Current State of HRA Research

May 29th, 2014

John Wreathall

President, John Wreathall & Co., Inc.

Topics in HRA

- Limited development of new methods
- Method reviews under way
- Area of need in HRA
- Incorporation of operators into HRA models & methods

Limited Development of New Methods (1)

- US NRC:
  - IDHEAS & Generic HRA Method
  - Joint EPRI/NRC-RES Fire HRA Guidelines
  - HRA approach for Level 2/3 PRA
  - Risk-Informed Approach to Understanding Human Error in Radiation Therapy
- South Korea:
  - Human Reliability Evaluator for Control Room Actions (HuRECA)
    - New method for computer-centric control room operations

Limited Development of New Methods (2)

- Electricité de France:
  - MERMOS* Level 1 post-initiator (now MERMOS-C) “industrialization” with MERMOS catalogs
  - Extensions of existing MERMOS-C method
    - Type A (pre-accident) human errors
    - Level 2 and fire PRA applications
  - Dedicated methods for specific analyses
    - MERMOS adaptation, or existing methods put into EDF context
      - Flooding, seismic, and multi-reactor accidents

**Méthode d’Evaluation de la Réalisation des Missions Opérateurs pour la Sûreté*

HRA Method Reviews Under Way

1. OECD Review: Establishing Desirable Attributes of Current Human Reliability Assessment (HRA) Techniques in Nuclear Risk Assessment
2. Nordic-German-Swiss Evaluation of Existing Applications and Guidance on Methods for HRA – EXAM-HRA

OECD Review of HRA Methods

- Review by joint task group under CSNI's Risk and Human and Organizational Factors Working Groups (WG HOF and WG Risk)
  - 12 methods across multiple countries reviewed
  - Reviewers from 10 countries (including US NRC)
  - Review criteria: construct validity, content validity, empirical validity, reliability, and usability
    - Assessed by ratings on 20 attributes
    - Multiple reviewers per method (usually 2)
  - Draft report being revised following reviews by WGs

EXAM-HRA

- Purpose & Aim:
  - To provide guidance for state-of-the-art HRA for PRA
    - to ensure that plant-specific properties are properly taken into consideration in the analysis
  - To improve consistency of in-depth HRA and human error probability (HEP) assessment
    - by providing a common basis for methods and guidance for HRA application and assessment
- Completion planned by December 2014

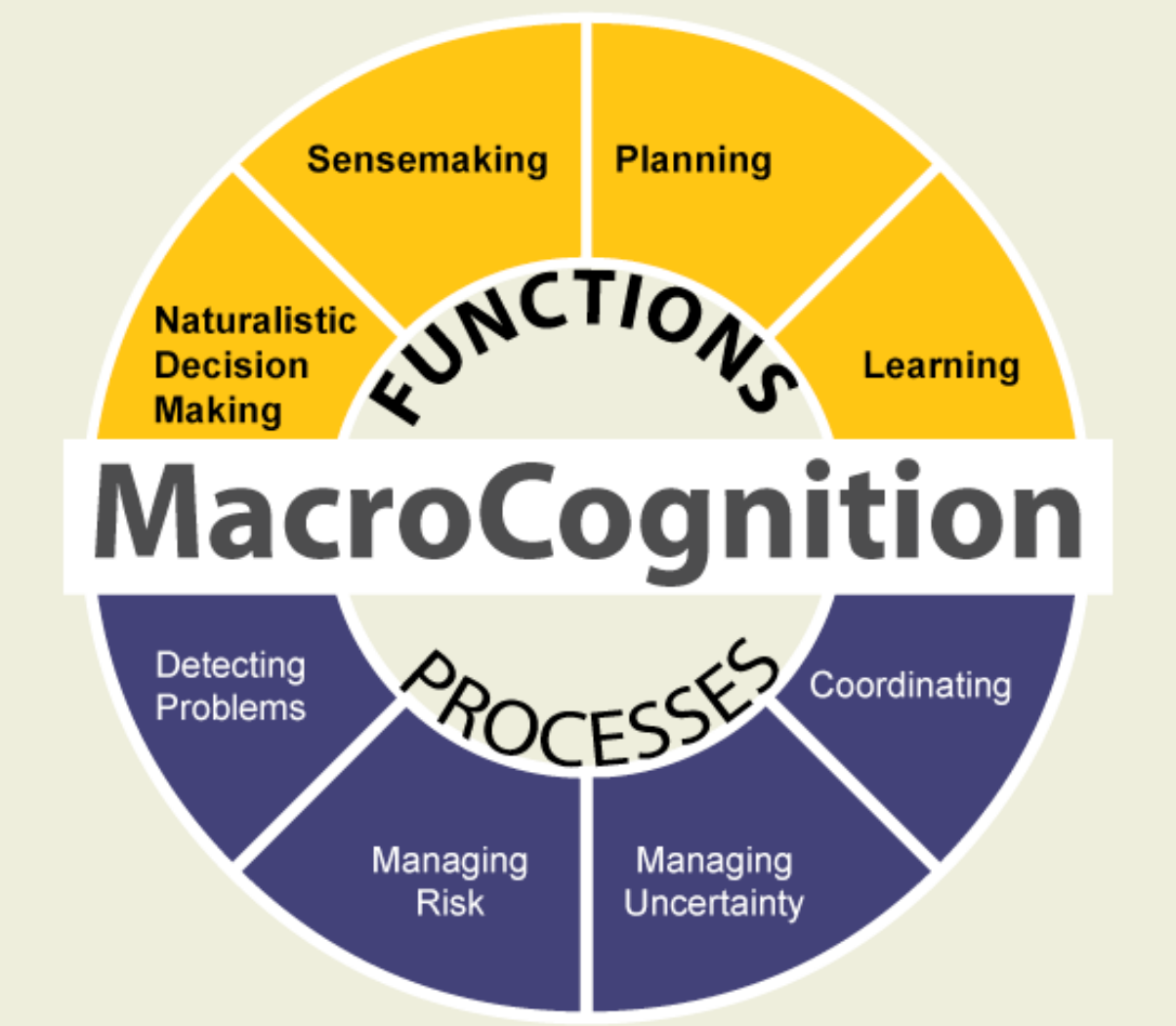
Area of Need in HRA

- International consensus and historic experience in HRA applications requires both *plant context* and *task context* be included in methods:
  - *Plant Context* describes plant conditions that operators are faced with
    - Qualitative analysis: “The story of the accident so far”
    - Nominal vs. off-normal, Level 1 vs. Level 2, etc.
      - e.g., Influence of uncertainties in underlying accident models
        - » Timing, accuracy in decision points, etc.
  - *Task Context* describes the features of the plant that determine how operators can respond
    - Performance shaping factors (PSFs)
      - Training, interface, procedures, …

Operator Inputs to HRA Models

- I have had no involvement in IDHEAS development or review
  - Unable to comment on role(s) of plant staff
- Very high degree of involvement by plant operators and trainers in ATHEANA and MERMOS methods
  - Also operational data used in CAHR (Germany) and NARA (UK)
- Generally, NPP operator inputs come in three stages of HRA development & application:
  - Creation of general models of *macrocognition*
    - Based on observations of multiple types of "operators"
  - Interpretation of models for NPP operator activities & tasks of interest in safety/PRAs
  - Quantification of models for specific plant and task contexts

HRA: Operators and Macrocognition



Macrocognition & HRA

Observations and interviews
Analyses of events

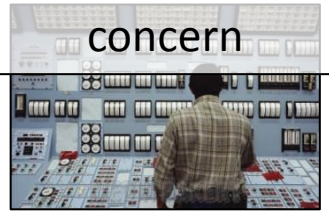
Generalized Models of Macrocognition

Description of NPP Operator Activities

PRA Models involving Human Actions

HRA Models

Plant contexts of concern



Task contexts of concern

HRA: Use of Practical (Operational) Experience

- Issue is to interpret generalized models in terms of NPP plant & task contexts that have been developed partly from observations of operators and event analyses
  - (Used to be an area of NRC strength)
- Application process and analyst's knowledge and skill is used to select appropriate model(s) to *actual plant practices* and *safety issues* being analyzed
  - Not all methods are applicable to all safety issues

Questions?

Backup slides

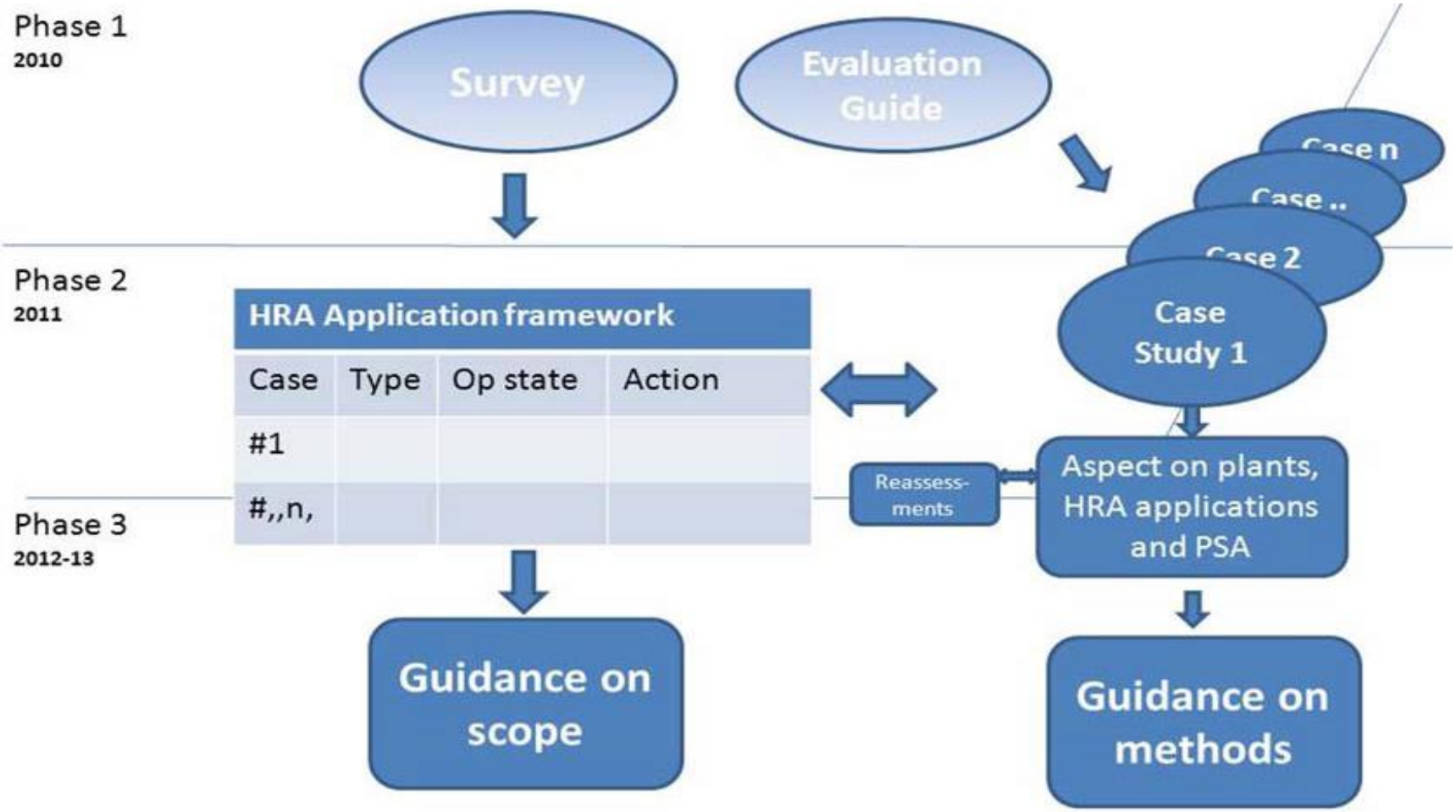
OECD Review

- Purposes:
  - To identify a set of desirable attributes for current HRA techniques used in nuclear risk assessment
  - To evaluate a set of HRA techniques used in OECD member countries against these attributes.
    - Aim to provide information to support regulators and operators when making judgements about appropriateness of HRA methods for conducting assessments in support of Probabilistic Safety [Risk] Assessments

EXAM-HRA

- Survey collected approximately 420 operator actions from six plant-specific PRAs
  - Reduced set of seven case studies used in evaluation
  - Evaluation identified:
    - Level of task
    - Scenario context
    - Task context
    - Definition and assessment of action
    - Resulting data
  - Categorization of findings:
    - Plant specific aspects
    - HRA applications
    - PRA applications
  - Work continues to December 2014 on HRA method evaluations

Exam-HRA


Phase 1
2010
Survey
Evaluation Guide
Case n
Case ..
Case 2
Case Study 1
Phase 2
2011
HRA Application framework
Case
Type
Op state
Action
#1
#,,n,
Reassess-ments
Aspect on plants, HRA applications and PSA
Phase 3
2012-13
Guidance on scope
Guidance on methods

Lesson Learned from the International HRA Empirical Study

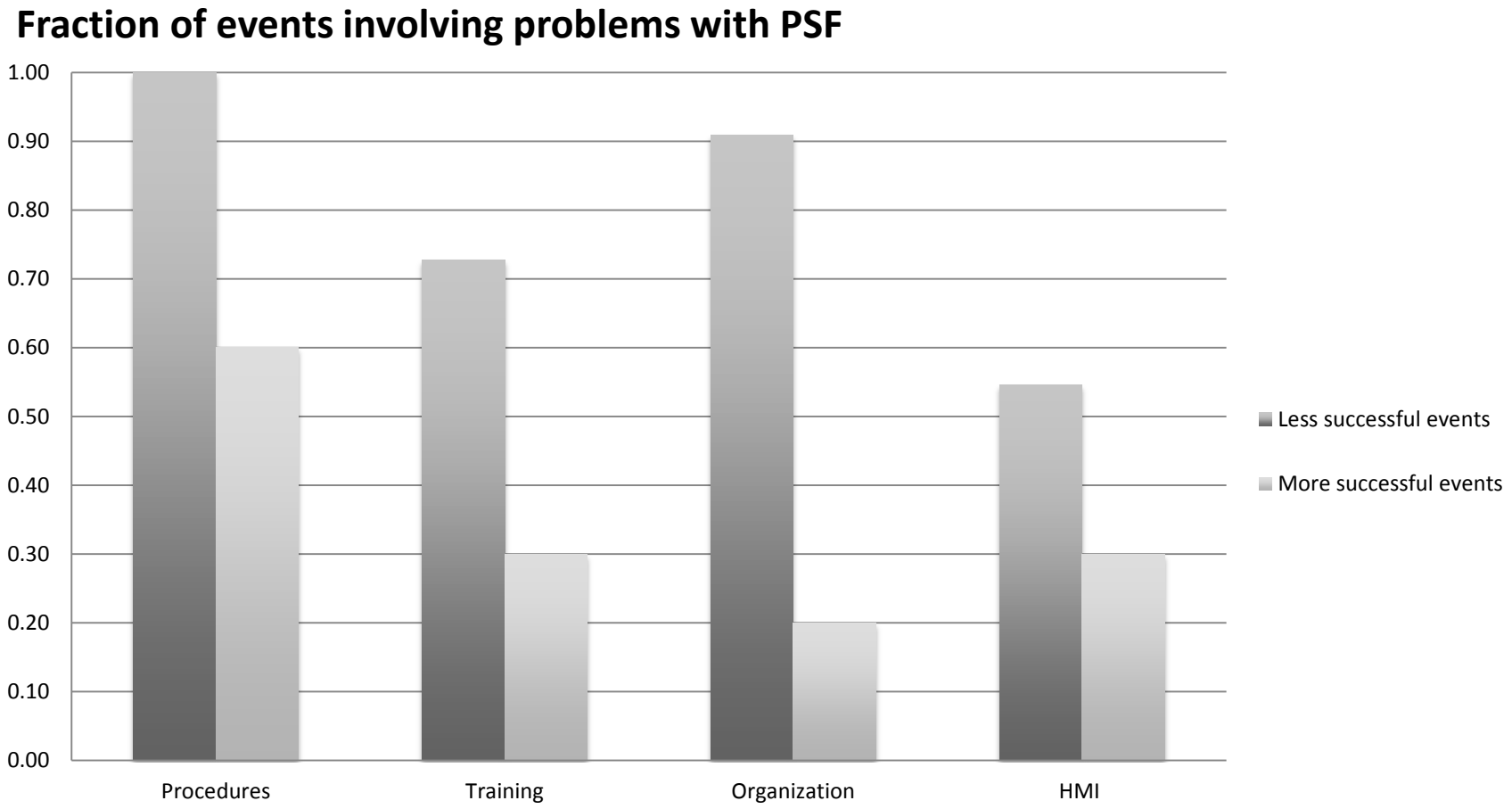
- "The [International HRA Empirical] study identified variability in predictions of human error probabilities, in part due to *deficiencies in the qualitative scenario analysis* for some HRA methods. The study showed that it can be difficult for HRA analysts to get a good understanding of how a scenario is likely to unfold, what challenges it may present to the operators, how the operators are likely to respond, and where they may experience performance problems."
  - *Improving Scenario Analysis for HRA: Case Studies of HRA Practice* (HWhP-047, Issue 1, 2013-07)

NUREG/CR-6753* Findings

- 37 events selected as potentially significant Accident Sequence Precursor (ASP) events
- Pre-accident (Type A) errors were major concern in establishing plant contexts
  - Average of 4 Type A errors per event
    - Failure to enforce standards
    - Lack of QA in procedure development
    - Failures to address prior equipment problems, etc.

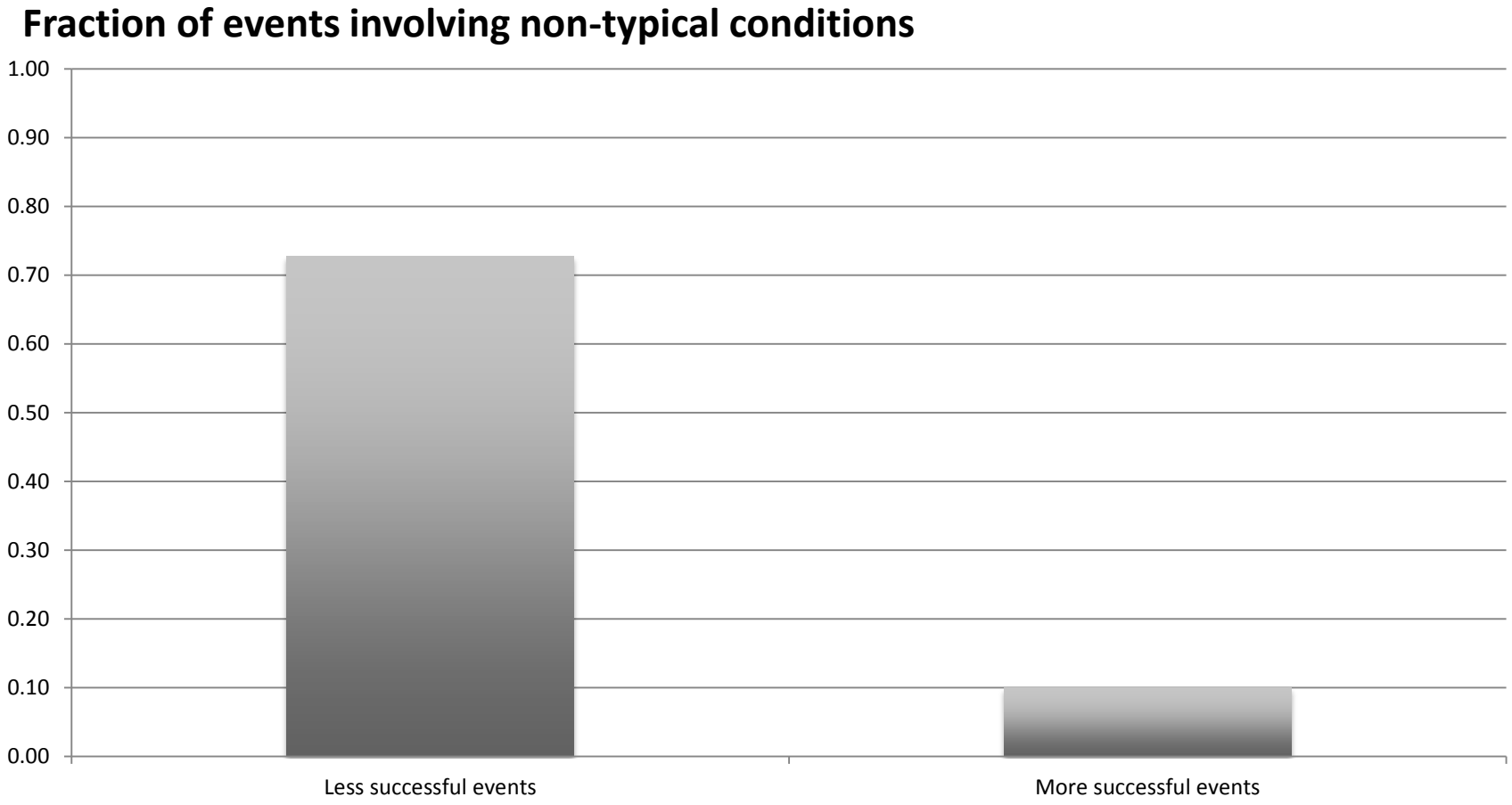
**Review of Findings for Human Performance Contribution to Risk in Operating Events*, INEEL, 2002

Not all PSFs are strong differentiators



Taken from Wreathall & Reason, *Latent Failures and Human Performance in Significant Operating Events, JWCo., Inc., 1993.*

But non-nominal plant contexts are…



HRA: Operators and Cognitive Science

- HRA is an engineering discipline:
  - A blend of *scientific knowledge* and *practical experience*
  - The science part is based on our understanding of **macrocognition**
    - Understanding how people make decisions and act on them under real-life conditions (not laboratory settings)
    - Largely based on studies of real people doing real work (including NPP operators & trainers) to develop *generalizable* frameworks & models
    - Pioneers include Klein, Woods, Roth, Weick, Hollnagel, Reason, Cacciabue, … and Wreathall

Macrocognition & HRA

Observations and interviews
Analysis of Events

Generalized Models of Macrocognition

Generalized models are built from observations and interviews of people doing real work and analyses of events, and built on theories of decision-making, etc.

Much of this development took place in 1980's to 2000's.

Macrocognition & HRA

Generalized Models of Macrocognition → Description of NPP Operator Macrocognitive Activities

These models are then interpreted for the activities of operators in NPPs, including Level 1 (and Level 2) responses.

Macrocognition & HRA

PRA Models involving Human Actions

Generalized Models of Macrocognition → Description of NPP Operator Macrocognitive Activities → HRA Methods and Models

Plant contexts of concern

Task contexts of concern

HRA methods and models are chosen to quantify failures in macrocognition for the plant and task contexts of concern. These should be identified from interviews with operators, trainers, and supervisors.