

# Modeling of Portable Mitigation Equipment in PRA

*Equipment Failure Rates  
and HRA Approaches*

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## Challenges to Crediting FLEX\* in PRA

- In many cases, modeling the use of portable equipment in a PRA is similar to modeling permanently-installed equipment
- Issues that require more research include:
  - Industry data on portable equipment failure rates is extremely limited
  - Human reliability analysis (HRA) methods may not directly apply to all of the actions during use of portable equipment
- EPRI is conducting research to address both of these issues

**\*The term “FLEX” is used here to refer to plant response strategies using onsite or offsite portable equipment and other flexible mitigation strategies. It is not intended to only refer to US FLEX strategies.**

# Portable Equipment Operation Data Collection

- EPRI has set up a web site to allow U.S. utilities to enter information on the use and failures of FLEX equipment
  - All US utilities have access to enter their testing in the database
  - The two national SAFER response centers are also entering data into the database
- Data
  - Testing interval and required test duration information for planned maintenance on the FLEX equipment
  - Failures and anomalies recorded during FLEX equipment testing
- Database
  - Database initially created to optimize preventative maintenance (PM) strategies for FLEX equipment (Example - Maintenance strategy for fuel injectors for turbine driven generators was revised based on observed failures)
  - Data collection was expanded to leverage the database to evaluate reliability numbers
  - Reporting and process must always balance the benefit obtained with the resources required

## Approach to Data Collection and Definitions

- Definitions are provided for entering the event type:  
( *\*See definitions in backup slides*):
  - Test Passed
  - Test Failed
  - Baseline PM Task Interval
  - Other
  
- For events categorized as “Test Failed” and “Other”, each entry description is reviewed by EPRI to determine if it constitutes a PRA Failure
  - An event, such as a battery failure, that initially causes the equipment to fail to start but may have been recovered would be classified as “Other” but might constitute a PRA Failure
  - Some display failures on 4kv turbine generators were reported as failures, but EPRI confirmed they did not affect the operation of the equipment itself, so it would not constitute a PRA Failure

## Current Status of Data Collection

- Initial data assessment suggests more understanding of issues of data completeness versus equipment performance is needed, for example,
  - SAFER Centers represent a larger than expected fraction of response
  - SAFER Centers equipment accounts for majority of all failure reports
    - Failures are dominated by one type of unique equipment that may not be representative of the industry FLEX equipment
- Initial indications that data is premature to calculate generic failure rates
  - Based on differences in number of individual entries for similar units, there are questions about the timeliness and completeness of the current data
  - Successes seem to be underreported in the database
  - Some observed failures may be indicative of initial “break-in” implementation of FLEX maintenance and operation

Additional analysis is required to understand data and calculate realistic equipment failure rates on a generic basis

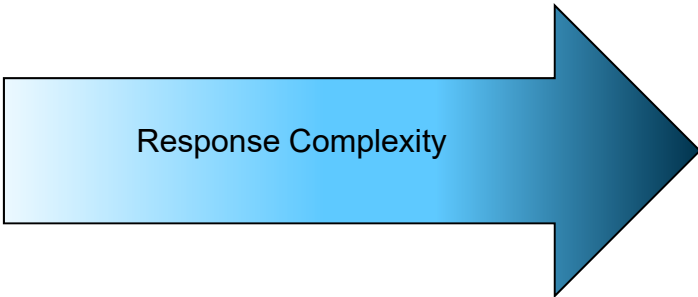
## Path Forward on Data Collection & Failure Rates

- EPRI will continue to evaluate data and will share recommendations and insights based on the current data review
- When data completeness issues are understood, EPRI will publish generic failure rates for use by the industry
  - Data classification should be transparent and consistent with existing failure rate calculations
- Further refinements to data collection and reporting may need to be implemented in conjunction with other stakeholders
- For plants currently modeling FLEX in the PRA:
  - Utilities can continue to assess their own equipment performance data and perform sensitivity studies to incorporate the use of FLEX equipment in their PRA models

# HRA for Flexible Mitigation Strategies and Portable Equipment

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# What is HRA for FLEX?



Actions can range from

- Simple execution of pre-staged equipment, pre-core damage

to

- Complex, coordinated actions, post-core damage

Limited decision making,  
Normal command and control,  
Limited coordination,  
Well proceduralized,  
Limited site damage

Dynamic decision making,  
Command and control not at MCR,  
Extensive coordination,  
Use of judgement,  
Extensive site damage



## FLEX HRA Status

### ■ Gap analysis performed on HRA for FLEX

**Report:** *“Incorporating Portable Equipment and Flexible Mitigation Strategies in PRA: Gap Analysis and Lessons Learned from Early Implementers”*  
([3002003151](#))

- Adaptation of existing method adequate for many needs
  - Additional guidance needed to standardize approach (starting in 2017)
  - Several utilities have applied existing methods to modeling these actions
- More challenging contexts exist that require additional research
  - Synergy with other on-going HRA research for common approach
    - External flooding (coordinating with NRC)
    - MCRA Abandonment (joint NRC research project)
  - Examples needed

# Human Reliability Analysis: High Priority Gaps

## ■ Execution

- Environmental effects on ex-CR actions
- Execution actions with lots of steps
- Use of non-Operations personnel with limited or no training
- Transportation and installation of equipment
- Local control actions requiring coordination

## ■ Constructing an integrated timeline & evaluation of timing

- Soft cues
- Sufficient manpower
- Applicability of HCR/ORE

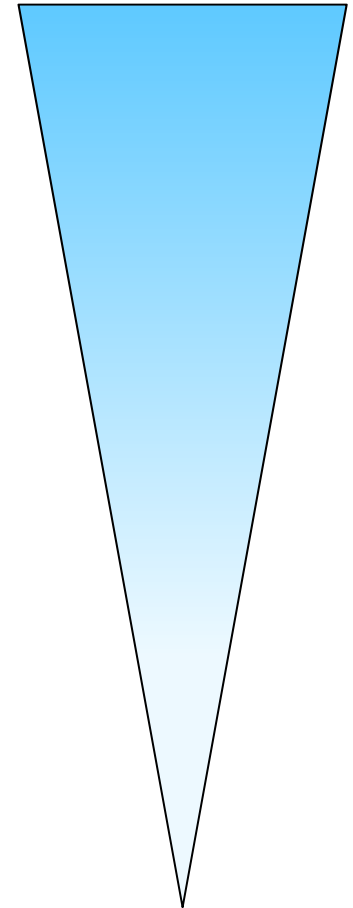
## ■ Use of judgment

- Prioritization not specified, but important for success
- Perceived viable alternate strategy
- Crediting actions when no explicit procedural link

## ■ Level 2 actions

- Command and control shift
- Interaction with TSC

Adaptation of  
existing methods



New research

# HFE Characteristics

Gap	FLEX	Ext. Flood	MCRA
<b>Non-Standard Execution Tasks</b> Transportation & Installation of equipment Sandbag wall construction	X	X	
<b>Uncertainty in Timing/Staffing</b> -Prioritization not specified -Soft Cues (judgment required or large uncertainty on timing/clarity of cue) -Additional crew availability questionable	X	X	X
<b>Decision Making</b> -Cue based on judgment or requires prioritization that is not pre-defined -prioritization when order is not specified but order is important to success -crediting actions when there is no explicit procedural link	X	X	X
<b>Environmental Effects on Execution</b> -Water and high winds -Timing of actions	X	X	
<b>Complex Execution Actions</b> -many steps or manipulations -high amount of coordination/communication	X	X	X
<b>Organizational Prioritization</b> Multi-unit/Multi-site coordination large scope resource management tasks Soft Cues/Cues from outside organizations	X	X	
<b>Complex Control Actions</b>	X	X	X
<b>Changes in command/control</b>	?	X	X

# Path Forward - FLEX Workshop

## ■ Q1 2018 – FLEX Workshop

### ■ Workshop Objectives:

- Share insights in modeling FLEX through illustrative examples
- Confirm use cases
- Obtain feedback on the approach and define path forward

### ■ Input and Audience:

- Examples curated and evaluated by EPRI
- **NEI and NRC contribution?**
- **Identify a focus group?**

### ■ Output:

- Reach agreement on where the examples show an acceptable approach
- Define issues and categorize:
  - Resolvable with additional research – use consensus values in the interim
  - Unresolvable – decide how qualitative and other information can be used to inform the decision
- Identify additional areas for clarification through new examples or expansion of existing examples

# FLEX HRA Workshop (continued)

- Examples (tentative)
  - Deploy, install and start pump
    - Variations on extremity of external hazard
  - ELAP declaration & DC load shed
    - Variations on level of judgement implied in the procedure
  - External flooding (qualitative only) -> dam break and sandbag wall
  - Refueling
  - Use of pre-staged equipment
  
- Items for discussion
  - Holistic view needed to avoid “tunnel vision” when evaluating a single HFE -> use of an integrated timeline
  - Time reliability and Time estimation; thresholds for feasibility
  - Latent failure modes
  - Adaptation of THERP and justification of surrogate values
  - Actions where the underlying failure mechanisms are not well understood by the nuclear community (e.g., how can you fail to build a sandbag wall?)

# What is Useful for Risk Management?

- Level of uncertainty ranges with complexity and context of action
  - Qualitative analysis can be useful in risk management and error reduction
- Credit for FLEX needs to be incorporated into RIDM process, similar to other sources of uncertainty



# Together...Shaping the Future of Electricity

# FLEX Database - Event Type Definitions

- Documented in “*EPRI FLEX Equipment Maintenance Event Collaboration Site Event Entry Instructions*”
- **Test Failed** – Use this designation for an equipment or sub-component issue which was identified before or during the performance of a maintenance activity that prevented the equipment from being able to meet its mission time. Examples of “Test Failed” may be identification of a defective control module on a pump which prevented the pump from completing a functional test. Events where multiple start attempts were made before the equipment would run or events where a dead battery was discovered but could be recharged or replaced quickly should be listed as “Other”.
- **Test Passed** – Use this designation to capture a test that passed outside of the regular maintenance events already captured using the “Baseline PM Task Interval” designation. Not many events are expected to be categorized using this designation.
- **Baseline PM Task Interval** – Use this designation to capture planned maintenance activities associated with the equipment being tracked within this database. The “PM Name” category is intended to capture the primary maintenance activities intended for tracking in this database.
- **Other** – Use this designation if there is not a PM or test associated with the event or if the event still leaves the equipment in a condition that allows it to fulfill its mission. When selecting “Other”, the user will be prompted to add a description in the open text field that summarizes the event in less than 100 characters. Examples of “Other” may be observed leaks, finding equipment damage such as inoperable gages, and similar equipment degradation or conditions that don’t prevent the equipment from operating.