The Rudiments of IAEA Safeguards Showing How Policy Drives Technical Goals

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Let Us Define What is Safeguards

INFCIRC 153 Para. 28: The Safeguards Technical Objective

Comprehensive Safeguards Agreement (CSA)
"Traditional Safeguards"

INFCIRC/153 Para. 28: The Safeguards Technical Objective

… the objective of safeguards is the *timely detection* of *diversion* of *significant quantities* of *nuclear material* from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and *deterrence of such diversion* by the *risk of early detection*…

NOTE KEY CONCEPTS:

- **Timeliness**
- **Significant Quantities**
- **Deterrence by Risk of Early Detection**

The Present Safeguards System - Basis

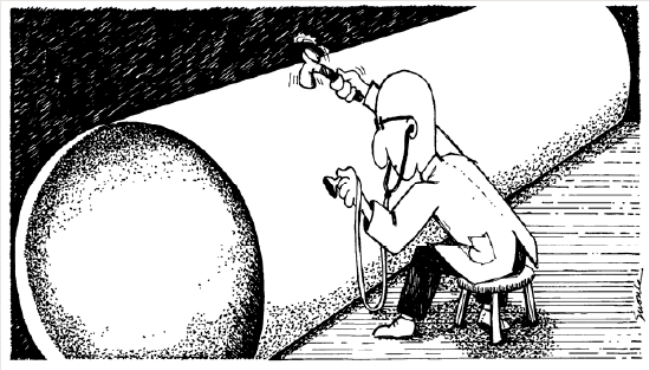
- **State Declarations** – the basis of everything – comes from the State

- **The principle of independent verification** –
  - – Started as a marriage of principles and practices borrowed from
    - ➢ Property accounting
    - ➢ Statistical quality control
    - ➢ Financial accounts auditing

- **Technology must support quantifiable independent verification for**
  - – **Timeliness Goals**
  - – **Significant Quantities Goals**
  - – **Deterrence by Risk of Early Detection by Inspectors**
    - ➢ **Inspector presence "SNRI" / Unattended systems**

The Safeguards Technical Objective - Guides Technology Development

- **Let us reiterate the following mantra…**
- **All Technology Should Work to Improve**
  - Reaching Timeliness Goals
  - Reaching Quantity Goals
  - Deterrence by Risk of Early Detection



IAEA Defines "Nuclear Material and SQ"

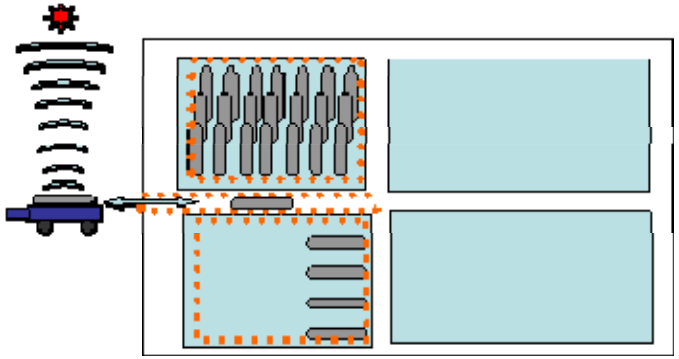
Nuclear Material	SQ in KG
Pu (<80% Pu-238)	8 kg Pu
U-233	8 kg U-233
HEU (=>20% U-235)	25 kg U-235
LEU (<20% U-235 including natural U and depleted U)	75 kg U-235 (or 10 t nat. U or 20 t depleted U)
Thorium	20 t Thorium

IAEA Defines "Timeliness" - Material Guidelines

Nuclear Material	Material Form	Conversion Time	IAEA Timeliness Goals
Pu, HEU or U-233	Metal	few days (7-10)	1 MONTH
Pure Pu components	Oxide (PuO_2)	few weeks (1-3)	
Pure HEU or U-233 compounds	Oxide (UO_2)	few weeks (1-3)	
MOX	Non-irradiated fresh fuel	few weeks (1-3)	
Pu, HEU or U-233	In scrap	few weeks (1-3)	
Pu, HEU or U-233	In irradiated fuel	few months (1-3)	3 MONTHS
LEU and Th	Unirradiated Fresh Fuel	order of 1 year	1 YEAR

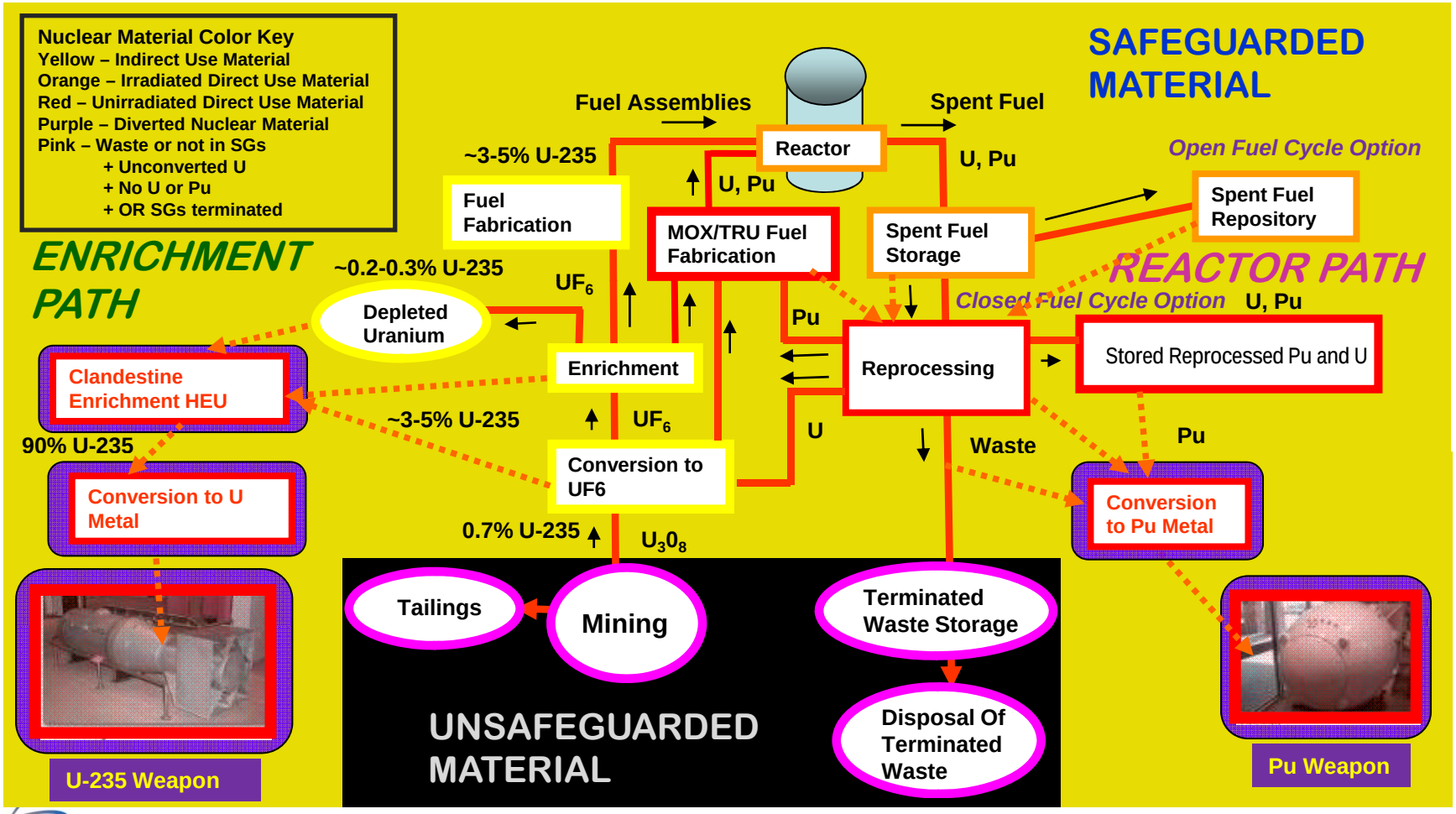
Deterrence by Risk of Early Detection

- Deterrence by Risk of Early Detection
  - Chance of detection shorter than goal period
  - Random inspections
  - UNARM technology
  - Process monitoring



UF6 CYLINDER MONITORING

Nuclear Fuel Cycle – Proliferation Aspects



Facilities Under IAEA Safeguards: Worldwide Milieu

FACILITY TYPE (DEFINED BY IAEA SAFEGUARDS CRITERIA)	WORLD LIST OF FACILITIES UNDER IAEA SAFEGUARDS
1. Light Water Reactors (LWRs)	180
2. On-Load Reactors (OLRs)	20
3. Other Types of Reactors	10
4. Research Reactors and Critical Assemblies (RRCAs)	170
5. Natural and Low Enriched Uranium Conversion & Fabrication Plants	50
6. Fabrication Plants Handling Direct-Use Material (MOX or HEU)	5
7. **Reprocessing Plants**	**10**
8. **Enrichment Plants**	**20**
9. Storage Facilities	80
10. Other Facilities (~60 Other Facilities under SGs)	60
11. Locations Outside Facilities (LOFs)	60-70

Strengthened Safeguards System (SSS)

Post Gulf War (1991) Iraq Clandestine Program Consequences

- **THE UPDATED OBJECTIVES**

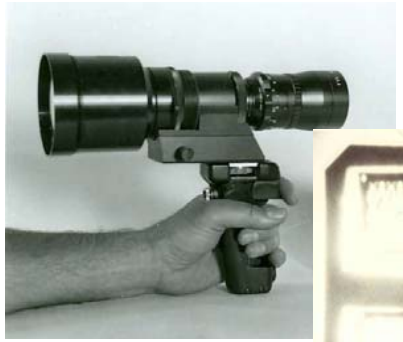
"the safeguards system should be designed to provide credible assurances that there has been no diversion of declared nuclear material and that there is no undeclared nuclear material and activities (BOG, March 1995)"

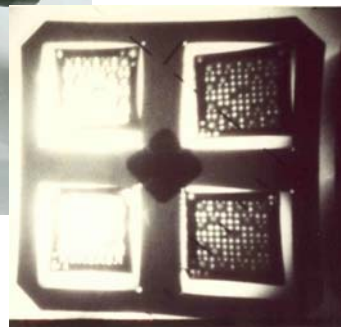
Consequences

- Additional Protocol – Complementary Access Activities
- Emphasis on information based safeguards
- Concept of Integrated Safeguards
- Increased transparency measures

IAEA Accountancy Verification Methods
Trust but Verify

- **Three levels of defects to detect with NDA Instruments:**
  - ***Gross defect***
  - ***Partial defect***
  - ***Bias defect***





- **Examples:**
  - ***Gross defect***
    - **Assembly missing/dummy sub**
  - ***Partial defect***
    - **>50% of pins missing from spent fuel assembly**
  - ***Bias defect***
    - **Enrichment or weight off by fraction in a product UF6 cylinder**

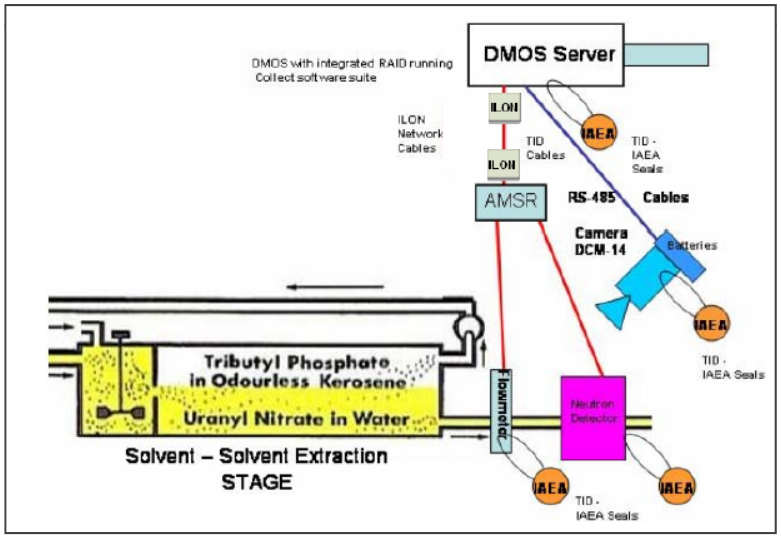
Verification Methods – The Options Available

- **Methods Available to IAEA Safeguards Inspectors by Criteria**
  - A - Identification
  - B - Weighing
  - C - Volume determination
  - D - Sampling and analysis - DA
  - E - Variables by NDA (bias defects)
  - F - Variables by NDA in attribute mode (partial defects)
  - G - Criticality check for verification
  - H - Attribute test by NDA (gross defects)
  - M - Facility specific method for in-process inventory verification

Verification Needs – Technology Gaps

- **Improved DA sampling – cost and timeliness**
- **NDA equipment – Lower Uncertainty/UNARM**
- **Process Monitoring for**
  - Accountancy
  - Additional Transparency

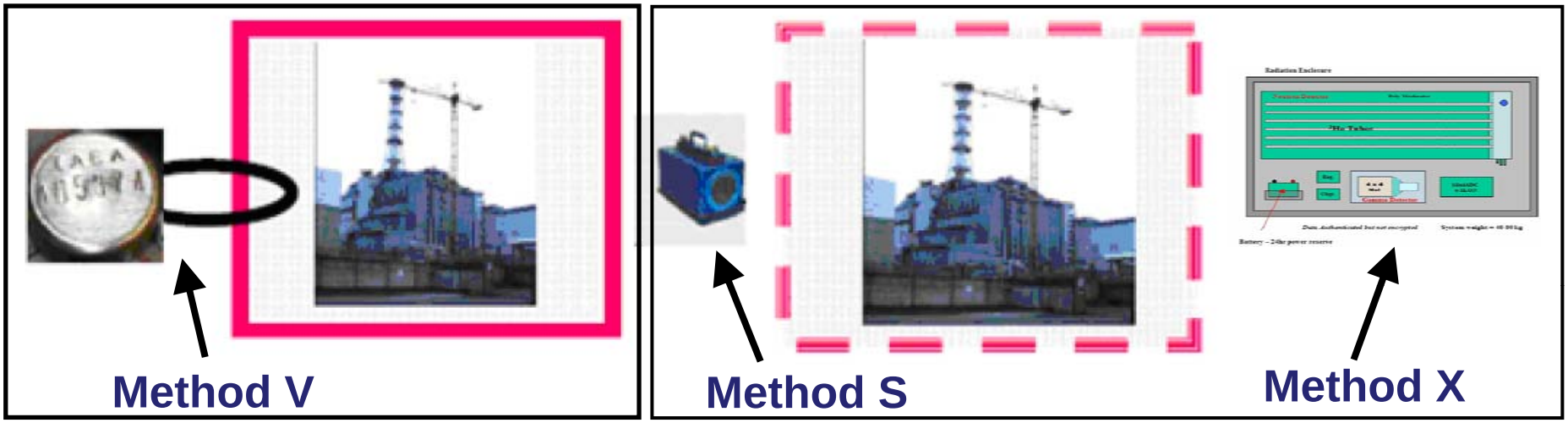
URANYL NITRATE – FLOW AND ENRICHMENT MONITOR TEST AT SPRINGFIELDS , UK (ORNL-LANL JOINT TASK)



URANYL NITRATE – FLOW AND ENRICHMENT MONITOR TOTAL SYSTEM SCHEMATIC

Containment and Surveillance Methods

With Example Chernobyl Shelter



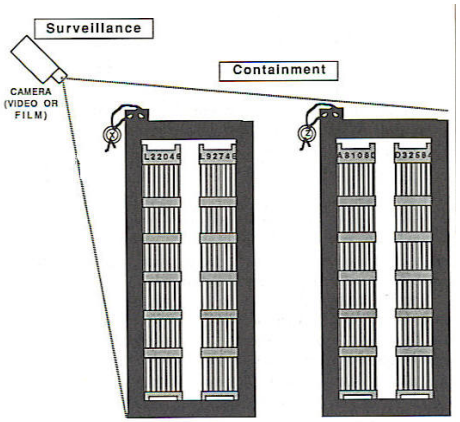
- **Methods Available to IAEA Safeguards Inspectors by Criteria**
  - S - Stratum under surveillance
  - V - Seal verification
  - X – Monitors
- **Maintain Continuity of Knowledge (CofK)!**
  - – Verification results
  - – Status of material and/or container

Containment and Surveillance Measures: Becoming more important

- **Containment and surveillance**
  - "Important complementary measures"
  - Complement accountancy
  - Cameras and seals
    - ➢Maintain knowledge established through prior verification


AP

- **Used to detect undeclared movements and access**
  - Reactor Cores, Spent Fuel
- **Increased use to detect facility misuse**
  - Enrichment beyond declared levels



Containment and Surveillance Needs

- Better cameras – image quality, color, reliability
- Seals security
- Authentication of signals
- UNARM integrated platform
- Tracking capability – RFID/GPS
- Radiation and other means to “see” objects

Undeclared Facility Methods: Reach SSS Goals

Methods Available to IAEA

- State Level Approach
  - Increased Information Analysis
  - Increased interest in DIV
- Additional Protocol in Force
  - Increased Info from State
  - Increased access to State
- Verification
  - AP Kit –NDA, DIV, ES
  - Wide Area ES

Undeclared Facility Technology Needs

- **Better data fusion and sifting**
- **Use of satellite photos and analysis**
- **Wide Area Environmental Sampling**
- **Environmental Sampling – Facility Specific – Timely!**
- **Ability to get expert analysis of above data**

Summary – The Big Safeguards Goals / Needs

Areas for Safeguards Technology Advancements

- **Total Fuel Cycle Concerns**
  - State Level Approach – Fuel Cycle in a State
  - Additional Protocol in Force
  - Broader Conclusion / Integrated Safeguards
  - Sensitive Technologies
    - Reprocessing
    - Enrichment
- **Reactor Path – Reprocessing**
  - Control of Spent Fuel - Source of Pu
  - Control of SF pool items - Targets for Pu production
  - Control of LEU fuel - Pu production in reactor
- **Enrichment Path – Enrichment Technology**
  - Control of Uranium – Conversion products – UF6 for enrichment
  - Control of Enrichment plant – misuse and diversion of product to HEU GCEPs
  - Control of LEU fuel - LEU for enrichment

Safeguards and Technology: The Technology Serves the Mission

- **Labs/Universities must respond to safeguards needs**
- **No need for solutions in search of problem**
- **Technology**
  - Must Solve Problems
  - Answer Questions