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TESTING AND ASSESSMENT OF INPUTS FOR PROLIFERATION ASSESSMENT TOOLS

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Summary

- Goal of Research: Develop, define, characterize, and test a limited group of critical attributes which
  - Can potentially be used in multiple proliferation risk assessment methodologies
  - Improve the auditability, transparency, and flexibility of assessment tools
  - Rely as little as possible on subjective judgment
  - Exclude internal interdependencies to the greatest degree possible
  - Make clear where subjectivity and dependencies can not be avoided and evaluate the effect

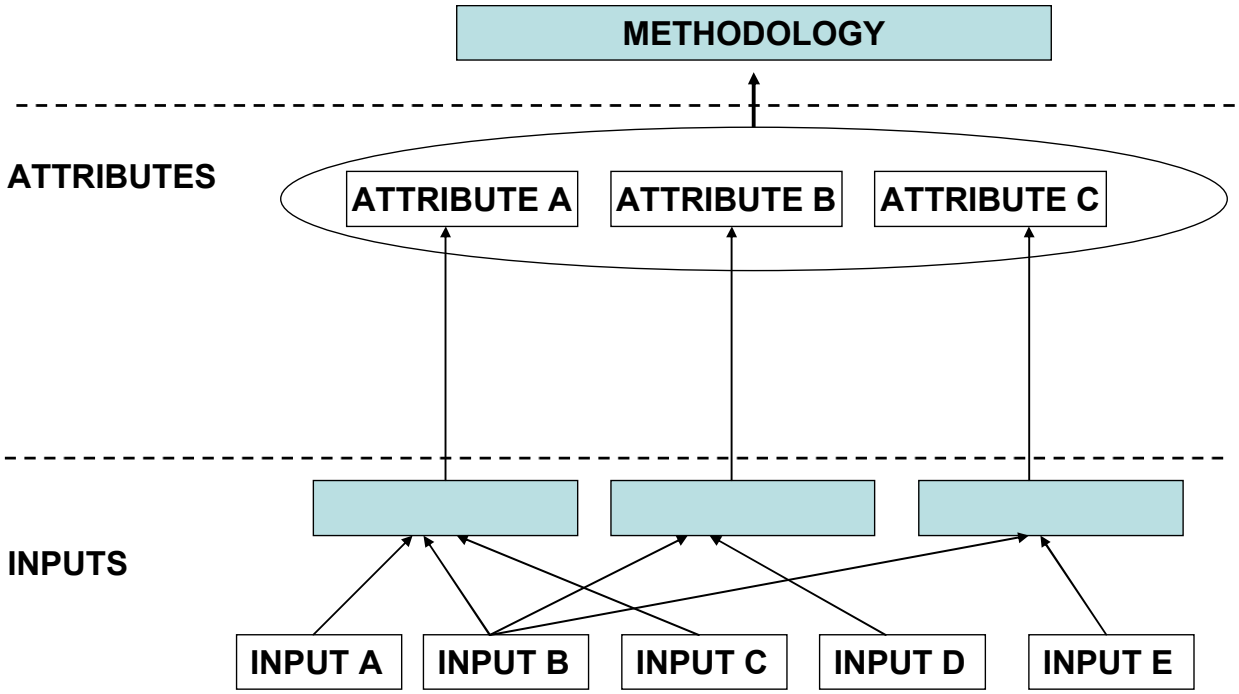
- Goal of Presentation:
  - Demonstrate an evaluation of a set of a draft set of inputs and attributes

Terminology, Definitions, and Assumptions (1)

- "Proliferation Assessment Tools"
  - Encompasses both "Proliferation Resistance" vs. "Proliferation Risk"; Work is relevant to both.
- "Proliferation"
  - Work is aimed at assessing the development *by a state* of weapons capabilities using *civilian nuclear technology* under state control and *international safeguards;*
  - Theft (insider or outsider) not considered

Terminology, Definitions, and Assumptions (2)

- Methodology = the process by which attributes are combined to allow analytic conclusions about systems
- Attribute = A measure of a system derived from one or more inputs
- Input = Discrete elements of a system, the most basic of which can be directly measured; May be a hierarchy of inputs



Desirable Characteristics of Technical Assessment Tools

1. **Auditable**

   Assessment tools should readily allow others to review results of application

2. **Transparent**

   Users should be able to easily determine *what* data was used *how* it was obtained, and how each element affects the results. The use of expert judgment should be explicit and the existence of relationships which may unintentionally weight or discount results should be identifiable

3. **Flexible**

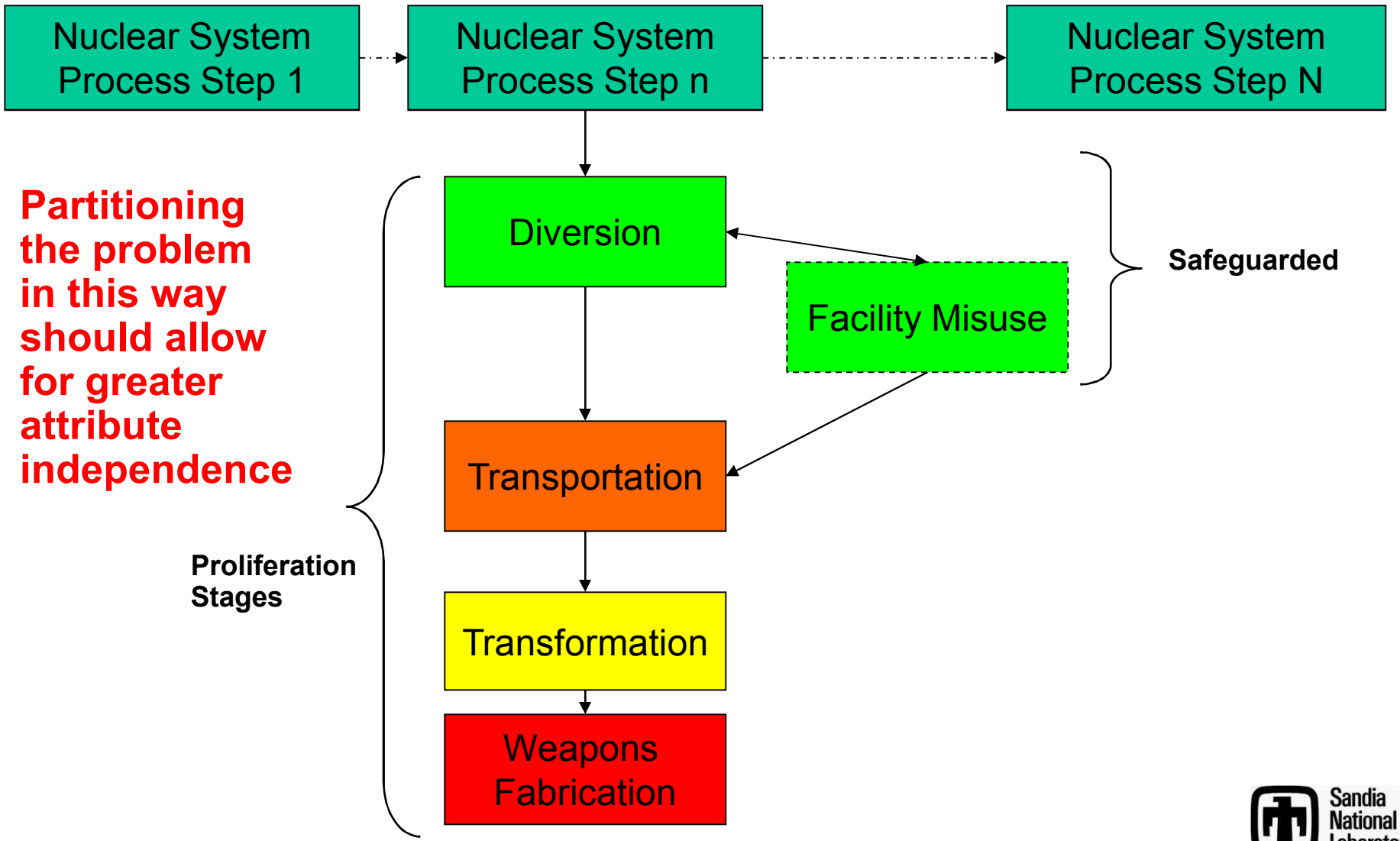
   - Allow for sensitivity analysis
   - Applicable to any nuclear process, facility or activity (or sets of technologies)
   - Applicable to multiple users with access to different levels of information

These characteristics highlight the importance of focusing on the foundations of assessment tools

Approach to Input Development and Evaluation

- Developed a draft set of inputs and attributes applicable to multiple aggregation approaches
- Method:
  - Subdivide proliferation pathways which begin in safeguarded civilian facilities into ever-smaller elements to reach as basic a level of input as possible
  - First subdivision guided by the Simplified Approach for Proliferation Resistance Assessment of Nuclear Systems (SAPRA) use of “proliferation stages”

Proliferation Stages



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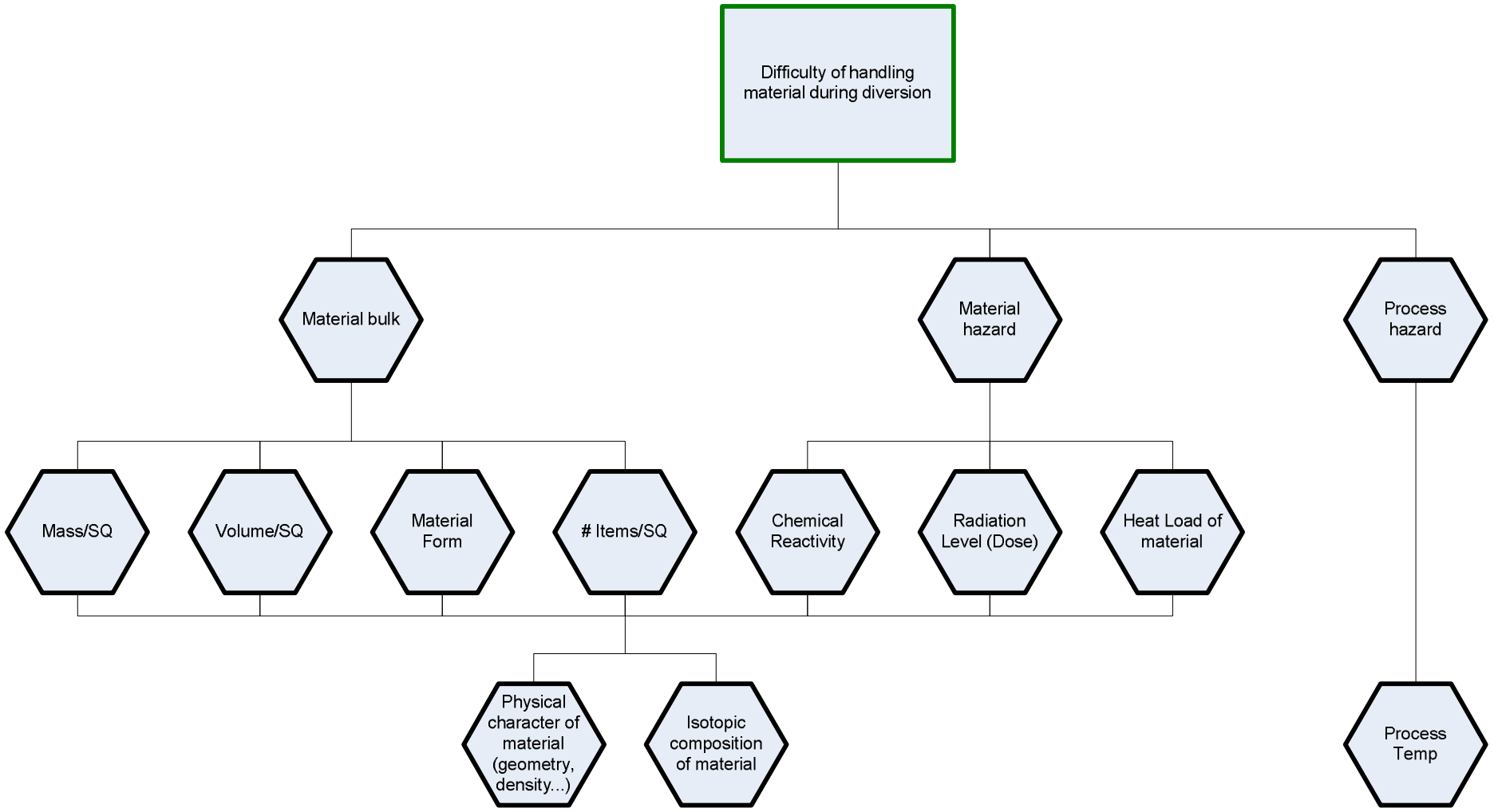
Example of Attribute and Input Development in Diversion Stage

- Material handling difficulty during diversion
  - Mass/SQ of nuclear material (mass)
  - Volume/SQ of nuclear material (volume)
  - Number of items/SQ (count)
  - Material Form – solid, powder, liquid, gas
  - Radiation level in terms of dose (Sv/hr)
  - Chemical reactivity
  - Process temperature
  - Heat load of material (Thermal watts)
- Difficulty of evading detection by the accounting system
- Difficulty of evading detection by the material control system
- Difficulty of conducting undeclared facility modifications for the purposes of diverting nuclear material
- Difficulty of evading detection of the facility modifications for the purposes of diverting nuclear material

Example of Input Mapping within an Attribute



Evaluating Inputs and Attributes (1)

- Use of Case studies
  - Substantial detail
  - Developed using standardized approach
- Example:
  - Host state diverts 2,174 kg of UF6 (equivalent to 75 kg of LEU enriched to 5 percent U235 – 1 SQ) over a protracted period.
  - Shipments arrive at the facility from a multi-national fuel supplier and are processed by the host state to produce LEU fuel for its power reactors.
  - Host state enriches the material diverted to high-enriched uranium and convert it to metal in a covert facility and fabricate a nuclear weapon.

Evaluating Inputs and Attributes (2)

- Within each case study, we test the attribute and input set across four characteristics:
  1. Quantifiability – the ability to associate a number on each input
  2. Completeness – an assessment of whether the input and attribute set accounts for all proliferation-relevant factors
  3. Subjectivity – where is subjective judgment required to obtain a number for each input
  4. Independence – the existence of relationships and dependencies between inputs and attributes

Quantification Evaluation

- **Three types of results:**
  1. **Input numbers could be calculated or obtained through direct measurement (assuming sufficient access)**
     - Example: Mass/SQ of nuclear material (2,174 kg of UF6 per SQ of finished product)
  2. **Input numbers had to be assumed due to lack of data (often due to the confidentiality of IAEA safeguards data or commercial confidentiality)**
     - Example: Uncertainty in accountancy measurements (given by scenario description)
  3. **Input numbers were associated with qualitative processes (e.g., yes = 1)**
     - Example: Chemical reactivity (High - highly toxic, highly corrosive)

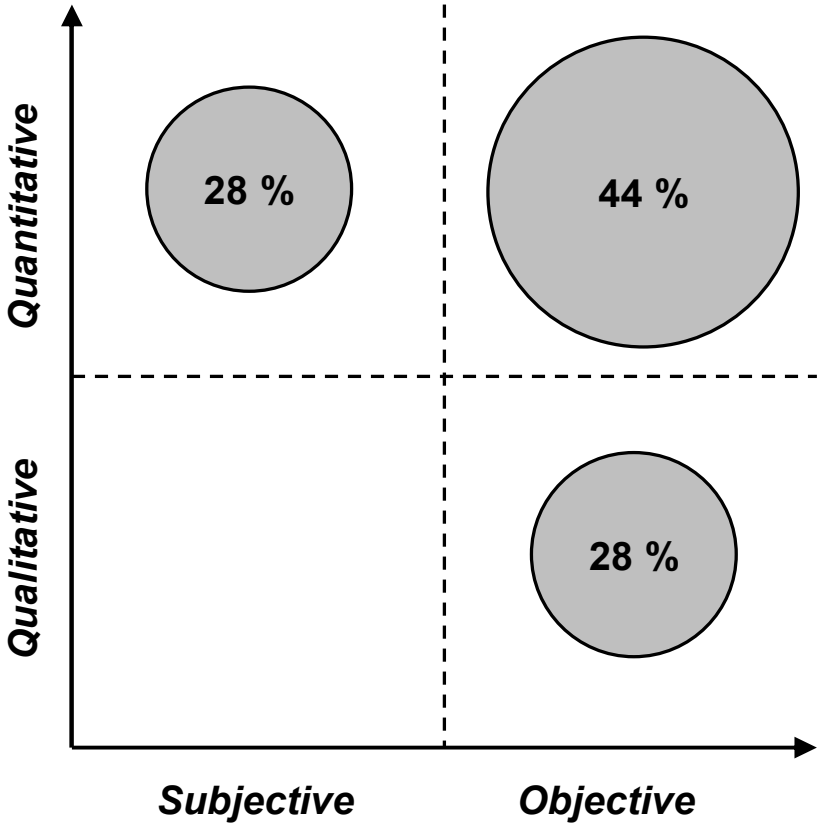
Completeness Evaluation

- Within this limited case study, the input parameters were a sufficient basis for analysis
- Some parameters were not applicable
- More case studies will need to be examined to fully evaluate completeness

Subjectivity Evaluation

- Objectively quantitative
  - E.g., Mass
- Objectively qualitative
  - E.g., Material form
- Subjectively quantitative
  - E.g., Percentage of facility under effective surveillance
- Subjectively qualitative
  - E.g., Need for nuclear engineering expertise

- We identified no inputs as being obtainable via subjective judgment and only expressible through qualitative terms. More than 40 percent were objectively quantifiable



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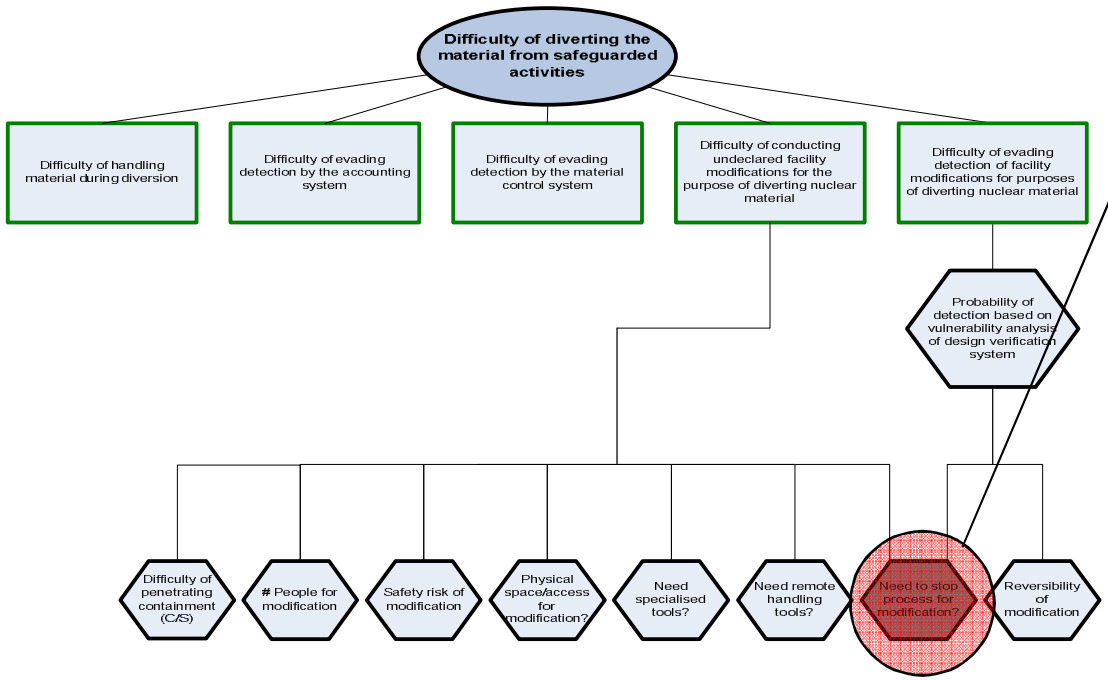
Independence Evaluation (1)

- Inter-relationships between inputs and attributes *may* result in a particular element being inappropriately counted multiple times during aggregation thereby giving it more influence on the analysis that it deserves.
- Initial analysis suggests two types of inter-relationships
  - Repeated use
  - Physical or conceptual dependency.
- The existence of inter-relationships, especially of the first type, do not necessarily adversely affect analysis.
- Testing helps the analyst identify where relationships may exist in a rigorous manner.
- Once identified, however, the analyst must review the nature of the relationship to determine whether it is indeed problematic.

Independence Evaluation (2)

- Visual identification through use of input maps
  - Single inputs contributing to multiple attributes



- "Need to stop process for modification?" was the only relationship identified in the diversion stage
- In this case, the input contributes differently to each attribute and was thus determined to have no adverse effect

- When the analysis is expanded, formalized statistical techniques, such as orthogonal sampling, may complement mapping
- When complex aggregation methods are employed, statistics tests may also be able to identify the magnitude of the relationship

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Further Evaluation and Testing

- Further testing across all stages of proliferation, evaluating alternative case studies, and likely employing more complex aggregation methods is necessary before conclusions can be reliably reached
  - Testing across multiple stages will likely reveal additional relationships including some in which a single input has contradictory effects (e.g., isotopic composition may make material accountancy more difficult but also make the fabrication of a weapon more difficult)

Conclusions

- Well-developed proliferation assessment tools have the potential to contribute nuclear system and safeguards technology development activities
  - Guide the efficient allocation of resources toward ends which strengthen the nonproliferation regime
  - Avoid mistakes that are costly to remedy after construction
- Strengthening the foundations of these tools can make a major contribution
- Even in the absence of a framework for aggregating data, a well develop list of inputs and attributes can serve as a “check-list” of critical technical factors
- The examples above show that our draft list substantially, but not completely, meets the identified performance targets
- Additional testing and evaluation is needed and could be the subject of future technical collaborations