

Exploring the Effects of Human Factors on Manual Ultrasonic Nondestructive Examination

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Research Goals



- ▶ Systematically evaluate the human factors that can affect ultrasonic testing (UT) examiners.
- ▶ Understand the key differences between qualification performed in a laboratory environment vs. performance during field examinations.
- ▶ Determine the highest priority human factors that may be impacting UT NDE performance in the field.

Background

- ▶ Nondestructive examination (NDE) is a critical maintenance function in nuclear power plants.
- ▶ Across many industries, maintenance errors comprise the largest proportion of human factors-related operational problems (as distinct from operator error in system control).
- ▶ It is now widely recognized in safety-sensitive complex systems, that “error” has its roots in the entire organization – not just a single individual performing an isolated task.
- ▶ The human factors aspects of NDE, and ultrasonic testing in particular, has been studied primarily through the “lens” of round-robin performance testing and POD– the human-machine model.
- ▶ The resulting focus on examiner performance has led to institutionalized practices:
 - ASME Code Requirements for Performance Demonstration (PD)
 - Specific procedure qualification
 - Refresher practice
- ▶ These practices have resulted in significant progress in improving NDE reliability over the past two decades, but there may be additional opportunities to address a broader range of human factors that can impact NDE in the nuclear industry.

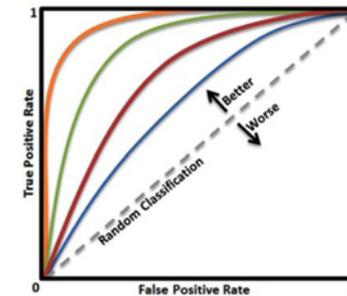
Back to the Future: The Need for a Systematic View of Human Factors in NDE



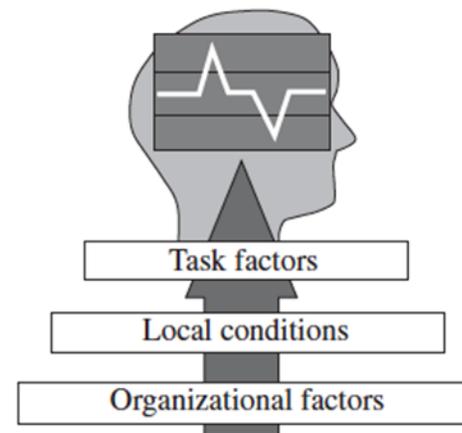
- ▶ “Although there is an increasing awareness of the importance of human performance in NDT, no systematic evaluations of the variables likely to influence the performance of technicians and/or the man-machine system have been conducted to date.” (Spanner, et al., 1986/NUREG/CR-4436)
- ▶ Relatively little work has been done over the past 30 years on human factors in NDE. Most research has focused on quantifying probability of detection (POD) in blind performance testing on samples, with less consideration of other factors that can influence outcomes in operational settings.
- ▶ Our working principle: The reality of the examination process is that numerous people and organizations are involved over a considerable time period, and research is needed to better understand these performance influencing factors.

Cascading Effects of Errors

- ▶ The prevailing focus of the few human factors studies done between 1986 and now has been “the examiner at the component” – and the corresponding POD measures
- ▶ Previous research suggests 42-65% of human performance problems in nuclear power plant events are attributable to maintenance, calibration, and testing
- ▶ These maintenance errors tend to result from cascading effects of organizational issues, local condition variations, with impacts on task performance



		Signal	
		Present	Absent
Response	Yes	Hit	False Alarm
	No	Miss	Correct Rejection



Part 1: Topic Characterization
and Literature Review

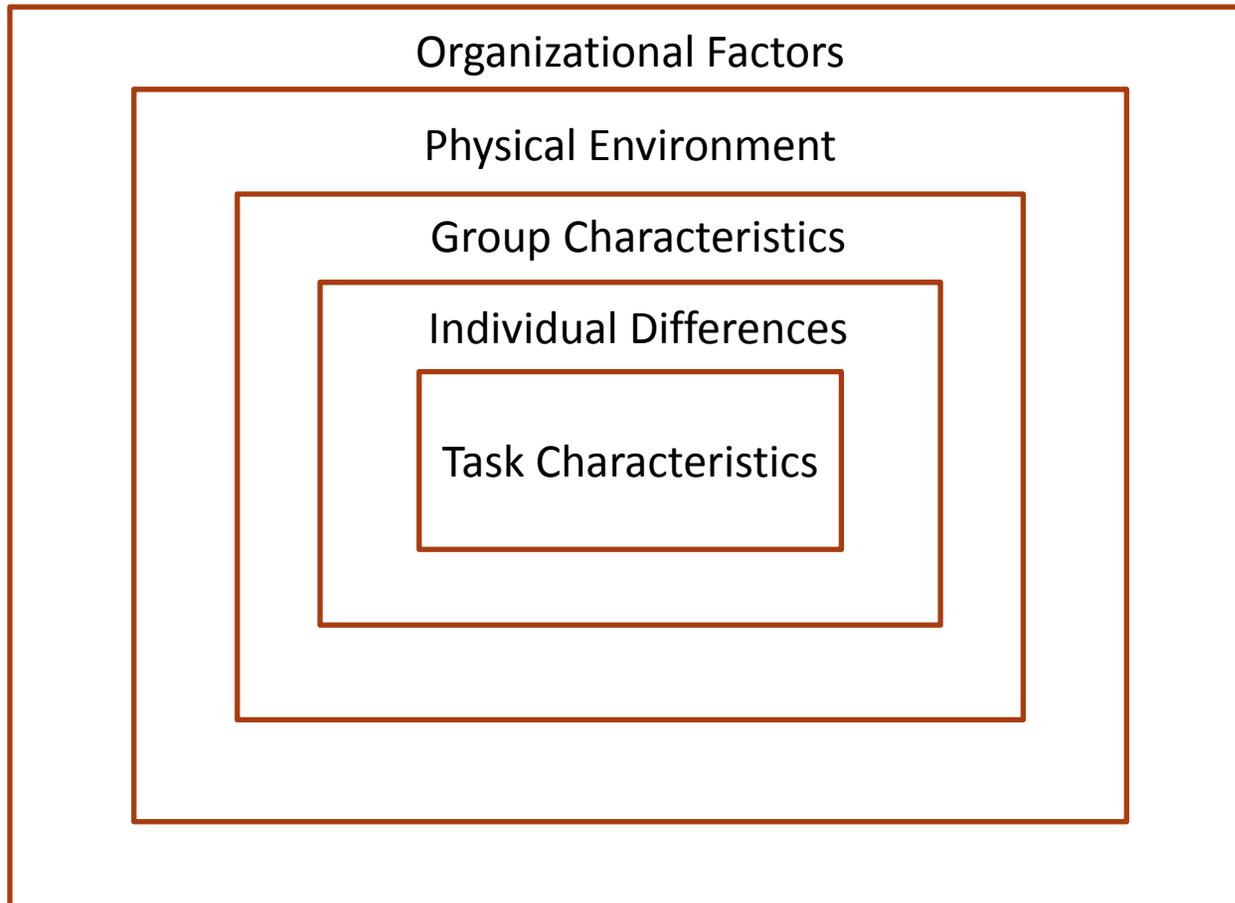


Part 2: Task Analysis and
Field Study

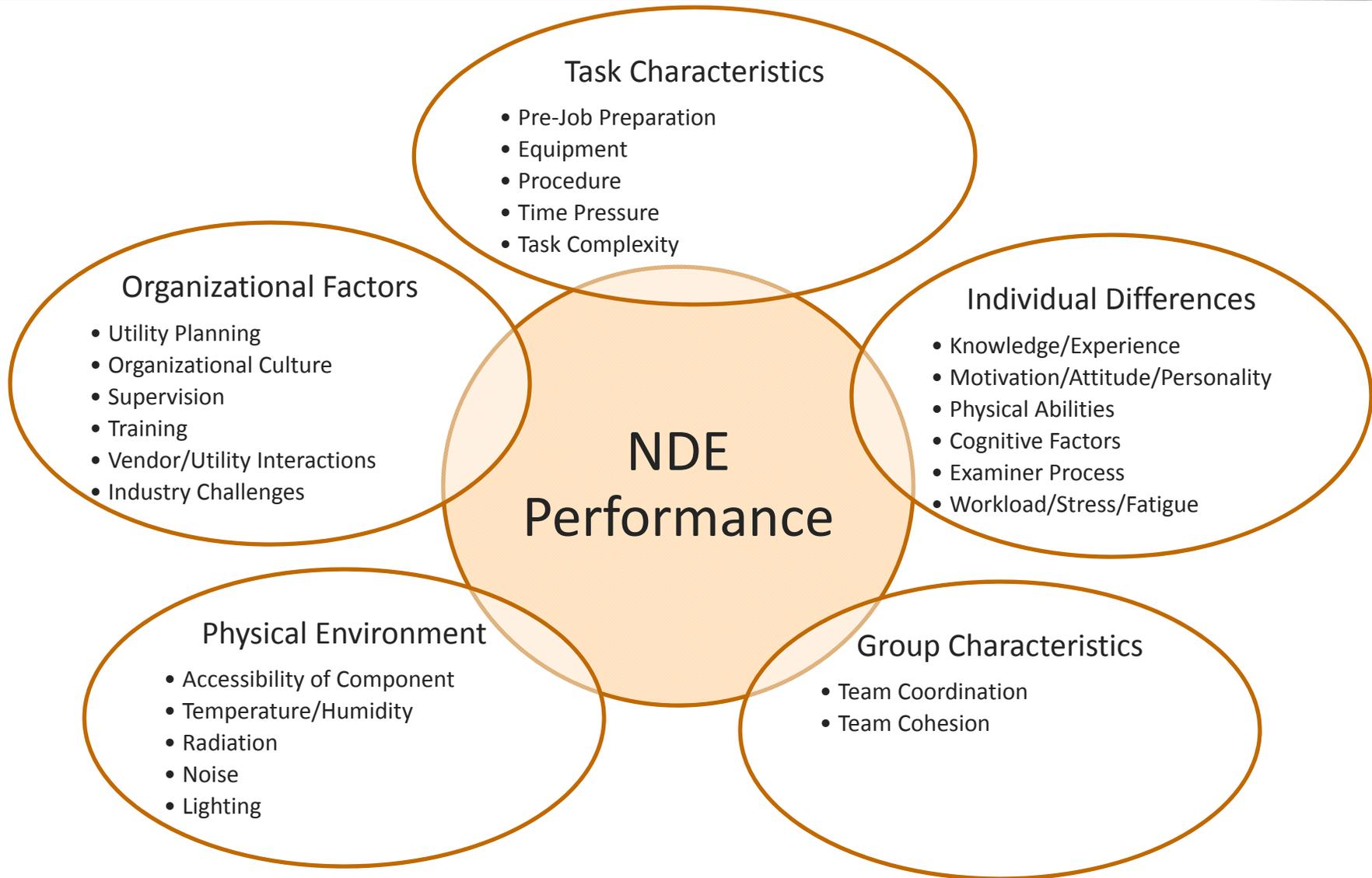


Part 3: Analysis and
Prioritization

Sociotechnical Systems Model



Performance Influencing Factors



Research Status



- ▶ Part 1: Characterization and Literature Review – COMPLETE
 - Literature Review report is publicly available at ADAMS Accession Number ML17059D745 (<https://www.nrc.gov/docs/ML1705/ML17059D745.pdf>)

- ▶ Part 2: Task Analysis and Field Study – IN PROGRESS

- ▶ Part 3: Analysis and Prioritization – PLANNING STAGE

Task Analysis and Field Study: Methods and Participants

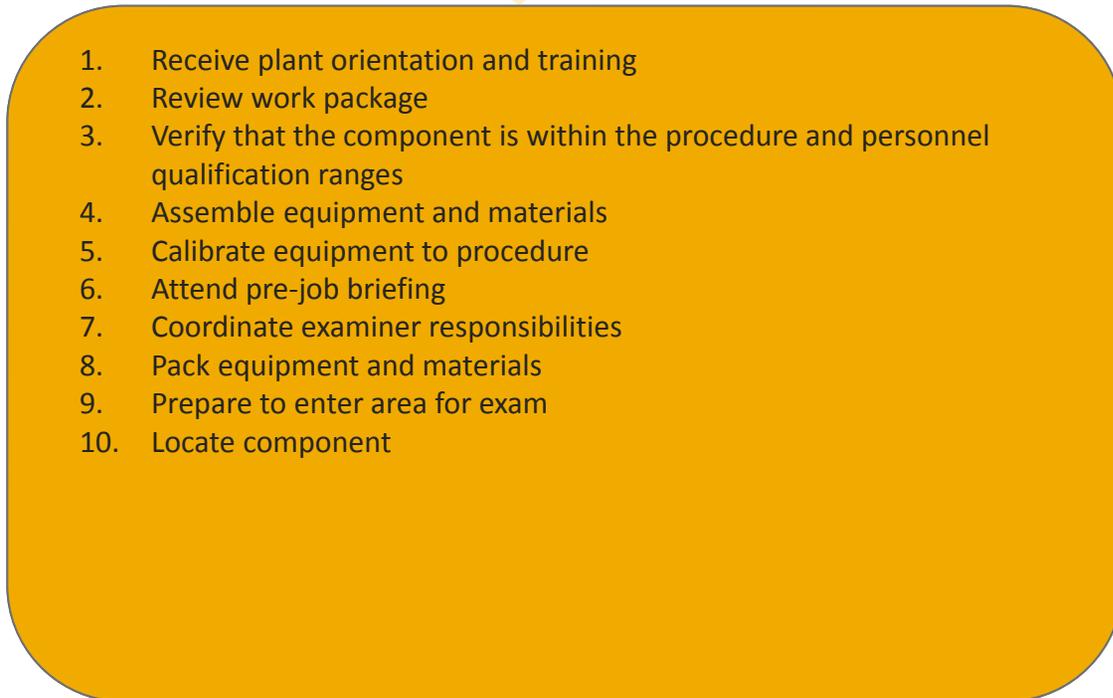
- ▶ Developed list of functions comprising manual UT from procedure reviews, prior studies of UT, and SME input
- ▶ Expanded functions to specific tasks and sub-tasks
- ▶ Developed structured interview protocol
- ▶ Completed analysis at EPRI to validate and expand task list with 11 subject matter experts
- ▶ Visited 3 nuclear power plants to observe UT NDE in the field
- ▶ Solicited subject matter expert participation via email
- ▶ Conducted face-to-face interviews with 9 subject matter experts
- ▶ Conducted two focus groups with 21 subject matter experts
- ▶ Reviewed detailed field notes and compiled transcripts
- ▶ Performed content analysis of field notes
- ▶ Detailed methods discussed in tech report in preparation



Results: Manual Ultrasonic Testing Task Analysis – A Sample

FUNCTION: A group of activities generally performed together to accomplish an overall goal.



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1. Receive plant orientation and training
 2. Review work package
 3. Verify that the component is within the procedure and personnel qualification ranges
 4. Assemble equipment and materials
 5. Calibrate equipment to procedure
 6. Attend pre-job briefing
 7. Coordinate examiner responsibilities
 8. Pack equipment and materials
 9. Prepare to enter area for exam
 10. Locate component

TASK: A smaller unit of behavior that provides information about the human-information processing demands, communication requirements, instrument interactions, etc.

Content Analysis of Interviews – Theme Development



- ▶ Analysis of themes is meant to provide a comprehensive view of the data and portray patterns across the participants*

- ▶ A theme is:
 - attributes, descriptors, elements or concepts
 - an implicit thread that “organizes a group of repeating ideas”
 - a “common point of reference” and portray aspects of how the participants understand the research questions

- ▶ The goal is to develop a comprehensive set of concepts:
 - captures the essence of interview and focus group responses,
 - can be used to prioritize and design potential mitigations
 - can specify additional programmatic research for technical basis and guidance development

- ▶ Preliminary analysis reveal 15 major themes and 53 associated issues

*Hsieh, H, Shannon, SE (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*. 15(9): 1277 – 1288

Ryan GW, Bernard HR. Techniques to identify themes. *Field Methods*. 2003; 15(1): 85-109

Results: Example Themes Derived from Content Analysis



- ▶ The extent and quality of utility planning can facilitate or impede examination. (69 comments)
- ▶ The individual examiner is responsible for a range of functions and tasks beyond simply performing the scan, including work site assessment in relation to the work package, individual scan techniques within procedure parameters, and evaluation and reporting of indications. (49 comments)
- ▶ Time pressure is pervasive and multi-faceted – when performing examination, while preparing, when evaluating indications and reporting. (36 comments)
- ▶ Training and practice is a valuable use of time, although opportunities may be limited for entry-level people. There are diverse sources of practice samples available, but no apparent system for utilization. (27 comments)
- ▶ Team coordination is a key element of performing a UT scan, and includes planning team composition, interactions at the inspection site and peer-check on scan completion and interpretation. (22 comments)

Next Steps

- ▶ Complete summary report on Part 2: Task Analysis and Field Study
- ▶ Plan for workshop in Spring/Summer 2018 to prioritize issues identified in field research
- ▶ Plan for future activities

**We need your expertise for continuing human factors
research input**



WE WANT YOU!

▶ Anticipated needs:

- Workshop participants
- Virtual SME panel
- Occasional telephone and email consults to clarify material
- Contact:

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**We thank our subject matter expert participants
and host utilities - we appreciate your
continuing support**

Future research efforts will benefit from your involvement

