

PR&PP Working Group Meeting

Panel #1

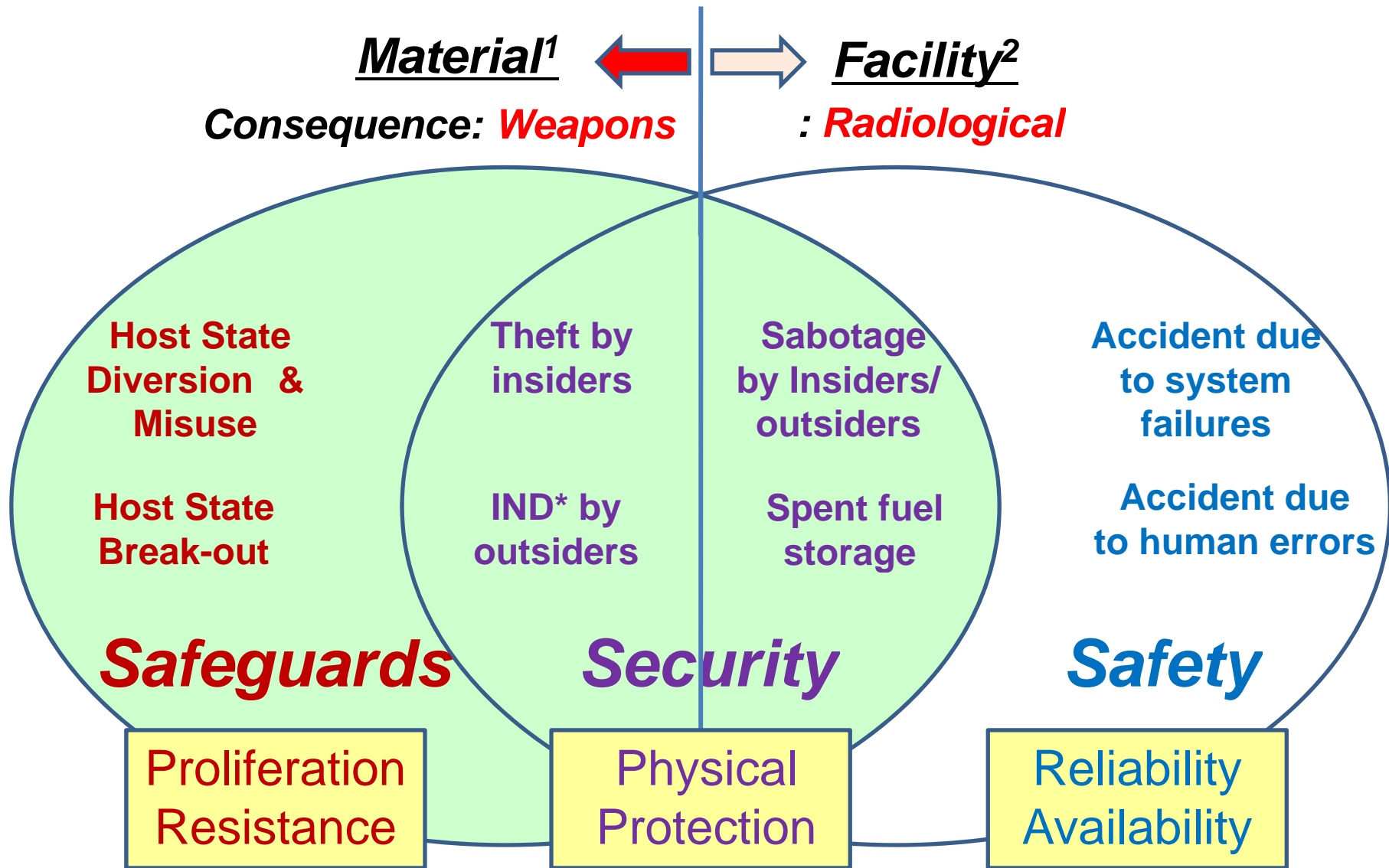
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3S Threat Space



1 Materials = Special Nuclear Material (Pu, HEU)

2 Facilities = fuel-cycle facility where SNM is handled & processed, or reactors

* IND = Improvised Nuclear Device

PR&PP Threat

Materials as Targets

- Proliferation Resistance (PR) scenarios:
 - Diversion of **target materials** covertly
 - Misuse of process to produce **target materials**
 - Abrogation (break-out) of treaty obligations and produce/use **target materials** overtly
- Physical Protection (PP) scenarios:
 - Theft of **target materials** (insiders)
 - Use **target materials** and produce improvised nuclear devices (IND) (outsiders + insiders)

Figure-Of-Merit (FOM)

$$FOM = 1 - \log_{10} \left(\frac{M}{800} + \frac{Mh}{4500} + \frac{M}{50} \left[\frac{D}{500} \right]^{\frac{1}{\log_{10} 2}} \right)$$

The 3-factor FOM based on critical mass (M), heat generation rate (h) and dose rate (D) is intended to measure material attractiveness for Physical Protection (PP)

Type of Material	Attractiveness Level*	Figure-of-Merit (FOM)*
Weapons Assembled weapons and test devices	A	---
Pure products Pits, components, buttons, ingots, rec-astable metal, directly convertible materials	B	> 2
High-grade materials Carbide, oxide, solutions (>25 g/l), Nitrate, fuel element and assemblies, alloy and mixtures; UF4/UF6 (>50% enriched)	C	1 – 2
Low-grade materials Solution (1 to 25 g/l), process residues requiring extensive reprocessing, moderately irradiated materials, Pu238, UF4/UF6 (>20%<50% enriched)	D	0 – 1
All other materials Highly irradiated forms, solutions (< 1 g/l), U (<20% ²³⁵ U or <10% ²³³ U), Any form any quantity	E	< 0

- Based on the DOE Graded Safeguards Table, and paper by C. G. Bathke, et. al., LA-UR-08-1966, 8th International Conference on Facility Operation, March 30-April 4, 2008, Portland, OR.

Applicability of FOM

- It is a numerical expression intended for a systematic categorization / classification of nuclear materials (based on the materials' intrinsic properties – **composition**).
- The DOE Graded Safeguards (US DOE M 474.1-1B) and the IAEA Categorization of Nuclear Material (INFCIRC225/Rev.5) are intended for **Physical Protection of nuclear materials** (**The 3-Factor FOM**)

Formulating to include the neutron emission rates which affect weapons yield and reliability, **the 4-Factor FOM can be used for Physical Protection, & perhaps, also Proliferation Resistance.**