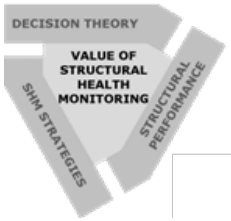
COST TU1402: Quantifying the Value of Structural Health Monitoring
2nd Workshop, 28.-29.09.2015, Boğaziçi University, Turkey

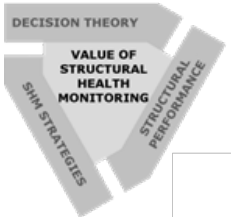


WG1: Principal Procedure and Test Cases

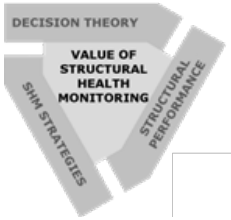
Sebastian Thöns

DTU Civil Engineering
Department of Civil Engineering

CERDA
Civil Engineering
Risk and Decision Analysis



Contents



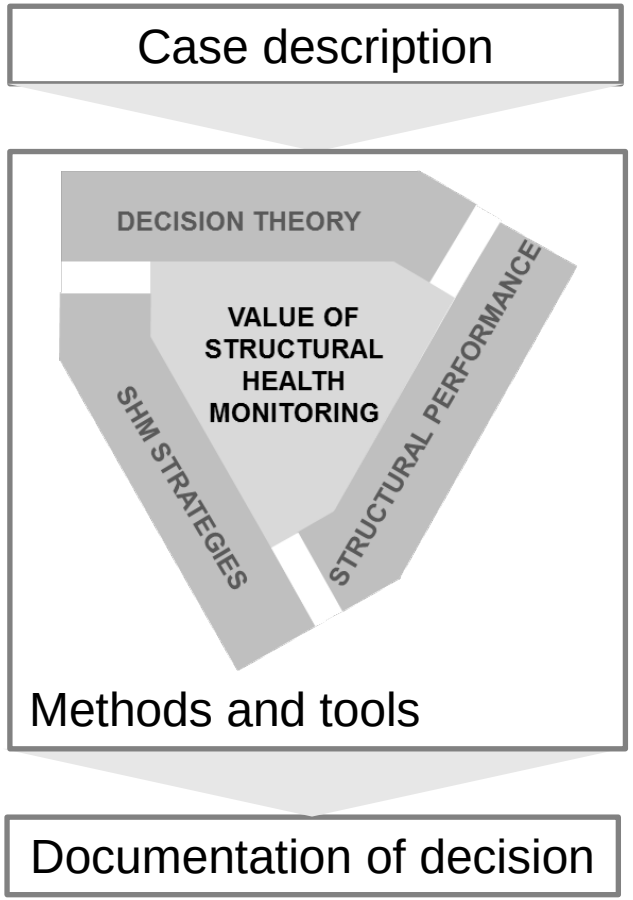
Introduction and purpose

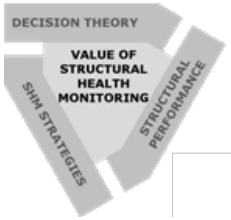
The principal procedure and the test cases are developed:

- To homogenize the thinking across Working Groups
- To identify methodological and computational challenges
- To form the basis for further development to case studies

The setup and development of fact sheets may take basis in the test cases.

Principle procedure

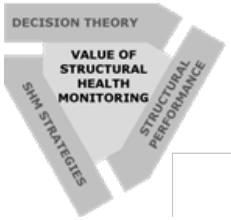




Case description

The case description should cover the infrastructure and the decision scenario.

- Infrastructure: Bridges, dams, offshore structures
- Decision scenario: Decision boundaries, decision variables and actions
    - Decision boundaries: Life safety, Performance, Serviceability, Functionality
    - Decision variables: SHM locations, SHM technologies, precision
    - Actions: Inspection, Repair, Retrofitting



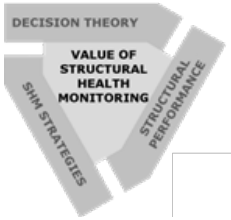
Decision theory

Decision analysis type

- Focus: Pre-posterior decision analysis (EVPI or EVSI)
- Prior, posterior decision analysis (CVPI or CVSI)

SHM information modelling

- Perfect information: Infinite precision and zero costs
- Sample information: Finite precision and costs



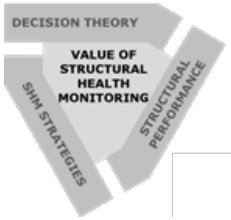
Structural performance

Physical, engineering and empirical models

- Ultimate Performance
- Deterioration
- Functionality
- Serviceability

Consequence models

- Component damage or failure
- Structural damage or failure
- Functionality and serviceability
- Life safety
- Environment



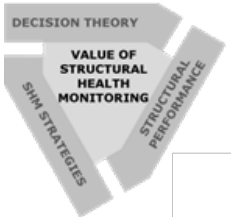
SHM strategies

SHM system and performance models

- Technologies and locations
- Precision and false alarms

Consequence models

- SHM Strategy
- Maintenance and operation
- Service life
- SHM system damage or failure
- Discount rate

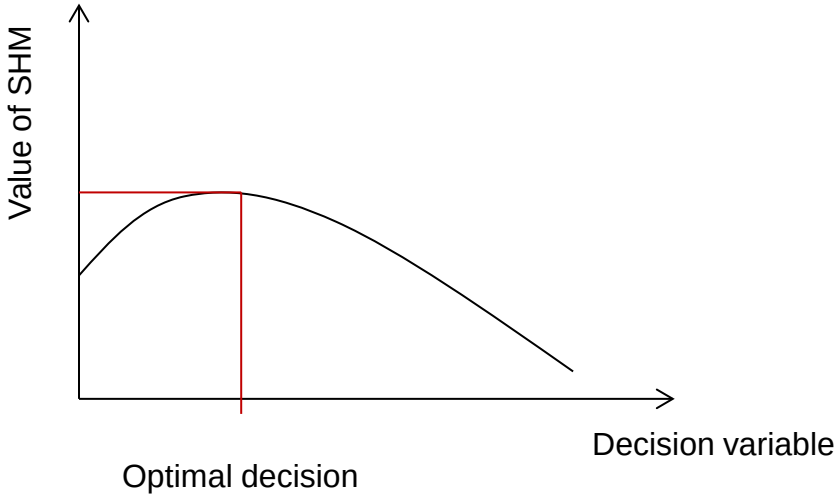


Methods and tools

Methods and tools are any numerical means to calculate the value of SHM.

- Normal or extensive form of decision analysis
- Decision trees
- Bayesian networks
- Structural reliability algorithms
- Methods for modelling SHM information in conjunction with the structural performance models
- Methods for modelling and coupling the structural deterioration and the structural reliability model

Documentation of decision

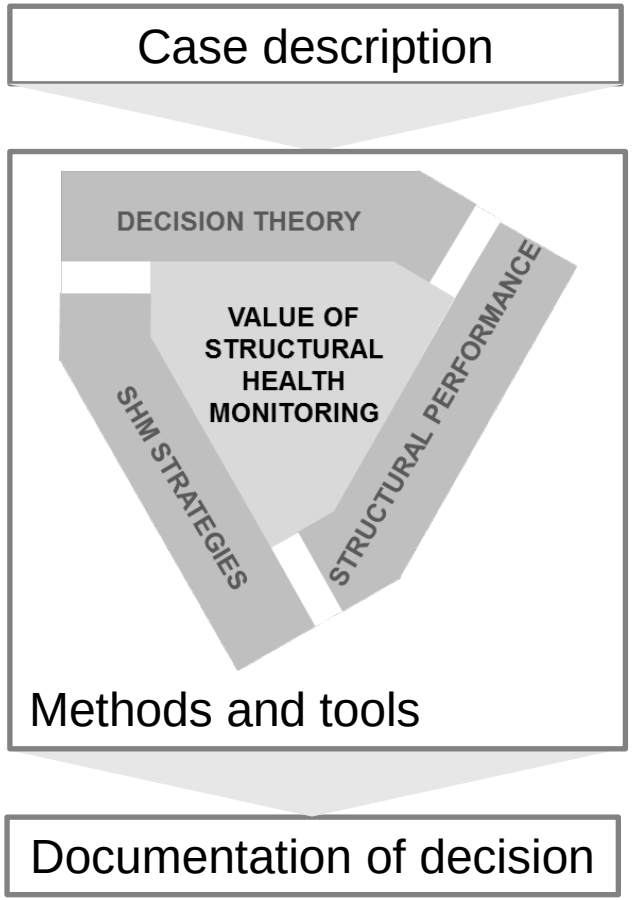


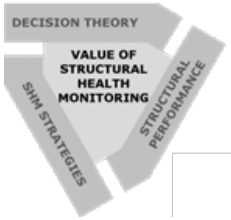
The value of SHM is calculated for the individual decision alternatives (Case description).

The optimal decision is documented.

Test case 1: Monitoring of deteriorating reinforced concrete

Principle procedure

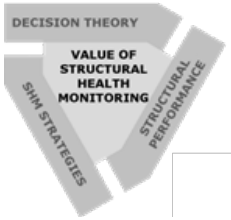




Case description

Reinforced and pre-stressed concrete bridges form an essential part of the road infrastructures and thus of societal mobility.

SHM in conjunction with a reliability and risk based structural management may efficiently support the reduction of the uncertainties of the deterioration process facilitating reduced risks and an efficient structural integrity management.

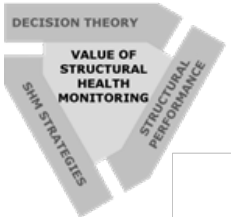


Structural performance

The structural performance is characterised by the structural reliability and the structural risks.

- Deterioration model
  - Chloride-induced reinforcement corrosion consisting of two phases: an initiation phase and a propagation phase

- Structural system reliability model
  - E.g. annual extreme value distribution of the traffic loads
  - Ultimate capacity by plastic hinge theory (multiple spans)
  - Coupling with the deterioration model

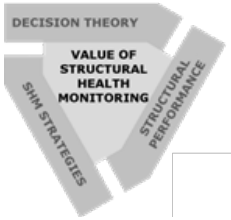


Structural performance

The structural performance is characterised by the structural reliability and the structural risks.

- Structural integrity management model
  - Time, reliability or risk based inspection and maintenance planning

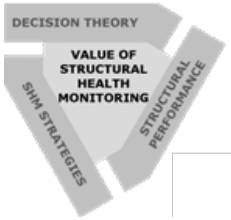
- Consequence model
  - Component damage and/or failure
  - Structural system collapse
  - Follow-up consequences



SHM strategies

The SHM strategies are utilised to collect information about the performance of the structural system and the deterioration mechanisms.

- Structural system performance
  - Algorithms building upon the analysis of deflection, strain, velocity and acceleration sensors measurements
    - Data normalisation
    - Damage detection algorithms
  - Load monitoring with strain gauges or deflection measurements

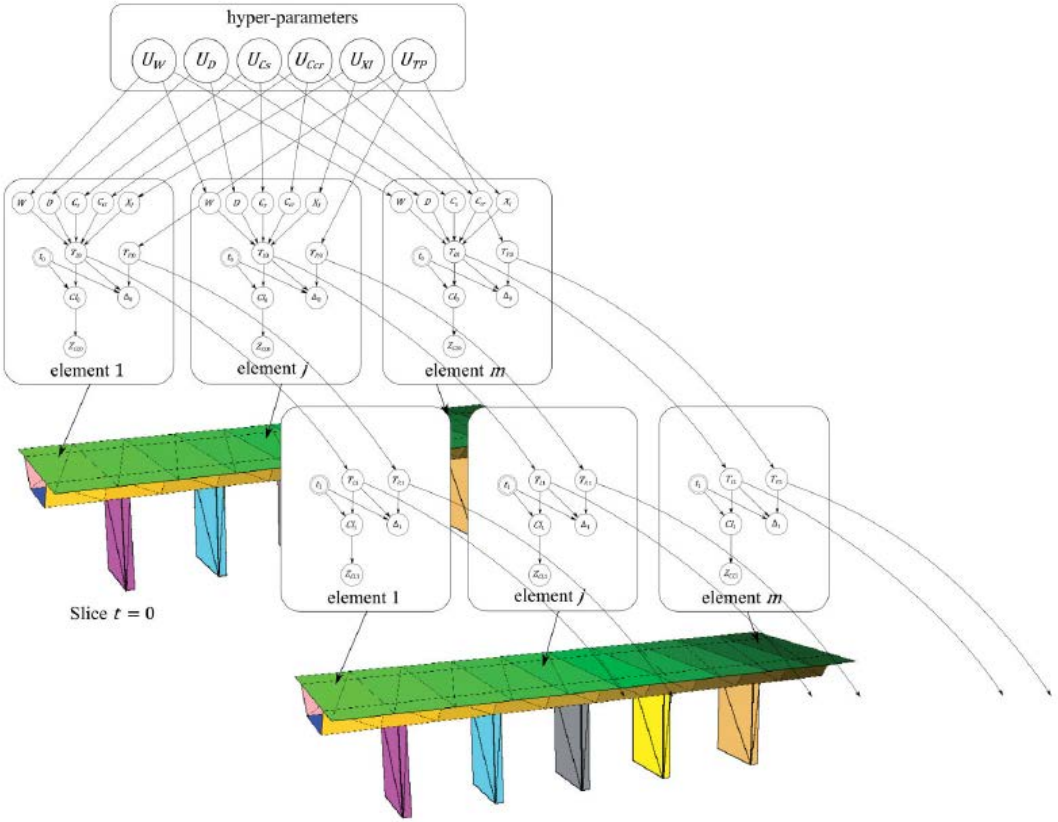


SHM strategies

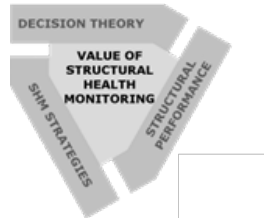
The SHM strategies are utilised to collect information about the performance of the structural system and the deterioration mechanisms.

- Deterioration mechanisms
  - Corrosion initiation sensors
  - Taking concrete cores for chloride concentration measurements
  - Half-cell potential measurements
  - Visual information of concrete surfaces
  - Strain gauge measurements

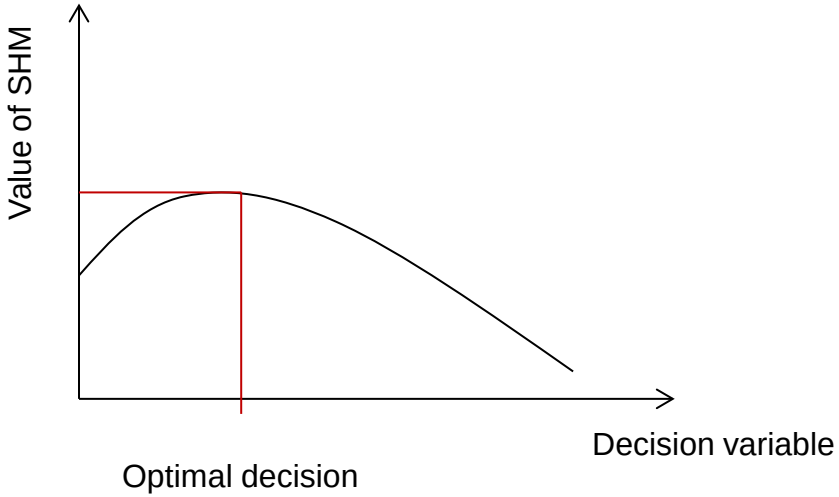
Methods and tools



Schneider, R., J. Fischer, M. Bügler, S. Thöns, A. Borrmann and D. Straub (2015). Assessing and updating the reliability of concrete bridges subjected to spatial deterioration - principles and software implementation. Structural Concrete(3/2015): 356-365.



Documentation of decision



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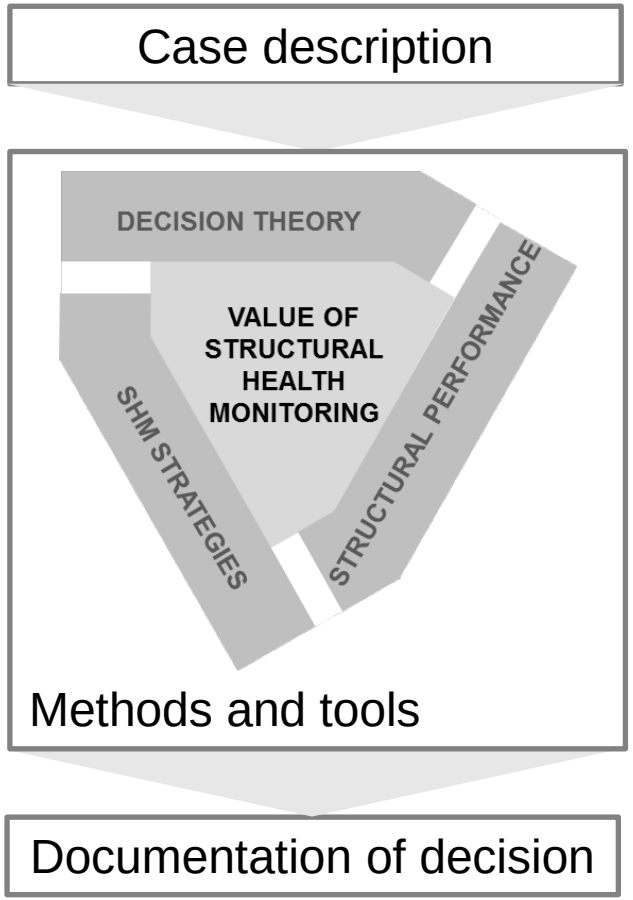
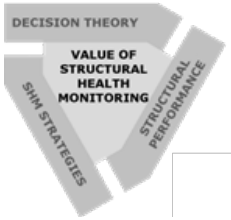
Test case 2: Monitoring of offshore wind turbine structures

Principle procedure

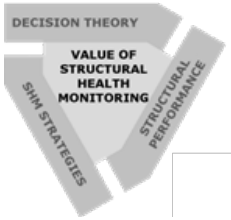




Case description

Wind parks combine uniquely sustainable, renewable, greenhouse gas free and low risk energy production and becoming an important part of the energy mix throughout Europe and worldwide.

Due to the limited accessibility and high costs of operation and maintenance activities there is large potential for supporting the operation of wind parks and thus energy production efficiency with SHM.



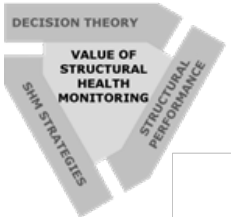
Structural performance

A wind turbine structural design is dominated by the dynamic behaviour, buckling and fatigue.

- Deterioration model
  - Fatigue, corrosion, scour
  - Grouted joint deterioration

- Structural system reliability model
  - Shell buckling, overall stability
  - Dynamic properties, resonance

The consideration of the rotor blades requires fibre reinforced materials specific models.



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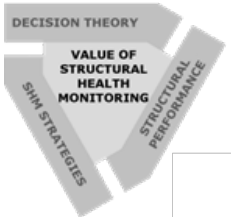

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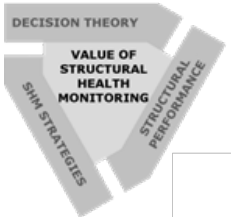
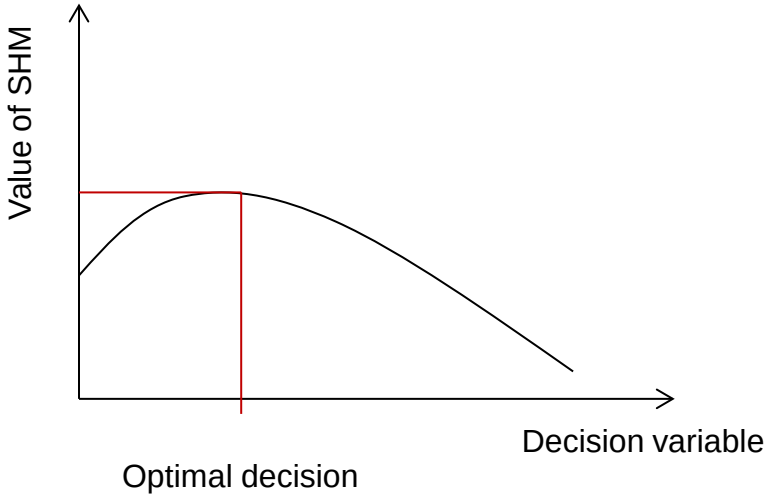


SHM strategies

The SHM strategies are utilised to collect information about the performance of the structural system and the deterioration mechanisms.

- Deterioration mechanisms
  - Measurement of the chemical environment for corrosion
  - Strain gauge measurements for fatigue
  - Fatigue sensors

Documentation of decision



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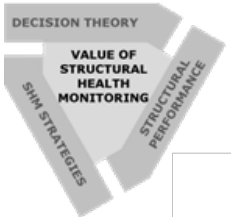
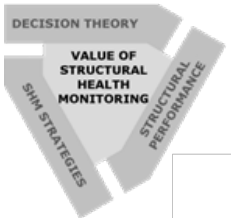


Further steps

1. How to be further developed?
2. Connection to flow charts?
3. Factsheets?



Thank you for your attention.

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