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U.S.-UK Bilateral Cooperation on a Safeguards Analysis for a Nominal Molten Salt Reactor Design

Mike Edmondson | UK National Nuclear Laboratory

4 November 2025



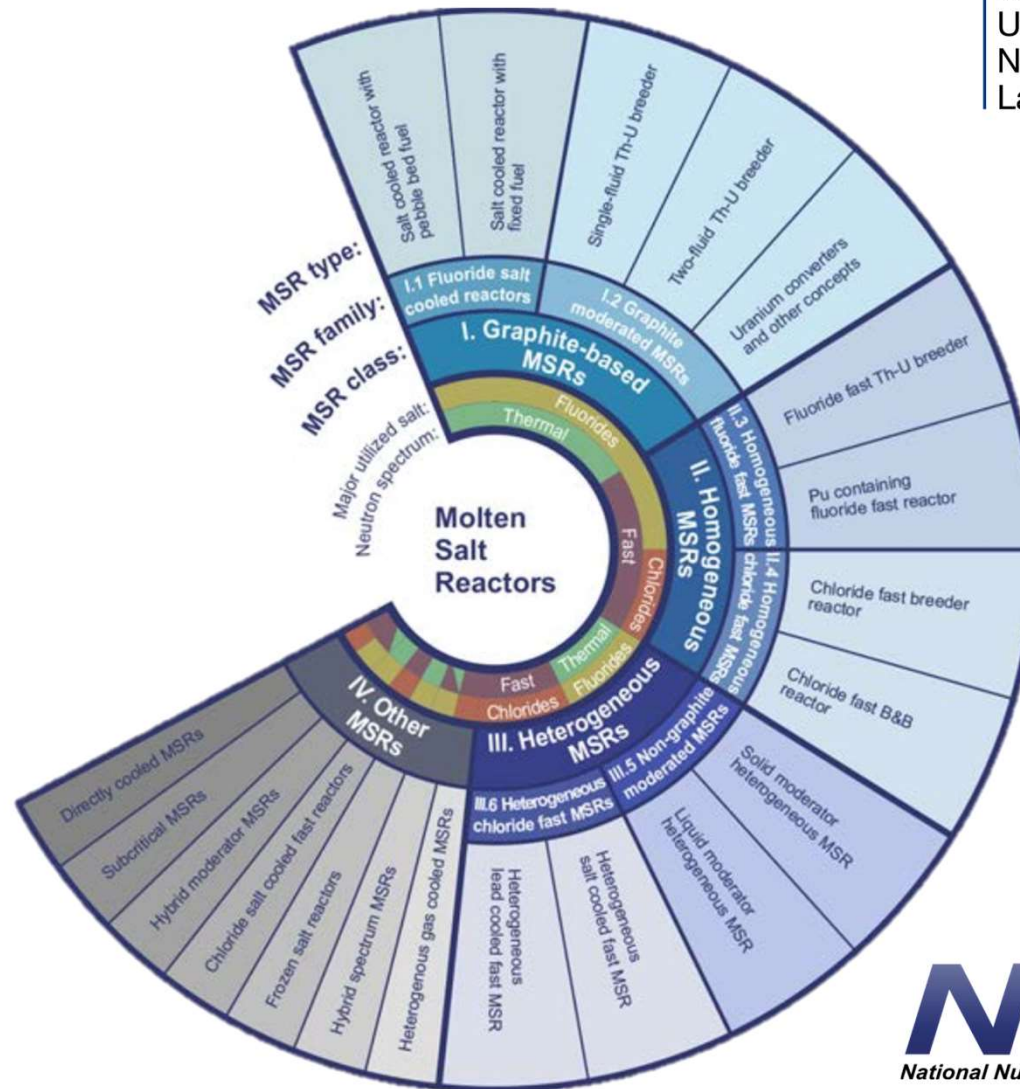
Our Motivations

- MSR designs vary immensely and evolve rapidly.
- Novel designs may require novel approaches.
- “Safeguards by Design” principles are a necessity.
- “Engineer connection, embrace discomfort, execute imperfectly”

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STATUS OF MOLTEN SALT REACTOR TECHNOLOGY
INTERNATIONAL ATOMIC ENERGY AGENCY
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NNSA
National Nuclear Security Administration

Our Technical Team

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➤ Idaho National Laboratory

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➤ Oak Ridge National Laboratory

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- Rob Marek
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- Anthony Belian



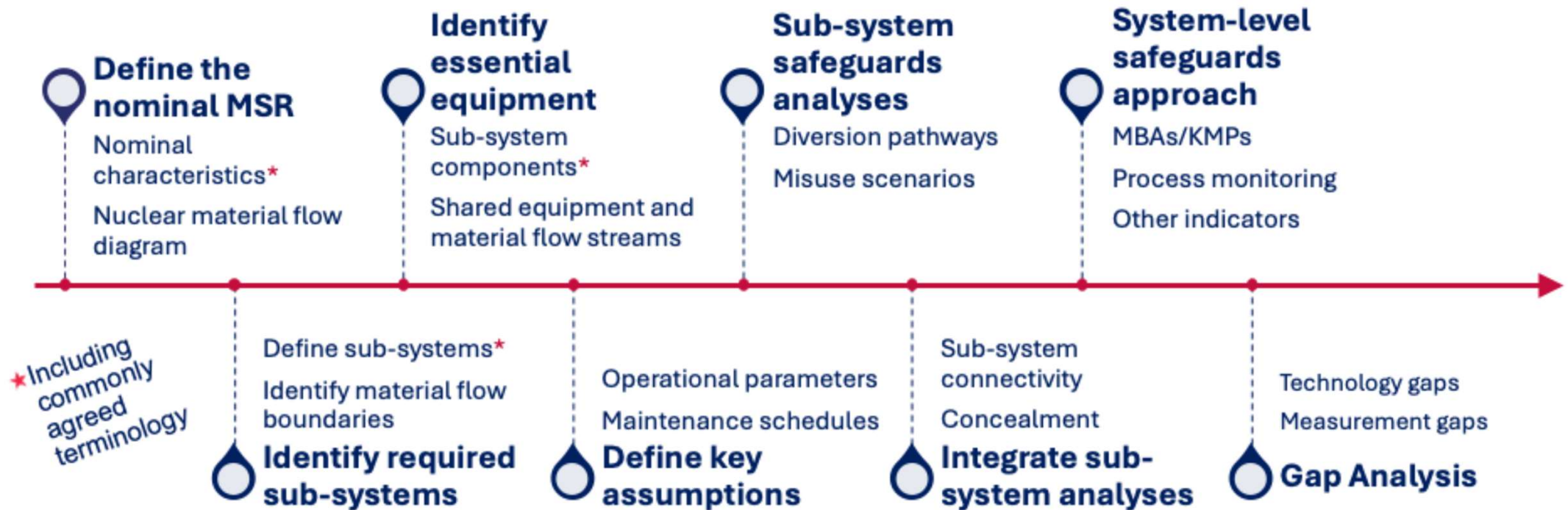
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Our Methodology

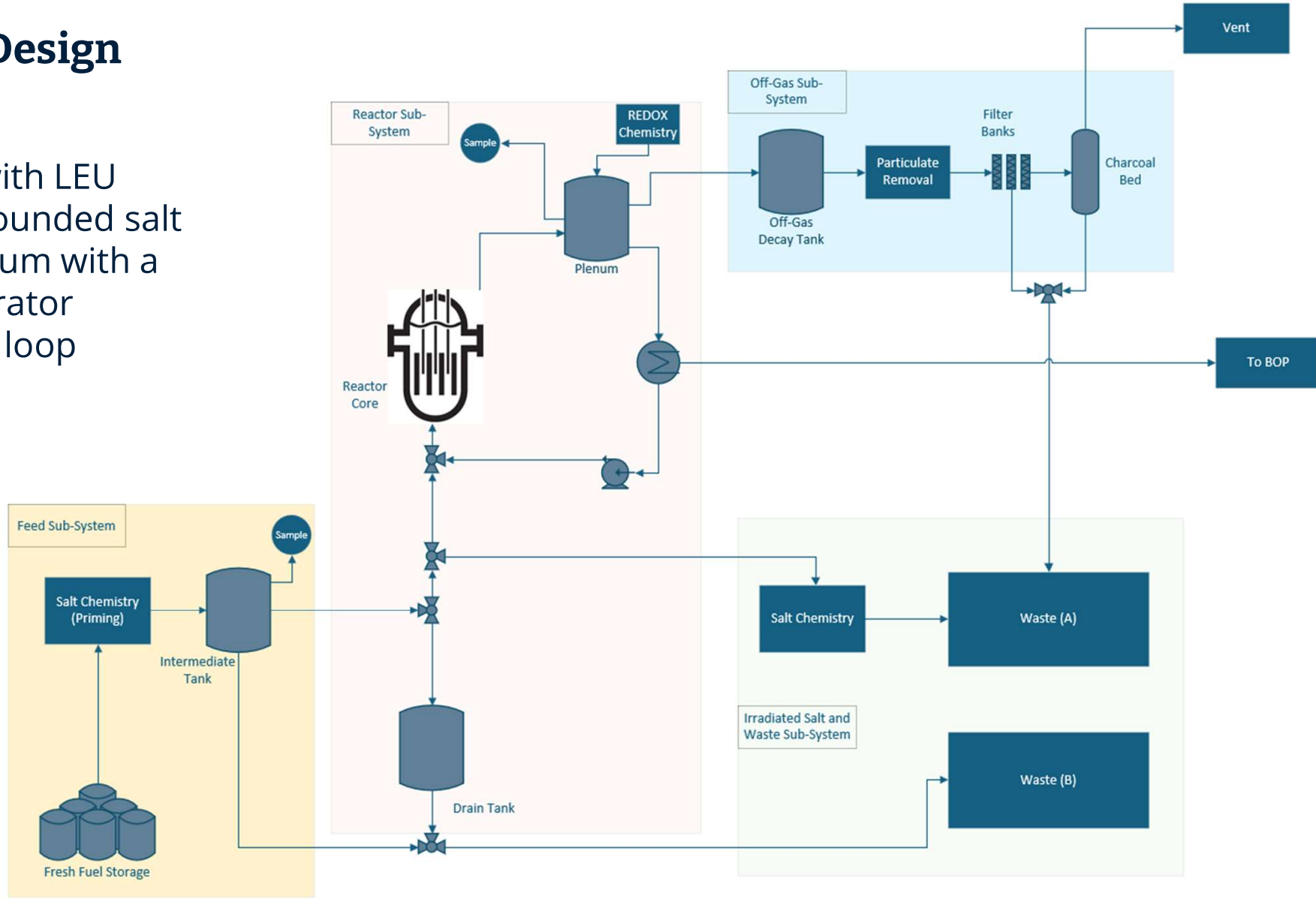


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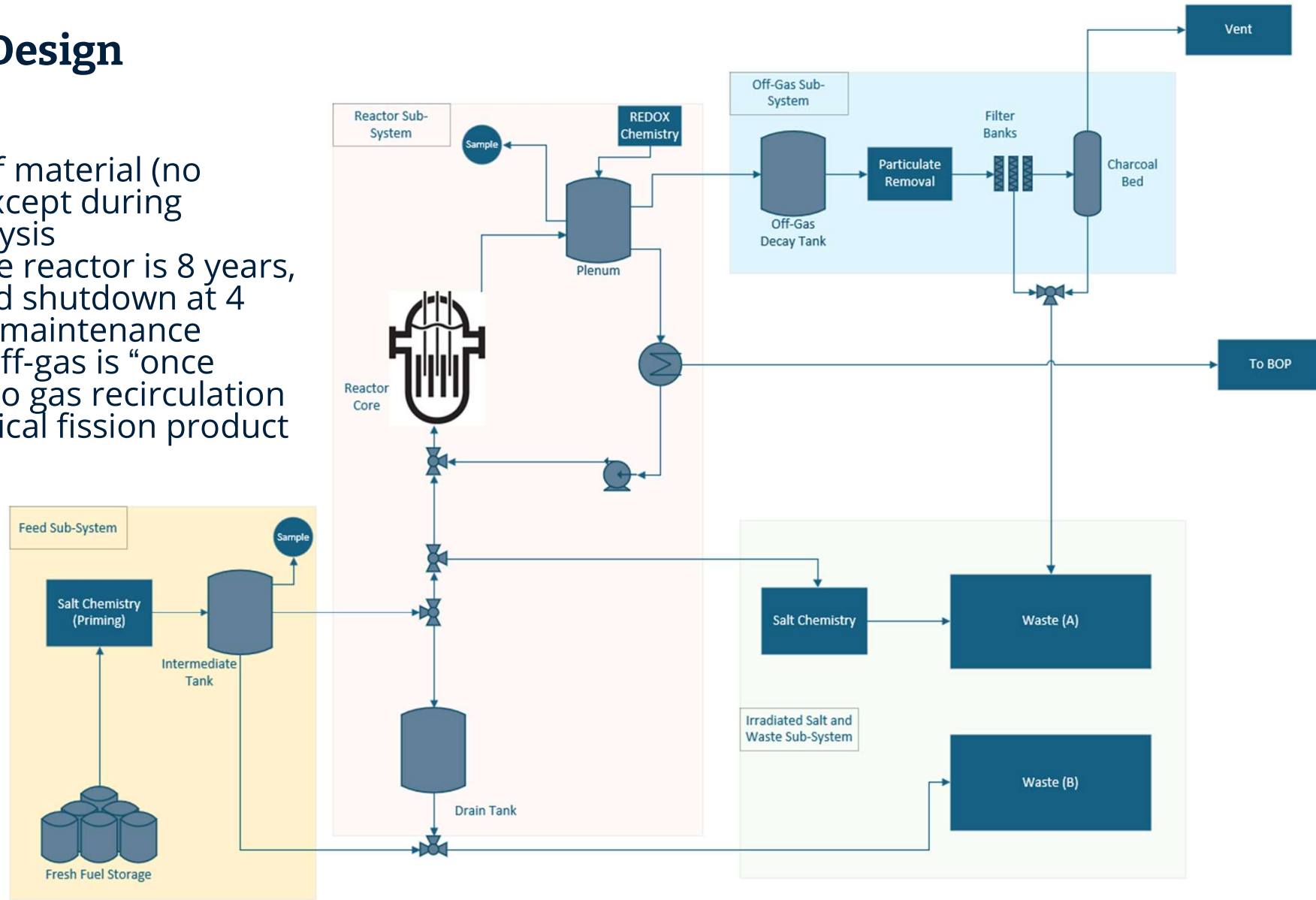
Nominal MSR Design

- Liquid-fueled with LEU
- Fluoride-compounded salt
- Thermal spectrum with a graphite moderator
- Single, primary loop



Nominal MSR Design

- Idealized flow of material (no material loss) except during safeguards analysis
- “Life cycle” of the reactor is 8 years, with a scheduled shutdown at 4 years for major maintenance
- Cover gas and off-gas is “once through”, with no gas recirculation
- No online chemical fission product removal



MSR Safeguards Approach Workshop



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Oak Ridge National Laboratory | 24-26 June 2025



National Nuclear Security Administration | National Nuclear Laboratory

Diversion Pathways and Misuse Scenarios



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	Diversion Pathways	Misuse Scenarios
Fresh Feed	24	17
Primary Salt Circuit	20	23
Reactor	34	28
Irradiated Salt and Waste	24	22
Off-Gas	13	13
Total	115	106



“RAG” Analysis

Classic “stoplight” analysis with three criteria

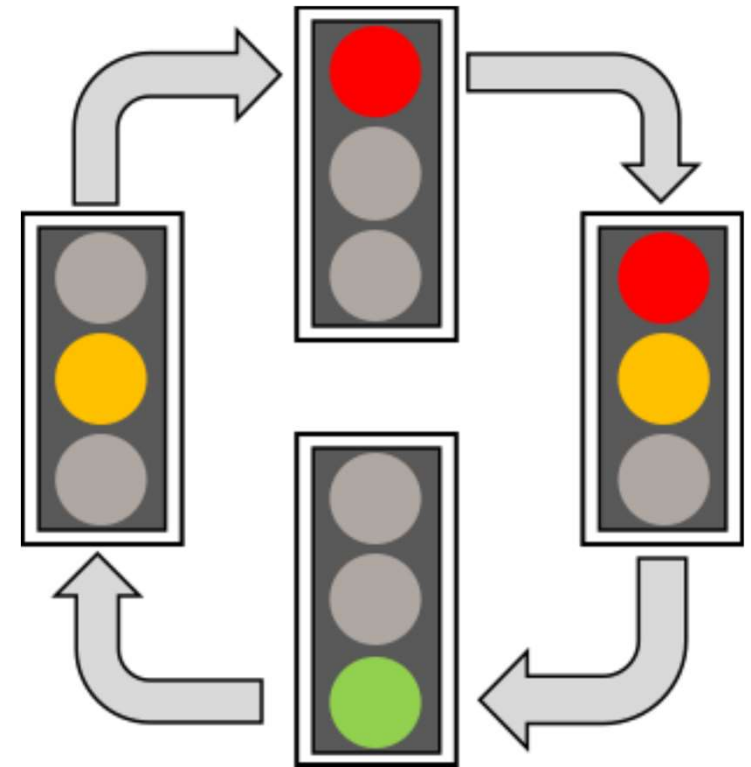
- Level of effort
- Quantity diverted
- Time of diversion

Three categories

- Red: most concerning for safeguards
- Amber: somewhat concerning for safeguards
- Green: least concerning for safeguards



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“RAG” Analysis Criteria



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	Quantity	Time to Complete	Level of Effort*
Red	1 SQ of Pu, ²³³U, or ²³⁵U	Less than one week	- Low radiation materials - No specialized equipment that is not already at the facility, - Technical knowledge within normal operations - Material obtained without raising suspicion
Amber	- Between 1 SQ and “tens” of g of Pu or ²³³U - Between 1 SQ and “couple” of kg of ²³⁵U	Between one week and one year	One or two of the “Level of Effort” factors
Green	“tens” of g of Pu or ²³³U “couple” of kg of ²³⁵U	Greater than one year	Three or more of the “Level of Effort” factors

Level of Effort Factors

- Material with high radiation levels
- Requires specialized equipment that is not already at the facility
- Excessive costs to complete
- Irrecoverable damage to systems or existing equipment required for operations
- Requires more than 10 individuals to execute
- Requires over 100 man-hours to plan or execute



Next Steps for Collaboration



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October-December

- Sub-system integration
- Taxonomy and terminology
- System vulnerability analysis

January-March

- System-level safeguards approach (KMPs, MBAs, I&C)
- Gap analysis

April-June

- Review and refine
- Internal presentation for feedback

July-September

- Open for public comment



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Thank You

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