Radiological Weapons as Means of Attack

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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.

Radiation is energy that comes from a source and travels through some material or through space. Light, heat, and sound are types of radiation. Atom-derived radiation is called iodizing radiation because it can produce charged particles (ions) in matter. Ionizing radiation is produced by unstable atoms. Unstable atoms differ from stable atoms because they have an excess of energy or mass or both. Unstable atoms are said to be radioactive. To reach stability, these atoms give off, or emit, the excess energy or mass. These emissions are called radiation. The kinds of radiation are electromagnetic (like light) and particulate (i.e., mass given off with the energy of motion). Gamma radiation and X-rays are examples of electromagnetic radiation. Beta and alpha radiation are examples of particulate radiation. Ionizing radiation can also be produced by devices such as X-ray machines.

Three types of radiation-induced injury can occur: external irradiation, contamination with radioactive materials, and incorporation of radioactive material into body cells, tissues, or organs. External irradiation occurs when all or part of the body is exposed to penetrating radiation from an external source. During exposure, this radiation can be absorbed by the body or it can pass completely through. A similar thing occurs during an ordinary chest x-ray. Following external exposure, an individual is not radioactive and can be treated like any other patient. External radiation does not make a person radioactive. The second type of radiation injury involves contamination with radioactive materials. Contamination means that radioactive materials in the form of gases, liquids, or solids are released into the environment and contaminate people externally, internally, or both. An external surface of the body, such as the skin, can become contaminated, and, if radioactive materials get inside the body through the lungs, gut, or wounds, the contaminant can become deposited internally. A person is externally contaminated if radioactive material is breathed in, swallowed, or absorbed through wounds. The environment is contaminated if radioactive material is spread about or uncontained. The third type of radiation injury that can occur is incorporation of radioactive material. Incorporation refers to the uptake of radioactive materials by body cells, tissues, and target organs such as bone, liver, thyroid, or kidney. In general, radioactive materials are distributed throughout the body based upon their chemical properties. Incorporation cannot occur unless contamination has occurred. The three types of exposure can happen in combination and can be complicated by physical injury or illness. In such a case, serious medical problems always have priority over concerns about radiation (such as radiation monitoring, contamination control, and decontamination).

Gamma radiation is able to travel many meters in air and many centimeters in human tissue. It readily permeates most materials and is sometimes called GÇ-penetrating radiation. GÇ- Gamma rays represent the major external hazard. Radioactive materials that emit gamma radiation and X-rays constitute both an external and internal hazards to humans. Dense materials are needed for shielding from gamma radiation. Clothing and turnout gear provide little shielding from penetrating radiation. Gamma radiation is detected with survey instruments, including civil defense instruments. Low levels can be measured with a standard Geiger counter (such as the CD V-700). High levels can be measured with an ionization chamber (such as a CD V-715). Gamma radiation frequently accompanies the emission of alpha and beta radiation. Instruments designed solely for alpha detection (such as an alpha scintillation counter) will not detect gamma radiation. Pocket chamber (pencils) dosimeters, film badges, thermoluminescent, and other types of dosimeters can be used to measure accumulated exposure to gamma radiation.

Beta radiation may travel meters in air and is moderately penetrating. It can penetrate human skin to the GÇ-germinal layer, GÇ- where new skin cells are produced. If beta-emitting contaminants are allowed to remain on the skin for a prolonged period of time, they may cause skin injury. Beta-emitting contaminants may be harmful if deposited internally. Most beta emitters can be detected with a survey instrument (such as a CD V-700, provided the metal probe cover is open). Some, however, produce very low energy, poorly penetrating radiation that may be difficult or impossible to detect. Examples of this are carbon-14, tritium, and sulfer-35. Beta radiation cannot be detected with an ionization chamber (such as the CD V-715). Clothing and turnout gear provide some protection against most beta radiation. Turnout gear and dry clothing can keep beta emitters off of the skin.

Alpha radiation travels a very short distance through the air and is not able to penetrate the skin. Alpha-emitting materials can be harmful to humans if the materials are inhaled, swallowed, or absorbed through open wounds. A variety of instruments have been designed to measure alpha radiation. Special training in the use of these instruments, however, is essential for making accurate measurements. An ionization chamber (such as a CD V-700) cannot detect the presence of radioactive materials that produce alpha radiation unless the radioactive materials also produce beta and/or gamma radiation. Instruments cannot detect alpha radiation through even a thin layer of water, blood, dust, paper, or other material, because alpha radiation is not penetrating. Alpha radiation cannot penetrate turnout gear, clothing, or a cover on a probe. Turnout gear and clothing can keep alpha emitters off of the skin.

There are two types of radiological weapons. A radiological dispersal device (RDD) includes any explosive device utilized to spread radioactive material upon detonation. Any improvised explosive device could be used by placing it in close proximity to radioactive material. A Simple RDD spreads radiological material without the use of an explosive. Any nuclear material (including medical isotopes or waste) can be used in this manner.
The main potential sources of such weapons GÇô barring covert transfer from outside the US GÇô 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 such weapons is controversial, and the impact can vary sharply because of the time require to accumulate a disabling or significant does of radiation through ingestion, inhalation, or exposure. According to US military reporting on their effects, notes that, GÇ£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. GÇ¥ Other findings of the Department of Defense provide important insights into the potential effectiveness of RDWs:

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:

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.

At the same time, a Department of Defense study notes that, GÇ£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.GÇ¥

The Practical Risks and Effects of Using Radiological Weapons

There is no question that small amounts of radioactive materials can be used to attack, threaten, and contaminate, and that the 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 limited use of small amounts of radiological weapons present 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 also differ sharply in terms of their use of sophisticated radiation detectors, and most responders are far more concerned with evacuation than the difficult problems of dealing with medical and decontamination aftermaths. In broad terms, however, 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 GÇô 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. These comments may be valid, but they also may not. 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.

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 GÇô 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.

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. 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.

++ 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.

++ 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.

++ 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.

++ 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.

++ Post attack radiological surveys can be very difficult for the same reasons.

++ 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.

Furthermore, considerably more 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.

More broadly, responders correctly assume that destruction and lethality are key criteria, 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.