the country, provides one such example.[11] Vladimir Orlov, a Russian nuclear safety expert, stated in July 1997 that: "The industry is seriously and dangerously underfunded - 70 percent of security devices at Russian facilities are outdated . . . Some of the staff working at these plants are desperately depressed and haven't been paid in months - and the temptation to smuggle nuclear material out is great. The situation is very serious."[12]

The problem is not limited to Russia; Ukraine, Kazakhstan and the Baltic states are in a similar predicament, and there have been leakages of non-weapons grade material from other states as well: 130 barrels of enriched uranium waste were stolen from a facility in South Africa in August 1994,[13] and there have been seizures of illicit nuclear materials in Switzerland, Poland, Turkey, Romania, Hungary, Bulgaria, the Czech Republic, Germany, Austria, Belgium, Italy and India.[14]

An additional problem has been a haemorrhage of personnel. The nuclear industry used to support entire cities, such as Tomsk, but cutbacks have resulted in thousands of layoffs.[15] Workers often lived in secret cities where they were well paid and highly

respected members of Soviet society. Since 1989, they have periodically been unpaid for months at a time; their wages have failed to increase in line with inflation and they have lost their cachet in society.[16] William Potter has estimated that between 1000 and 2000 individuals have detailed knowledge of nuclear weapons design and another 3000 to 5000 have been directly involved in the production of plutonium and enrichment of uranium in the former Soviet Union.[17]

Money is not the only possible way for scientists to be recruited: the Aum Shinrikyo cult attracted Russian scientists and research students' attention through vast donations to leading facilities. Aum then attempted to persuade them to join the cult itself. It partially succeeded, having a follower who worked in the I.V. Kurchatov Institute of Atomic Energy, and another in the Mendeleyev Chemical Institute, a facility that researched nerve gas, among other things.[18]

It is questionable whether terrorist organizations, intent on maintaining tight security, would risk using a non-member to help construct a weapon, no matter what their expertise or their salary. However, this does not preclude groups, such as Aum Shinrikyo, from recruiting specialists to their cause.[19] Moreover, the information required to design and construct a crude nuclear device is so readily available that the major barrier to micro-proliferation is the ability of groups to obtain sufficient fissile material. Thus, the importance of non-state actors' ability to exploit the increased vulnerability of people and fissile material remains considerable. Russia, with US assistance, is improving its accountability and control system, but the extent of the problem remains vast.[20]

The precise extent of nuclear trafficking, the so-called grey market, is much debated: a March 1996 General Accounting Office report linked lax control over fissile material to several nuclear thefts and the threat of nuclear blackmail, but found no direct evidence of a market operating within the former Soviet Union.[21] This would suggest that the trade is still in its infancy, that it is still a series of opportunistic one-off deals, and has yet to be firmly established. In fact, there has yet to be a single unequivocated example of stolen nuclear materials reaching a bona fide customer.[22] Of 278 radioactive theft incidents recorded by the Russian MVD (the Russian Ministry of the Interior) between January 1992 and December 1995, only eight involved a purchase, in each case by a middleman.[23]

That there have been no unequivocal cases of a transaction involving stolen fissile material may be as much a reflection of the ability to apprehend these smugglers as the absence of such a market.[24] There clearly are states (and maybe sub-state actors), such as Iran, that would be willing buyers for such material. Equally, there is solid evidence of individuals who have been able to obtain such material, but who have little contact with buyers. It is these individuals that have been caught as they tried to find a market for their product. The real risk, in terms of a market developing, comes from middlemen willing to exploit an individual's access to sources of material and also having contacts with buyers. The obvious candidates for such a role would be ex-KGB or intelligence agents, the military or organized crime in Russia.[25]

The Sellers

There have been six clear-cut smuggling cases involving weapons-grade nuclear material, but these all occurred between 1992 and 1994, so it might be possible to regard this as a problem in the past an aberration. It would, however, be rash to do so. Although it is possible, in view of the lack of weapons-grade seizures since 1994, to suggest that the volume of this trade is extremely small, it does not reflect an absence of such trade, only that the traffickers have not been caught. Moreover, there is little doubt that the quantities of non-weapons-grade material being trafficked are increasing.[26] It is also important to note that there is currently no consensus among experts as to whether weapons-grade material is obligatory in building a nuclear-yield bomb. R.W. Selden, of the Lawrence Livermore Laboratory, has argued that "The concept of . . . plutonium which is not suitable for explosives is fallacious." Hans Blix, Director General of the International Atomic Energy Agency has argued that: "The Agency considers high burn-up reactor-grade plutonium and in general plutonium of any isotopic composition . . . to be capable of use in a nuclear explosive device. There is no debate on the matter in the Agency's Department of Safeguards."[27] The views of neither Selden nor Blix can be lightly dismissed. If they are correct, then weapons-grade material does not equate to weapons-usable material. Therefore, the lack of weapons-grade seizures may not preclude the construction of a crude nuclear-yield weapon using non-weapons-grade material.

While it is possible that the market has been inflated in Germany, where most of these supposed sting operations have occurred, there is increasing evidence that there are several more conduits into the West which have grown in significance, as the profile of the German one has risen and thus decreased its usefulness to nuclear smugglers. It seems clear that progressively more and more material is being brought through southern routes rather than through Eastern Europe. Examples of these alternative routes are suggested by cases such as the seizure of 255 grams of uranium-238 in Macedonia or by the arrest of seven Siberian criminals trying to sell 5kg of uranium-235, stolen from Kazakhstan, to contacts in China or Pakistan.[28] In many cases traditional routes for smuggling a range of other goods are being utilized for the nuclear traffic. Testifying before a Senate Committee on 20 March 1996, John Deutch, then Director of Central Intelligence, stated:

The countries of Central Asia and the Caucasus - Kazakhstan, Armenia, Azerbaijan, Kyrgyzstan and Uzbekistan - form transit links between Asia and the West, and the Middle East and the West. The break-up of the Soviet Union has resulted in the breakdown of the institutions that kept many smugglers and questionable traders out of this region. The pervasive control once exerted by a combination of the Soviet KGB, the Soviet military, and the Soviet border guards no longer exists. Even before the break-up, however, some of the southern borders, especially with Afghanistan, were penetrable. According to anecdotal information from recent travellers to these areas, anything can go across the borders in these countries for a minimal price.[29]

Smuggled goods from Afghanistan in the past have included antiques, drugs and conventional weaponry. The Pakistani town of Peshawar, on the border with Afghanistan, seems to be a center for this trade. It is also a thriving market for nuclear equipment,

some of it weapons-usable, stolen from reactors and military installations within the former Soviet Republics. Goods on offer are reputed to include ultra-powerful magnets, catalysts and alloys to make thermo-nuclear devices and enriched uranium. Iran, India and Pakistan all are alleged to be buyers, and there is the added risk of terrorists also making use of the Peshawar market: religious extremists from Algeria, Kashmir, Egypt and Sudan used the town as a rear base in the war between the Soviet Union and the Afghan mujahedin. Many are still in Peshawar. A great deal of the material available in the town is fake: worthless but dangerous radioactive waste passed off as enriched uranium. In part, this reflects many of the local sellers own ignorance of the properties of the smuggled goods. There are numerous stories of material being transported and stored recklessly by Afghan traders who are then fatally irradiated as a result.

The extent of the nuclear market in Peshawar is hard to assess, but even Pakistani officials such as General Naseerullah Babar, the Interior Minister, concede that it exists, " . . . there was someone here offering [nuclear material]. They bring photographs and things, though not the material itself."[30] At least some of the smuggling is concealed under legitimate exports, for example, shipments of cesium-137, correctly labelled and with the required paperwork, may also include a quantity of illicit nuclear material, such as highly-enriched uranium (HEU) or plutonium. Such practices form an important part of the criminal proliferation in the former Soviet Union.[31]

There are several different varieties of nuclear trafficker currently operating. Much of the detected smuggling so far has been by amateurs simply trying to make some fast money.[32] In some cases, these individuals have no knowledge or experience of nuclear material, so there are instances of someone carrying cesium in his shirt pocket and dying as a result; or of a St. Petersburg butcher who stored enriched uranium in his fridge and tried to sell it at weekly street markets in the city. That such people can acquire material is indicative of just how easy gaining access to it really is. In many cases, they are simply people who are desperate to find a way to maintain their livelihoods. The situation at the Zvezda repair yard in 1997 provides a good indication of their plight; there, striking workers, frustrated at their inability to force the Russian government to pay their overdue wages, threatened to sabotage the nuclear submarines at the yard.[33] It would be quite plausible to believe that given the opportunity these workers also might resort to theft of the available nuclear material.

These amateurs are almost invariably simply opportunists: they rarely have past criminal records, links to organized crime or illegal business involvement. Instead, they tend to be employees or former employees of the nuclear-industrial complex, are linked to such an insider, or live in the vicinity of a vulnerable facility.[34] They also rarely appear to have a customer in mind at the time of the diversion or theft; rather, they have been willing to seize their chance and then seek a buyer.[35] Although they may desire to traffic nuclear material, the capacity of such amateurs to do so is severely limited by their inability to effectively find a market for the material they acquire. Consequently, the proliferation threat posed by these amateurs arises, not from an immediate danger, but from the possibility that they would provide a vital supply of nuclear material to middlemen, if a nuclear black market were to be established.

A more sophisticated group are those opportunist entrepreneurs and business people who regard trafficking simply as an extension of their existing activities. The Russian Internal Affairs Ministry Economic Crimes Division has reported that, of the 172 people arrested for nuclear smuggling in 1993, 10 were directors of small commercial enterprises and 2 were low-level employees of the same firms. These dealers have export licences and Western bank accounts and trade legally and illegally in goods such as oil, weapons or rare materials. Nuclear trafficking is simply a highly profitable sideline, one done primarily on consignment.[36] As such, they already have contact with potential buyers of nuclear material and, along with the mafiya, would be prime candidates to fulfill the intermediary or middleman role in a developing nuclear market.

The extent of the Russian mafiya's role in nuclear trafficking is difficult to assess. If detected, such activity would increase the likelihood of a crackdown on the criminal sector as a whole. Thus, it offers relatively low incentives for them, especially while other activities, such as drug smuggling, are so lucrative, providing an easily accessible mass market and little physical danger from the materials.[37] In fact, there is some evidence that the main mafiya groups positively discourage such activities in case they endanger other interests or risk the considerable leverage the mafiya enjoys with political and law enforcement officials.[38]

Although the Russian authorities have made numerous arrests of individuals with links to organized crime attempting to smuggle non-weapons grade nuclear material, there is little evidence currently that large organized crime groups per se, with established structures and international connections, are involved in the trafficking of fissile materials.[39] This appears to have been a largely economic decision; there is a more clearly established market for dual-use isotopes and non-fissile material and the mafiya have been involved in the trade of these. However, there appears to be only one clear-cut case of organized criminal involvement with fissile material trafficking: in 1993, a Volgograd businessman offered 2.5 kg of highly-enriched uranium to a gang based in the Central Volga region to pay off a debt he owed to them. The gang sought buyers in the Baltic states and Europe, but, unable to find any, refused to accept the material as payment for the debt.[40]

These criminal organizations do possess the means to acquire nuclear materials by threats or bribery and, almost certainly, the network to move them out of the country.[41] In truth, organized crime is not monolithic and is barely organized. It is closely intertwined with government, and, increasingly, the line between political and criminal agendas has been blurred. By 1996, there were an estimated 8000 organized crime groups in Russia, many with increasingly sophisticated international links.[42] In 1994, the official Russian estimate was that such groups controlled 40,000 state and private organizations, including hundreds of state enterprises, companies, co-operatives, banks and markets.[43] In August 1995, the MVD estimated that organized crime controlled over 400 banks and 47 exchanges; Professor Lydia Krasfavina, of the Institute for Banking and Financial Managers, suggests that up to 80 percent of private banks in Russia may be controlled by criminal groups.[44] The official figure for mafiya membership, 20,000 to 25,000, is almost certainly understated: other sources suggest the number is closer to 120,000.[45] Furthermore, this figure reflects only active members of the mafiya: the true numbers of

people involved may be as high as three million.[46] Russian organized crime is a series of networks encompassing criminals, businessmen, politicians, bureaucrats, security and military personnel, who between them are more than capable of moving stolen fissile material without Western intelligence forces ever being aware of the fact. The relative ease with which this could be achieved suggests that it would be extremely rash to exclude the possibility of organized crime being involved in nuclear trafficking and certainly not as the result of any moral strictures.[47] However, although the capacity to smuggle material undoubtedly exists, as yet, the mafiya's desire to do so remains questionable.

Among those best able to engage in nuclear smuggling are former Soviet bloc military and intelligence personnel, some of whom spent their Cold War careers moving material and technology from West to East, and now find themselves, using the same methods, able to simply reverse the route.[48] Unlike the previous categories of amateurs, businessmen and the mafiya, such members of the armed forces are potentially in the position of having both access to nuclear material and the possibility of finding a buyer. This would obviously apply more to those who had contacts in other states, such as intelligence personnel or high-ranking officers. Others, without such contacts, are more likely to be akin to the amateurs described earlier, simply exploiting their access to nuclear material.

Like the scientists of the former Soviet Union, many military personnel greatly resent the deterioration in standards of living, budgets and social status, and might be willing to exploit the lax security surrounding fissile material.[49] In October 1996, Russian Defence Minister General Igor Rodionov warned that the army was demoralized and on the brink of revolt over unpaid salaries and poor conditions. Furthermore, this situation applied equally to the Strategic Rocket Forces, the section of the army responsible for security of Russia's nuclear armory.[50]

Given their poor work conditions, there is no substantial reason to believe that personnel responsible for Russia's weapons of mass destruction (WMD) are more reliable than the demonstrably corrupt military officials assigned to other duties.[51] There are already several examples of military personnel using their access to nuclear material for their profit. On 29 November 1993, Lieutenant-Colonel Alexei Tikhomirov, of the Russian Navy, and Oleg Baranov, Deputy Administrator of the Polyarnyy submarine base, stole 4 kg of uranium from the Navy's nuclear weapons and fuel store in Murmansk, in the hope of selling it for $50,000. Lieutenant Dimitri Tikhomirov, Alexei's brother, and in charge of a nuclear reactor, helped them handle the fuel. The thieves walked through a hole in the perimeter fence, forced the padlock on the fuel-store door, and stole 3 fuels rods containing uranium 235 enriched to 20 percent. The theft was not discovered until twelve hours later, by which time Tikhomirov and Baranov had smuggled the fuel into the top security Polyarnyy naval base where it was stored in Baranov's garage for seven months, until Dimitri got drunk and boasted to fellow officers, when the three were arrested.[52] The theft would have taken even longer to detect were it not for the fact that the thieves left the door to the warehouse open. Otherwise, according to the case's prosecutor, it "could have been concealed for ten years or longer."[53]

The Buyers

The main buyers for nuclear material are unclear. The purchase of such material would probably save proliferator states 8-10 years on their weapons programs and, in view of the time and facilities required for manufacture, improve the chances of maintaining the secrecy of the project.[54] It seems unlikely, however, that this will replace the proliferator state's normal process of hidden weapon acquisition; states will use the black market to facilitate the indigenous development of a nuclear capability, rather than as a substitute for it. States derive considerable regional and international leverage from their nuclear programs and are unlikely to be willing to abandon them in favor of an external supply system that is bound to be unpredictable and unreliable, particularly when every effort is being made internationally to shut it down altogether.[55]

Whether this equates to an increased likelihood of state-sponsored nuclear terrorism is more problematic. It would be imprudent to exclude the possibility: indeed, the former Director General of MI5 has argued that: "Some two dozen governments are currently trying to obtain such technology. A number of these countries sponsor or even practise terrorism, and we cannot rule out the possibility that these weapons could be used for that purpose."[56] However, sponsoring states would have to be completely certain of plausible deniability in perpetuity for any terrorist attack, since the repercussions from states that have been the victim of an act of nuclear terrorism could be immense. Furthermore, having given a client terrorist group a nuclear weapon, the sponsor state has very little control over the group, and may even be subjected to blackmail by the organization. It makes more sense to suggest that, having obtained fissile material, a state would use its own agencies to exploit the situation. As Richard Falkenrath argues, unless a state could guarantee complete control over its client group, it is very unlikely that it would use a terrorist organization to deliver a nuclear device because the stakes are too high, in which case the problem essentially becomes one of deterrence.[57] This is certainly true for a nuclear-yield weapon, but may not be so for radiological devices, since it might be possible to ensure that such a weapon dispersed radiation covertly, minimizing the risk of detection. Whether a state would choose to utilize such a capability is another question, but it is not inconceivable; it certainly would be an effective weapon to create widespread panic and to intimidate officials. However, by and large, states seem to seek membership of "the nuclear club" for the security, prestige and leverage that it conveys on a regional and global level, rather than for the overt intention of imminently using the new capability.[58] It is worth noting that while there are a number of states that sponsor terrorism and ave a chemical or biological weapons capability, there is little evidence that there has been biological or chemical terrorism by sub-state actors as a result.

As yet, there is little evidence that terrorist groups are buyers in their own right.[59] However, if the flow of nuclear materials out of Russia continues, it is probably only a matter of time before a well-resourced organization is able to become a purchaser. Such a group need not be state-sponsored; the Aum Shinrikyo cult had a billion dollars and 40,000 members spread worldwide.[60] As former Director of Central Intelligence Deutch has stated: "We currently have no evidence that any terrorist organization has obtained

contraband nuclear materials. However, we are concerned because only a small amount of material is necessary to terrorize populated areas."[61]

It is worth noting that cost alone is unlikely to be the factor that precludes terrorist groups from acquiring fissile material. Although Aum was exceptional in terms of its assets, an increasing number of terrorist organizations are self-funded. This is as a result of two interrelated trends. First, the amount of state-sponsorship of terrorism which, although never as widespread as sometimes was claimed, was still a significant element in international terrorism, has decreased dramatically with the end of the Cold War and the declining necessity for surrogate warfare in other states. Second, to compensate for the first trend, terrorist groups have become increasingly involved in racketeering and transnational crime. The Revolutionary Armed Forces of Columbia (FARC), for example, has been heavily involved in drug trafficking. A study of the finances of Columbian guerrilla groups found that they doubled between 1991 and 1994 with drugs contributing to 34 percent of their income, extortion and robbery 26 percent and kidnappings 23 percent.[62] Many of these activities are international: the Liberation Tigers of Tamil Eelam are allegedly involved in fraud, extortion, alien smuggling and drug trafficking in Canada, all to aid their cause in Sri Lanka.[63]

It is increasingly obvious that the relationship between terrorism and crime is increasing in the 1990s. The connection between the two types of illegal organization stems, in part, from the increased accessibility of international crime for terrorists, arising from easier travel, communications and money-laundering in the modern world. In some cases, terrorism itself has become a source of income: both the Irish Republican Army and the Ulster Defence Association have construction rackets that largely determine which firms receive the building contracts (in exchange for a kickback) to reconstruct the areas of Belfast wrecked by the two groups' violence.[64]

Whether this equates to terrorist groups having considerable disposable income, and therefore being potential buyers of fissile material, is questionable. It seems likely that only the largest, most sophisticated groups would be able to exploit these opportunities. For others, terrorism probably remains an expensive occupation, especially for underground organizations that must support members who are unlikely to have another form of income. Rather than building up their assets, most groups seem to lead a relatively hand-to-mouth financial existence, dictated by immediate operational needs, as well as the prerequisite of maintaining the group as a viable organization.

The move away from state-sponsorship may be important for another reason as well. It may mean that those terrorist groups, unconstrained by the agendas of actors that have a stake in the international system and that are clearly vulnerable to reprisals from other states, may have greater freedom of action. No longer restrained by this influence, they may be more inclined to take radical action, possibly even involving weapons of mass destruction.

The Possibility of a Terrorist Nuclear-Yield Device

Despite all of this, setting off a nuclear-yield bomb would require that a group somehow acquire a weapon an extremely difficult proposition. At the time of writing, there was no credible evidence in the public domain indicating that any nuclear warheads had been stolen or diverted successfully from Russian stockpiles and therefore were available for terrorists' use. However, there may have been at least one case in which a fissile material component of a weapon was stolen and then recovered.[65] The more likely alternative is that terrorists intent on building a nuclear-yield device would try to acquire fissile material, rather than an intact weapon. This would seem to preclude all but the most affluent or state-sponsored terrorist groups, since the biggest challenge remains the acquisition of fissile material. It is worth recalling that the design for a crude nuclear device has been publicly accessible for 25 years, and that it relies on technology which, while challenging in the 1940s, is almost certainly no longer so. This is especially the case if one assumes that terrorists would be content with a crude nuclear weapon, of variable and uncertain yield. Easiest to construct would be a gun-type assembly, using around 50 to 60 kg of HEU. It could be build by a small group, using the open literature, and without requiring testing of components or a great deal of technical equipment, the cost of which would be a fraction of a million dollars. A uranium device undoubtedly would require a simpler design than would a plutonium one. However, the difficulty in acquiring sufficient quantities of HEU may mean that it is the plutonium device that is the more likely type of nuclear-yield bomb for a terrorist group.

The relative value of plutonium as the material of choice for a terrorist group is a matter of considerable debate. The conventional wisdom is that a group would have to use weapons-grade plutonium, machined into a sphere and surrounded by shaped conventional explosives that, when detonated simultaneously, to the micro-second, would compress the sphere and create a super-critical mass. The degree of engineering required to achieve this would make the building of such a device at least very difficult for terrorists if not impossible. However, as was mentioned earlier, the idea that constructing such plutonium nuclear-yield devices would be difficult, or even that it is compulsory to use weapons-grade material, is disputed. Frank Barnaby has argued that, if a terrorist group were to steal plutonium oxide it could be converted to plutonium metal in "a straightforward chemical process."[66] By using a portion close to critical mass (about 8 kg of metal), it would not be necessary to shape the conventional high explosive to achieve a super-critical mass. Instead, the desired effect could be achieved by stacking the explosives around the plutonium and using enough detonators to create a symmetrical shock wave. An electronic circuit that generated a high-voltage square wave would enable the detonators to be fired simultaneously enough to achieve the desired result. Alternatively, plutonium oxide itself could be used for a crude nuclear device by placing about 35 kg of reactor-grade plutonium (in the form of plutonium oxide crystals) in a spherical container and surrounding it with a large quantity of conventional high explosive. The simultaneous detonation of this explosive would almost certainly result in the release of significant energy from nuclear fission. Even if it did not work, the result would be a singularly unpleasant radiological dispersal device, since the explosion would cause the plutonium oxide to be scattered over a wide area.[67]

Radiological Terrorism

It still seems unlikely that most terrorist organizations would seek to enrich material for a yield-producing device; it is simply too complex and requires considerable expertise and cost to achieve. The more telling argument against it, however, is that enrichment would be unnecessary if as suggested above a crude nuclear bomb can be made with material that is not weapons-grade. Moreover, even low-grade fissile material would have considerable utility as the basis for a radiological device. Materials in this category can be stolen more easily from nuclear, industrial and research facilities than can weapons-grade material.[68] A radiological device would be extremely easy to construct; it need only be a aerosol can, or a bomb with a radioactive coating or with a container of radioactive material next to it. The materials for it are so widely available (cesium-137, for example, is commonly used in hospitals for X-rays), that it is by far the most likely form of nuclear device, as well as the least catastrophic. However, it would still have considerable value as a terrorist weapon, since the mere fact of being "nuclear" would almost certainly ensure that it had a considerable impact on the public's imagination and fear, and thus on a governmental response. For the same reason, being "nuclear," it conveys an added prestige and status on the perpetrators. While radiological devices are not ideal for creating mass casualties, they would have a vast impact and could, potentially, pose a considerable problem for an extended period. Once authorities became aware of an incident, they probably would be able to clean up the radiological effects of a device, but restoring public confidence would be very difficult.[69] Clearly, the disruption would be immense and somewhat similar to the situation in Tokyo on 15 April 1995, when the Aum cult threatened fresh attacks on the subway, bringing the entire city to a grinding halt for the day, and mobilizing an estimated one-third of Japan's police force to defend the city. Commutrs stayed at home, refusing to take the risk of being the victims of another sarin attack.[70]

The use of low-grade nuclear material for terrorism or extortion is already a fact. In 1985, plutonium tri-chloride was placed in reservoirs serving New York by a man demanding that murder charges be dropped against Bernard Goetz, who shot four black youths allegedly attempting to mug him on the subway. The danger posed by this attack was small: plutonium is largely insoluble and so is an ineffective means of contaminating water supplies.[71] In another case, the Russian mafiya allegedly killed a Moscow businessman in 1993, using gamma-ray emitting pellets, placed in his office.[72] The CIA are also concerned that non-fissile, radioactive materials could be used in a terrorist device designed to create psychological or economic trauma to contaminate buildings or localized areas. The concern is that the proliferation of fissile material out of the former USSR will result, not in a terrorist nuclear bomb, but rather in a nuclear-enriched conventional explosion. Such a bomb would cause panic and could make whole areas no-go zones without requiring the cost, difficulty or risk that is entailed by a nuclear-yield device.

The most important sub-state use of radiological material occurred on 23 November 1995, when Chechen guerrilla leader, Shamyl Basayev, informed the Russian television network, NTV, that four cases of radioactive cesium had been hidden around Moscow. NTV discovered a 32 kg case in Isamailovo Park. Wrapped in a yellow plastic bag, it was emitting 310 times the normal amount of radioactivity. Basayev had threatened

repeatedly to attack Moscow with nuclear or chemical weapons, and had already proved his ability to create "terrorist spectaculars" by taking 1500 people hostage in Budennovsk in June 1995. Russian officials largely dismissed the nuclear threat, claiming that the material was cesium-137, used in X-ray equipment or some industrial processes, capable of emitting only 100 times the background amount of radioactivity. However, the truth about the material is less important than the credibility of the threat, as demonstrated by the precautions the Russian authorities took, sending emergency search teams out around the city with Geiger counters. If the Chechens had sought to inflict harm on the city's residents, they could have left the container open, and allowed the contents to disseminate through the park. Dzhokar Dudayev, the Chechen leader, did claim that there were conventional explosives with the nuclear material, threatening radiological dispersal, but this was a hoax. Basayev was intent on displaying capability and on ensuring that his threats to launch further attacks against Moscow, unless Russia withdrew from Chechnya, were taken seriously. His warning was plausible because the state of the Russian nuclear industry made it impossible to rule out the possibility that the Chechens had indeed acquired dangerously radioactive material.

It is almost impossible to generalize on the extent of the risk to the public from a radiological dispersal device; it depends so much on the material used, the means of dispersal, population density, weather conditions, and the period of public exposure. However, in their publication on crude nuclear weapons the International Physicians for the Prevention of Nuclear War argue that:

. . . [T]he consequences of a radiological weapon using plutonium in amounts that are potentially available for a terrorist attack are very largely long-term in nature: primarily increased cancer incidence, particularly of lung, bone, and liver cancer . . . Thus in health effect terms, the impact of such a weapon would be hidden for several decades, and probably would not be dramatic. However, given the public aversion to cancer risk, and the fears engendered by plutonium as a potential carcinogen, there are likely to be immediate and dramatic responses by the emergency services.[73]

To a very large extent, though, the effects of a radiological weapon are dependent on the type of material used. While weapons-grade plutonium might cause limited damage, other elements such as cesium or even radioactive waste, are potentially lethal, very rapidly. In 1987, in Goiana, Brazil, two adults broke open a cesium source found abandoned in a clinic, and allowed children to play with the glowing material inside. Within days, four people died, and 249 others were contaminated. There was public hysteria, and thousands of cubic metres of soil had to be removed for decontamination.[74]

Terrorists' Weapon Selection

The decision as to whether or not to use a nuclear-yield device, or a radiological weapon, or neither, is largely dependent not only on the type of terrorist group concerned, but also on the target selected. An attack requiring the destruction of an enormous area, such as an army base, or the death of as many people as possible, conceivably might require the use of a full-scale nuclear weapon. However, in terms of destructive capability, a radiological

device is unlikely to improve significantly on conventional weapons. This, then, leads to the question: why would one use such a weapon, since acquiring fissile material would involve so much more effort than conventional terrorism? Part of the answer must lie in its publicity value, and the fear it is capable of engendering. Radiological terrorism is potentially attractive to terrorists because it sets them apart from other groups, it takes terrorism to a new level, and, because it evokes the word "nuclear," and all that the word conjures up in the minds of the public. Furthermore, in an age where the Western mass media are increasingly cautious about covering events in other parts of the globe, such an attack virtually guarantees worldwide coverage for the group and its cause.[75] The ability of terrorists to otherwise attract this sort of coverage hinges on two aspects: either they must involve victims of interest to the world's media, which probably means citizens of Western countries, or else the implications or scale of the attack must be so immense that it is covered for its own sake. This is increasingly hard to achieve. On 31 January 1996, a suicide truck bomber drove into the Central Bank in the heart of Colombo's business district. The 500 kg of high explosive killed nearly 100 people, injured 1400 others and caused millions of dollars worth of damage, and possibly cost billions of dollars in loss of business confidence. In spite of this, the coverage of the incident was modest in the Western press, certainly compared to an incident such as the World Trae Center (WTC) bombing, or the Peru hostage siege. For example, the New York Times, The Times and The Globe and Mail all carried the Sri Lanka bombing on their front pages on 1 February 1996. However, in each case, by 2 February the story has been relegated to a small article on an inside page. In contrast, the siege in Lima continued to receive front-page coverage even after the situation had settled down to a long drawn out stalemate between the terrorists and the Peruvian security forces. At the moment, it is still possible to argue that massive conventional attacks attract just as much coverage as previous, non-conventional actions: the publicity around the WTC and Oklahoma attacks, the bombing of the Marine Barracks in Beirut, or the destruction of Pan-Am 103 was just as intense as that surrounding the sarin attack in Tokyo by Aum. It is no less so for the fact that there have now been several such devastating attacks in the past 15 years. Perversely, given the immense destructiveness associated with nuclear weapons, radiological terrorism offers terrorists the opportunity to obtain vast publicity without necessarily having to kill many people, at least not visibly or immediately. However, the sorts of groups that might consider this an advantage are those whose strategy is based on an element of rationality, those that do have an earthly objective, and therefore those that are likely to be reluctant to potentially commit themselves to being considered responsible for continuing to kill people decades after the attack.

While fatalities from international terrorism peaked at 800 in 1987, followed by 663 in 1988, 661 in 1983 and 467 in 1993,[76] the percentage of incidents in 1995 (29 percent) that involved at least one fatality was higher than at any time since 1968.[77] However, mass murder remains a relatively rare terrorist phenomenon. There have been no instances to date where terrorists have resorted to nuclear weapons for mass destruction. There are a number of important reasons for this. Traditional terrorists are technologically conservative, preferring to use tried and tested methods to achieve their aims; they have yet to reach what Bruce Hoffman has termed "their killing potential," using conventional weaponry, so have little need to be innovative.[78] Although most of

these groups prefer off-the-shelf weaponry with which they are familiar and confident, some groups are also adept at adapting or improving their weaponry. One example would be the Red Army Faction's (RAF) successful development of attacks on moving vehicles between its attempt on General Haig's life in 1979 and the assassinations of Karl Heinz Beckurts in 1986 and Alfred Herrhausen in 1989. Although not conclusive, this suggests that such groups favor an incremental approach to escalating their violence; they improve and develop existing tactics. Nuclear weapons would represent a major leap in both the tactics and level of violence employed, so would run counter to this trend of a gradual progression. More important yet, an act of mass destructive terrorism would almost certainly be counter-productive for most types of terrorist groups, and especially for those that rely on some degree of popular support for their justification. This is so because any such attack would be bound to be disproportionate to the terrorists' demands and so risks alienating the group's constituency.

Non-traditional groups, however, are more willing to wholly improvise their weaponry. The WTC bombers used readily available fertilizer as the main component of their device. William Studeman has suggested that such groups

also are capable of producing and using more sophisticated conventional weapons as well as chemical and biological agents. They are less restrained by state sponsors or other benefactors than are the traditional groups. These groups appear disinclined to negotiate, but instead seek to take revenge on the United States and Western countries by inflicting heavy civilian casualties . . .[79]

In the past, Brad Roberts argues, terrorism was clearly instrumental, at least in part; groups sought legitimacy and "a seat at the table." However, now it is possible to see organizations that "don't seem to care about establishing legitimacy, but just want to strike a blow in anger and kill as many people as possible . . . For them, the calculation of the right level of violence seems to have no upper bounds."[80]

Nuclear weaponry, appearing to incorporate cosmic energy and possessing the ability to destroy human life on earth, seems to transfer world-destroying capabilities from the deity to humans and thus make the terrorist the arbiter of human destiny in the place of God, making it potentially attractive to millenarian groups such as Aum Shinrikyo.[81] Since chemical weapons do not so obviously contain these cosmic elements, the rationale behind the cult's tactical choice is unclear. There can be no doubt that there exists a fascination with nuclear weapons which is starting to have an impact on the tactical decisions of would-be attackers. Three New Yorkers were arrested in June 1996 for plotting to kill the chief investigator for Brookhaven and two officials of the local Republican Party by planting radioactive material in their food and in their cars. Rather than trying to use the five cases of radium that they stole from a defence contractor, it would have been far more straightforward and effective to rely on conventional means for the assault.[82] White supremacists in the USA also continue to experiment with WMD. However, these incidents have mostly involved chemical and biological, rather than nuclear weapons. In December 1995, Thomas Lewis Lavy attempted to smuggle 130 grams of ricin (a nerve agent) into the USA from Canada and, in May 1995 Larry Wayne

Harris, a former member of the Aryan Nations, was arrested after he successfully mail-ordered three vials of bubonic plague bacteria for $240 from the American Type Culture Collection.[83] It is therefore important to consider terrorists' use of chemical and biological weapons as alternatives to nuclear weapons.

Chemical and Biological Weapons

The factors that mitigate against most terrorists, and especially those with left-wing or nationalist-separatist motivations, resorting to nuclear weapons apply equally to both biological and chemical weapons. Aum represented a new type of apocalyptic terrorist group, but even groups such as Aum are not certain to resort to these weapons again. It is possible that the cult represented a unique combination of factors, motivated by revenge, apocalyptic desires and material greed. It would be unwise, however, to preclude the possibility that they were not unique and may represent the pattern of future attempts to produce mass destructive terrorism. Many terrorist groups mimic other groups' actions, so the fact that one chemical attack has occurred would significantly increase the likelihood of another such incident.[84]

Despite Aum's example, terrorists use of either chemical or biological agents is a rarity. At least in part, this is a result of the same factors that have restricted the terrorist use of nuclear devices: a fear of the response by both governments and potential supporters, along with a belief that such an act would be not only unnecessary, given the potential of conventional weapons, but also disproportionate and counterproductive. This is especially so, given the abhorrence with which chemical and biological weaponry is widely regarded. This repugnance exceeds even that for nuclear weapons, which are, at least, acknowledged and legitimate instruments of states in a way that other weapons have not been since the 1925 Geneva Protocol on Chemical and Biological Weapons. Of course, that has not prevented many states from continuing to produce, and even use, both up to the present.[85] Furthermore, and certainly compared to conventional weapons with which terrorists are familiar, chemical and biological weapons would present a significant risk to the terrorists themselves, arising from the toxic nature of the materials being handled. This is one of the most significant barriers to terrorist use of biological weapons in particular. The extent of the risk is apparent in the record of the US biological weapons program between the 1950s and early 1970s. Even under the most tightly controlled and well-funded conditions there were at least four fatalities and 400 other non-fatal incidents as a result of the accidental exposure of workers to the biological agents.[86] Furthermore, weaponizing the biological agent would be problematic, given that dispersal in a water supply would be ineffective, and that an open air dispersal method would pose as great a risk to the terrorist as to the target audience.[87] The possibility of self-sacrifice might not be a significant disincentive to some groups (in which the role of the martyr is prestigious within the group and often in the wider community as well), but it may represent a barrie at the production stage. While there is ample evidence of suicidal terrorists being willing to die delivering their weapon and attacking the enemy in the process, there is little proof that any terrorists favor taking risks that are not absolutely necessary in manufacturing their weapon. To die killing an adversary may be one,

acceptable, thing; to die mixing chemicals or preparing a biological agent may be quite another.

Both chemical and biological weapons would have some appeal for a terrorist group intent on a non-conventional attack because, certainly compared to a nuclear weapon, chemical and biological weapons have the potential to be cheap and are lethal in small quantities, easing the problems of production, concealment, transportation and delivery. They are also less likely to be detected immediately and so increase the likelihood that the terrorists would "get away with it." In addition, due to the possibility of pre-testing and, in spite of the uncertainties described above, they are still likely to be more reliable than a nuclear weapon.[88] Furthermore, the lead time between, in John Deutch's phrase, "desiring and acquiring" a useful capability is much shorter for chemical weapons than for their nuclear equivalent. Shoko Asahara ordered his cult to develop chemical weapons in 1993, only slightly over a year before the Tokyo attack. It is for these reasons that the most immediate mass-destructive terrorist threat is from a chemical or biological weapon. That said, if the prospects for nuclear non-proliferation were to deteriorate significantly, this would compel a rapid reassessment of the situation in light of the greater destructive scope of nuclear weapons.[89] However, while these advantages undoubtedly do apply when chemical and biological weapons are compared to a nuclear-yield device, they are much less obvious when the comparison is with a radiological dispersal device, since all of these factors are equally applicable to a weapon using highly radioactive material, such as cobalt-60; thus, it would be unwise to exclude the possibility of this variety of nuclear terrorism now.

Biological agents, in particular, have the potential to be extremely effective and potent weapons. Since pathogenic micro-organisms are able to rapidly multiply within a host, only small quantities of the agent are required to cause widespread casualties over an extended area, especially if it is disseminated through the air in the form of an aerosol. Furthermore, many animal pathogens, such an anthrax or brucellosis, are highly lethal when inhaled, but are not passed from one individual to another. Therefore, they have the advantage that it would be possible for the terrorists to control partially the extent of the attack by using such agents. However, other types of potential biological weaponry are contagious, such as pneumonic plague bacteria, or haemorrhagic fever viruses, such as Ebola, and could be used with the objective of causing mass casualties from an epidemic. Aum certainly considered this possibility. Members of the cult were sent to Zaire in 1992, ostensibly to minister to the victims of the Ebola virus as part of their "African Salvation Tour," but, in reality, to collect samples of the disease to aid production of biological weapons.[90] Once back in Japan, the cult was unable to cultivate its samples into a usable form. A biological weapon attack would almost certainly be undetectable, both because it is odorless, colorless and tasteless, and because its effects would not be manifest for hours or even days, depending on the agent used. Therefore, the likelihood would be that, if the attack was conducted covertly, its perpetrators would have ample time to make their escape, an attractive proposition for most terrorists.

Either a chemical or a biological attack by terrorists has the potential to be extremely lethal. However, both the terrorists' probable inexperience with the agents and the

weather conditions make the effective dissemination and thus prediction of the results of the attack exceptionally difficult for the group. Even under the best of conditions, there is considerable uncertainty as to the results; Aum apparently launched two biological attacks in Tokyo, with no effect at all.[91] This obviously heightens other difficulties, such as the problems associated with acquiring and then using the requisite amounts of the agent for the desired result.[92] Particularly in the case of biological weapons, this leaves open the possibility that the effects could range from non-existent to a worldwide epidemic. [93] Even if terrorists were willing to accept massive, indiscriminate casualties, this does pose difficulties of reliability and effectiveness. Consequently, terrorists might be more inclined to channel their efforts into other types of weapons.

As an example of this problem, Aum had particular difficulty in finding an effective means of delivery for its chemical weapons. This problem is especially acute due to the highly hazardous nature of the agents. This risk could be minimized by using "binary" chemical weapons, since they are easier to produce, transport and use. This means that two precursor chemicals are stored separately and then mixed to form the agent immediately before use. There are methods to achieve this mixing process automatically, or by remote-control, but these have, so far, proved too technologically difficult or unreliable (as the Aum example shows). The most likely possibility is that terrorists would have to manually mix the precursor chemicals, an extremely hazardous procedure, and one that, at least in part, defeats the purpose of separating the chemicals in the first place.[94] Clearly, chemical and biological weapons, as well as nuclear ones, are not straightforward to use, which is a major reason why a massive conventional attack remains a more realistic option for the majority of terrorists.

Conclusion

It is becoming increasingly apparent that there are two, interrelated, yet separate trends in terrorism today. There remain traditional-type terrorist groups, such as the IRA or Sendero Luminoso, that are still technologically conservative in most cases. However, there has been a significant growth in organizations that do not fit this pattern comfortably, inspired by a range of motivations, from a desire to visit an apocalyptic vision on the world, to a wish to punish a government or even an entire culture. The latter type have in common that they are anti-social in its most literal sense. In many cases as amateur organizations, they are willing to use improvized, low-tech weaponry, but, unbound by the constraints of public opinion, they are also willing to contemplate the use of mass-destructive weapons. Undoubtedly, they aspire to higher levels of violence than has been the case with other, more traditional terrorist organizations. Although, like most terrorist organizations, these groups base their tactical decisions on a largely rational combination of feasibility and necessity, they are also willing to regard mass terrorism as justifiable. The way that they achieve that may depend on the availability of the different types of raw material.

The increased accessibility of fissile material probably has had relatively little impact on the likelihood of a terrorist nuclear bomb; it remains difficult and expensive to build when compared to a conventional weapon. The latter, given most terrorists' unfamiliarity

with mass destructive weaponry, would be likely to be safer to use as well. The probability of all but a cult group using such a device remains low. Aum may have investigated the possibility of building a nuclear bomb, but it was still a long way from achieving it, and consequently chose a more straightforward method of creating terror. This is not to deny the importance of Aum's attack. It set a precedent, being the first terrorist group to attempt an act of mass destruction, using non-conventional means. As Brian Jenkins has argued: "It breaks a taboo, and has psychological import. Others will ask whether such tactics should be adopted by them. It is now more likely that at least some will say yes."[95] According to Bruce Hoffman, "we've definitely crossed a threshold. This is the cutting edge of high-tech terrorism for the year 2000 and beyond. It's the nightmare scenario that people have quietly talked about for years coming true."[96] If a terrorist group was intent on a non-conventional attack designed to cause mass casualties, chemical or biological weapons, in spite of the uncertainty of effect and the difficulties of weaponization, remain more likely options than a nuclear-yield device. However, fissile material availability has made the feasibility and thus the credibility of a threat or hoax involving radiological terrorism a much more real possibility, one that would have to be taken seriously and would give considerable leverage to any group using such a threat. It offers the terrorist organization the possibility of many of the positive effects of a full nuclear attack, without a similar risk. Although the materials for chemical or biological weapons are also widely available, the relative ease of access to low-grade nuclear materials, aong with the low-risk potential benefits for the terrorist group, mean that a radiological attack is the most plausible type of high-publicity, low-fatality, non-conventional terrorism in the world today.

Endnotes

I am indebted to Dr. David Charters, Maureen McCartney-Cameron, and the two referees for this article, all of whom offered invaluable comments and suggestions to earlier versions of this paper.

1. Graham Allison, Testimony to US Congress, 104th Congress 1st Session, US Senate Foreign Relations Committee, Subcommittee on European Affairs, Hearings held 23 August 1995.

2. "Sceptical Bear Ill-Disposed to Having Its Claws Clipped," Financial Times, 15 January 1996, p. 4.

3. Graham Allison, Testimony to US Congress, 104th Congress 2nd Session, "Global Proliferation of Weapons of Mass Destruction," US Senate Governmental Affairs Committee, Permanent Subcommittee On Investigations, Hearings held 13 March 1996.

4. Alexander Rahr, "Soviet Fear of Nuclear Terrorism," Report on the USSR, 2, no. 13 (30 March 1990), p. 11.

5. Thomas Cochran, cited in William Potter, "Before the Deluge? Assessing the Threat of Nuclear Leakage From the Post-Soviet States," Arms Control Today, (October 1995), p. 13.

6. Ibid.

7. Phil Williams and Paul Woessner, "Nuclear Material Trafficking: An Interim Assessment," Transnational Organized Crime, 1, no. 2 (Summer 1995), pp. 211-12; Potter, "Before," p. 12.

8. Interview with Leonard Spector (Director, Nuclear Non-Proliferation Project, Carnegie Endowments for International Peace, Washington, DC), 5 November 1996.

9. John Sopko, "The Changing Proliferation Threat," Foreign Policy, 105 (Winter 1996/97), p. 10.

10. Williams and Woessner, "Nuclear," pp. 211-12; US General Accounting Office, "Nuclear Nonproliferation: Status of US Efforts to Improve Nuclear Material Controls in Newly Independent States," GAO/NSIAD/RCED-96-89 (March 1996), pp. 18-19.

11. See also, for example, Richard Beeston, "Russian 'Secret City' Admits Uranium Stolen By Civilians," The Times, 25 August 1994, p. 8. For theft by scientists, see T. de Waal, The Times, 8 May 1996, p. 13; or Chris Bellamy and Phil Reeves, "Western Spies find No Shortage of Secrets," The Independent, (British daily), 8 May 1996.

12. Mark Franchetti, "US Atom Workers Help Russia," The Sunday Times, 20 July 1997.

13. John Deutch, Testimony to US Congress, 104th Congress 2nd Session, "Global Proliferation of Weapons of Mass Destruction," US Senate Governmental Affairs Committee, Permanent Subcommittee On Investigations, Hearings held 20 March 1996.

14. A. Robitaille and R. Purver, "Smuggling Special Nuclear Materials," Canadian Security Intelligence Service, Commentary, 57 (May 1995).

15. "Uranium, Plutonium, Pandemonium," The Economist, 5 June 1993, p. 105.

16. "Darkness Visible," The Economist, 25 December 1993 - 7 January 1994, pp. 47-50. Oleg Bukharin, "The Future of Russia's Plutonium Cities," International Security, 21, no. 4 (Spring 1997), p. 134.

17. William Potter, "Exports and Experts: Proliferation Risks from The New Commonwealth," Arms Control Today, (January/February 1992), p. 34. These numbers are disputed: in 1992, Gennadi Evstaf'ev claimed that, of about 100,000 scientists involved in some way with the production of WMD, only "several tens" had the knowledge to produce a bomb. However, many other knowledgeable Russian sources put the figure at 2000 to 4000 scientists with high level expertise and a couple of hundred

who know in theory how to build a nuclear bomb from start to finish. D.L. Averre, "Proliferation, Export Controls and Russian National Security," Contemporary Security Policy, 17, no. 2 (August 1996), p. 195.

18. David E. Kaplan and Andrew Marshall, The Cult At the End of the World: The Incredible Story of Aum (London: Random House, 1996), pp. 73-76.

19. Interview with Richard Falkenrath (Executive Director, Center for Science and International Affairs, JFK School of Government, Harvard University), 12 November 1996.

20. "Threat of Nuclear Terrorism Increasing," Central News Network, 22 August 1995.

21. US General Accounting Office, "Nuclear."

22. James L. Ford, "Nuclear Smuggling: How Serious a Threat?" Institute for National Strategic Studies, Strategic Forum, 59 (January 1996).

23. Rensselaer W. Lee, "Plenary Address," Institute for National Security Studies, Center for Strategic Leadership, Report of the Executive Seminar on Special Material Smuggling, 13 September 1996, p. 21.

24. Sopko, "The Changing," p. 11.

25. Interview with Thomas Cochran (Senior Scientist, Natural Resources Defence Council, Washington DC), 21 November 1996.

26. Potter, "Before," p. 12.

27. R.W. Selden, "Reactor Plutonium and Nuclear Explosives," Lawrence Livermore Laboratory, 1976; and Hans Blix, "Letter to the Nuclear Control Institute, Washington, DC," 1990, both cited in International Physicians for the Prevention of Nuclear War, "Crude Nuclear Weapons: Proliferation and the Terrorist Threat," IPPNW Global Health Watch, Report Number 1 (1996), p. 8.

28. "Pair Tried to Sell Uranium," The Globe & Mail, (Canadian daily), 4 April 1997, p. A8; "Arrests in Uranium-Theft Case," The Globe & Mail, 5 April 1997, p. A8.

29. Deutch, Testimony.

30. Tim McGirk, "A Year of Looting Dangerously," The Independent, 24 March 1996.

31. Lee, "Address," p. 23.

32. Bernd Schmidbauer, "Nuclear Smuggling and Nuclear Terrorism," (in German), Internationale Politik, 50, no. 2 (February 1995).

33. Geoffrey York, "Unhappy Russian Workers Threaten Nuclear Disaster," The Globe & Mail, 2 July 1997, pp. 1-2.

34. Rensselaer W. Lee, "Post-Soviet Nuclear Trafficking: Myths, Half-Truths, and The Reality," Current History, (October 1995), p. 345.

35. Potter, "Before," p. 12.

36. Lee, "Post-Soviet," p. 346.

37. Potter, "Before," p. 14.

38. Mark Galeotti, "Mafiya: Organised Crime in Russia," Jane's Intelligence Review, Special Report Number 10 (June 1996), p. 19.

39. Global Organized Crime Project, "The Nuclear Black Market," Center for Strategic and International Studies, Washington, DC, 1996, p. 17.

40. Rensselaer W. Lee, "Recent Trends in Nuclear Smuggling," in Phil Williams, ed., Russian Organized Crime: The New Threat? (London: Frank Cass, 1997), pp. 111, 114.

41. Williams and Woessner, "Nuclear ," pp. 215-17.

42. Guy Dunn, "Major Mafia Gangs in Russia," in Williams ed., Russian Organized Crime , p. 63.

43. Graham H. Turbiville Jr., "Mafia in Uniform: The 'Criminalization of the Russian Armed Forces," Foreign Military Studies Office, Fort Leavenworth, Kansas, July 1995, pp. 3-5.

44. Phil Williams, "Introduction: How Serious a Threat is Russian Organized Crime?" in Williams, ed., Russian Organized Crime , p. 16.

45. Galeotti, "Mafiya," p. 4.

46. Dunn, "Major Mafiya," p. 63.

47. Sopko, "The Changing," pp. 6-7.

48. See, for example, Roger Boyes, "Bonn Uncovers Nuclear Leaks at Military Base," The Times, 25 August 1994, p. 8.

49. Jennifer G. Mathers, "Corruption in the Russian Armed Services," The World Today, 51, nos. 8-9 (August/September 1995), pp. 169-70.

50. James Adams and Carey Scott, "US Fears Grow As Russia Loses Nuclear Grip," The Sunday Times, 27 October 1996, p. A19.

51. Turbiville, "Mafia," p. 17.

52. Channel 4 News, (British Television), "Nuclear Smuggling," 15 February 1995.

53. Potter, "Before," p. 10.

54. Oleg Bukharin, "Nuclear Safeguards & Security in the Former Soviet Union," Survival, 36, no. 4 (Winter 1994-95), p. 53.

55. Rose Gottemoeller, "Preventing A Nuclear Nightmare," Survival, 38, no. 2 (Summer 1996), p. 172.

56. Stella Rimington, Security and Democracy - Is There a Conflict? The Richard Dimbleby Lecture 1994, (London: BBC Educational Developments, 1994), p. 9.

57. Falkenrath, Interview.

58. An interesting discussion on why states proliferate is contained in Scott Sagan, "The Causes of Nuclear Proliferation," Current History, 96, no. 609 (April 1997).

59. Williams and Woessner, "Nuclear," p. 222.

60. "Thinking the Unthinkable," New Scientist, 11 May 1996, p. 3.

61. Deutch, Testimony.

62. S. Kendall, "Columbia Measures the Cost of Violence," Financial Times, 12 November 1996.

63. Samuel D. Porteous, "The Threat From Transnational Crime: An Intelligence Perspective," Canadian Security Intelligence Service, Commentary, 70 (Winter 1996), pp. 5-6.

64. Charles Hanley, "Increasingly Guerrillas Financed By Drugs," The Toronto Star, 29 December 1994, p. A19.

65. Potter, "Before," p. 13.

66. Plutonium from spent fuel elements is often stored at reprocessing plants as plutonium oxide. See International Physicians for the Prevention of Nuclear War, "Crude," pp. 8-9.

67. Ibid.

68. Louis Freeh, Testimony to US Congress, 103rd Congress 2nd Session, "International Organized Crime and its Impact on the United States," US Senate Governmental Affairs Committee, Permanent Subcommittee On Investigations, Hearings held 25 May 1994, p. 62.

69. Spector, Interview.

70. Kaplan and Marshall, The Cult, p. 271.

71. Mark Hibbs, "Plutonium Thieves Pose No Threat to Drinking Water, LLNL Reports," Nucleonics Week, 36, no. 6 (9 February 1995), p. 13.

72. Phil Williams and Paul Woessner, "The Real Threat of Nuclear Smuggling," Scientific American, 274, no. 1 (January 1996), p. 30.

73. International Physicians for the Prevention of Nuclear War, "Crude," p. 38.

74. Sopko, "The Changing," pp. 7-8.

75. Garrick Utley, "The Shrinking of Foreign News: From Broadcast to Narrowcast," Foreign Affairs, 76, no. 2 (March/April 1997), pp 2-10.

76. Bruce Hoffman and Donna Kim Hoffman, "The Rand-St Andrews Chronology of International Terrorism, 1994," Terrorism and Political Violence, 7, no. 4 (Winter 1995), p. 185.

77. Bruce Hoffman and Donna Kim Hoffman, "The Rand-St Andrews Chronology of International Terrorist Incidents, 1995," Terrorism and Political Violence, 8, no. 3 (Autumn 1996), p. 87.

78. Bruce Hoffman, "Terrorist Targeting: Tactics, Trends and Potentialities," Terrorism and Political Violence, 5, no. 2 (Summer 1993), p. 23.

79. William O. Studeman, Testimony to US Congress, 104th Congress 1st Session, "Hearings on the Omnibus Counterterrorism Act of 1995," US House of Representatives Judiciary Committee, Hearings held 6 April 1995.

80. Brad Roberts, cited in Robert Taylor, "All Fall Down," New Scientist, 11 May 1996, pp. 32- 33.

81. Michael Barkun, "Millenarian Aspects of 'White Supremacist' Movements," Terrorism and Political Violence,1, no. 4 (October 1989), p. 431.

82. Reuters, "NY Police Uncover Plot Against Politicians," 13 June 1996; John T. McQuiston, "Third Man Held in Plot to Use Radium to Kill NY Officials," New York Times, 14 June 1996, p. B2.

83. Sopko, "The Changing ," pp. 4-6.

84. Brad Roberts, "Terrorism and Weapons of Mass Destruction: Has the Taboo Been Broken?" Politics and the Life Sciences, 15, no. 2 (September 1996), pp. 216-17.

85. Jonathan B. Tucker, "Chemical/Biological Terrorism: Coping with a New Threat," Politics and the Life Sciences, 15, no. 2 (September 1996), p. 169.

86. Ron Purver, "Chemical and Biological Terrorism: The Threat According to the Open Literature," Canadian Security Intelligence Service, (June 1995), p. 42.

87. W. Mullins, cited in Ibid.

88. Ibid, p. 96.

89. John Deutch, Conference on Nuclear, Biological, Chemical Weapons Proliferation and Terrorism, 23 May 1996, Internet source: http://www.odci.gov/cia/public_affairs/speeches/ archives/1996/dci_speech_052396.html

90. Kaplan and Marshall, The Cult, pp. 96-97.

91. Ibid., pp. 94-96.

92. Graham Pearson, "Chemical/Biological Terrorism: How Serious a Risk?" Politics and the Life Sciences, 15, no. 2 (September 1996), pp. 210-11.

93. Purver, "Chemical and Biological," p. 41.

94. Ibid., p. 172.

95. Brian Jenkins, cited in Ron Purver, "The Threat of Chemical/Biological Terrorism," Canadian Security Intelligence Service, Commentary, 60 (August 1995).

96. Bruce Hoffman, cited in Kaplan and Marshall, The Cult, p. 289.