# The Potential of Open Source Information in Supporting Acquisition Pathways Analysis to Design IAEA State Level Approaches

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*Ispra, Italy*

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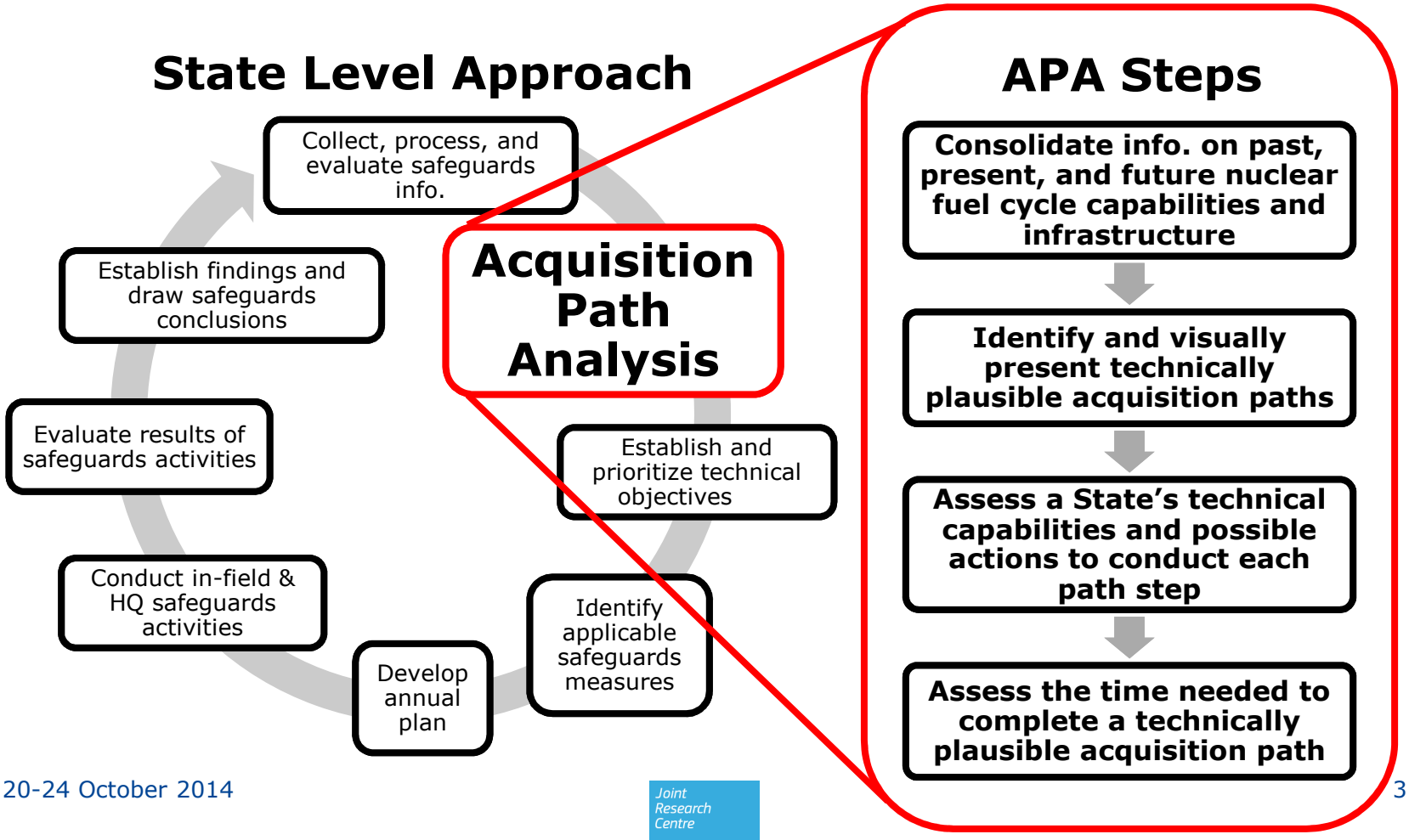
# Outline

- Acquisition Pathways Analysis and the State Level Approach
- Open source information defined
- Roles of open source information in the APA
- Informational and analytical uncertainties
- Summary

# Acquisition Pathways Analysis: Technical Backbone of the State Level Approach



# What is Open Source Information?

Open source information:

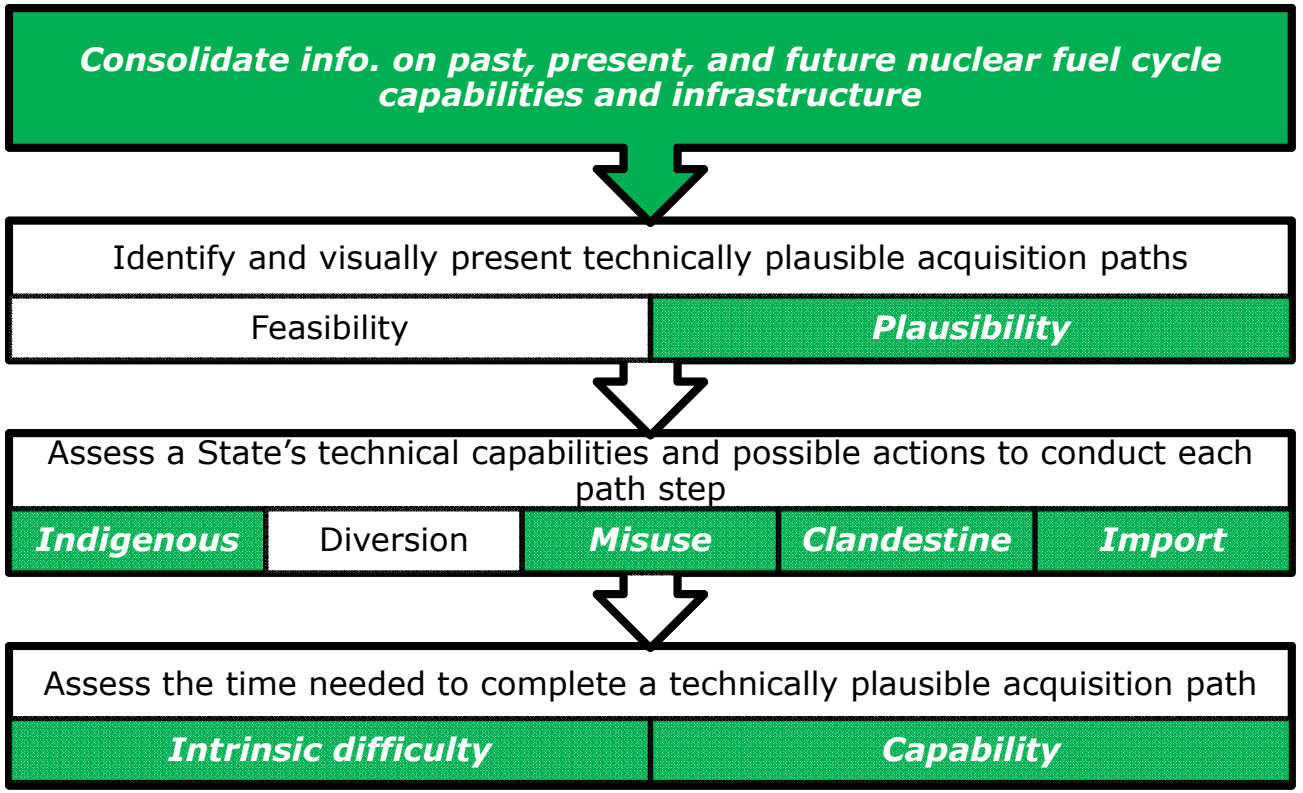
- "…publicly available information that anyone can lawfully obtain by request, purchase, or observation" – US intelligence community [1]
- "…information generally available from external sources, such as scientific literature, official information, information issued by public organizations, commercial companies and the news media, and commercial satellite imagery" [2][and trade data]. IAEA

| Analytical Area | Description |
|---|---|
| Technical and Official Information Analysis | Scientific literature, official information, information issued by public organizations, commercial companies |
| Media Monitoring | News, blogs, social networks |
| Imagery Analysis | Commercial satellite imagery, ground-level imagery |
| Trade Analysis | Trade data, legal/illicit procurement information |



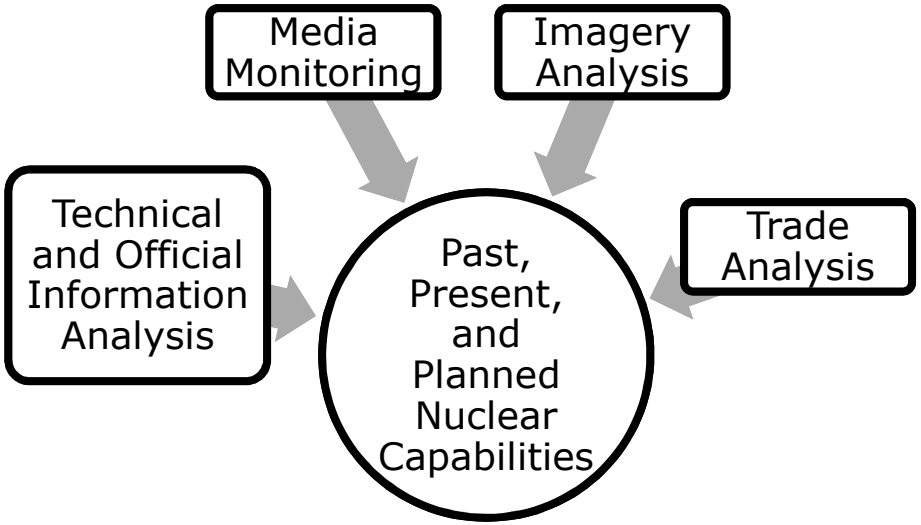
[1] Best & Cumming, "Open Source Intelligence (OSINT): Issues for Congress", CRS, 2007
[2] IAEA, "The Safeguards System of the [IAEA]"

# Roles of Open Source in the Four Steps of the APA



# Open Source Contributes to the Consolidated Information on a State's Past, Present, and Planned Nuclear Capabilities

| Information Collection Areas [1] | |
|---|---|
| Present Nuclear Fuel Cycle | Declared facilities, LOFs, and sites |
| | Exports and imports of nuclear material |
| | Nuclear fuel cycle related R&D |
| | Exports and imports of equipment and non-nuclear material |
| | Uranium mines and concentration plants |
| | Pre-34(c) material holders |
| Past nuclear fuel cycle activities | |
| Planned nuclear fuel cycle activities | |
| Identified anomalies | |



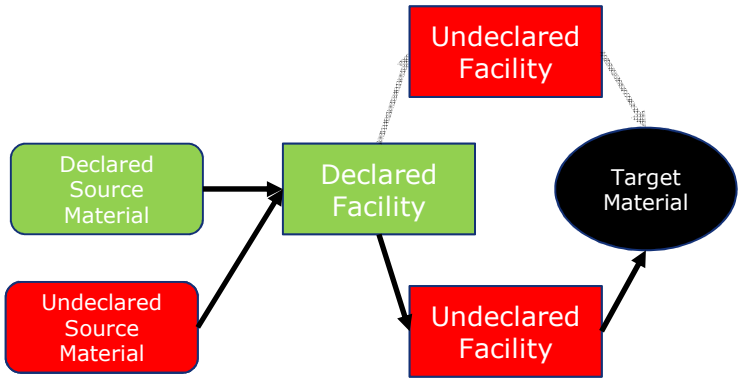

[1] Renis, "Conducting Acquisition Path Analysis for Developing a State-level Safeguards Approach" INMM, 2014.

# Feasible Path Step Identification: State Declarations and the Physical Model are Paramount

**Identification of *feasible* path steps:**

Starting with declared capabilities….


Feasible pathways are identified via a process of addition




*Feasibility* reflects technological possibilities irrespective of a state's ability to pursue the path.

Verified state declarations and the physical model [1] are the most valuable sources of information -> Open sources play a corroborating role



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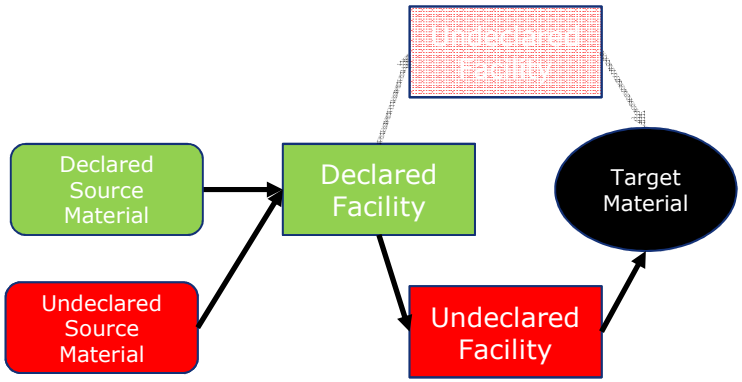
[1] Liu & Morsy, "Development of the Physical Model," IAEA Safeguards Symposium, 2007.

# Open Source Contributes to Plausibility Assessments

*Plausibility* is a preliminary assessment of completion time:

- Acquisition paths are considered technically plausible if the State could, "*…from a technical point of view, acquire at least one significant quantity of weapons-usable material within five years.*"[1]

**Identification of *plausible* path:**




**Types of Path Steps:**
- **Indigenous** production of pre-34(c) material
- **Diversion** of declared nuclear material in declared facilities or LOFs
- Undeclared production or processing of nuclear material in declared facilities or LOFs **(misuse)**
- Undeclared production or processing of nuclear material in undeclared facilities **(clandestine)**
- Undeclared **import** of nuclear material[1]



[1] Renis, "Conducting Acquisition Path Analysis for Developing a State-level Safeguards Approach" INMM, 2014.

# Open Source's Contributions to State Technical Capability Assessment Varies by Path Step Type

| Step Type | Information Needs | Role of Open Source |
|---|---|---|
| **Indigenous Production** | Sources of nuclear material containing U/Th not yet suitable for fuel or enrichment | CSA-only: may be only source of information<br>CSA+AP: corroboration of state declarations |
| **Diversion** | Nuclear material quantities and characteristics | OS plays corroborating role, verified state declarations are paramount |
| **Misuse** | Capability to modify facilities and handle material | OS contributes to state capability assessment |
| **Clandestine** | Knowledge and infrastructure | OS may be only source of information available to the agency, corroboration of third-party information |
| **Import** | Indications of import | OS may be only source of information available to the agency, corroboration of third-party information |

# Open Source Supports Estimates of Completion Time

Completion time is a combination of:

- Intrinsic difficulty of the step
- Technical capability of the state to complete the step

**Historical Completion Times [1]**

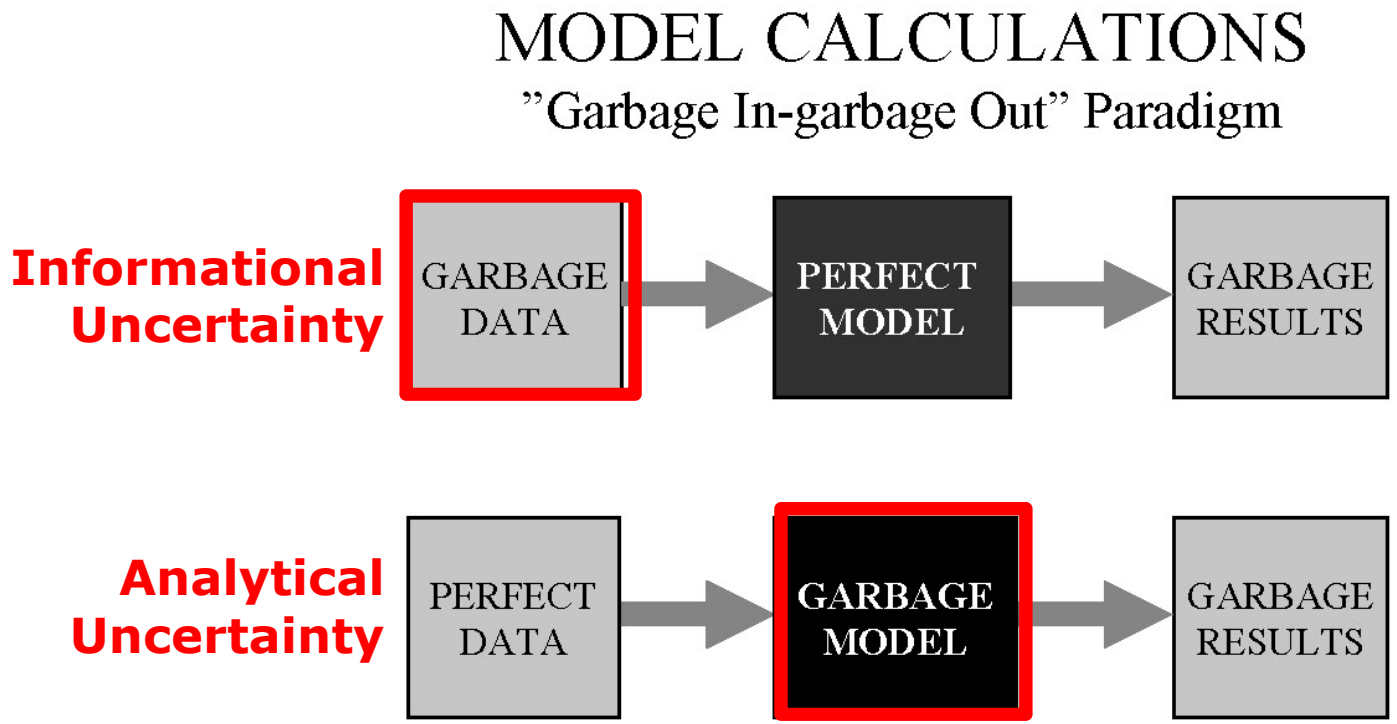
| Technology | Success Rate | Average Time to Pilot Plant (years) | Average Time to Production (years) |
|---|---|---|---|
| Enrichment (diffusion) | 83% | | 6 |
| Enrichment (centrifuge) | 39% | 8 | 14 |
| Enrichment (EMIS) | 9% | 2 | 3 |
| Enrichment (chemical) | 0% | 6 | 11 |
| Enrichment (aerodynamic) | 33% | 7 | 18 |
| Enrichment (laser) | 0% | | |
| Graphite-moderated production reactors | 100% | 1 | 2-11 |
| Heavy-water-moderated production reactors | 42% | 1 | 2-6 |
| Research reactors | 21% | | 4-5 |
| Reprocessing | 68% | 6 | 10 |



Joint Research Centre

[1] Zentner, et al. "Nuclear Proliferation Technology Trends Analysis," PNNL, 2005

# Sources of Uncertainty When Estimating Time



# Open Source Information May be Incomplete, Unreliable, Ambiguous, and Deceptive


| Open Source | Denial and Deception Methods[1] |
|---|---|
| Technical and Official Information & Media Monitoring | • Manage publications<br>• Use widely available technical information<br>• Alternative or modified processes<br>• Claim legitimate applications<br>• Alter, mask, or suppress effluents |
| Imagery Analysis | • Conceal or place within other secure facilities<br>• Mask true use |
| Trade Analysis | • Shuffle, divert acquisitions<br>• Obtain from multiple suppliers/intermediaries<br>• Mix with legitimate uses<br>• Develop clandestine networks<br>• Produce indigenously<br>• Divert equipment from legitimate activities<br>• Alternative processes<br>• Claim legitimate uses |

[1] Adapted from: "Technologies Underlying Weapons of Mass Destruction," Office of Tech. Assessment, 1993.

# Quantitative and Qualitative Judgments May be Misleading when Assessing Intrinsic Difficulty

## Quantitative estimate of a "quick and dirty" reprocessing facility [1]

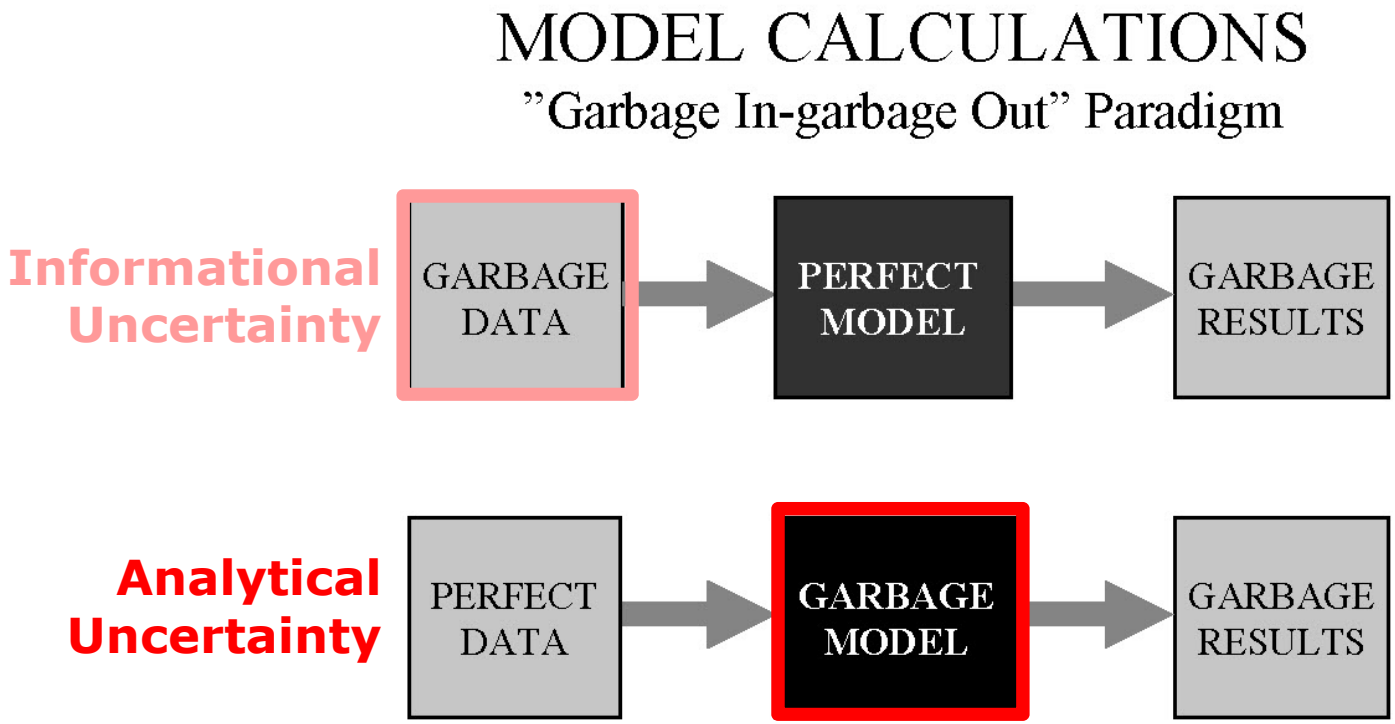
| Study | Description | Personnel | Time |
|---|---|---|---|
| Oak Ridge (1977) | *"…some materials could be acquired from a small industry such as winery, dairy, or oil refinery."* | | • Lead time: 4-6 months<br>• 10 kg in ~1 week |
| Sandia (1996) | *"a relatively simple process…operated by an adversarial group in makeshift or temporary facilities such as a remotely located warehouse or small industrial plant"* | 6 (BS-level chemist/ chemical engineer, mechanical engineer, electrical engineer) | • Lead time: 6 months<br>• 1 SQ in 8 weeks |

## Qualitative judgments may be misleading: Is enrichment hard or easy?[2]

| Hard? | Easy? |
|---|---|
| *"…all enrichment techniques demand sophisticated technology and large and expensive facilities"* | *"…it is feasible for countries with no prior experience, 'that possess relatively little technical skills and which have relatively little industrial activity to produce enriched uranium for nuclear weapons by means of a small centrifuge plant.'"* |

[1] Gilinsky, et al. "A Fresh Examination of the Proliferation Dangers of Light Water Reactors," NPEC, 2004.
[2] Kemp, "The Nonproliferation Emperor Has No Clothes," International Security, 2014.

# Sources of Uncertainty When Estimating Time

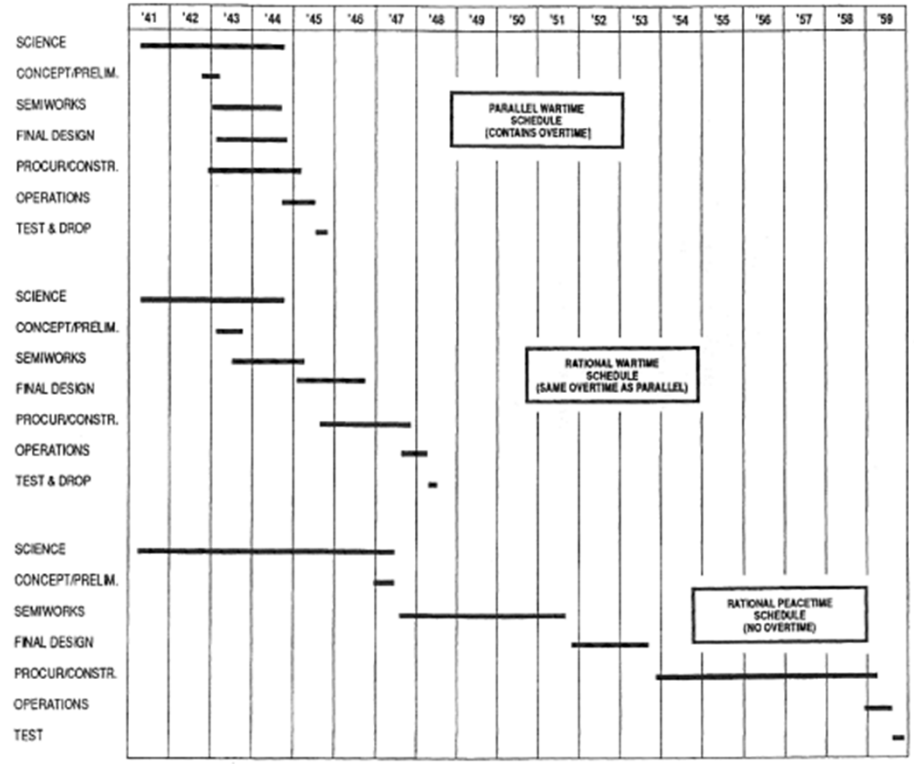


# Completion Time: Analytical Processes Propagate Informational Uncertainties

| Step Type | Production Factors | Description |
|---|---|---|
| Diversion | Mostly fixed | Facility design and material properties are fixed in the short-run |
| Misuse | Fixed and variable | Process modifications are considered, but existing facilities impose constraints over the short-run |
| Clandestine/ Indigenous | Variable | No constraints on production in the long-run |

**Increasing analytical uncertainty**

# Completion Time: Technical Estimates May Be Erroneous




Hanford Gannt Chart [1]

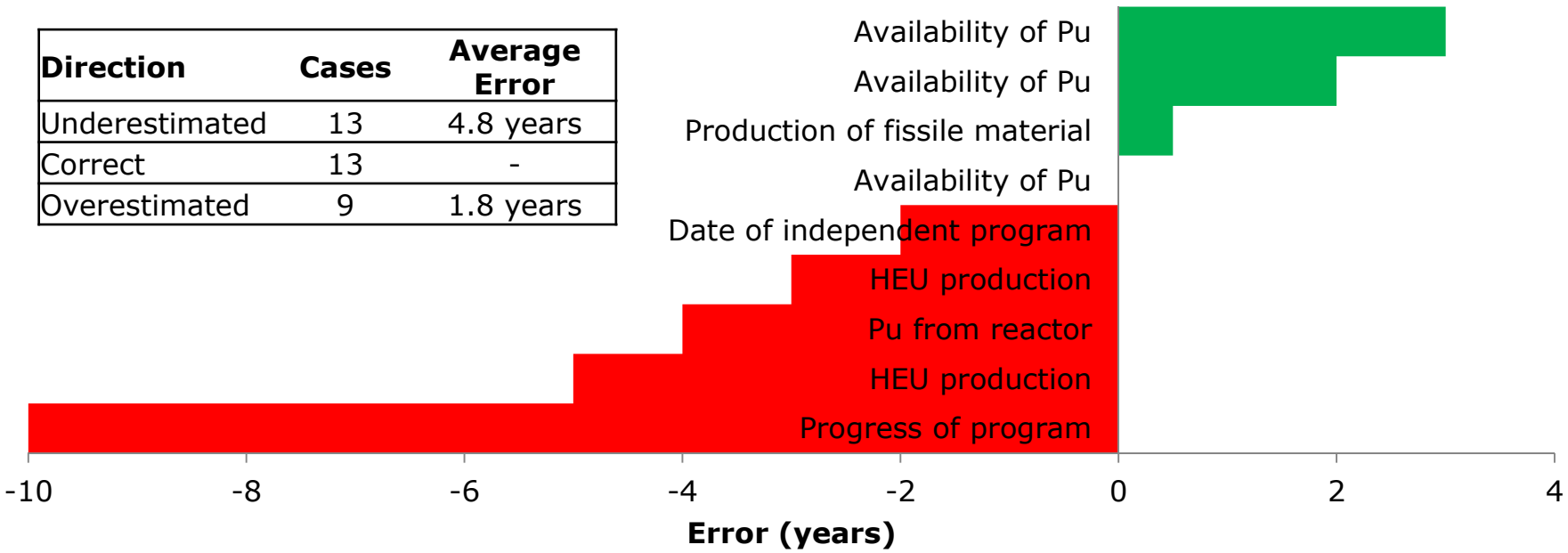
| | |
|---|---|
| **Parallel wartime :** | **~ 5 years** |
| **Rational wartime :** | **~8 years** |
| **Rational peacetime :** | **~19 years** |

[1] Thayer, "Management of the Hanford Engineer Works in World War II: How the Corps, DuPont, and the Metallurgical Laboratory Fast Tracked the Original Plutonium Works," 1996

# Completion Time: Forecasting Errors Can Undermine Plausibility Determinations

**Misestimates of Foreign Nuclear Capabilities**

| Direction | Cases | Average Error |
|---|---|---|
| Underestimated | 13 | 4.8 years |
| Correct | 13 | - |
| Overestimated | 9 | 1.8 years |




A capability judged to be implausible within five years may exist!

Derived from: Montgomery and Mount, "Misestimation: Explaining US Failures to Predict Nuclear Weapons Programs," Intelligence and National Security, 2014.

# Summary

| APA Path Step | Path Step Type | Role of Open Source | Uncertainties | |
|---|---|---|---|---|
| | | | Info. | Analytical |
| Consolidated information | - | Contributes to all-source information collection | - | - |
| Path Identification | Feasible steps | State declarations and physical model are paramount | - | - |
| | Plausible steps | See Technical Capability and Time | | |
| Technical Capability | Indigenous | CSA-only: may be only source | - | - |
| | | CSA+AP: corroboration | - | - |
| | Diversion | Corroboration of declarations | | Mostly fixed factors |
| | Misuse | Capabilities to modify/exploit existing equipment | Denial and deception | Fixed and variable factors |
| | Clandestine & Import | Informs assessment of state's capability | Denial and deception | Variable factors |
| Estimating Time | - | Informs assessment of the intrinsic difficulty of a step | Potentially misleading statements | Errors may be comparable to technical plausibility criterion |

# Conclusions

- Open sources can support Acquisition Pathways Analysis
- Depending on the APA stage, the role of open sources could vary from corroboration of already known information to providing indicators of possible undeclared nuclear activities
- The nature of open source evidence requires careful management of informational and analytical uncertainties
- Needs to be seen together with all other safeguard relevant information sources to be  assessed

# Acknowldegments

The work here presented is being carried out within the project "Innovative concepts and methodologies for Nuclear SAFeguards", INSAF funded by the European Commission (EC) Euratom Horizon2020 Research and Training Programme, as contribution to the EC Support Programme to the IAEA.

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# Information Consolidation: Roles of Open Source

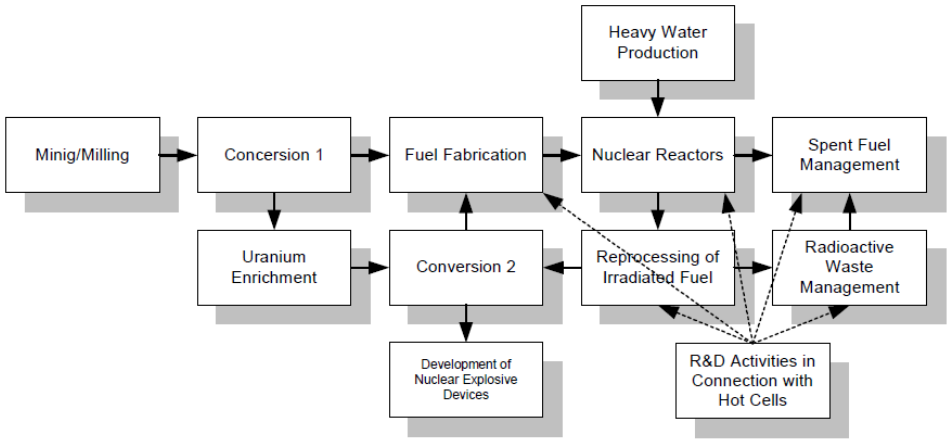
| Information Collection Areas | | Potential Role of Open Source Analysis | Technical/ Official Information Analysis | Media Monitoring | Imagery Analysis | Import/ Export Analysis |
|---|---|---|---|---|---|---|
| Present nuclear fuel cycle | Declared facilities, LOFs, and sites | CSA-only: Corroboration (facilities & LOFs)<br>CSA+AP: Corroboration (sites) | Y | Y | Y | - |
| | Exports and imports of nuclear material | Corroboration of state declarations | Y | Y | - | Y |
| | Nuclear fuel cycle related R&D | CSA-only: main source of information<br>CSA+AP: corroboration of state declarations | Y | Y | - | Y |
| | Exports and imports of equipment and non-nuclear material | CSA-only: main source of information<br>CSA+AP: corroboration of state declarations | Y | Y | - | Y |
| | Uranium mines and concentration plants | CSA-only: main source of information<br>CSA+AP: corroboration of state declarations | Y | Y | Y | Y |
| | Pre-34(c) material holders | CSA-only: main source of information<br>CSA+AP: corroboration of state declarations | Y | Y | - | Y |
| Past nuclear fuel cycle activities | | Corroboration of initial declaration | Y | Y | Y | Y |
| Planned nuclear fuel cycle activities | | Indications of plans to acquire capabilities | Y | Y | Y | Y |
| Identified anomalies | | Indication and investigation of anomalies | Y | Y | Y | Y |

# Path Step Types: Roles of Open Source

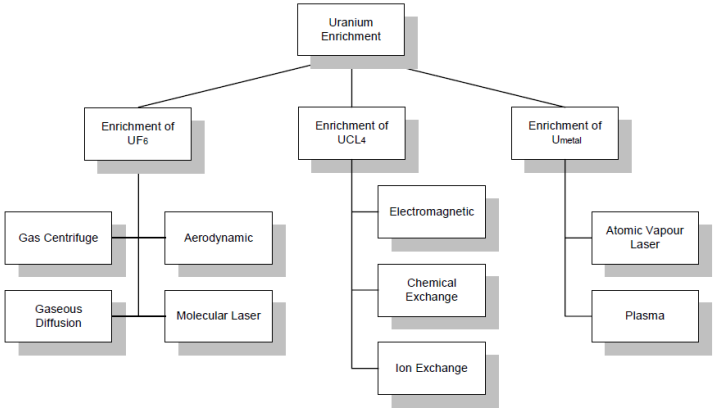
| Acquisition Path Step Type | Technical/Official Information Analysis | Media Monitoring | Imagery Analysis | Import/Export Analysis |
|---|---|---|---|---|
| **Indigenous Production** | U/Th deposits, production activities/ capabilities | Current and planned activities | Monitoring of sites | Import/export of material and equipment |
| **Diversion** | IAEA-reported anomalies found during inspections | Third-party information* | - | - |
| **Misuse** | Technical capability to modify facilities and handle material | Third-party information* | - | Import/export of material and equipment |
| **Clandestine** | Knowledge and infrastructure | Third-party information* | Investigation of possible sites | Import/export of material and equipment |
| **Import** | Indications of import | Third-party information* | - | Import/export of material and equipment |

* e.g. national intelligence agencies, non-governmental organizations, dissident groups, whistle-blowers, etc.

# IAEA Physical Model




**Top level acquisition path**



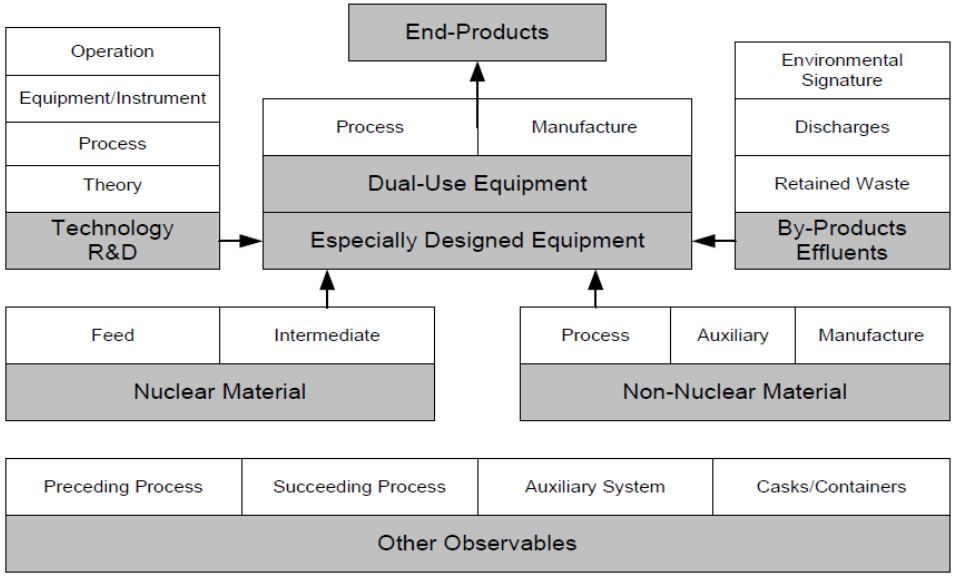

**Acquisition path for uranium enrichment**



Liu & Morsy, "Development of the Physical Model," IAEA Safeguards Symposium, 2007.

# IAEA Physical Model (continued)

## Eight Elements of a Process




## Strength of Indicator

- **Strong:** if process A implies and is implied by indicator X
- **Medium:** if process A implies indicator y and indicator y may imply process A
- **Weak:** if process A may imply indicator z and indicator z may imply process A



Liu & Morsy, "Development of the Physical Model," IAEA Safeguards Symposium, 2007.