Human Factors in NDE: Progress Update

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Background

- Project started in 2015 at NRR request
- Coordinated efforts with EPRI through MOU
- Research goals:
  1. Systematically evaluate the human factors that can affect UT examiners
  2. Identify future actions to address human factors challenges in NDE
- Multi-method approach

Research Approach

TOPIC CHARACTERIZATION

- Obtain high-level understanding of NDE human factors
- Methods: SME discussions, code reviews, plant visits, EPRI visits
- NRC Technical Letter Report: “Review of Human Factors Research in Nondestructive Examination” https://www.nrc.gov/docs/ML1705/ML17059D745.pdf

TASK ANALYSIS

- Detailed description of examiner task
- Methods: 61 SME interviews, procedure reviews, plant visits, EPRI visits
- NRC/PNNL Technical Letter Report (PNNL-27441): “Human Factors in Nondestructive Examination: Manual Ultrasonic Testing Task Analysis and Field Research.” https://www.nrc.gov/docs/ML1817/ML18176A055.pdf

STRATEGIC PLANNING

- Identify areas for future action
- 2 interactive presentations to stakeholders – what is working, what is not?
- Joint NRC/EPRI Presentation publicly available (ML18214A191)
- Additional findings will be incorporated into forthcoming NRC NUREG

Factors Identified by Examiners as Important

Planning

- Timely communications between utility and vendor
- Completeness and accuracy of work package
- Adequate preparation of component
- Availability of work opportunities and personnel

Preparing

- Variations in standards and expectations across organizations
- Adequate time for preparation
- Equipment selection, setup, and usability
- Proper calibration
- Calculation of exam coverage
- Procedure usability
- Last minute changes or delays during preparation
- Quality of pre-job brief

Conducting

- Disruptions or delays in conducting exam
- Identification of correct component
- Awareness when conditions do not match expectations
- Accessibility of component
- Distractions from external sources during exam
- Distractions due to physical environment
- Time pressure during scanning
- Field conditions affect signal interpretation (relevant vs. non-relevant)
- Working in pairs

Reporting

- Adequate time for documentation
- Lack of standardized process for documentation

Training and Practice

- Access to samples to practice detecting flaws
- Opportunities for feedback
- Opportunities for gaining practical on-the-job experience

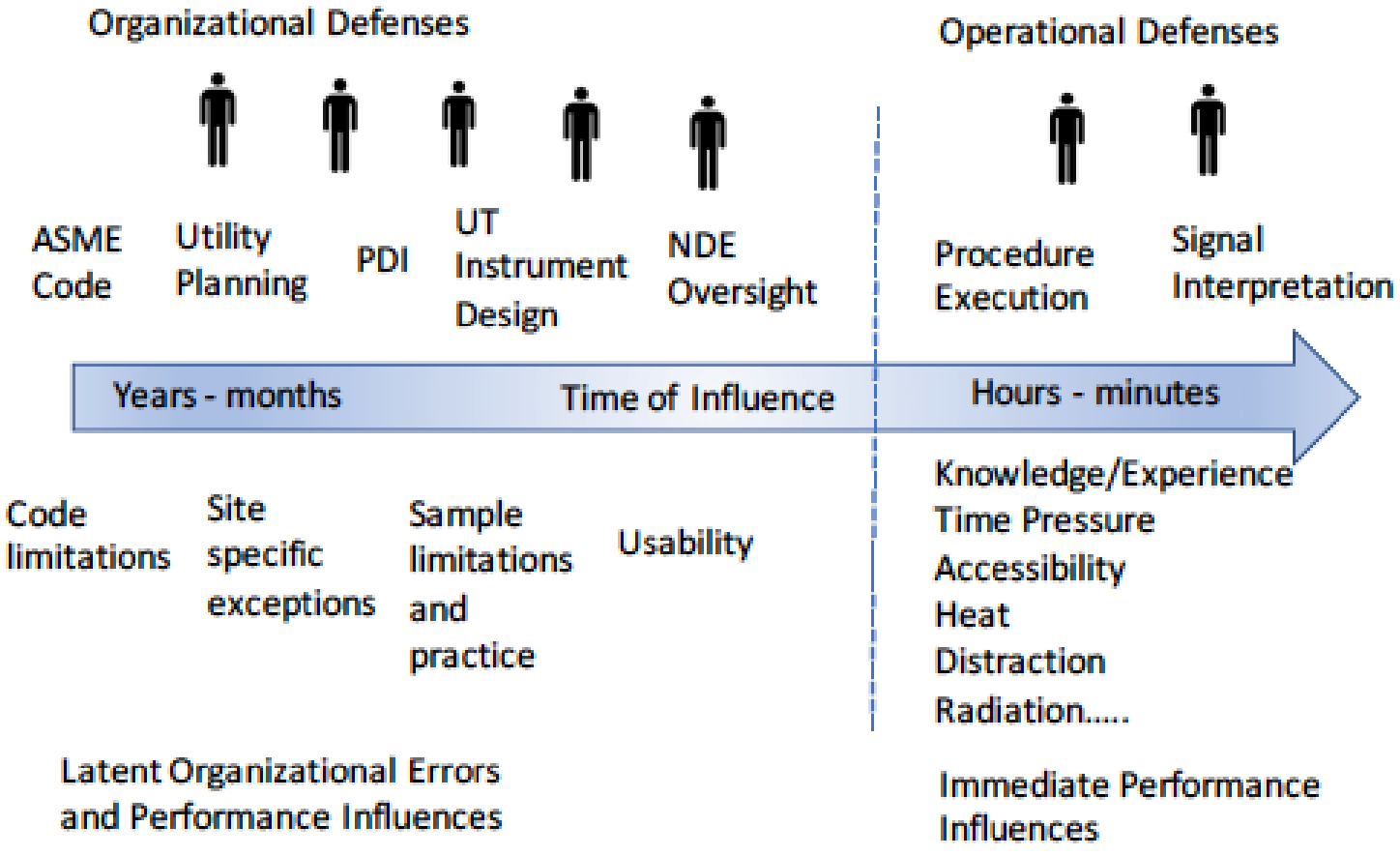
Summary of Stakeholder Feedback (1 of 2)

- Training and Practice
  - Access to samples improving (e.g., EPRI Specimen Management Tool (SMT))
  - Post-job briefs would be opportunity for feedback, but not as consistently practiced as pre-job briefs
  - Desire for more practical experience, barriers exist when Level 1 field experience not prioritized
- Planning Exam
  - EPRI Best Practice document addresses utility/vendor communication, potential gap in disseminating best practice information
  - Good practice of having walk down prior to exam
- Preparing for Exam
  - Some equipment allows calibrations to be performed automatically – reduces opportunity for calibration errors
  - Last minute changes are a significant issue, but difficult to change
  - Pre-job brief quality has improved significantly in last 10 years

Summary of Stakeholder Feedback (2 of 2)

- Conducting Exam
  - Using Level III as buffer can help with distractions during exam
  - Perceived time pressure recognized as problem, may be lessened through communication (i.e., during pre-job brief)
  - Positive comments regarding working in pairs, but can be dependent on composition of pair—better to have two knowledgeable examiners
  - Recent positive results with team scanning seem to be reducing skepticism toward the practice
- Reporting Results
  - Adequate time for documentation is a recognized challenge, can be dependent on workload and pressure from utility
  - Lack of standardized documentation a frustration, errors can be mitigated by sharing sample documentation prior to inspection
  - Possible opportunity to better standardize documentation across industry with same code requirements and more uniform procedures

Research Findings Useful for Developing Error Modeling Frameworks to Identify Error Mitigation Opportunities



Systematic Identification of Error Types, Precipitating Factors and Potential Consequences (1 of 2)

Error Type	Selective Precipitating Factors	Potential Consequences
	Planning Examination	
Incorrect inspection requirements	Plant drawings wrong	Flaw undetected, false positive on wrong component, need to re-do exam on proper component, additional examiner dose
Component to be inspected not properly prepared	Poor communication with craft specialties	Increased examiner workload, stress, fatigue; time pressure
Inspection vendor with wrong training and certifications	Wrong requirements, poor communication with vendor	Increased examiner workload, stress, fatigue; time pressure
Schedule conflicts with other maintenance procedures	Over scheduling to reduce outage length	Exam delayed, not performed, or time pressure upon examiner
	Preparing for Examination	
Incomplete or erroneous pre-job briefing	Time pressure, incomplete or inaccurate information used in planning	Conditions or procedure execution not as expected
Need to repeat calibration	Incorrect file recalled on instrument, new shift, temperature change	Increased examiner workload, stress, fatigue; time pressure
Material left behind (e.g., probes, etc.)	Memory lapse, incomplete pre-job briefing	Need to exit exam area to retrieve necessary items, exam delayed, time pressure
Excessive wait time to enter controlled area	Over-scheduling other work in same area; many other crew in HP area	Inefficient use of examiner time, fatigue, delay of other procedures

Systematic Identification of Error Types, Precipitating Factors and Potential Consequences (2 of 2)

	Conducting Examination	
Wrong component examined	Work package error, wrong drawings, prepped wrong component	Flaw undetected, false positive on wrong component, need to re-do exam on proper component, additional examiner dose
More time required at pipe than planned	Surface conditions poor, undocumented accessibility problems	Stop exam, re-surface, do exam with limitations, additional dose, time pressure
Incomplete exam coverage	Obstructions, surface prep	Flaw undetected
Erroneous data recording	Noise, heat, visibility	Missed indications, erroneous documentation
Procedure steps left out	Informational use procedure	Failure to execute procedure as written, need to re-do exam
	Reporting Examination	
Documentation inaccurate or incomplete	Large number of welds examined before documentation, inadequate note taking, poor team coordination at weld	Critical information about conditions left out of report
Documentation not to plant standards	Varying formats across utilities, varying coverage calculator methods, examiners unfamiliar with plant expectations	Information left out of report, re-work of reports, need to re-do exam
Plant personnel escalate unimportant finding	Premature communication with non-NDE personnel prior to full evaluation	Unnecessary oversight from Outage Control Center
Failure to escalate finding of potential flaw in timely manner	Lack of post-job briefing, inadequate communication between vendor and utility	Time pressure, failure to properly characterize indication

Human Factors in NDE: Next Steps

- NRC team preparing NUREG in FY19 – formal publication of research results
- Human factors insights will be incorporated into other ongoing projects (e.g., Training and Practice)
- NRC may pursue additional human factors research topics following completion of NUREG

Training and Practice for NDE

Training and Practice Research Questions

- How much time does it take for a person to learn to a criterion of mastery?
- What are the factors that determine retention of information (e.g., time, repeated use, practice)?
- How many hours are required to become proficient?
- What kinds of hours are required (e.g., field, classroom, lab)?
- What kinds of retraining or practice are necessary, over what period?
- How much retraining or practice is necessary to maintain or enhance competency?

Step 1: Literature Review

- Basic Science of Learning
  - Study of how people learn
- Science of Training & Instruction
  - Study of how to help people learn
- Science of Expert Performance
  - Study domain experts

Product: Detailed review of the relevant areas and finding, with a written report ~ Summer 2019.

NEXT STEPS:

- Understanding current training/practice
  - Subject matter experts for in-person or telephone interviews are desired – Please contact us

Thank You

If you have questions or interest in participating in future research, please email:

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