

Value of Information Analysis Identifying Data Requirements for Digital Twins

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UK Research
and Innovation

Risk Management in Engineering

‘From a conservative starting point engineers need to be dragged, kicking and screaming, towards the use of more complex models because they are less well validated, more expensive to perform and, most importantly, erode that reassuring safety margin.’¹

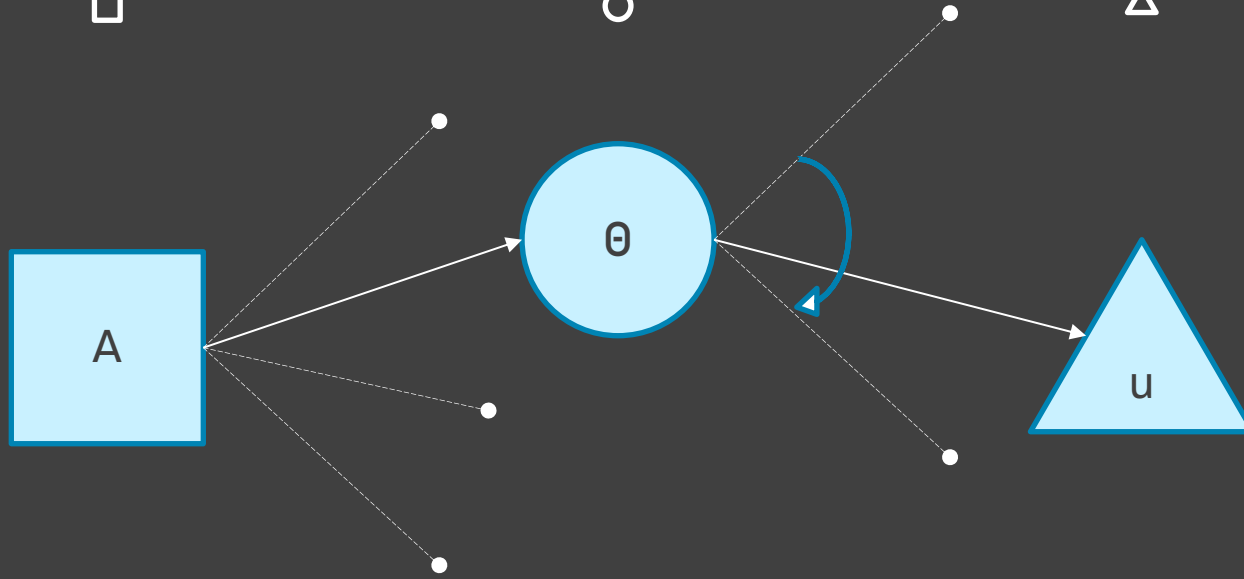
1. Demaid, A. *‘Fail-safe’*. Second edition. The Open University, 2004. ISBN: 0 7492 5900 0. url: fracturetraining.com

Risk Management in Engineering

Risk Mitigation?
Decision
□

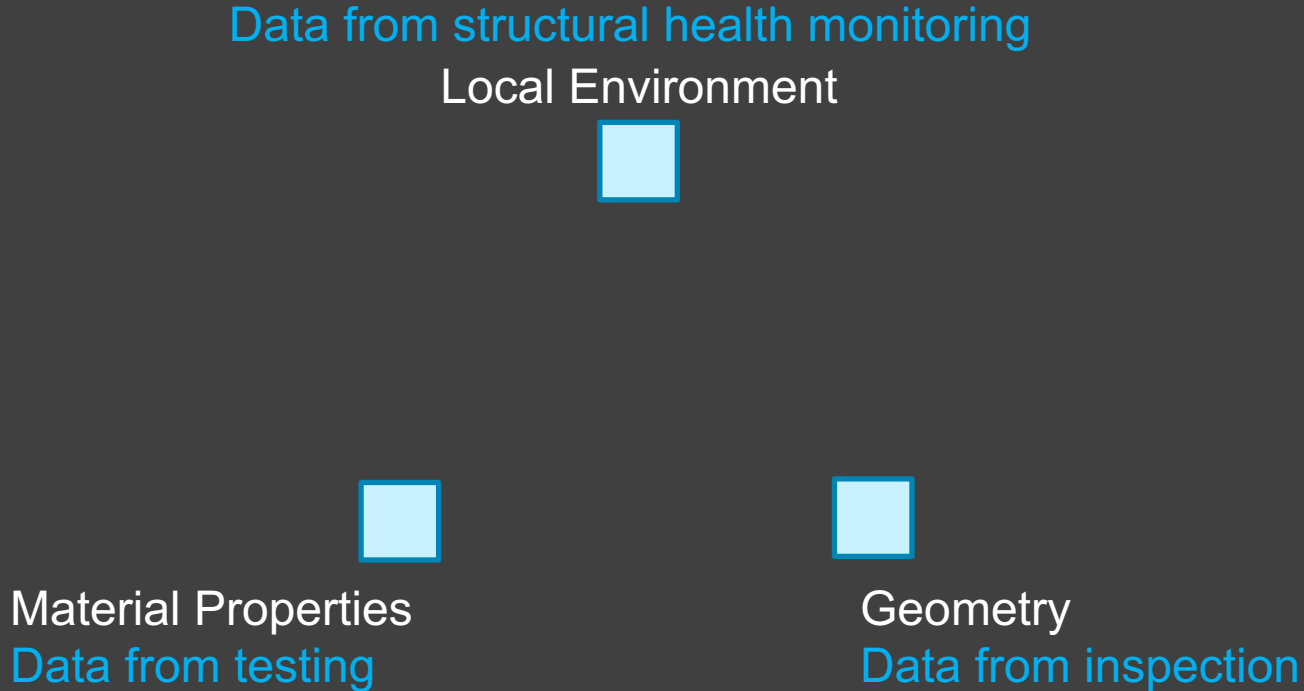
Structural Condition
Uncertain
○

Risk
Cost or Utility
△



$$a^* = \arg \max_{a \in A} E[u(a, \pi(\theta))]$$

Digital Twins in Structural Integrity Management



Value of Information

Opportunity to collect testing, monitoring or inspection data.

- Should you?
- How good does the data need to be?
- How much should you be willing to pay for it?

Answer the above questions with a replicable, interpretable, quantitative analysis.

Value of Information

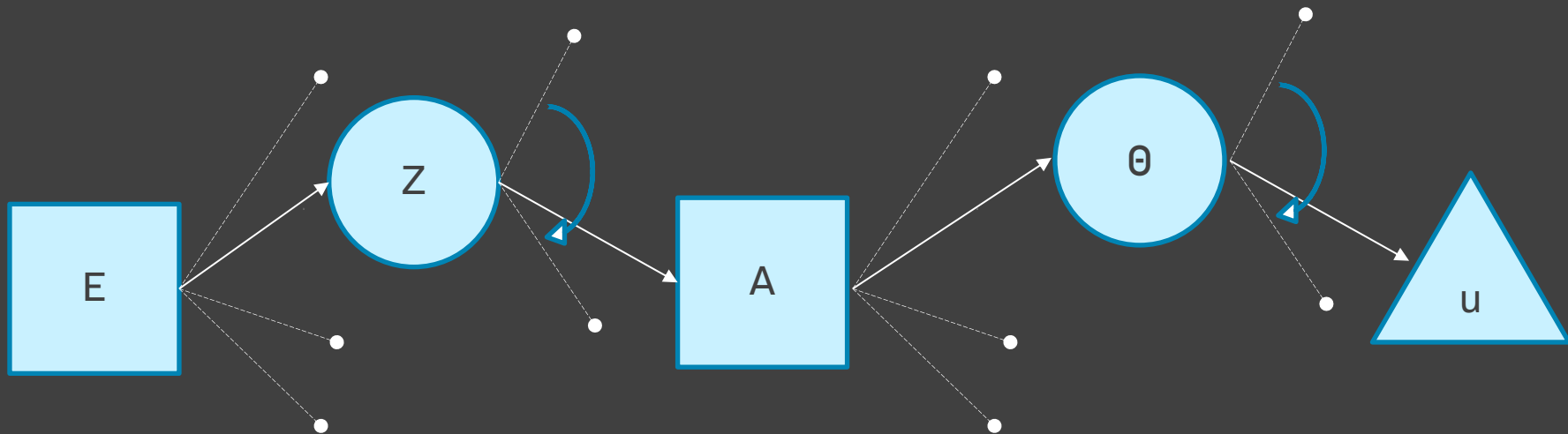
Collect Data?
Decision
□

Results
Uncertain
○

Risk Mitigation?
Decision
□

Structural Condition
Uncertain
○

Risk
Cost or Utility
△



$$e^*, a^* = \arg \max_{a \in A, e \in E} E[u(a, e, \pi(\theta_a | z))]$$

$$Vol_{e_i} = E[u(a_{e_i}^*, \pi(\theta | z_{e_i}))] - E[u(a^*, \pi(\theta))]$$

Some Propositions

- Decisions are required, in the absence of perfect information.
- SIM is an application of decision making under uncertainty.
- Digital twins should support consistent and coherent decision making.
- Digital twins should be developed using intelligent data acquisition plans (Vol).

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