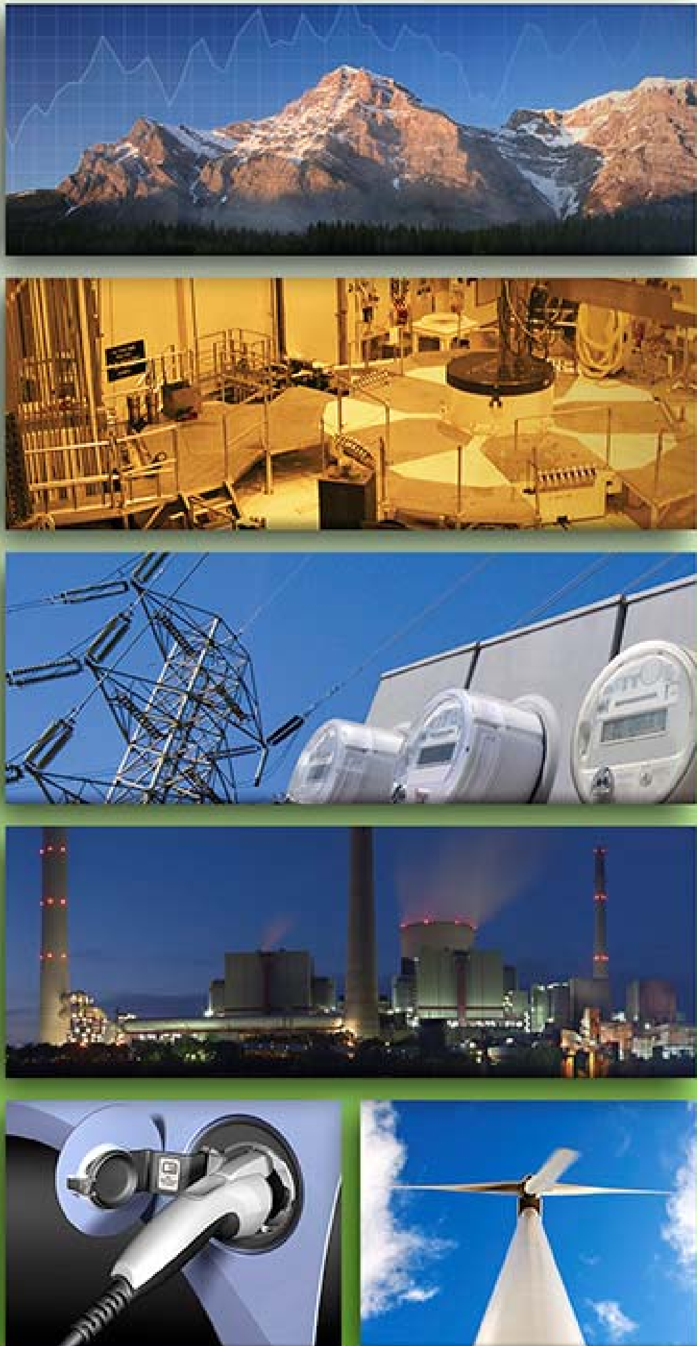

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EPRI Radiation Management Program Highlights from 2010

Phung Tran
Sr. Project Manager, EPRI

ISOE ALARA Symposium/ EPRI Radiation Protection Conference

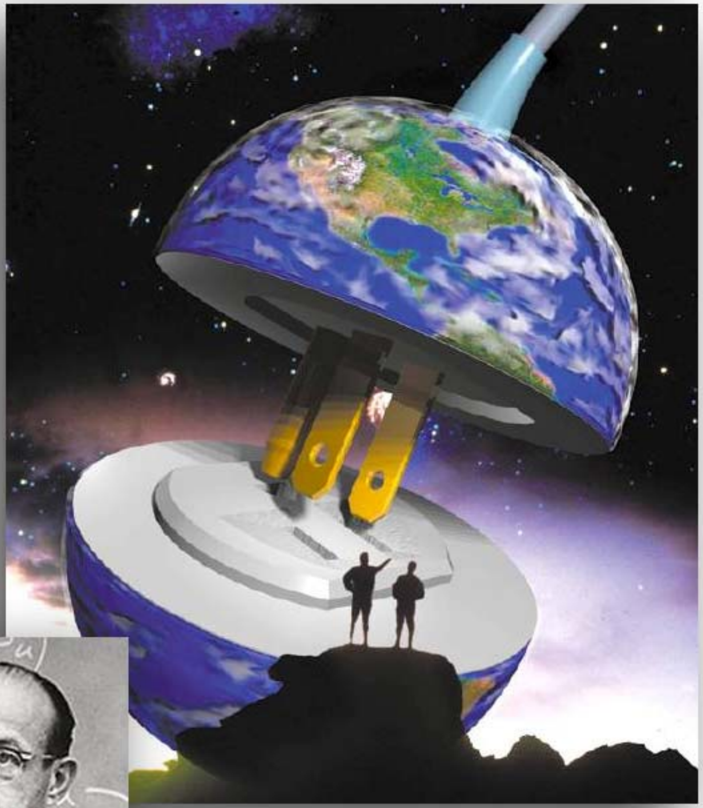
January 10-12, 2011

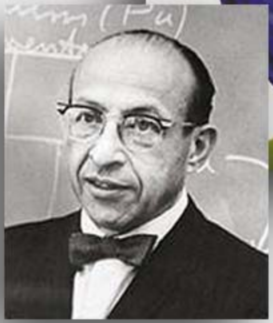
Presentation Outline

- EPRI Background
- Radiation Management Program Drivers and Research Strategy
  - Radiation Field Reduction Program
    - 2010 Highlights:
      - Cobalt Reduction Sourcebook
      - Evaluation of impacts of power uprates and operational events on radiation fields- results in 2011
  - Radiation Protection/ ALARA Program
    - 2010 Highlights:
      - Recommendations in ICRP -103 : Evaluation of High Dose Jobs and Technology Solutions
      - 3D EDE ALARA Planning Project at Kewaunee- project in progress

Our History…

- Independent, nonprofit center for public interest energy and environmental research
- Founded by and for the electricity industry in 1973, post concerns from US Congress after blackouts
- Collaborative resource for the electricity sector
- Major offices in Palo Alto, CA; Charlotte, NC; Knoxville, TN
  – Laboratories in Knoxville, Charlotte and Lenox, MA





Chauncey Starr
EPRI Founder

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Our Mission…

To conduct research on
key issues facing the electricity
sector…on behalf of its members,
energy stakeholders, and society.

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Our Members

- EPRI members generate more than 90% of the electricity in the United States
  - 450+ participants in more than 40 countries
  - Within Nuclear: Argentina, Belgium, Brazil, Canada, Czech Republic, France, Japan Mexico, South Africa, South Korea, Spain, Sweden, Switzerland, United Kingdom and United States

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2010 Program Deliverables

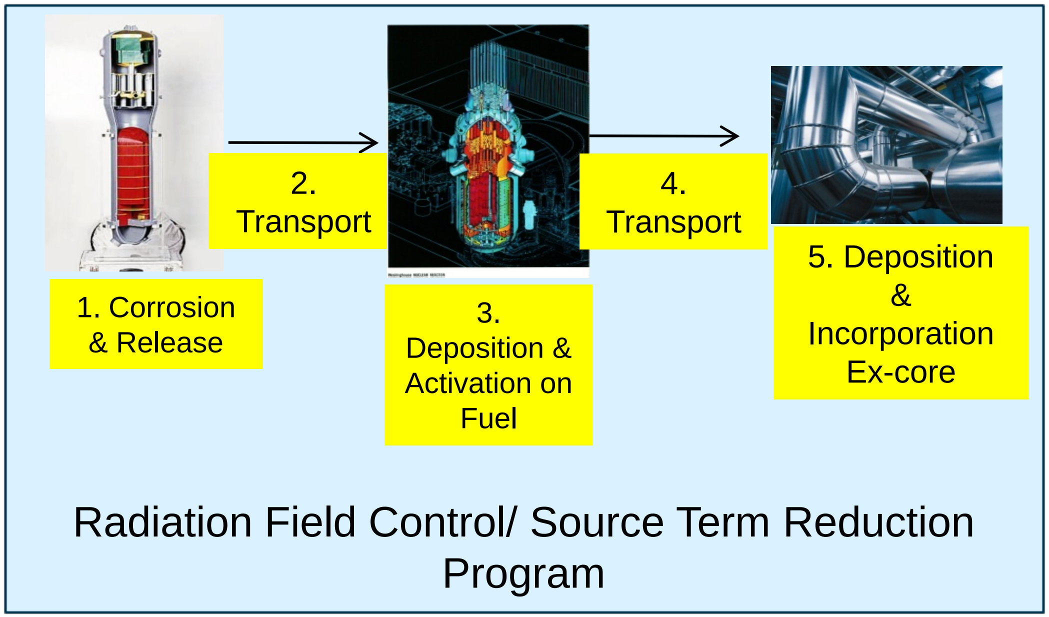
LLW and Radiation Management

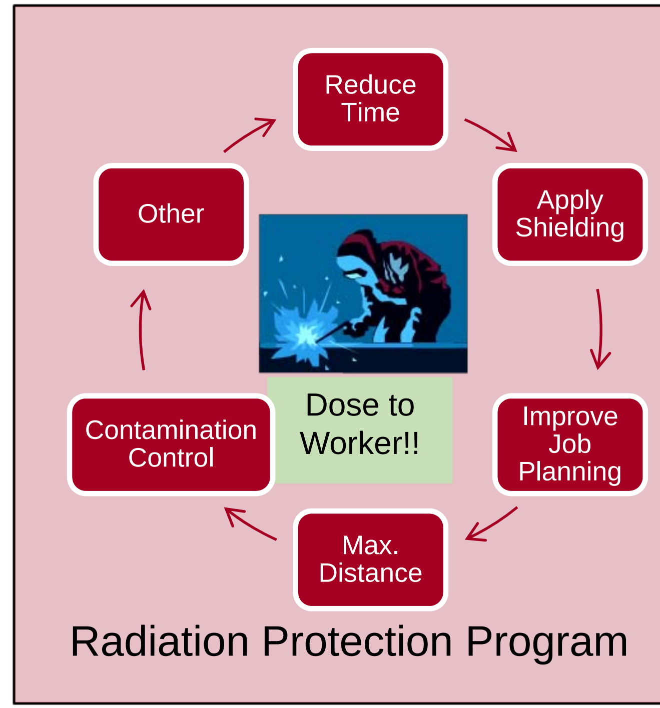
More detailed presentation at this meeting ★

Radiation Management (Objective 2)

- EPRI Cobalt Reduction Sourcebook, 1021103, 12/10 ★
- Recommendations in ICRP-103 and Its Potential Impacts to the Nuclear Industry Workforce:Evaluation of Nuclear Industry High Dose Jobs and Technology Solutions), 1021100, 12/10 ★
- Evaluation of Moldable Shielding for Permanent Installation, 1021101, 9/10
- Evaluation of Location Tracking Technologies for Radiation Protection Remote Monitoring, 1021182, 9/10
- Scaffold Program Optimization and Dose Reduction Guide (collaborative with NMAC),1021102, 9/10 ★
- Recommended Practices for Maintaining Radiation Safety of Radiographic Operations at a Nuclear Power Plant (w/NDE), 1022356, 12/10

Radiation Management Program Strategy





Reduce Radiation Fields and Reduce Contamination

RP2020 Strategies

- Reduce radiation fields—EPRI
- Improve technologies utilization—EPRI
- Align RP workforce supply and demand-NEI
- Standardize RP criteria & practices—NEI/INPO/EPRI
- Inform and Influence RP regulations—NEI
- Improve RP transparency and openness-NEI

Radiation Management Program Elements

Action Plan Program

- Radiation Management Program

Technical Areas

- A. Radiation Field Reduction
- B. Optimized Radiation Protection

Research Elements

A. Radiation Field Reduction:
- **1. Source Term Characterization**
- **2. Radiation Field Reduction Technologies**

B. Optimized Radiation Protection:
- 1. **Worker Dose Characterization**
- 2. **Dose Mitigation Strategies:**
  - ALARA Job Planning
  - Dose Calculation (EDE)
  - RP 2020Technology
- **3. RP Program Optimization**

Application Solutions (S*)

- 1. Radiation Management & Source Term Strategy Group
- 2. Radiation Protection & Source Term Assessments

* Self Directed Funding

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Radiation Management Program Drivers and Goals

- Regulatory Drivers (NRC):
  - 10 CFR 20 and 10 CFR 50, Appendix I Update to Align with ICRP 103 Recommendations

Most Significant Change May Be in the <u>Reduction of Individual Dose Limits</u>

- Industry Performance Drivers (INPO):
  - New INPO cumulative radiation exposure (CRE) dose goals (cycle median) by the end of 2015:
    - PWR: 55 person-Rem
    - BWR: 110 person-Rem
  - Eliminate/Reduce High Radiation Areas
  - Reduce Contaminated Areas
    - Reduce Personal Contamination Events (PCEs)

Potential Mitigation Strategies and Operational Factors that Impact Radiation Field Control

Corrosion and release	• Core design modifications • Zinc injection • Fuel cleaning • Surface preconditioning of corroding surfaces
Corrosion product transport	• Chemistry environment • Temperature • Corrosion product composition
Deposition and activation on the fuel	• Distribute boiling on the fuel • Zinc injection (prevent incorporation, crud stability) • Fuel cleaning
Activated product transport	• Chemistry environment • Temperature • Crud morphology
Deposition and incorporation into surfaces	• Zinc injection • Decontamination/Flushing • Electropolishing/Stabilized Chrome • Chemistry Environment/Shutdown Ops/Fuel Cleaning

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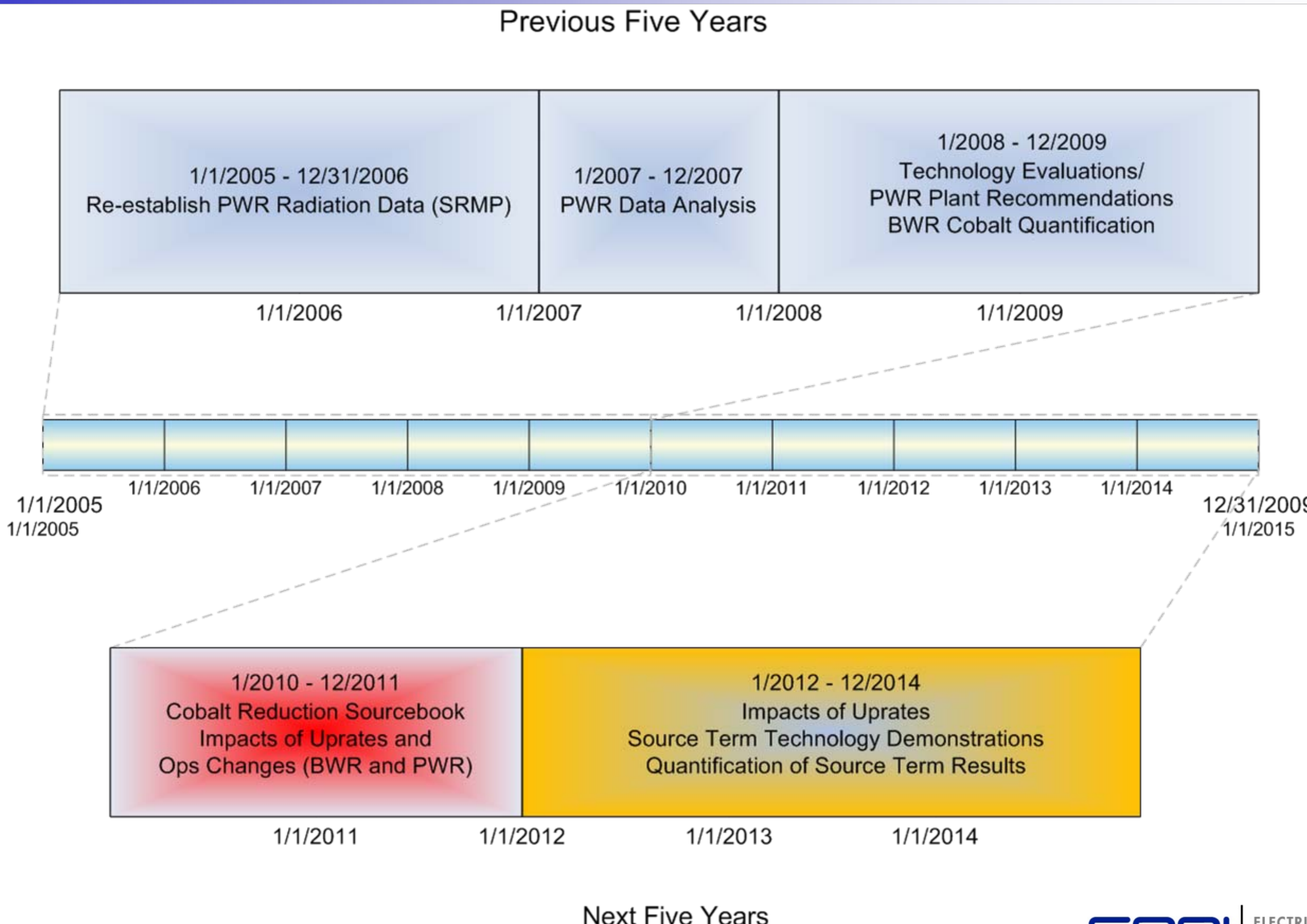
Radiation Field Reduction Program



Objectives of Cobalt Reduction Sourcebook (1021103)

- Define dominant sources of elemental cobalt in BWRs and PWRs
- Assess key radiation field mitigation technologies and their expected effectiveness
- Provide a generalized cobalt reduction strategy and identify program owners

Valuation Strategy

1) Tabulated lists of available Co reduction methods, expected time to observe benefits, and approximate costs for BWR and PWR plants

2) A series of flowcharts for implementing a Co reduction strategy for BWR and PWR plants

PWR Co Reduction Summary Table (excerpts*)

Technology/ Strategy	Benefits	Concerns	Expected Time Required Before Dose Rate Reduction	Approximate Cost
Elemental Cobalt Sources				
Improved valve maintenance monitoring with XRF	Reduce Stellite particles to core	None	2-3 cycles for core fuel replacement needed before expected reduction in RW ^{60}Co concentrations. Best case ^{60}Co decay curve after core replacement.	~$80K plus training and maintenance
Activity Removal Methods				
Local system chemical decontamination	High decontamination factors on piping	Waste and critical path.	Immediate reduction of dose rates.	~ $1 million, depends on system
In-vessel vacuuming	Removes particulate activity	Filters must be handled and stored	Immediate reduction of local particulate radiation fields.	~$50K
Out-of-Core Surface Incorporation Prevention				
Zinc injection	Proven results, large experience base	Fuel concerns for high duty cores	^{60}Co decay curve due to no new cobalt incorporation into oxide films. Faster decay curves possible if other gamma emitters are also mitigated.	~$300K/unit if no fuel exams or fuel cleaning required
Electropolishing	Significantly lower dose rates, reduced contamination levels	Must be performed with replacement components	Immediate results with newly installed equipment, contamination rates are 50% or greater slower.	~$10K with small components, more for SG Channel heads

*Full table evaluates 14 PWR technologies and strategies

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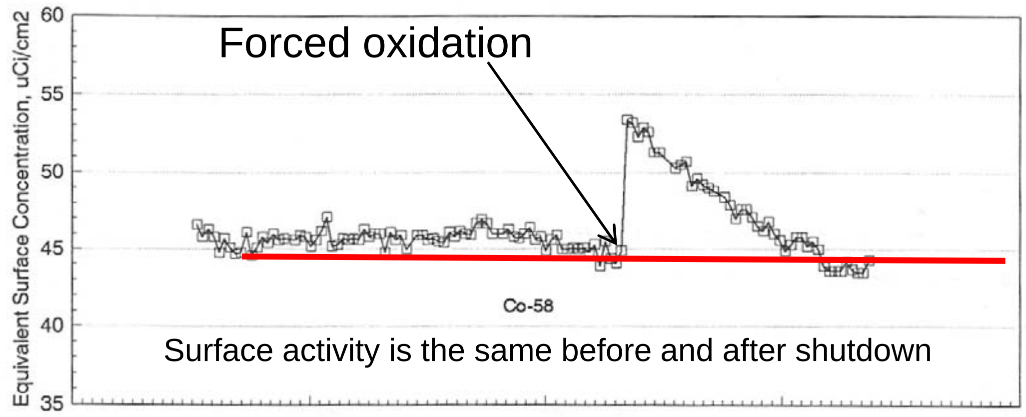
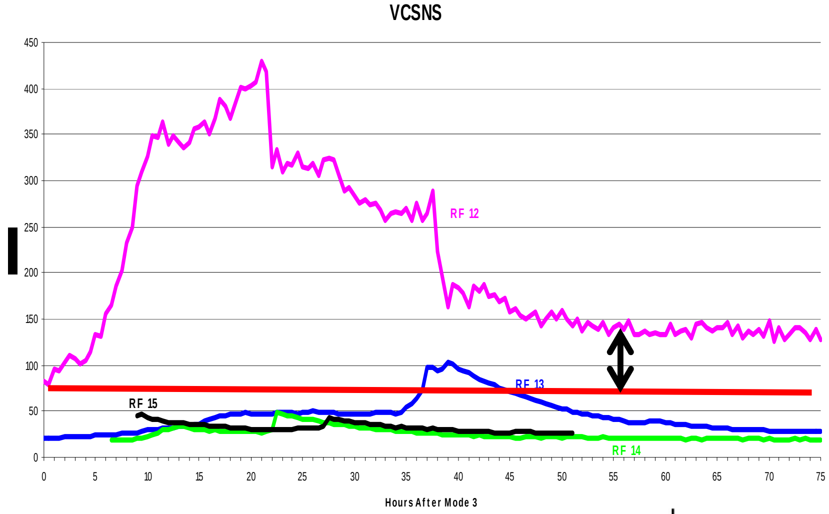
2010-2011: Dose Rate Impacts from Power Uprates and Operational Events

Background

- Uprates and aggressive core designs have changed the form of activity on fuel
  - Previously it was soluble or stayed on fuel but now more activity is released
- Electronic dosimetry of low-flow systems shows higher dose rates after shutdown (VC Summer example)
  - More activity being transported
    - Uprated cores change transport mechanisms
    - Plant trips and non-standard operations
  - Trends observed in PWRs and BWRs



Increased Dose Rate after Shutdown (VC Summer RF 12)



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Dose Rate Impacts from Power Uprates and Operational Events

Objectives

- Explore the operational causes for dose rate increases for PWRs and BWRs
- Determine if operations can be modified to reduce dose rate increases or anticipate them and develop contingency plans

Benefits

- Improve dose estimation for abnormal operations and outages by anticipating potential increases or minimize the impacts
- Improve contingency planning

Dose Rate Impacts from Power Uprates and Operational Events

Tasks:

- Benchmark several BWRs and PWRs for BRAC, SRMP, and auxiliary system dose rates
  - Choose plants with installed Electronic Dosimeters throughout cycle
  - Demonstrate using ED to prioritize system flushes after shutdown
- Use results to compare to chemistry, core design, and operations
  - Determine causal factors for higher dose rates in auxiliary systems
  - Attempt SRMP point/auxiliary system dose rate correlation
- Assess particulate deposition mechanisms and causes
  - Identify PWR and BWR plant operations that may lead to particulate deposition
  - Determine additional data requirements
- Develop recommendations or strategies for anticipating and/or minimizing dose rate increases due to known operational events

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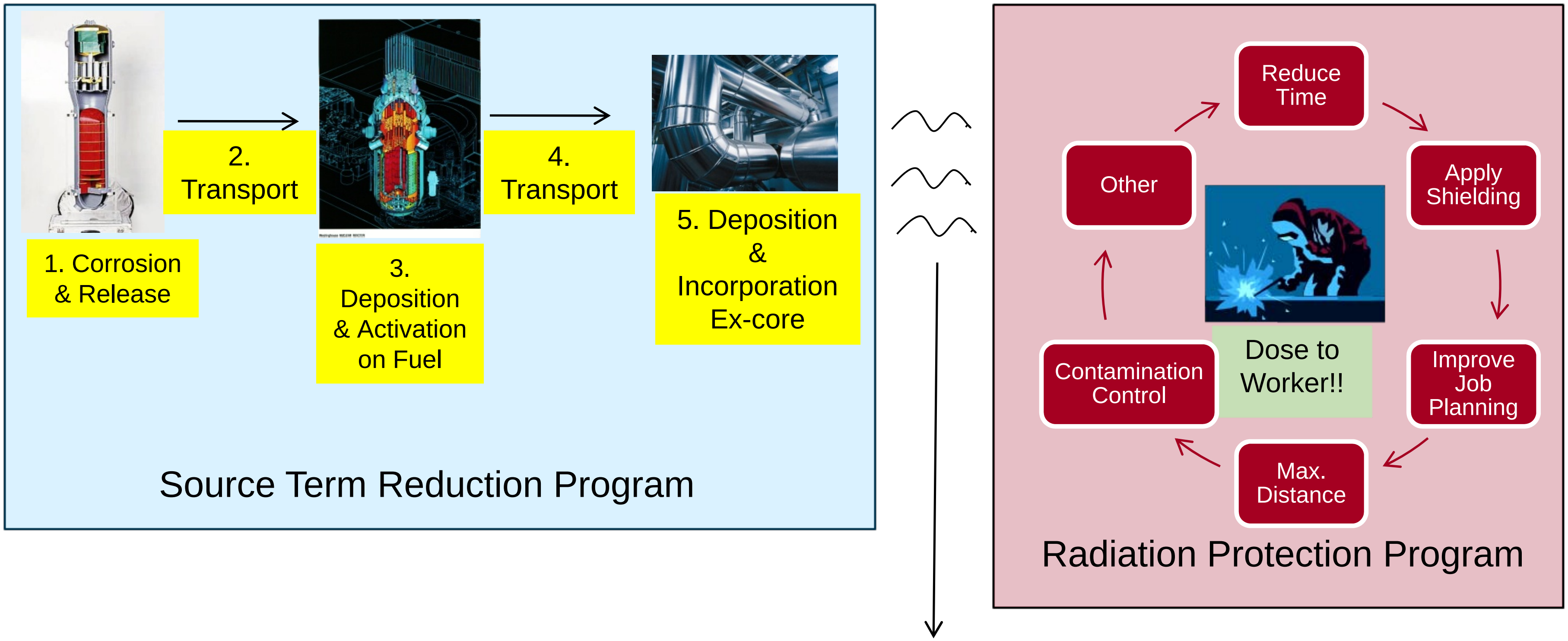
Radiation Management Program Strategy



Reduce Radiation Fields and
Reduce Contamination

2010: Recommendations in ICRP-103 and Its Potential Impacts to the Nuclear Industry Workforce: Evaluation of Nuclear Industry High Dose Jobs and Technology Solutions- (1021100)

Identification of High Dose Workers:

- Data Sources: PADS (NEI), Outage Reports, Plant/Vendor interviews
- Identify workers (and their respective Utility/Company) that are >1 rem.

Identification of High Dose Tasks:

- Identify representative top high dose workers and their tasks.
- Site interviews to detail specific worker tasks and radiological environment.

Identify Cause of High Dose for Each Selected Worker:

-High radiation fields?

-Prolonged time at work site?

-Required but repetitive task (go from plant to plant)?

Identify Mitigating Solutions and Disposition Pathways:

- Responsible organization:-EPRI, INPO, NEI, or Specific Utility/Vendor?
- Can RP technology help?

-Engage other groups (e.g. NDE, Maintenance, Materials, etc).

Variability in How Industry Tracks Dose by Task/Job

What we asked for (workers with dose > 500 mrem):

Year:

Worker No.	Company	Trade	Task	Plant where dose received	Dose at this station (mrem)	Dose at other facilities (mrem)	Total Dose for year	Comments
unique identifier	e.g., Westinghouse, Bartlett, Utility	e.g., RP Tech, Carpenter, NDE Specialist	e.g., Reactor assesmbly/dissassembly, nozzle dam jumping, nozzle ISI, etc.	Your station	OK in rem or mSv, just list units	(if available)	(if available)	

What we have received:

Department	Craft	Site Dose
MAINTENANCE	MECHANIC	1231 mr
MAINTENANCE	MECHANIC	1074 mr
MAINTENANCE	MECHANIC	995 mr

32414	S&W - STONE & WEBSTER ENGINEERS	IRONWORKER	2R20 S/G PRIMARY SIDE INSPECTION AND REPAIRS - Support Activities in Non LHRAs (Staging equipment on the platforms/ Equipment removal/ tool and parts running/ repairs off the SG work platforms)	8	674	42	716
			ROUTINE MAINTENANCE ACTIVITIES - UNIT-2 - MAINTENANCE ACTIVITIES IN UNIT 2 HRAs	6			
			EC-7014 Permanent Shield Rack - EC-7041 Install Permanent Shielding Rack - Regen Heat Exchanger	660			

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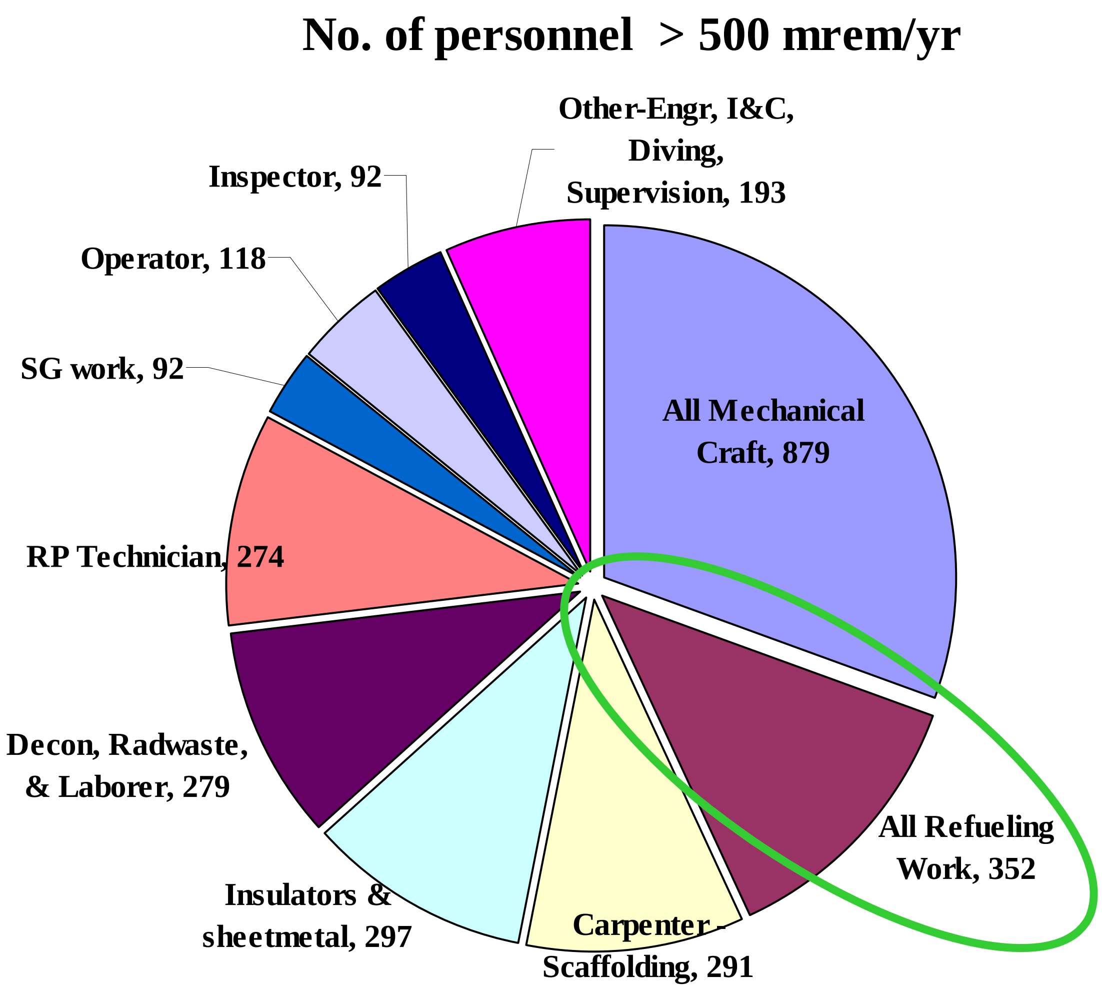
Number of Personnel with Dose > 500 mrem/yr by Trade



- Sample from 42 Units over 3 years
- Includes number of workers with dose > 500 mrem
- Grouped for simplicity but have ability to identify subtasks, example:
  - Refueling-Mechanical Workers (stud removal, disassembly, assembly)
  - Refueling technical/specialist
  - Refueling-CRD work
  - Refueling - instrumentation

2011

- Based on analysis, select a few high dose activities for industry optimization (2011-2015)
  - First proposed task for optimization: Refueling
    - Form industry working group for each high dose activity
    - Identify, evaluate, and/or demonstrate technologies that may help reduce radiation fields or improve worker efficiency

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2010-2011: 3D EDE ALARA Planning Tool (in collaboration with FIATECH)

Phase 1: EPRI Dose Calc. Module (Sector Funds)	*Phase 2: Field Testing of Prototype Tool*	*Phase 3: Field Demo at NPP of Final Tool*	*Integrate w/Location Tracking System*
2010	*2011*	*2012*	… *??*

Objective:

- Work with FIATECH and 3D Technology Providers to develop the **<u>next generation</u>** ALARA and work planning tool.

Description:

- Leverage and adapt advanced 3D technologies from other industries to **<u>enhance work planning</u>** and provide more **<u>accurate dose estimation</u>**.
- Integrate with remote monitoring systems for **<u>dynamic monitoring</u>** of work activities.

Benefits:

- Optimize work activities and work flow
- Develop "What-if" scenarios to identify radiation field reduction opportunities to further reduce worker dose.

Schedule:

- 3 year project, started in 2010 (2010 scope funded by Nuclear Sector)

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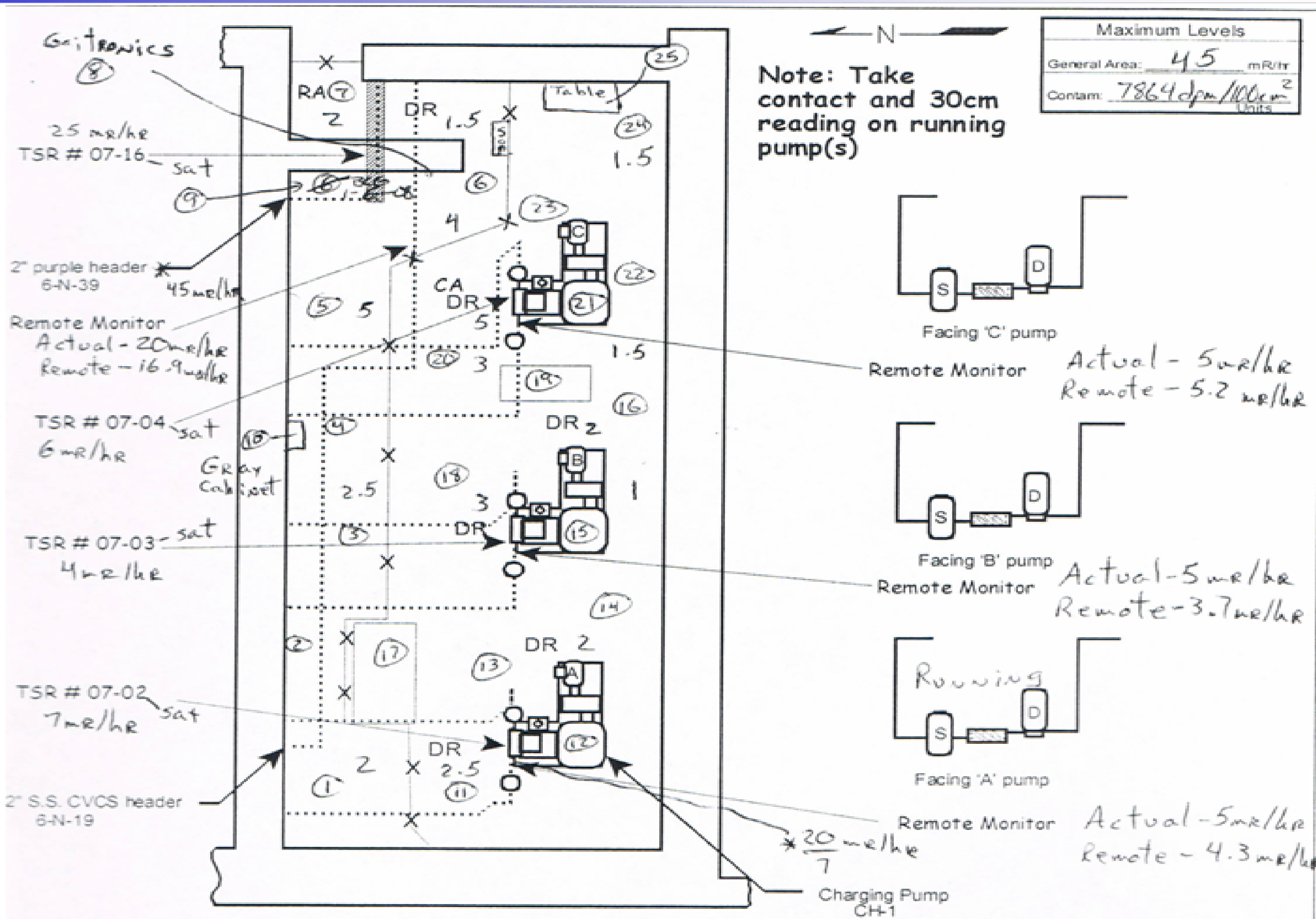
Goals for Project

- Project Goals:
  1. Develop dose algorithms using 3D simulation technology and typical survey/radiation field measurements to estimate worker dose and improve ALARA job planning. Algorithm can be used to develop “what-if” ALARA optimization scenarios.
  2. Work with FIATECH/vendor to develop standard software implementation and protocols that encourages “plug and play”

Dose Algorithm (EPRI)
EDE vs DDE → Software Implementation & Standards Protocol (FIATECH) → Utility Demo (Host Utility)

Example of Today's Radiological Survey Map



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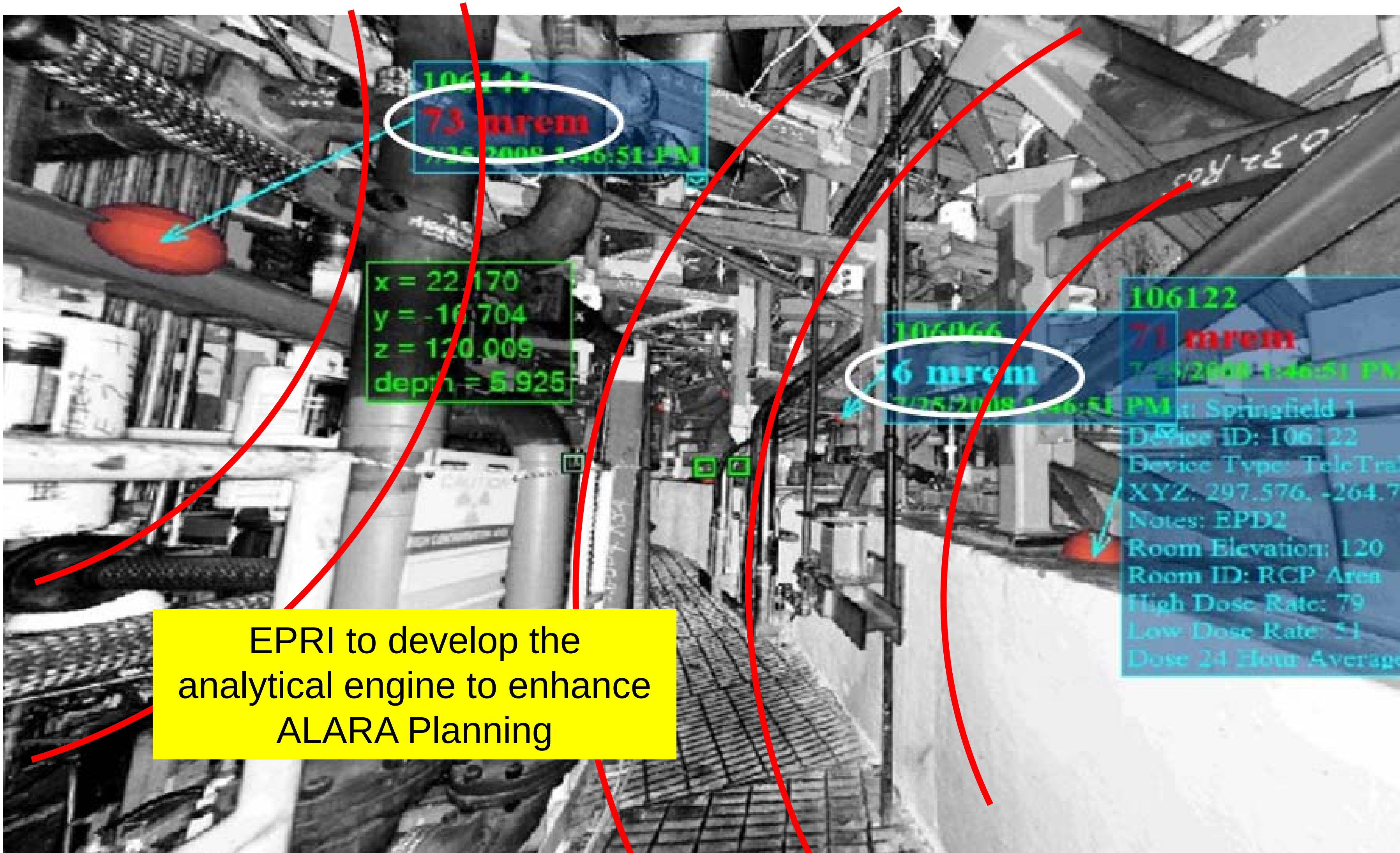
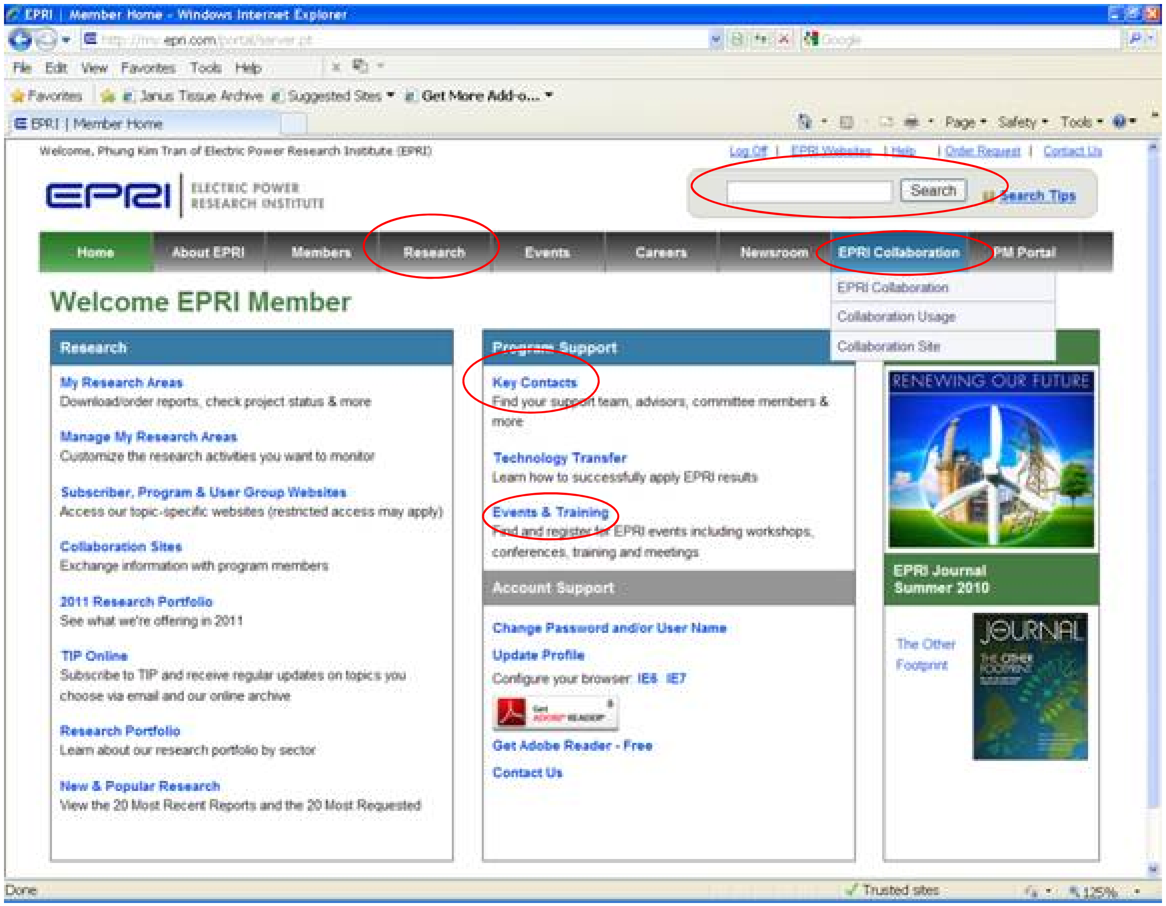
Example of the Next Generation Survey Map



EPRI to develop the analytical engine to enhance ALARA Planning

Contact Information



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