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NDE reliability

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RIC
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NDE reliability

- Key factors in NDE reliability
- Recent OE and industry actions
- Research directions
- Technical highlight: Acoustic Mouse



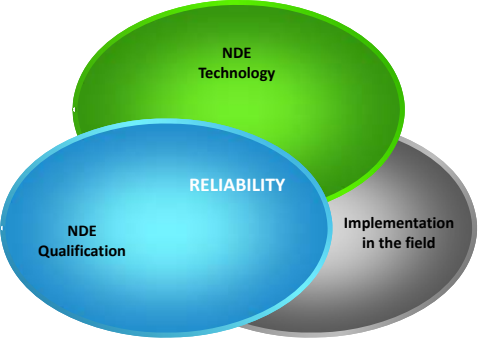




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Factors in NDE reliability



RELIABILITY

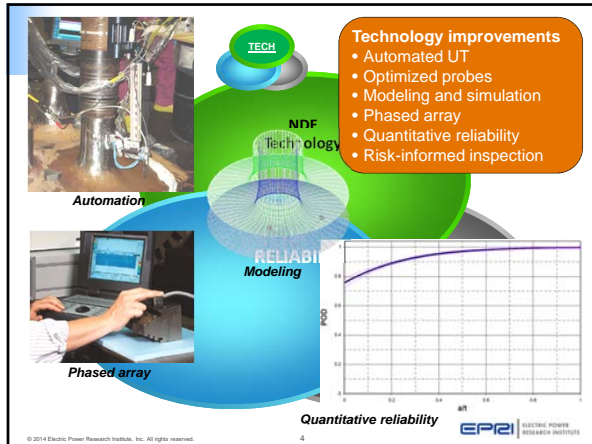
NDE Technology

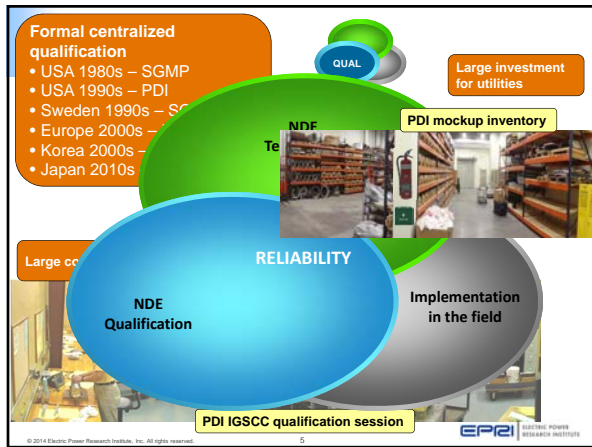
NDE Qualification

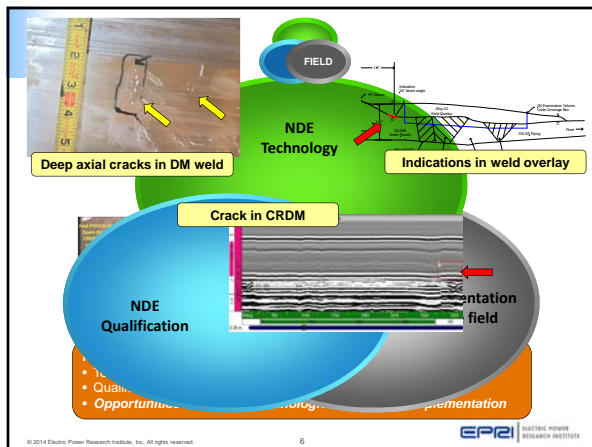
Implementation in the field

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Industry response

Focus of industry actions post-North Anna

- NIFG industry group was formed
NDE Improvement Focus Group
- NDE improvements
Published 2013 for industry action
 - Extent of Condition
 - When to use encoded UT technology
 - Examiner proficiency
 - Pre-job brief
 - Oversight
 - Team scanning
- NIFG sunset late 2013



Reports:
 3002000041
 3002000091
 3002000204

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Team scanning effectiveness assessment

- Experimental evaluation of the effectiveness of team scanning, performed according to 2013 NIFG guidance
- Performed standard Appendix VIII personnel demonstration tests that a single examiner would perform for flaw detection
 - 2 teams performed Supplement 10 (DM weld) demonstrations
 - 2 teams performed Supplement 12 (austenitic and ferritic piping) demonstrations
 - Test sets met all requirements for an Appendix VIII qualification
- Results
 - Both Supplement 10 teams passed DM weld flaw detection
 - Both Supplement 12 teams passed austenitic weld flaw detection
 - One of the Supplement 12 teams passed ferritic weld flaw detection

Report: 3002002048

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NDE IP FG Status for Diablo Canyon

- Industry's qualification process for weld overlays was evaluated by an NDE Integration Committee Focus Group, which determined that:
 - The generic UT procedure was technically acceptable as qualified
 - PDI specimen set includes an appropriate representation of geometry and flaw conditions, and that PDI continues to expand its specimen inventory
- PDI revised the generic procedure to include improvements recommended in the DCPD root cause evaluation; revision was published as PDI-UT-8 Revision G, September 13, 2013
 - Additional guidance for the examiner to consider when determining the proper scan speed
 - Additional guidance to assist the examiner in maintaining the proper scan gain for the 0-degree scans
 - Additional guidance for the detection of fabrication defects (lack of bond and/or inter-bead lack of fusion) with angle beam examinations for non-parallel WOL surfaces
 - Updated the procedure to latest PDI format

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Industry Status for Harris Nuclear Plant OE

- The NDE Integration Committee is working with the MRP Inspection TAC to address this issue
- Root cause items were addressed in a report that provides guidance for preparing and performing RVCH examinations
 - Materials Reliability Program: Utility Preparation for Nondestructive Evaluation of Reactor Vessel Upper Head Penetrations (MRP-360), December 2013; MRP is considering NEI 03-08 implementation guidance
 - Guidance is provided in several areas:
 - Need for supplemental NDE and/or qualifications
 - Multiple analysts in an environment with minimal distractions
 - Utility review, oversight, and coverage assessment

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Research directions

Research directions to improve reliability


- Potential process improvements
 - ✓ – Multiple reviews
 - ✓ – More and better training and opportunities for practice
- Technology development
 - ✓ – Easier encoding
 - ✓ – Technology for oversight
- Longer horizon
 - ✓ – Software to analyze the data independently
 - ✓ – Modeling and simulation
 - ✓ – Acoustic mouse

✓ = work is in progress

Which of these can we implement while achieving cost stability or reductions?

This is research into possible solutions – some are long-term, some may not work

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- For encoded NDE
 - Add analysts
 - Cost impact small
 - Could be remote
 - Workforce available?
- For manual NDE
 - Repeat the exam
 - Dose impact, workforce
 - Record the data in a reviewable form
 - Possible ✓
 - (later in this presentation)

✓ = work is in progress

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- Manage at the site
 - Don't allow collaboration until analysis is complete
 - Then let the analysts compare results and discuss

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- Guidance is in place to ensure a degree of hands-on practice
 - Guidance is most robust for DM welds
 - Hands-on training is expensive
 - Travel, mockups
 - Virtual hands-on training is in development
 - (next slides) ✓

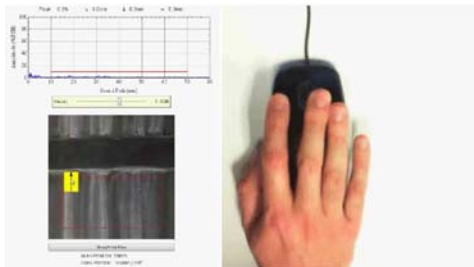
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UT simulator

For training, practice, and exposure to OE



- Enhanced graphics and further controls are proposed.

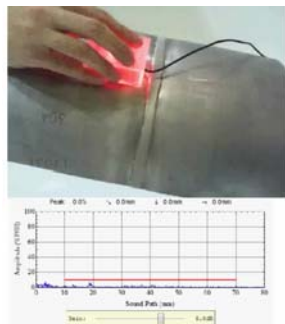
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Proof of Concept: Enhanced Version

- Wedge-shaped mice can be made.
- Dummy mockups: only the outer shape is important
 - Inexpensive plastic mockups can be used.

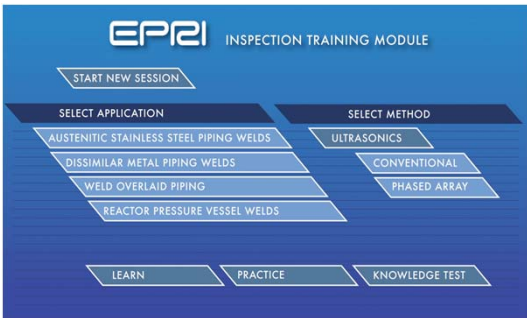


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Simulator scope



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- Robotic scanning is very expensive to mobilize
 - Backup scanners and parts, technicians, operators
 - Manually-driven encoded scanners are simpler but still costly to mobilize
 - Smaller-scale encoded solution may be possible ✓
 - One-dimensional encoding with phased array UT
 - Optical 'scene' encoding

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- Direct oversight of manual UT is costly in labor and dose
 - A simple approach could be video monitoring of the inspection scene
 - Better approach – wearable technology for the manual examiner ✓
 - (next slides)

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**Improvement of manual UT reliability:
Augmented reality technology**

- Augmented reality: ergonomic presentation of data, sometimes superimposed over one's real-time view of the world
 - Classic example: the yellow first-down yardage marker on TV
 - Several commercial apps exist or are in development



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Focus of industry NDE improvements post-North Anna

- Extent of Condition
- ★• NDE Implementation
- ★• Oversight
- Appendix VIII
- ★• Examiner Proficiency



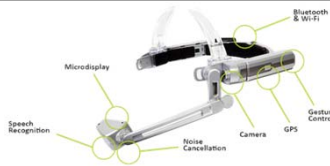
★ **Potential contributions by AR**

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Objectives for AR




- **Under-eye display of the ultrasonic instrument screen**
 - **Ergonomic** – examiner can see the hand, probe, and weld at the same time as the instrument screen
 - **Safety** – frees up one of the inspector's hands, because he doesn't have to hold the UT instrument
- **Head-mounted video recording of what the inspector sees**
 - **Oversight** – the recording provides evidence of examination coverage, scanning speed and scan pattern
- **Independent review**
 - **Independent review** by experts viewing the video recording of the hand-probe-weld scene, synched with the ultrasonic response recording


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- Analysis of massive data volumes
 - Shearon Harris showed us that even with two analysts, we can miss something
 - Other applications with massive data:
 - Remote visual
 - Steam generator tubing
- Research approach:
 - Software to analyze 
 - CRDM UT
 - Remote VT
 - (Already exists for SG tubing)

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- Modeling group established within EPRI NDE three years ago
 - Evaluating models 
- High NRC interest
 - Highest research priority in recent User Need Request from NRR to RES
 - EPRI is establishing an MOU Attachment with RES on this topic
- Stakeholder agreement on how to use it, and how to reach proper conclusions, is key

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Research directions to improve reliability

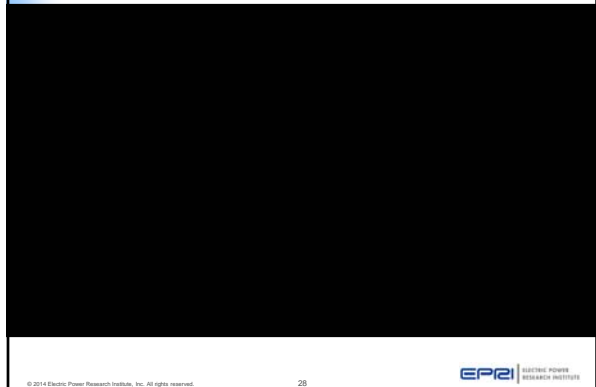
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- Optimum solution
 - Fully encoded and recorded data
 - Purely manual scan
- In development
 - Looking good but not all the technology hurdles have been overcome yet

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Manual UT (left); Automated UT (right)



Acoustic Mouse – best of both worlds

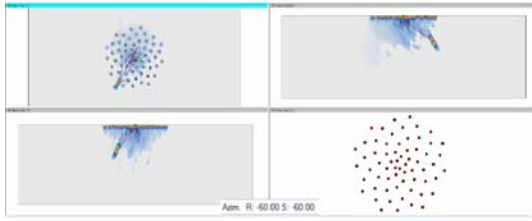
	Manual UT	Automated UT	Acoustic Mouse
Cost	\$ ✓	\$\$\$\$\$\$	\$\$ ✓
Speed	Fast ✓	Slower	Fast ✓
Equipment	Minimal ✓	A lot	Minimal ✓
Inspection record	Ultrasonic data is not recorded	Entire data volume recorded ✓	Entire data volume recorded ✓
Independent review	No	Yes ✓	Yes ✓
Reliable interpretation	Less	More ✓	More ✓
Proof of coverage	No	Yes ✓	Yes ✓

Acoustic Mouse - principle



- Tracks its position by watching the motion of reflectors in the component
- Builds a map: can lift and reposition the probe, and the system isn't lost

Getting to 2-D tracking and 3-D imaging



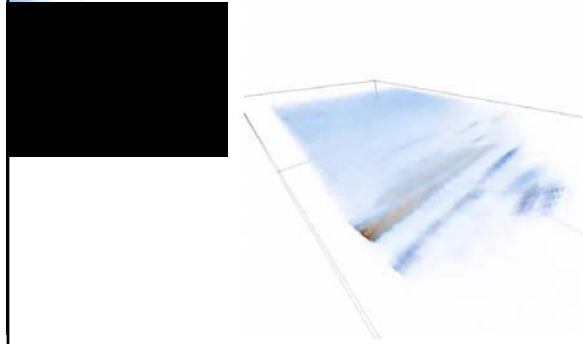
- Looks in all directions
- Focuses at all depths

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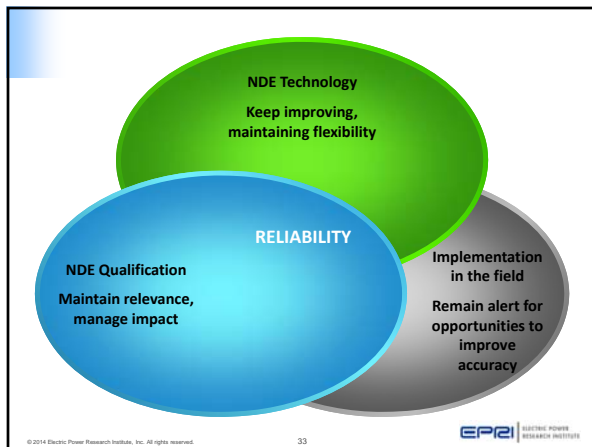
Acoustic Mouse – Fully encoded data with fully manual scanning



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