

Verification issues
or
Why we need ~~statesmen~~ politicians

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What do we need to verify?

- The dismantlement of declared warheads
- The absence of undeclared nuclear material
- The peaceful use of civilian nuclear facilities

An equation

$$R^{\alpha\beta} - \frac{1}{2}Rg^{\alpha\beta} + g^{\alpha\beta}\Lambda = \frac{8\pi G}{c^4\mu_0}(F^{\alpha\psi}F_{\psi}{}^{\beta} + \frac{1}{4}g^{\alpha\beta}F_{\psi\tau}F^{\psi\tau}).$$

A more relevant equation

Total amount of fissile produced –
Total amount present = 0

(in theory)

Declarations and records

- States submit comprehensive declarations of all fissile material production and holdings (including 'alternative' fissile materials as well as details of isotopics, locations, uses etc.)
- States make plant operating records available.
- The inspectorate checks for self-consistency of the declaration and the authenticity of records (using standard forensic techniques).

Nuclear forensics

- GIRM (graphite isotope ratio method) is applicable to graphite-moderated reactors.
- 34 out of 45 Pu production reactors were GMRs.
- 1995—1997: Trawsfynydd test
 - 3.63 ± 0.19 MT Pu produced
 - Within 100 kg of the “correct” answer

But what about?

- Heavy water-moderated reactors? (11 out of 45 Pu production reactors)
- Enrichment plants?
- Reprocessing plants?

Material Unaccounted For

- There is always a difference between the amount of material calculated to be present and the amount actually there called the Material Unaccounted For (MUF).
- Exists in every nuclear facility in the world.
- Indistinguishable from diversion.

Example: Sellafield MUF

BNFL on Sellafield MUF of 0.5%:

“These uncertainties exist in all industrial processes, for example the gold industry experiences the same thing when extracting gold from ores – the amount recovered never precisely matches the amount estimated in the ore.

No nuclear material has been stolen. Figures change from year to year. Negative numbers do not mean material has disappeared; positive numbers don't mean material has been created.”

UK and US inventories

	UK		US	
	Pu (MT)	HEU (MT)	Pu (MT)	HEU (MT)
Calculated holdings	3.22	21.64	102.3	623.5
Measured holdings	3.51	21.86	99.5	620.3
MUF	-0.29	-0.22	2.8	3.2
MAV	>0.2	>0.6	>3.4	>10

Material unavailable for verification

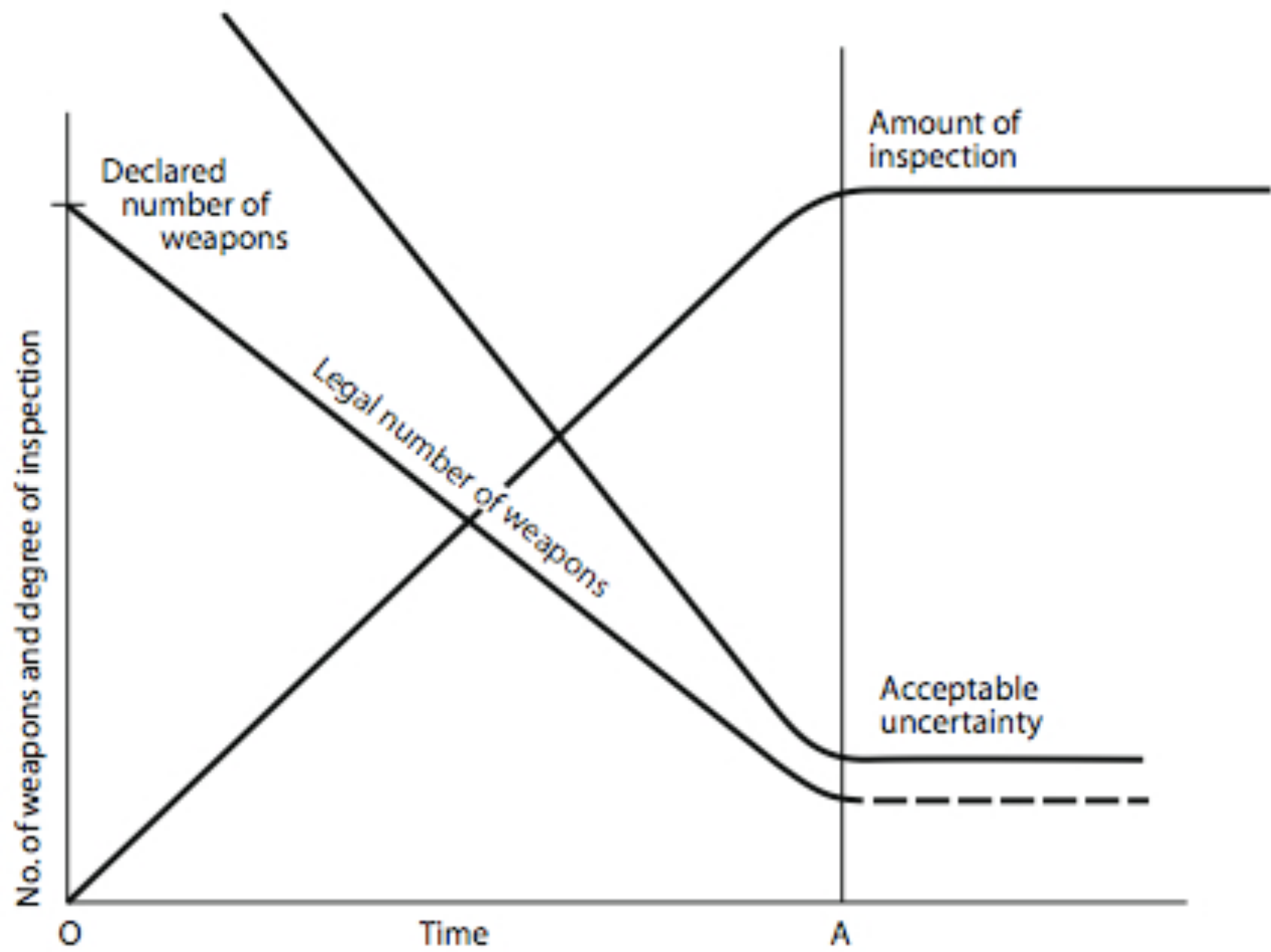
- Material that was
 - Used in tests
 - Burnt in reactors
 - Lost in waste
 - Decayed
- could not be verified with any accuracy (even though the state may have accurate figures).

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What does this all mean?

- Substantial uncertainties in fissile-material inventories are unavoidable. Even with blameless intentions and honest accounting, such uncertainties would be on the order of at least a few per cent of production.
- This problem can be mitigated somewhat—but not alleviated entirely.



Three questions for Wiesner

- Does successful verification build confidence in states' intentions?
- How small would the acceptable uncertainty at zero nuclear weapons really be?
- Can effective enforcement make up for verification imperfections?