JCSS

Joint Committee
on Structural Safety

Workshop on Assessment of Existing Structures

28th and 29th January 2021

What makes the value of information?

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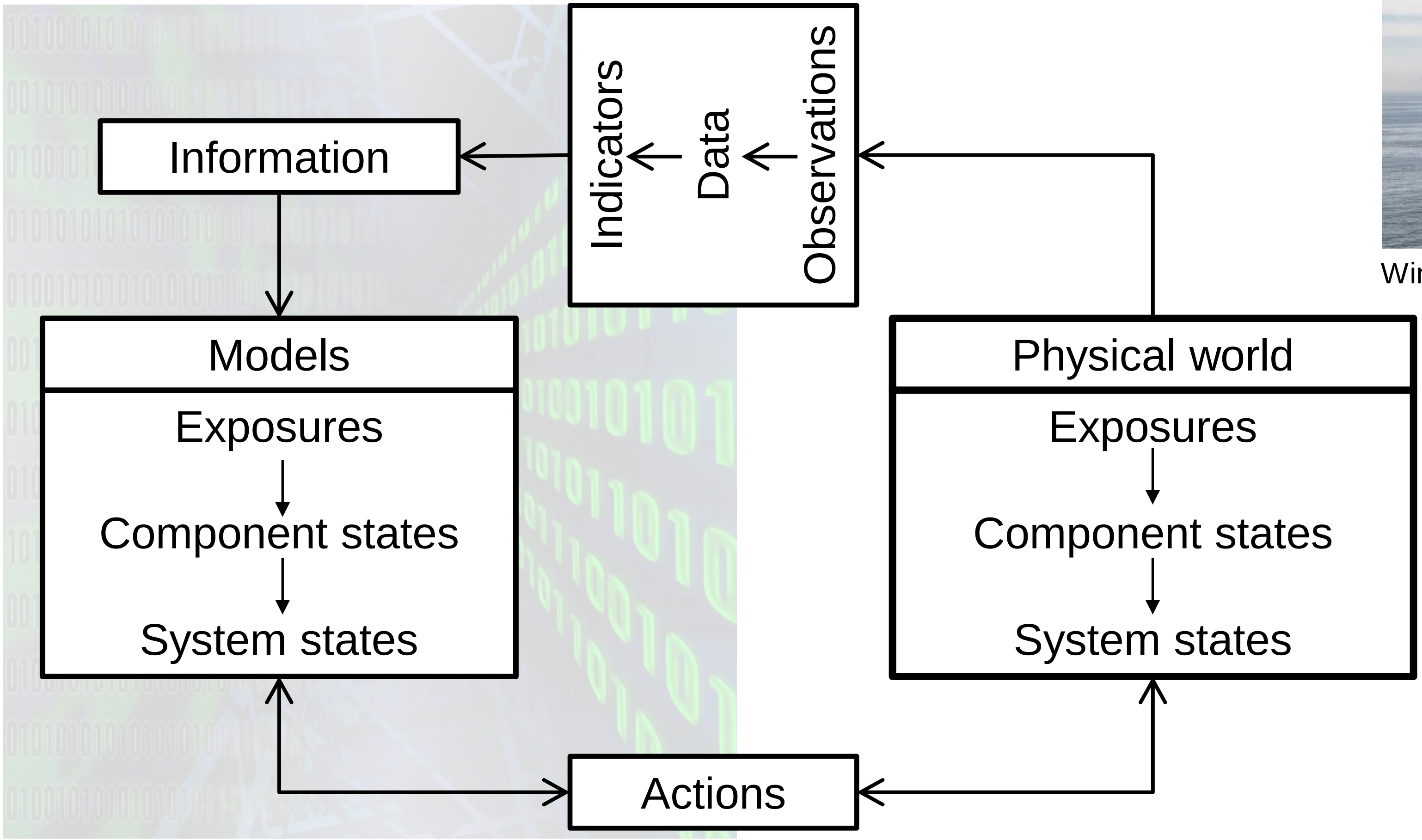
Models and existing structures



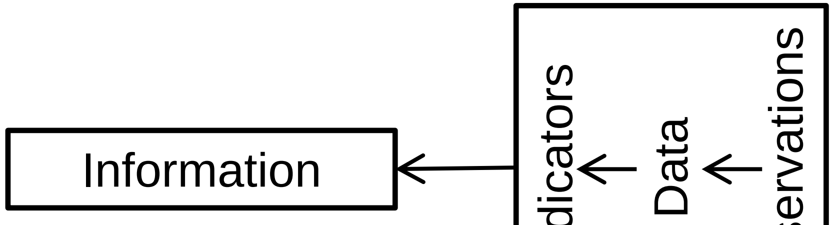
Wind Park Global Tech 1

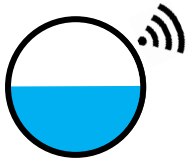
Biblis Nuclear Power Plant

Storebælt Bridge

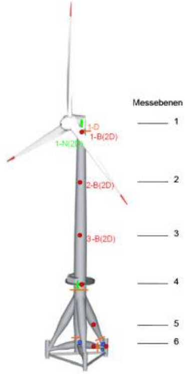
Based on TU1402 Factsheet on Framework and Categorization for Value of Information Analysis, 8th TU1402 Workshop, March 2017.

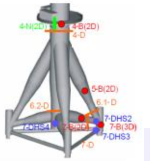
Structural health information (SHI)



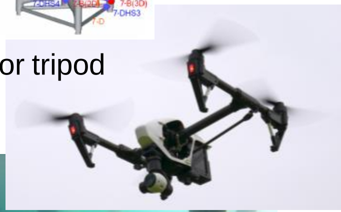


Flooded member detection





Sensor system for tripod prototype



Inspection with UAVs and ROVs

Alternating Current Field Measurement (ACFM)

Visual inspection with a diver

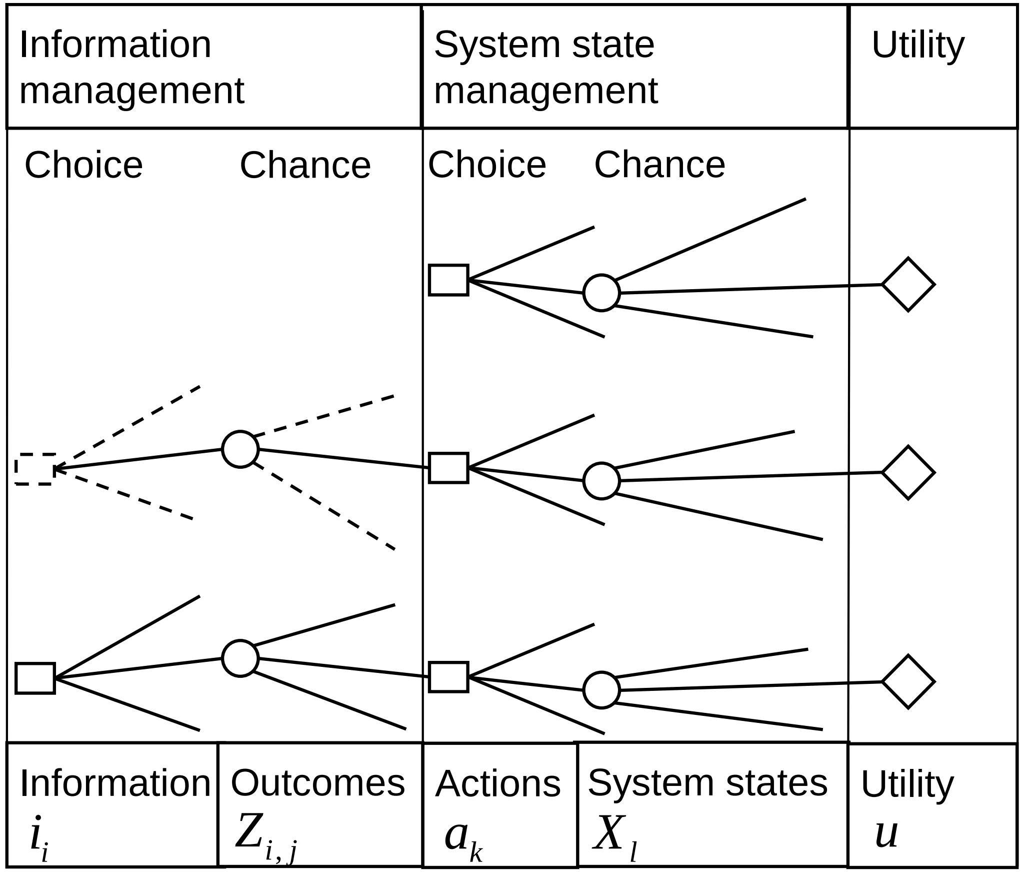
Structural health information (SHI) is based on observations, data and indicators.

- Wide range of technologies and concepts
  - Monitoring, NDT, NDE, inspection, measurements
- Many monitoring systems is use

But how to use SHI from existing structures in engineering for value creation?

- Adaptation of system states of existing structures. Then SHI can potentially:
  - Reduce risks
  - Be optimised for value
  - Used for optimising action implementation and value

Utilisation of information value and decision analyses



Prior DA

$$U_{Prior}\left(a_k\right)=\max_{a_k} E_{X_l}\left[u\left(a_k,X_l\right)\right]$$

Posterior DA

$$U_{Post}\left(Z,a_k\right)=\max_{a_k} E_{X_l|Z}\left[u\left(a_k,X_l\right)\right]$$

Pre-posterior DA

$$U_{PrePost}\left(i_i,a_k\right)=\max_{i_i} E_{Z_{i,j}}\left[\max_{a_k} E_{X_l|Z_{i,j}}\left[u\left(a_k,X_l\right)\right]\right]$$

Thöns, S. (2019). Quantifying the Value of Structural Health Information for Decision Support: TU1402 Guide for Scientists, COST Action TU1402, www.cost-tu1402.eu/action/deliverables/guidelines.

Prior decision analysis for action optimisation

Utility action

$$U_{Prior}(a_k) = \max_{a_k} E_{X_l}\left[u(a_k, X_l)\right]$$

$$= \max_{a_k} \sum_{X_l} u(a_k, X_l) \cdot P(X_l) - c(a_k)$$

Engineering action

$$U_{Prior}(a_k) = \max_{a_k} \sum_{X_l} u(X_l) \cdot P(X_l \mid a_k) - c(a_k)$$

Action types

- Utility actions influence the system state utility
- Engineering actions influence the system state reliability

An action has a cost.

Posterior decision analysis for action optimisation

$$U_{Post}(Z,a_k) = \max_{a_k} \sum_{X_l} u(a_k, X_l) \cdot P(X_l \mid Z)$$
$$-c(a_k) - c(Z)$$

Posterior value of information Z in respect to prior DA

Utility action

- Change of system state utility by different optimal action
- Change of system state reliability due to information

$$U_{Post}(Z,a_k) = \max_{a_k} \sum_{X_l|Z,a_k} u(X_l) \cdot P(X_l \mid Z, a_k)$$
$$-c(a_k) - c(Z)$$

For an engineering action

- Change of system state reliability due to information
    - Often referred to risk reduction in conservative design situations
    - Solely in the model world: Potentially sustainable.

Pre-posterior decision analysis for information and action optimisation

$$U_{PrePost}(i_i, a_k) = \max_{i_i, a_k} \sum_{Z_{i,j}} \sum_{X_l} u(a_k, X_l) \cdot P(X_l \mid Z_{i,j}) \cdot P(Z_{i,j}) - c(a_k) - c(i_i)$$

Predicted information value in respect to prior DA

Utility action

- By change of system state utility due to indication dependent optimal actions (partly different from prior DA optimal action)

$$U_{PrePost}(i_i, a_k) = \max_{i_i, a_k} \sum_{Z_{i,j}} \sum_{X_l} u(X_l) \cdot P(X_l \mid Z_{i,j}, a_k) \cdot P(Z_{i,j}, a_k) - c(a_k) - c(i_i)$$

Engineering action

???

Pre-posterior decision analysis for information and action optimisation

$$U_{PrePost}(i_i, a_k) = \max_{i_i, a_k} \sum_{Z_{i,j}} \sum_{X_l} u(X_l) \cdot P(X_l \mid Z_{i,j}, a_k) \cdot P(Z_{i,j}, a_k)$$
$$- c(a_k) - c(i_i)$$

Total probability theorem

$$\sum_{Z_{i,j}} P(Z_{i,j} \mid X_l) \cdot P(X_l) = P(X_l)$$

$$U_{PrePost}(i_i, a_k) = \max_{a_k, i_i} \sum_{X_l} u(X_l) \cdot P(X_l \mid a_k) - c(a_k) - c(i_i)$$
$$= U_{Prior}(a_k) - c(i_i)$$

Predicted information value in respect to prior DA

Engineering action

- ... will lead to equivalency to a prior DA apart from cost of information...

Information value cannot be predicted with an engineering action without a utility implication.

More to come in ICOSSAR 1 P.C.

Conclusions

Posterior value of information

- Positive or negative
- Potentially valuable and sustainable for conservative engineered structures

Predicted value of information

- Requires a utility change

Information – like scientific knowledge - need to be connected to utility for having a value.

Outreach

Europe has the knowledge of the SHI value prediction in engineering.

- The use of SHI is hardly codified preventing industrial utilisation and competition.

US tech giants: “Business model development with obtained data”

- Prepare entry for urban development: Sidewalk Labs as the urban innovation entity of Alphabet Inc.

The European construction industry should be prepared and go ahead of competition.

- 18 million direct jobs in EU with 9% of the EU's GDP

Thank you for your attention.

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