Strategic Approach for Obtaining Material and Component Aging Information

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Outline

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- Purpose
- Background
- Harvesting Experience
- Approach to Strategic Harvesting
- Engagement with Other Stakeholders

Purpose

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- Create a framework for a strategic approach to harvesting ex-plant materials to support regulatory needs associated with SLR
  - Ex-plant materials offer unique environmental exposure that cannot be entirely replicated by laboratory testing with fresh materials

- Align high priority data needs identified in SLR/LTO activities with harvesting opportunities from decommissioning plants

Background

- To date, harvesting opportunities have been limited due to few decommissioning plants
  - Zion in U.S., Zorita in Spain
- However, several U.S. plants have already shut down or are planning to do so in the near future
  - Kewaunee, SONGS, Crystal River, Vermont Yankee, Oyster Creek
- This provides a unique opportunity to plan harvesting to address the highest priority technical and regulatory issues

Harvesting Experience

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- Past harvesting efforts have generally involved reactive decision-making
  - Limited opportunities to acquire ex-plant materials
  - Limited strategic planning for harvesting
- Harvesting projects with NRC involvement:
  - Reactors internal materials from Zorita
  - Concrete from Zorita
  - Neutron absorber material from Zion
  - Cables from Zion and Crystal River

Zorita Internals Research Project (ZIRP)

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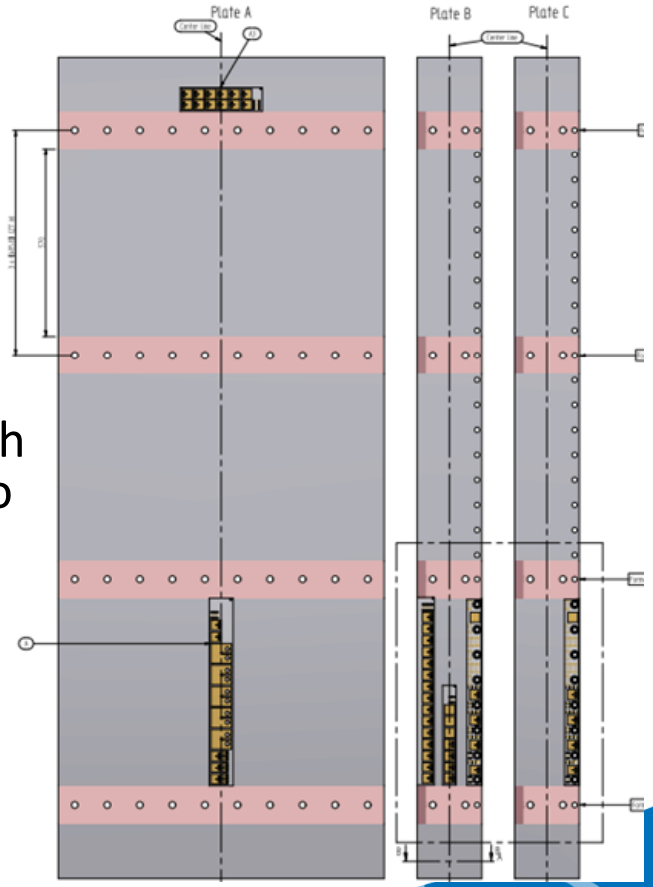
- **Materials Harvested**:
  - Baffle plate and core barrel weld materials
- **Scope**:
  - Mechanical testing (tensile, CGR, FT)
  - Microstructural characterization (void swelling)
- **Purpose**:
  - High-fluence (up to 50 dpa) IAD effects with representative LWR exposure conditions to
  - Support regulatory decision-making associated with SLR
- **Timeline**:
  - Initial discussions in 2006, harvesting in 2013, testing ongoing through 2016
- **Coordination**:
  - EPRI, international consortium, Studsvik, Halden



ZIRP Timeline

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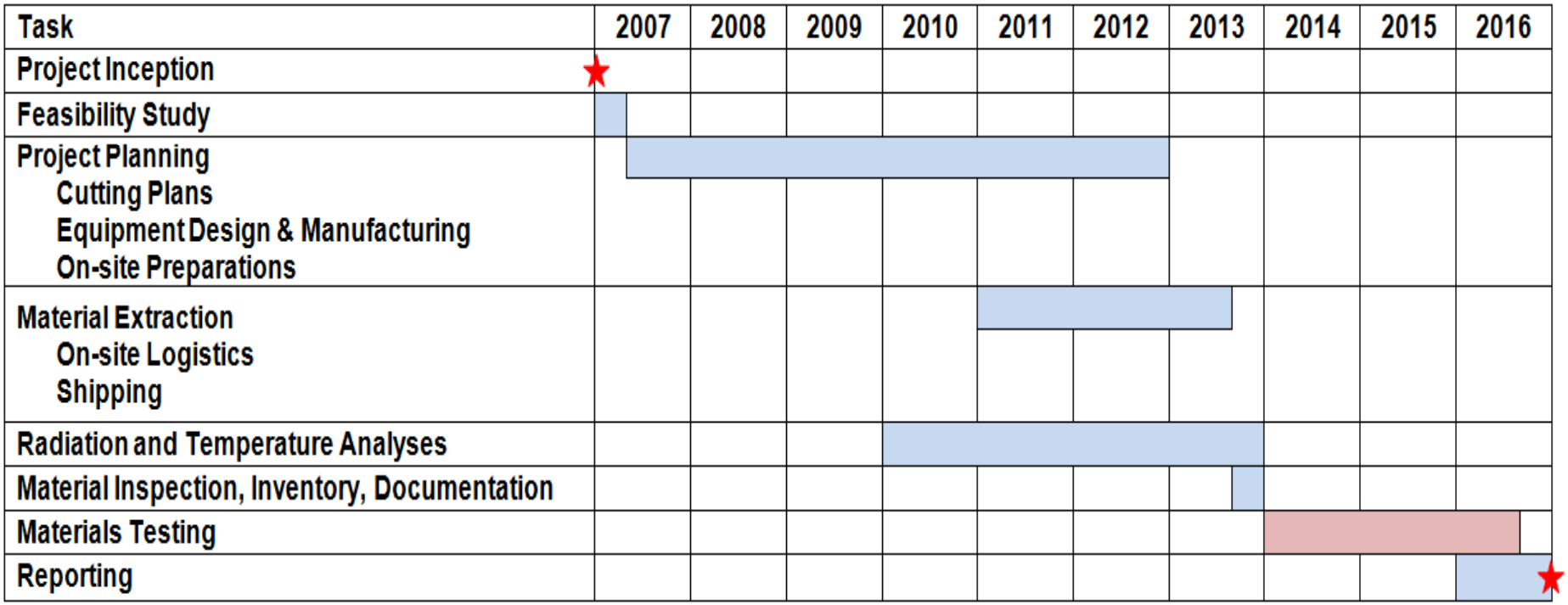

Neutron Absorbers from Zion

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- **Materials Harvested**:
  - Select Boral® NAM panels from Regions 1 and 2 of the Zion SFP
- **Scope**:
  - Visual and microstructural examinations (incl. areal density)
  - Corrosion testing
- **Purpose**:
  - Identify degradation mechanisms and estimate degradation rate
  - Confirm results of in-situ areal density measurements
  - Provide confirmatory data to support regulatory decision-making
- **Timeline**:
  - Initial discussions in 2014, harvesting in 2015, testing in 2015-2016
- **Coordination**:
  - EPRI, ZionSolutions, SRNL

Concrete from Zorita (Plan)

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- **Materials Harvested**:
  - Concrete from structures that are in close proximity to RPV
- **Scope**:
  - Mechanical testing (compressive, tensile, modulus of elasticity)
  - Microstructural characterization
  - Physical change
- **Purpose**:
  - High fluence in combination with temperature and humidity that are representative of LWR environmental effects on structural and shielding performance
  - Supports regulatory decision-making associated with SLR
- **Timeline**:
  - Initial discussions in 2014, harvesting in 2015, testing 2016-2018
- **Coordination**:
  - NRC , ENRESA and CSN

Cables: Zion and Crystal River

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- **Materials Harvested**:
  - Low and Medium Voltage Cables
- **Scope**:
  - Condition monitoring to assess cable performance under normal operating conditions (accelerated aging) and accident conditions
- **Purpose**:
  - Cable degradation due to normal operating environment and accident conditions
  - Supports regulatory decision-making associated with SLR
- **Timeline**:
  - Initial discussions in 2012; Cable samples harvested from Zion in 2013
  - Plan is to harvest additional samples from Crystal River and Zion in 2015
  - Testing expected to be completed in 2017
- **Coordination**:
  - ORNL, Zion Solutions, NIST, EPRI

Approach: Integrated Aging Degradation Need/Resource Interrogatory Tool

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- Utilize various sources of technical information with respect to anticipated degradation in NPPs out to 80 years of operation
  - NRC, DOE, EPRI, IAEA
- Identify high-priority data needs that could be addressed through harvesting ex-plant materials
  - Focus on identifying characteristics of important systems, structures, and components (SSCs) for harvesting
- Evaluate what relevant ex-plant material from decommissioned reactors is projected to be available for potential harvesting given previously identified needs

Sources: PMDA & EMDA

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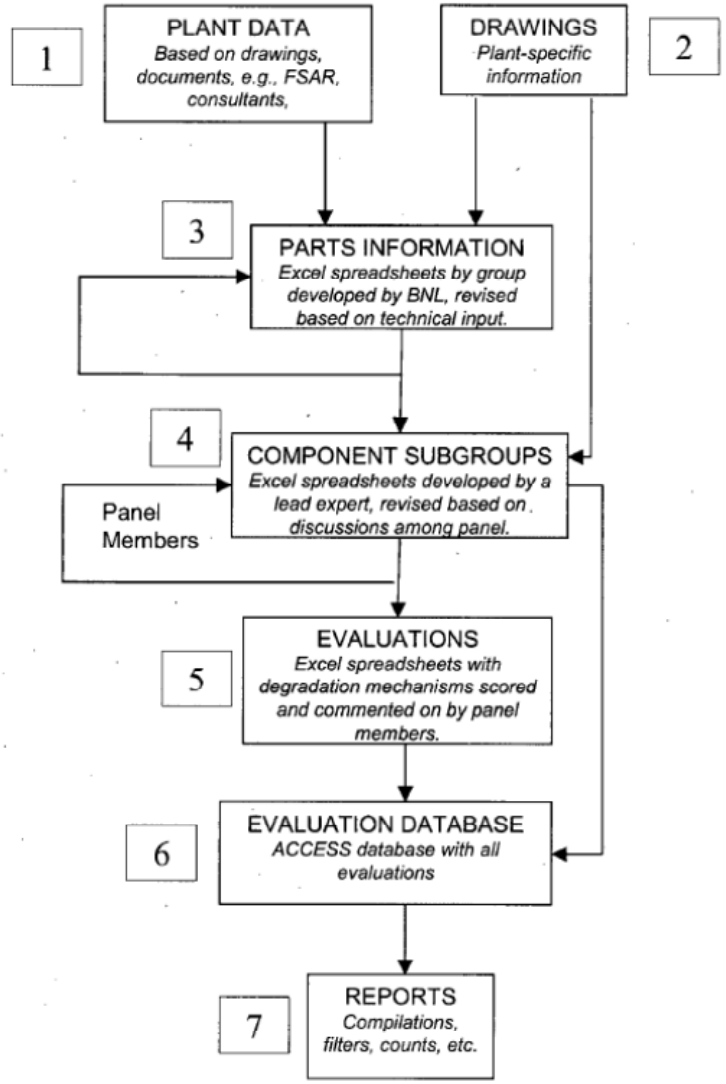
How does one try to predict the future?

- Experts were tasked with
  - Listing passive reactor components
  - Reviewing relevant degradation mechanisms
  - Determining the degree to which the components were susceptible to these mechanisms
  - Determining confidence level in their predictions
- The PMDA panel evaluated 3863 components (2203 for PWRs, 1603 for BWRs) for their susceptibility to 16 degradation mechanisms.
  - Documented in NUREG/CR-6923
- The EMDA panels investigated issues of reactor aging beyond 60 years to identify possible knowledge gaps, and provided an expansion of scope and time
  - Documented in NUREG/CR-7153

Sources: PMDA & EMDA



EMDA *(NUREG/CR-7153)*

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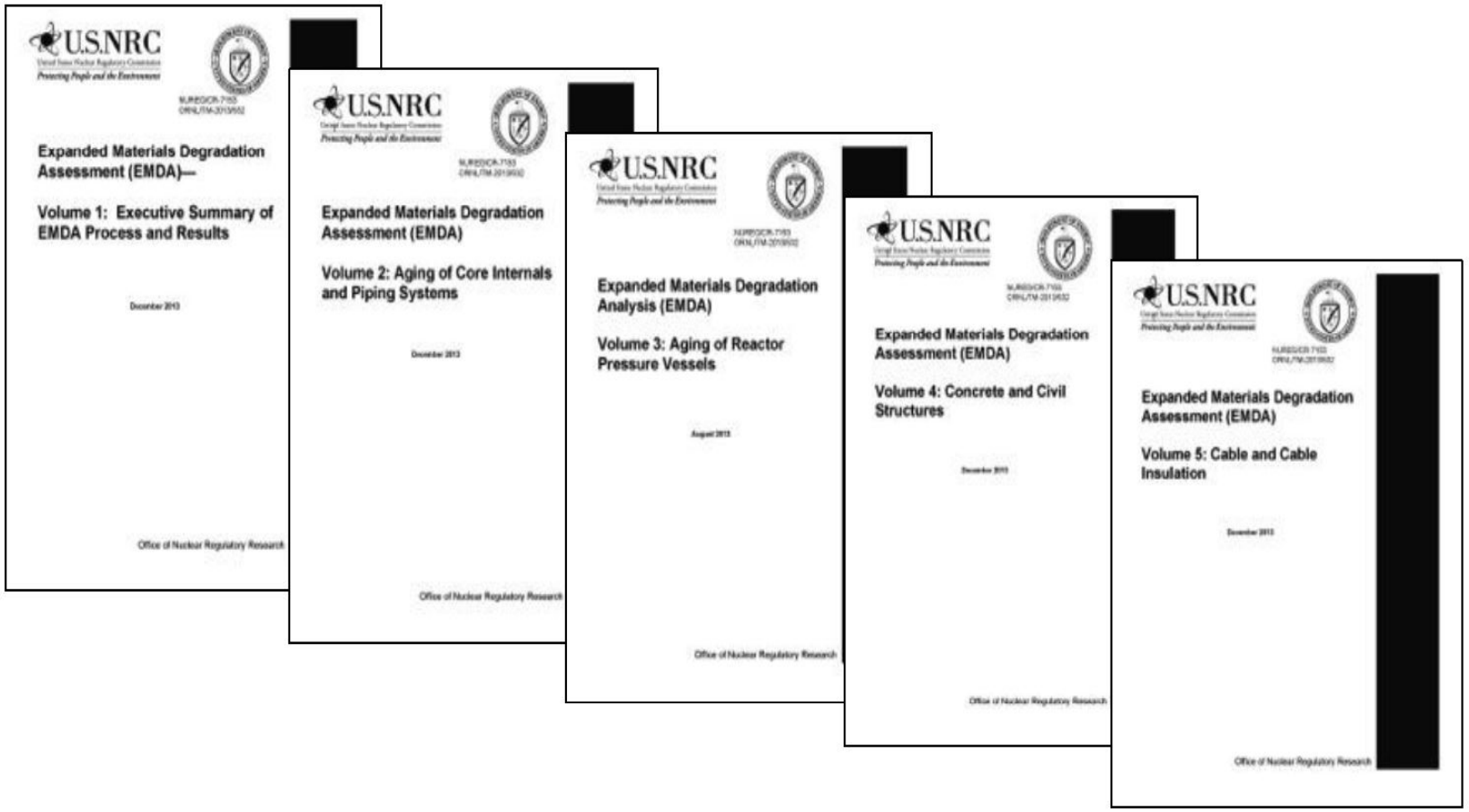
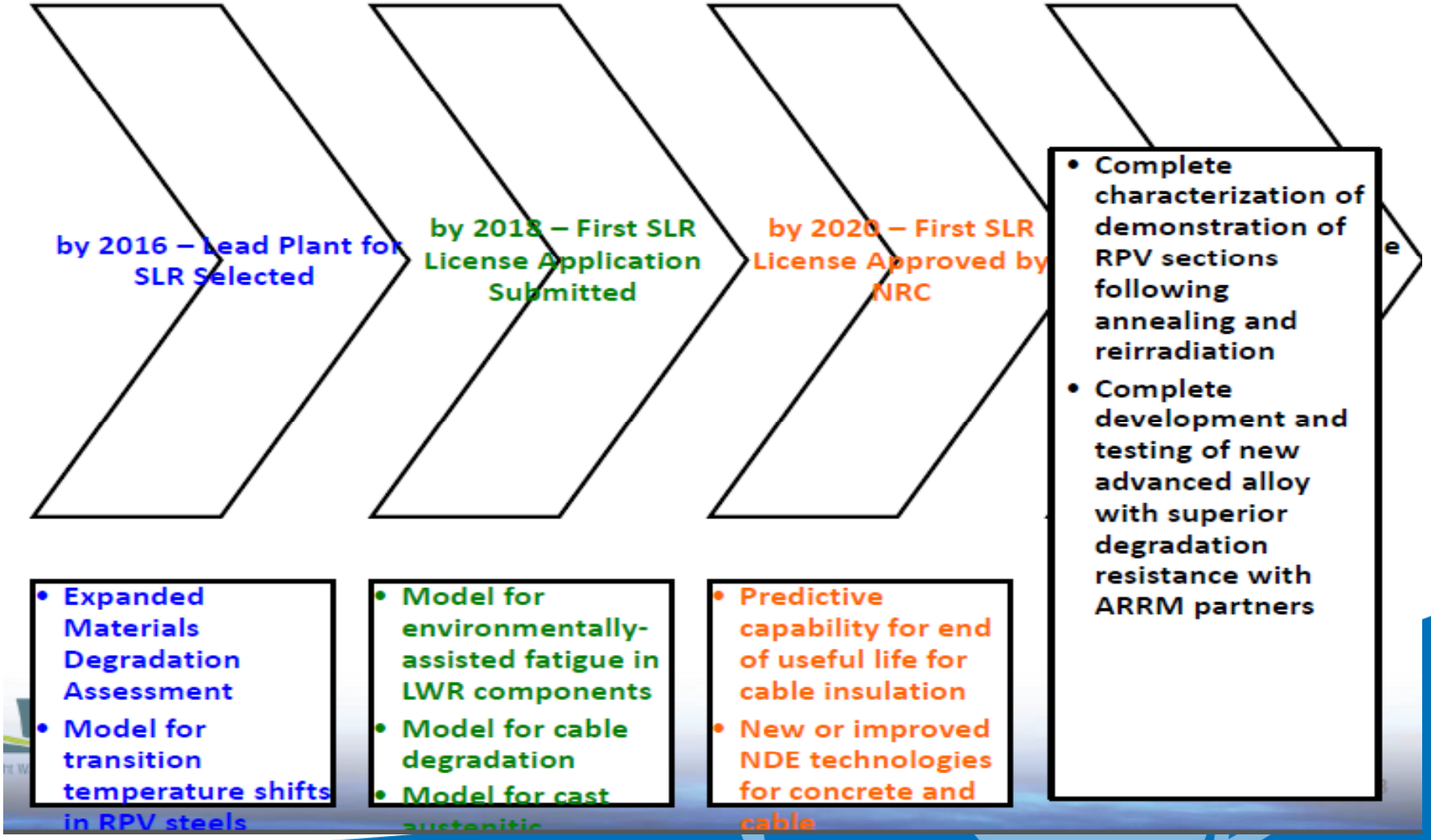
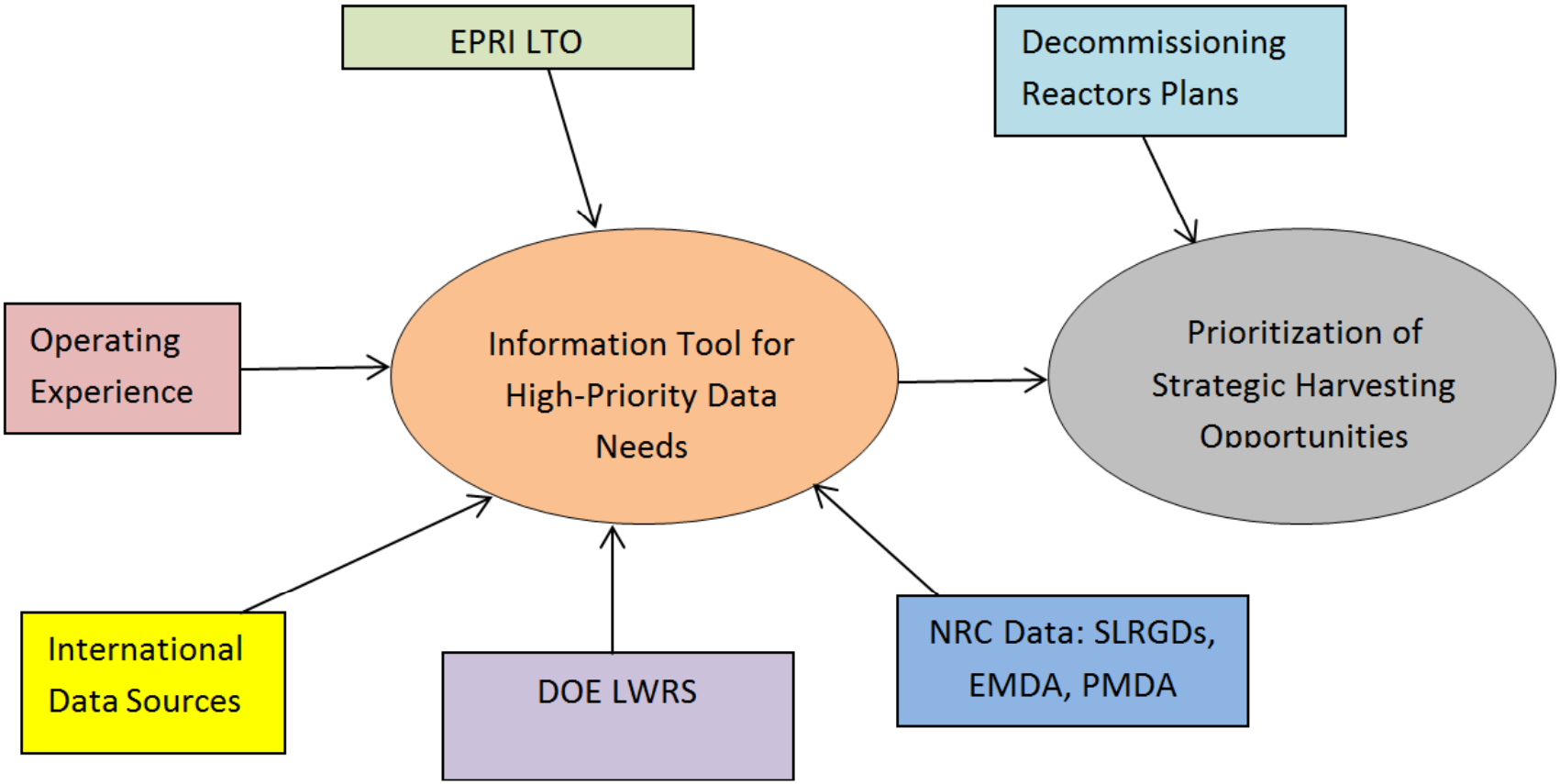


Source: DOE LWRS Program

(J. Busby, Overview Presentation to NESCC May 12, 2015)



The Vision: Integrated Aging Degradation Need/Resource Interrogatory Tool



Implementation

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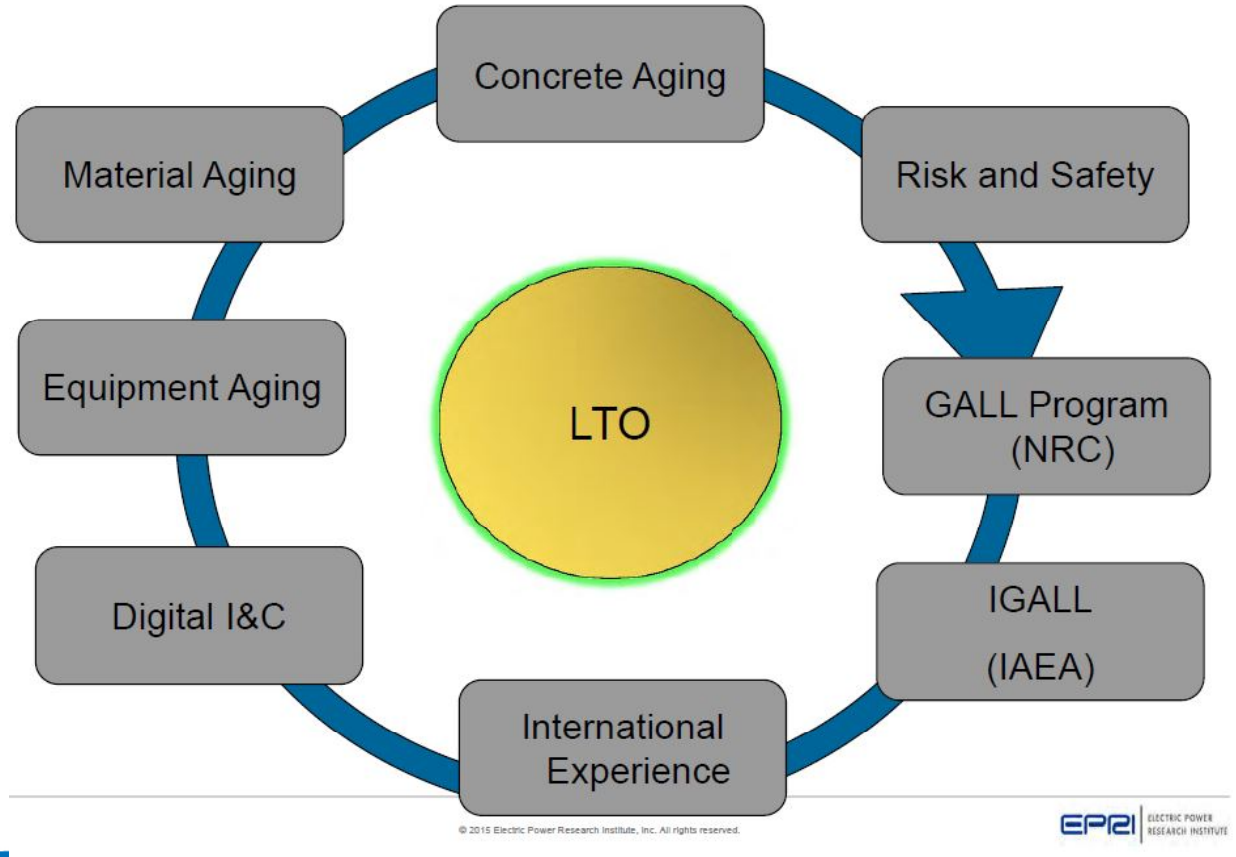
- What might the output of this activity look like?
  - For example, the review may show there is value in acquiring CASS material around 15% delta ferrite with various dose ranges (<0.08 dpa, 1–3 dpa, and >5 dpa)
- Once that need is identified, this activity would identify what SSCs might be the best candidates for harvesting
  - For example, perhaps lower support columns would be identified as the ideal SSC to address the CASS data need
- As decommissioning plants announce their plans, there is a clear list of SSCs and their characteristics (metallurgy, temperature, fluence, etc.) that would be desired to address the data need

Coordination with EPRI and DOE

- NRC has memorandums of understanding with EPRI LTO and DOE LWRS covering exchange of information related to SLR and welcomes the involvement of other stakeholders.



Stakeholder Engagement

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- IAEA CRP: Evaluation of Structures and Components Material Properties Utilizing Actual Aged Materials Removed from Decommissioned Reactors for Safe LTO.

- Conduct public workshops to further refine the concept of useful database of research objectives for ex-plant materials

- NRC welcomes collaboration under current EPRI/LTO and DOE/LWRS MOUs.

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Acronyms

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- ARRM – advanced radiation resistant materials
- CGR- crack growth rate
- CRP – coordinated research project (IAEA)
- CSN – Spanish regulator
- EMDA- expanded materials degradation assessment
- ENRESA – Spanish decommissioning authority
- FT – fracture toughness
- GALL – Generic Aging Lessons Learned
- IAD – irradiation-assisted degradation
- IGALL – international GALL
- LTO – long-term sustainability
- LWRS – LWR Sustainability
- MOU – Memorandum of Understanding
- NAM – neutron absorbing material
- NIST – National Institute of Standards & Technology
- NPAR – nuclear plant aging research
- PMDA – Proactive Materials Degradation Assessment
- PTS – pressurized thermal shock
- RPV – reactor pressure vessel
- SFP- spent fuel pool
- SLR – subsequent license renewal
- SLRGDs – subsequent license renewal guidance documents
- SRP-LR standard review plan for license renewal