



## Advanced Reactors – Technical Readiness Activities by the Office of Nuclear Regulatory Research

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## NRC Implementation Action Plan

- **Strategy 1:** Acquire/develop sufficient knowledge, technical skills, and capacity to perform non-LWR regulatory reviews
- **Strategy 2:** Acquire/develop sufficient computer codes and tools to perform non-LWR regulatory reviews
- **Strategy 3:** Establish a more flexible, risk-informed, performance-based, non-LWR regulatory review process within the bounds of existing regulations, including the use of conceptual design reviews and staged-review processes
- **Strategy 4:** Facilitate industry codes and standards needed to support the non-LWR life cycle (including fuels and materials)
- **Strategy 5:** Identify and resolve technology-inclusive policy issues that impact the regulatory reviews, siting, permitting, and/or licensing of non-LWR nuclear power plants (NPPs)
- **Strategy 6:** Develop and implement a structured, integrated strategy to communicate with internal and external stakeholders having interests in non-LWR technologies

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## Office of Research Support

- RES activities are directed primarily towards “Computer Codes and Tools” (Strategy 2) and “Codes and Standards” (Strategy 4)
  - **“Computer Codes and Tools” Efforts Focus On:**
    - Design Basis / Normal Operations: Fuel Performance, Neutronics, Thermal-Hydraulics
    - Beyond Design Basis Events: Severe Accident Phenomena and Consequence Analysis
  - **“Codes and Standards” Efforts:**
    - Identification of Issues Requiring New/Expanded Standards
    - High Temperature Standards

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## Preparation & Training

- Significant effort in 2017 to “get up to speed”. Several staff became involved, and received training in advanced non-LWR technologies and potential analysis tools.
- RES staff were involved in:
  - EPRI/GAIN Workshops (Modeling & Simulation, Fuel Safety, T/H)
  - MSR Chemistry Workshop
  - MSR Technology Training
  - MOOSE/BISON training
  - Meetings with DOE experts at national laboratories.

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## Formation of an NRC Code Suite

- Unlike conventional LWRs, computer codes for non-LWRs must be tightly coupled. “*Multi-physics*” is the term commonly applied.

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    graph TD
      A[System Thermal-Hydraulics] <--> B[Reactor Kinetics]
      A <--> C[Subchannel (Local) Thermal-Hydraulics]
      B <--> D[Fuel Performance]
      C <--> D
  
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## Formation of an NRC Code Suite

- **Considerations that influence selection of analysis codes :**
  - Does a code contain the correct physics & modeling features?
  - Is it more economical to develop an NRC code, or adopt use of a code developed elsewhere (DOE, commercial, international)?
  - If a non-NRC code is used, how does the NRC maintain its independence (especially if used by an applicant)?
  - Can a code be developed for application to more than one reactor design type?
  - What applicable verification & validation (V&V) exists for a particular code?

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### Design Basis Events

- Thermal-Hydraulics**
  - A “pre-PIRT” exercise was completed to identify modeling and simulation needs for fuel salt MSR. Panel covered both T/H and neutronics.
  - A similar “pre-PIRT” on SFR phenomena and modeling features is being prepared.
  - An MOU with DOE has been prepared for access and use of the CASL & NEAMS codes by NRC.
  - Pilot study initiated to couple TRACE with MOOSE/BISON.
  - Several staff have received training on MOOSE and BISON
  - SAM and PRONGHORN (DOE) codes obtained and are being tested at NRC.

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### Design Basis Events

- Fuel Performance**
  - Considering the use of BISON for some advanced non-LWR fuel types.
  - FAST (combination of FRAPCON and FRAPTRAN) being developed and updated to accommodate non-cylindrical geometries and include advanced reactor material properties.
- Neutronics**
  - Develop fine group library and group structure that is applicable to SFRs.
  - Upgrade PARCS neutronics code so that it accounts for the reactivity effect of axial and radial core expansions .
  - Obtaining and reviewing international partner contributions (CAMP members) for TRACE/PARCS fast reactor cross-sections & reactivity.

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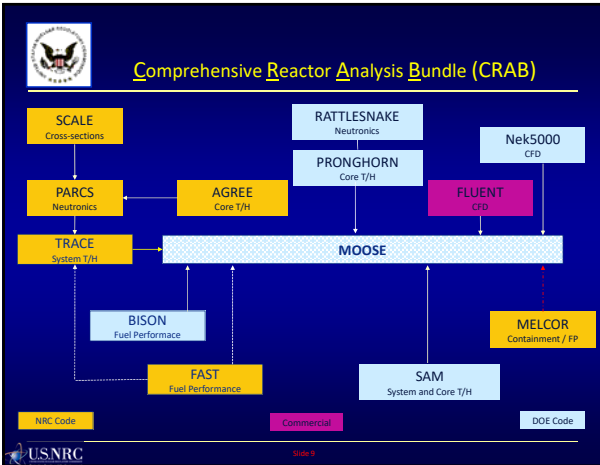
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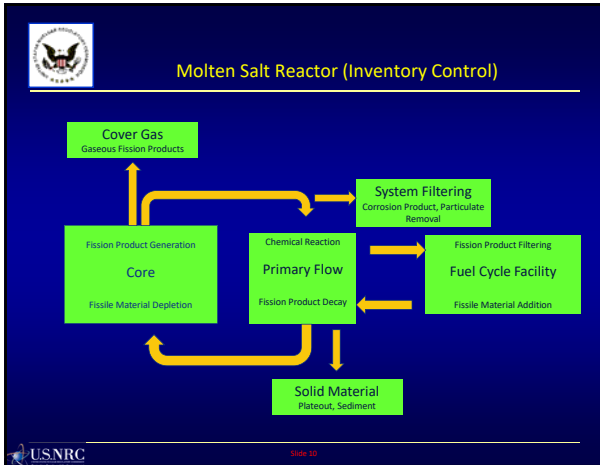
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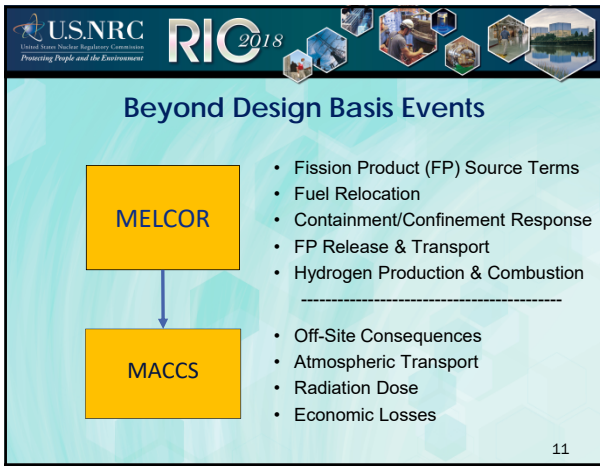
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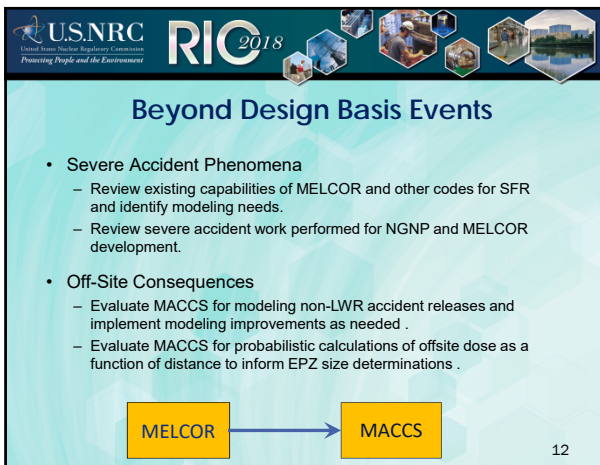
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## Materials and Component Integrity

- Primary objective is to assess performance needs and identify material/component issues for non-LWR reactors.
- Identification of gaps in knowledge, experimental data, and assessment tools for GCRs, SFRs and MSR.
  - Operational data & past experience reviewed for GCRs, SFRs.
  - Detailed literature review performed for MSR materials data.
    - Limited high-temperature creep data at the highest possible core outlet temperatures
    - Limited data on salt purity effects on coolant compatibility and performance
    - Limited data and mechanistic understanding on irradiation degradation effects
- **NRC Standards Activities for non-LWRs**
  - ASME Section III, Division 5 – High Temperature Materials
  - ANS Working Groups

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## 2018 Path Forward

- Activities in 2018 will continue to prepare for non-LWR licensing submittals. Generic approach taken in order to apply to multiple technologies and design features.
  - “Gap Analysis” : Use PIRTs to define required code capabilities.
  - “V&V Preparation”: Identify assessment needs, data.
  - “Plant Modeling”: Conceptual models for near-term applicants.
  - Continued support for Codes & Standards activities.
  - PRA review of previous non-LWR applications & support for regulatory guidance and policy.

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## Summary

- Activities to support non-LWR plant licensing were initiated in 2017, and progress is being made.
  - Several staff members becoming familiar with new plant designs, and modeling & simulation challenges.
  - Preliminary set of codes identified.
  - DOE codes are under consideration and being tested.
  - High temperature materials issues under consideration.
- Efforts in 2018 to continue to be primarily generic and focus on the identification of gaps in knowledge, experimental data, and modeling requirements for GCRs, SFRs and MSR.

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