Description of Process for Quantifying Operator Actions in Palisades PTS Analysis

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Process Based on ATHEANA
(A Technique for Human Event Analysis)

- Improved HRA method (NUREG-1624, Rev. 1) that considers how operators may be "set up" to take actions that make plant less safe, or fail to take actions to make plant more safe
  - besides omission errors, attempts to identify potential for errors of commission
- Goal is to develop a thorough understanding of the scenario context(s) faced by a crew as the basis for determining
  - which unsafe actions (UAs) might occur
  - the probability of a UA (the uncertainty distribution of the UA probability)
- Links plant conditions, performance shaping factors, and human error mechanisms

Development of Context

- The UAs modeled in the PRA and their likelihoods are dependent on scenario *context* involving:
  - Plant condition characteristics such as:
    - severity/timing & specifics of scenario
    - alarms/instruments/controls/equipment availability/layout
    - potential nuisance alarms, distractions
    - behavior of parameters
    - support system failures
  - Factors/practices most affecting operator response such as
    - procedure/step hierarchy & clarity/potential misinterpretation
    - time to get to/thru required procedural steps and/or EOP transfers vs. time preferred/required to take actions
    - degree of training/familiarity with plant conditions/scenario
    - training or other biases, response tendencies, and informal rules that could confuse the crew given the plant conditions
    - crew dynamics and operator roles

Development of Context
(continued)

- The UAs modeled in the PRA and their likelihoods are dependent on scenario *context* involving (continued):
  - Potential mismatches between crew expectations and scenario characteristics
  - Other traditional PSFs such as workload, time of day, environmental factors
  - List of 50+ factors we will step through (quickly), also identifying factors likely to contribute to uncertainty
- In the process, determine whether any additional UAs need to be included in the models (errors of omission or commission)

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Process For Quantifying Each UA

- Step 1 - Identify/develop context for UA - Palisades staff provides initial discussion of human action and expected context:
  - Initiator and critical functions required to prevent PTS
  - Scenario characteristics (plant conditions, equipment failures, other human actions prior to UA of interest, expected behavior of critical parameters)
  - Relevant procedures, critical procedural steps, crew responsibility, training
  - Timing for critical actions (how long from the initiating event before critical parameters will indicate the human action, time available to complete response once indications reached, time to execute the action)

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Process For Quantifying Each UA (continued)

- Step 1 - Identify/develop context for UA - Palisades staff provides initial discussion of human action and expected context (continued):
  – Other scenario concerns (e.g., CD), other crew activities, potential distractions
  – Crew expectations regarding scenario evolution
    - Could the scenario evolve somewhat differently than expected and thereby create confusion?
  – Which instrument failures would cause confusion?
    - What sources of information would be used for back-up?
  – Ask whether any other potential unsafe human actions are likely given the context (e.g., errors of commission)

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Process For Quantifying Each UA (continued)

- Step 2 - Identification of Important Factors
  - The judges as a group identify the key or driving factors of the plant-specific context expected to influence the crew with respect to the UA being quantified and any other factors that could significantly contribute to uncertainty about the probability of the UA
  - Using the “worksheet” factor list (provided by Sandia) in combination with the context identified in step 1:
    - test the results of step 1 against the factor list
    - strike-out those factors from the check list that are already included from the step 1 analysis
    - strike-out those factors that contribute minimally to probability estimate or its uncertainty
    - highlight the remaining factors that have substantial uncertainty, may affect the probability of the human actions, and have not yet been explicitly included.

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Process For Quantifying Each UA (continued)

- Step 2 - Identification of Important Factors (continued)
  - While reviewing the factors in the list and those identified in Step 1, assess the nature of the uncertainty and the degree of uncertainty associated with each of the factors in terms of predicting failure likelihood
    - ask how much could the probability of the action vary due to insufficient information about the occurrence of the factor or its effects (e.g., time-of-day)
  - Factors identified as having limited effects on the UA of interest should be dropped from further consideration
  - Factors thought to contribute significantly to the probability estimate or its uncertainty should be noted and considered in determining the uncertainty distribution of the UA probability, particularly their impact on the “tails” of the distribution

Process For Quantifying Each UA (continued)

- Step 3 - Estimating Probabilities of UAs
  - In thinking about what a particular probability will be, try to imagine how many crews out of 10, 100, 1000 etc. would you expect to commit the UA, given the identified context.
    - "Likely" to occur ~ 0.5 (5 crews out of 10 would fail)
    - "Infrequently"occurring ~ 1E-1 (1 crew out of 10 would fail)
    - "Unlikely" to occur ~ 1E-2 (1 crew out of 100 would fail)
    - "Extremely unlikely" to occur ~ 1E-3 (1 crew out of 1000 would fail)
    - Note that other values, e.g., 3E-2, 5E-3... are acceptable.

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Process For Quantifying Each UA (continued)

- Step 3 - Estimating Probabilities of UAs (continued)
  - Each judge independently develops an uncertainty distribution for UA probability
    - Suggestion is to identify 1st, 10th, 25th, 50th, 75th, 90th, and 99th percentiles (we can discuss what seems necessary)
    - Accounts for all identified sources of uncertainty

Process For Quantifying Each UA (continued)

- Step 3 - Estimating Probabilities of UAs (continued)
  - Begin by asking what the worst case for the probability of failure would be (determine 99th percentile)
    - “Bad” factors that could occur randomly (and reasonably credible) are operative (e.g., middle of the night, weakest crew)
    - The negative effects of all important factors are at their strongest (e.g., worst case for possible level of workload)
  - Next ask what the best case for the probability of failure would be (determine 1st percentile)
    - Best crew, daytime, few distractions
    - “Ideal” control room conditions, e.g., all instruments working, parameters as expected, etc.

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Process For Quantifying Each UA
(continued)

- Step 3 - Estimating Probabilities of UAs (continued)
  - Estimate UA probability at which 50% of the crews would have a higher failure rate while 50% would have a lower failure rate (account for variability in the important factors and thinking about their relative likelihood)
  - Fill-in the distribution with other estimates (e.g., UA probability at which 25% of the crews would have a lower failure rate and 75% would have a higher failure rate).

Process For Quantifying Each UA (continued)

- Step 4 – Final Estimates for Probabilities of UAs
  - Each judge provides his/her estimate with brief explanation
  - Based on other judges explanations, can revise estimate
  - “Test” estimates to be sure what is really intended and not biased in either optimistic or pessimistic direction
  - All judges work toward a consensus (final) estimate

An Example from Oconee PTS Analysis

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