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DEFENDING AMERICA

REDEFINING THE CONCEPTUAL BORDERS OF HOMELAND DEFENSE

TERRORISM, ASYMMETRIC WARFARE AND NUCLEAR WEAPONS

Final Draft

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The following report is an excerpt from the final draft of a book on Homeland Defense being prepared as part of the CSIS Homeland Defense project. A substantially revised version will be published as a Praeger book later in 2001.

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Nuclear Weapons as Means of Attack

No one questions the potential dangers posed by a covert or terrorist attack using nuclear weapons. Table 4.9 shows a list of known nuclear powers that are not allies of the US, and several of these states may become hostile in the future. A number of other countries are conducting nuclear weapons research efforts, have carried out enough nuclear research to deploy weapons relatively quickly, or could build a nuclear weapon if they could find a source of fissile material

The real question is whether any state actor would take the risk of conducting a covert or proxy attack or of aiding an extremist/terrorist group, and whether any extremist/terrorist group could acquire or make a weapon on its own. At present, these risks seem to limit the probability of a nuclear attack on the US. However, effective Homeland defense must deal with the cumulative probability of such attacks over at least a 25-year period. The process of proliferation described earlier does not create high confidence that the US can count on future restraint over an extended period. International peacetime restraint is also not a valid basis for estimating risk. Much of the risk stems from how actors would behave in a contingency involving an extreme crisis in which past patterns of behavior could change quickly and with little warning.

Lethality and Effectiveness

There are many uncertainties associated with the employment of nuclear weapons in covert, proxy, or terrorist/extremist attacks on the US.[1] There is no way to predict the yield or how successful given proliferants will be in implementing fusing, yield enhancement, delivery system accuracy, and other technologies. Many studies simply "assume a baseline case of a weapon using 1950s vintage U.S. technology – a simple fission weapon with a tens of kilotons yield that could be delivered by aircraft or tactical missiles. However, it is at least conceivable that a state might smuggle a thermonuclear weapon into the US or explode one off its coasts, and fission weapons can range in yield from less than a kiloton to 100 kilotons or even megatons.

A nuclear detonation releases vast amounts of energy that is manifested as blast effects. In the case of a small (10 KT) fission weapon, the blast is roughly 50 percent of the total energy, while the remainder is heat (35 percent) and nuclear radiation (15 percent). About 4 percent of this radiation is prompt ionizing radiation, and 10 percent is fallout. The Electromagnetic Pulse (EMP) accounts for the remaining one percent.[2] Thermal energy becomes the dominant method of destruction in high yield weapons such as thermonuclear or fusion weapons.

The height-of-burst also has a critical impact on weapons effects. If the fireball does not touch the ground, there may not be militarily significant fallout. At higher altitudes, however, the Electromagnetic Pulse (EMP) from a nuclear weapon – a powerful radio wave – can damage electronic equipment at considerable distances.

These factors are of critical importance in estimating the lethality of a covert or terrorist nuclear attack because the explosion is likely to take place at ground-level or a relatively low altitude, which produces maximum fallout at the cost of diminished blast, thermal, and radiation effects. Most attacks are also likely to take place in cities, which would contain the radiation, blast, and thermal effects beyond the fireball, but ensure that a high population density was affected by fallout. It is important to note that most nuclear effects research for war fighting purposes assumes that a weapon will be used at much higher altitudes to avoid fallout and not interfere with military operations, and assumes that the weapon will affect a relatively open space.[3]

To put the issue of weapons yields into historical perspective, the weapon used at Hiroshima on August 6, 1945 had a nominal yield of 12 kilotons; the weapon used at Nagasaki on August 9, 1945 had a yield of 23 kilotons. The thermonuclear weapon the US tested at the Bikini Atoll in the spring of 1954 had a yield of 15 megatons, and the FSU tested a 50-megaton weapon in 1961. This latter test had a yield over 4,000 times larger than the yield of the weapon at Hiroshima.

Even a one-kiloton device, however, could have a massive impact, particularly because such devices are likely to be set off near ground level and be inefficient enough to increase the amount of direct fallout. An OTA study estimated that a one-kiloton terrorist device would still produce 5-psi overpressure out to 442 meters, and 600 rems of radiation out to 808 meters. (This compares with 4.4 miles for 5-psi for a one-megaton weapon and 600 rems to 2.7 kilometers.) It should be noted, however, that buildings normally cut these distances by about 25% in the case of blast and 75% in the case of direct radiation.[4]

Table 4.10 and Chart 4.4 show that yield can have a major impact on lethality, and that it is dangerous to assume that any response team will be able to characterize the impact of an explosion until it actually occurs. At the same time, Chart 4.5 warns that even a relatively lethal nuclear weapon would not necessarily be more lethal than even a relatively simple biological weapon.

Once again, the data on the lethality and the damage posed by such threats also suffer from major uncertainties that could be of great importance in Homeland defense:

- There are no reliable models of nuclear weapons effects in major urban areas involving massive complexes of high rise steel and glass buildings. The containment effects of modern cities are extremely difficult to model. Military studies indicate, for example, that modern buildings can reduce the effect of blast, thermal, and radiation by 40-60%, but they do not specifically address modern heating and air conditioning systems, and the sheltering effects are not designed to take glass into account and the internal impact on the building.[5]

- Nuclear explosions create a wide range of different effects that can interact on the human body. The recent literature on military models for predicting casualties indicates that such models are not reliable, and states that, “The US Army Office of the Surgeon General is developing a system of casualty estimation that will provide rapid and reasonably accurate estimates of the number of types of casualties produced by a given enemy nuclear attack.” This system, however, is not yet available.[6] The military handbook on the subject acknowledges that medical facilities will probably be saturated or collapse in the event of a major attack, but effectively dodges the problem of diagnosis and triage, and assumes that adequate medical professionals and facilities are available to allow extended triage and preventive medical treatment.[7] The Defense Threat Reduction Agency (DTRA) is working on more sophisticated models tailored to attacks on the US but it again is unclear when any unclassified results will be available.

- The impact of prompt radiation is extremely difficult to estimate, and lethal and serious doses can vary sharply according to exposure even in the same areas. Even personnel equipped with dosimeters present major problems in triage because dosimeter readings cannot be used to judge whole body radiation, and a mix of physical symptoms have to be used to judged the seriousness of exposure. The impact of radiation poisoning also changes sharply if the body has experienced burns or physical trauma.[8] In the case of treatable patients, significant medical treatment may be required for more than two months after exposure.

- Fallout can vary sharply according to the size and nature of a weapon and its placement, and in the size and lethality of particles and water vapor. While most fallout settles within 24 hours, this varies according to wind pattern and movement through the affected area. The drop in actual radiation of the affected material is much slower, but logarithmic. Radiation at the first hour after the explosion is down about 90%, and radiation is only about one percent of the original level after two days. Radiation only drops to trace levels, however, after 300 hours.[9]

- The test data on the longer-term (after 24 hours) effects of radiation are highly uncertain and the longer term impacts of radiation are so speculative as to be impossible to estimate. As a result, virtually all estimates of the impact of nuclear weapons ignore the long-term casualties (96 hours to 70+ years) caused by radiation, such as cancer, and the impact of a weapon on the environment in terms of the poisoning of water and food supplies. The data on treatment of exposures from zero to 530 cGy of exposure do not even seem to call for recording the probable level of exposure.[10]

- There is little data on the steadily growing seriousness of EMP on urban areas filled with computers and solid-state communications and control devices.[11]

- Most models of fallout assume relatively neat patterns of distribution or plumes that give state and local responders a relatively clear picture of probable lethality and casualty effects. It is uncertain how realistic these models really are. Weather patterns could produce far more erratic patterns of distribution, and some estimates indicate that the "worst case" area covered by the overall plume could easily be twice the area used as the reference case. There is little detailed or parametric modeling of these uncertainties, and of the burden they place on response teams. These uncertainties also are much greater for the much larger areas covered by low levels of radiation over time.

- The problem is further complicated by trying to estimate the specific mix of radioisotopes and radionuclides that will be produced and then become induced in the soil. The hazard prediction models used by the Department of Defense are under review, and it is not clear when new models will be available.[12]

- There is often a gap between generic data on radiation, burn, and physical effects and the assumed level of treatment required. Much of the federal, state, and local response literature effectively dodges around the issue of triage, and the problem of choosing who will receive limited medical treatment and how these victims will be selected. It does not describe what is done with the assumed dying and untreatable. The broader issue, however, is what indicators will be used for triage and deciding treatment and what treatment should actually be employed.

- Food and water contamination can be a serious problem, and add to the response burden in any major attack.[13] Fallout presents special problems since sheltered civilians may not have access to safe water, and urban water systems may be affected.

- Corpse disposal may be a major problem as may disposal of dead animals and birds. This aspect of response seems to be largely ignored.

- Even military medical handbooks fail to address the psychological impacts of prompt and longer-term effects.

Is There a Threat from State Actors, Proxies, Terrorists, and Extremists? The Problem of Getting the Weapon

Two other key questions shaping the nuclear threat are (a) whether state actors can obtain such weapons and will take the risk of using them covertly or giving them to a proxy, and (b) whether terrorists can obtain such weapons or obtain the fissile material they need to make such weapons. The answers to these questions are heavily dependent on whether nuclear weapons become available from an existing nuclear weapons state, or a state or independent group can obtain fissile material.[14]

The basic design features and technology needed for nuclear weapons are well understood. Iran and North Korea are estimated to have nuclear weapons or to be able to acquire them in five years. The IAEA found in 1992 that Iraq had two fully functional implosion weapons designs, and the skills needed to make the timing devices, neutron initiators, and high explosive lenses for these weapons.

There are two primary ways of making a nuclear device. The first route is a gun-assembly weapon – like the one used at Hiroshima that propels a subcritical mass of uranium-235 (U-235) into a second, also subcritical, mass of U-235, in order to produce the critical mass needed for a nuclear explosion. The second route is to make an implosion weapon like the one used at Nagasaki. In such a device, an outer shell of chemical high explosives surrounds a subcritical sphere of fissionable nuclear material, for example, plutonium-239 (Pu-239)**.** Precise detonation of the "entire" sphere results in an implosion that produces a critical mass and the resulting nuclear explosion.

Unlike most means of attack, the two basic materials needed for any such weapon – U-235 and Pu-239 – are very difficult to obtain. This is particularly true of the optimal weapons grade nuclear materials for a weapon, although mixed isotope plutonium (reactor grade material) can be used in nuclear weapons. The Department of Defense reports that such a device would be less efficient and might have a less predictable yield. However, a weapon using non weapons-grade plutonium was successfully detonated in a 1960s test.[15]

Production of fissile material is probably impossible for most terrorist and extremist movements. At present, Russia seems to be the only state that might lose control over weapons grade U-235 or P-239, although the US Department of Defense feels this risk is diminishing,[16]

> Security of weapons-usable nuclear materials in Russia is another serious concern. While the Russian government is committed to nuclear security, continuing turmoil in society, corruption and resource shortages complicate this commitment. The combination of lax security for nuclear materials at some facilities, poor economic conditions and the growing power of organized crime in Russia mean that the potential for the theft and subsequent smuggling of these materials will continue to cause concern.
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> At the same time, the Russians have taken seriously the threat from a potential Chechen insurgent attack on a nuclear power facility and have made security upgrades. In the past, there have been incidents of weapons-usable materials being diverted from Russian nuclear facilities. The largest seizures of such materials out-side of the FSU occurred in 1994, where 2.7 kilograms of Highly Enriched Uranium (HEU) were found in the Czech Republic and about 360 grams of plutonium was seized in Germany. However, confirmed incidents of smuggling of weapons-usable nuclear materials, primarily plutonium and HEU, have declined but continued at a low rate. This decrease may be due to several factors: decreased smuggling through Western Europe, where detection is more likely; shifting of smuggling pathways through the southern tier of former Soviet states, where detection is highly unlikely; or improved security at Russian nuclear facilities Nevertheless, reports of theft of nuclear materials continue to emanate from the former Soviet block countries.
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> For example, in September 1999 one kilogram of reportedly uranium-235 (enrichment unconfirmed) was seized in the Republic of Georgia. In another recent case, 10 grams of weapons-grade HEU was confiscated in Bulgaria. In addition to reports of actual nuclear materials being offered for sale, there have been numerous accounts of radioactive isotopes such as californium-252, strontium-90, and cesium-137
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> However, in the longer term, the implementation of the U.S.-sponsored Material Protection, Control, and Accountability Program at Russian nuclear facilities likely will lead to a reduction of the number of incidents of diversion of weapons-usable materials. HEU and plutonium are also being recovered from Russia's ongoing warhead elimination effort, although a considerable degree of uncertainty remains about the overall security of Russia's large inventory of nuclear material. Several programs are under way to alleviate the security problems for this material.
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> First, the U.S. DOE is assisting former Soviet states with physical security improvements at nuclear facilities in an effort to institute accurate accounting procedures for nuclear materials.
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> Second, pursuant to a Cooperative Threat Reduction (CTR) implementing agreement with the Russian Ministry of Atomic Energy, DoD is helping to build a state-of-the-art storage facility for long-term secure storage of HEU and plutonium from disassembled nuclear weapons. This facility is located at Mayak, about 1,400 kilometers east of Moscow near the Ural mountains. Third, the United States is purchasing 500 metric tons of HEU derived from disassembled Russian warheads. This material is being blended down in Russia into low-enriched uranium suitable for use in nuclear power reactors. Shipments to the United States began in 1993 and will continue over the next 20 years; as of mid-2000, about 100 tons of HEU had been transferred from Russia to the United States.

> Finally, Russia has agreed to shut down its remaining plutonium-producing reactors. DoD is assisting the Russian Ministry of Atomic Energy pursuant to a CTR implementing agreement in the conversion of reactor cores so they will not produce weapons-grade plutonium. The weapons-grade plutonium produced since January 1997 will be placed under bilateral safeguards. Concern about security is not confined to nuclear items, but extends also to facilities in the FSU that house chemical or biological warfare-related materials. In addition, numerous scientists and technicians previously involved in key programs face severe salary reduction, complete loss of pay, unemployment. States, such as Iran, that are seeking to establish their own weapon capabilities may try to exploit the situation by attempting to recruit such individuals. However, Western programs, such as the International Science and Technology Center (ISTC), the U.S. Civilian Research and Development Foundation (CRDF), the Nuclear Cities Initiative (NCI), and the Initiatives for Proliferation Prevention (IPP) are expressly designed to address this "brain drain" problem.

These problems in obtaining fissile material led the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction to draw relative optimistic conclusions about the ability of terrorist groups to use nuclear weapons:[17]

> Perhaps the only certain way for terrorists to achieve bona fide mass destruction would be to use a nuclear weapon. In this area, however, the challenges are arguably the most formidable. Although the collapse of the Soviet Union heightened Western fears about security at Russian military facilities, it appears that Russian strategic and tactical weapons are perhaps more secure than had been initially feared. Where there maybe particular concern, however, is during their transportation for maintenance or dismantling, when the Russian weapons apparently are not subject to the same strict security measures.
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> But even if terrorists were able to steal or acquire through black market purchase a stolen nuclear weapon, they would still face a number of significant obstacles in using or detonating it. Strategic nuclear warheads are immense and would be extremely difficult to move either easily or clandestinely.
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> Tactical nuclear weapons, such as artillery projectiles, admittedly, are far lighter and easier to conceal, making them potentially much more attractive items for terrorist theft or illicit acquisition. Moreover, many tactical nuclear weapons, and most strategic nuclear devices, are equipped with permissive action links (PALs) or other protective mechanisms designed to prevent accidental or unauthorized detonation.
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> In addition, some nuclear devices have tamper-proof seals that will disable the weapon if unauthorized personnel attempt to disassemble it. It would be extremely difficult, therefore, for terrorists to circumvent or overcome these built-in protective measures; some of the smaller tactical weapons (including the KGB's alleged nuclear bombs concealed in small suitcases) admittedly may have had little or no protective devices or locks installed and, thus, the safety measures designed to thwart unauthorized detonation would be more easily overcome.
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> In the absence of assurance about the status and control of all Russian nuclear weapons, we must remain vigilant. Terrorists who were either unable or unwilling to steal a nuclear device or were unsuccessful in obtaining one on the putative black market that has surfaced in the countries of the former Soviet Union and Warsaw Pact, might attempt to build one
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> Their first hurdle, however, would be in acquiring sensitive nuclear material (SNM), that is, either highly enriched uranium (HEU) or plutonium (Pu) suitable for fashioning a nuclear device. Mining and processing uranium or building a reactor to create plutonium would of course be impractical (although, it should be noted, Aum's most grandiose aims embraced this possibility); terrorists would, therefore, have to steal SNM or conceivably purchase it on the black market. A number of authorities in recent years repeatedly

have expressed concern about illicit access to nuclear materials and technology, particularly in the former Soviet Union. Minatom, the Russian entity with responsibility for nuclear weapons, has itself complained about a lack of qualified personnel and adequate control systems, and the security at HEU storage facilities has also been reported to be grossly inadequate.

Given this apparent lack of security, and the fact that 250 tons of HEU and 50 tons of weapons-grade plutonium has been stockpiled in Russia, the risk of illicit acquisition from SNM storage facilities should be considered a serious threat. Potentially less worrying, however, is the supposed "black market" for these substances. Between 1992 and 1996, more than 1,000 claims were made involving the illicit sale and smuggling of nuclear material; however, only six instances were substantiated, and none of those involved the quantities needed to construct an effective "homemade" device that could cause mass casualties-thereby suggesting that the black market, if it exists at all, is limited in size and grossly exaggerated in impact.

...To be sure, small amounts of SNM have been diverted illegally, apparently from Russian facilities. It is worth noting, however, that all of the SNM stolen to date is not sufficient to make a single nuclear device and that reported thefts of weapons grade material have dropped in recent years. Ongoing improvements in Russian nuclear security procedures should further reduce the incidents of theft.[18]

Building a nuclear device capable of producing mass destruction presents Herculean challenges for terrorists and indeed even for states with well-funded and sophisticated programs. According to one analysis, minimum requirements include "personnel, skills, information, money, facilities, equipment, supplies, security, special nuclear materials…and, usually, other specialized and hard-to-obtain material."

According to another assessment, a successful program hinges on obtaining enough fissile material to form a super-critical mass for each of its nuclear weapons (thus permitting a chain reaction); arriving at weapon design that will bring that mass together in a tiny fraction of a second, before the heat from early fission blows the material apart; and designing a working device small and light enough to be carried by a given delivery vehicle. It is important to emphasize that the above represents the minimum requirements. If each one is not met, concludes the assessment, "one ends up not with a less powerful weapon, but with a device that cannot produce any significant nuclear yield at all or cannot be delivered to a given target."

That being said, it is clear that certain types of nuclear devices are easier to create than others. Two types of weapons systems, for example, can create nuclear fission: the implosion device and the "gun" type. In the former, explosives compress a sphere of HEU or plutonium into a small ball, thus achieving supercriticality and a nuclear chain reaction. Even the simplest implosion weapon, however, requires the fabrication of complex components, such as high-explosive lenses, high-performance detonation systems, and fusing and firing circuitry.

The gun-type device, on the other hand, employs HEU exclusively. Using a high explosive, the system fires a subcritical HEU projectile into a subcritical cylinder of HEU to form a solid mass of critical material. Although it uses relatively scarce HEU, the gun-type device is considered technically easier to fabricate; and many analysts accordingly argue that terrorists attempting to make a bomb "in house" will build a gun-type device.

There is disagreement, however, about what level of expertise and other resources are required to construct such a weapon. According to one authority, "most states and some exceptionally capable non-state actors" could build a highly destructive 10-kiloton weapon in several months at a cost of a few hundred thousand -dollars- assuming they had access to sufficient quantities of fissile material.

Other experts, however, are far more skeptical in their estimates of the capabilities required. Although much of the information about nuclear weapons design and production has become public knowledge

> during the past 50 years, it is still extraordinary for non-state entities to attempt to embark on a nuclear weapons R&D program.
>
> Indeed, even technical requisite knowledge and hands-on experience are not enough to build an effective nuclear weapon. As an Office of Technology Assessment report explains, "[k]nowledge must be supplemented by industrial infrastructure and the resources to carry a nuclear weapon program to completion. The technologies for building cars and propeller-driven airplanes date back to early in this century, but many countries still cannot build them indigenously."
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> Moreover, the fact that a number of states-despite aid from other nuclear powers, their own intense motivations, the provision of considerable resources, alongside concerted espionage activities designed to support their R&D programs-still struggle to build a nuclear weapon capability, suggests that the technical challenges remain immense.
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> In the case of South Africa, for example, it took scientists and engineers-who were endowed with a large and sophisticated infrastructure-four years to build their first gun-type system. Nevertheless, any nuclear weapons program will inevitably involve a number of people, and significant resources, equipment, and facilities. As noted earlier, all of that activity inevitably will materially increase the risk of exposure of the terrorist group to detection by intelligence and law enforcement agencies.

Such comments, however, again assume that a state would not use or supply a nuclear weapon in an asymmetric attack, provide a nuclear device to a terrorist movement, or offer a sanctuary and fissile material. These risks of weapons transfers led the National Commission on to draw different conclusions about the risks a state might provide independent groups with nuclear material:[19]

> Terrorists could acquire more deadly CBRN capabilities from a state. Five of the seven nations the United States identifies as state sponsors of terrorism have programs to develop weapons of mass destruction. A state that knowingly provides agents of mass destruction or technology to a terrorist group should worry about losing control of the terrorists' activities and, if the weapons could be traced back to that state, the near certainty of massive retaliation. However, it is always difficult and sometimes dangerous to attempt to predict the actions of a state. Moreover, a state in chaos, or elements within such a state, might run these risks, especially if the United States were engaged in military conflict with that state or if the United States were distracted by a major conflict in another area of the world.
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> The Commission was particularly concerned about the persistent lack of adequate security and safeguards for the nuclear material in the former Soviet Union (FSU). A Center for Strategic International Studies panel chaired by former Senator Sam Nunn concluded that, despite a decade of effort, the risk of "loose nukes" is greater than ever. Another ominous warning was given in 1995 when Chechen rebels, many of whom fight side-by-side with Islamic terrorists from bin Ladin's camps sympathetic to the Chechen cause, placed radioactive material in a Moscow park.

US intelligence experts have become increasingly concerned that Pakistan may develop surplus fissile material production capacity over the next few years. At least some analysts have also raised the issue of whether a China that became hostile to the US might sell fissile material in the future. An number of experts on proliferation also question why any state that does contemplate a nuclear attack on the US would risk the use of an easily attributable ballistic missile attack, rather than use of a far less attributable covert or proxy attack. The perceived risk of fissile transfers or nuclear weapons use may also change over time. If nuclear weapons and highly lethal biological weapons are used against targets elsewhere in the world, the end result might well be to make the nuclear threat to the US far more “thinkable.”

The Problem of Delivery

Nuclear weapons are large and potentially detectable. This is particularly true of large boosted or thermonuclear weapons that states might use to launch a catastrophic attack on the US, and of the kind of relatively crude or implosion device that an extremist or foreign terrorist might be able to build. Most primitive gun devices would, for example, be at least 2-2 1/2 meters long and weigh well over 1,000 pounds.

A crude implosion device might be more compact, but would still be very heavy. At the same time, the FSU seems to have built small nuclear weapons weighing less than 200 pounds, somewhat similar to the atomic demolition munitions the US withdrew from service years ago. The advanced thermonuclear devices Russia uses on its MIRV'd missiles are relatively compact and weigh well under 1,000 pounds. As is the case with yield, there are no rules regarding the size and weight of a nuclear device, particularly if one can be acquired or stolen from a nuclear power. It is also possible that the fissile core of a weapon could be delivered in separate component form, and then matched with the rest of the weapon. This would sharply reduce the size and detectability of even a crude basic weapon.

Radiation would present a detectability problem, as it would for radiological weapons. Nuclear devices can, however, be shielded and the core of a weapon might be smuggled into the US in many different ways. Thousands of large containers enter US ports every day, and less than 3% are searched or inspected. The northern and southern borders are porous enough so that some drug smugglers do no even bother to carefully conceal the drugs they are smuggling, and a device might be routed through a relatively open border for small craft like Alaska or Hawaii.

Several attack models also involve rigging weapons to go off if the storage device is opened, it is scanned in certain ways, or even if a GPS unit indicates it is in a US port and approaching customs. Unless excellent human intelligence is available to the US, unmanned delivery would offer a relatively high assurance of success and a self-destruct device would reduce the risk of attribution – particularly in a broad crisis. Detonation on detection, scan, or entry into a port area before customs is now sufficiently low tech so that it can be used by a wide range of potential attackers.

Dealing with the Risk and Impact of Nuclear Attacks

There is no present way to predict whether a state actor, proxy, or terrorist/extremist will (a) be willing to take the risk of launching a nuclear attack on the US over the coming decades, or (b) be able to acquire a weapon or device. Like the more lethal forms of biological weapons, the use of nuclear weapons would almost certainly lead to massive US retaliation if the US could identify the attacker, and would pose a high level of risk.

At the same time, this judgment assumes that the attacker is deterrable. This is not necessarily true of a regime acting under extremis that acts because it feels it has no other choice, or which is certain it will fall in any case. It is not true of a proxy, terrorist, or extremist that is willing to accept destruction or martyrdom to achieve a goal. It is not true of a state or terrorist that assumes – rightly or wrongly – that an attack cannot be attributed or will be ambiguous enough so that it can escape dramatic punishment. It is also at least possible that such an attack could occur as the result of escalation to the use of weapons of mass destruction in another theater in which the US is deeply involved – such as Korea, the Taiwan Straits, Israel, etc.

The problem with nuclear risk assessments – as with similar risk assessments affecting chemical and biological weapons – is that history is often shaped by extreme events that occur without warning and which are only explainable long after the event. History is also filled with examples in which escalation was not gradual or "rational," in which the weaker side acted in unpredictable ways. No one looking at the history of the *20th* Century has any reason to assume that sudden catastrophic events will not occur in the *21st* Century. At the same time, no one can assume that because such events can occur, they will occur. There simply is no clear nexus of probabilities to act upon.

Problems in Responding to a Nuclear Attack

There are many problems in the way defenders and responders currently deal with nuclear weapons:

- Far too much current response planning seems to treat nuclear weapons the way that it treats attacks using highly sophisticated biological weapons. It treats them as sufficiently improbable so that it is tacitly assumed that legal procedures and civil rights issues can be treated in the same way as much more moderate and limited attacks using explosives, chemical weapons, and unsophisticated biological weapons. There is no true sense of emergency. It is tacitly assumed that a state of true emergency would follow the use of a nuclear weapon, not come from convincing evidence of a serious risk such an attack is planned or underway.

- The focus on terrorist weapons leads to a lack of concern over efforts to determine the type and size of a weapon in the attackers hands, and providing both defenders and responders with as clear a set of warning signals as possible. If a state is involved, the prospect of a boosted or thermonuclear weapon being available may grow steadily over time, and there is no guarantee that the loss or sale of an FSU weapon would involve a small or limited yield. Just as all weapons of mass destruction are not the same, all nuclear weapons are not the same and intelligence and defense must give early characterization high priority.

- Responders are well aware that even a relatively small nuclear event would saturate, if not destroy, their capabilities. As a result, most local and state responders concentrate on planning for events they can manage and making limited preparations to deal with nuclear effects on an ad hoc basis. This seems perfectly realistic given current resources. There is, however, a basic policy issue that needs to be addressed: What – if anything – can be done cost-effectively to provide serious response capability to a nuclear attack beyond regional improvisation and limited federal aid?

- Many models and simulations, including those publicly briefed by DTRA, assume relatively simplistic blast, thermal, immediate radiation, and plume/fallout models. Work is underway to model urban effects more realistically, and to develop workable real-time monitoring and detection grids that can characterize and predict fallout and plume effects. It is not clear, however, what systems are practical, and serious problems seem to exist in determining the threshold of radiation to be used for warning and response, and the level of accuracy needed when radiation is deposited in very different levels over a given region. The present models seem to present a serious risk of misleading responders and to have uncertainties in affected area coverage with factors of at least 2-3. There is a possible need for zero-based parametric modeling.

- Like mass biological incidents, no one really seems to want to confront the issue of triage, and of deciding who gets treatment, who is left at risk, and who dies. This simply is not a realistic approach. Triage cannot be improvised by practitioners without a major risk of wasting inadequate resources on the moving dead and leaving the curable untreated. Creating systems to decide what level of risk is involved in urging people to stay put or evacuate, how to control the media, and what level of detail to provide should not be left up to responders in a crisis. Such planning can only be done at a federal level, but it is uncertain that the leadership and moral courage is present to do it.

- Responders correctly focus on immediate effects. Serious questions do arise, however, as to dealing with lower levels of radiation that affect the mid to long-term death rate, but which may or may not merit immediate response and treatment. This issue was ignored in civil defense planning during the Cold War because there was no way to deal with it in a mass attack upon the US. It cannot be ignored in a limited attack. As Hiroshima and Nagasaki showed, the physical and psychological impacts can last more than half a century, and there is a serious risk of "syndromes" where the exposed and non-exposed alike become major problems.

- Decontamination and recovery planning and options seem to be far too ad hoc. It is unclear what level of pre-event capability is cost-effective, but this should not be left up to change.

Once again, it is important to note that the psychological and political impact of any nuclear explosion would be vast, regardless of the damage it inflicted. As a result, even an successful explosion at sea or in the air near US territory would, under some scenarios, be a victory for an attacker. Any strike on US territory would be even more of such a victory, and in many US ports, an explosion at sea-level would deposit immense amounts of slightly radioactive water or "rain out" over a wide area, plus do major direct damage to an American city. Like some biological weapons, nuclear weapons are also "stand-off" weapons. They do not need to be near the target to do major damage. In fact, offsetting a weapon upwind from a city or facility and setting it off at ground level would produce massive fallout problems over a wide area. This, however, greatly increases the detection and intercept area and the potential problems in carrying out and coordinating detection and defense activities.

Cost-Effectiveness of Real-World Options

It is not clear that federal, state, and local defense and response efforts are now seriously concerned with developing new options for improving US defense and response capabilities to nuclear attacks. There well-organized federal teams designed to help track down a nuclear weapon and disarm it, and there are DOE and DTRA models of nuclear attacks that can help responders to train and predict some of the effects of a nuclear attack. The existing federal effort is discussed in depth in the following sections of this analysis, but nuclear attacks seem to be treated as "worst cases" that are so unlikely that they generally receive less attention than biological attacks.

At the same time, it is clear that many of the options and issues affecting Homeland defense against nuclear attacks are similar to those for major biological attacks:

- The role of intelligence in defense and response needs to be addressed to determine the probable ability to detect the development of specific types and yields of nuclear weapons and the nature of the delivery systems. The need to communicate warning to responders and treatment facilities as well as defenders needs to be addressed.

- Zero-based investigation is needed of the probable effects and lethality of nuclear weapons in urban environments, including longer-terms effects and low levels of radiation.

- As part of this effort, the need to be able to model and predict the effect of the atmospheric boundary level, and estimate the combined impact of air movements, temperature, and day-night conditions in an urbanized environment is critical to predicting effects and the capability for detection. The need for models capable of reflecting local wind and weather conditions, and water flows is equally important. Nominal models of plumes and weather effects are now so uncertain that they may do more harm than good in providing guidance for detection and response.

- Specialized intelligence and defense capabilities must be developed for warning, detection, characterization, and defense. This is not only a task for the national intelligence, security, and law-enforcement community, but also for federal, state, and local law enforcement and state National Guard units. The problem of finding cost-effective mixes of specialized CBRN expertise, and linking these efforts to response activities will present a constant challenge in terms of law, resources, organization, and training.

- As part of the development of intelligence, defense, and response capabilities, explicit analysis is needed of the trade-offs between the risk posed by mass attack and the separation of foreign intelligence from law enforcement, and the priority given to prosecution versus defense. The scale of the *treat* and the needed response times call for almost total integration of the intelligence, defense, and response effort, but this now presents major legal and organizational problems.

- The ability to convincingly identify attackers needs to be determined, as well as the possible timelines, as part of an effort to create a credible threat of retaliation and punishment at the military and law-enforcement levels.

- Zero-based investigation is needed of how to link the detection and characterization of each major form of nuclear weapons effect to a system capable of measuring the scale and lethality of attacks. Efforts to develop advanced real time detectors need to be tied to a clear plan for deployment as a system – including fixed versus mobile sensor arrays and the possible use of municipal vehicles as sensor platforms. This should include the ability to provide the data needed to identify the need for containment, isolation, treatment, disposal, and decontamination. This examination must address fundamental cost-effectiveness issues as to whether systems can or should be deployed without strategic and tactical warning, and can be rapidly deployed.

- The problem of providing integrated detection and characterization of all forms of nuclear weapons effects must be addressed at the same time, along with its cost-effectiveness. The limits of such systems, their level of accuracy and error, and their ability to reliably address the scale and area of coverage of attacks must be addressed .

- The potential role of any such a detection and characterization system must be examined in a broader context. Methods of transmitting data to defenders, responders, and caregivers – including hospitals and public health facilities need to be identified. As part of such systems, a clear linkage needs to be established between local detection and characterization and communication of the results to state, regional, and federal authorities. Methods need to be developed to use the results to immediately alert caregivers and local, state, and federal authorities to assemble the necessary containment and treatment resources. Contingency plans need to be developed to use the media to alert those in and near the affected area as to what to do in the presence of ***a*** given levels of fallout and radiation.

- Current efforts to develop detectors need to be recalibrated to consider the problems of telemetry, and triage, particularly triage involving the intensive treatment resources needed for burns and radiation .

- The cost-effectiveness of enhancing local public health capability needs examination as does the overall cost-effectiveness of developing suitable response local government systems. It is easy to call for federal support, and HHS/FEMA training and aid efforts. The tangible benefits per dollar in terms of lasting capabilities to deal with attacks are far from clear.

- Adding courses on radiation treatment to current medical and post-graduate training may be cost-effective.

- The hospital seems to be the current weak link in most serious attacks. The cost-effectiveness of federal programs, regulations, and tax credits in creating hospitals with improved treatment capabilities needs serious examination. At present, far too much of the defense/response effort would simply end in overloading existing medical treatment facilities.

- Efforts are already underway to create specialized National Guard and reserve CBRN defense units. The capability to contain, isolate, perform triage, and treat seems to be the critical current weak link in such efforts, and is compounded by the lack of well-funded public-health programs capable of organizing and training reserves of local caregivers.

- Civil defense options need to be reexamined in terms of building design and modification, personal defense equipment, and possible home protection and care options. These need to be examined in terms of their real world cost-effectiveness, and value in dealing with the full spectrum of CBRN attacks.

- A comprehensive plan is needed for dealing with local, state, and national media. This must involve education efforts, voluntary agreement to provide coverage that will inform without creating panic or misinformation, and some effort to provide clearly official coverage that viewers and listeners will trust. Consideration is needed of bringing back some form of authorized civil defense network in the effect of large-scale nuclear and biological attacks.

- Much of the current planning effort sees one major attack with one agent used in a form that federal, state, and local authorities clearly detect and characterize as the "worst case." Defense and response needs to examine cases involving multiple attacks, deception and false alarms, false characterization, and late detection. The problem of dealing with contagious disease outbreaks that are only detected after they have reached at least scatter regional or national levels is particularly important.

- The nation needs to be prepared for the "morning after." A clear plan is needed for Presidential response and national leadership in the event of a successful attack, and to prepare the American people for both follow-on attacks and the need for a US response.

- The issue of retaliation and counter-offensive options in the event of foreign attacks must be transformed into credible options that can be communicated in ways that reassure our allies, create a clear context for American counter-attacks that the world will understand, and which deter attackers.

The problem with this long list of issues and requirements is the same as is the case for major biological attacks, particularly when considered in the light of the need for federal response to existing public health care and entitlements needs, the existence of the full spectrum of CBRN attacks, the addition risks posed by missile and critical infrastructure attacks, and existing national security requirements. The checklist of necessary defense and response options is *very* long, the short-term risks are low, the effectiveness of most options is uncertain, and the cumulative cost is high. Furthermore, it is not possible to prioritize defense and response at this point in time, and the effectiveness of any program may be determined by its weakest and/or most expensive link. Anyone can call for action. Developing an affordable and well-justified program is an entirely different matter.

Rethinking the Unthinkable About Nuclear Attacks on the US Homeland

Given this background, it is clear that the US needs to make far better efforts to address the problem of responding to nuclear attacks in a number of key areas

- There are no reliable models of nuclear weapons effects in major urban areas involving massive complexes of high rise steel and glass buildings. The containment effects of modern cities are extremely difficult to model. Military studies indicate, for example, that modern buildings can reduce the effect of blast, thermal, and radiation by 40-60%, but they do not specifically address modern heating and air conditioning systems, and the sheltering effects are not designed to take glass into account and the internal impact on the building.[20]
- Nuclear explosions create a wide range of different effects that can interact on the human body. The recent literature on military models for predicting casualties indicates that such models are not reliable, and states that, "The US Army Office of the Surgeon General is developing a system of casualty estimation that will provide rapid and reasonably accurate estimates of the number of types of casualties produced by a given enemy nuclear attack." This system, however, is not yet available.[21] The military handbook on the subject acknowledges that medical facilities will probably be saturated or collapse in the event of a major attack, but effectively dodges the problem of diagnosis and triage, and assumes that adequate medical professionals and facilities are available to allow extended triage and preventive medical treatment.[22] The Defense Threat Reduction Agency (DTRA) is working on more sophisticated models tailored to attacks on the US but it again is unclear when any unclassified results will be available.
- The impact of prompt radiation is extremely difficult to estimate, and lethal and serious does can vary sharply according to exposure even in the same areas. Even personnel equipped with dosimeters present

major problems in triage because dosimeter readings cannot be used to judge whole body radiation, and a mix of physical symptoms have to be used to judged the seriousness of exposure. The impact of radiation poisoning also changes sharply if the body has experienced burns or physical trauma.[23] In the case of treatable patients, significant medical treatment may be required for more than two months after exposure.

- Fall out can very sharply according to the size and nature of a weapon and its placement, and in the size and lethality of particles and water vapor. While most fall out settles within 24 hours, this varies according to wind pattern and movement through the affected area. The drop in actual radiation of the affected material is much slower, but logarithmic. Radiation at the first hour after the explosion is down about 90%, and radiation is only about one percent of the original level after two days. Radiation only drops to trace levels, however, after 300 hours.[24]
- The test data on the longer-term (after 24 hours) effects of radiation are highly uncertain and the longer term impacts of radiation are so speculative as to be impossible to estimate. As a result, virtually all estimates of the impact of nuclear weapons ignore the long-term casualties (96 hours to 70+ years) caused by radiation, such as cancer, and the impact of a weapon on the environment in terms of the poisoning of water and food supplies. The data on treatment of exposures from zero to 530 cGy of exposure do not even seem to call for recording the probable level of exposure.[25]
- There is little data on the steadily growing seriousness of EMP on urban areas filled with computers and solid-state communications and control devices.[26]
- Most models of fall out assume relatively neat patterns of distribution or plumes that give state and local responders a relatively clear picture of probable lethality and casualty effects. It is uncertain how realistic these models really are. Weather patterns could produce far more erratic patterns of distribution, and some estimates indicate that the "worst case" area covered by the overall plume could easily be twice the area used as the reference case. There is little detailed or parametric modeling of these uncertainties, and of the burden they place on response teams. These uncertainties also are much greater for the much larger areas covered by low levels of radiation over time.
- The problem is further complicated by trying to estimate the specific mix of radioisotopes and radionuclides that will be produced and then become induced in the soil. The hazard prediction models used by the Department of Defense are under review, and it is not clear when new models will be available.[27]
- There is often a gap between generic data on radiation, burn, and physical effects and the assumed level of treatment required. Much of the federal, state, and local response literature effectively dodges around the issue of triage, and the problem of choosing who will receive limited medical treatment and how these victims will be selected. It does not describe what is done with the assumed dying and untreatable. The broader issue, however, is what indicators will be used for triage and deciding treatment and what treatment should actually be employed.
- Food and water contamination can be a serious problem, and add to the response burden in any major attack.[28] Fallout presents special problems since sheltered civilians may not have access to safe water, and urban water systems may be affected.
- Corpse disposal may be a major problem as may disposal of dead animals and birds. This aspect of response seems to be largely ignored.
- Even military medical handbooks fail to address the psychological impacts of prompt and longer-term effects.

It is far harder to make specific recommendations about courses of action as to how to better respond to nuclear attacks. A great deal of detailed program planning, cost analysis, and net technical assessment is needed which have no yet been performed. However, possible priorities include:

- Improved modeling of real-world urban effects. Modeling of fallout and "rain out" plumes in ways tailored to improve response planning.
- Near real time fallout corridor modeling and data mining. Modeling for needed level of state, regional, and federal response.
- Detection and diagnostic systems – either distributed or rapidly deployable. (e.g. the public transportation sensor grid).
- Monitoring of actual distribution of fallout and weapons effects to give local responders a more precise picture of short and long term response requirements. Real-time transmission to responders, and state, regional, and federal actors. (Often 12-48 hour time window for critical response actions).
- Systems for instant detection and diagnostics, guidance for response and triage. Dosimeters are useless for this purpose. Need clearly defined stay or flee guidance.
- Cheap portable systems for real-time triage analysis.
- Improved detection and characterization of residual threats, decontamination technologies and decon effectiveness measuring systems.
- Hospital technology solutions, rapidly deployable care technology.
- Cheap, simple civil defense options: Masks, no cost what to do technology and advice, media warning and advice alert systems.

Table 4.9

US Department of Defense Estimate of Potential National Threats Intentions Involving Nuclear Weapons

China

China currently has over 100 nuclear warheads and is increasing the size, accuracy, and survivability of its nuclear missile force. It is likely that the number of deployed Chinese theater and strategic systems will increase in the next several years. However, as its strategic requirements evolve, it may change the pace of its modernization effort for its nuclear missile force (particularly if the United States deploys NMD); any warhead improvements will complement China's missile modernization effort. China currently is not believed to be producing fissile material for nuclear weapons, but has a stockpile of fissile material sufficient to improve or increase its weapons inventory. China has ratified the NPT and signed the CTBT, and has declared it will never use its nuclear forces against a non-nuclear weapons state. China maintains a no-first- use pledge in its strategic nuclear doctrine and regards its strategic nuclear force as a deterrent against intimidation or actual attack. Thus, China's stated doc-trine reportedly calls for a survivable long-range missile force that can hold a significant portion of the U.S. population at risk in a retaliatory strike. As China's strategic forces and doctrine further evolve, Beijing will continue to develop and deploy more modern ICBMs and SLBMs

India

On 11 and 13 May 1998, India conducted what it claimed were five nuclear explosive tests. According to Indian officials, the 11 May tests included a fission device with a yield of about 12 kilotons, a thermonuclear device with a yield of about 43 kilotons, and a third test with a yield of about 0.2 kilotons. An Indian spokesman stated that the first set of tests was intended "to establish that India has a proven capability for a weaponized nuclear program."

India claimed that its 13 May tests had yields of about 0.5 and 0.2 kilotons, which were carried out to gener-ate additional data for computer simulations. According to the Chairman of India's Atomic Energy Commission, the tests enabled India to build "an adequate scientific database for designing the types of devices that [India] needs for a credible nuclear deter-rent." The tests triggered international condemnation and the United States imposed wide-ranging sanctions against India.

The tests were India's first since 1974, and reversed the previously ambiguous nuclear posture where Indian officials denied possession of nuclear weapons. Indian officials cited a perceived deterioration of India's security environment, including increasing Pakistani nuclear and missile capabilities and perceived threats from China, to justify the tests. India has a capable cadre of scientific personnel and a nuclear infrastructure, consisting of numerous research and development centers, 11 nuclear power reactors, uranium mines and processing plants, and facilities to extract plutonium from spent fuel. With this large nuclear infrastructure, India is capable of manufacturing complete sets of components for plutonium-based nuclear weapons, although the acquisition of foreign nuclear-related equipment could benefit New Delhi in its weapons development efforts to develop and produce more sophisticated nuclear weapons. India probably has a small stockpile of nuclear weapon components and could assemble and deploy a few nuclear weapons within a few days to a week. The most likely delivery platforms are fighter-bomber aircraft. New Delhi also is developing ballistic missiles that will be capable of delivering a nuclear payload in the future.

India is in the beginning stages of developing a nuclear doctrine. In August 1999, the Indian government released a proposed nuclear doctrine prepared by a private advisory group appointed by the government. It stated that India will pursue a doctrine of credible minimum deterrence. The document states that the role of nuclear weapons is to deter the use or the threat of use of nuclear weapons against India, and asserts that India will pursue a policy of "retaliation only." The draft doctrine maintains that India "will not be the first to initiate a nuclear strike, but will respond with punitive retaliation should deterrence fail." The doctrine also reaffirms India's pledge not to use or threaten to use nuclear weapons against states that do not possess nuclear weapons. It further states that India's nuclear posture will be based on a triad of aircraft, mobile land-based systems, and sea-based plat-forms to provide a redundant, widely dispersed, and flexible nuclear force. Decisions to authorize the use of nuclear weapons would be made by the Prime Minister or his "designated successor(s)." The draft doc-trine has no official standing in India, and the United States has urged Indian officials to distance themselves from the draft, which is nor consistent with India's stated goal of a minimum nuclear deterrent. India expressed interest in signing the CTBT, but has not done so. It has pledged not to conduct further nuclear tests pending entry into force of the CTBT. Indian officials have tied signature and ratification of the CTBT to developing a domestic consensus on the issue. Similarly, India strongly opposed the NPT as discriminatory but it is a member of the IAEA. Only four of India's 13 operational nuclear reactors currently are subject to IAEA safeguards. In June 1998, New Delhi signed a deal with Russia to purchase two light-water reactors to be built in southern India; the reactors will be under facility-specific IAEA safeguards. However, the United States has raised concerns that Russia is circumventing the 1992

NSG guidelines by providing NSG trigger list technology to India, which does not allow safeguards on all of its nuclear facilities. India has taken no steps to restrain its nuclear or missile programs. In addition, while India has agreed to enter into negotiations to complete a fissile material cutoff treaty, it has not agreed to refrain from producing fissile material before such a treaty would enter into force.

Iran

Although a signatory to NPT and the CTBT, Iran also is seeking fissile material and technology for weapons development through an elaborate system of military and civilian organizations. We believe Iran also has an organized structure dedicated to developing nuclear weapons by trying to establish the capability to pro-duce both plutonium and highly enriched uranium. Iran claims to desire the establishment of a complete nuclear fuel cycle for its civilian energy program. In that guise, it seeks to obtain whole facilities that could be used in numerous ways in support of efforts to produce fissile material for a nuclear weapon. The potential availability of black market fissile material also might provide Iran a way to acquire the fissile material necessary for a nuclear weapon.

Iran’s success in achieving a nuclear capability will depend, to a large degree, on the supply policies of Russia and China or on Iran’s successful illicit acquisition of adequate quantities of weapons-usable fissile material. Russia is continuing work on a 1,000-megawatt power reactor at Bushehr. Although Russian officials have provided assurances that Russian cooperation with Iran will be limited to the Bushehr reactor project during the period of its construction, the United States Government is aware that a number of Russian entities are engaged in cooperation with

Iran that goes beyond this project. One of Iran’s primary goals is the acquisition of a heavy water-moderated, natural uranium-fueled nuclear reactor and associated facilities suitable for the production of weapons-grade plutonium. Although Bushehr will fall under IAEA safeguards, Iran is using this project to seek access to more sensitive nuclear technologies from Russia and to develop expertise in related nuclear technologies. Any such projects will help Iran augment its nuclear technology infrastructure, which in turn would be useful in supporting nuclear weapons research and development.

In the past, Chinese companies have been major suppliers of nuclear-related facilities and technology albeit under IAEA safeguards. China pledged in 1997 that it would not undertake any new nuclear cooperation with Iran and that it would close out its two existing projects –a small research reactor and a zirconium production facility, which will produce cladding for nuclear fuel –as soon as possible. (Neither of these two projects poses a significant proliferation concern.) China also agreed to terminate cooperation on a uranium conversion project. This project would have allowed Iran to produce uranium hexafluoride or uranium dioxide, which are the feedstock materials for the manufacture of weapons grade plutonium. In addition, China announced new export controls in June 1998 that cover the sale of dual-use nuclear equipment. China appears to be living up to its 1997 commitments.

Iraq

Iraq has ratified the NPT. Nevertheless, before the Gulf War, Iraq had a comprehensive nuclear weapons development program that was focused on building an implosion-type device. The program was linked to a ballistic missile project that was the intended delivery system. From April 1991 to December 1998, Iraqi nuclear aspirations were held in check by IAEA/ UNSCOM inspections and monitoring. All known weapons-grade fissile material was removed from the country. Although Iraq claims that it destroyed all of the specific equipment and facilities useful for devel-oping nuclear weapons, it still retains sufficient skilled and experienced scientists and engineers as well as weapons design information that could allow it to restart a weapons program.

Iraq would need five or more years and key foreign assistance to rebuild the infrastructure to enrich enough material for a nuclear weapon. This period would be substantially shortened should Baghdad successfully acquire fissile material from a foreign source.

Libya

Libya has ratified the NPT, but has not signed the CTBT and has long intended to develop or acquire nuclear weapons. Libya has made little progress, ho-ever, as its nuclear program lacks well-developed plans, expertise, consistent financial support, and adequate foreign suppliers. In the face of these difficulties, nonetheless, Libya likely will continue to try to develop a supporting infrastructure. Libya has a Soviet-supplied research reactor at Tajura that is under IAEA safeguards. The Russians may become actively involved in the modernization of the Tajura nuclear research center and, in 1999, Tripoli and Moscow resumed discussions on cooperation involving the Tajura reactor as well as a potential power reactor deal. Should this civil sector work come to fruition, Libya could gain opportunities to conduct nuclear weapons-related research and development. Libya reportedly also is trying to recruit foreign scientists and technicians to aid its program.

North Korea

The 1994 Agreed Framework between the United States and North Korea froze nuclear weapons material production at the

Yongbyon and Taechon facilities. However, the United States believes North Korea pro-duced and diverted sufficient plutonium for at least one nuclear weapon prior to the agreement. (In any event, North Korea will have to satisfy the Interna-tional Atomic Energy Agency (IAEA) as to its exact plutonium holdings before key nuclear components can be delivered for the two light-water reactors that are to be provided under the Agreed Framework.) North Korea removed spent fuel from the Yongbyon reactor in 1994. Had Pyongyang reprocessed the spent fuel from the Yongbyon reactor, it could have pro-duced enough plutonium for several nuclear weapons. As part of the Agreed Framework, the IAEA has main-tained a continuous presence at Yongbyon, and IAEA personnel have monitored canning of the spent fuel from the reactor. The canning of all accessible spent fuel rods and rod fragments, which was carried out by a team from the United States, under the auspices of the Department of Energy (DOE), was completed in April 2000. The U.S. team maintains a presence at the site to continue maintenance activities. In 1998, the United States became concerned about an underground construction project at Kumchang-ni, in northern North Korea. The site was believed to be large enough to house a plutonium production facility and possibly a reprocessing plant. Through successful negotiations, U.S. officials were permitted to visit the facility at Kumchang-ni in May 1999. Based on the 1999 team's findings, it was concluded that the facility as then concurrently configured, was not suited to house graphite-moderated reactors or reprocessing operations. A second visit to Kumchang-ni was conducted in May 2000, during which the team found no evidence to contradict the 1999 conclusions. In the summer of 1999, the United States dispatched former Secretary of Defense William Perry to consult with North Korea on key U.S. security concerns such as its nuclear and missile programs. In the North Korea Policy Review, Dr. Perry concluded that the nuclear freeze instituted at Yongbyon's facilities remained in effect, although the U.S. remains concerned about possible continuing North Korean interest in a nuclear weapons program. Moreover, there is some evidence that North Korea has tried to procure technology that could have applications in its nuclear program. North Korea has ratified the NPT. It has not signed the Comprehensive Test Ban Treaty (CTBT). Dr. Perry recommended that the U.S. should seek the complete and verifiable cessation of testing, production, and deployment of missiles exceeding the parameters of the MTCR, and the complete cessation of export sales of such missiles and the equipment and technology associated with them.

Pakistan

As a response to India's tests, Pakistan conducted its own series of nuclear tests in May 1998. Pakistan claimed to have tested six devices, five on 28 May and one on 30 May. Dr. A. Q. Khan, a key figure in Pakistan's nuclear program, claimed the five devices tested on 28 May were boosted fission devices: a "big bomb" and four tactical weapons of low yield that could be used on small missiles. He also claimed that Pakistan could conduct a fusion or thermonuclear blast if it so desired. The United States imposed additional sanctions against Pakistan as a result of these tests. Pakistan has a well-developed nuclear infrastructure, including facilities for uranium conversion and enrichment and the infrastructure to produce nuclear weapons. Unlike the Indian nuclear program, which uses plutonium for its weapons, Pakistan's program currently is based on highly-enriched uranium. However, Pakistan also is developing the capability to produce plutonium for potential weapons use. An unsafe-guarded heavy-water research reactor built at Khushab will produce plutonium that could be reprocessed for weapons use at facilities under construction. In the past, China supplied Pakistan with nuclear materials and expertise and has provided critical assistance in the production of Pakistan's nuclear facilities. Pakistan also acquired a significant amount of nuclear-related and dual-use equipment and materials from various sources principally in the FSU and Western Europe. Acquisition of nuclear-related goods from foreign sources will remain important if Pakistan chooses to continue to develop and produce more advanced nuclear weapons, although we expect that, with the passage of time, Pakistan will become increasingly self-sufficient. Islamabad likely will increase its nuclear and ballistic missile stockpiles over the next five years.

Islamabad's nuclear weapons are probably stored in component form. Pakistan probably could assemble the weapons fairly quickly and has aircraft and possibly ballistic missiles available for delivery. Pakistan's nuclear weapons program has long been dominated by the military, a dominance that likely has continued under the new military government and under Pakistan's new National Command Authority (NCA), announced in February 2000. While Pakistan has yet to divulge publicly its nuclear doctrine, the new NCA is believed to be responsible for such doctrine, as well as nuclear research and development and wartime command and control. The NCA also includes two committees that advise Pakistan's Chief Executive, General Musharraf, about the development and employment of nuclear weapons.

Pakistan remains steadfast in its refusal to sign the NPT, stating that it would do so only after India joined the Treaty. Consequently, not all of Pakistan's nuclear facilities are under IAEA safeguards. Pakistani officials have stated that signature of the CTBT is in Pakistan's best interest, but that Pakistan will do so only after developing a domestic consensus on the issue, and have disavowed any connection with India's decision. Like India, Pakistan expressed its intention to sign the CTBT, but, so far, has failed to do so. While Pakistan has provided assurances that it will not assemble or deploy its nuclear warheads, nor will it resume testing unless India does so first; it has taken no additional steps. Pakistan has agreed to enter into negotiations to complete a fissile material cutoff agreement, but has not agreed to refrain from producing fissile material before a cutoff treaty would enter into force.

Russia

Moscow increasingly has stated it will rely more heavily on its nuclear forces for deterrent purposes, especially given the serious deterioration of their conventional forces' capability. Russia conditionally ratified (START II) in May 2000, which, once it enters into force, will limit the number of operational launchers and deployed warheads to 3,000-3,500. In June 1999, former President Yeltsin proposed discussions with the United States for further force reductions in the context of a START III Treaty, with proposed force levels of 1,500-2,000.

The Russian nuclear warhead stockpile is being reduced as a result of tactical nuclear warhead reduction initiatives, while the START I treaty (which entered into force in December 1994) and system aging have resulted in the reduction of deployed strategic warheads. In December 2000, the stockpile was estimated to be well under 25,000 warheads, a reduction of over 11,000 warheads since eliminations began in 1992. By the end of 2010, the overall stockpile likely will be further reduced, depending on the economic situation in Russia, Moscow's willingness and ability to abide by tactical nuclear warhead reduction pledges, and future arms control agreements. Moscow has consolidated many of its strategic and tactical warheads at central storage locations, and numerous warhead storage sites for holding warheads have been deactivated since the early 1990s. While this consolidation has improved security, current resource shortages have subjected the nuclear storage system to stresses and risks for which it was not designed. Indeed, warhead reductions have had the collateral effect of increasing near- to mid-term fissile material storage requirements, pending the long-term elimination relevant weapons-usable fissile materials.

While Russia's strategic nuclear forces will retain considerable capability over the next ten years and will serve as its primary means of deterrence, the overall force is expected to continue to decrease because of arms control, economic constraints, and aging equipment. Within ten years, the number of operational strategic warheads will continue to decline. At the same time, however, production of warheads will continue into the 21st century as new strategic missile systems are deployed and obsolete warheads replaced.

For strategic delivery, Russia retains a significant strategic ballistic missile force of some 1,130 operational ICBMs and SLBMs. There no longer are any operationally deployed ICBMs in Ukraine, Kazakhstan, and Belarus. More than 1,250 FSU ICBMs and SLBMs have been removed from the overall force since 1991. This force is likely to decline further as a result of systems aging, chronic funding problems, and arms control agreements. On the other hand, Russia has begun deployment of a new ICBM, the SS-27 (TOPOL-M), and has other missiles planned for deployment in the 21st century. Russia has ratified the NPT and the CTBT.

Because of economic and other difficulties facing Russia and its armed forces, tactical nuclear weapons will remain a viable component of its general purpose forces for at least the next decade. Russia likely believes that maintaining tactical nuclear forces is a less expensive way to compensate for its current problems in maintaining conventional force capabilities. In late 1991 and early 1992, Russia agreed in the Presidential Nuclear Initiatives to a dramatic reduction in its tactical nuclear forces, including the elimination of its ground-launched tactical weapons. Russia still has significant numbers and types of delivery systems capable of performing the tactical nuclear mission. For example, Russia continues to have large inventories of tactical SRBMs (SS-21s), deactivated SCUDs, and a variety of artillery capable of delivering NBC weapons. In fact, Russia employed its tactical SRBMs (with conventional warheads) against the Chechens in the fall of 1999. Air systems include fighter aircraft and bombers. Naval tactical nuclear systems include torpedoes, anti-shipping and anti-sub-marine warfare missiles, and air-launched munitions carried on naval aircraft. Further, Russia's industrial base can support production of the full range of solid-and liquid-propellant ballistic missiles, space launch vehicles, and all associated technologies.

In November 1993, the Russian Ministry of Defense formally dropped its wholly declaratory "no first use" of nuclear weapons policy. In its place, the Ministry of Defense published its Basic Provisions of the Military Doctrine of the Russian Federation, in which it articulated its current nuclear policy: "The Russian Federation will not employ its nuclear weapons against any state party to the treaty on the nonproliferation of nuclear weapons, dated 1 July 1968, which does not possess nuclear weapons except in the cases of (a) an armed attack against the Russian Federation, its territory, armed forces, other troops, or its allies by any state that is connected by an alliance agreement with a state that does not possess nuclear weapons or; (b) joint actions by such a state with a state possessing nuclear weapons in the carrying out or in support of any invasion or armed attack upon the Russian Federation, its territory, armed forces, other troops, or its allies."

The current Russian doctrine and strategy involving the use of nuclear weapons, reiterated in October 1999, states that "the possibility of the use of nuclear weapons has not been excluded if the situation deteriorates during the course of conventional war." A revised version of this document was approved by then-Acting President Putin in January 2000, which further lowers the threshold for nuclear use in order to protect Russia's national interests and territorial integrity; it states: "The application of all forces and means, including nuclear weapons, if necessary to repel armed aggression, if all other measures for resolving the crisis situation have been exhausted or proven ineffective." In April 2000, the Russians elaborated on this threshold, stating that "the Russian Federation retains the right to use nuclear weapons in response to the use of nuclear weapons, or other types of weapons of mass destruction against itself or its allies, and also in response to large scale aggression with the use conventional weapons in situations critical to the national security of the Russian Federation."

Syria

Syria is not pursuing the development of nuclear weapons. However, it retains an interest in nuclear technology and has a small Chinese-supplied research reactor, which is under IAEA safeguards. In addition, in May 1999, Syria signed a broad nuclear cooperation agreement with Russia, which includes the construction of a small light-water research reactor, which will be subject to IAEA safeguards. Syria currently lacks the infrastructure and trained personnel to establish a nuclear weapons program. Syria has ratified the NPT, but has not signed the CTBT.

Source: Adapted by Anthony H. Cordesman from Department of Defense, Proliferation and Response, January 2001

Table 4.10

The Thermal and Blast Effects of Nuclear Weapons - Part One: The US Department of Defense Estimates

Radii of Effects in Kilometers versus Weapons Yield

Effect	1 KT	20 KT	100 KT	1 MT	10 MT
Nuclear Radiation (1,000 cGY or lethal dose in open)	0.71	1.3	1.6	2.3	3.7
Blast: 50% incidence of translation with subsequent impact on a Non-yielding surface	0.28	1.0	1.4	3.8	11.7
Thermal: 50% incidence of 2nd degree burns to bare skin, Kilometer visibility	0.77	1.8	3.2	4.8	14.5
Duration of Thermal Pulse in Seconds	0.12	0.32	0.9	2.4	6.4

Ranges in Kilometers for Probabilities of Flying Debris

Yield in KT	Probability of Serious Injury		
	1%	50%	99%
1	0.28	0.22	0.17
10	0.73	0.57	0.44
20	0.98	0.76	0.58
50	1.4	1.1	0.84
100	1.9	1.5	1.1
200	2.5	1.9	1.5
500	3.6	2.7	2.1
1000	4.8	3.6	2.7

Ranges in Kilometers for Translational (Blast) Injuries

Yield in KT	Range for Probability Blunt Injuries & Fractures			Range for Probable Fatal Injuries	
	-1%	50%	99%	-1%	50%
1	0.38	0.27	0.19	0.27	0.19
10	1.0	0.75	0.53	0.75	0.53
20	1.3	0.99	0.71	0.99	0.71
50	1.9	1.4	1.0	1.4	1.0
100	2.5	1.9	1.4	1.9	1.4
200	3.2	2.5	1.9	2.5	1.9
500	4.6	3.6	2.7	3.6	2.7
1000	5.9	4.8	3.6	4.8	3.6

Source: Adapted from Table 2-1 and Table 2-7 of FM 8-10-7 and Table IV of FM-8-9, Part I, and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-2 and 2-3.

Table 4.10

The Thermal and Blast Effects of Nuclear Weapons - Part Two: The British RUSI Estimates

Radius of Effect in Kilometers

Yield in Kilotons	Metals Vaporize	Metals Melt	Wood Burns	3rd Degree Burns	5 psi/ 160 mph Winds	3 psi 116 mph Winds
10	0.337	0.675	1.3	1.9	1.3	1.6
20	0.477	0.954	1.9	2.7	1.6	2.0
50	0.754	1.5	3.0	4.3	2.0	2.7
100	1.0	2.0	4.3	5.7	2.7	3.5
200	1.5	2.8	5.7	8.0	3.5	4.5

Impact of Killing Effects by Yield

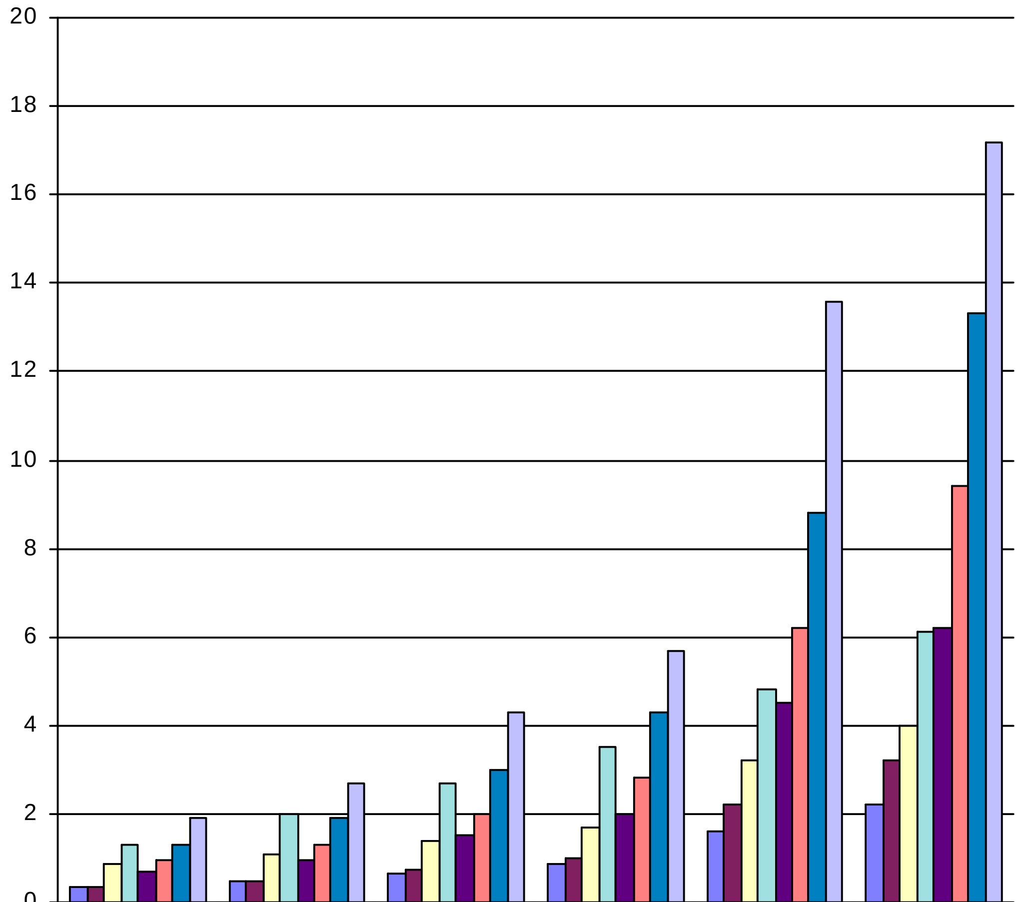
Cause	Effect	Radius in Nautical Miles		
		40 KT	170 KT	1MT
Overpressure	Lethality threshold	0.1	0.15	0.25
(crushing)	Severe lung damage	0.7	1.1	2.1

	Broken eardrums	0.3	0.5	0.8
Translation	Personnel in open (1%)	0.9	1.6	3.3
	Personnel near structures (1%)	1.0	1.9	3.8
	Personnel near structures (50%)	0.6	1.0	2.1
Thermal	Third degree burn – 100%	1.5	2.6	5.2
	No burns – 100%	2.8	4.8	8.7
	Retinal burn – daytime safe distance	20.0	23.0	25.0
Radiation	Lethal does (1,000 rads)	0.7	0.8	0.9
	No immediate harm (100 rads or less)	1.0	1.1	1.2

Source: Adapted by Anthony H. Cordesman from the Royal United Services Institute, Nuclear Attack: Civil Defense, London, RUSI/Brassey's, 1982, pp. 30-36; and Office of Technology Assessment, "The Effects of Nuclear War," Washington, US Congress, OTA-NS-89, May 1979, pp. 43-46.

Chart 4.4

The Nominal Lethality of Different Nuclear Weapons
(Seriousness of Effect in Kilometers as a Function of Yield)

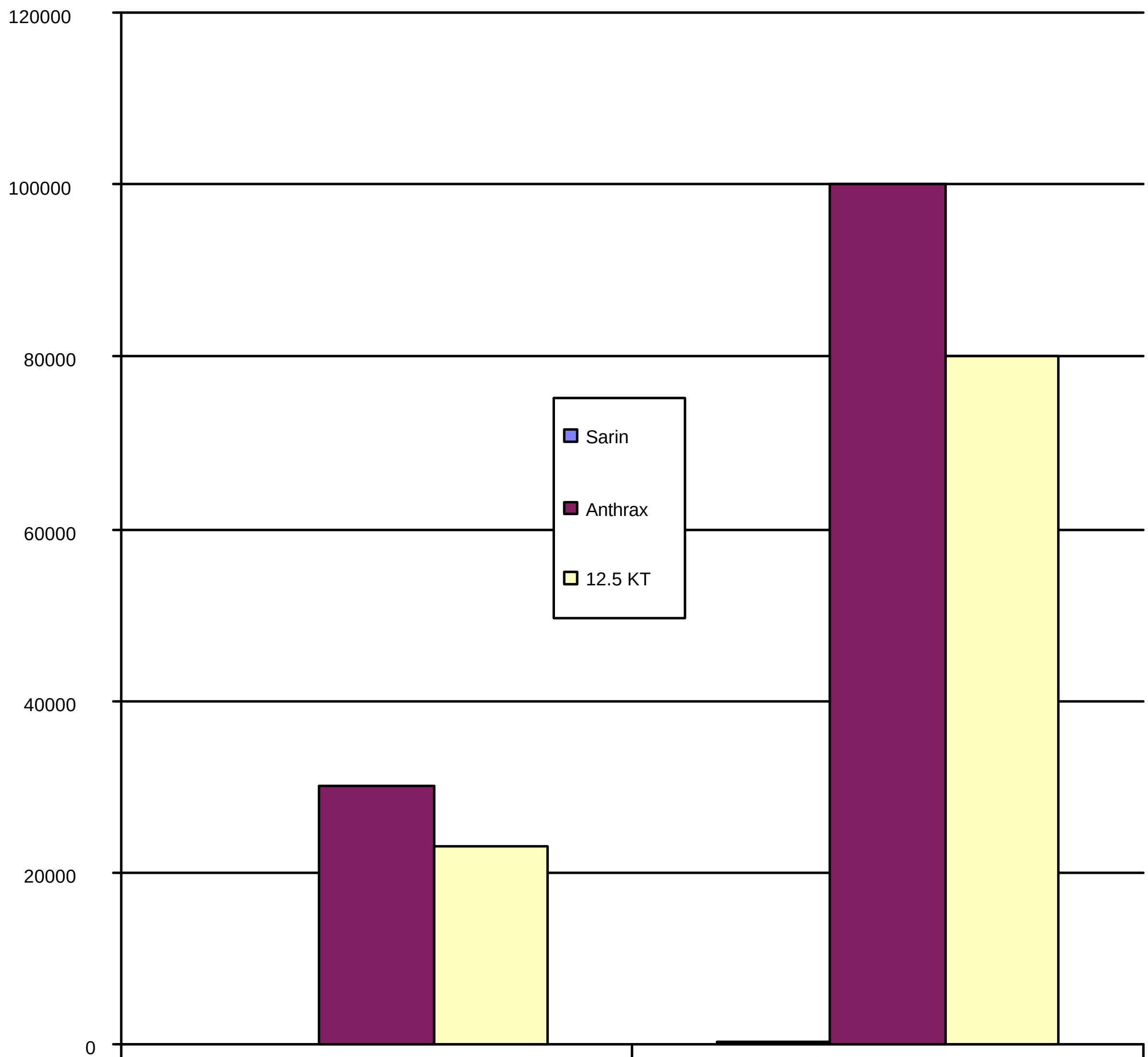


	10KT	20 KT	50 KT	100 KT	500 KT	1 MT
Fireball	0.352	0.464	0.67	0.884	1.6	2.2
Metals Vaporize	0.337	0.477	0.754	1	2.2	3.2
10-Psi	0.875	1.1	1.4	1.7	3.2	4
5-Psi	1.3	2	2.7	3.5	4.8	6.1
Metals Melt	0.675	0.954	1.5	2	4.5	6.2
Plastics Melt/Ignite	0.954	1.3	2	2.8	6.2	9.4
Wood chars/Burns	1.3	1.9	3	4.3	8.8	13.3
3rd Degree Burns	1.9	2.7	4.3	5.7	13.6	17.2

Source: Adapted by Anthony H. Cordesman from the Royal United Services Institute, Nuclear Attack: Civil Defense, London, RUSI/Brassey's, 1982, pp. 30-36

Chart 4.5

The Relative Killing Effect of Chemical vs. Biological vs. Nuclear Weapons



	Low	High
Sarin	60	200
Anthrax	30000	100000
12.5 KT	23000	80000

Source: Adapted by Anthony H. Cordesman from Victor A. Utgoff, The Challenge of Chemical Weapons, New York, St. Martin's, 1991, pp. 238-242 and Office of Technology Assessment, Proliferation of Weapons of Mass Destruction: Assessing the Risks, U.S. Congress OTA-ISC-559, Washington, August, 1993, pp. 56-57.

Radiological Weapons as Means of Attack

Radiological weapons that employ conventional explosives or other means to scatter radioactive material are another important means of attack. Radiological weapons are generally felt to be suitable largely for terror, political, and area denial purposes, rather than mass killings. Unlike nuclear weapons, they spread radioactive material contaminating personnel, equipment, facilities, and terrain. The radioactive material acts as a toxic chemical to which exposure eventually proves harmful or fatal.

The main potential sources of such weapons – barring covert transfer from outside the US – are hospital radiation therapy (Iodine-125, Coblat-60, Cesium-137), radiopharmaceuticals (Iodine-131, Iodine-123, Technetium-99, Thalium-201, Xenon-133), nuclear power plant fuel rods (Uranium-235), universities and laboratories and radiography and gauging (Cobalt-60, Cesium-137, Iridium-192, and Radium-226). Such materials can be delivered by a wide variety of means, including human agents, the destruction of a facility or vessel containing radioactive material, shipments or remote control devices that explode and disseminate the agent, placement in facilities or water supplies, or using aircraft, missiles, and rockets. Radiological dispersal weapons (RDWs) can also be used to contaminate livestock, fish, and food crops.

The effectiveness of radiological weapons is controversial, and their potential impact can vary sharply because of the time require to accumulate a disabling or significant does of radiation through ingestion, inhalation, or exposure. US military reporting on their effects notes that, "There are no official casualty predictions for radiological dispersal weapons (RDWs). Because of the nature of the weapon, verification of the use of the weapon may prove difficult."[29] Other findings of the Department of Defense provide important insights into the potential effectiveness of RDWs:[30]

> Such a weapon would not produce a nuclear yield; but would spread contamination. While such weapons would produce far less immediate damage than devices that result in nuclear detonations, radiological weapons have enormous potential for intimidation. Targeting a nuclear reactor in an antagonist's territory to produce an accident releasing nuclear material would be another option.

There are hundreds of nuclear reactors and many more nuclear sources throughout the world, such as radiological materials used in hospitals. Both international and national measures control these items and associated materials and thereby contribute to proliferation prevention. However, post-war investigations in occupied Iraq showed that at least some of these control regimes could be circumvented, even by a state that was a nominal adherent to the Nuclear Non-Proliferation Treaty. Near-term concerns include the accumulation of large quantities of plutonium from reactors that is intended for reprocessing and/or storage, and the status of nuclear materials in the New Independent States that previously comprised the Soviet Union.

The Practical Chances of Using Radiological Weapons

A December 1999 report by the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction drew the following conclusions about the ability of terrorist groups to use radiological weapons:[31]

In the view of some authorities, theft of a nuclear device or building a weapon "in house" are the least-probable courses of action for a prospective nuclear terrorist. Far more likely-for all the reasons cited above-is the dispersal of radiological material in an effort to contaminate a target population or distinct geographical area.

The material could be spread by radiological dispersal devices (or RDDs)-i.e. "dirty bombs" designed to spread radioactive material through passive (aerosol) or active (explosive) means. Alternatively, the material could be used to contaminate food or water. This latter option is, however, considerably less likely given the huge quantities of radioactive material that would be required. The fact that most radioactive material is not soluble in water means that its use by a terrorist would be unlikely and impractical, if the purpose is to contaminate reservoirs or other municipal water supplies, because the radioactive material will settle out or be trapped in filters. Those factors, coupled with the fact that any radioactive material will present safety risks to the terrorists themselves, collectively indicate the serious difficulties for any adversary attempting to store, handle, and disseminate it effectively.

Radiological weapons kill or injure by exposing people to radioactive materials, such as cesium-137, iridium-192, or cobalt-60. Victims are irradiated when they get close to or touch the material, inhale it, or ingest it. With high enough levels of exposure, the radiation can sicken and kill. Radiation (particularly gamma rays) damages cells in living tissue through ionization, destroying or altering some of the cell constituents essential to normal cell functions.

The effects of a given device will depend on whether the exposure is "acute" (i.e., brief, one time) or "chronic" (i.e., extended). There are a number of possible sources of material that could be used to fashion such a device, including nuclear waste stored at a power plant (even though such waste is not highly radioactive), or radiological medical isotopes found in many hospitals or research laboratories. Although spent fuel rods are sometimes mentioned as potential sources of radiological material, they are very hot, heavy, and difficult to handle, thus making them a poor choice for terrorists. Other sources, such as medical devices, might be much easier to steal and handle. These materials, however have a lower specific activity than the materials in reactor fuel rods (although large unshielded sources are quite dangerous). Presumably, terrorists could steal a device (either in transit or at the service facility or user location) and remove the radioactive materials.

Radioactive materials are often sintered in ceramic or metallic pellets. Terrorists could then crush the pellets into a powder and put the powder into an RDD. The RDD could then be placed in or near a target

> facility and detonated, spreading the radiological material through the force of the explosion and in the smoke of any resulting fires. Of course, the larger the radioactive material dispersal area, the smaller the resulting dose rate. Although incapable of causing tens of thousands of casualties, a radiological device, in addition to possibly killing or injuring any people who came into contact -with it "could be used to render symbolic targets or significant areas and infrastructure uninhabitable and unusable without protective clothing."
>
> A combination fertilizer truck bomb, if used together with radioactive material, for example, could not only have destroyed one of the New York World Trade Center's towers but might have rendered a considerable chunk of prime real estate in one of the world's financial nerve centers indefinitely unusable because of radioactive contamination. The disruption to commerce that could be caused, the attendant publicity, and the enhanced coercive power of terrorists armed with such "dirty" bombs (which, for the reasons cited above, are arguably more likely threats than terrorist use of an actual fissile nuclear device), is disquieting.

A Department of Defense study notes that, "Iraqi and Russian separatists Cechnya have already demonstrated practical knowledge of RDWs. The availability of material to make RDWs will inevitably increase in the future as more countries pursue nuclear power (and weapons) programs and radioactive material becomes more available."[32]

The Practical Risks and Effects of Using Radiological Weapons

Small amounts of radioactive materials can be used to attack, threaten, and contaminate, and the very risk of radiation poses a serious psychological problem. Covert attacks might produce slow radiation poisoning, and agents might be deliberately designed to make cost-effective decontamination difficult, time-consuming, or impossible. The use of small amounts of radiological weapons also presents the problem that there are no reliable criteria for determining what dose is dangerous or lethal, particularly if effects like long-term increases in the cancer rate are included.

Responders differ sharply in terms of their use of sophisticated radiation detectors, and most responders are more concerned with evacuation than the difficult problems of dealing with medical and decontamination aftermaths. In broad terms, these effects are somewhat similar to those of using a chemical weapon. They are not catastrophic, and even the contamination of most critical facilities could be dealt with – at the cost of interruptions in service and efficiency.

The large-scale weaponization of radiological materials presents a different issue. The above comments made some relatively casual assumptions about how easy or difficult it is to obtain and convert radioactive materials into a form that could be broadly disseminated over a wide area. There are significant disputes over how easy it is to grind up radioactive materials and spread them over an area larger than a single facility, and the unclassified literature seems to be based on generalizations rather than detailed technical analysis. This does not mean that such attacks are not possible, but it does mean that considerably more evidence is needed as to what can and cannot be done.

One possible option is a systematic attack on a nuclear power plant. This would require considerable expertise, access to the basic design of the plant and ideally to a full set of plans, and either an exceptionally efficient saboteur or a trained team. In most cases, it would require considerable time and effort to bypass safeguards and controls. The possible venting or overload of a reactor could then act as a radiological weapon, however, and cover hundreds of square kilometers as well as have a major potential affect on regional power supplies and some aspects of the US military nuclear program.[33]

Alternatively, an attacker might seize significant amounts of radioactive material from spent fuel storage, or during the nuclear fuel cycle, which involves milling, conversion, enrichment, fuel fabrication, and disposal of waste – as well as reactor operations. A seizure of spent fuel would be particularly dangerous during the first 150 days after the downloading of the reactor because Iodine-131 and Iodine-123 are present, is extremely volatile, and affects the thyroid.[34]

Work by the Department of Defense indicates that the following problems exist in trying to detect and estimate the impact of radiological weapons:

- The impact of prompt radiation is extremely difficult to estimate, and lethal and serious doses can vary sharply according to exposure even in the same areas. Even personnel equipped with dosimeters present major problems in triage because dosimeter readings cannot be used to judge whole body radiation, and a mix of physical symptoms have to be used to judged the seriousness of exposure. The impact of radiation poisoning also changes sharply if the body has experienced burns or physical trauma.[35] In the case of treatable patients, significant medical treatment may be required for more than two months after exposure.

- Prompt detection and decontamination can have a major effect, and about 95% of external agents can be removed by simply removing outer clothing and shoes.[36]

- The spread of airborne radioactive particulates can vary sharply according to the size and nature of a weapon and its placement, and in the size and lethality of particles and water vapor. While most will settle within 24 hours, this will vary according to wind pattern and movement through the affected area. The drop in actual radiation of the affected material is generally much slower, but logarithmic. Radiation at the first hour after the explosion is down about 90%, and radiation is only about one percent of the original level after two days. Radiation only drops to trace levels, however, after 300 hours.[37]

- The test data on the longer-term (after 24 hours) effects of radiation are highly uncertain and the longer term impacts of radiation are so speculative as to be impossible to estimate. As a result, virtually all estimates of the impact of RDWs ignore the long-term casualties (96 hours to 70+ years) caused by radiation, such as cancer, and the impact of a weapon on the environment in terms of the poisoning of water and food supplies. The data on treatment of exposures from zero to 530 cGy of exposure do not even seem to call for recording the probable level of exposure.[38]

- The problem is further complicated by trying to estimate the specific mix of radioisotopes and radionuclides that will be produced and then become induced in the soil. The hazard prediction models used by the Department of Defense are under review, and it is not clear when new models will be available.[39]

- There is often a gap between generic data on radiation and the assumed level of treatment required. Much of the federal, state, and local response literature effectively dodges around the issue of triage, and the problem of choosing who will receive limited medical treatment and how these victims will be selected in the case of large scale exposures. It does not describe what is done with the assumed dying and untreatable, and some literature seems to assume that doses from zero to 70 cGy can be largely ignored, while other literature is more concerned with long-term effects. The broader issue of what indicators will be used for triage and deciding treatment and what treatment should actually be employed is generally not addressed because so many different RDWs and types of attack are possible.

- The characterization of RDWs presents a significantly greater problem than does detection, and estimating the type and effects of a specific RDW is difficult. This is particularly true of contamination with RDWs or if detection only occurs after significant exposure. Because of the limitations of dosimeters and other detection equipment, bioassay is generally need to determine the level and type of effects. This is critical with inhalation and ingestion.[40]

- Post attack radiological surveys can be very difficult for the same reasons.[41]

- Corpse disposal may be a major problem as may disposal of dead animals and birds. This aspect of response seems to be largely ignored.

- Even military medical handbooks fail to address the psychological impacts of prompt and longer-term effects.

- Food and water contamination can be a problem, and add to the response burden in any major attack.[42]

Experts agree that additional study is needed of the different kinds of agents that might be used, of their different effects and risks, of the problem of characterizing the weapon versus detecting radiation, and of how triage, monitoring, and treatment need to be applied. The same is true of decontamination. As is the case with chemical and biological weapons, there is also a need for far more analysis of what kind of detection grids or systems are needed, of what level of shielding or masking would be effective, and of how to predict dissemination and effects.[43]

More broadly, responders correctly assume that destruction and lethality are key criteria they will have to deal with in an emergency, but the main purpose of such an attack might be political or psychological. As is the case with chemical and biological weapons, public and world perceptions of the impact of such attacks would initially be based on the fact they occurred at all. It is also far from clear how the public would react to even the most successful decontamination effort, and how well the US could guarantee the effectiveness of such a decontamination effort. Past incidents of nuclear smuggling and black market sales have also demonstrated that it is far easier to obtain some form of radioactive material than fissile material.

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[1] See Center for Counterproliferation Research, "The Effects of Chemical and Biological Weapons on Operations, What We Know and Don't Know," National Defense University, February 1997; p2NBC2 Report No.90-1, Physiological and Psychological Effects of NBC Environment and Sustained Operations on Systems in Combat, P2NBC2 Test Reports, "Technical Papers and Bibliographies," US Army Chemical School, Ft. McClellan, Alabama, January 4, 1990, CB -013725.0; p2NBC2 Report No.90-2, Physiological and Psychological Effects of NBC Environment and Sustained Operations on Systems in Combat, p2NB C2 Test Reports, "Program Overview ," US Army Chemical School, Ft. McClellan, Alabama, January 4, 1990, CB -013726; p2NBC2., Physiological and Psychological Effects of NBC Environment and Sustained Operations on Systems in Combat, p2NBC2Test Reports, "Program Wrap-Up, Annotated List of Findings," US Army Chemical School, Ft. McClellan, Alabama, January 1995, EAI Report 69-2/95/002F; John A Mojecki, "Combined Arms in a Nuclear/Chemical Environment (CANE), Phase IlA; Summary Evaluation," ORI, Inc. for Commandant," US Army Chemical School, Ft. McClellan, Alabama, May 31,1987.

[2] FM 8-10-7, Figure 2-1.

[3] See Table 2-1 and Table 2-7 of FM 8-10-7 and Table IV of FM-8-9, Part I, and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-2 and 2-3

[4] Office of Technology Assessment, "The Effects of Nuclear War," Washington, US Congress, OTA-NS-89, May 1979, pp. 43-46.

[5] See USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, Section 2, Field Manual (FM) 1.1-31-2, FM 3-7, and FM-8-10-7.

[6] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 2-6.

[7] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-6 to 2-23, and 2-28 to 2-29, FM 8-9, Table 6-II, and FM 8-10-7, Table 4-2.

[8] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-5 to 2-23.

[9] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 2-15.

[10] See AFRRI, AmedP-6©, and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-15

[11] These issues are poorly dealt with in most weapons effect manuals, but are discussed in summary form in Office of Technology Assessment, "The Effects of Nuclear War," Washington, US Congress, OTA-NS-89, May 1979.

[12] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 3-16 to 3-17; Joint Publication 3-11 (Draft), FM-8-9, FM 8-10-7, AMEED Center and School’s, Effects of Nuclear Weapons and Directed Energy on Military Operations, and DoD 5100.52-M Nuclear Accident Response Procedures Manual – NARP.

[13] See AMEED Center and School, Effects of Nuclear Weapons and Directed Energy on Military Operations, (especially p. 1-34) and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 3-15 to 3-16.

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[14] For a good technical summary of the issues involved in making such weapons, see Office of Technology Assessment, "Background Paper: Technologies Underlying Weapons of Mass Destruction," Washington, US Congress, OTA-BP-ISC-115, December 1993, and "The Effects of Nuclear War," Washington, US Congress, OTA- NS-89, May 1979.

[15] http:// www .defenselink.mil/pubs/prolif/access tech.html

[16] Office of the Secretary of Defense, Proliferation and Response, Washington, Department of Defense, January 2001, "Transnational Threats."

[17] First Annual Report of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction, "Assessing the Threat," December 15, 1999, www.rand.org/organization/nsrd/terrpanel, pp. 94-115.

[18] OSD, Proliferation: Threat and Response (Washington, D.C.: USGPO, 1997), accessed at http://www.defenselink.mil/pubs/prolif97/ trans.htrnl#terrorism.

[19] National Commission on Terrorism, Countering the Changing Threat of International Terrorism, June, 2000, http://www.fas.org/irp/threat/commission.html

[20] See USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, Section 2, Field Manual (FM) 1.1-31-2, FM 3-7, and FM-8-10-7.

[21] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 2-6.

[22] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-6 to 2-23, and 2-28 to 2-29, FM 8-9, Table 6-II, and FM 8-10-7, Table 4-2.

[23] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-5 to 2-23.

[24] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 2-15.

[25] See AFRRI, AmedP-6©, and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-15

[26] These issues are poorly dealt with in most weapons effect manuals, but are discussed in summary form in Office of Technology Assessment, "The Effects of Nuclear War," Washington, US Congress, OTA-NS-89, May 1979.

[27] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 3-16 to 3-17; Joint Publication 3-11 (Draft), FM-8-9, FM 8-10-7, AMEED Center and School's, Effects of Nuclear Weapons and Directed Energy on Military Operations, and DoD 5100.52-M Nuclear Accident Response Procedures Manual – NARP.

[28] See AMEED Center and School, Effects of Nuclear Weapons and Directed Energy on Military Operations, (especially p. 1-34) and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 3-15 to 3-16.

[29] USACHPPM TG-238; USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 3-4 to 3-6.

[30] http://www.defenselink.mil/nubs/i2rolif/access tech.html

[31] First Annual Report of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction, "Assessing the Threat," December 15, 1999, www.rand.organization/nsrd/terrpanel, pp. 114-117.

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[32] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 3-4.

[33] Joint Publication 3-11(Draft), Table E-2-6; USACHPPM TG-238; USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 3-16 to 3-17.

[34] USACHPPM Technical Guide 244, pp. 3-4 to 3-6: IAEA, Summary report on the post accident review meeting on the post accident review meeting on the Chernobyl accident, International Nuclear Safety Center (http://www.insc.anl.gov/); Uranium Information Center (http://www.uic.com.au/); and http://www.ulondon.org/netpower.html/);

[35] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-5 to 2-23.

[36] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 3-30.

[37] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 2-15.

[38] See AFRRI, AmedP-6©, and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 2-15

[39] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 3-16 to 3-17; Joint Publication 3-11 (Draft), FM-8-9, FM 8-10-7, AMEED Center and School's, Effects of Nuclear Weapons and Directed Energy on Military Operations, and DoD 5100.52-M Nuclear Accident Response Procedures Manual – NARP.

[40] USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 3-35 to 3-39.

[41] See USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, p. 3-32 to 3-34.

[42] See AMEED Center and School, Effects of Nuclear Weapons and Directed Energy on Military Operations, (especially p. 1-34) and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 3-15 to 3-16.

[43] The core of US treatment and management radiological expertise is located at the Armed Forces Radiobiology Research Institute (AFRRI) in Bethesda, Maryland. AFRRI holds courses on the medical effects of radiation and provides consultative and response support to radiological disasters. AFFRI continues to conduct research to advance the treatment of blood disorders, radiobiological and chemotherapy, and wound healing to the pre- and post-exposure treatment of ionizing radiation exposure.