Applying the Joint Intervenor Approach to Utility Risk Management

Presentation to: S-MAP Phase II Participants

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Topics for this presentation

- Introduction and Purpose
- Summary of the Five Step Test-Drive Process
- Description/Discussion of the Individual Steps
- Evaluating Test-Drive Success
- Next Steps
- Questions

Introduction and Purpose

- The Joint Intervenor Whitepaper presented the methodology
- The purposes of this presentation are:
  1. Provide a quick refresher on the methodology and how it works
  2. Provide a roadmap for S-MAP participants (utilities, intervenors, and regulators) on the steps involved in completing the test drive
- A key aspect of the test-drive: we need utilities to participate, and welcome participation from other parties
  – The test drive is designed to be illustrative and be applied to assets/issues common to multiple utilities (e.g., poles, pipe)

Summary of the Five-Step Process

- Step 1: Develop the multi-attribute value function
  - The value function captures the structure with which we will measure the consequences of failure (CoF) and the reductions in risk made possible by utility risk mitigation programs. It applies to <u>all</u> test drive problems
- Step 2: Develop condition-dependent hazard rates
  - The condition-dependent hazard rates allow us to measure the likelihood of failure (LoF) for different failure events, whether those events are asset-related (e.g., poles, pipe) or non-asset-related (e.g., cybersecurity, worker training, etc.)
- Step 3: Develop Probability Distributions for Asset Failure Consequences
  - Failure events may have a wide range of potential CoF values. We estimate CoF values in terms of how they change the attribute levels

Summary of the Five-Step Process (cont.)

- Step 4: Identify Alternative Mitigation Measures
  - To evaluate risk mitigation strategies, we have to know the possible mitigation strategies and how those strategies affect both LoF and CoF.
- Step 5: Analysis and Ranking of Risk Mitigation Alternatives
  - Using the information from Steps 1 – 4, we will formulate and solve a dynamic optimization model. In other words, we look at how the probability of failure changes over time depending on asset condition and, based on that behavior and the consequences of failure, develop an optimal mitigation strategy.
  - For those who are familiar with dynamic programming techniques used in decision analysis, our methodology is similar.

Step 1: Develop the Multi-Attribute Value Function

- Step 1 takes place with a group composed of utilities, intervenors, and regulators. It consists of five tasks:

1. Define high-level attributes (Step 1-1) [For example, "safety," "reliability," "environmental quality," etc.]
2. Create an attribute structure such that measurable attributes are at the bottom (Step 1-2) [Determine how high level attributes are observed and measured.]
3. Specify natural units and ranges of natural units (Step 1-3) [For safety, the best case is no deaths or injuries; the worst case might be large loss of life.]

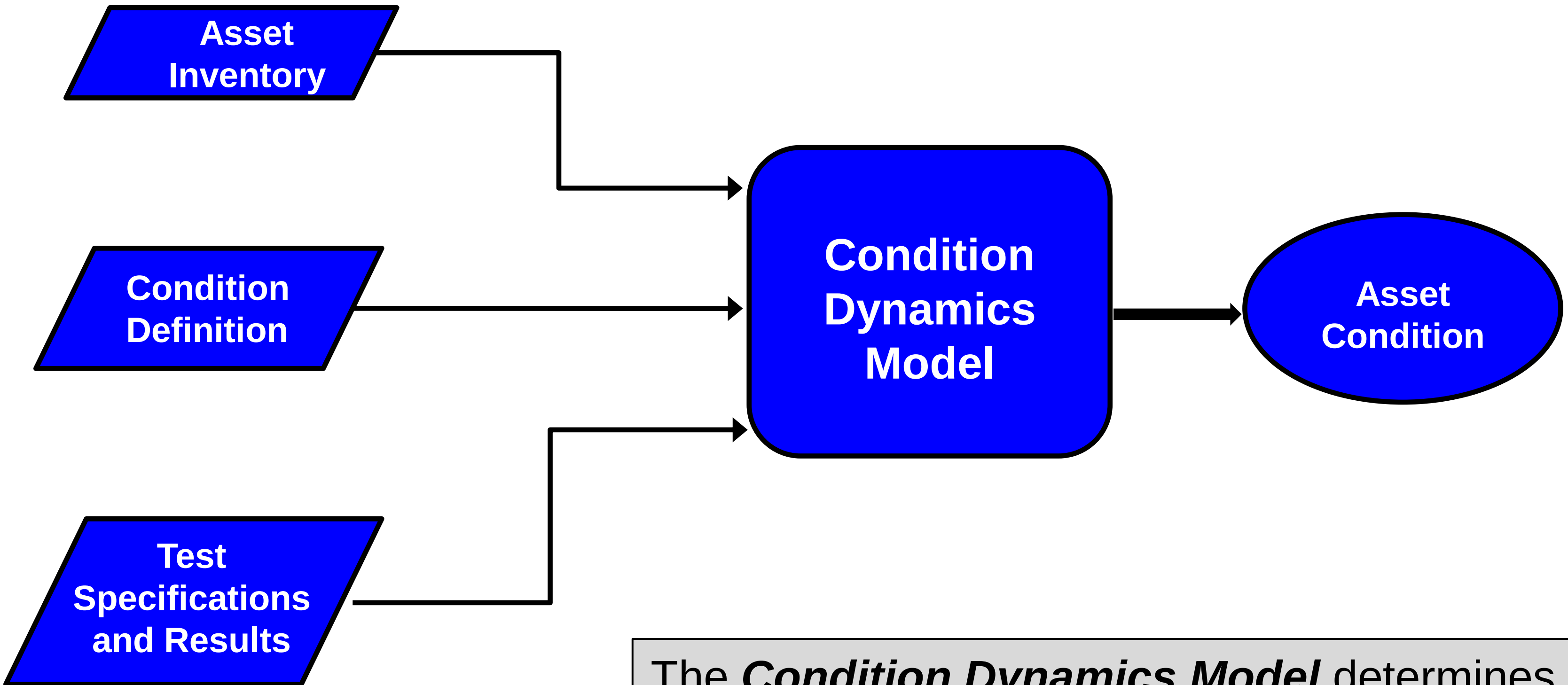
Step 1: Develop the M/A value function (cont.)

4. Specify scaled units for each attribute (Step 1-4) [We use scales of 0 – 100, where 0 is best and 100 is worst. The scales need not be linear. For example, the scale value of lost service for 10 hours need not be equal to 10 times the scale value of one hour of lost service.]
5. Specify the attribute weights (Step 1-5) [This is done by evaluating the tradeoffs people make between changes in levels of pairs of attributes. Note: the proposed webinar will go through the weight calculation exercise.]

- Our role is to act as facilitators for the definitions/choices/tradeoffs made by the group and, based on those choices, calculate the attribute weights based on the tradeoffs the group makes.

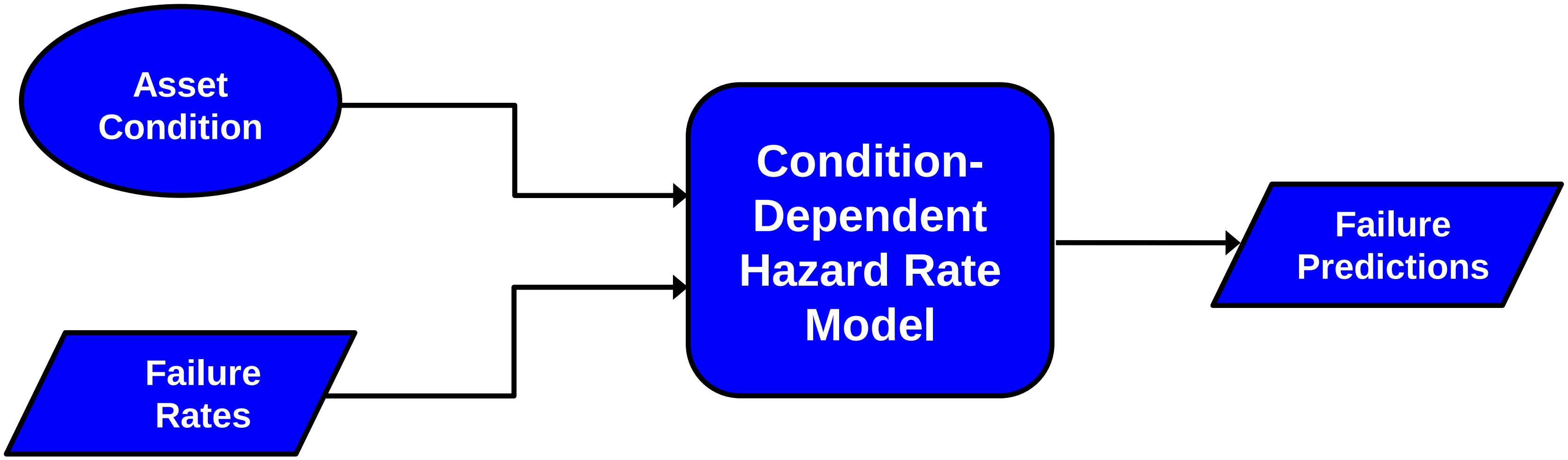
- The multi-attribute value function is the same for all types of assets and all events. This allows us to make risk management decisions at the enterprise level.

Step 2: Develop condition-dependent and unconditional hazard rates



The ***Condition Dynamics Model*** determines how an asset's condition is likely to change over time, given its current condition

Step 2: Develop condition-dependent hazard rates (cont.)



The ***Condition-Dependent Hazard Rate Model*** specifies failure probability for an asset, given its condition and the occurrence of events that affect failure

Step 2: Develop condition-dependent hazard rates (cont.)

- Step 2 takes place with a group composed of utilities, intervenors, and regulators. It consists of 10 tasks (and two optional ones)

1. Define asset conditions (Step 2-1) [Define possible conditions, e.g., good, fair, poor]
2. Specify dynamic behavior of asset condition (Step 2-2) [As assets age, condition changes. We use a Markov model to represent these changes]
3. Test the Markov model and revise parameter estimates as needed (Step 2-3) [We work with SMEs to determine if initial parameters in Step 2-2 are reasonable, and revise if necessary]
4. Identify and describe the different ways to observe the condition of an asset (Step 2-4) [Asset condition is uncertain. Tests, e.g., pole inspection or pipeline ILI, can help resolve that uncertainty]

Step 2: Develop condition-dependent hazard rates (cont.)

5. Specify the condition-dependent hazard rates (Step 2-5) [The hazard rate is the probability that an asset fails before the end of a time interval (usually a year), which depends on asset condition at the beginning of the interval.]
6. Compute and review unconditional hazard rates and revise the parameter estimates as needed (Step 2-6) [We combine Steps 2-1 to 2-3 and 2-5 to determine the probability that a randomly selected asset will fail before the end of a time interval.]

Note: The **unconditional** hazard rate is the probability that a randomly chosen asset (when we know nothing about its condition) will fail. Calculating unconditional hazard rates is important because: (i) the condition of all utility assets is typically not known with certainty; and (ii) the unconditional hazard rate is the LoF value used in the methodology; (iii) the unconditional hazard rate is used in the methodology to calculate the benefits of testing asset condition. (If the utility always knew the condition of every single asset with certainty, there would be no need for testing.)

Step 2: Develop condition-dependent hazard rates (cont.)

7. Define threats and specify the effects of threats on condition-dependent hazard rates (Step 2-7) [We work with the group to determine external threats that affect asset condition, hence the probability of failure.]
8. Specify interactive threats and effect of interactions on condition-dependent hazard rates (Step 2-8) [Threats can interact, which means they may arrive at the same time and jointly affect the condition-dependent hazard rate.]
9. Specify arrival rates (e.g. X times per year) of threats. (Step 2-9) [Using the cond. dep. hazard rates and the impacts of external threats, we calculate LoF.]

Step 2: Develop condition-dependent hazard rates (cont.)

10. Review unconditional hazard rates and revise parameter estimates as needed (Step 2-10) [This step is similar to Step 2-6. Here, we are estimating the probability that a randomly selected asset will fail when external threats also are included.]
11. Specify failure dependencies (Step 2-11)(optional) [Failure of any asset may change the probability that another asset in the asset inventory will fail.]
12. Identify consequential non-asset related events (Step 2-12)(optional) [e.g. human error, poorly trained workforce (which contributes to human error), etc.]

Note: Non-asset related events are analogous to outside events (e.g., an earthquake) that affect the condition-dependent hazard rates. They have arrival rates and affect LoF, CoF. These easily fit into the Joint Intervenor methodology.

Step 3: Develop Probability Distributions for Consequences of Asset Failure

- Step 3 takes place with a group composed of utilities, intervenors, and regulators. It consists of 2 tasks:

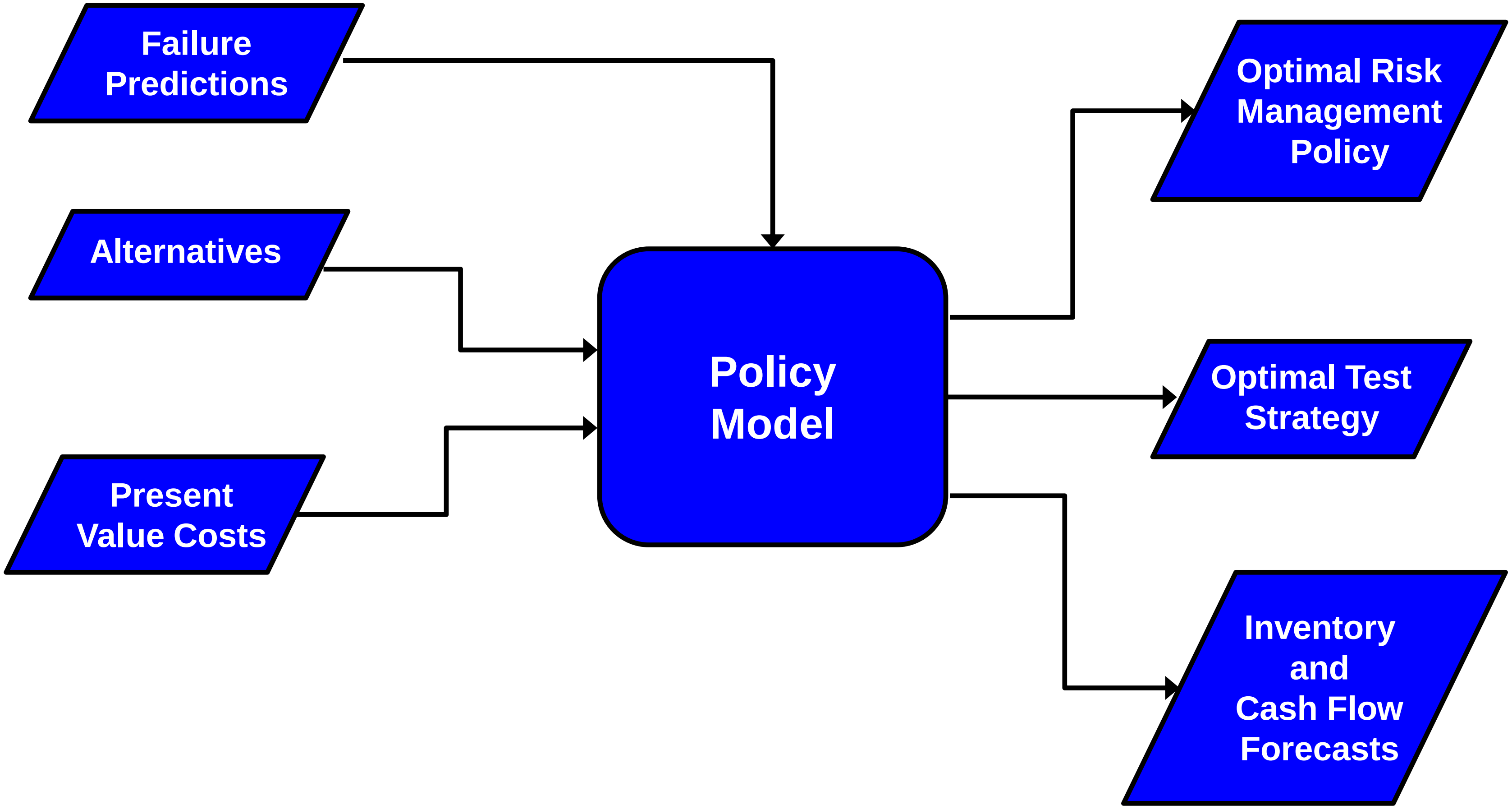
1. Specify the consequences of failure in terms of the changes in attribute levels (Step 3-1) [In general, consequences of an asset failure won't be known precisely. We typically ask SME's to provide 10%-50%-90% CoF estimates.]
2. Specify the effect of multiple failures on the changes in attribute levels associate with the occurrence of the failure event (Step 3-2) [CoF for multiple asset failures may not be additive. SMEs will specify these interactive effects.]

Step 4: Identify Alternative Mitigation Measures

- Step 4 takes place with a group composed of utilities, intervenors, and regulators. It consists of 2 tasks:

1. Identify the alternative risk mitigation measures (Step 4-1) [For each mitigation alternative, we need to know the cost, which should be the present value of all cash flows associated with the mitigation alternative. Also, we ask whether the identified mitigation measures are mutually exclusive, can be combined, etc.]
2. Express the consequences of applying the risk mitigation measures both before and after a failure, including the effect of the risk mitigation measures on multiple failures (Step 4-2) [Ask SMEs to estimate how each mitigation measure affects LoF and CoF]

Step 5: Analysis and Ranking of Risk Mitigation Alternatives



Step 5: Analysis and Ranking of Risk Mitigation Alternatives (cont.)

- Step 5 is where we apply the information gathered in Steps 1 – 4 to rank alternative mitigation measures. It consists of 4 tasks and the creation of a dynamic optimization model (i.e., one that considers how asset condition and failure rates change over time, the effects of testing, etc.)

1. Compute the risk-reduction for each mitigation measure (Step 5-1) [Estimate how risk (LoF x CoF) changes when mitigation measures are applied.]
2. Rank the alternatives and report the results (Step 5-2) [The ranking is based on risk reduction per dollar spent.]

Step 5: Analysis and Ranking of Risk Mitigation Alternatives (cont.)

3. Impose constraints as applicable and find the portfolios of risk mitigation measures that maximize the risk reduction achieved subject to the applicable constraints (Step 5-3) [Identify applicable constraints, e.g., budget, and rank measures based on those constraints. When constraints are added, the optimal selection of mitigation measures may be very different than the ranking in Step 5-2.]
4. Perform sensitivity studies (Step 5-4) [Examine how the rankings, optimal portfolios change when inputs change. Sensitivity studies can help identify where collecting additional data is most valuable.]

Evaluating Test Drive Success

- We suggest five criteria to measure test drive success:
  1. Quality of the outputs: Does the Joint Intervenor methodology provide measures of risk reduction and risk-spend efficiency? Does the methodology select portfolios of risk-reduction measures that provide the greatest risk reduction, given any constraints we impose?
  2. Transparency: Are the methodology's inputs, outputs, and transformation of inputs into outputs clear and easily followed? Are the computations that determine the portfolios of measures from the inputs to the methodology clear?
  3. Logical and Explainable: Is it logical and explainable as to why the model operates the way it does, including the operations to determine the portfolios of risk-reduction measures, calculate the risk-reduction provided by those portfolios, and calculate the risk-spend efficiency?

Evaluating Test Drive Success (cont.)

4. Sensitivity analysis: Does the methodology allow us to easily evaluate how the answers change when inputs change? And, consequently, does the methodology allow us to identify areas where collecting additional data is most valuable?
5. Ease of Considering Alternatives: Does the methodology provide a straightforward means for the Commission and parties to examine alternative impacts on cost and risk reduction under alternative portfolios of mitigations?

Next Steps

- Group selects test-drive problems to be evaluated
  - We recommend a gas pipeline asset problem (e.g., vintage pipe) and an electric transmission/distribution problem (e.g., wooden poles).
- Webinar on development of the multi-attribute value function that measures CoF values
  - Purpose: illustrate a worked example for Step 1, explaining attribute selection, attribute scales, and how attribute weights are calculated based on pairwise tradeoffs of changes in attribute levels.
- Working group to develop test-drive multi-attribute value function that will be applied to all test drive problems
  - Note: the value function must be the same, regardless of the test problem (e.g., electric, gas). Otherwise, we cannot compare enterprise-level mitigation plans consistently.

Next Steps (cont.)

- Webinar that presents results for a previous study we prepared
  - Purpose: explain Steps 2 – 5 and how optimal policies were developed.
- Test-drive problem-specific working groups for Steps 2 – 5.
- Analysis and solution identification (Step 5).
- Present test-drive results.
- Evaluate success of test-drive.