

The Next Steps for International Safeguards at Gas Centrifuge Enrichment Plants

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Research Questions

Dissertation Title:

The Co-development of Gas Centrifuge Enrichment Technology and International Safeguards

Last Year's CVT Talk:

What do ongoing trends in gas centrifuge enrichment technology mean for international safeguards? What can the IAEA do to keep pace with these trends?

This Year's Talk:

How can inspectorates keep pace with these trends?

[what can we learn from previous efforts to develop safeguards approaches for enrichment plants, and how can we apply those lessons to strengthen safeguards today?]



Outline

**1. Recap: The Case for Unattended Measurement Systems (UMS)
for Verifying the Absence of GCEP Misuse**

**2. Why Expanding the Use of UMS in Commercial GCEP Safeguards
Will Likely be Challenging**

**3. A Discussion of [Past] Controversial GCEP Safeguards Issues,
and Why GCEP Safeguards is the Way it is Today**

4. Steps Forward



Timely Misuse Detection

- IAEA comprehensive safeguards objectives at gas centrifuge enrichment plants (GCEPs) include timely detection of facility misuse to produce UF_6 enrichments above declared maximum, especially HEU (Cooley et al., INMM 2007).
- There exists a potential for rapid HEU production through misuse of modern, commercial-scale GCEPs. Unattended technologies for detecting signatures of GCEP misuse can address timeliness needs, potentially allowing for real-time detection (IAEA Dept. of Safeguards Long-Term R&D Milestone 5.2)



Why Move to Unattended Measurement Systems for Detecting Misuse?

- The Hexapartite Safeguards Project (HSP, 1980-1983) found that 4-12 Limited Frequency Unannounced Access (LFUA) inspections within cascade areas would be “appropriate” for facilities up to about 1000 tSWU/a
- Safeguarded gas centrifuge enrichment plants (GCEPs) have grown in capacity over the last decade, with the largest now at 5,400 tSWU/a
- If global demand for nuclear energy follows favorable projections, enrichment capacity will need to grow (in the long-term)
- Unsafeguarded GCEPs in excess of 10,000 tSWU/a could fall under an Fissile Materials Cutoff Treaty (FMCT)

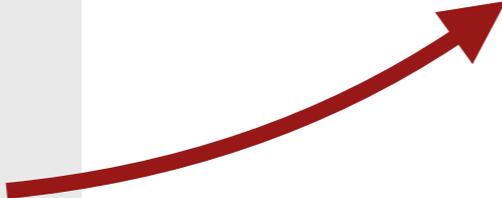
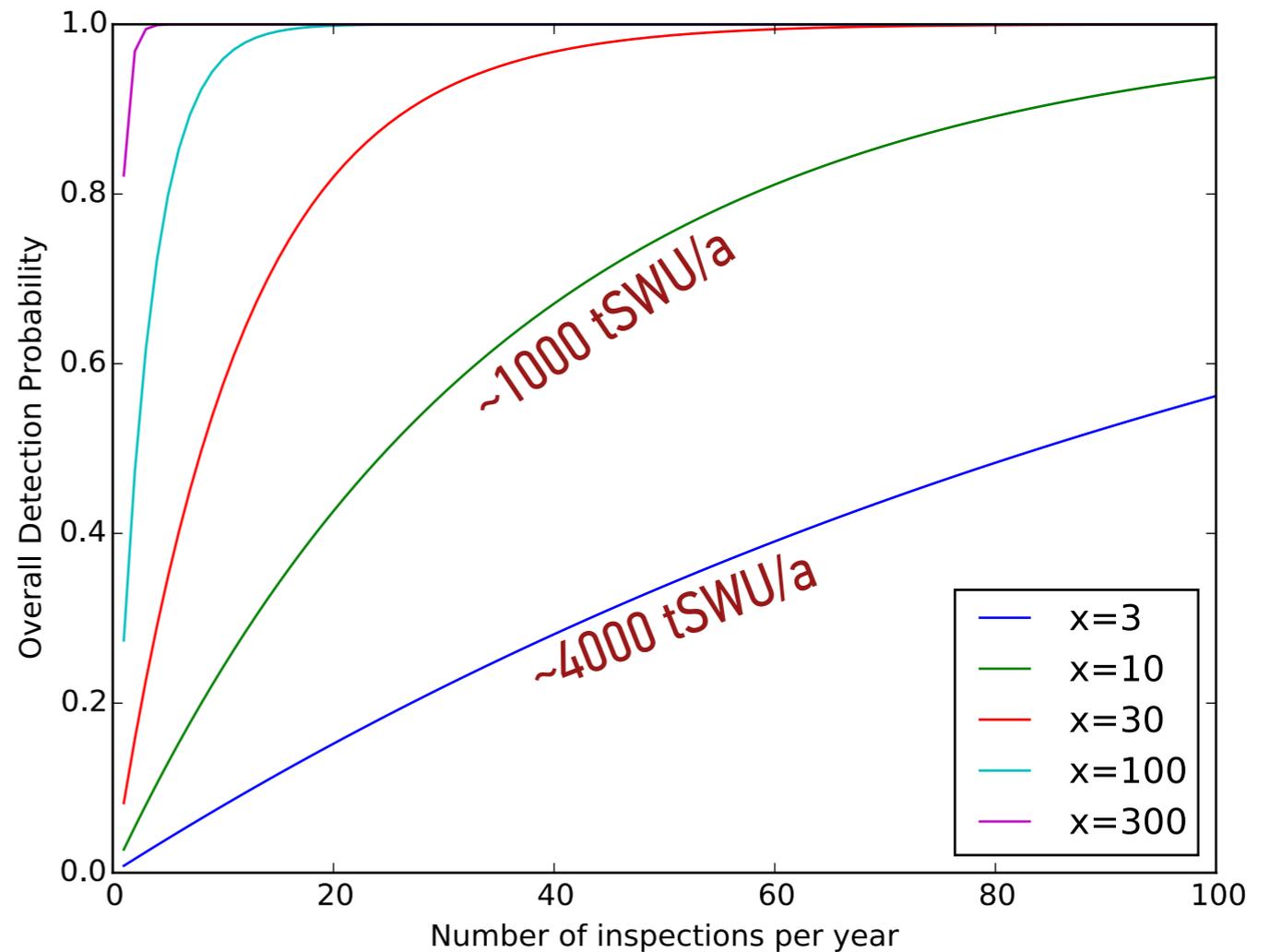


Thinking Numerically about Misuse

HSP Goal: 1-3 month inspection
 timeliness goal for HEU production
 -> 4-12 LFUAs/year
 (assuming misuse can be effectively
 detected *post facto*)

**Detection probability for a misuse
 period of x days using s inspections
 within a period of time t :**

$$P = 1 - \left(1 - \frac{x}{t}\right)^s, \quad s \leq t$$



**Dozens of LFUA visits per year:
 probably unrealistic**



A Menu of Unattended Measurement Systems for Detecting Misuse



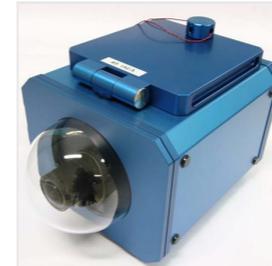
On-Line Enrichment Monitoring (unit headers)



Electronic, remote-indicating seals on potentially significant sampling ports



On-Line Flow Monitors (unit headers)



IAEA surveillance cameras at cascade hall access points, and/or on sampling ports



Unattended NDA for detecting HEU presence in process areas



Open path gas detection systems for HF



Neutron singles counters for monitoring ^{235}U transfer at feed/withdrawal stations

Remote transmission capability (real-time data or go/no-go signals) to inspectorate headquarters

The Road to Strengthening Contemporary GCEP Safeguards

Strengthening GCEP safeguards isn't just a matter of building the required technology!

The JCPOA non-precedent:

[for 15 years or longer]: “Iran will permit the IAEA the use of on-line enrichment measurement and electronic seals which communicate their status within nuclear sites to IAEA inspectors...” (JCPOA, Annex I, N.67.1)

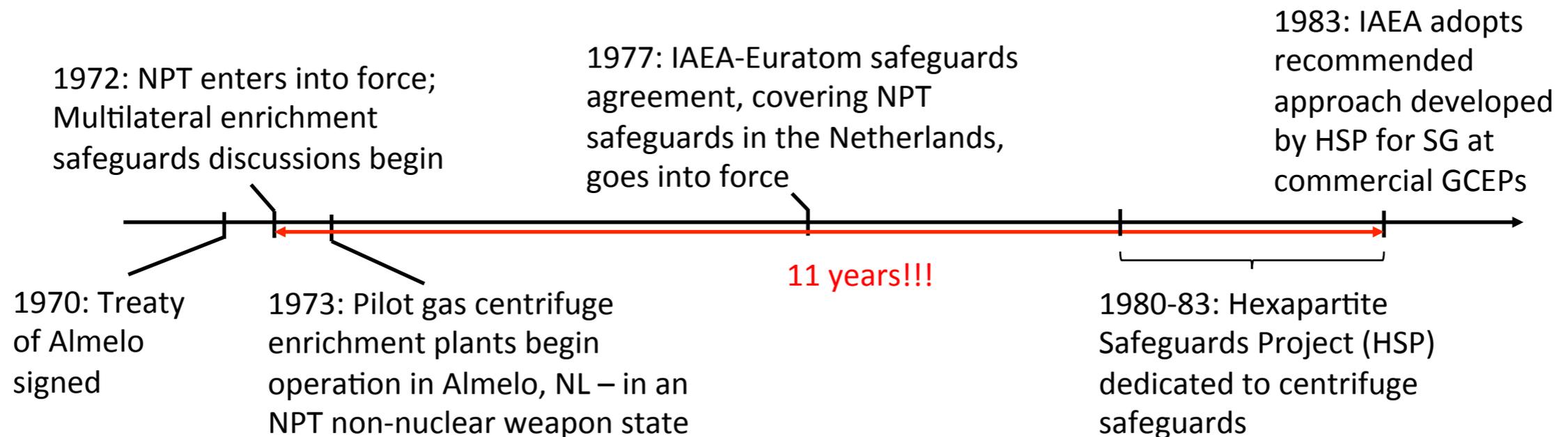
“..all provisions contained in the JCPOA are only for the purposes of its implementation between the E3/EU+3 and Iran and should not be considered as setting precedents for any other State or for principles of international law and the rights and obligations under the Treaty on the Non-Proliferation of Nuclear Weapons and other relevant instruments, as well as for internationally recognized principles and practices” (S/RES/2231, ¶27)

Even in the Western world, GCEP safeguards issues can be and have been politicized and/or contentious (not to mention in Brazil)



Initial efforts to develop a GCEP safeguards approach were highly politicized and protracted.

A highly abridged timeline:

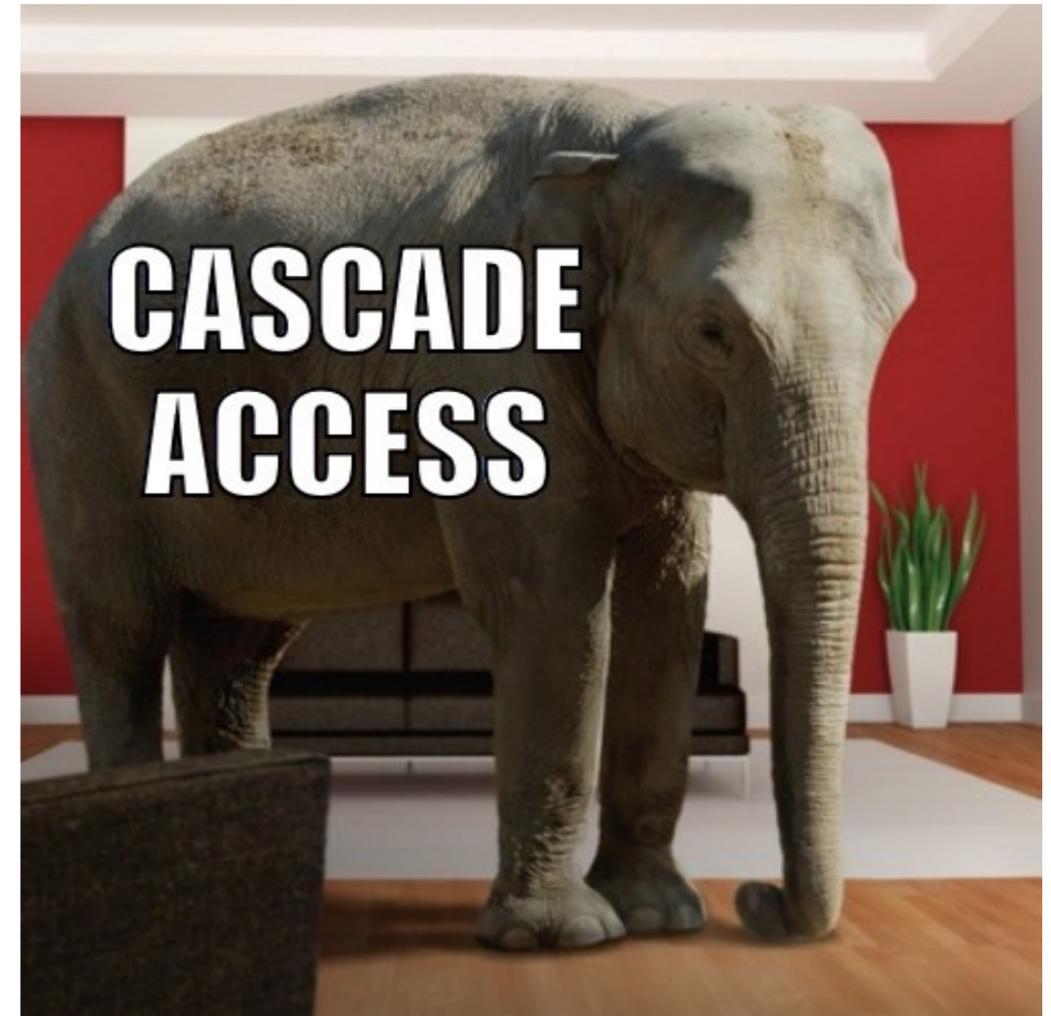


What happened in those 11 years = 3 dissertation chapters (plus 1 covering 1945-72)



Why did GCEP safeguards cause so much controversy in the 1970s and 80s?

- INFCIRC/153 does not prescribe a framework for addressing misuse, unlike for material accountancy
- IAEA was initially ‘driving blind’ with no in-house technical GCEP expertise
 - Initial “working hypothesis” (1972) that GCEP safeguards could be carried out without cascade access
 - Late 1970s: the IAEA changes its assessment during Almelo design information verification
- Other contentious issues:
 - maximum routine inspection effort (MRIE);
 - right/obligation of inspectorates to verify undeclared activities and material under comprehensive safeguards (INFCIRC/153-type)
 - accusations of “evangelistic perfectionism” (“missionarisch-perfektionistische Safeguards-Auffassung”)—can safeguards be too ambitious?



Adapted from <https://imgur.com/gallery/y8ATc>

Politicization in the HSP

- The agreed LFUA frequency itself was a product of political compromise
- November 1981: HSP parties agree to “launder” team reports to remove direct references to clandestine capacity and material
- Summer/Fall 1982: ‘Troika’ insists that cascade header enrichment monitoring is the only acceptable form of NDA allowable during LFUAs, due to security concerns, and in resistance to an NDA-heavy U.S. proposal

3.7 Limitierungen des Zugangsmodelles

- Mittlere Zugangsfrequenz

Gewählte Kompromißformel: 4 - 12 mal/Jahr für Anlagen bis zu 1.000 t UIA/a Kapazität.

...

Hauptnutznießer dieses Kompromisses sind die US, die durch erneute Reduzierung ihrer Anlagengröße (jetzt 1. Ausbaustufe 1.100 t UFA/a begründet mit Mittelfreigabe) auf ca. 12 x/Jahr von ursprünglich 2 x wöchentlich kamen.

Wir bestanden formal mit Hinweis auf IC-Entscheidung und technisch mit Hinweis auf Frequenz des Außenbereiches, die in Almelo z.Z. bereits bei 12/Jahr liegt, auf 4/Jahr.

Gerstler, “Multilaterales Kooperationsprogramm Kontrollmaßnahmen für GUZ-Anlagen “Hexapartite-Safeguards-Project: Zusammenfassender Bericht der HSP-Sitzung vom 13.-16.12. in London,” PA AA, B 72 (ZA)/129441, December 23, 1982.



Incremental Evolution of GCEP Misuse Verification Measures

[enabled by the fact that INFCIRC/153 is not prescriptive about verification measures for misuse?]

Political dispute subsides over between GCEP technology holders IAEA role in detecting undeclared material/activities; complementary access introduced under Model Additional Protocol (1990s)

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Short Notice Random Inspections to feed/withdrawal areas, with mailbox declarations (mid 2000s)

Cascade Header Enrichment Monitor (1985) ->

Continuous Enrichment Monitor (early 1990s) ->

On-line Enrichment Monitor (early 2010s)

Environmental swipe sampling in cascade areas (mid 1990s)



What does this mean for the future?

For novel fuel cycle technologies: To avoid setting unfortunate precedents, inspectorates need to be equipped with the necessary technical expertise to independently evaluate new fuel cycle technologies (and precedents are sticky).

Formal technical fora (modeled after the HSP) to address contemporary GCEP safeguards may not be optimally productive, given current political dynamics among all technology holders.

Incremental improvements to GCEP misuse verification can and should continue. These should be negotiated informally between the IAEA and the relevant authorities in technology holder States.

There can be such a thing as too much equipment—efficiency is crucial.

