On the needs for updates of European nuclear/radiological emegency management tools to address warfare fallout scenarios

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RDD warfare scenarios

Novel scenarios (after EURANOS): Intentional harm / contamination to civilians / soldiers

RDD's ('dirty bombs') - 'terrorists choice'

RDD first deployed in 1945 in connection with US army 'Trinity' test – to study fallout effects

According to leaked secret documents, Al Qaeda have long ago been capable of producing powerful RDD's

Fallout particle characteristics depend widely on bomb construction design, explosive amounts, and physicochemical form of contaminants.

From 0 to 80 % of the contamination may be aerosolized. Particle sizes expected to range from tenths of a micron to a few hundred microns

Thinkable wartime scenario to create fear and restrict access

Russian minister of defence: "concerned about possible provocations by Kyiv involving the use of a dirty bomb". Concerns expressed in June 2023.

‘Normal’ focus for ‘dirty bomb’ radionuclides

Radionuclide	Typical physicochemical form of large existing sources	Existing strong sources and their strengths
^{60}Co	Metal (can be dissolved in acid - liquid)	Sterilisation irradiator (up to 400,000 TBq). Teletherapy source (up to 1000 TBq)
^{90}Sr	Ceramic ($SrTiO_3$) - insoluble, brittle, soft (Mohs hardness: 5.5), can be powdered	Radioisotope thermoelectric generator (1000-10.000 TBq)
^{137}Cs	Salt (CsCl) (can be dissolved - liquid)	Sterilisation irradiator (up to 400,000 TBq). Teletherapy source (up to 1000 TBq)
^{192}Ir	Metal – soft - Mohs hardness 6.5 (can be powdered), insoluble in water	Industrial radiography source (up to 50 TBq)
^{226}Ra	Salt ($RaSO_4$) (can be powdered), very low solubility	Old therapy source (up to 5 TBq)
^{238}Pu	Ceramic (PuO_2) - insoluble, can be powdered	Radioisotope thermoelectric generator (up to 5,000 TBq)
^{241}Am	Pressed ceramic powder (AmO_2)	Well logging source (up to 1 TBq).
^{252}Cf	Ceramic (Cf_2O_3) - insoluble	Well logging source (up to 0.1 TBq).

In countries with nuclear programs virtually any radionuclide may be made in large amounts

(see, e.g., Harper et al., 2007; Ferguson et al., 2003; Argonne, 2005)

Example: Sr-90 dirty bomb explosion in Copenhagen

Exposure type	Effective exposure period	Max. Dose at 250 m (mSv) *	Max. Dose at 2500 m (mSv) *
External from outdoor contam.¤	10 d	10	0.1
External from indoor contam.¤	T½ = 60 d	30	0.3
External from skin contam.¤	T½ = 0.2 d	40	0.4
Internal from inhalation (plume)	A few hours	30	0.3

¤ Dose at depth of basal layer of human skin epidermis
* In wind direction

Illustrative excel modelling estimates based on realistic parameter values for a simplified scenario involving a 1000 TBq Sr-90 ‘dirty bomb’ detonation

The ground contamination at 250 m distance was ca. 10 MBq per square meter
The ground contamination at 2500 m distance was ca. 0.1 MBq per square meter

Note: Sr-90 in ceramic form is not easy to aerosolize (5% assumed on basis of Harper’s experimentation, 2007).
If state facilities in some countries are involved, the contaminant may be tailored for this use.

Nuclear warfare: what should we know to be prepared?

Various scenario types could be envisaged (low probability – high impact?)

Depending on bomb type, yield and explosion height, possibly many immediate casualties, but also a fallout problem far outside a zone of mass destruction

Most likely bombs would be relatively small (most acceptable by international community), and might be used for tactical purposes in the battlefield

The radionuclides are for some part ‘familiar’, but may to different degrees be mobile and ready for uptake depending on physicochemical properties of the contaminants

Atmospheric dispersion and ingression depends greatly on particle sizes, densities, effective release height, etc.

Knowledge of particle solubility is also essential to enable reliable modelling of resultant doses

Air blast mean particle size can decrease with increasing bomb yield (by almost a factor of 10 between bomb yields of 0.01 and 10 Mt), and particle size is different in cloud stem and canopy

Nuclear ground level burst

Features:

Much soil, dust and debris taken up into the fireball

Stabilized plume top for 10 kT surface based nuclear detonation: ca. 7 km

Stabilized plume top for 1 kT surface based nuclear detonation: ca. 2.5 km

More than 90 % of activity associated with particles between 10 and 100 μm (upper limit depends on nature and amount of entrained ground material).

Particles larger than ca. 20 μm are essentially not following air stream dispersion. Anyway, the larger particles typically only carry contamination on a thin surface layer. Irregular or spherical shape (varies).

Particle density: 1-3 g/ccm reported for early US tests (1965)

Nuclear air burst

Features:

No quantities of surface material assumed to be taken into the fireball

Usually detonated at a height of 100 m to 1 km, and stabilized plume top a bit higher than that for ground level burst.

Radioactive residues evaporate and nucleate and further condense into small particles with diameters within the range of 0.01 to 20 μm.

The smallest and largest of these will have high deposition velocities due to respectively Brownian diffusion and gravitational settling.

Generally spherical shape and radioactive throughout.

Particle density: 3 – 4.3 g/ccm reported for early US tests (1965)

Concluding: Some immediate preparedness needs

Enabling current computerized decision support systems to estimate consequences of these types of threats – much new parameterization is needed.

Enabling the use of European decision support handbooks to address these types of scenarios, for which they were not intended.

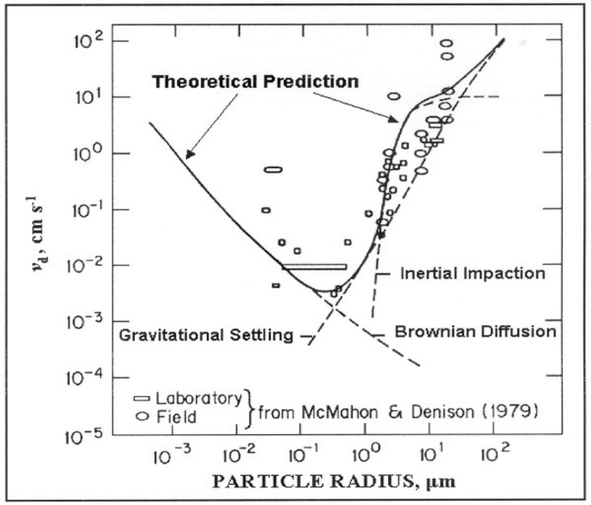
Validation of new models and parameters.

Evaluation of potentially relevant protection strategies.

Addressing public advice and communication strategies

Addressing psychological, socioeconomical and ethical issues.

Preparations for operationalization in practice of intervention.



Relevant issues for nuclear blasts and particularly fallout scenarios will be addressed (if funded) in the PREDICT proposal submitted in July to EU/PIANOFORTE (BfS lead).