OAK RIDGE National Laboratory

Domestic MC&A and Licensing

Michael Dion, Karen Hogue, Logan Scott,
Greg Westphal

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- Savannah Fitzwater (DOE PM) and Ben Cipiti (NTD @ SNL)

"…focused on addressing near term challenges advanced reactor vendors face in meeting U.S. domestic Physical Protection System (PPS) and MC&A requirements."

Thrust Areas:

Physical Protection Systems
- Reduce number of on-site responders
- Reduce upfront costs
- Evaluate enhanced safety systems
- Evaluate unique sabotage targets

Pebble Bed Reactor MC&A
- Evaluate regulatory approach
- Determine driving requirements
- Evaluate new monitoring technologies

Microreactor PPS and MC&A
- Develop a licensing framework
- Develop approaches appropriate to the very small scale
- Evaluate new monitoring technologies

Liquid Fueled MC&A
- Evaluate regulatory approach
- Develop baseline accountancy approaches
- Evaluate new measurement and monitoring technologies

International Considerations
- Consider international safeguards requirements
- Interface with NNSA programs
- Support the Gen-IV PR&PP working group

Vendor Engagements
- Design-specific MC&A and PPS challenges.
- NNSA partnerships
- Translate to lessons learned or generic deliverables.

https://energy.sandia.gov/programs/nuclear-energy/safety-security-and-safeguards-for-advanced-nuclear-power/advanced-reactor-safeguards/

NRC Regulations: 10 CFR

- Siting and construction: Part 50–Domestic Licensing of Production and Utilization Facilities or Part 52–Licenses, Certifications, and Approvals for Nuclear Power Plants.
- Part 70–Domestic Licensing of Special Nuclear Material (SNM)
  - Part 74–graded requirements for the control and accounting of SNM

It is not expected that the regulations will be modified or that an exception will extend to liquid-fueled MSRs due to the significant difference in fuel form and other operational characteristics compared to solid fueled reactors with large assemblies.

SNM and MC&A

- SNM defined as Pu, ^{233}U, or enriched uranium in mass 233 (^{233}U) or 235 (^{235}U)
  - Graded scale based on the ease with which it could be used by an adversary: low strategic significance (Cat III), moderate strategic significance (Cat II), or strategic SNM (Cat I).
- Material Control & Accountability (MC&A) and physical security ensure SNM is not stolen or diverted.
  - MC&A is based on performance objectives

SNM and MC&A

- SNM defined as Pu, ^{233}U, or enri
  - ≥2 kg Pu
  - ≥5 kg ^{235}U (in U enriched to ≥20 wt%, i.e., highly enriched uranium (HEU))
  - ≥2 kg ^{233}U
  - ≥5 kg of a *formula quantity* = (g contained ^{235}U) + 2.5 × (g ^{233}U + g Pu)

  or 235 (^{235}U)
  - Graded scale based on the ease
    adversary: low strategic significance (Cat III), moderate strategic significance (Cat II), or strategic SNM (Cat I).
- Material Control & Accountability (MC&A) and physical security ensure SNM is not stolen or diverted.
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SNM and MC&A

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  - Gra… h it could be used by an adv… III), moderate strategic sign… nce (Cat I).
- Mater… C&A) and physical securi… verted.
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Less than a formula quantity of strategic SNM but

- >1 kg of ^{235}U (in U enriched to ≥20 wt%)
- >0.5 kg of ^{233}U or Pu
- >1 kg = (g contained ^{235}U) + 2 × (g ^{233}U + g Pu)
- ≥10 kg ^{235}U (in U enriched to ≥10 wt% but <20 wt%)

SNM and MC&A

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  or 235 (^{235}U)
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    significance (Cat II), or strategic signific
- Material Control & Accountability (M
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  - MC&A is based on performance objec

Less than an amount of moderate strategic significant but:

- >15 g ^{235}U (in U enriched to ≥20 wt%)
- >15 g of ^{233}U
- >15 g of Pu
- >15 g = (g contained ^{235}U) + (g Pu) + (g ^{233}U)

- <10 kg but >1 kg of ^{235}U (in U enriched to ≥10 wt% but <20 wt%)
- ≥10 kg ^{235}U (in U enriched above natural but <10 wt%)

SNM and MC&A

- SNM defined as Pu, ^{233}U, or enriched uranium in mass 233 (^{233}U) or 235 (^{235}U)
  - Graded scale based on the ease with which it could be used by an adversary: low strategic significance (Cat III), moderate strategic significance (Cat II), or strategic significance (Cat I).
- Material Control & Accountability (MC&A) and physical security ensure SNM is not stolen or diverted.
  - MC&A is based on performance objectives
- **MC&A approach is proposed as a Fundamental Nuclear Material Control (FNMC) plan**

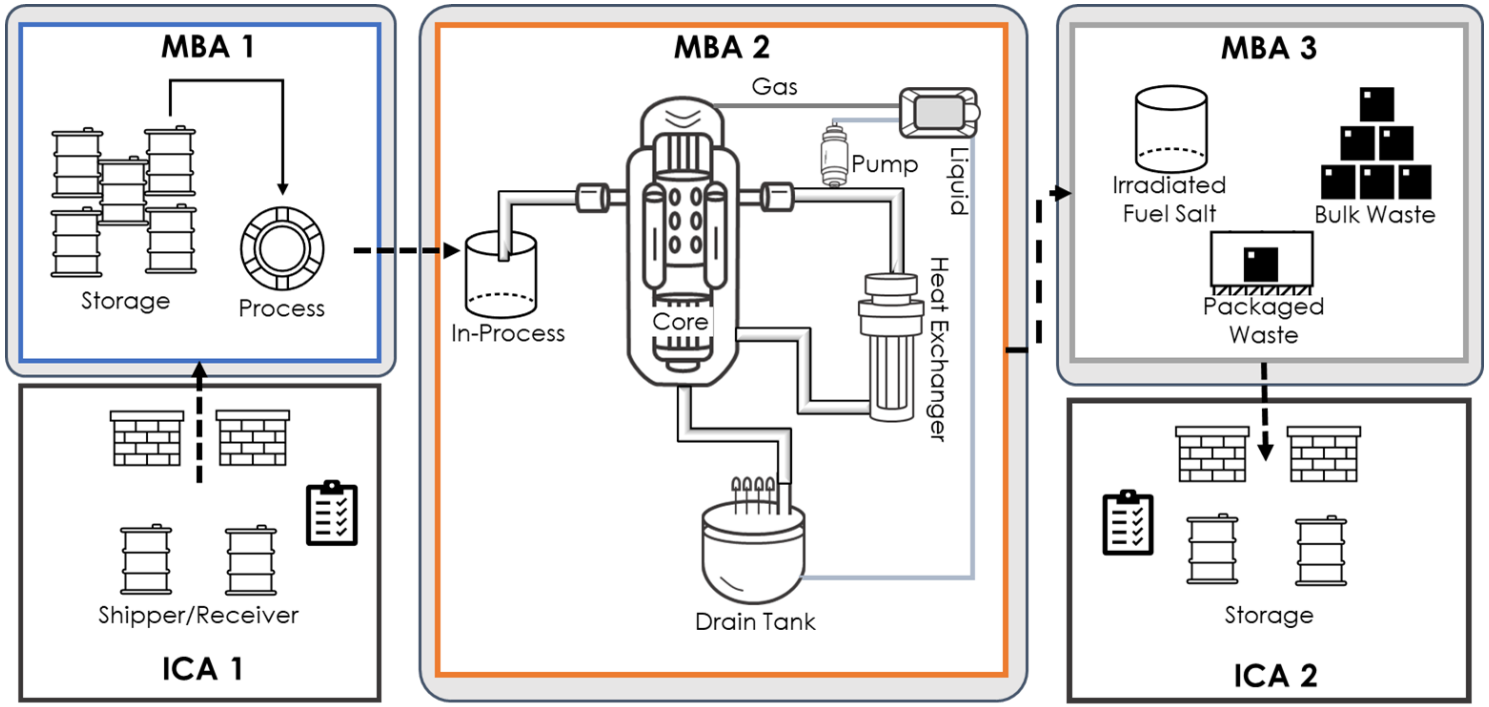
MSR Design Facility Components

Considerations for FNMC plan

- *Irradiated Fuel Salt* – highly radioactive preventing access could be used for reliance on containment and surveillance. Monitoring, sampling and measurement should be performed whenever possible. Sampling fuel salt can be used with modeling to provide a strong case to downgrade material and to perform dynamic inventories.
- *Fresh Fuel* – TIDs used for fresh fuel containers. Facility needs a capability to measure material (UF_4), enrichment, etc., to resolve any discrepancies resulting from gross weight inconsistency, seal failure, or excessive ID investigation. FNMC plan must include how material will be accounted for during online fueling.
- *Reactor Containment* – Loop style compared to integral may provide greater access to SNM. All side streams (SNM) should be monitored and measured whenever possible. Provide a means to detect and quantify holdup of SNM.
- *Wastes* – Fuel salt removed from containment should be sampled and measured to validate model. Equipment should be measured to quantify holdup. Transfer of SNM must be quantified with measurements.

Proposed Boundary Approach

- Physical areas localize material inventories, and processing.
- Control SNM transfer from ICA→MBA, MBA→MBA, and MBA →ICA



- ICA – internal control area: discrete item storage and inventories, TIDs, etc. no (or minimal) new measurements.
- MBA – material balance area: for SNM processing and (re)measuring.

Conclusions

- SNM is categorized and MC&A is moving towards performance based (as opposed to prescriptive).
- Liquid-fueled MSRs with circulating fuel will need to develop an FNMC plan for domestic licensing.
- FNMC considerations and suggestions for design specific components were provided.
- The MC&A approach should localize material inventories and processing of SNM.
- The generic framework presented should help guide the licensee in efforts to accommodate licensing requirements.

Acknowledgements

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- The MC&A group at the NRC for their support and conversation.
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Questions?