



# Innovation and Nuclear Regulation: It's Possible

## ARPA-E Workshop on Optimal Operations for Advanced Reactors

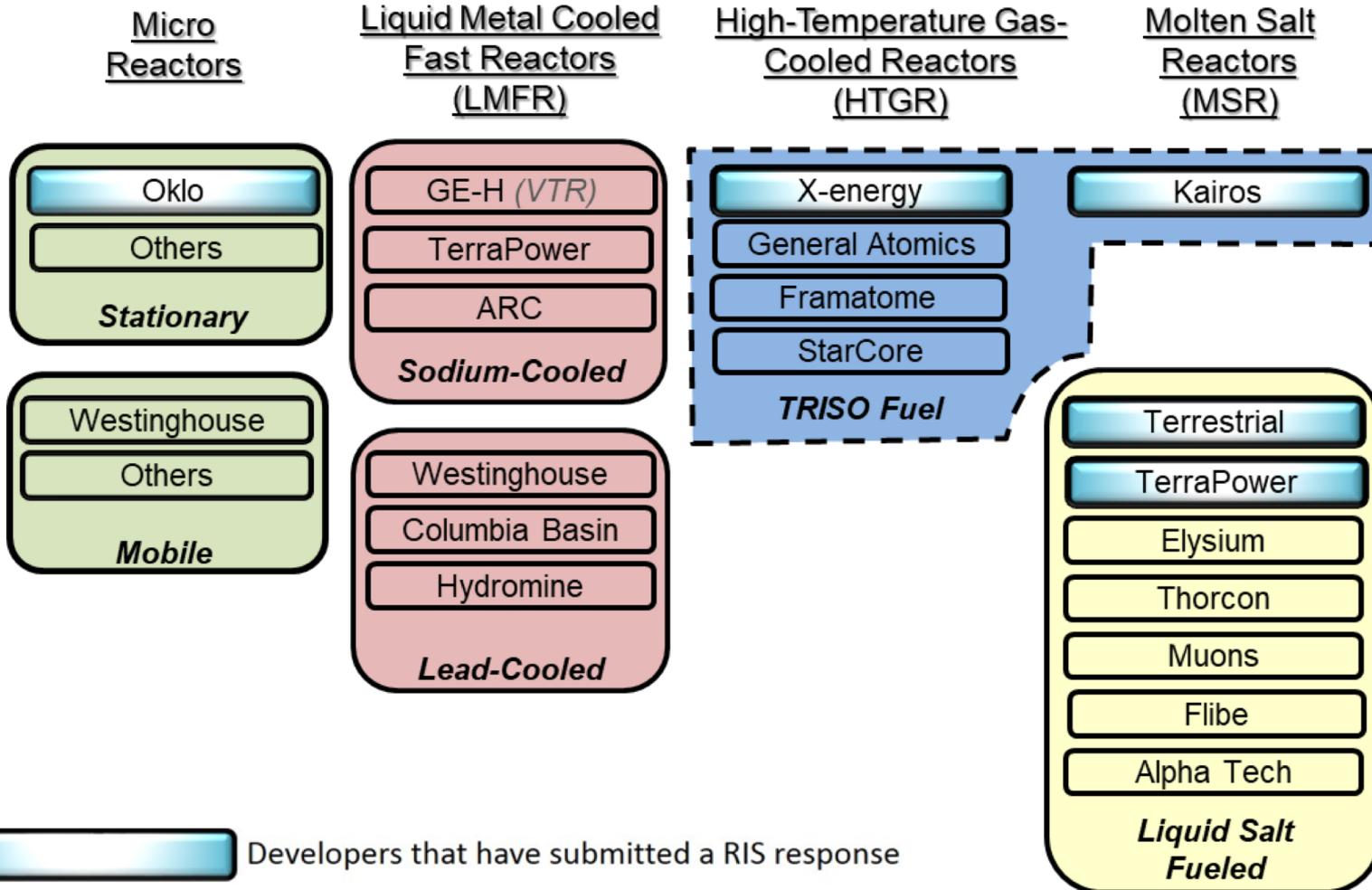
John Monninger, Director  
Division of Advanced Reactors

May 15, 2019



- NRC mission and role
- State of regulation for advanced reactors and the path forward
- How we consider innovation and advancements that can make reactors better

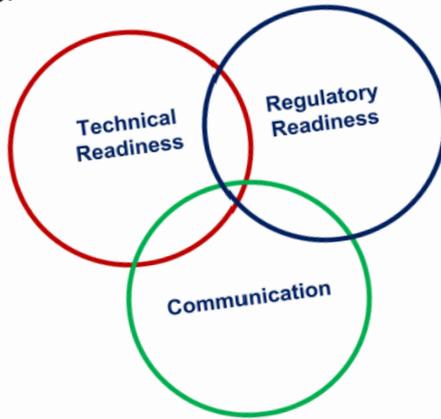
# Non-LWR Landscape



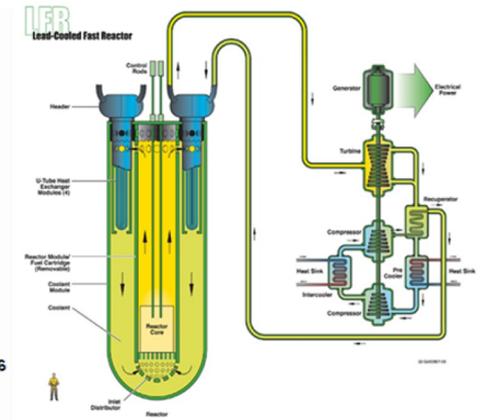
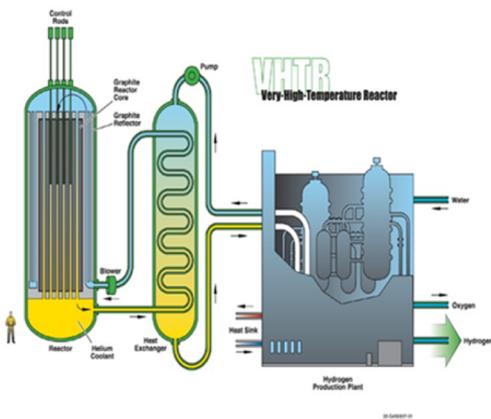
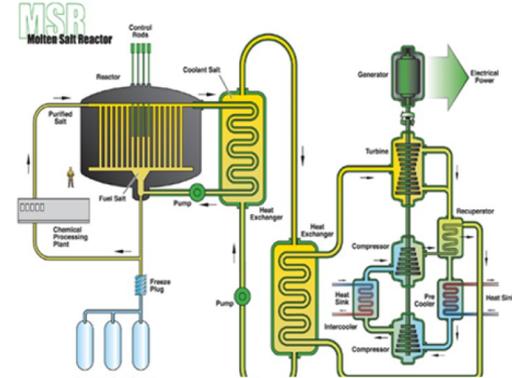
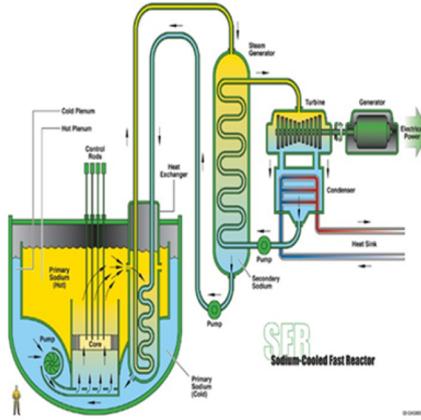
# NRC's Advanced Reactor Program Vision and Strategy

ML16356A670

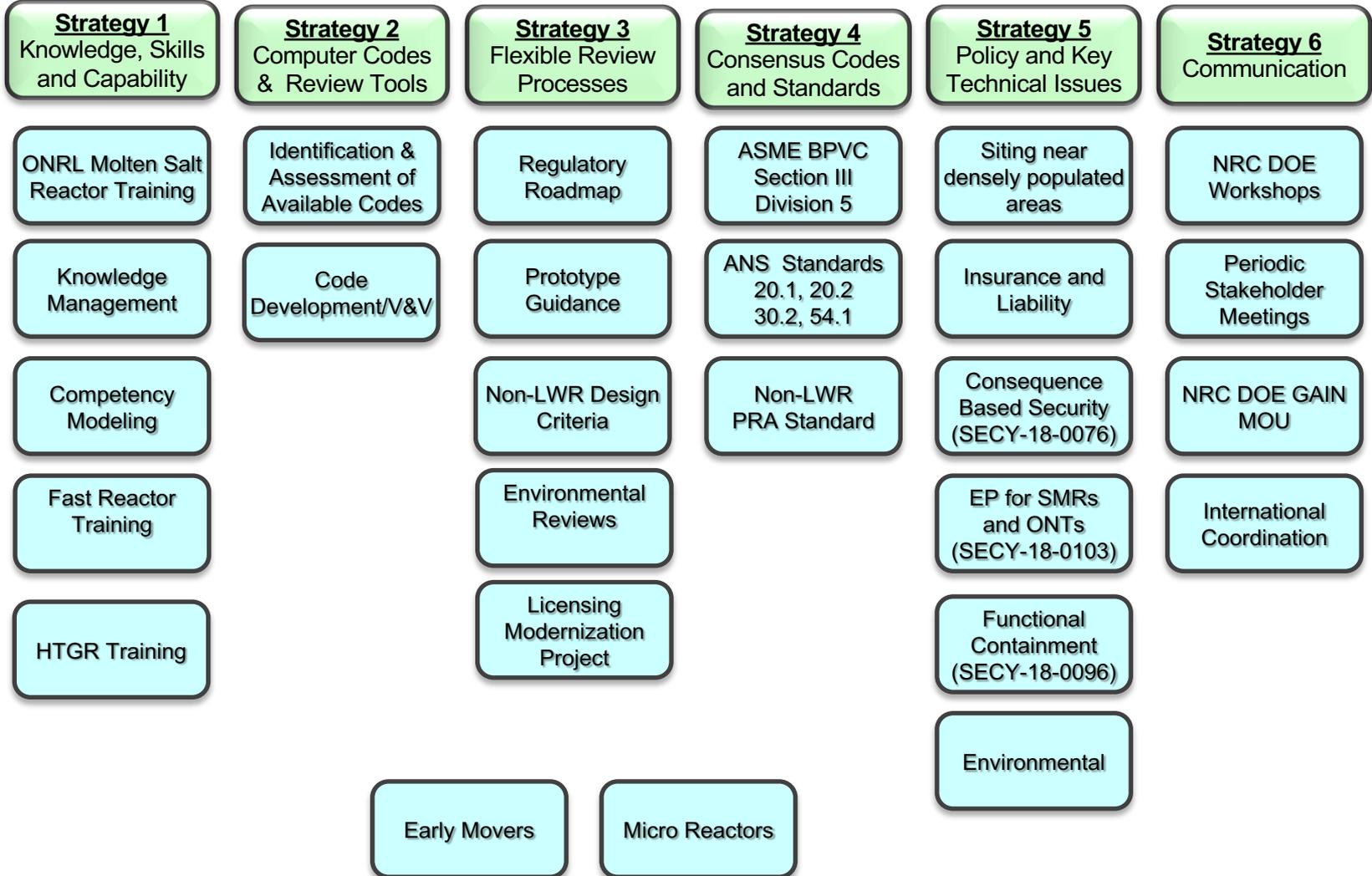
**NRC Vision and Strategy:**  
 Safely Achieving Effective and Efficient  
 Non-Light Water Reactor  
 Mission Readiness



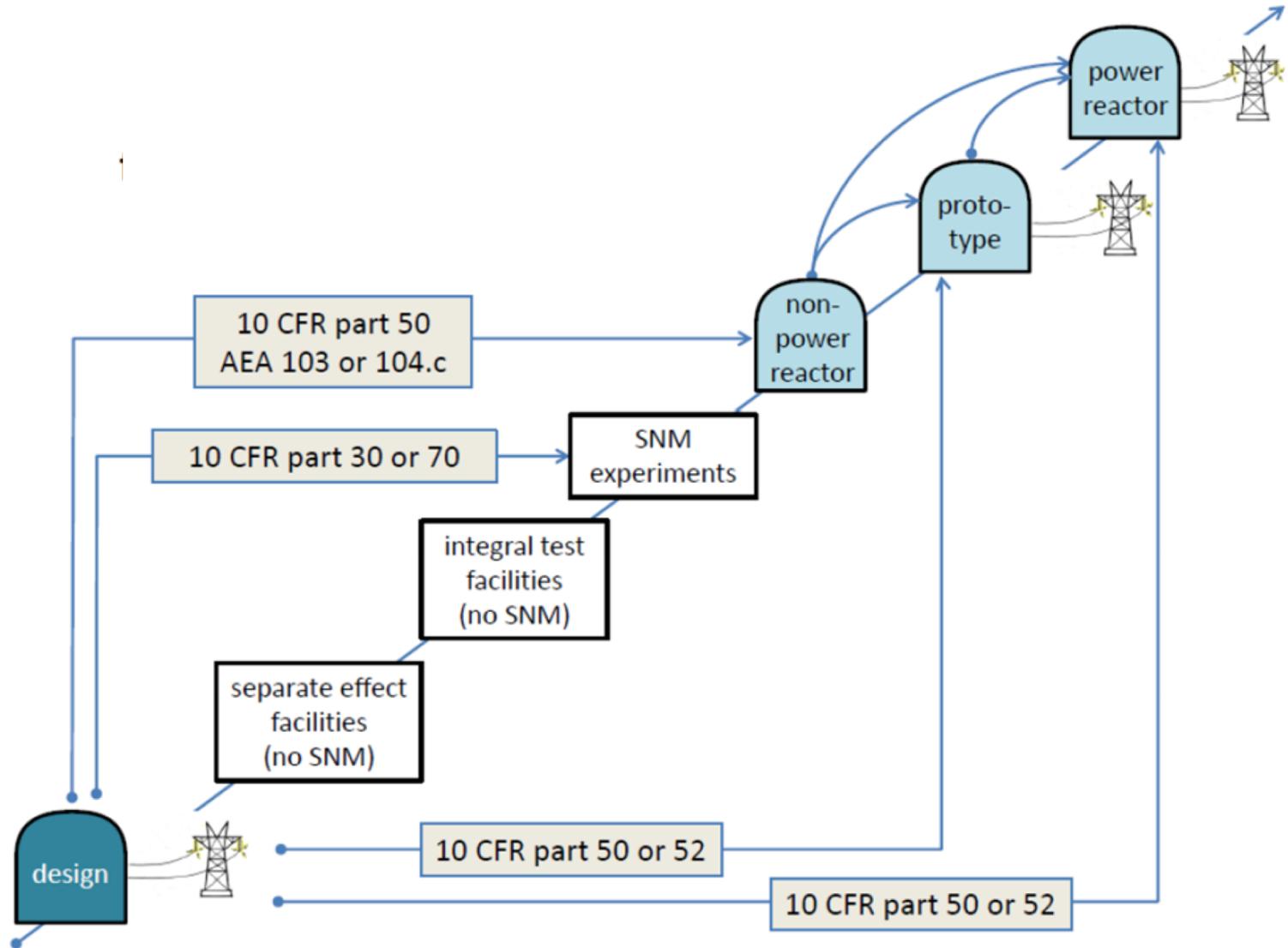
December 2016



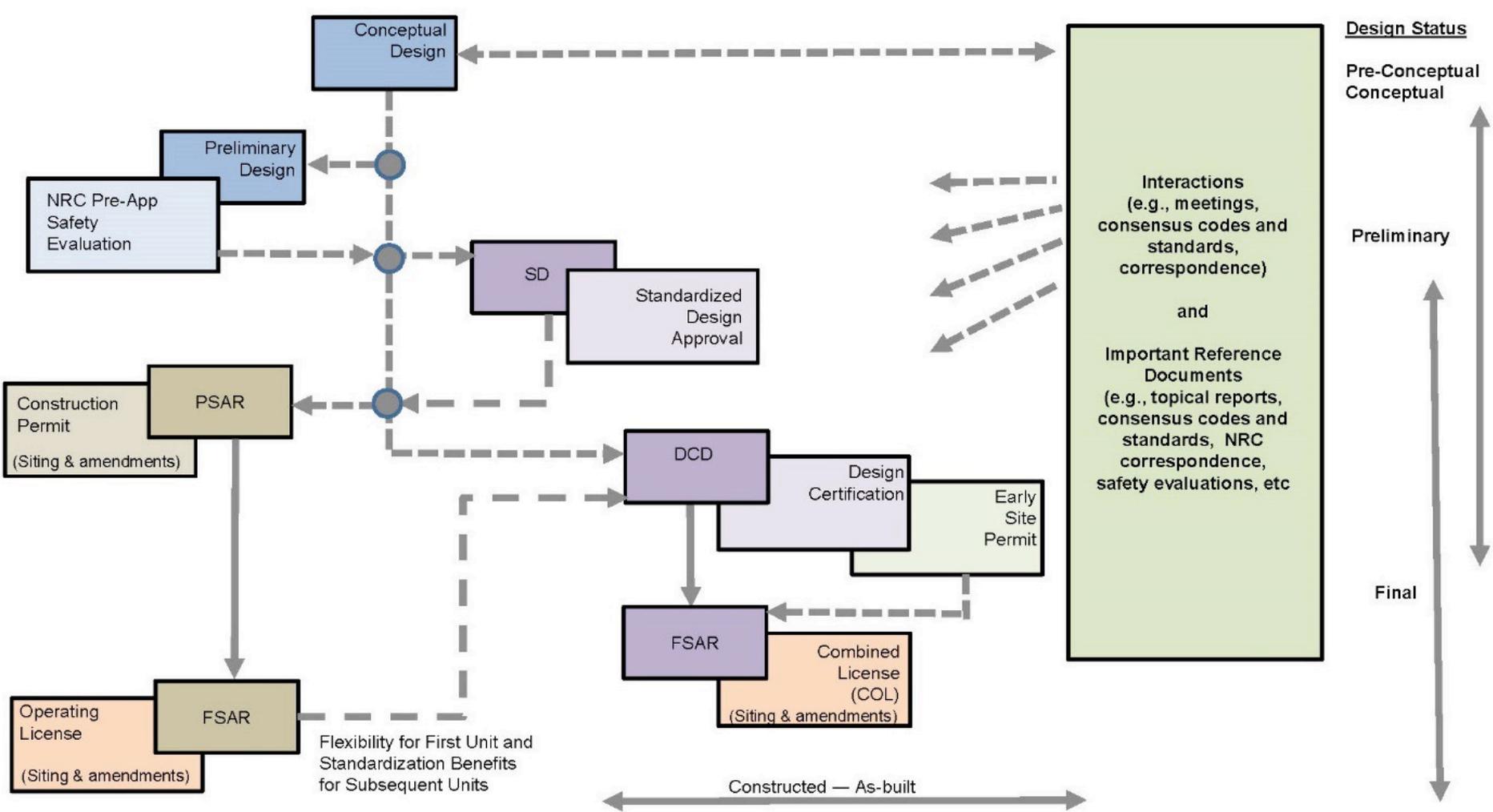
# Implementation Action Plans



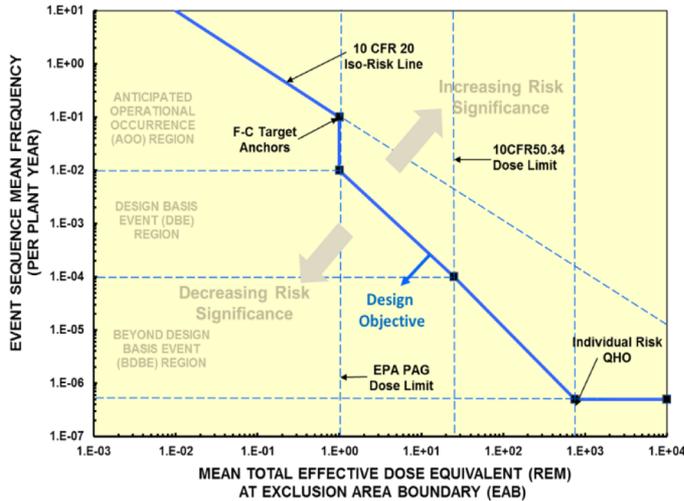
# Potential Licensing Pathways



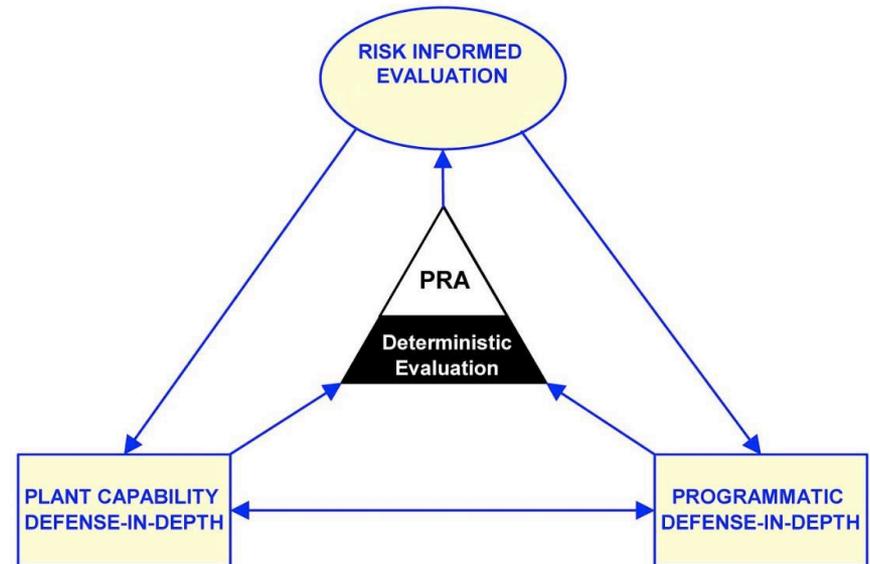
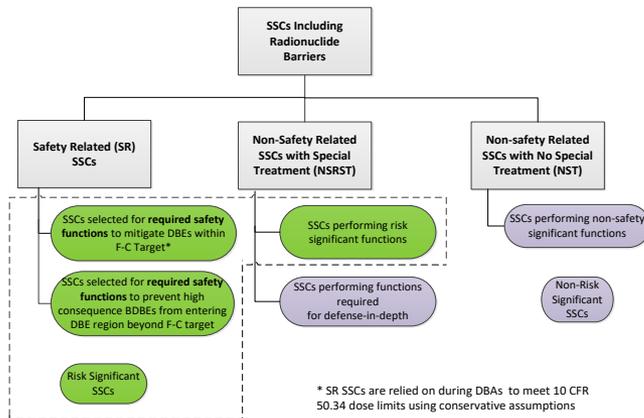
# Flexible Regulatory Engagement



# Licensing Modernization Project



- Licensing Basis Events
- SSC Classification
- Defense in Depth

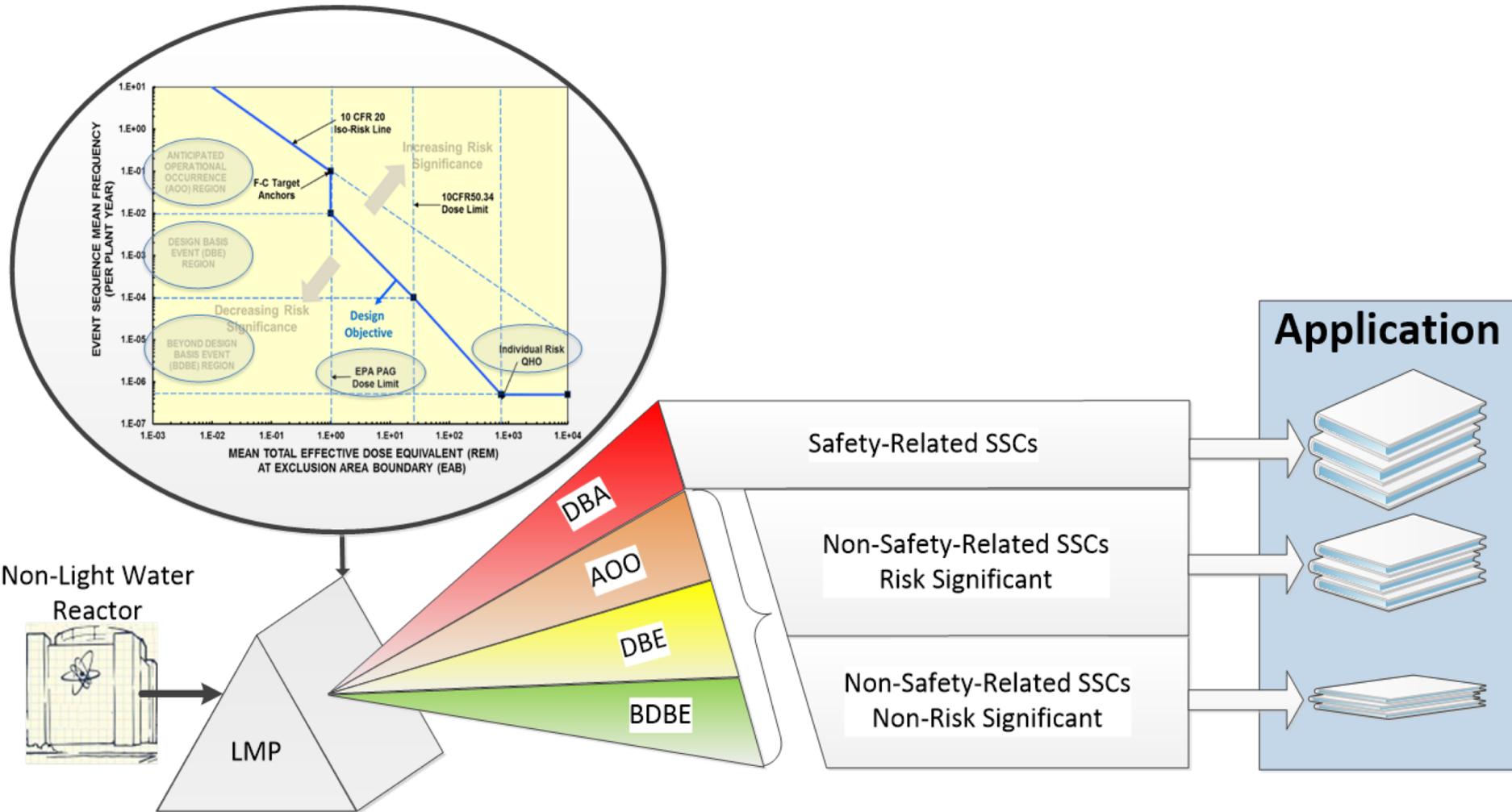


# Licensing Modernization Project

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- Staff released working draft of DG-1353 in September 2018
  - DG-1353 would endorse NEI-18-04
  - Staff also prepared associated draft SECY paper
- ACRS Subcommittee meetings held June 19 and Oct 30, 2018, and Full Committee meeting was held Feb 6, 2019
  - Supportive letter issued dated March 20, 2019
- Several pilots have been conducted and more are planned
- DG-1353 issued for public comment on May 3, 2019
- Next Steps:
  - Issue SECY paper
  - Final RG planned for late 2019
  - LMP “Phase 2” in planning
- “Part 53” would build off the LMP foundation

# Focusing the Content of Applications

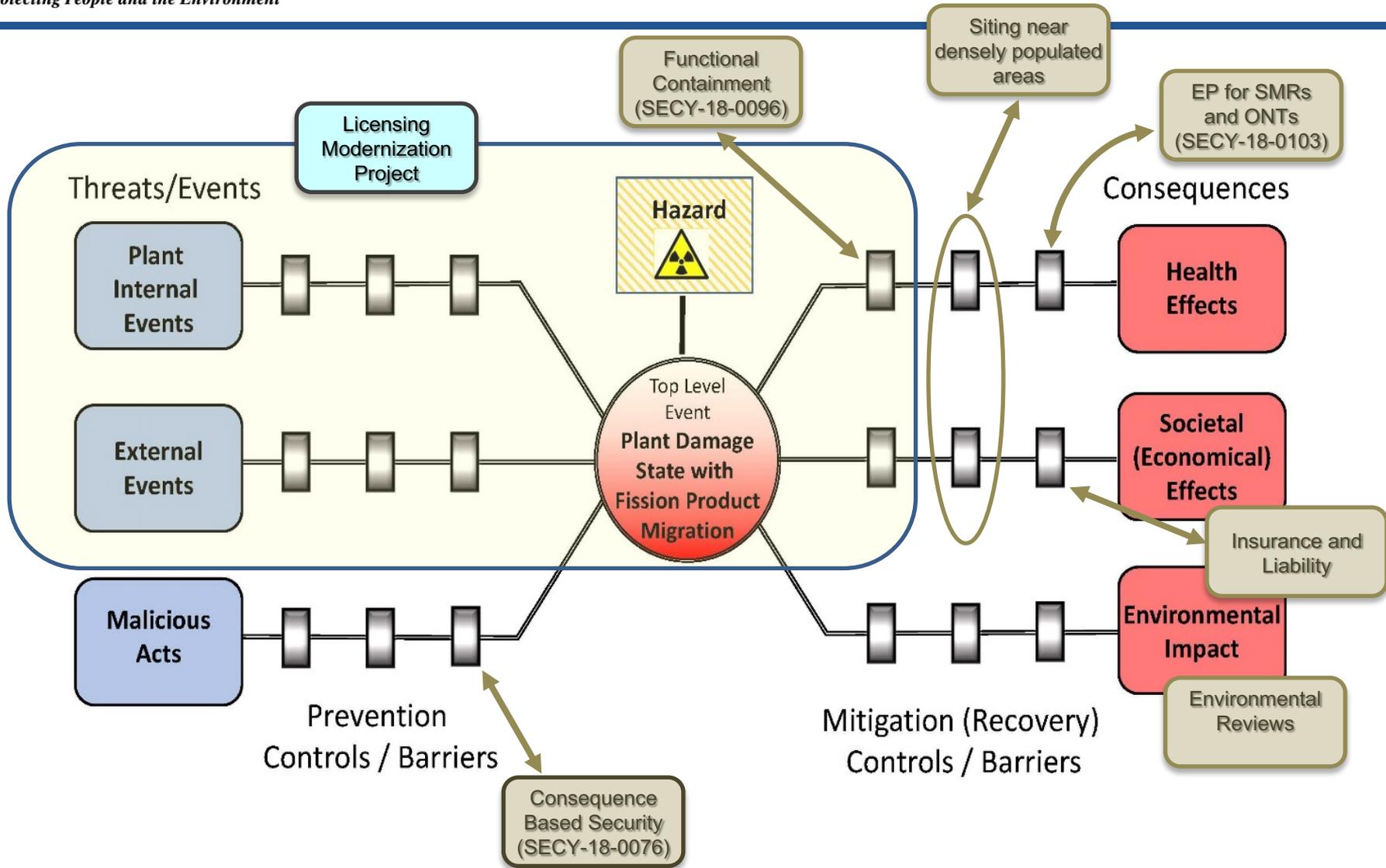


# Other Licensing Initiatives

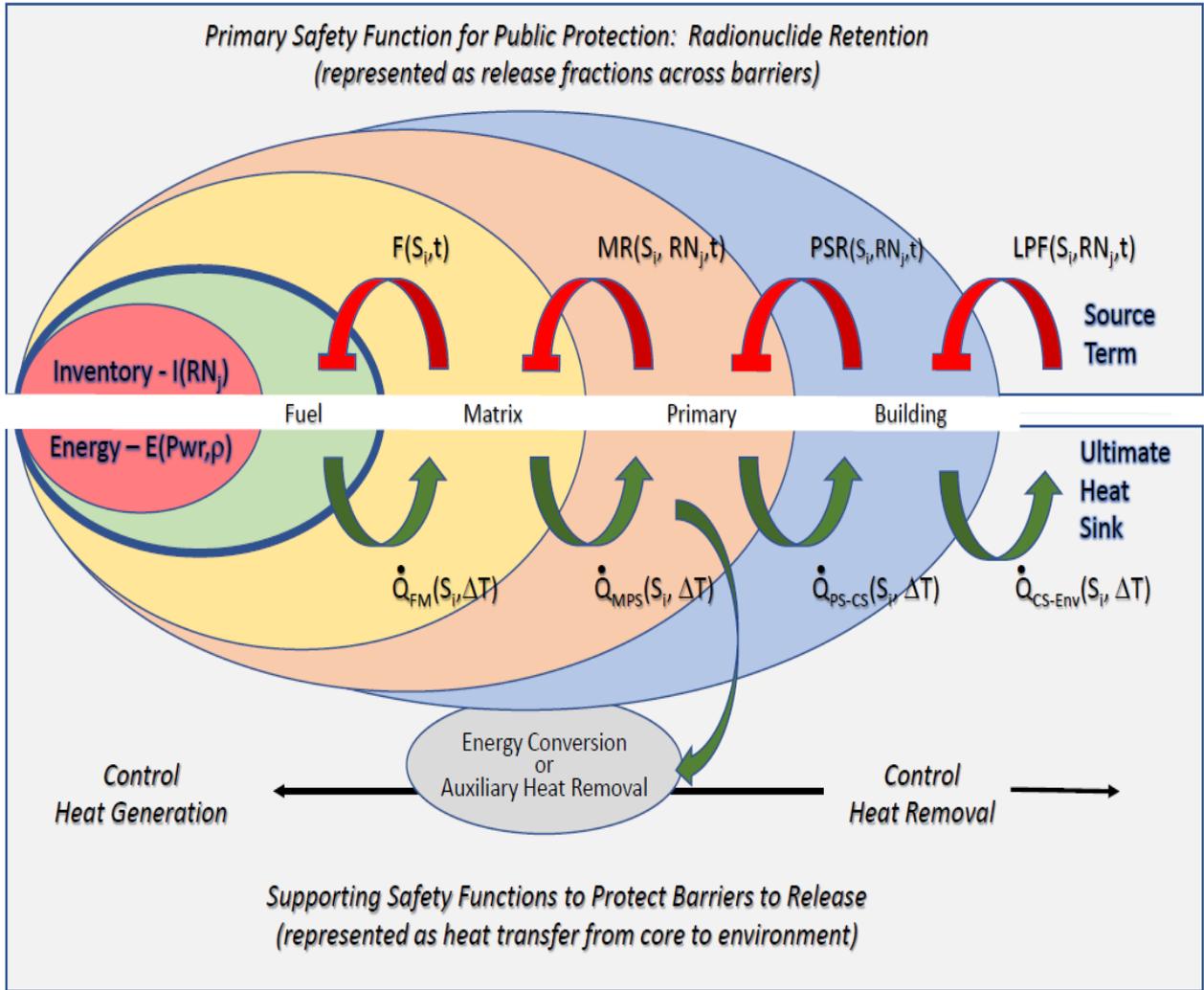
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- Advanced Reactor Design Criteria
- Functional Containment Performance
- Emergency Planning Requirements
- Security Requirements
- Siting Guidance
- Industry Codes & Standards (e.g., ASME Section III, Division 5, Non-LWR PRA Standard)

# Integrated Design / Review



# Fundamental Safety Functions and Mechanistic Source Term



$I(RN_j)$	Inventory
$RN_j$	Radionuclide Groups (j)
$E$	Heat Energy
$Pwr$	Power Level
$\rho$	Reactivity
$F$	Fuel Release Fraction
$MR$	Matrix Release Fraction
$PSR$	Primary System Release Fraction
$LPF$	Building Leak Path Factor
$S_i$	Event Sequences (i)
$t$	Time
$\dot{Q}$	Heat Transfer
$FM$	Fuel to Matrix
$MPS$	Matrix to Primary System
$PS-CS$	Primary System to Cooling System
$CS-Env$	Cooling System to Environment
$\Delta T$	Temperature difference

# Core Team Concept

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- Successfully implementing for OKLO, Kairos, and X-Energy pre-application reviews
- Core team consists of subject matter experts from NRO, NMSS, NSIR, NRR, RES, and OGC
- Integrated/risk-informed review
- Provides stability to applicant
- Process oriented guidance rather than prescriptive guidance
- Effective and efficient use of NRC resources

# Micro Reactors

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- DOE/DOD interest
- Pushing the envelope further
  - EP
  - Security
  - Staffing
  - Remote/Autonomous Operations
  - Environmental
  - Siting
  - Oversight
  - Transportation (Portable)
- Need to scale review to consequences

# Notable External Drivers

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- Nuclear Energy Innovation Capability Act (NEICA)
- Nuclear Energy Innovation and Modernization Act (NEIMA)
  - Staged licensing
  - Risk-informed licensing
  - Technology-inclusive regulatory framework
- Stationary Micro-reactors - Nuclear Defense Authorization Act
- Portable Micro-reactors – Interfacing with DoD and DOE

# NEIMA Reports

#	Summary of Action	Due to Congress
1	<p>Provide report to Congress on expediting and establishing stages in the licensing process for commercial advanced reactors that will allow implementation of the licensing process by January 14, 2021. (NEIMA Section 103(b)(1) to (b)(4))</p> <ul style="list-style-type: none"> <li>• Evaluate strategies for fuel qualification</li> <li>• Evaluate associated policy issues</li> <li>• Evaluate collaboration with standards-setting organizations and incorporation of consensus codes and standards</li> <li>• Evaluate options for improving the efficiency, timeliness, cost-effectiveness and predictability of licensing reviews</li> <li>• Evaluate extent to which commission action or policy change needed</li> </ul>	07/13/2019
2	<p>Provide report to Congress on “increasing, where appropriate, the use of risk-informed and performance-based evaluation techniques and” guidance for commercial advanced reactor licensing within the existing regulatory framework. (NEIMA Section 103(c)(1) to (c)(4))</p> <ul style="list-style-type: none"> <li>• Evaluate ability to develop and implement RIPB evaluation technique and guidance by Jan 14, 2021 including policies and guidance for resolution of LBE selection, mechanistic source term, containment performance, EP, fuel qualification and other previously identified policy issues.</li> <li>• Evaluate extent to which commission action required.</li> </ul>	07/13/2019
3	<p>Provide report Congress on completing rulemaking to establish a technology-inclusive regulatory framework &amp; ensuring NRC has adequate expertise, modeling &amp; simulation capabilities, or access to those capabilities, support evaluation of commercial adv RX license applications. (NEIMA Section 103(e)(1) to (e)(4))</p> <ul style="list-style-type: none"> <li>• Evaluate ability to complete rulemaking by December 31, 2027</li> <li>• Evaluate the extent to which additional legislation, or Commission action or policy change is needed</li> <li>• Evaluate the need for additional Commission expertise, modeling, and simulation capabilities, or access to those capabilities</li> <li>• Evaluate the budgets and timeframes for acquiring or accessing the necessary expertise</li> </ul>	07/14/2021
4	<p>Provide a report to Congress on preparing the licensing process for research and test reactors within the existing regulatory framework (NEIMA Section 103(d)(1) to (d)(4))</p> <ul style="list-style-type: none"> <li>• Evaluate the unique aspects of research and test reactor licensing and any associated legal, regulatory, and policy issues the Commission should address to prepare the licensing process for research and test reactors</li> <li>• Evaluate the feasibility of developing guidelines for advanced reactor demonstrations and prototypes to support the review process for advanced reactors designs</li> <li>• Evaluate extent to which commission action or policy change needed</li> </ul>	01/14/2020

# Making Progress

**The ability and willingness of the NRC to become more adaptive is crucial to continued investment in the diverse array of advanced nuclear technologies under development in the U.S.**

## Takeaways

NRC has a reputation for being rigid and inhospitable to innovation. For companies that are reimagining the design of a nuclear reactor, that makes it pretty tough to attract investment. But based on Third Way analysis, NRC has made major progress over the past few years to modernize its structure and processes to better accommodate advanced reactor developers. While licensing a new nuclear reactor will always be challenging, these steps are a positive indicator that NRC is willing to adjust in order to keep up with fast-evolving technologies.

*“I’m encouraged by the current Commission and its dedication to efficiency and innovation. Change can start at the top, but it also must permeate to all levels of staff, if it is to have lasting and practical impact. I’m confident it can be done, but it will indeed require transformation.”*

*As Dr. David Hill, Chief Technology Officer of Terrestrial Energy USA, has remarked, “Terrestrial Energy USA has been delighted with the amount of preparatory work the US NRC has done to ready itself to license the IMSR [Integrated Molten Salt Reactor] in the USA.”*

## Conclusion

Through its transformative and collaborative efforts, the NRC is becoming more transparent, communicative, and flexible in its approach to the regulatory process and interactions with advanced reactor developers. Advanced reactor industry stakeholders are engaged with the Commission, and have acknowledged its willingness to adapt and innovate in its procedures. Although further adjustments are necessary, the NRC has endeavored to ensure its efforts to accommodate advanced reactor technologies in the regulatory process are feasible, effective, and holistic.

# Addressing Challenges

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- Planning for the broad range of designs under development - Uncertainty in number, type and timing of applications
- Some developers have limited regulatory experience
- Expanding NRC staff organizational capacity
- Ensuring coherence of new licensing approaches
- Pursuing paradigm shift in regulatory reviews

# References

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- NRC Vision and Strategy (ML16356A670)
- Implementation Action Plans (IAPs) (ML17165A069 and ML17164A173)
- Regulatory Review Roadmap including prototype guidance (ML17312B567)
- RG 1.232, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors" (ML17325A611)
- SECY-18-0011, "Advanced Reactor Program Status" (ML17334B217)
- SECY-19-0009, "Advanced Reactor Program Status" (ML18346A075)
- SECY-18-0076, "Option and Recommendations for Physical Security for Advanced Reactors" (ML18052B032)
- SECY-18-0096, "Functional Containment Performance" (ML18114A546)
- SECY-18-0113, "Proposed Rule: Emergency Preparedness for Small Modular Reactors and other New Technologies," (ML18134A086)
- NEI-18-04, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development," (ML18271A172)
- Preliminary Draft DG 1353, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Content of Applications," (ML18264A093)