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Radiation Emergencies - Scenarios, Consequences and Preparedness

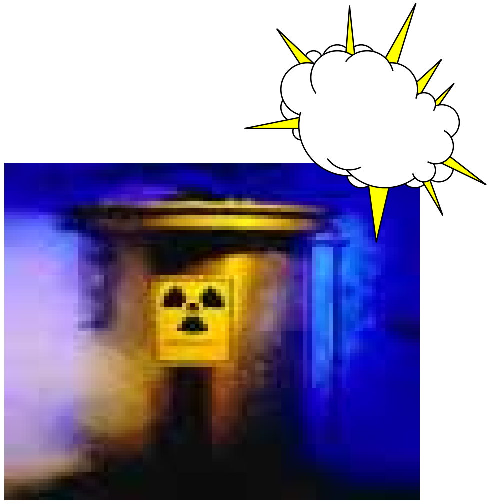
4th EURADOS Winter School

Radiological emergencies – Internal exposures

Rome, 3 February 2010

Content

- Potential scenarios and consequences
- Using past accidents to develop preparedness
- What should we plan to do?
- The way forward



Radiation emergency scenarios

Scenario: Civil Nuclear Facilities

- Nuclear reactors and other facilities
  - Reprocessing plants
  - Fuel fabrication
  - Research establishments

- Well developed and exercised preparedness arrangements
- Early response structures in place eg monitoring

Public Health Consequences

- For most “reference accident” scenarios the doses are likely to be low, a few mSv

- Emergency countermeasures within the vicinity of the site (out to a few km)
- Evacuation
- Sheltering
- Stable Iodine (for operational nuclear reactors)

- Food restrictions possible for 10s to 100s of km

Past Accidents: Civil Nuclear

Chernobyl RBMK

2,000 PBq of I-131

Three Mile Island PWR

300 TBq of Xe-133

Windscale 700 TBq of I-131

Scenario: Military accident

- **Submarine Reactor**
  - Similar to civil reactors but much smaller scale
- **Nuclear Weapons** or special nuclear materials in transit
  - Potentially high inhalation dose to those very close to the accident (U-235 or Pu-239)
  - Conventional explosion hazard and associated injuries
  - Sheltering (5 km downwind) reduce doses to a few mSv

Past Accidents

2 weapons intact

2 weapons suffer conventional explosion

1,600 tonnes of waste shipped to US

Palomares, Spain 1966 - Mid air collision involving B52 bomber and refuelling jet - 4 Nuclear weapons on board

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Past Accidents

The casings from two of the recovered Palomares weapons

Scenario: Transport Accidents

- Internationally agreed safety standards
- Various types of packages
  - Which package depends on amount and form of material being transported
  - The more dangerous the material the more robust the package
  - Excepted, Industrial, Type A, Type B, Type C
- Potential doses expected to be low

Public Health Consequences

- Due to high level of containment or low level of radioactive material doses are low
  - a few μSv to a few mSv
- More likely to be conventional injuries
  - Fire
  - Chemical
  - Crush
  - Trauma

Scenario: Industrial Accidents

- A range of scenarios
  - Large sources at industrial plants eg sterilisation plants
  - Industrial radiography
- "Orphaned" sources

Public Health Consequences

- Internal and external exposure pathways
- Generally limited to a small number of people who are in close proximity to the source of radiation
  - Doses between a few 100 mSv to several Sv
- Possible that a large number of people could be exposed to low levels
  - A few 100s μSv to a few mSv

Past Accidents

Goiania, Brazil - 50 TBq 137Cs

Istanbul, Turkey - 27 TBq 60Co

Juarez, Mexico - 37 TBq 60Co (6000 metal pellets)

San Salvador - 0.66 PBq 60Co

Belgium - 60Co source in sterilisation plant

Scenario: Small scale incidents

- A wide range
  - Lost and damaged sources
  - Empty packaging
  - Hoaxes

- All have potential to cause public concern
- Response procedures need to be in place

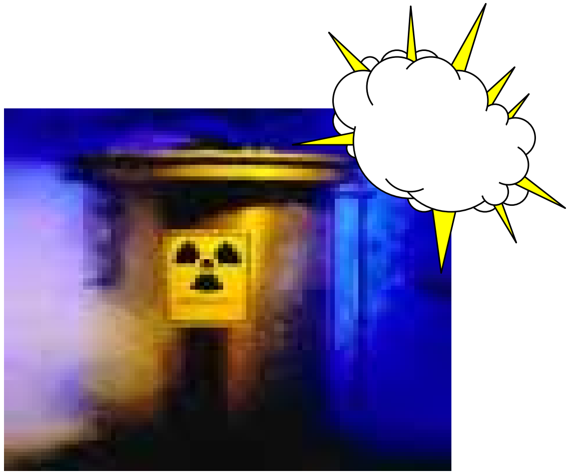
Potential Malicious Scenarios

NOT based on detailed threat assessment

NOT based on past terrorist events

NOT radionuclide specific

In public domain



Why use radioactivity for terrorism?

- Adverse health effects
- Fear factor
- Contamination problems
- Socio-economic consequences
- Political consequences

Comparison with conventional nuclear accidents

- No site specific emergency plan
- Probably no warning
- No perimeter fence monitors - delayed detection
- Probably urban rather than rural

Scenario: Radiological Dispersion Device

- Conventional explosive device with radioactive material or other means of dispersal
- Source with previous legitimate purpose
- Small source - high specific activity - <<kg quantities of radionuclide
- Activities up to “TBq scale” more readily available than “PBq scale”

RDD - Strontium RTG

Photographs courtesy of IAEA

RDD - Americium

Radiological Dispersion Device

- Early harm

  - Radiation exposure
  - Skin contamination
  - Wound contamination
  - Inhalation exposure pathway
  - Embedded particles
  - Conventional injuries probably exceed radiation induced (ICRP 96)

Radiological Dispersion Device

- Longer term consequences
  - Potential stochastic effects from external and inhalation pathways
  - Environmental decontamination and recovery
  - Food restrictions
  - Psychological effects
  - Socio-political effects

Radiological Emplacement Device (RED)

- Description

  Physically small but intense beta/gamma source placed or distributed in populated area

- Aim(s)

  To cause actual or suspect radiation injury

  To produce distributed urban radioactive contamination

Radiological Emplacement Device

- Discovery
  - Patients presenting?
  - Prior intelligence
  - Covert radiation monitoring
  - Fortuitous discovery
  - Perpetrator announcement

Radiological Emplacement Device

- Early harm

  - External radiation exposure
  - Contamination if source “corrupted”
  - Potential for deterministic effects if large quantities used (>TBq) and exposure times sufficient

Radiological Emplacement Device

- Longer term consequences
  - Potential stochastic effects
  - Environmental decontamination and recovery
  - Food restrictions
  - Psychological effects
  - Socio-political effects

Improvised Nuclear Device (IND)

Major explosion impact

"Ring" of prompt radiation exposure

Short half-life "fallout" - ground contamination - external radiation

Electromagnetic Pulse

Explosion/Fire

Other potential scenarios?

- Combination with conventional attack
- Combination with other CB attack?
- One real incident + hoaxes/minor

The way forward

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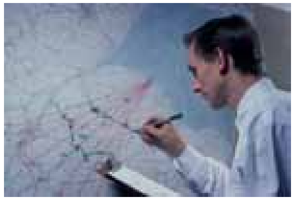
What we need to plan for

- An effective response which includes

- Rapid radiological protection advice and information

- Radiological assessment
- Environmental/personal radiation monitoring
- Medical treatment



Communication

Effective communication essential and should be well planned to:-

- Recognise the psychological impact
- Provide the public with timely and accurate information
- Accommodate the “worried well” who are likely to overwhelm the response

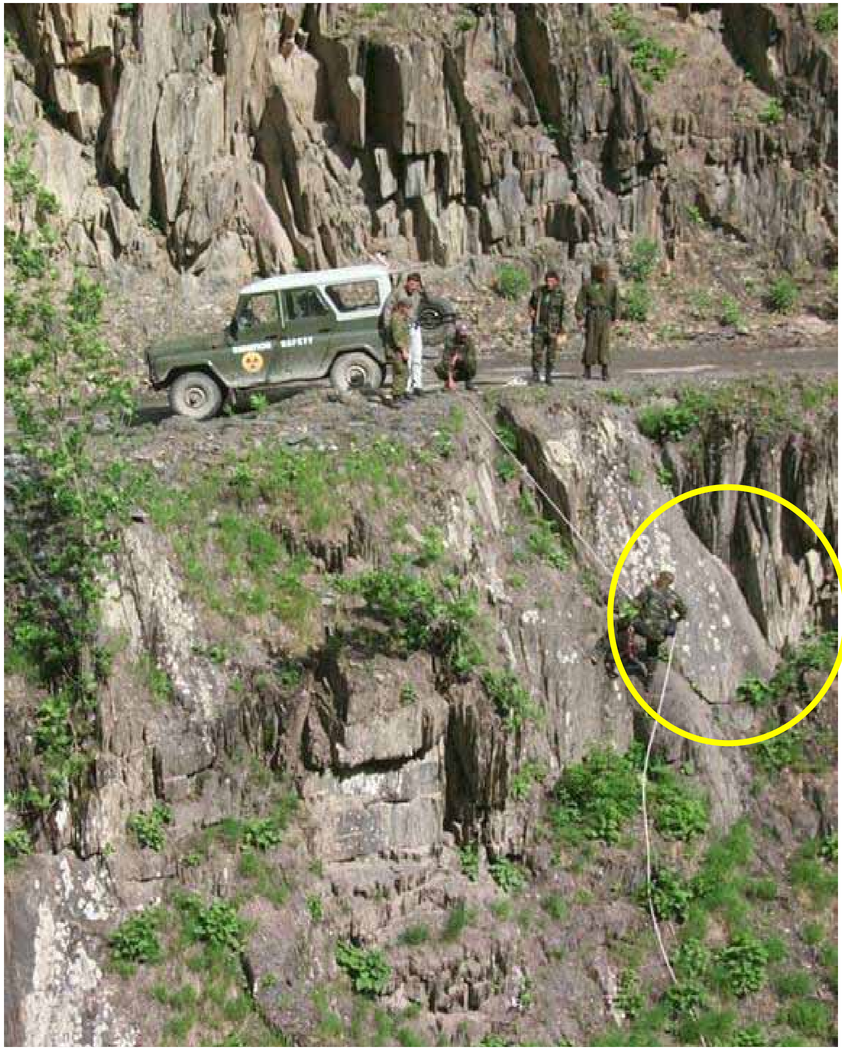
Using past accidents to develop preparedness

Polonium-210 "event"

- On 23 November 2006 Alexander Litvinenko died in a London hospital
- Cause of death : poisoned with radioactive Polonium-210
- Case became a criminal investigation

Radioactive contamination was found to be present at places he and "persons of interest" had visited across London

IAEA action plan for orphan sources



Terrorism changes the range of the credible

Extendibility and resilience of emergency plans

CBRN threat from terrorists

But important to remember….

- Radiation is radiation!
- Some differences in response arrangements
- Security issues
- Different radionuclides
- Different environment

Radiation Protection in the Newly Independent States

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