FINAL PRESENTATION

Radioactive materials are used around the globe to provide benefits to mankind in many fields, including medicine, research, and numerous industrial applications. The usage has developed since the early days of nuclear energy to include numerous applications, dozens of radiological source producers and suppliers spread across six continents, and on the order of a billion sources world-wide. The growth of terrorism during the 1990s and more recently has heightened concerns about some of the same radiological sources, namely whether they could be used in radiation dispersal devices (RDDs), or "dirty bombs" so as to create both panic and potentially large economic consequences.

RDDs or *dirty bombs* are devices that disperse radioactive materials. They can take many forms - from containers of radioactive materials wrapped around with conventional explosives, to aerosolized materials sprayed using conventional equipment, and to manual dispersion of a fine powder into the environment. An RDD attack can produce general panic, health consequences including immediate fatalities and long-term increases in cancer incidence, long-term denial of property use, disruption of services, and property and facility decontamination needs.

Radioactive materials

There are many radioactive materials available, however, some are rare, used in highly secured organizations, too radioactive or disintegrate in a short span of time. The chosen materials have to meet the following criteria:

- ***Availability (preferably off the shelf)***
- ***To cause disruption and panic***
- ***Harmless to the user***
- ***Simple to execute***

Radiation

There are several types of ionizing radiation

Alpha – [redacted] internally they can be very harmful if inhaled or ingested.

Beta – [redacted] Like alpha they are more hazardous when inhaled or ingested. [redacted]

Gamma - Gamma rays can easily pass completely through the human body or be absorbed by tissue, thus constituting a radiation hazard for the entire body. [redacted]

They are usually accompanied with alpha or beta particles.

X Ray – Less penetrating than gamma rays. [redacted]

Neutron – the most penetrating, [redacted]

...Their sources

There are several hundred radioactive sources. In order to achieve our goal, the source has to be widely available. The following lists several options, each one has many uses.

[redacted]

Americium 241 [redacted]

Cesium 137 – [redacted]

Cobalt 60 – [redacted]

Strontium 90 [redacted]

Tritium – [redacted]

Californium 252 – [redacted]

...And their uses

When constructing an RDD (radioactive dispersal device a.k.a Dirty Bomb) you face constraints arising from the radioactivity of the source. To cause a large amount of radioactive contamination, we would be drawn toward very high activity sources. However, in order to prepare the source for effective dispersal by removing the shielding, we would risk exposing ourselves to lethal doses. Even in suicidal missions we might not live long enough to deliver a very highly radioactive RDD that uses gamma-emitting sources and is not shielded. If we tried to protect ourselves by shielding the source, the weight of the RDD could significantly increase thereby increasing the difficulty of delivering the device and causing successful dispersion of the radioactive material.

[redacted]

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Security risk

The key properties that determine security risks are and type of radiation; half life of the radiation; amount of the material; shape; size; shielding and portability of the source. Using many of these characteristics the IAEA has categorized radiation sources by radiation safety hazards. [redacted]

[redacted]

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The possible damage

Below are extracts from articles in relations to RDD. Since there has never been an RDD used, they can only speculate on the outcome.

[redacted] *a nuclear physicist and provost of the California institute of technology testified before the senate foreign relations committee,* **" if just three curies (a fraction of a gram) of an appropriate isotope was spread over a square mile, the area would be uninhabitable according to the recommended exposure limits protecting the general population. While the direct health effect would be minimal (for each 100,000 people exposed, some 4 cancer deaths would eventually be added to the 20,000 lifetime cancers that would have occurred otherwise) the psychological effects would be enormous.**

[redacted]

[redacted]

The actual health effects would depend on:

1. The conventional explosive, if this method were used.
2. The type and amount of radioactive material dispersed.
3. The weather conditions
4. The terrain
5. Population density
6. Emergency response

[redacted]

[redacted]

….and Health effects

Measuring radiation doses is done in sieverts.

[redacted]

The table provides information on the health effects of ionized radiation.

Equivalent dose in siverts (whole body)	Immediate health effects	Delayed health effects
[redacted]	none	Premature aging, possibility in off-spring, some risk if excess tumors.
[redacted]	Most persons experience little or no reaction. Sensitive individuals may experience radiation sickness.	Premature aging, genetic effects and some risks of tumors.
[redacted]	Nausea and vomiting. Radiation sickness – spontaneous abortion or stillbirth.	Some tissue damage. Reduction in lymphocytes leaves the individual temporarily very vulnerable to infection. There may be genetic damage after conception to off spring, benign of malignant tumors, premature aging and shortened life span.
[redacted]	Nausea vomiting on the first day. Diarrhea and probable skin burns. Apparent improvement in 2 weeks thereafter. Fetal or embryonic death if pregnant.	Radiation-induced atrophy of the endocrine glands including the pituitary, thyroid and adrenal glands. Persons in poor health prior to exposure or those who develop a serious infection may not

		survive. The healthy adult recovers to somewhat normal health in about three months, but may have permanent health damage, develop cancer or benign tumors, and will probably have a shortened lifespan.
[redacted]	Nausea, vomiting, diarrhea, epilation (loss of hair), weakness, malaise, vomiting of blood, bloody discharge from the bowels or kidneys, nose bleeding from the gums and genitals, subcutaneous bleeding, fever, inflammation of the pharynx and stomach, and menstrual abnormalties. Marked destruction of bone marrow, lymph nodes and spleen causes decrease in blood cells.	Radiation-induced atrophy of the endocrine glands including the pituitary, thyroid and adrenal glands. Within 60 days after exposure, death is closely correlated with the degree of leukocutopenia (decrease in the number of white blood cells). Around 50 percent die in this time period. Survivors experience keloids, ophthalmologic disorders, malignant tumors and psychoneurological disturbances.
[redacted]	Nausea, vomiting, diarrhea followed by apparent improvement. After several days: fever, diarrhea, blood discharge from the bowels, hemorrhage of the larynx, trachea, bronchi or lungs, vomiting of blood and blood in the urine.	Death in about 10 days. Autopsy shows destruction of tissue, including bone marrow, lymph nodes and spleen; swelling and degeneration of the intestines; genital organs and endocrine glands.
[redacted]	Immediate death – "frying of the brain".	None.

Heath effects shown assume a linear, no-threshold for stochastic effects

Conclusion

A few grams of cobalt 60 with several pounds of explosives are enough to close an area the size of Manhattan. Unfortunately the carrier will be one of the many victims once the device has been detonated. Why, because unless there is appropriate shielding, the radiation emitted from the source will kill anyone who handles it. Another problem with cobalt is in its retrieval [redacted] The Monterey Institute of International Studies suggests that one would require millions of smoke detectors to create a RDD. Dispersing a fraction of a gram with a huge amount of explosive will send it miles away, rendering the radiation quite irrelevant. If it was dispersed in an area covered by four walls then the radiation could imbed itself in the building causing problems in the clean up.

The americium meets the criteria I have set.

Availability – smoke alarms are available from most stores, industrial gauges are considered low hazards yet they can contain 1 curie of americium but are harder to acquire.

Cause disruption and panic – it will not be able to do much more than that unless americium is extracted from several gauges.

Harmless to the user - the alpha particles emitted cannot penetrate the skin,

Simple to execute – collect as much as you can and stick it to an explosive device. If the collection of several curies are achieved a simple container to seal the material would be advisable. i.e a coke can.

Cesium 137 is one of the most favored options for an RDD. It is both powerful and widely available. [redacted] Problems arise in decontamination, as cesium would chemically bond with building materials.

Availability – widely used in industries. Not available off the shelf.

Cause disruption and panic – the ability to cause a major panic, can result in malignant tumors and shortening of life

Harmless to the user – usually comes with lead shielding.

Simple to execute –.a few grams would be enough

Tritium comes in gaseous form, lighter than air it would rise into the sky once released. [redacted] Tritium would not be useful stuck to a pound of dynamite but it may have other uses. If the luminous bulb from an exit sign were thrown into an unventilated room the tritium would be inhaled causing contamination to the occupants.

Availability – available off the shelf in watches (very small quantities) and luminous exit signs

Cause disruption and panic – the ability to cause a major panic if a tube was thrown into a building

Harmless to the user – if the tube was to break, make sure there is ventilation available

Simple to execute –several tubes from a luminous exit sign thrown into a building (however the tubes are hardened, so it may require some force)

[redacted]. This presentation is more concerned with what is available, rather than what is the most powerful radioactive material yet impossible to get hold of or the most rare. Because there have been no cases of a dirty bomb, all the scenarios provided are supposition, based on variables. What is certain is that a RDD does not need to cause casualties to be effective. Disruption of the medical services as well in the delay of the clean up would add to the final cost. If a large enough dose of radioactive material was used then areas may become uninhabitable thus becoming a constant reminder to everyone. In other words, whereas the blast would cause much of the initial damage, the after effects of the radiation could pose a long term hazard.

Late Edition: -

Two types of radioactive materials I did not investigate are Uranium and Plutonium. These are the two materials used in producing a nuclear reaction. Not available off the shelf I decided to leave these radioactive materials out of this research. However the following information has come to hand on the uses of depleted uranium. A question asked about hazardous materials presented the following answer.

[redacted]

[redacted]

[redacted]