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Calculating Expected and Observed Risks in an Advanced Transparency Framework*

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Project Scope

- Utilizing the framework developed by Sandia National Laboratories & Japan Atomic Energy Agency (JAEA)
  - Demonstrate advanced transparency at the Monju Nuclear Fuel Cycle Model at the International Nuclear Information Training Center/JAEA
  - Implement advanced technology at the Monju Fast Reactor
- New innovations:
  - Continuous, real-time monitoring of process and signal data internal to nuclear fuel cycle facilities to ensure safe and secure operations
  - Generation of an international *remote monitoring test bed* in support of an advanced transparency concept

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Transparency is a confidence building approach among political entities to ensure civilian nuclear facilities are not being used for the development of nuclear weapons

A system is transparent when all parties feel that the diversion risk is at an acceptable level. For this to occur, proliferation risk should be monitored in a continuous fashion.

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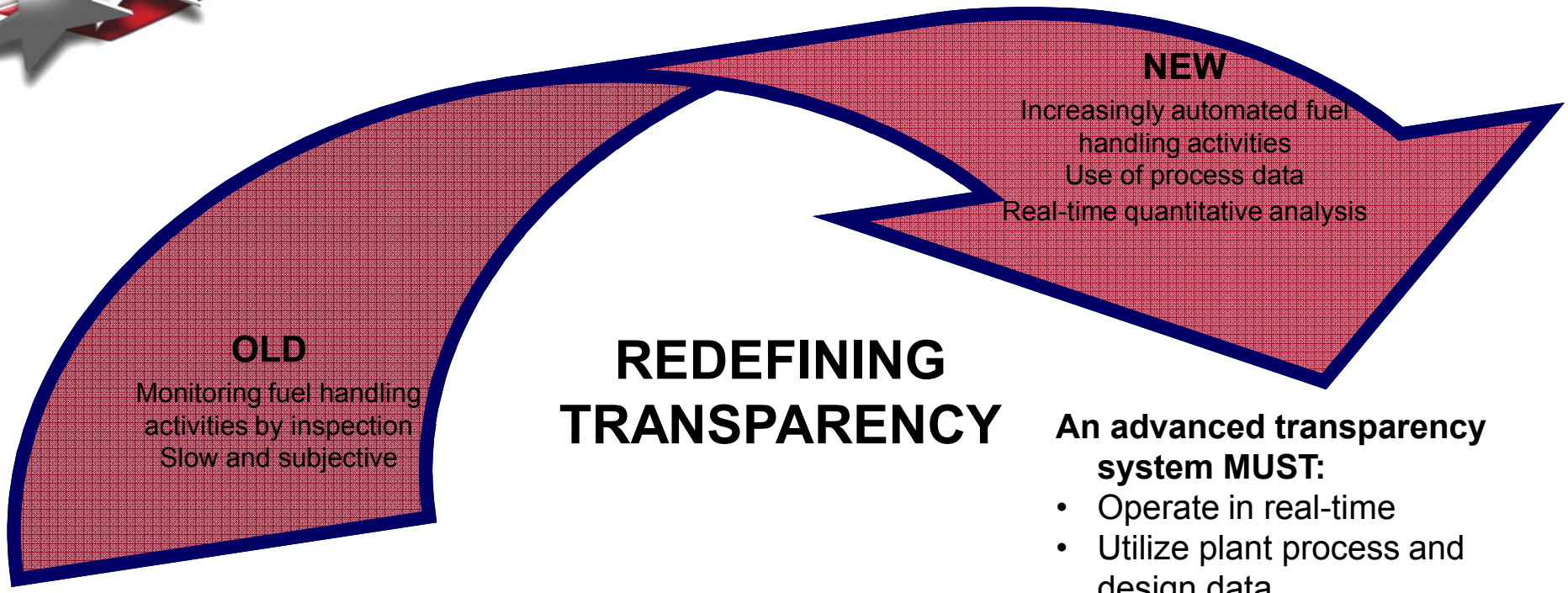

REDEFINING TRANSPARENCY

A traditional transparency system involves:

- Use of external devices
- Comparison of recorded and declared activities
- Provides no feedback

An advanced transparency system MUST:

- Operate in real-time
- Utilize plant process and design data
- Utilize declared plant processes
- Conduct real-time, quantitative analysis of proliferation-risk
- Securely provide analysis to the facility and authorized parties

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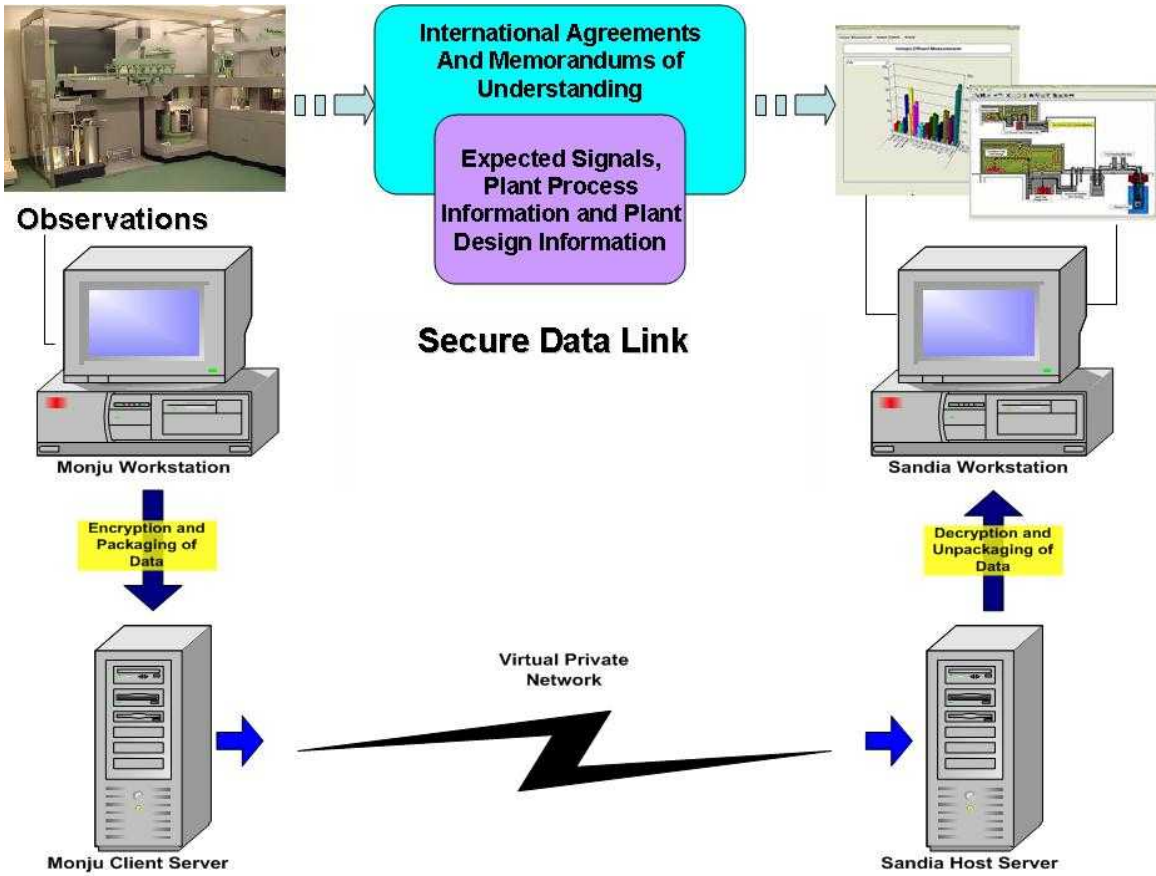
The Transparency Framework

- Plant process is automated
- Plant process data is immediately available for analysis
- Measures diversion risk
- Secure communication protocol between remote locations
- Secondary verification of operations



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Technical Developments

- Accurate collection of signals internal to the Monju Nuclear Fuel Cycle Model
- Live collection and transfer of these signals from the Monju Database Server (in Japan) to Sandia
- Accurate interpretation of signals in accordance with model operations

- Detection of “manual override events” or interruptions in automated processes
- Timely information supporting real-time assessment of conditions

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Proliferation Risk & Diversion Risk

- Proliferation Risk:
  - Defined as the risk of materials acquisition, transformation and weapons fabrication.
  - We focus on the risk that a facility may be used for proliferation *by the host nation*.
  - Risk is assumed to be acceptable when the facility operates under normal conditions as declared by licensing and export control agreements.

- Diversion Risk:
  - Is the risk of diverting nuclear material *through the declared operations*.
  - Incorporates the probability and consequences of a *host nation* diverting nuclear materials *from a commercial facility*.
  - Quantified in terms of significant quantities (SQs) of nuclear material potentially diverted.
  - Our project calculates diversion risk in real-time from process data.

Diversion Risk Model

- The diversion risk model identifies two types of risk: *expected* and *observed*.
- A fundamental component is the comparison of “expectations” and “observations.”
  - “Expectations”
  - “Observations”
- An instantaneous comparison between expectations and observations provides the foundation for calculating diversion risk.

Expected vs. Observed Risk

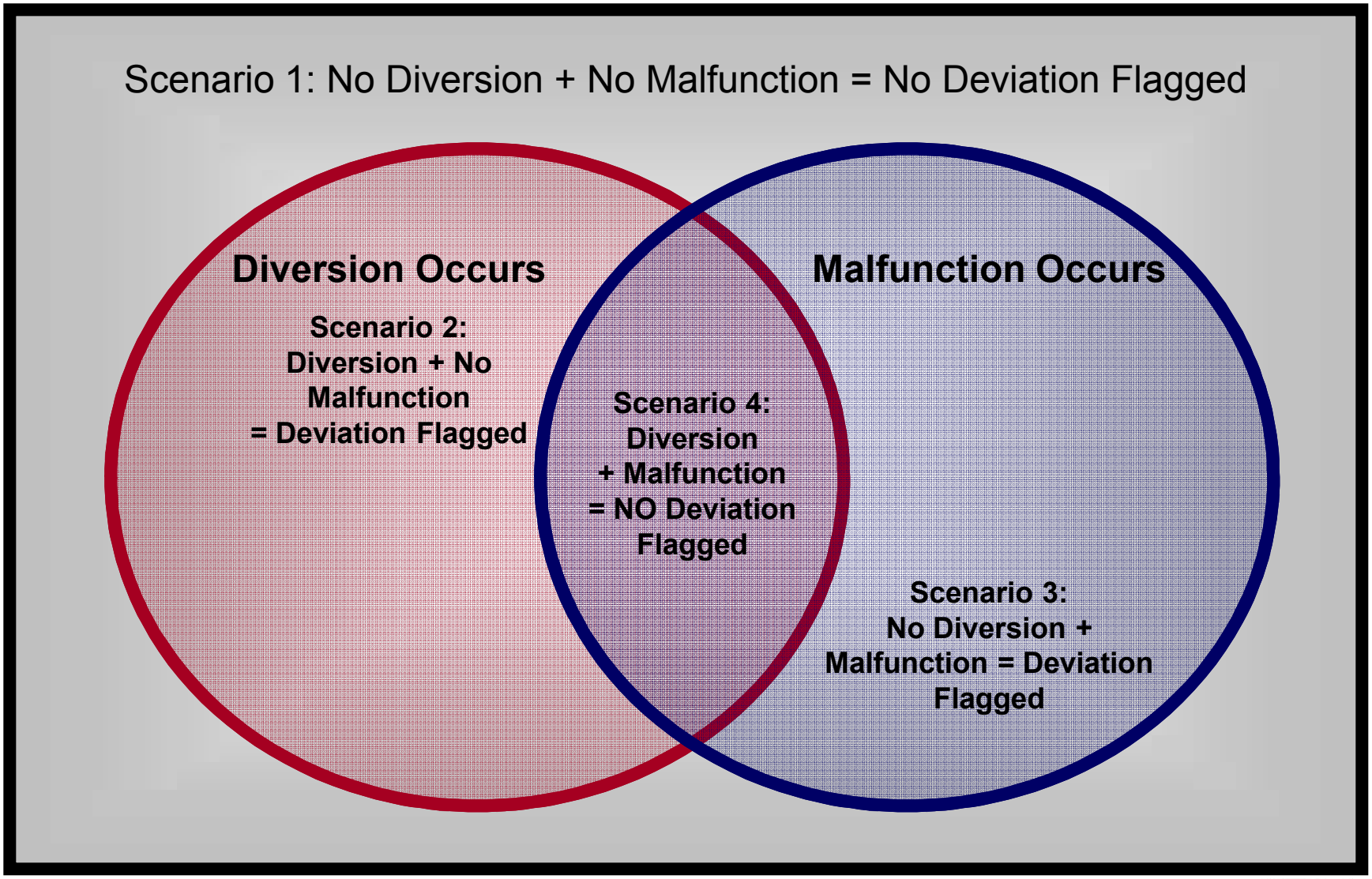
- "Expected risk" is the risk introduced by the existence of the facility based on planned and declared operations.
  - Represents the normal baseline risk.
  - Is dependent upon plant design and processing capabilities.
  - Plant design should have the goal of making this risk as small as possible.

- "Observed risk" is measured in real time during plant operations and is based on the signals transmitted by sensors.
  - Calculated at every process step via a comparison of actual operations to planned and declared operations (the foundation for expected risk).

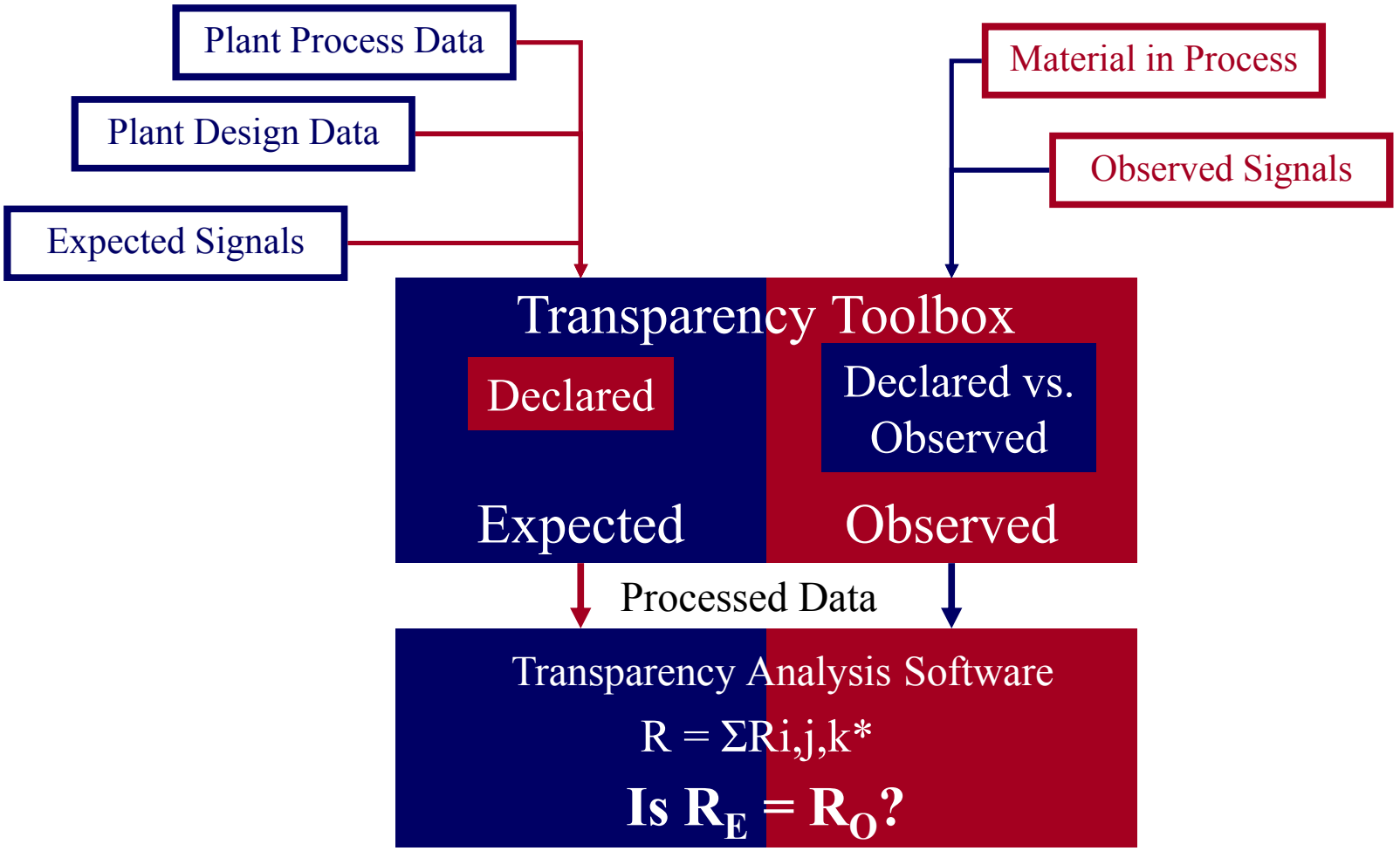
Components of Risk

- The risk of an event occurring is calculated as the product of two components:
  - the probability that the event will happen and
  - the consequences of such an event if it did occur.
- The diversion risk model assesses the probability of diversion by interpreting the set of observed signals for an operation.
  - Probability of sensor malfunction is considered in this calculation.
- A “significant quantity” (SQ) is used as the measure of consequence to account for material attractiveness and other related factors.

Diversion Risk Scenarios



Diversion Risk Analysis



*where i,j,k = step, process, plant

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Risk Calculations

- $R_{i,j,k}$ denotes the diversion risk for the i^{th} step of the j^{th} process in the k^{th} plant.
- Diversion risk for an individual process step:

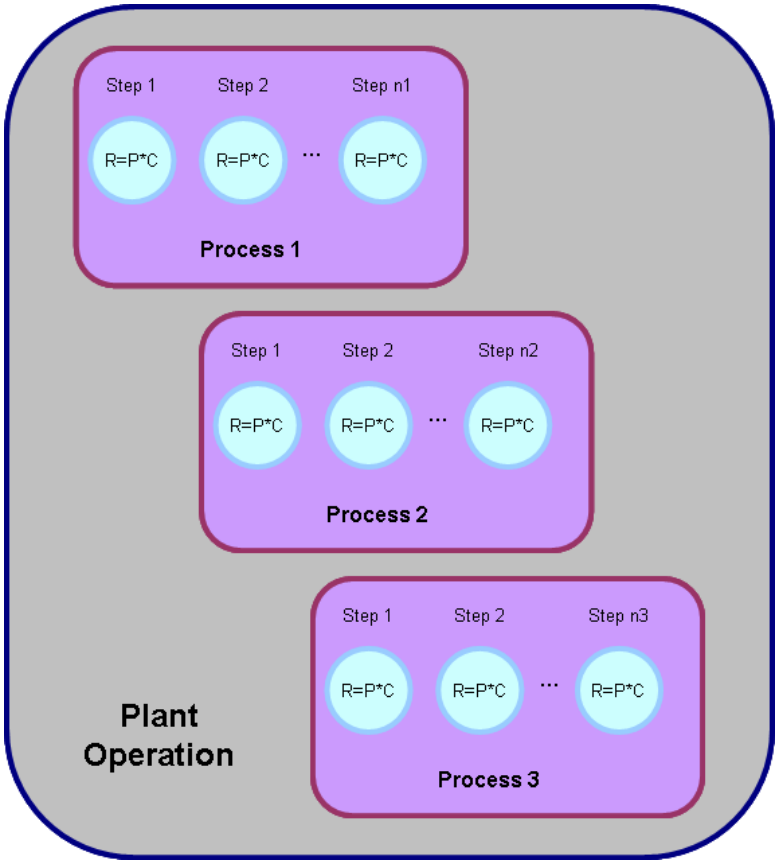
$$R_{i,j,k} = P_{i,j,k} \times C_{i,j,k}$$

- The diversion risk for a multi-step process:

$$R_{j,k} = \sum_{i} R_{i,j,k}$$

- The diversion risk for the entire plant operation:

$$R_{k} = \sum_{j} R_{j,k} = \sum_{i,j} R_{i,j,k}$$



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Example Calculations

Conclusion

- SNL and JAEA are cooperating to develop an advanced transparency framework capable of assessing diversion risk in support of overall plant transparency.
- Transparency Framework principles:
  - “Expected risk” is the risk introduced by the existence of the facility based on planned and declared operations.
  - “Observed risk” is based on the real-time transmission of signals during the completion of declared operations.
- Risk comparison interpretation:
  - When expected risk = observed risk, no increase in diversion risk.
  - When expected risk < observed risk, potential for diversion of nuclear materials at the facility.