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## PFM Panacea or Devil's Bargain?

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### Deterministic versus Probabilistic



- **Deterministic analyses**
  - Used to define what is possible, what we are confident in
  - Firmly established in consensus standards and time-proven design rules
  - Satisfy our urge to "know" the answer, or at least sustain an illusion of a simple, direct answer even when the reality is more complex
    - Our 'deterministic' analyses are in reality often probabilistic cases constrained with bounding assumptions to render them 'deterministic'
- **Probabilistic analyses**
  - Help us understand what is likely, how likely, and how confident we should be in that outcome
  - Methods and protocols are much less well-defined
  - Place a notably higher burden on the analyst to: *define the methodology, populate the case matrix with complex inputs, evaluate the results, and defend the entire process*
- These methods are typically complementary, not competitive

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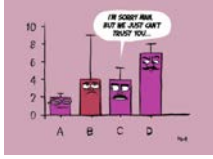
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### Judgements in Uncertainty



- Much of our reality is uncertain
  - Uncertainty permeates both our lives and our work as engineers
  - We routinely evaluate uncertain inputs when making personal and technical decisions
  - Yet when it is time to make big decisions, we often act as though an uncertain future is some surprising new thing
- Research suggests humans are mentally well-equipped to consider uncertainty, but we are not necessarily equipped to consistently do it well
  - "Judgements in uncertainty" - an established field of behavioral science research
  - Humans seem better adapted to process and retain **event frequencies** (e.g., 5 of 10) **vice single event probabilities** (e.g., 50%)
  - Various cognitive errors are well documented in the literature that lead to invalid probabilistic conclusions (e.g., air travel riskier than other transportation modes)

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## Probabilistic Engineering

- Advanced computational capabilities have made it possible to more fully expose and consider probabilistic aspects of problems
  - *when we need to know more about the answer*
- These additional insights demand that we confront challenging decisions previously masked by conservative assumptions including:
  - Inputs:
    - Can we realistically characterize key input variabilities?
  - Methodology:
    - Does it appropriately sample input distributions?
    - Are uncertainty and bias quantified / assessed?
    - Has the code been adequately validated?
  - Establishing Acceptance Criteria:
    - How good is "good enough"?
    - How safe is "safe enough"?
    - *High value and high consequence structures can fail, albeit rarely*



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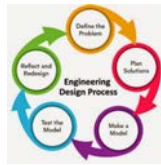
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## Engineering Acceptance

- Engineering background is an appropriate foundation to learn and effectively apply probabilistic approaches
- Probabilistic analytical 'tools' likely not well-taught in most undergraduate engineering curricula
- Even within the engineering community thoughtful communication and targeted training are likely needed for understanding and acceptance of probabilistic methods



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## Public Acceptance

- The public is a critical stakeholder
- Large-scale societal judgements of technically complex issue uncertainties are particularly challenging and rarely dispassionate (e.g., nuclear power plant event probabilities)
- Even experts applying probabilistic tools to inform "judgements in uncertainty" will expose differences of opinion – *no less so with the public*
- Effective communication with the public on complex technical topics is always challenging
- Public communication regarding probabilistic decision-making
  - Might begin with acceptance standards and their bases
  - Should:
    - Be carefully planned
    - Draw on relevant behavioral research
    - Thoughtfully executed
    - Fully transparent



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### Panacea or Devil's Bargain?

- Deterministic and Probabilistic methods generally are complementary, not opposing options
- Probabilistic methods:
  - Can provide deeper insights into the likelihood of complex events occurring but demand more effort to develop, implement, and defend
  - Acceptance by technical and non-technical stakeholders will likely require an increased focus on effective communication and education

*There is no such thing as a true panacea  
and  
Despite very real challenges, "devil's bargain" is far too harsh*

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