Analysis of the Impact of Limitations of Historical Analogues & Case Studies for Systems Engineering Modeling

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Value Models for Optimization

- Design engineering uses value models for optimization.
- VDD (Value-Driven Design) assigns value to extensive attributes.
- Maximizing an objective function that converts the set of full attributes into a score.
- This allows for the central goal of the design to be achieved with minimal budget complications or schedule delays [6].

Historical Analogues for Value Models

- You don’t always have access to perfect data sources.
- Sometimes value models are based on historical analogues [1].
- Value models for the NASA Artemis Human Landing System were developed using data from:
  - previous human lunar landers
  - system attributes (stakeholder preferences)

What are historical analogues?

- Past systems or projects that are deemed similar enough to an inquired system or project that it may be reasonably used to base estimates and decisions off of.
- Historical analogues are used in a variety of contexts to serve as a benchmark for research topics, assist in making future predictions in terms of data, and/or provide insight toward decision making.

What issues do they present?

- Historical analogues possess certain limitations that can potentially produce unfavorable results if used irresponsibly, such as:
  - publication bias
  - survivorship bias
  - historical bias

Publication Bias

- Publication bias is a type of bias in academic literature where studies with favorable results are more likely to be published than those with insignificant or negative findings.
- Significance may be subjective.
- Limitations exist within the methods used to detect publication bias.

Publication Bias Example

- Authors of one study systematically reviewed publication bias within other studies on publication bias [4].
- Using a funnel plot, 26 studies were observed out of the 100+ that were considered.
- A slight preference toward publication of positive results was found within 23/26 studies, but nothing statistically significant of the data asymmetry (P = 0.13).
- However, not publishing this study would be an example of publication bias.

Recent Studies on Publication Bias

- One study on publication bias within social science observed that motivation may be a factor of publication bias [2].
- Unsuccessful results are deemed less interesting by researchers.
- A belief that unsuccessful results are unpublishable was observed as well.

Publication bias in engineering

- Data rights limiting the availability of data from systems produced by other organizations.

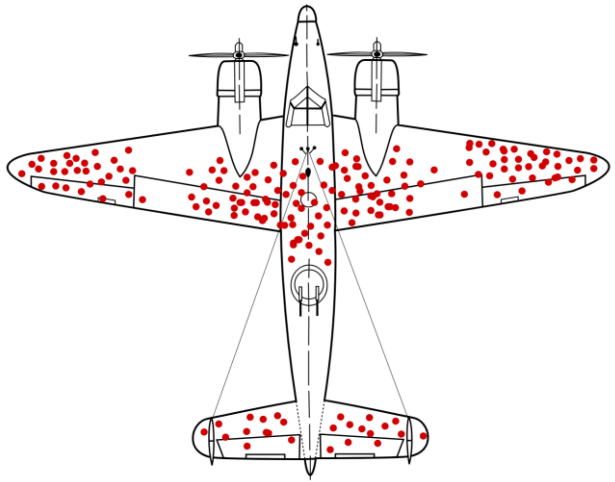
- Emphasis on major successes & failures; less emphasis on “ordinary”, mildly-successful systems.

Survivorship Bias

- Survivorship bias is a type of bias that excludes failed outcomes, or underrepresents them.
- Often happens unintentionally.

Survivorship Bias Example

- Armor and bullet holes in WWII airplanes [3].
- Aircraft vulnerability was assessed using data from surviving aircraft.



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Recent Studies on Survivorship Bias

- Survivorship bias of COVID-19 mental health surveys [5].
- Results indicated survivorship bias of:
  - Demographic differences
  - Data on initial mental health
  - Follow-up survey participation

Survivorship Bias in Engineering

- Long service-life systems
- Hard to get data on design alternatives that never made it to production.
- Quality control process:
  - If you only have data on items that passed quality control, it can be difficult to estimate consistency of a design, for example.

Next Steps

- Publication bias - Apollo Triad
- Survivorship bias - Service Life

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