

ADVANCED REACTOR SAFEGUARDS & SECURITY

Physical Security for MSRs

*Molten Salt Reactor Program Annual Review
April 24, 2026*

PRESENTED BY

Alan Evans- Sandia National Laboratories

SAND2026-20088PE

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.



Outline

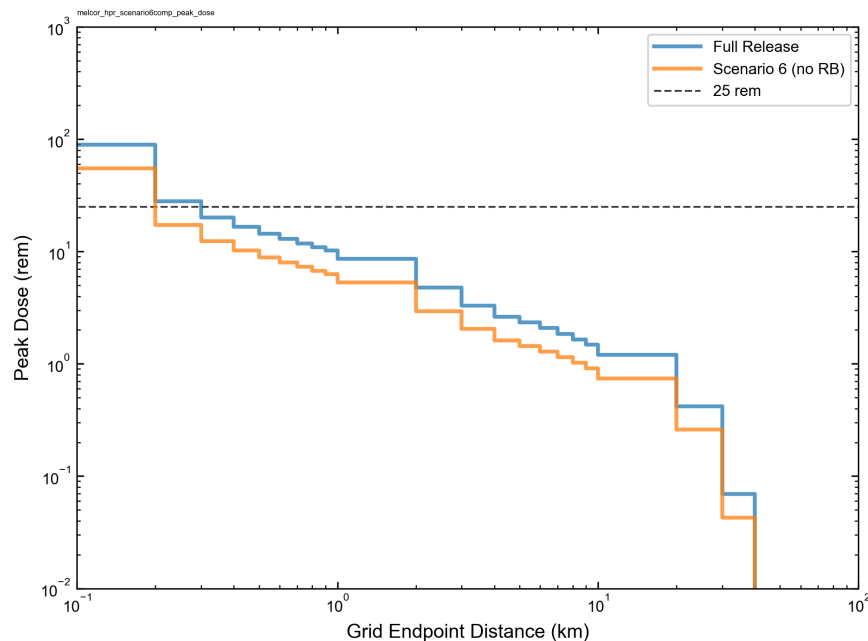


- Discuss physical security regulatory changes impacting new nuclear reactors
- Discuss methods to create cost-effective physical security systems agnostic of plant design
- Questions

Regulatory Changes



- The release of NRC Part 53 rulemaking creates a pathway for nuclear reactors to use a performance-based approach for physical security systems
 - Based on category of nuclear material and radiological consequences
 - <25 rem/2hr (unmitigated) at the site boundary alleviates a licensee from many requirements
 - >25 rem/2hr requires the implementation of a performance-based physical security system → Requires design and analysis efforts, but could reduce long-term security implementation costs



Nuclear Material	U-235 Enrichment	Nuclear Material Category		
		Category I	Category II	Category III
U-235	≥ 20 wt%	≥ 5 kg	< 5 kg and ≥ 1 kg	< 1 kg and ≥ 15 g
U-235	≥ 10 and < 20 wt%		≥ 10 kg	< 10 kg and ≥ 1 kg
U-235	> Nat. and < 10 wt%			≥ 10 kg
U-233 or Pu		≥ 2 kg	< 2 kg and ≥ 0.5 kg	< 0.5 kg and ≥ 15 g
Mixed	≥ 20 wt%	≥ 5 kg	< 5 kg and ≥ 1 kg	< Cat II and ≥ 15 g
		as calculated by: = grams U-235 + 2.5 *(grams U-233 + grams plutonium)	as calculated by: = grams U-235 + 2.5 *(grams U-233 + grams plutonium)	as calculated by: = grams U-235 + grams U-233 + grams plutonium

Consequence Analysis



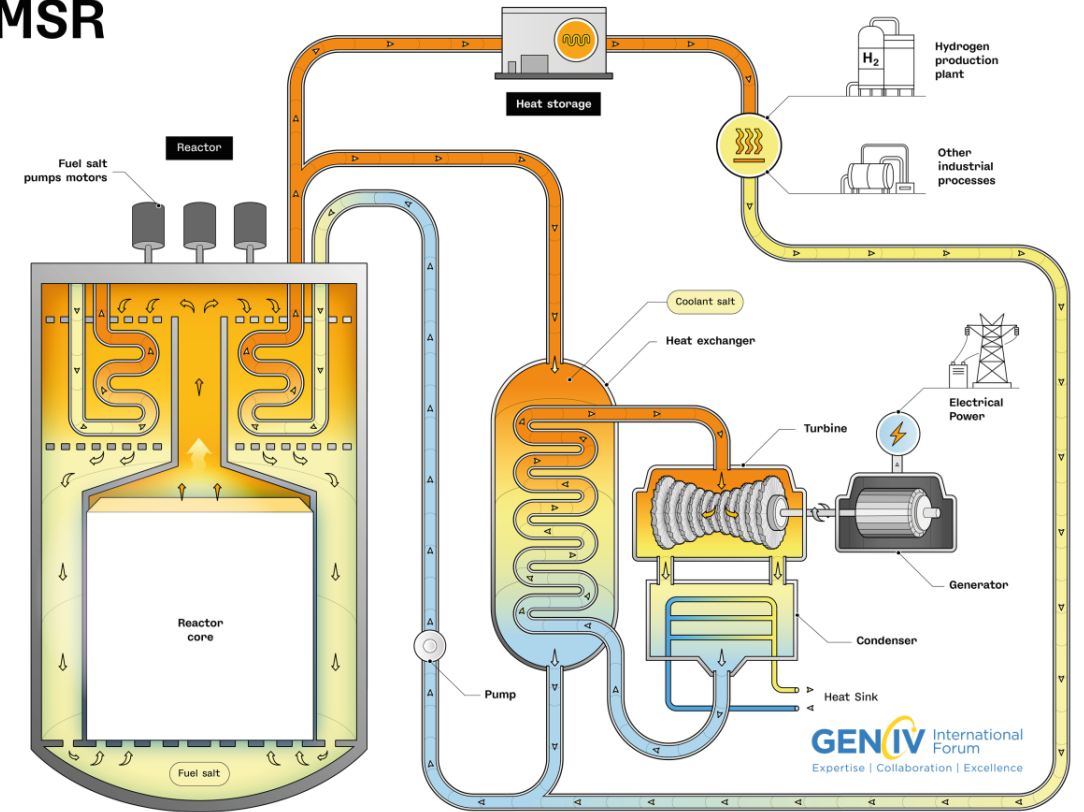
- We currently do not have a good understanding of direct adversary attacks (direct adversary explosive placement) on MSR fuels
- We currently do not have a good understanding of indirect adversary attacks on MSR facilities (adversaries attacking safety systems)
- More R&D is needed in this space to evaluate consequences for MSRs and ability to license under NRC Part 53
- **Will need interface with safety and security (physical and cyber)**

Securing a Molten Salt Reactor



- Understanding of where nuclear material may be located within the facility
- Understanding of radioactive inventory and items with potential radiological consequences
 - When using the release consequence thresholds all sources of radioactive inventory must be considered

MSR



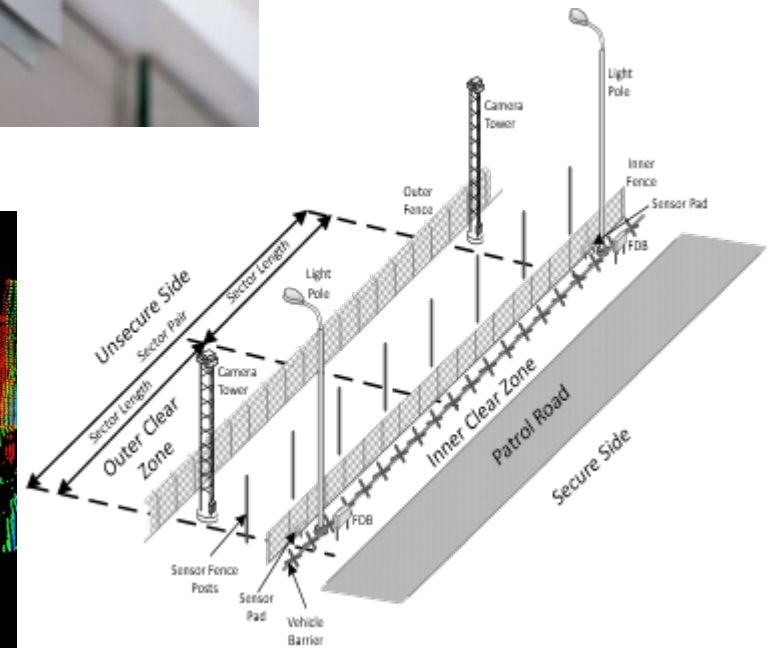
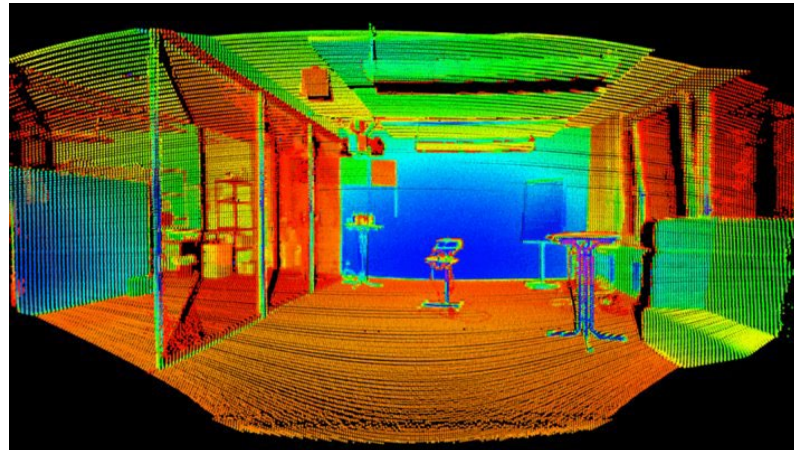
Molten Salt Reactor

<https://www.gen-4.org/generation-iv-criteria-and-technologies/molten-salt-reactors-msr>

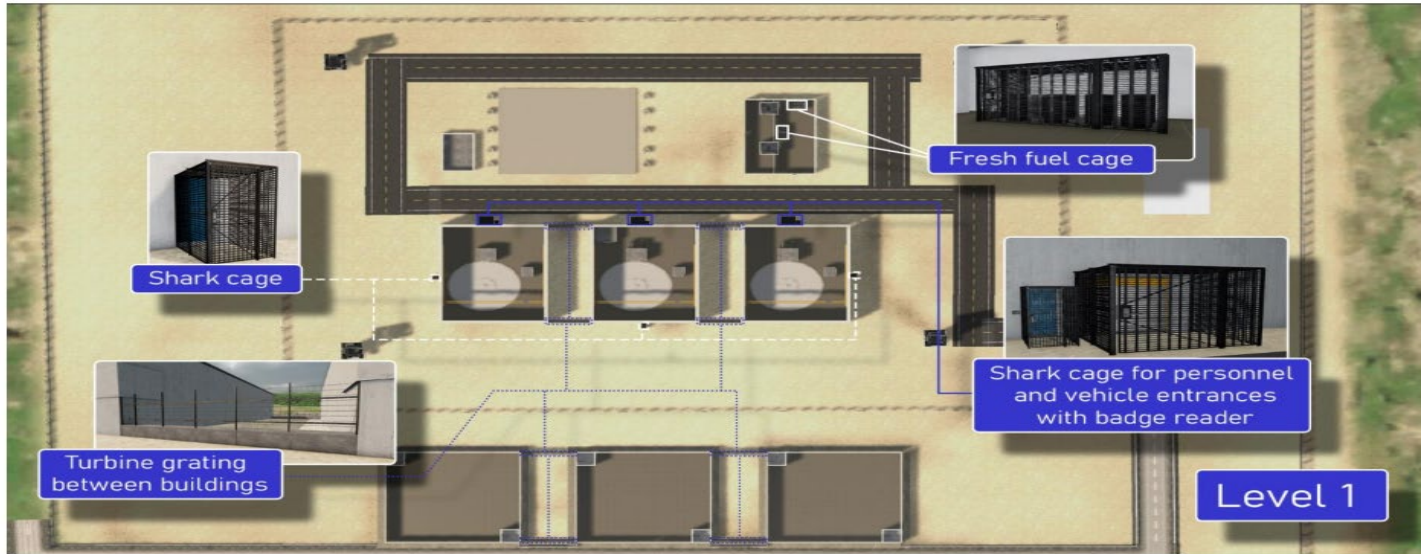
Detection



- Intrusion detection for performance-based facilities is more robust with multiple layers.
- New technologies may save cost.
- Consider alarm assessment and reporting to on-site responders or local law enforcement.



Delay



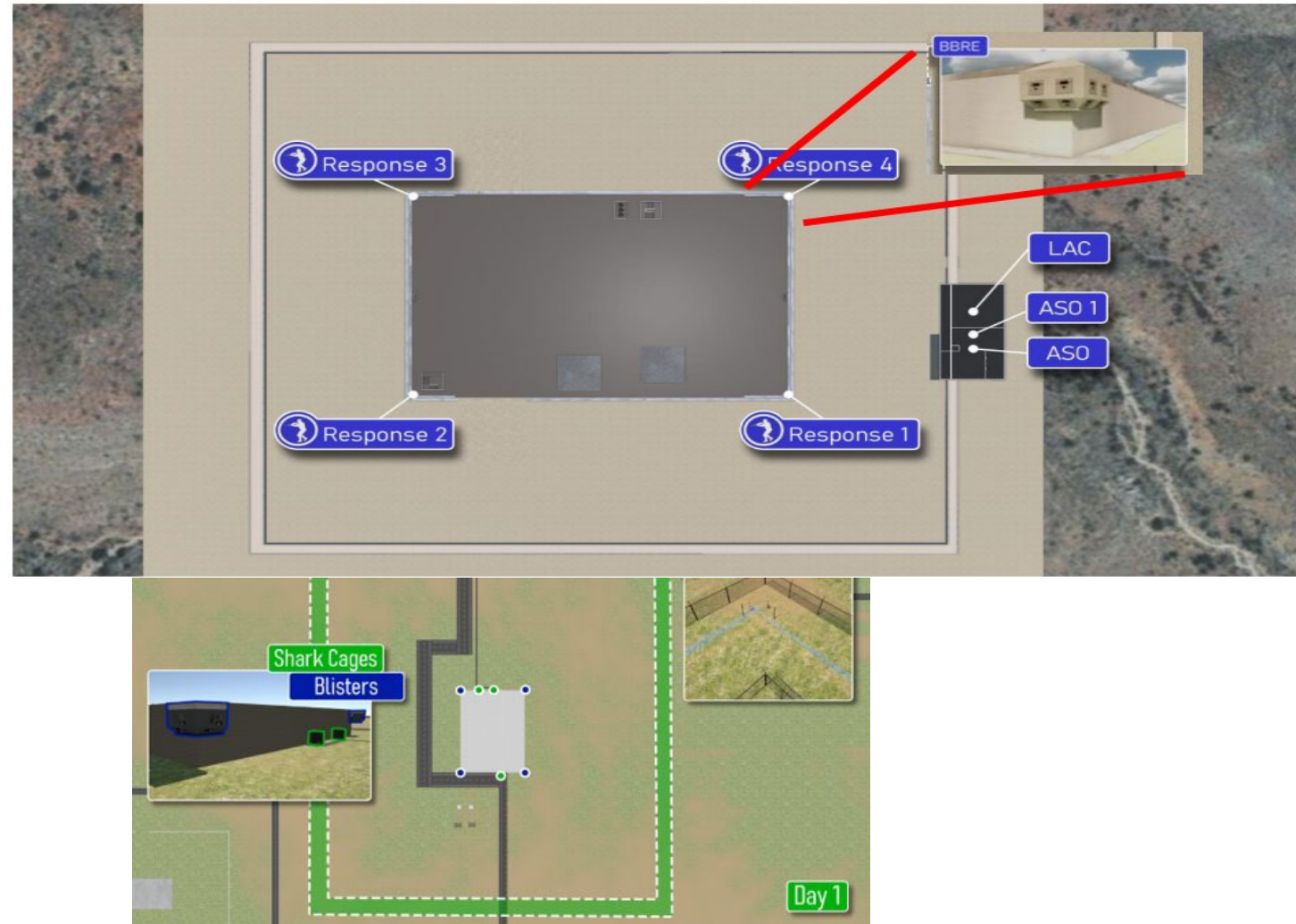
- Delay should be integrated to ensure that the response force can neutralize the adversary force
- Delay should increase the overall adversary task time
- Delay should force the adversary along a path that is more advantageous for the response force



Response



- One square/rectangular building with all targets contained allows for the most efficient response force strategy
- Blisters/hardened fighting positions offer a more elegant design
- CAS and communications





Conclusions and Recommendations

- Molten salt reactors present some unique challenges to security compared to other reactor types
- **However, many general recommendations can be used to improve and enhance security in a performance-based approach**
 - Use detection to support the function of a response
 - Use delay to channel adversaries into locations that are more advantageous for the response force
 - Use delay to create tasks that adversaries have to accomplish while under-fire
 - Provide as clean of a site layout for the response force to have overlapping fields-of fire and clear fields-of-view to the perimeter of the facility