Radiological/Nuclear Hazards

Improvised Nuclear Devices (IND)
Radiological Devices

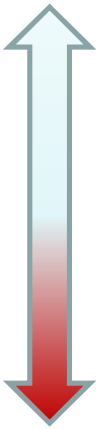
Objectives

- Discuss items that you might see in normal transit.
- Understand the threat of nuclear and radiological terrorism
- Compare the consequences and probability of use of Improvised Nuclear Device, and radiological dispersal devices
- Understand types and availability of materials interest for use in an RDD.

Threat Assessment
What is the Threat?

Radiological materials or weapons with the potential of being used to initiate a malevolent radiological incident.

- Improvised Nuclear Device (IND)
- Radiological Dispersal Device (RDD)
- Radiation Exposure Device (RED)
- Lost or stolen legitimate radioactive materials

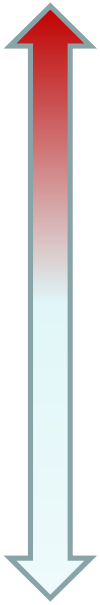


Low probability

High probability

Categories of Radioactive Materials

Most likely



Least likely

Industrial – Cs-137, Co-60, Ir-192, Sr-90, Ra-226

Medical – Tc-99m, Tl-201, Tl-201, Ga-67, I-123, I-125, I-131, In-111, Cs-137, Co-60, Ir-192

Naturally Occurring Radioactive Materials (NORM)
K-40, U-238, Th-232 and decay products

Special Nuclear Materials (SNM) – U-235, Pu-239, U-233

Types of Nuclear Material

- **Special Nuclear Material (SNM) Detected**
  - Special Nuclear Material means either plutonium or uranium enriched to 20 percent or more in the isotope U-235.
  - Detection means a radiological signature for plutonium or U-235 is detected by detectors and/or secondary border crossing or green border interdictions. SNM must be confirmed by appropriate Laboratories.
- **Suspect Radiological Dispersion Device (RDD)**
  - An RDD may consist of a quantity of radioactive material that could be used in a high-explosive device to spread contamination over an area.
- **Contaminated Material**
  - Some material or commodities being shipped may have been unknowingly fabricated with enough radioactive material to generate an alarm.
  - For example, metal objects have been manufactured with contaminated steel produced in foundries where radioactive material was mistakenly mixed into the production process

Types of Nuclear Material (cont)

- **Naturally Occurring Radioactive Material (NORM)**
  - **NORM** is an acronym for ***N**aturally **O**ccurring **R**adioactive **M**aterial*, which includes all radioactive elements found in the environment. This includes:
    - Long-lived radioactive elements, such as uranium, thorium, potassium, and any of their decay products, such as radium and radon.
    - Routine items in commerce that are not under statutory regulation and contain small concentrations of NORM, for example,
      - potassium-40 in fertilizer,
      - ceramic tiles, granite
      - Aggregate/crushed rock,
      - propane, granite
      - counter tops,
      - floor tiles,
      - sandblasting media,
      - fiberglass rolls
      - compressed liquid CO2, chili mash,
      - floor polish, CRT tubes,
      - hot tub shock chemicals, etc!
  - The majority of the alarms are caused by NORM.

“Normal” Radioactive Material

- Material containing naturally occurring radioactive material is in transit.
- Most is not labeled, but may set off alarms
- Determining what is normal versus what is a threat is key to the process
- Remember - Radioactive materials are colorless, odorless, tasteless, and cannot be detected by the human senses

Propane Truck/Tank

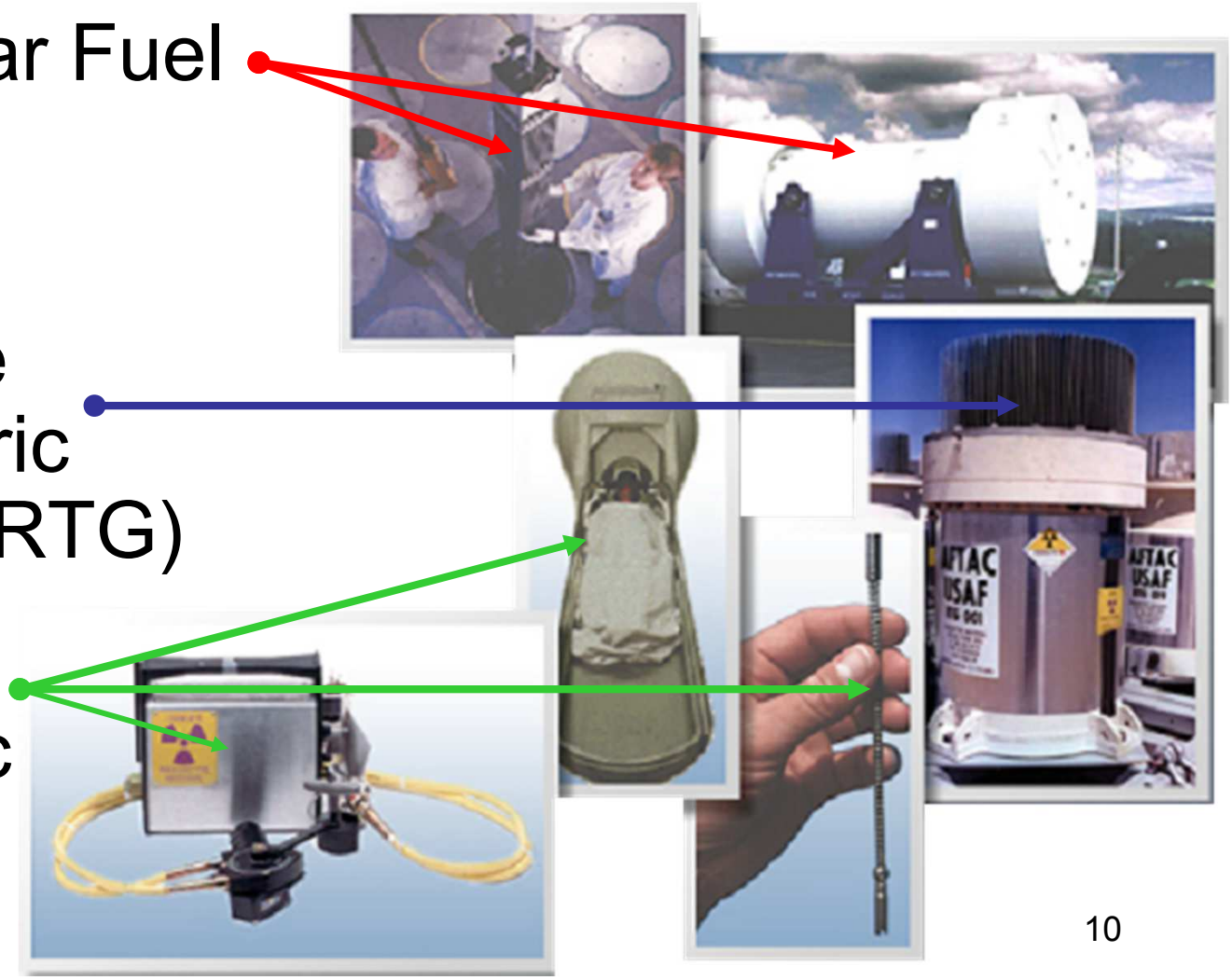
- Propane is very common!
- K-40, Ra-226

Sandblasting media/abrasive

–Th-228, Th-232, K-40, Ra-226

Sources of Highly Radioactive Material

- Spent Nuclear Fuel & High Level Waste
- Radioisotope Thermoelectric Generators (RTG)
- Medical & Radiographic Sources



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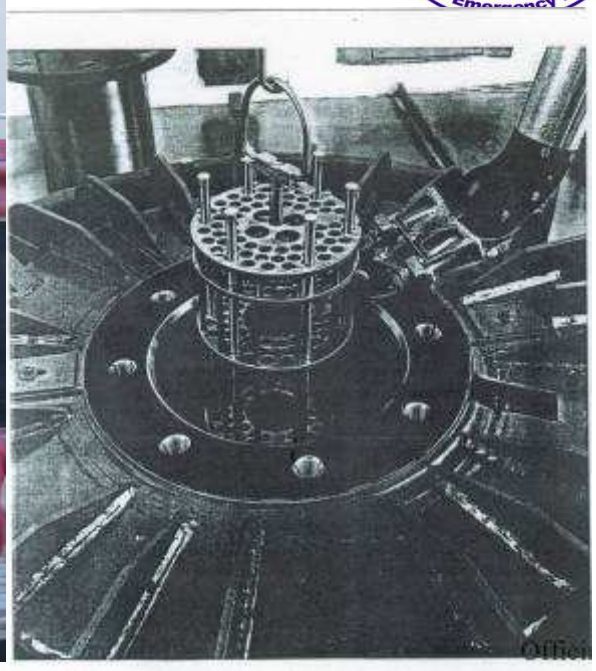
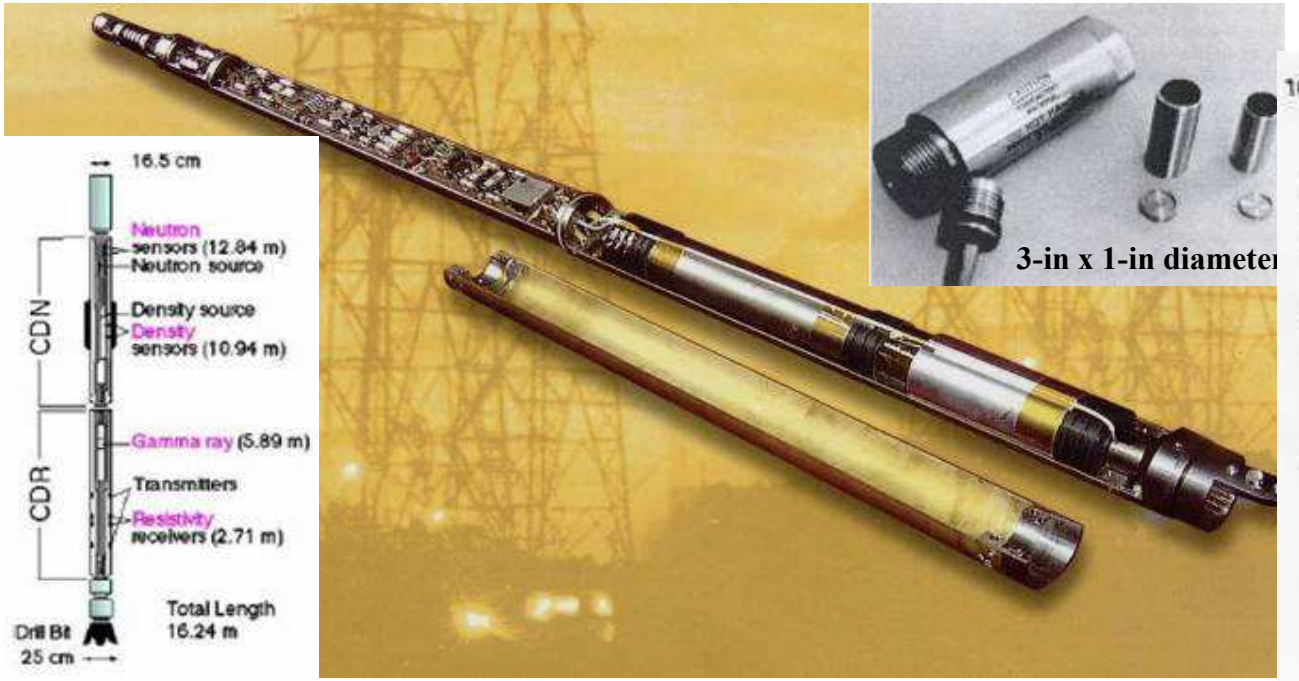
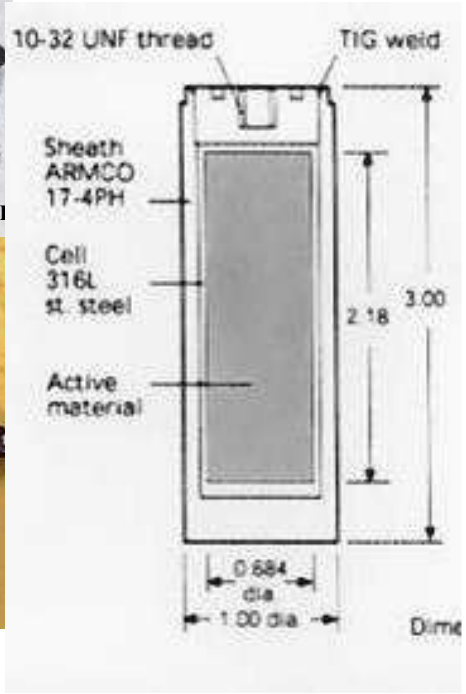
Transport of Co-60 Pencils for Sterilization Irradiators



- 250,000 Curies per shipping cask
- Potentially vulnerable to theft

Am-241/Be
Well Logging Neutron Source





- **Am/Be Sources for well logging**
  - Up to 20 Ci of Am-241, mixed with beryllium to produce neutron output
  - Dispersible pressed powder
  - Portable, vulnerable to theft
  - No disposal path for Am/Be sources. Adds to security problem

Ir-192 Radiography Sources

- **Ir-192 radiography sources**
  - Up to 200 Ci of Ir-192
  - Very hard metal, very difficult to disperse.
  - Portable, vulnerable to theft

Shielding Requirements Limit Portability

For gamma sources: the higher the activity, the more shielding you require to transport the source.

Small radiography sources:

- **Typical activity MBq to GBq**
- **10-20 kg shielding**

Medium radiography sources:

- **Typical activity ~1TBq**
- **100-200 kg of shielding**

Large industrial source:

- **Typical activity – 100's of TBq**
- **Thousands of kg of shielding**

Hazards

- “NORM” is expected
- Radiation or Nuclear Hazards can come from man-made sources
- It is important to understand both the possibility of someone obtaining an IND or RDD and the potential difference in the consequences of the uses of an IND or RDD

Malevolent Acts
Radiological/Nuclear Terrorism

Device Type	Dispersal Form	Economic Effects	Health Effects	Comments
Radiation Exposure Device (RED)	None	Low	Radiation sickness	Could impact thousands; Lethality difficult; No lasting economic impact
Food or Water poisoning	Dissolve or mix	Medium	Serious health effects over large population	**Not unique** Other poisons more readily available
RDD for Area Denial	Many	High	Few (if any) prompt health effects; Slight increased cancer risk	**Unique** aspect of radiological material

Malevolent Acts
Radiological/Nuclear Terrorism

Subject	IND Attack	RDD Attack
Primary Threat	Catastrophic Event Hundreds of thousands dead or injured Contamination spread over hundreds of miles	Economic and Psychological impact Hundreds dead or injured Contamination spread over tens of miles
Potential of State and Local Being Overwhelmed	Significant	Minor
Sources of Fatalities and Injuries	Prompt Radiation Thermal Tumbling and other blast related effects Fallout	Blast Fallout
Shift from Response to Recovery	Slow	Rapid
Radiation Effects	Acute and Long-term	Increased latent cancer risk
Radiation Decay	Rapid (7-10 Rule)	Typically slow

RDD Risk in Perspective: Risk = Probability x Consequences

Consequences
Death,
Destruction,
Dollars

10 kiloton Improvised Nuclear Device (IND)
10^5 prompt deaths,
destruction ~ 2 km radius
1000s square km contamination

Hiroshima, Japan 1945

RDD (1000 Curies)
Few radiation deaths
Several square km contamination

Goiania, Brazil 1987

Event Probability (~Availability of Source Material)

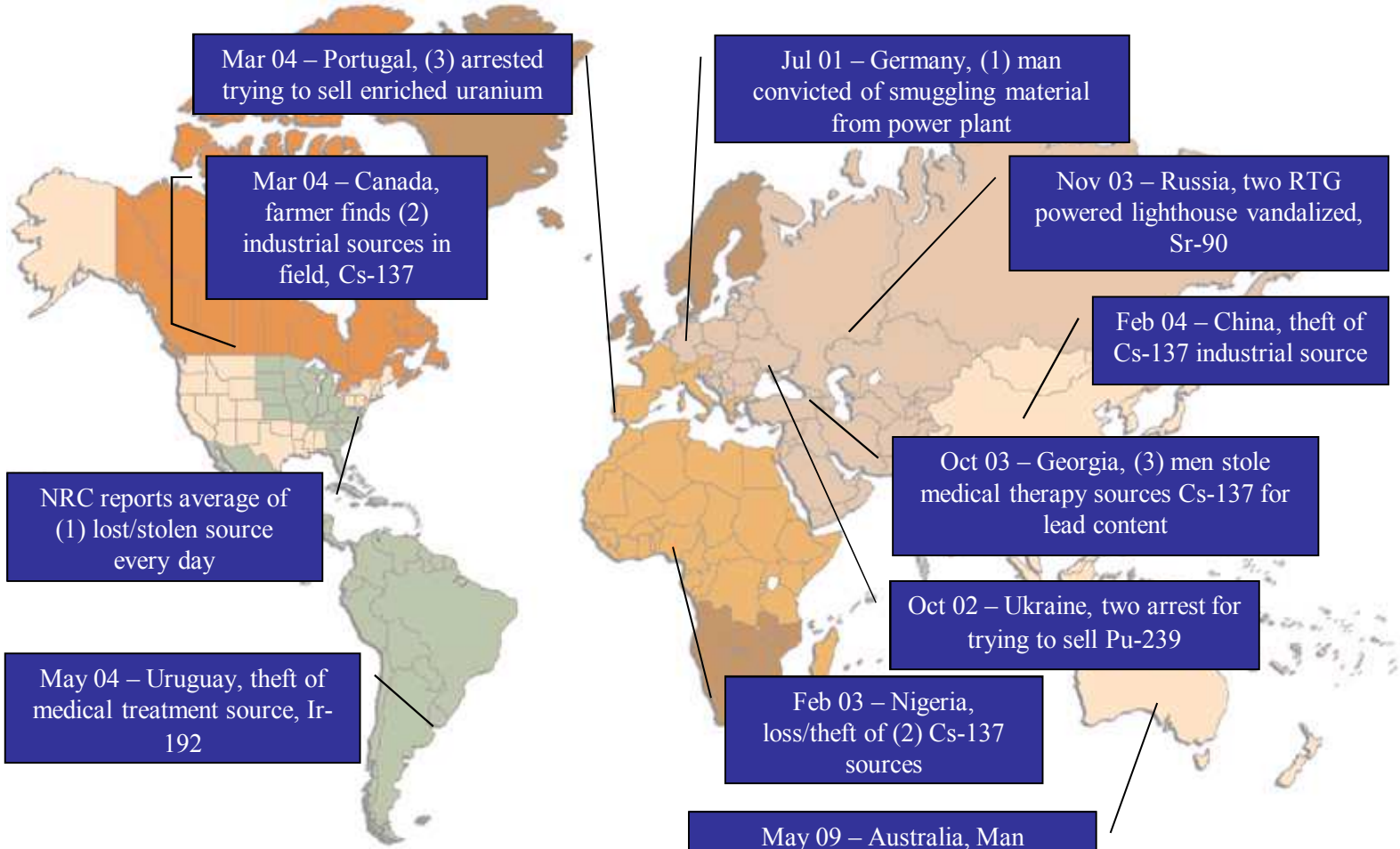
Effects of Nuclear Device vs. RDD

A nuclear device (atomic bomb) releases an enormous amount of energy while an RDD releases a comparatively small amount of energy.

≠ **RDD**

An RDD's main purpose is to frighten people and contaminate buildings or land with radioactive material.

Incidents Around the World



Hazard Potential

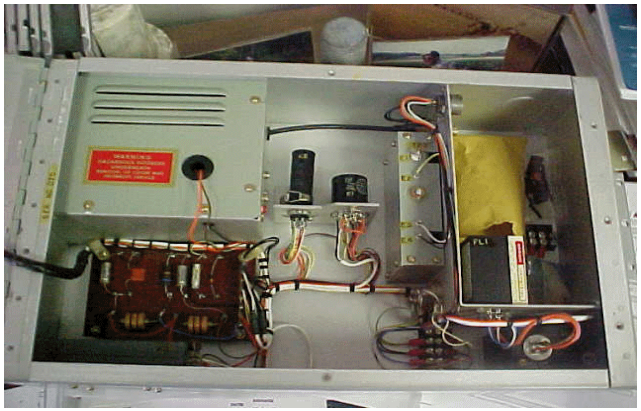
- **Recognizing that the event may involve radioactive material:**
  - **Increased radiation levels detected during routine monitoring (such as a vehicle portal, or law enforcement use of radiation pagers)**
  - **Increased radiation levels during screening at special events**
  - **Intelligence reports or media release**

Misuse of Highly Radioactive Material

- Expose people to an external source of radiation.
- Disperse radioactive material using conventional means.
- Use of “Dirty Bomb” Radiological Dispersal Device

Characteristics of an RDD

- Contains radioactive material
- Conventional explosive or other means of dispersal
- Has the intent to disperse the radioactive materials
- NOT a nuclear explosion



Characteristics of an RDD

- Radioactive material does not enhance the dispersion
- Fatalities are NOT a result of radiological exposure
- Contamination may hamper the response and recovery – area of denial
- Psychological effects may be significant

Top 10 Threats for Use in RDD's

1. Transportation of cobalt-60 sources
2. Teletherapy source user facilities (Hospital cancer treatment centers)
3. Disused and orphaned RTGs
4. Orphaned seed irradiators
5. Industrial irradiators, blood irradiators, and radiography sources in use

Top 10 Threats for Use in RDD's

6. Sales and resales of cobalt-60 sources and radiography sources
7. RTG, research irradiator, and well-logging source users
8. Disused well-logging sources
9. Sales and resales of radiography sources and blood irradiators
10. Transportation of radiography, well-logging, and blood irradiators

Some Possible RDD Materials

- Mortar Fire or other Explosive Distribution of Radiological Material
  - Special Nuclear Material (no yield) and Spent Fuel Rod Material Molybdenum-99, Cobalt-60, Cesium-137, Strontium-90, Americium-241
  - Medical Sources (Iridium-192, Phosphorus-32, Radium-226, Iodine-131, Thalium-230)

- A Hot Source Hidden in a Public Location is Probably more Effective at Producing Radiological Casualties than an RDD

The Top Radionuclides: Factors Considered in Prioritization

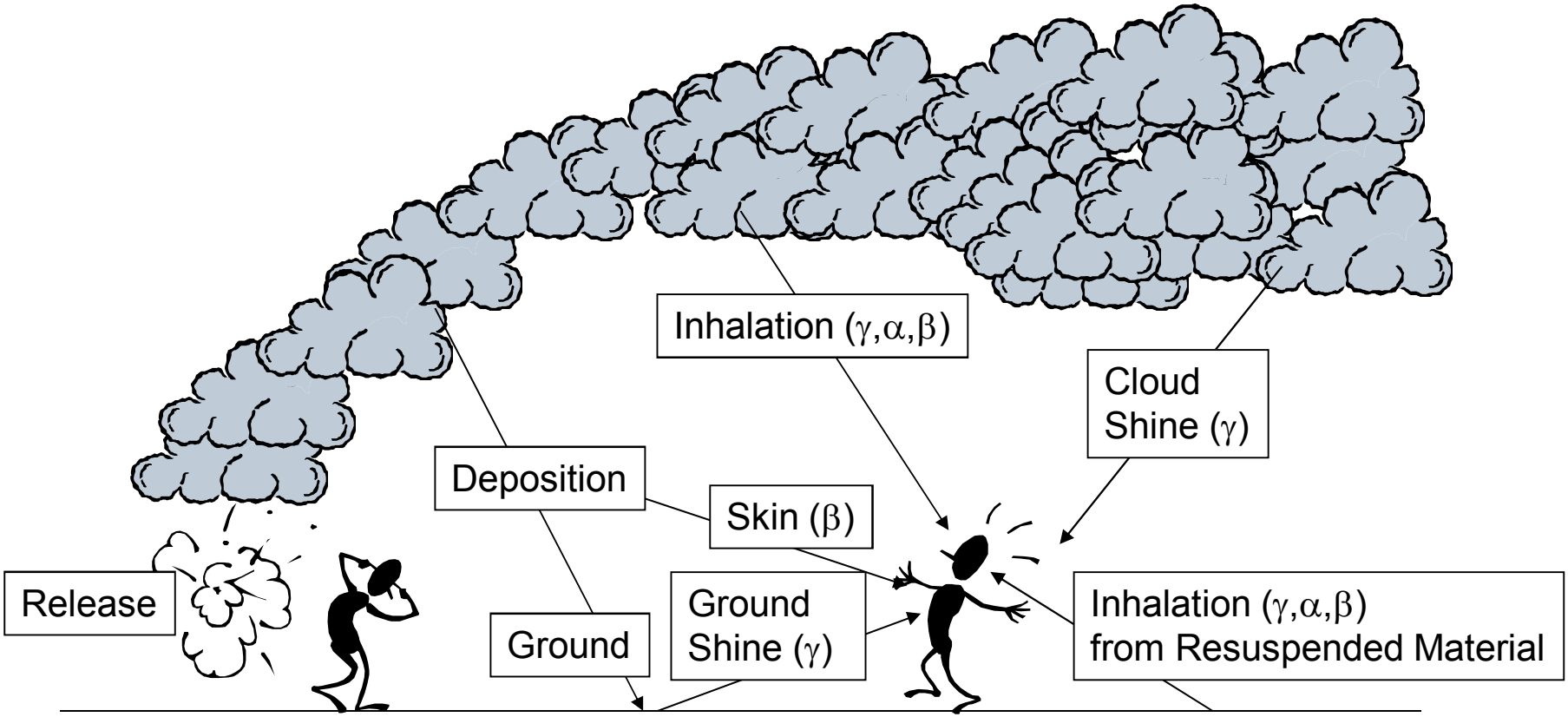
Nuclide	Quantity needed to deny access to 1 sq. km	Particle size on each square meter	Quantity used in typical application	Number of Sources/ Applications in US	Ease of dispersal	Cleanup difficulty	Security Comments
Cs-137	40 Curies (Ci) 2 gm gamma	50 micron	1000s Ci	Hundreds/ Irradiators	Very easy (pressed powder, salt)	Very difficult	Theft of large amounts possible
Co-60	11 Ci 0.1 gm gamma	15 micron	1000s Ci	Hundreds/ Irradiators	Not easy (hard metal)	Difficult	Theft of large amounts possible
Am-241	25 Ci 7 gm alpha	50 micron	10-20 Ci	Thousands/ Well logging	Very easy (pressed powder, oxide)	Difficult	Accumulation of several sources possible
Ir-192	110 Ci 0.2 gm gamma	15 micron	100 Ci	Thousands/ Industrial radiography	Not easy (hard metal)	Difficult	Accumulation of several sources possible
Sr-90	431 Ci 2 gm beta	50 micron	100,000 Ci	Hundreds/ Old Soviet RTGs	Easy (sintered ceramic)	Difficult	Theft of Russian RTGs. US RTGs secured
Pu-238	29 Ci 2 gm alpha	30 micron	100,000 Ci	Just In Time (JIT)/ U.S. RTGs for space power	Easy (ceramic oxide)	Difficult	U.S. RTGs are made JIT for NASA deep space missions and secured

Goiania Brazil 1987: RDD Lessons

Source
~ 2.5 cm dia.
~ 1400 Ci, Cs-137
CsCl salt (powder)

- ~ 60 gm of Cs-137 (1400 Ci) generated 40 tons of radwaste for disposal
- Main Cleanup effort: 755 persons x 3 months = 68,000 person-days
- Cleanup threshold: ~ 10 Ci/km^2 (ground contamination)
- Significant psychological effects on the immediate population
- 4 deaths

Major pathways from release



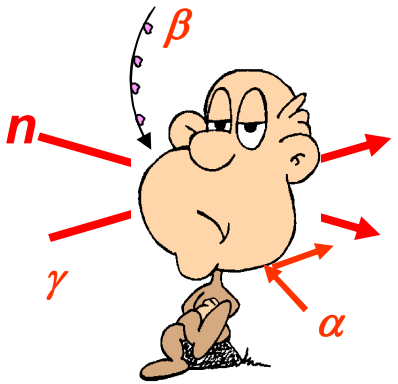
Types of Radiation and Exposures

Alpha (α) radiation
- External: no skin penetration, no health risk
- Internal: damage soft tissue, health risk
- Examples: Pu-238, Am-241

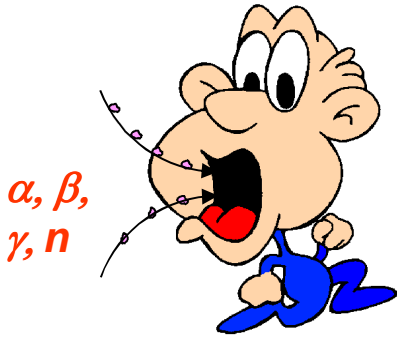
- **Beta (β) radiation**
  - External: some penetration, skin burns
  - Internal: damage soft tissue, health risk
  - Examples (pure β-emitter): Sr-90

- **Gamma (γ) radiation**
  - Highly penetrating
  - External and internal health risk
  - Examples (β and γ) : Cs-137, Co-60, Ir-192

- **Neutron (*n*) radiation**
  - Highly penetrating
  - External and internal health risk
  - Cf-252, Am-241/Be (small sources)



External



Internal

RDD Issues

- Hot Sources are more Dangerous (for the bad guys and the good guys)
- Hot Sources are Easier to Detect with our Search Gear
- Explosion and Subsequent Fragmentary Damage is more Significant than Radiation Damage
- Conventional Explosive Ordnance Disposal with Health Physics Support
- Cleanup could be Difficult & Costly

Threat of Nuclear/Radiological Terrorism

"We are not just dealing with the possibility of governments diverting nuclear materials into clandestine weapons programs," he said. "Now we have been alerted to the potential of terrorists targeting nuclear facilities or using radioactive sources to incite panic, contaminate property, and even cause injury or death among civilian populations."

IAEA Director General Mohamed ElBaradei, Press release, Nov. 1, 2001

The population density substantially exceeds the average value during major events like concerts, performances, sport competitions etc. The potential number of RTE victims in this case might be very high