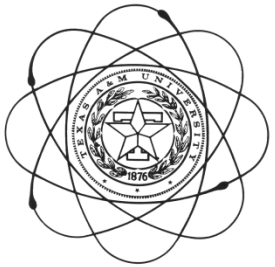
Radiological and Nuclear Devices and Terrorism

John W. Poston, Sr.

Professor
Department of Nuclear Engineering
Texas A&M University



Objectives

- **Provide an overview of potential use of radioactive materials in terrorist activities**
- **Address some of your own questions about this important concern**

Please Remember This about Terrorist Incidents!!

"Nuclear, chemical, and biological weapons are *inherently terrifying*: in most scenarios for their use, the fear they would cause would dwarf the injury and death."

Jessica Stern

The Ultimate Terrorists

1999

Definition

“Terrorism is a method of coercion of a population or its leaders or both, through fear or traumatization.”

Gerald Holton

Reflections on Modern Terrorism

2002

Historical Context

"Terrorism is the expression of a constant theme in military history – the deliberate targeting of civilians in order to undermine their support for the policies of the political leaders."

Caleb Carr
The Lessons of Terrorism
2002

Radiological Terrorist Threats

- Weapons of mass destruction (WMD)
- Improvised nuclear devices (IND)
- Radiological dispersal devices (RDD)
- Radiation exposure devices (RED)

“All nuclear weapons are primarily political, not military weapons – cards in a psychological poker game of nuclear threats.”

Jorma K. Miettinen
The Bulletin of the Atomic Scientists – 1977

WMD and IND

- Nuclear weapons – most likely to be a fission-type weapon
- Most likely to be U-235 devices
- Sources of weapons
  - A weapons-producing country
  - Purchased weapons
  - Stolen weapons
  - Homemade weapons

Distribution of Fission Energy

	MeV
Kinetic energy of fission fragments	165 ± 5
Instantaneous gamma-ray energy	7 ± 1
Kinetic energy of fission neutrons	5 ± 0.5
Beta particles from fission products	7 ± 1
Gamma rays from fission products	6 ± 1
Neutrinos from fission products	10
Total energy per fission	200 ± 6

Equivalents of 1 kiloton of TNT

Complete fission of 0.057 kg (57 grams or 2 ounces) fissionable material

Fission of 1.45×10^{23} nuclei

10^{12} calories

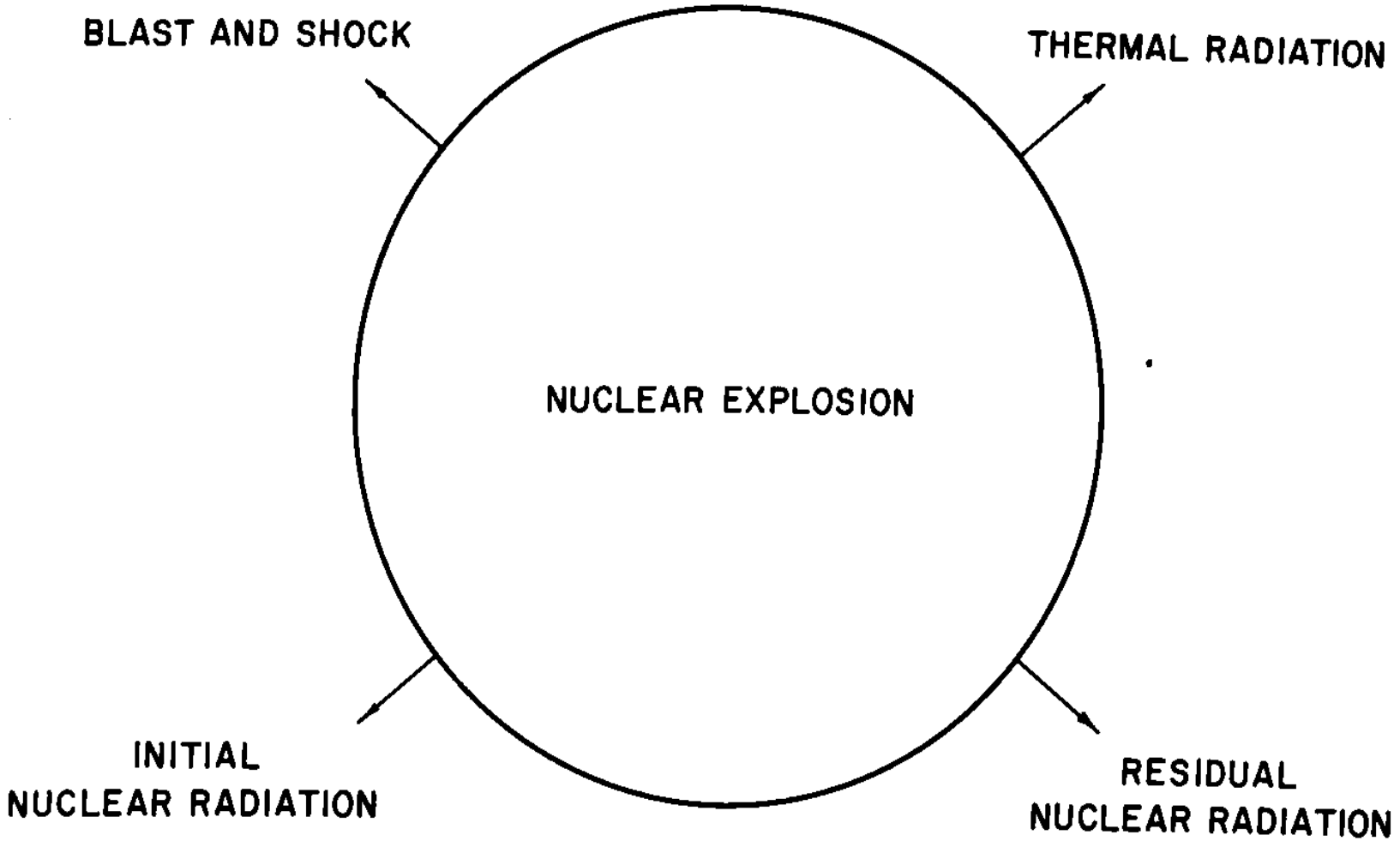
2.6×10^{25} million electron volts

4.18×10^{19} ergs (4.18×10^{12} joules)

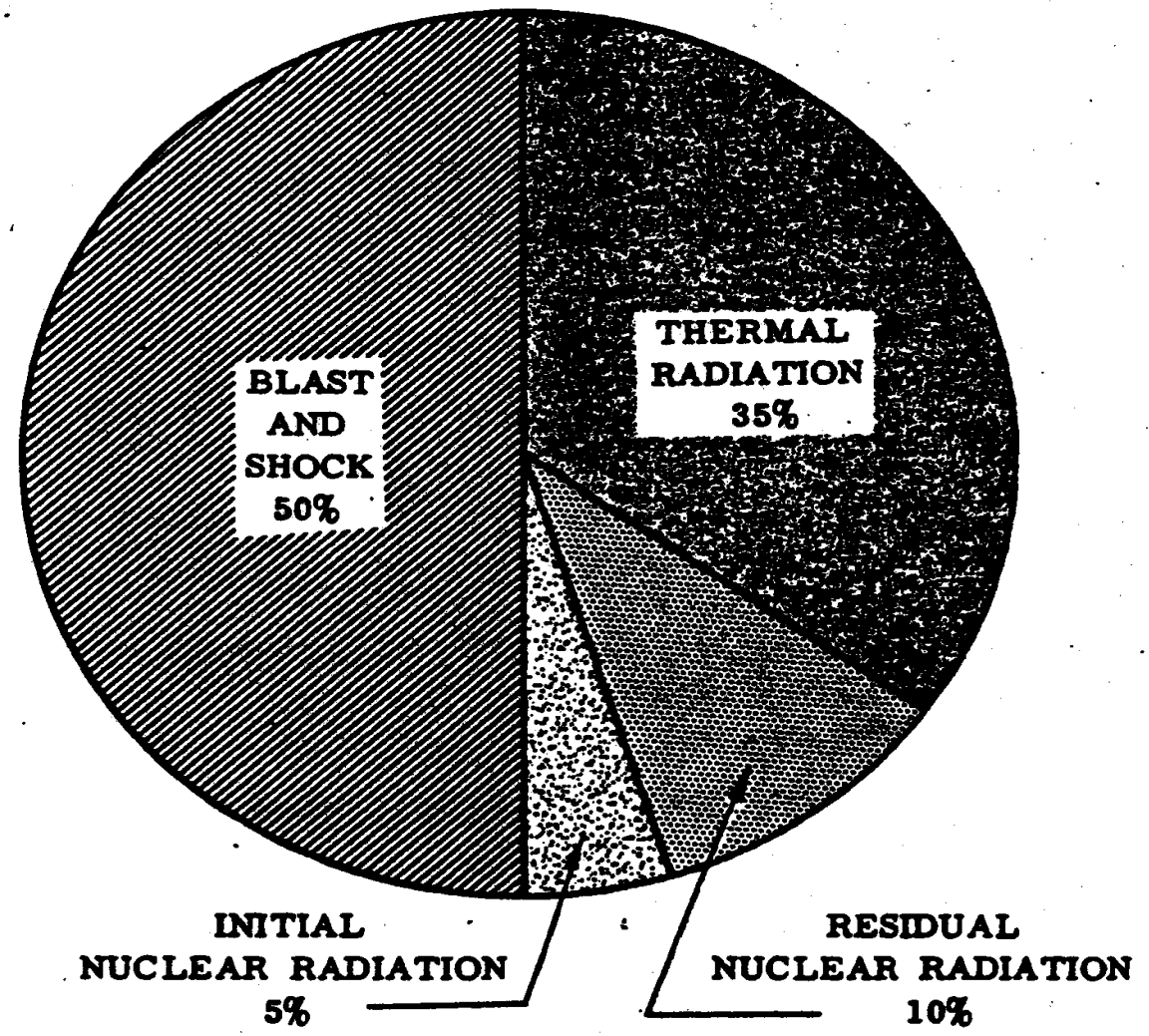
1.16×10^{6} kilowatt-hours

3.97×10^{9} British thermal units

Effects of a Nuclear Explosion



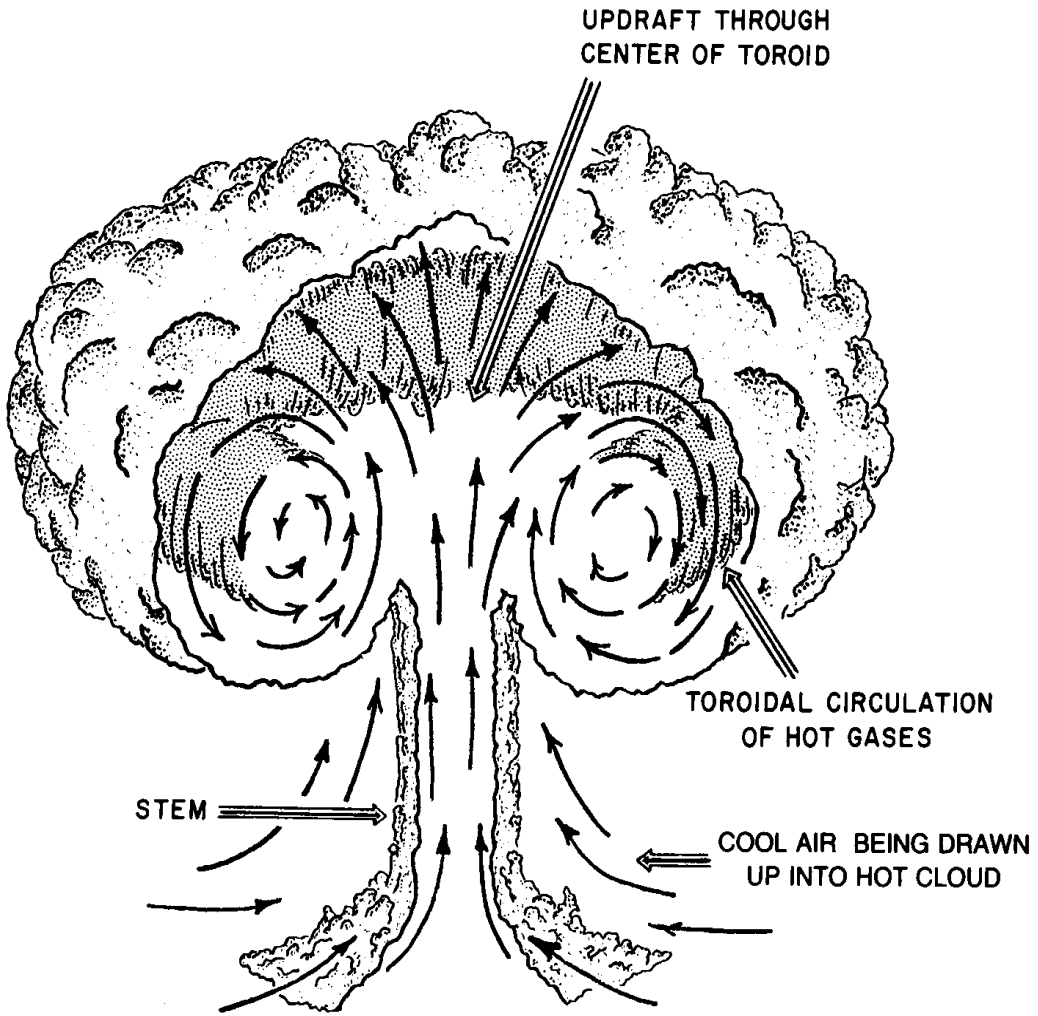
Distribution of Fission Energy in a Typical Air Burst



Fission Warhead

- Destruction and loss of life are due primarily to heat (35%) and concussive force (50%)
- Only 5% of the energy released appears as prompt nuclear radiation
- Radiation is an effect but only a secondary effect
- Problem with fallout and other nuclear debris over a wide area (10%)
- Large area could be destroyed due to destruction of dwellings and fires and loss of infrastructure

Artist's Conception of Toroidal Circulation within the Radioactive Cloud from a Nuclear Explosion



Rate of Rise of Radioactive Cloud from a 1-Megaton Air Burst

Height (miles)	Time (minutes)	Rate of Rise (miles per hour)
2	0.3	330
4	0.7	270
6	1.1	220
10	2.5	140
12	3.8	27

Fission Facts

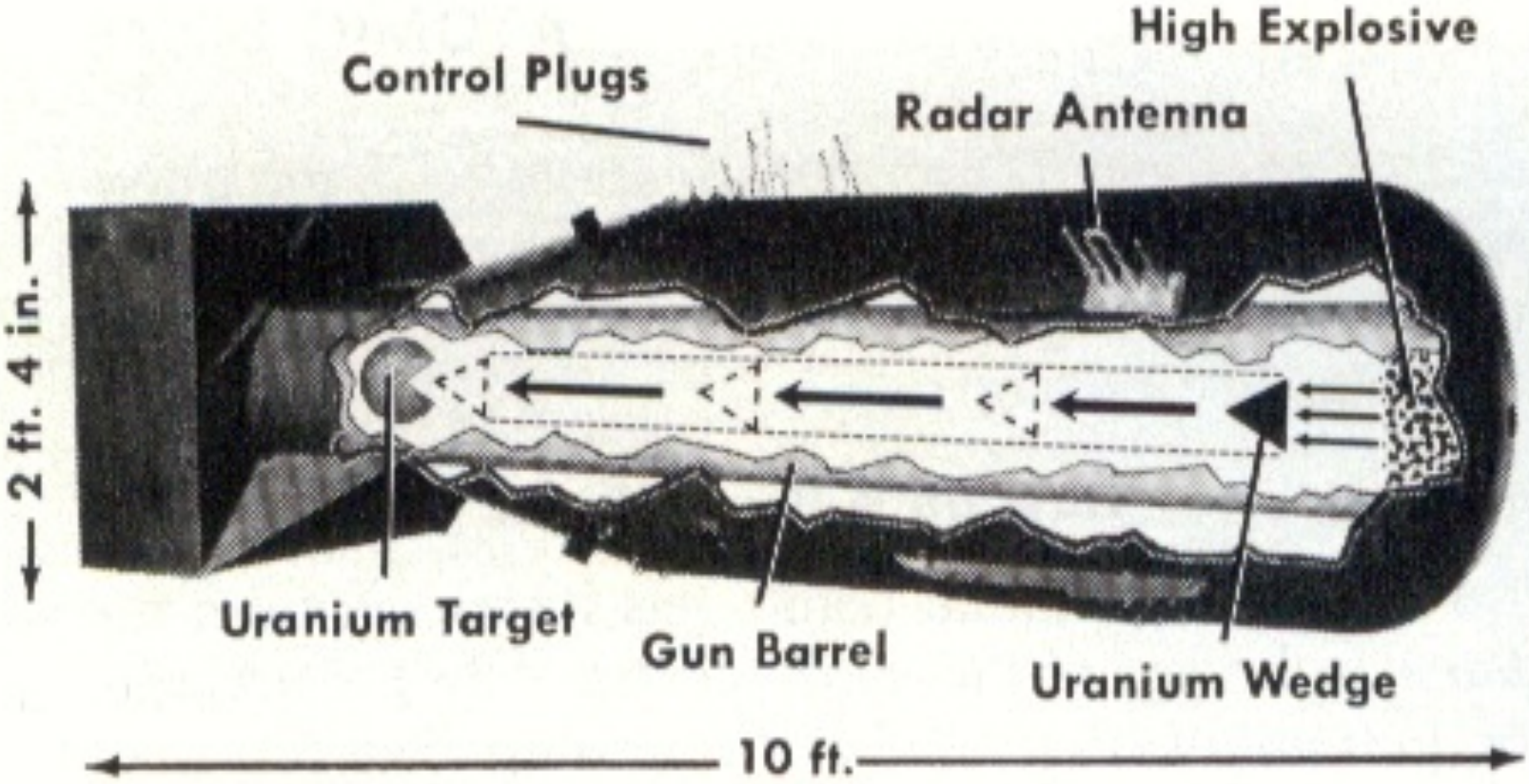
- In the fission of U-235, 300 different radionuclides are produced
- These radionuclides (called fission products) represent 36 different elements
- About 3 x 10^{23} fission product atoms are created per kiloton (kT) - about 2 ounces
- A 1 Mt device would produce about 125 pounds of fission products

Fission Facts

- At one minute after the explosion, the fission product activity due to a 1 kT device is about 10^{21} dps (~3 x 10^{10} Ci)
- For every increase in time by a factor of 7, the dose rate decreases by a factor of 10:

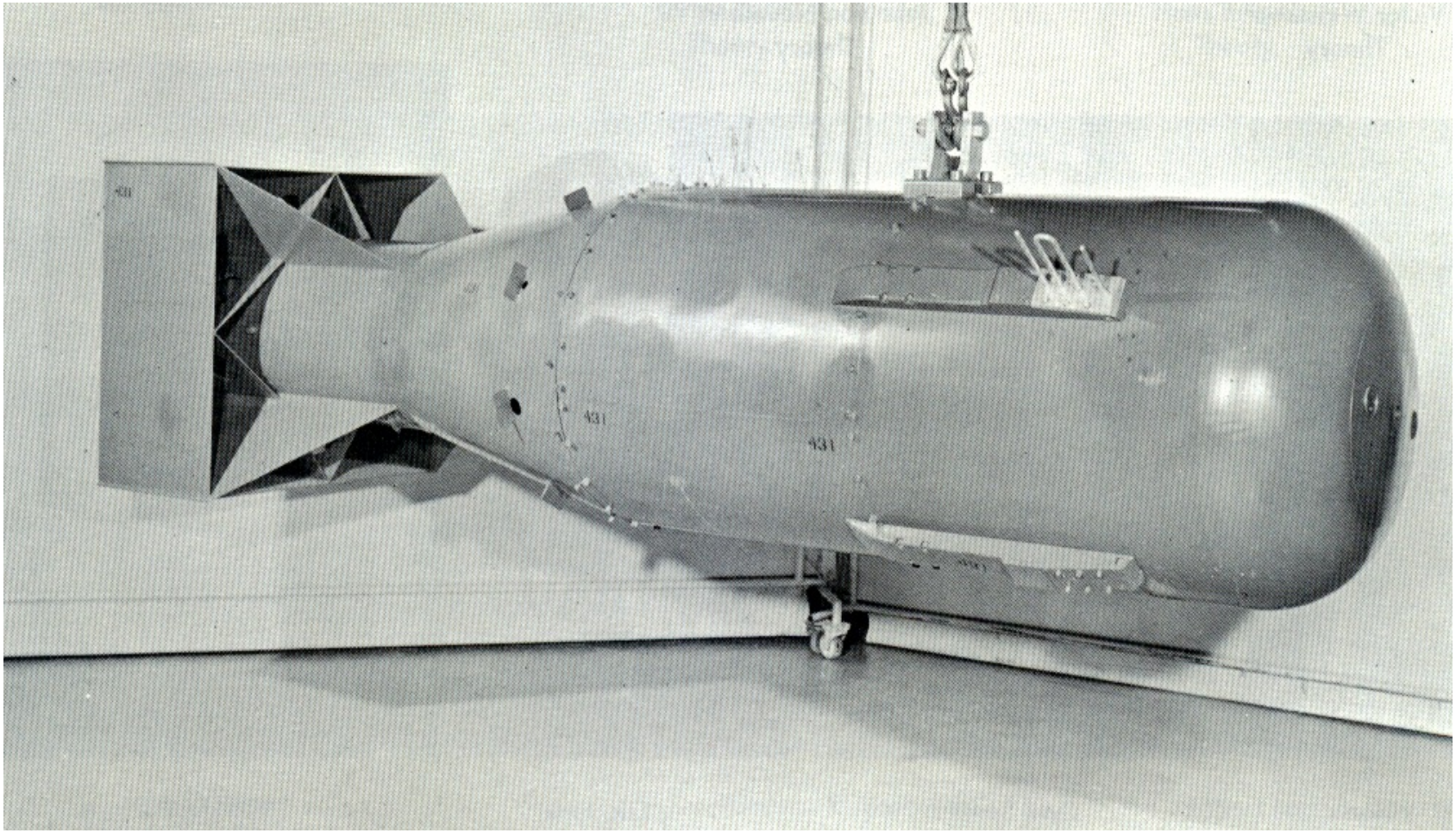
1 hour	dose rate = 1
7 hours	dose rate = 1/10^{th}
49 hours (7 x 7)	dose rate = 1/100^{th}
343 hours (7 x 7 x 7)	dose rate = 1/1000^{th}

U-235 Gun Barrel Design



Little Boy

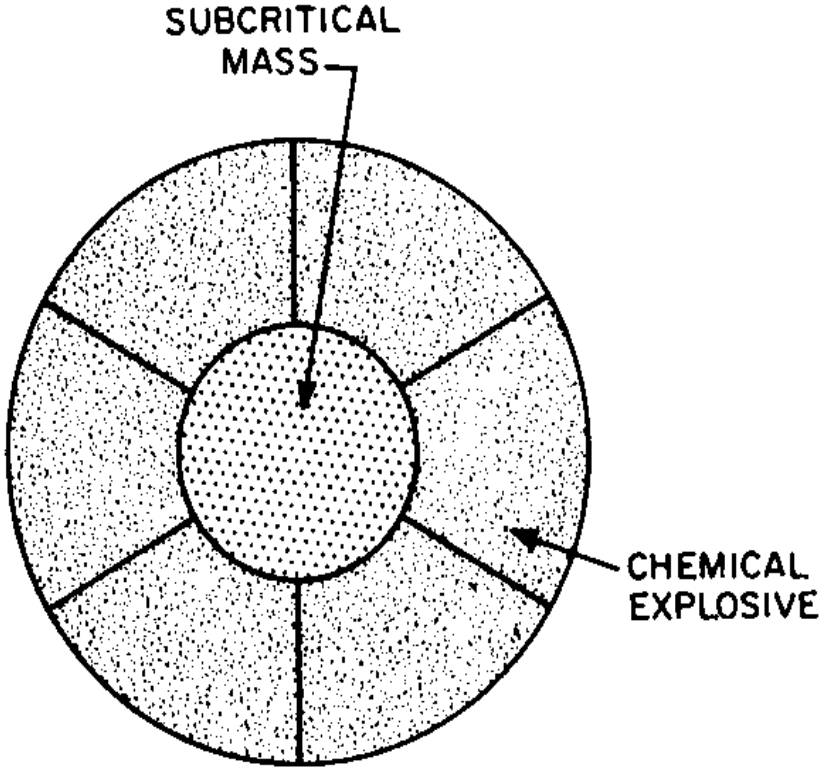
(U-235 Gun Barrel Design)



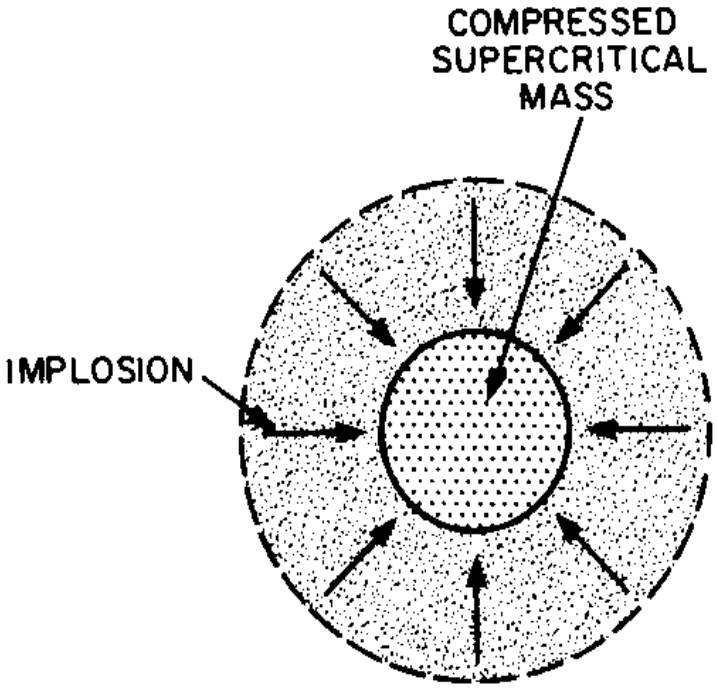
Little Boy

- Gun-type weapon made with enriched U-235
- Dropped on the city of Hiroshima on August 6, 1945 @ 8:16 AM
- Weighed 9,000 pounds and was 27 inches in diameter
- Height (epicenter) was 1,903 ft.
- Nuclear yield - 15 ± 3 kT

Implosion-Type Nuclear Device – Pu-239

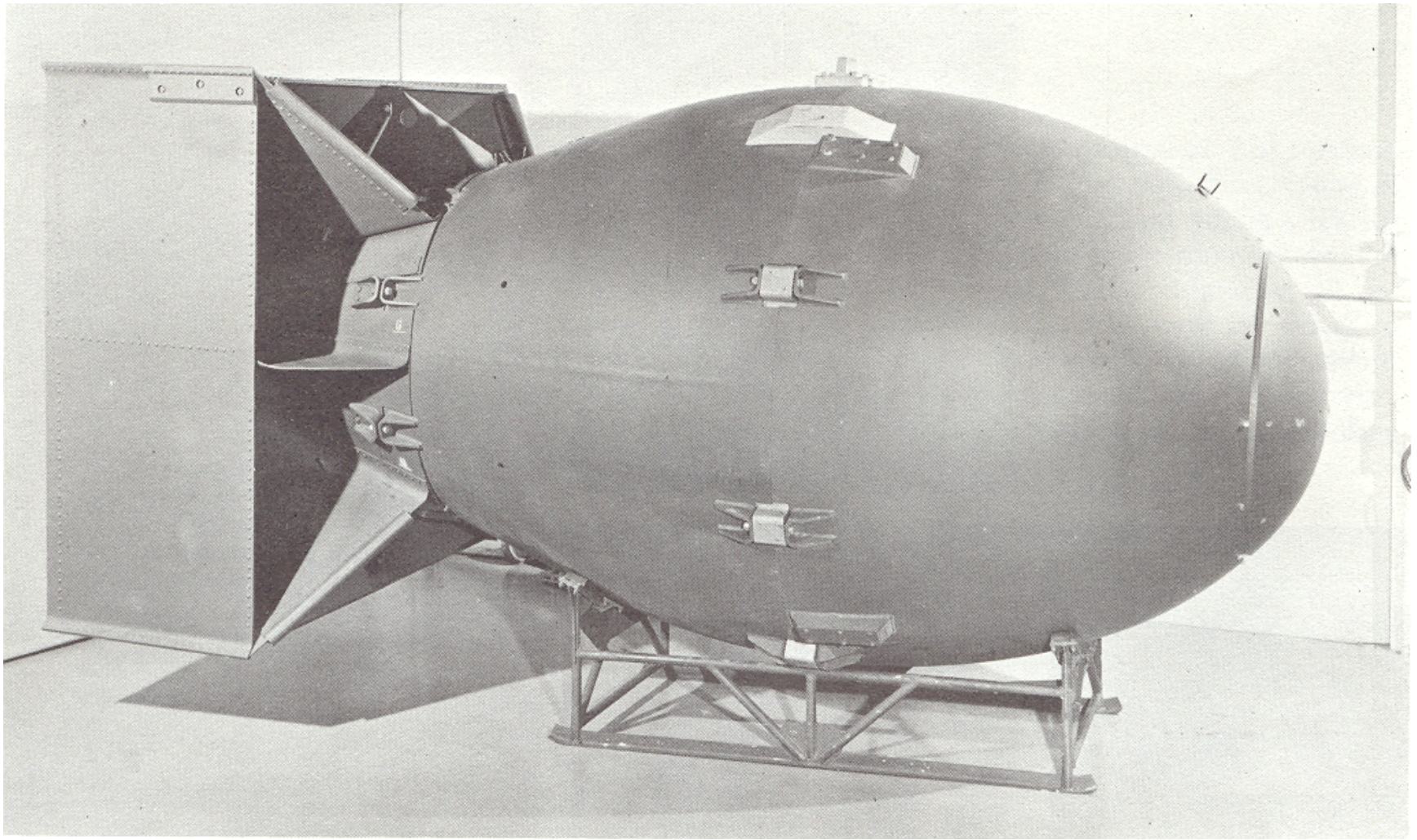


(BEFORE FIRING)



(IMMEDIATELY AFTER FIRING)
THEN EXPLODES

Fat Man



Fat Man

- Pu-239 implosion-type device
- Dropped on the city of Nagasaki on August 9, 1945 @ 11:02 AM
- Weapon was 60 inches in diameter and 128 inches long
- Weighed 10,000 pounds
- Epicenter (height) was 1,650 ft.
- Nuclear yield - 22 ± 2 kT

Who Has Nuclear Weapons?

United States **United Kingdom**

France **Russia** **China**

Confirmed

India **Pakistan**

Suspected

South Africa **Israel** **Iran**

North Korea **Iraq** **Brazil**

NUCLEAR WEAPONS

"Highly specialized skills are required to disable nuclear weapons, and with the reduced demand for expertise in nuclear weapons, the pool of scientists with these skills is shrinking."

Jessica Stern

The Ultimate Terrorists

1999

NUCLEAR WEAPONS

"The U.S. government knows little about how to disable Russian weapons – and yet if nuclear weapons are stolen they are most likely to be Russian."

Jessica Stern

The Ultimate Terrorists

1999

What's a Dirty Bomb?

A Dirty Bomb

- This is a slang term for what is really called a “radiological dispersal device”
- This is classed as one of several “weapons of mass destruction” - WMD
- Typically, uses explosives and a radioactive material to be dispersed into the environment

Why are "Dirty Bombs" on Everybody's Mind?

- Conventional explosives can be obtained from many sources
- Of 26 terror acts in US in past 22 years, 17 have involved explosives (www.cdi.org)
- Although not as readily available, potential radioactive contamination sources could take several forms:
  - Examples: gauges, testing sources, waste materials (note: sources not necessarily domestic)
- High "population terror" potential, given public's apprehension about radiation

Radiological Dispersal Devices

- Use explosives and a radioactive material to be dispersed
- Intent is to spread contamination over a wide area to disrupt normal, daily life
- Once explosion occurs, spread of radioactivity depends primarily on wind speed and direction
- However, some devices do not require explosives

Radiological Dispersal Device

- **In reality, an RDD is really a "weapon of mass disruption" because of the panic it will produce**

Radiological Dispersal Devices

- Not much known about RDD's used in an urban environment
- Most atmospheric dispersion models do not include considerations of buildings and other structures
- Sources of radioactive material
  - Spent nuclear fuel
  - High-intensity therapy sources
  - Radioactive waste
  - Others

Radiological Dispersal Devices

- The RDD challenge is the acquisition of the material
- The security on these types of materials is generally quite high
- Terrorists have some difficulty obtaining and concealing these materials from detection
- Sources that pose a risk are likely to be life-threatening to the terrorists

Radiological Dispersal Devices

- Unlikely to have significant amounts of iodine present
- May involve only one (or a few) radionuclides
- Activity required to be life-threatening is enormous and may be self-limiting
- Most likely impacts – fear and panic of the public

Radiological Exposure Devices

- The covert use of radiation or radioactivity to expose some portion of the population
- Source(s) may be “positioned” without the knowledge of law enforcement or the general public
- There may be no announcement of the event nor claim of responsibility

Radiological Exposure Devices

- These activities could be very difficult to detect
- Will probably depend on careful medical diagnosis of first victims and follow-up
- Could be man-power intensive
- Some radiation detectors are in use in public places – especially in large cities

TERRORIST INCIDENTS

"Experts tend to focus on probabilities and outcomes, but public perception of risk seems to depend on other variables: there is little correlation between objective risk and public dread."

Jessica Stern

The Ultimate Terrorists

1999

Threats Involving Radioactivity

- **In rank order of probability**
  1. **Radiation Exposure Device** (RED)
  2. **Radiological Dispersal Device** (RDD)
  3. **Conventional explosive at "nuclear facility"**
  4. **Tactical nuclear device or an IND**

Questions

- Can a nuclear reactor become a nuclear weapon?
- Can an attack on a nuclear power plant result in a nuclear explosion?
- Will a “dirty bomb” cause large losses of human life?
- What are the major impacts of a “dirty bomb?”

Questions

- What is being done to prevent (avoid) such terrorist attacks?
  - Obtaining material from other countries
  - Assisting other countries with security upgrades
  - Securing or replacing large radioactive sources, e.g., teletherapy sources in the U.S.
  - Safeguarding research reactors

References

- *The Effects of Nuclear Weapons*, S. Glasstone and P. J. Dolan, U. S. government Printing Office, Washington, DC,1977.
- "Management of Terrorist Events Involving Radioactive Material," **NCRP Report No. 138**, National Council on Radiation Protection and Measurements, Bethesda, MD, October 24, 2001
- *The Ultimate Terrorists*, Jessica Stern, 1999.
- *The Lessons of Terrorism*, Caleb Carr, 2002.

References

- “Reflections on Modern Terrorism,” Gerald Holton, The Reading Room, Vol. 4, 187-196; 2002.
- “Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism,” **NCRP Commentary No. 19**, National Council on Radiation Protection and Measurements, Bethesda, MD, December 31, 2005

References

- "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for decision Makers," **NCRP Report No.165**, National Council on Radiation Protection and Measurements, Bethesda, MD, January 11, 2010.