Vulnerability Assessment for Sabotage during Nuclear Transport in Germany

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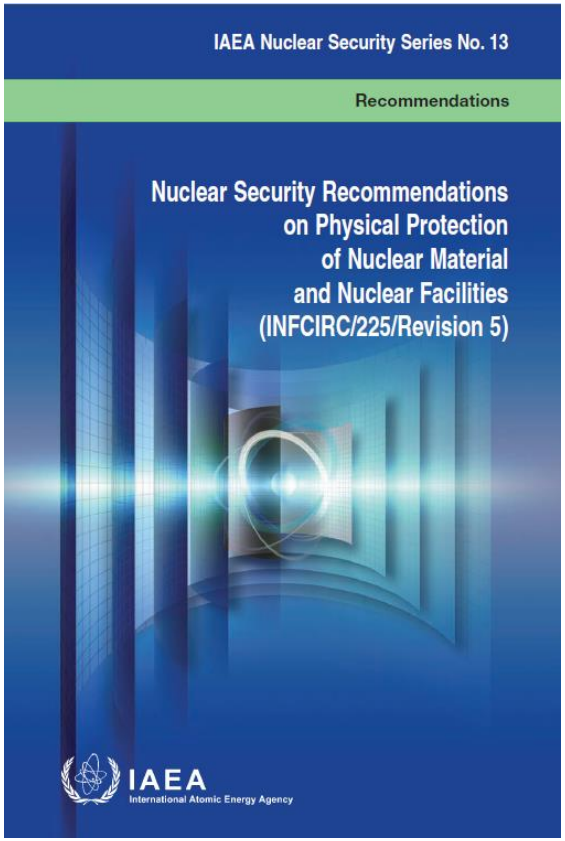
Motivation

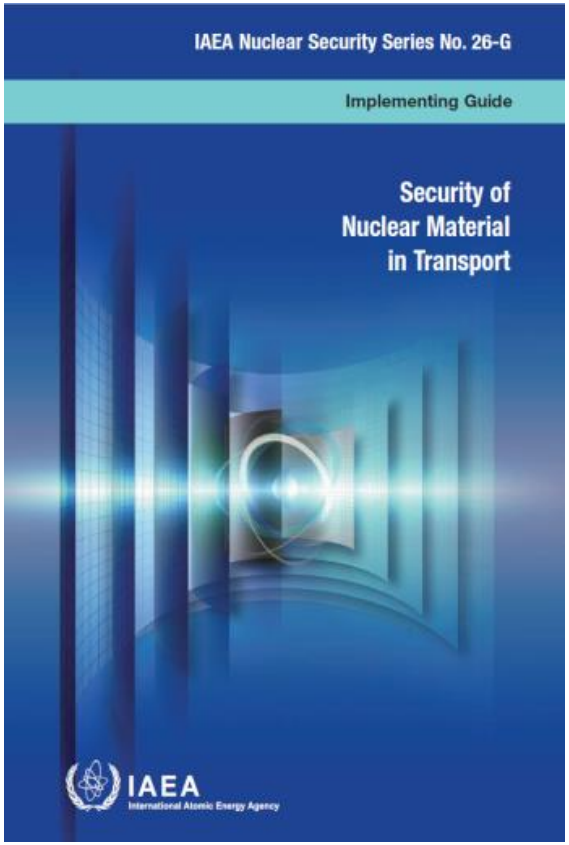
Nuclear Security Series No. 13, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities:



- Radioactive material has to be protected against unauthorized removal since it could have significant consequences if dispersed or used otherwise for a malicious act
- …the State should define protection requirements that correspond to the level of potential radiological consequences.

Motivation

Nuclear Security Series No. 26-G, Implementing Guide, Security of Nuclear Material in Transport:



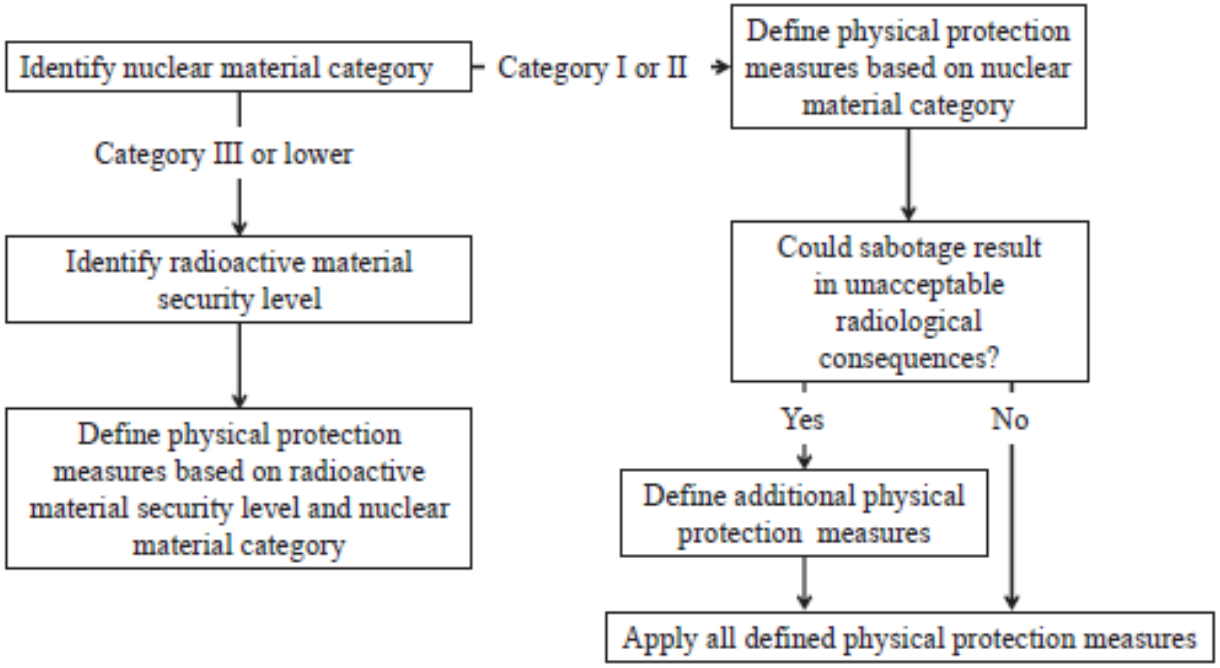
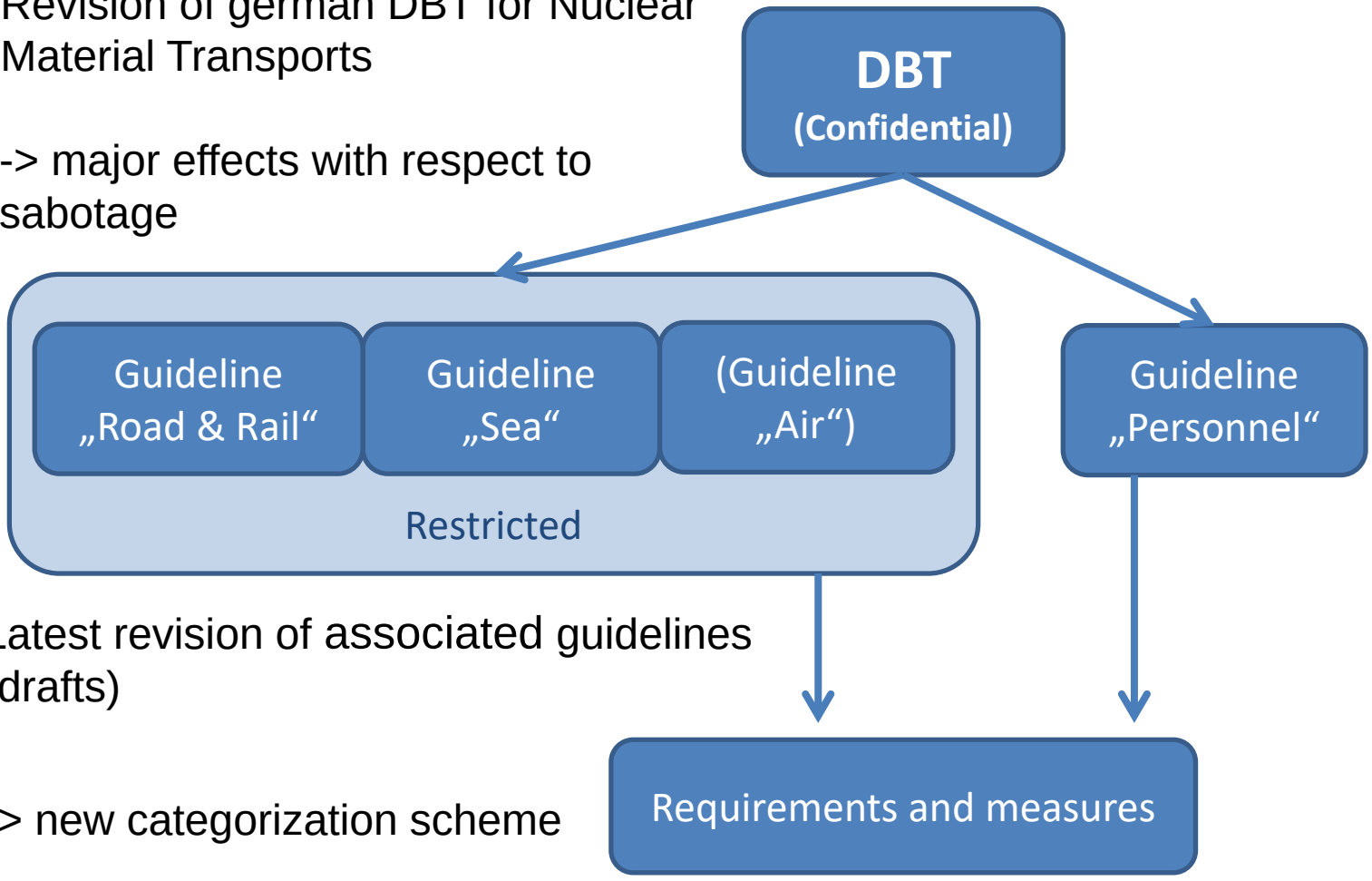


FIG. 1. Defining physical protection measures to account for all risks.

Motivation

Revision of german DBT for Nuclear Material Transports

-> major effects with respect to sabotage



Latest revision of associated guidelines (drafts)

-> new categorization scheme

Motivation

Material	Form	Category I	Category II	Category III[a]
1. Plutonium[b]	Unirradiated[c]	2 kg or more	Less than 2 kg but more than 500 g	500 g or less but more than 15 g
2. Uranium-235	Unirradiated[c]			
	— Uranium enriched to 20% ^{235}U or more	5 kg or more	Less than 5 kg but more than 1 kg	1 kg or less but more than 15 g
	— Uranium enriched to 10% ^{235}U but less than 20% ^{235}U	n.a.[d]	10 kg or more	Less than 10 kg but more than 1 kg
	— Uranium enriched above natural but less than 10% ^{235}U	n.a.[d]	n.a.[d]	10
3. Uranium-233	Unirradiated[c]	2 kg or more	Less than 2 kg but more than 500 g	50 bu
4. Irradiated fuel (The categorization of irradiated fuel in this table is based on international transport considerations. The State may assign a different category for domestic use, storage and transport, taking all relevant factors into account)			Depleted o uranium, th low enriched fu (less than 10% fissile content)[e, f]	

Source: Table 1 of Ref. [2].

[a] Quantities not falling in Category III, natural uranium, depleted uranium or thorium should be protected at least in accordance with prudent management practice.

[b] All plutonium except that with isotopic concentration exceeding 80% in ^{238}Pu.

[c] Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level e hielded.

[d] n.a.: not applicable.

[e] Although this level of protection is recommended, it would be open to States, upon evalua of physical protection.

[f] Other fuel which by virtue of its original fissile material content is classified as Categ , while the radiation level from the fuel exceeds 1 Gy/h (100 rad/h) at 1 m unshielded.

Sabotage leads to unaccaptable radiological consequences: „Sabotage-relevant (FS)“

Results in six Categories:
Cat. I
Cat. II
Cat. III
Cat. I FS
Cat. II FS
Cat. III FS

Motivation

Nuclear Material Transport categorized as

Cat I FS

Cat II FS

Cat III FS

-> additional requirements:

- prevent unacceptable consequences
- …

Motivation

Within licensing process…

… the applicant has to (i. a.)

- categorize the Nuclear Material Transport,
- to prove that there are no unacceptable radiological consequences as a result of a sabotage

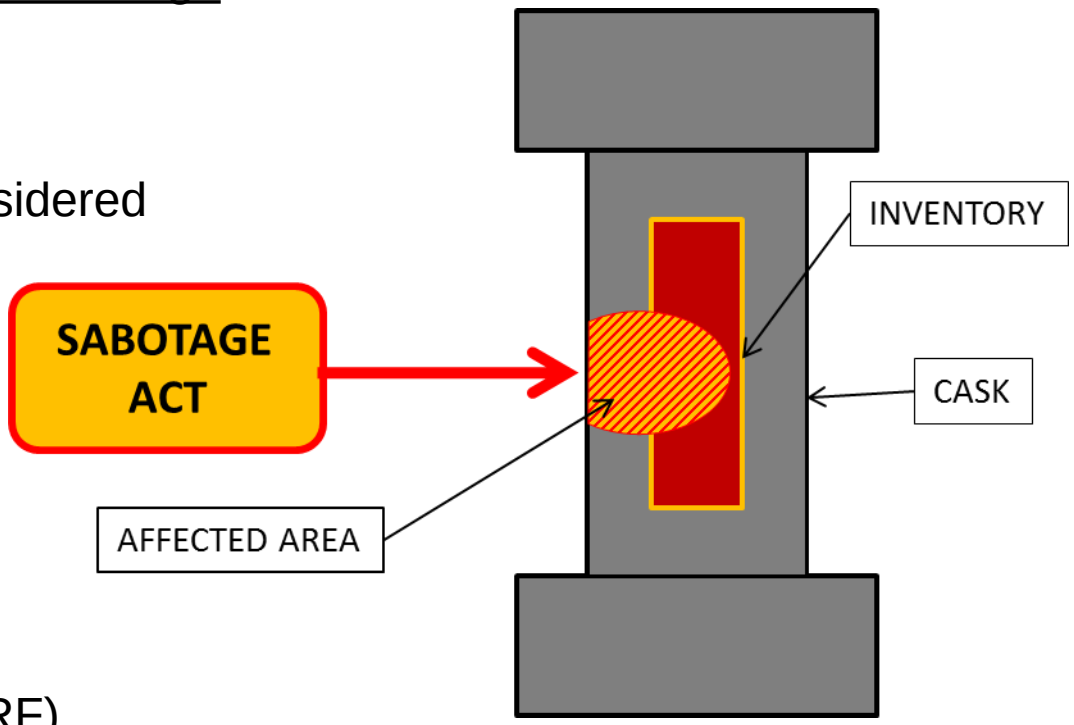
… the Competent Authority proves with the help of third party experts whether the requirements are fulfilled

For Categorization and for proving effectiveness of additional measures:
Assessing radiological consequences

Assessment of Potential Consequences of Sabotage during Nuclear Transport

First step: Categorization regarding Sabotage

- Sabotage affects cask
- No additional structures are considered
- No measures



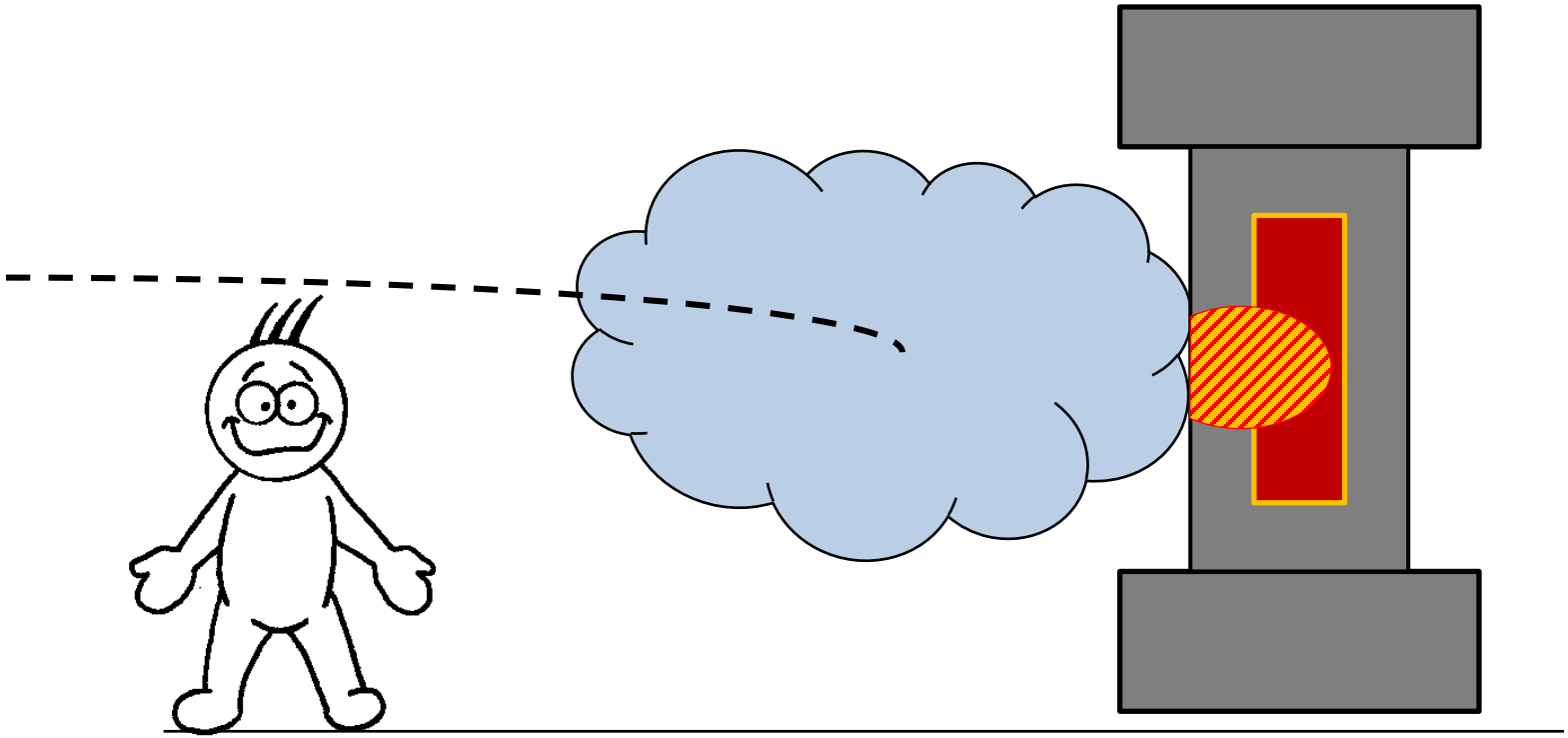
Assessment:

- Damage Pattern of:
  - Cask
  - Inventory
- Airborne Release Fraction (ARF) of inventory (respirable aerosols)
- Aerosol transport process from the inside of the cask to the environment

Assessment of Potential Consequences of Sabotage during Nuclear Transport

Second step:

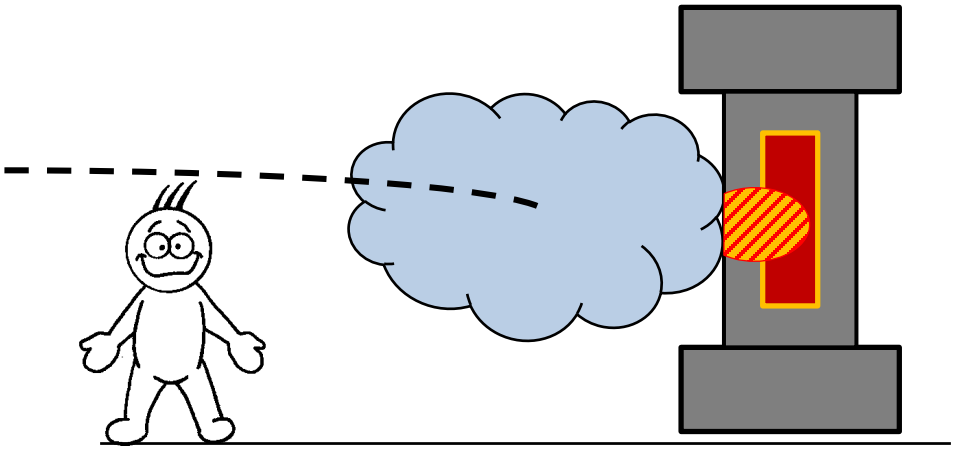
- Determination of dispersion of respirable particles
- Dose calculation



Assessment of Potential Consequences of Sabotage during Nuclear Transport

Definition of boundary conditions:

- What are unacceptable radiological consequences?
- Dose for one person or a group?
- Distance?
- Locations?
- Exposure for which period?
- Velocity of wind?
- Rain?
- …



Assessment of Potential Consequences of Sabotage during Nuclear Transport

If the Nuclear Material Transport is categorized as „sabotage-relevant“ (FS) additional measures have to be added.

One requirement: Unacceptable radiological consequences have to be prevented.

Assessment starts again taking into account all measures

Challenges

Two main questions:

- What could be suitable measures?
- How can the effectiveness of the systems be proved?

Challenges

What could be suitable measures?

- Add as much material around the cask that no sabotage act leads to any radiological consequences
  - Passive measure
  - Heavy
  - Large-sized
  - Heat removal
  - …

- Add less material around the cask to mitigate the damage of cask and inventory and with this the release of particles
  - Passive measure
  - Maybe heavy
  - Maybe large-sized
  - Sufficiency
  - …

Challenges

What could be suitable measures?

- Add active systems like sprinkling systems/foams to wash out particles
  - Active system
  - Need of triggering
  - Efficiency
  - …

Challenges

How can the effectiveness of the systems be proved?

- Performing experiments
- Numerical simulations
- Inspections of implemented measures

Summary

- Revision of german DBT for Nuclear Material Transports: Major effects with respect to sabotage
- Revision of guideline (draft): New categorization regarding sabotage followed by new requirements
- Precise assessment of radiological consequences needed
- Challenges resulting from the new regulations (suitable measures, prove efficiency)

Thanks for your attention!