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UNIVERSITI TEKNOLOGI MALAYSIA

NUCLEAR PHYSICS SEMINAR
PHYSICS DEPARTMENT
FACULTY OF SCIENCE, UTM

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NUCLEAR SECURITY

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4.00 – 5.00 pm

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A rich student the son of a goldsmith sends an e-mail to his dad, saying:

Dear Dad ,Berlin is wonderful, people are nice and I really like it here, but Dad, I am a bit ashamed to arrive at my college with my pure-gold Ferrari 599GTB when all my teachers and many fellow students travel by train.

Your son, Nasser

The next day, the son gets a reply to his e-mail
from his dad:

My dear loving son. Twenty millions US Dollar has just been transferred to your account. Please stop embarrassing us. Go and get yourself a train too.

Love, Your Dad

MUST YOU TAKE NOTES

A Couple in their nineties are both having problems remembering things. During a checkup, the doctor tells them that they're physically okay, but they might want to start writing things down to help them remember Later that night, while watching TV, the old man gets up from his chair.

"Want anything while I'm in the kitchen?" he asks. "Will you get me a bowl of ice cream?"
"Sure."
"Don't you think you should write it down so you can remember it?" she asks.
"No, I can remember it."
"Well, I'd like some strawberries on top, too. Maybe you should write it down, so you will not forget it?"

He says, "I can remember that. You want a bowl of ice cream with strawberries.“

"I'd also like whipped cream. I'm certain you'll forget that, write it down?" she asks.

Irritated, he says, "I don't need to write it down, I can remember it! Ice cream with strawberries and whipped cream - I got it, for goodness sake!"

Then he toddles into the kitchen. After about 20 minutes, the old man returns from the kitchen and hands his wife a plate of bacon and eggs.

She stares at the plate for a moment.
"Where's my toast?"

The workers who work with radiation must wear monitoring devices that keep track of their total absorption, and alert them when they are in a high radiation area.


Survey Meter


Pocket Dosimeter

Radiation Alarm

Radiation Badge

Radiation Misconceptions

- Radiation does not give you *super human* powers

- Radiation will not make you glow in the dark

NPP PLANNING

- Cabinet decision on 26 June 2009: Nuclear Energy is an option of energy source for electricity generation post 2020
- Preparation of National Nuclear Regulatory Policy
- Strengthening Nuclear Regulatory Authority (AELB)
- Development of technical guidelines related to NPP activities
- Potential power operator engaged
- Triga Mark II Puspati - upgrading project to enhance technical capability
- NGOs engagement to support NPP
- 2 or 3 Universities engaging in Nuclear Engineering and Safety Courses
- Sitting planning in the process
- Reviewing the international conventions ensuring compliance to peaceful uses of nuclear energy

What can radiation do?

bring a smile on the faces of people of a

‘Dark-sides’ of radiation usage

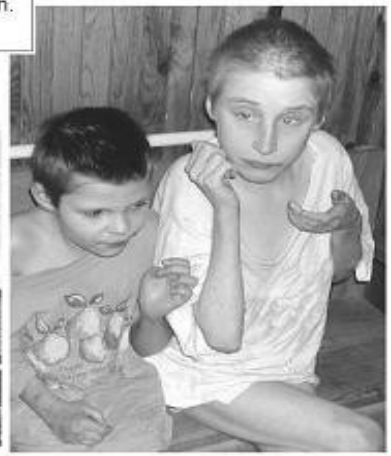
Birth defects were the norm for years following the Chernobyl incident

Children in Belarus, Russia and Ukraine have been suffering from the effect of the radiation released in 1986. The Rechitsa orphanage in Belarus has been caring for the huge population of sick children.

Photo Credit: Julien Behal/Chernobyl Children's Project

The reactor disaster in Chernobyl took place on April 26, 1986. The reactor was encased as a temporary solution to secure the site for only 20-30 years.

Photo Credit: Julien Behal/Chernobyl Children's Project



Mentally handicapped children exposed to radiation

Photo Credit:
Alex Ernes/ Blacksmith Institute

International Atomic Energy Agency (IAEA)

138 Member States

2247 Staff from more than 90 countries

6 Departments

"The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world.

Six Departments of the IAEA

- **Management**
  - Policy, Legal Advice, and Administrative Support
- **Nuclear Sciences and Applications**
  - Peaceful Uses of Nuclear Technology
- **Safeguards**
  - Verification of Peaceful Uses of Nuclear Material
- **Technical Co-Operation**
  - Technology Transfer
- **Nuclear Energy**
  - Nuclear Power, Fuel Cycle, and Waste Management

- **Department of Nuclear Safety and Security**
  - Office of Nuclear Security
  - Division of Nuclear Installation Safety
  - Emergency Preparedness and Response Division
  - Division of Radiation, Transport and Waste Safety
    - Policy and Programme Support Section
    - Waste Safety Section
    - Radiation and Transport Safety Section
      - National and Global Infrastructure Enhancement for Radiation, Transport and Radioactive Waste Safety
      - Radiological Protection of Patients
      - Safety of Transport of Radioactive Materials
      - Control of Radiation Sources

AELB, ACT AND REGULATIONS

Main Act

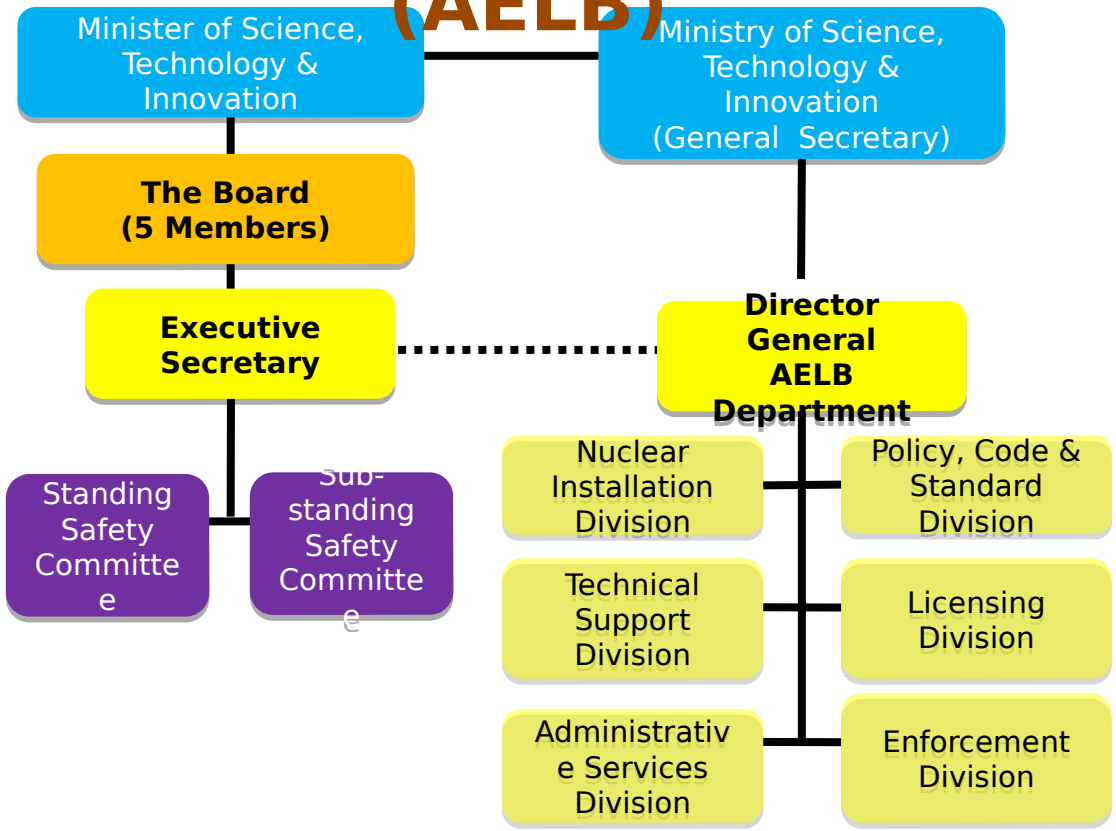
Atomic Energy Licensing Act 1984 (Act 304)

- To provide for the regulation and control of atomic energy;
- For the establishment of standards on liability for nuclear damage; and
- For matters connected therewith or related thereto.

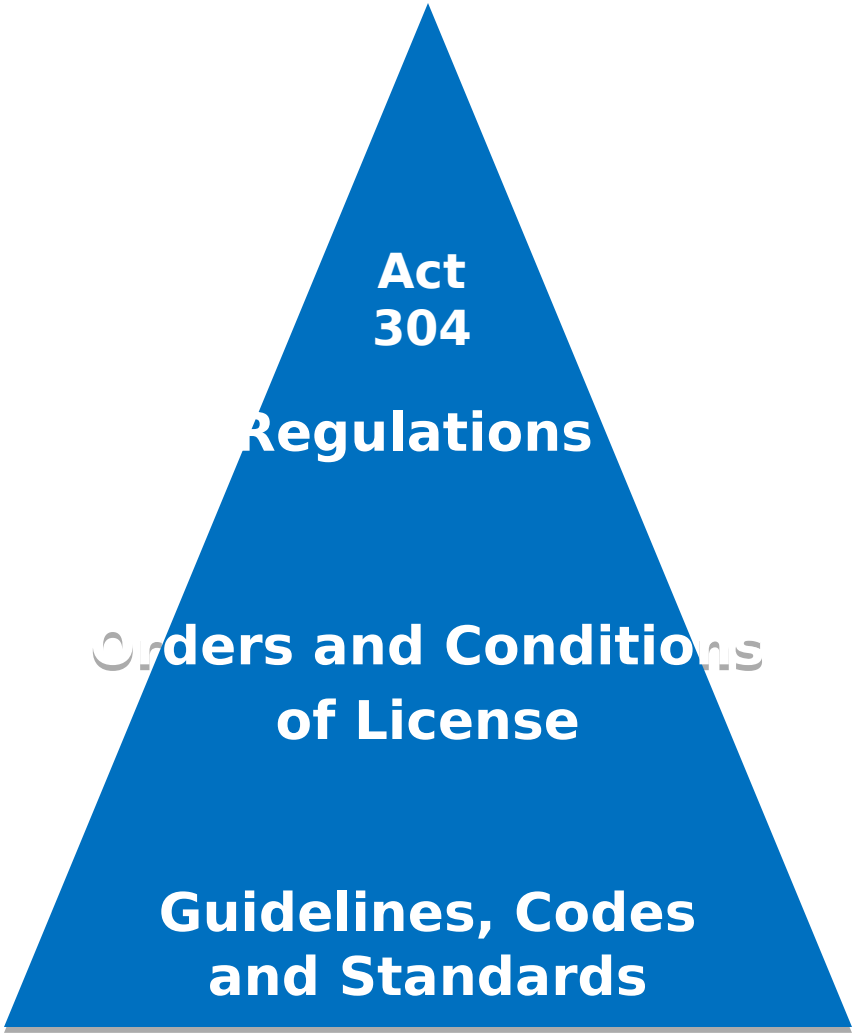
Regulatory Body:

- AELB was establish under Section 3 of the Act 304.
- Ensuring safety, security and safeguarding peaceful nuclear activities.

Atomic Energy Licensing Board (AELB)



HIERARCHY OF LEGAL SYSTEM



- Act: provides the basic law concerning the development and utilization of atomic energy and safety regulations.
- Regulations: provides more detailed provisions entrusted by the Act.
- Provides additional requirement which not stated in the regulations or special matters related to provisions entrusted by the Act
- Provides guides, codes and standards to comply with and achieve goal im-pose in regulations

Nuclear Security-Mobile Expert Support Team (MEST)

IAEA

This is to certify that

Mr Suhairul Bin Hashim

has successfully completed
In-depth Training Course
on Expert Support
for
Malaysian Nuclear Security Laboratory

Organized by the IAEA
30 November – 11 December 2015
VIENNA, AUSTRIA

Mr Daming Liu

Section Head
Nuclear Security of Materials outside of Regulatory Control Section
Division of Nuclear Security

MALAYSIA CONTEXT

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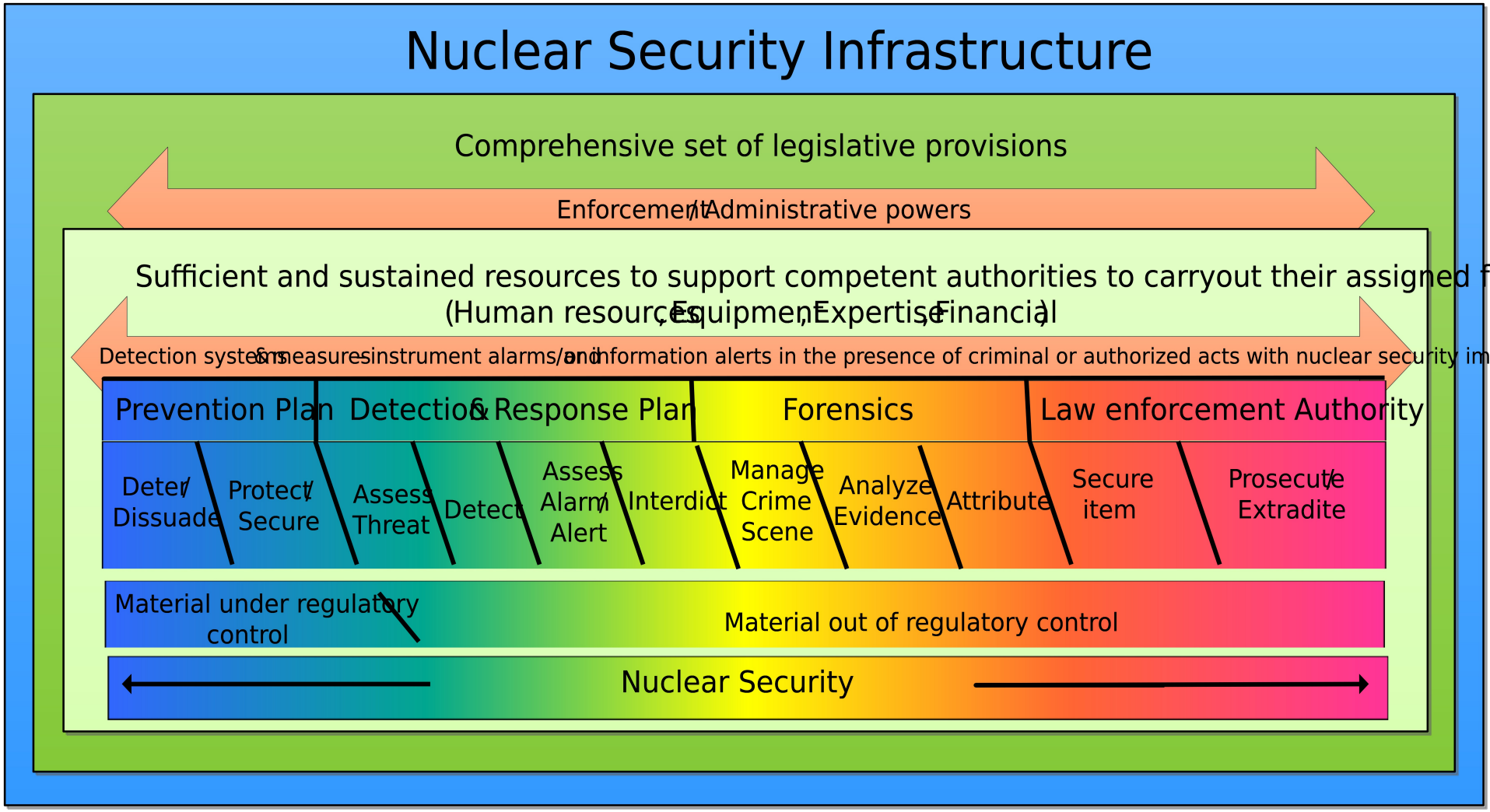
Background

Definition of a Nuclear Security Event:

An event,

involving nuclear or other radioactive material out of regulatory control, that is assessed as having potentially harmful consequences on persons, property, society and the environment.

MEST in Nuclear Security Infrastructure



Generic response scheme

Three questions in case of an alarm:

- **Is this a real alarm or a false alarm?**

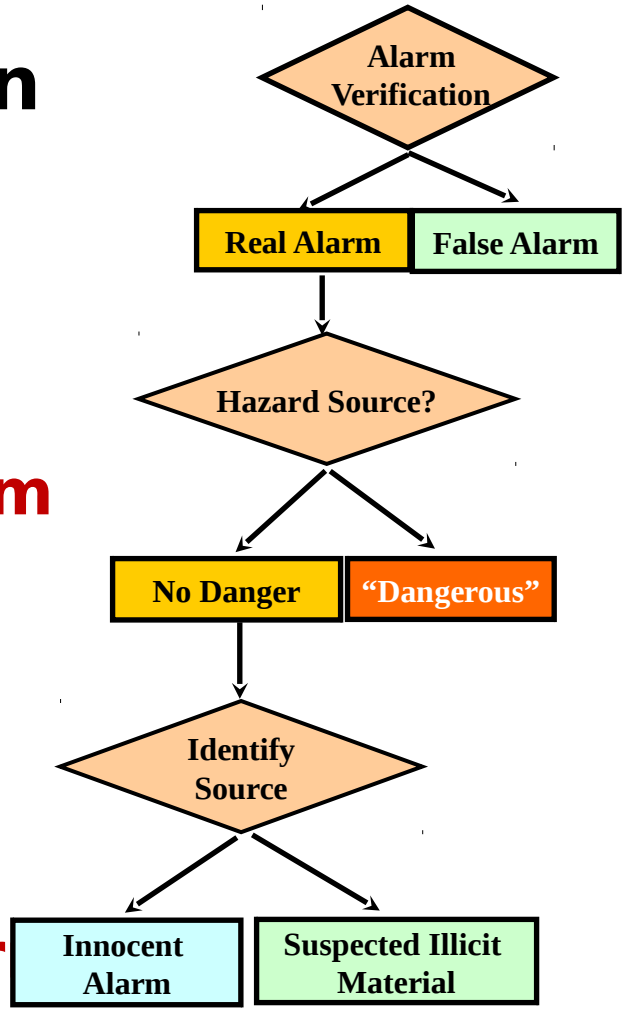
  Action: Verification of alarm

- **Can the radioactive source harm persons?**

  Action: watch dose rate, neutron indication and look for traces of contamination

- **Is this an innocent or non-innocent (illicit trafficking) alar**

  Action is based on instrument results and transport documents



Generic response scheme

Intelligence/ Information

Dose rate Indication (Use handheld instruments)

Assess Hazard & Locate Source

<100 µSv/hr @ 1 m & NO neutrons & NO surface contamination

Use RID

ALARM

Verify Alarm with instruments

Verification

VERIFIED Alarm

>100 µSv/hr @ 1 m &/OR neutrons &/OR surface contamination

Contact Expert Support Team

Identify Source

Suspected Illicit Source

Inconclusive results

Contact Expert Support Team

Radiation Detection Instrument

NO Alarm Verified

Innocent Source

If required

Safety Procedures

Isolate Source

Notification Procedure

Activate Emergency Response

False Alarm

Record Details

Stop

Record Details

Stop

Investigation

Seize Materials

Temporary Storage

Legal Process

Rationale for Expert Support

Functions of the FLOs:

- DETECT: Use detection equipment and procedures implemented at the duty station and into FLOs procedures
- VERIFY: Respond to detection
- ASSESS: Perform secondary inspection
- Make basic decisions to release or hold (innocent, security, safety)
- FOLLOW UP: Seize, detain, protect

Rationale for Expert Support

Functions of the FLOs:

- Apply criteria as defined in response procedures
- Make basic decision to characterise threat
    - No threat
    - Activate MEST
    - Activate emergency response plan
    - Notify regulatory authority
- Secure the area if needed
- Documentation (logbook)

Rationale for Expert Support

Functions of MEST:

- MEST is a service (like maintenance)
- MEST is a critical element of BME system
  - must be established before the system goes live
- MEST is involved in operational and tactical response to radiation alarm:
  - Material categorization (legal or not)
  - Recovery
- MEST is designed to match operational constraints of FLO (e.g. 24/7 on-call, 30 min response time, etc.)

Rationale for Expert Support

Why is expert support essential?

- FLOs are not used to deal with radioactive material, they may become insecure and reduce the sensitivity of the detection equipment to avoid weak alarms
- Detection follow-up may not be done properly
- If the categorization is based on wrong results, wrong conclusion can be drawn
- Nuisance with innocent alarms
- Relevant cases may slip

When may expert support be required?

If specific criteria are met during the detection and categorization process by FLO:

- Categorization is inconclusive
  (e.g. verified alarm but source is not identified)
- Dose rate at 1 meter distance is more than 100 µSv/h
  - and/or presence of neutrons
  - and/or possible surface contamination
- Identification results showing
  - Uranium, or
  - Plutonium
- Safe storage of seized materials needed

When may expert support be required?

- Missing or wrong shipment documents for transport of industrial or nuclear isotopes or medical isotopes not in-vivo
- Natural radioactive materials in shipment, or medical isotope in-vivo, with dose rate exceeding national permitted limits
  - Illicit trafficking of nuclear or other radioactive material is suspected
  - Heavy shielding
  - Masking problem with NORM or medical isotope
  - Medical isotope not in a person, or with incorrect shipping papers
  - Isotope identified or labeling is inconsistent with shipping document

Objectives

- Identify the threats:
  1. Nuclear weapons and devices
  2. Radiological devices
- Identify types of materials used in nuclear weapons and devices
- Identify materials suitable for radiological devices
- Evaluate the R/N threat

Identify the RN Threat

What do we protect against?

- Nuclear Weapons
- Improvised Nuclear Devices (IND)
- Radiological Dispersal Devices (RDD)
- Radiological Exposure Devices (RED)

'***ORPHAN***' SOURCES are radioactive sources which:

- Were never subject to regulatory control; or
- Were initially regulated, but then:
  - ✓Abandoned,
  - ✓Lost or misplaced,
  - ✓Stolen, or
  - ✓Removed without authorization.

'VULNERABLE' SOURCES are radioactive sources which:

- Are currently under regulatory control; but
- For which the control is insufficient to provide assurance of long term safety and security.
- Note: Vulnerable sources could relatively easily become orphaned.

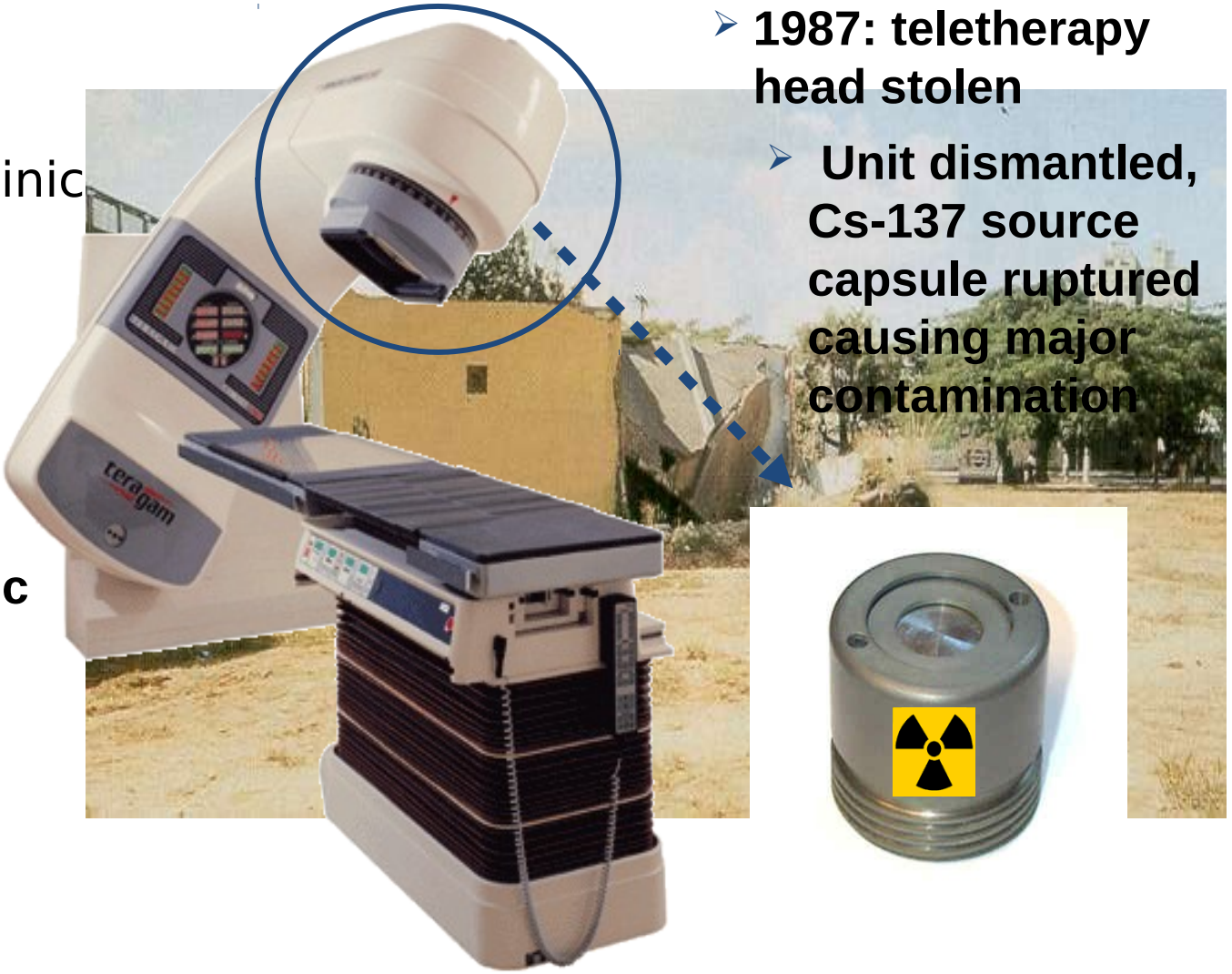
*'**DISUSED**'* SOURCES are radioactive sources which:

- Are no longer in use or intended to be used.
- Note: a *disused source* may still represent a significant radiological hazard.
- It differs from a *spent source* in that it may still be capable of performing its function; it may be disused because it is no longer needed.

Goiânia, Brazil

- 1985: Private radiotherapy clinic closed down

  - **50.9 TBq (1375 Ci) caesium-137 teletherapy machine left in abandoned clinic**



- **1987: teletherapy head stolen**
  - **Unit dismantled, Cs-137 source capsule ruptured causing major contamination**

Goiânia, Brazil

Exposure of large number of public:

- 112 000 people monitored
- 249 people contaminated
- 49 people 0.1 - 6.2 Gy
- 4 people died
  - 6 y old girl
  - 18 y old man
  - 22 y old man
  - 38 y old mother

Goiânia, Brazil

Major contamination of property:

- 85 houses significantly contaminated
- 200 people evacuated
- 7 houses demolished

Gilan, Iran

Resulting in severe radiation burns to the chest

Istanbul, Turkey

- December 1998: Two containers sold as scrap and broken open
- 3.3 TBq (88 Ci) cobalt-60 source unshielded
- Containers dumped
- 10 persons with acute radiation syndrome
- 404 persons medically examined
- 23.5 TBq (636 Ci) cobalt-60 source unaccounted

Istanbul, Turkey

1993: 3 disused teletherapy sources packaged and stored by a private company awaiting return to supplier in USA

February 1998:
2 packages transferred to inappropriate storage facilities

Inappropriate storage facilities

Samut Prakarn, Thailand

- October 1999: 3 disused teletherapy sources stored by a private company at unsecured parking lot
- Jan/Feb 2000 unauthorized removal of one unit - dismantled for scrap

15.7 TBq (425 Ci) cobalt-60 source unshielded

- **10 people highly exposed**
- **3 of whom died**
- **no contamination**

Lilo, Geo

Lilo military training center

- 1997: 11 Georgian soldiers developed radiation induced skin lesions and acute radiation syndrome

Abandoned sources (Cs-137, Co-60, Ra-226) found at various locations:

- **in coat pocket**
- **on building site**
- **in buildings**
- **buried in grounds**
- **in refuse mound**
- **on soccer pitch…**

Radiological accidents in Georgia.

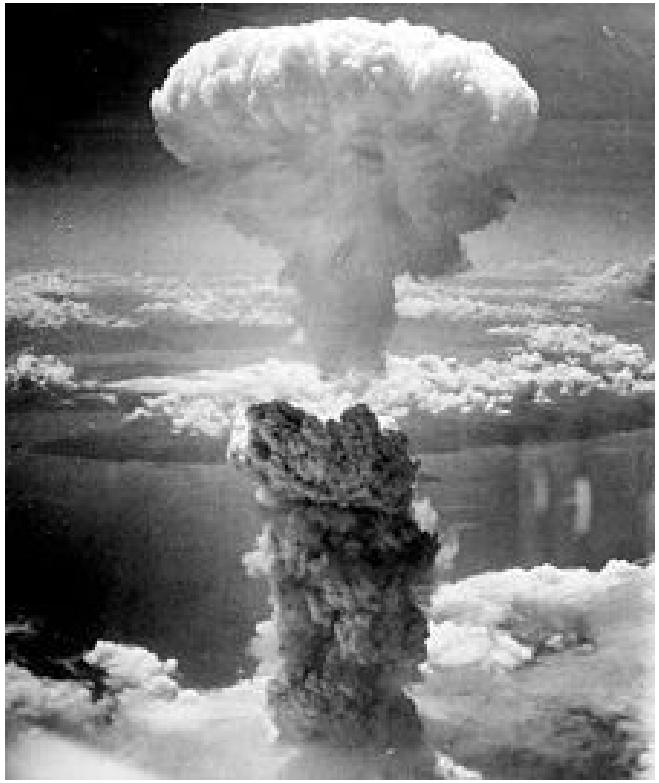
December 2001, Lja, Georgia

A group of woodcutters find 2 hot ‘objects’ in the forest.

(unshielded strontium-90 sources, each approx. 30,000 Ci !)

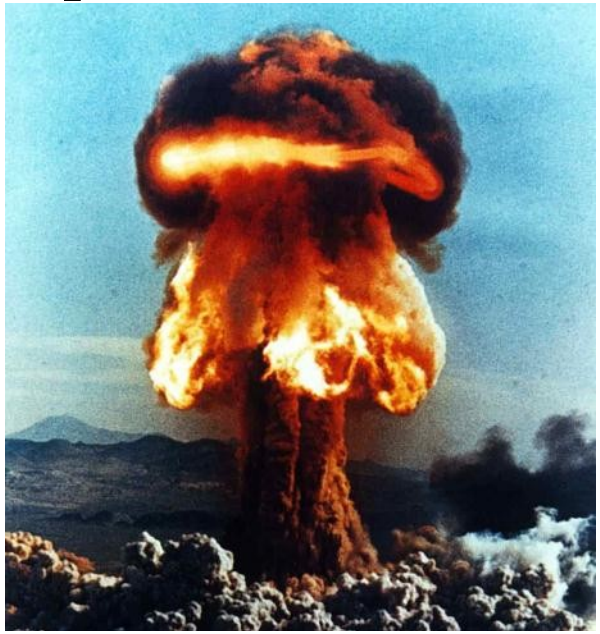
Brief history of nuclear weapon

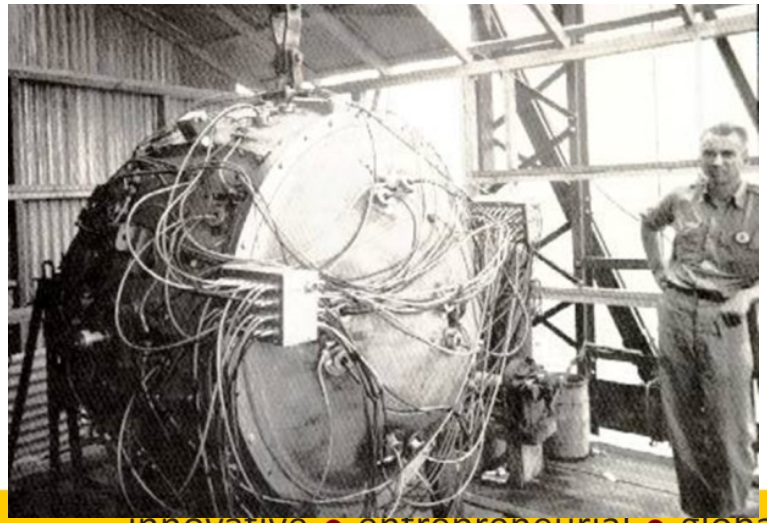
- United States (1945)
- USSR (1949)
- United Kingdom (1952)
- France (1960)
- China (1964)
- India (1974)
- Pakistan (1998)
- North Korea (claim, test 2006)



Nuclear weapons

- Stolen military warhead with initialization device
- High destruction
- 100.000ds of killed and wounded
- Wide ranged exposure
-





Improvised Nuclear Device – IND

- Self-made nuclear device:
  - HEU and Plutonium from nuclear fuel cycle
  - Redesigned military warhead
- High destruction
- 10.000nds of people killed and wounded
- wide ranged exposure and contamination

Material used in nuclear devices

- Critical mass depends on bomb design and reflector material
  - Uranium-235:
    - HEU (> 90% U-235): 12-50 kg
    - HEU (20% U-235): 400 kg
  - Plutonium-239
    - Weapons grade Plutonium (> 93% Pu-239): 6-10 kg
  - Uranium-233: about 15 kg
  - Other materials
- Conventional explosives and detonators
- Advanced initiation technology

Uranium-235

- Natural uranium contains 0.7% of the fissile isotope U-235
- To make a nuclear weapon it is necessary to raise U-235 content up to at least 20% (HEU), but preferably >90% (wg-HEU)
- Enrichment: process to increase the content of one isotope by gas diffusion, gas centrifuge, laser,…
- In commercial reactors nuclear fuel U-235 is <5% enriched (LEU) and cannot be used for nuclear weapon
- Some research reactors and naval propulsion reactors use fuel based on HEU
- IAEA significant quantity is 25 kg

Plutonium-239

- **Plutonium does not exist in nature**
  - Pu is generated in nuclear reactors by neutron irradiation of uranium
  - After reactor irradiation Pu is contained in spent fuel along with other fission products (highly radioactive)
  - Pu can be extracted from spent fuel through sophisticated chemical processes
- Pu from commercial reactors has an isotopic composition not favorable to design a NW
- wg-Pu is produced in dedicated military reactors
- IAEA significant quantity is 8 kg

Tungsten sphere of approximate size of IAEA significant quantity of Plutonium

Radiological Dispersal Device – RDD

- High contamination and distribution ra
- Low effect to public's physical health
- High effect on public's mental situatio (mass panic and disruption)
- High effect to economy
- High restoration costs
- Examples of dispersal:
  - Explosion (Dirty Bomb)
  - Air circulation (air condition, subway stations)
  - Agriculture aircrafts

Radiological Exposure Device – RED

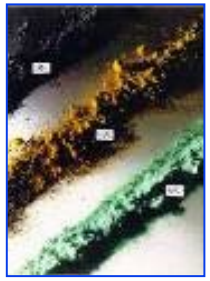
- Radioactive material placed in tactical location
- Provides high exposure rate to public
- Only a small group of people will get harmed or killed

Materials suitable for RED/RDD

- Source Material
- Special Nuclear Material (SNM)
- Radioactive Sources
  - Low activity sources
  - Industrial sources (Sr-90, Co-60, Ir-192, Cs-137, Se-75)
  - Instruments with radioactive sources
  - Medical sources
  - Sterilization
  - Radioisotope Thermal Generators (RTGs)
- Spent fuel, high level waste
- Good dispersal probabilities (e.g. CsCl)

Reactor Fuel pellets

Plutonium powder



Three forms of Uranium

Radiography instrument

Calibration sources

RTG

Well logging source

Source material (not to be confused with radioactive "sources") as defined by the International Atomic Energy Agency (IAEA) is: *Uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentration as the Board of Governors shall from time to time determine; and such other material as the Board of Governors shall from time to time determine.*

Special Nuclear Material (called Special Fissionable Material by the IAEA) is defined as *plutonium, uranium-233, or uranium enriched in the isotopes uranium-233 or uranium-235.*

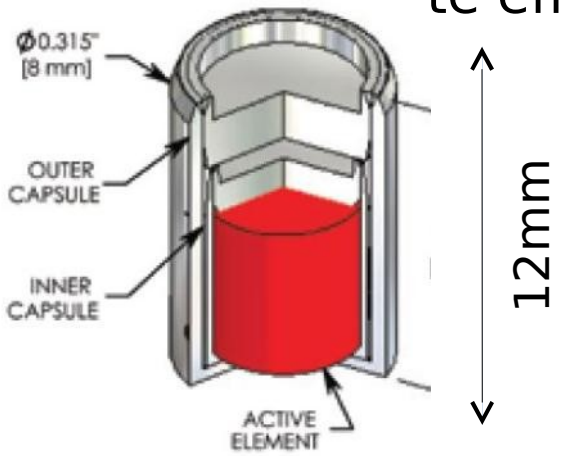
Radioactive sources include radioactive material used in medical activities, sterilization or irradiation facilities, heat sources, and instruments. They vary from kBq to TBq in source strength; low to high in activity.

The last category includes spent nuclear fuel and high level radioactive waste. This is the most radioactive material category and the material is produced by nuclear fission in nuclear reactors.

Efficiency of dirty bomb depends on good knowledge about explosives (explosion, blast and smoke probabilities)

Material suitable for RED/RDD

- Size of radioactive material could be several mm^3 only
- Example: Cs-137 with 100 TBq, exposure time 1 hour:
  - Dose at 1m distance > 7 Sv – dead within 2 weeks
  - Dose at 2.7 m distance about 1 Sv – radiation sickness
  - Dose at 8 m distance about 115 mSv – theoretically higher prc te effects (cancer)



Cs-137
148 GBq
8x12 mm

Summary of Necessary Elements

	NW	IND	RDD	RED
Material available from	WG-Pu or HEU (>90%) from military	Commercial Pu or HEU from nuclear fuel cycle	Commercial radioactive source	Commercial radioactive source
Weaponization technology	Sophisticated and confidential	Complex but available	Trivial	Trivial
Explosive Yield (tons of TNT equivalent)	20 kt to 1 Mt	< 20 kt (HEU gun) 0 to 2000 t (Pu)	< 1 ton	0
Blast damage radius	7 km	< 1 km	100 m	0
5 Sv prompt dose	2.5 km	< 1 km	< 10 m in non dispersed cond., exposure 1 hour	< 10 m, exposure time 1 hour
Immediate casualties	50 000	< 2 000	few by blast	0
Delayed casualties	Hiroshima 70 000		few	few

Nuclear Material: How much is there?

- Under IAEA Safeguards
  - Plutonium:
    - 795 tonnes in irradiated fuel
    - 89 tonnes separated
    - 14 tonnes separated in reactor fuel
  - Highly Enriched Uranium (HEU >= 20%)
    - 32 tonnes
  - Low Enriched Uranium (LEU is < 20%):
    - 54 875 tonnes

- Not under Safeguards (Military and non-Safeguard States)

  Weapons states have many hundreds of tons of Weapon Grade Plutonium and HEU

Radioactive Material: How much there?

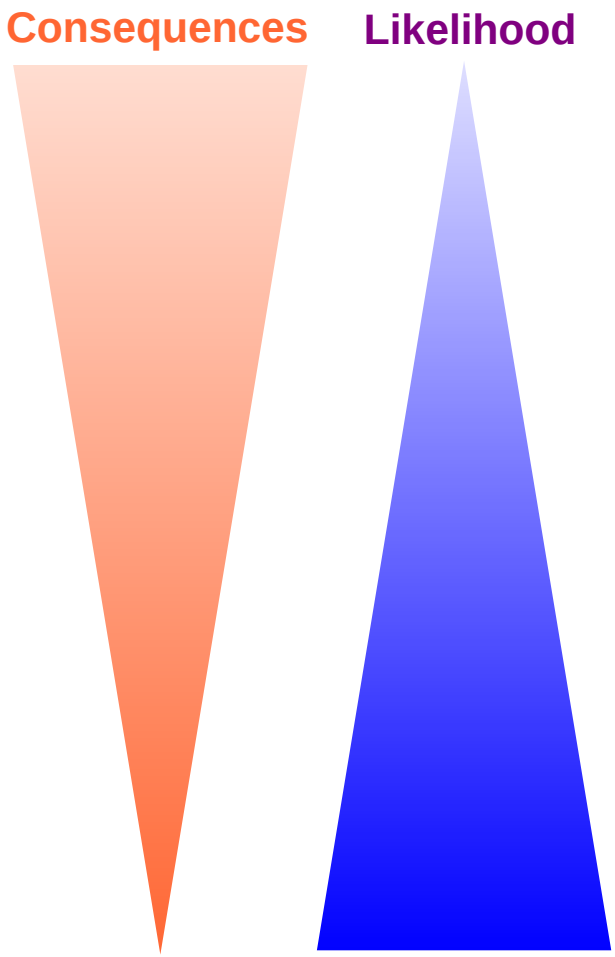
- Millions of radioactive sources in use in the world
  - Over 3,000 Medical Tele-therapy Units, 120 000 Brachytherapy Facilities
  - 50 000 Radiography Facilities; Over 100 Commercial Irradiators; 500 000 industrial sites
- Tremendous Number of Shipments
  - 20 000 000 per year

The Risk Equation

- Seizure of Nuclear Weapons – of particular concern are thousands of deployed and stored nuclear weapons and materials

- Theft or purchase of fissile material to build a Nuclear Explosive Device or an Improvised Nuclear Device (IND)

- Attack on or sabotage of nuclear facilities, including nuclear power plants spent fuel storage sites or weapons production facility



Factors to be considered for MEST

- Number of sources
- Quantity (activity)
- Half-life
- Radio toxicity (α, β, γ, or n)
- Form
- Accessibility
- Dispersal method

Conclusion

- Too much nuclear and radioactive material is not properly secured.
- Evident interest of terrorists to acquire such material.
- Possible criminal and intentional unauthorized acts involving such material are a continuing worldwide threat.
- Even though nuclear terrorism does not stop at national borders, the responsibility for establishing an appropriate nuclear security regime rests entirely with individual states.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Any
Questions