



COST Action  
TU I402

Quantifying the Value of Structural Health Monitoring



# Novel pro-active SHM tool devoted to bridge maintenance based on damage identification

Helder Sousa <sup>a</sup>, Árpád Rozsas <sup>b</sup>, Arthur Slobbe <sup>b</sup>, Wim Courage <sup>b</sup>, Agnieszka Bigaj van Vliet <sup>b</sup>



Industry Innovation Days – Workshop hosted by BRISA Group in Lisbon, 19<sup>th</sup> and 20<sup>th</sup> April 2018

Short-Scientific Mission (joint collaboration BRISA Group, Portugal & TNO, Netherlands)

• **Objective**

# How could we anticipate damages for the Lezíria Bridge by using the available data

Development of a NOVEL PRO-ACTIVE SHM tool devoted to bridge maintenance based on DAMAGE IDENTIFICATION by F analysis and PROBABILISTIC methods

• **Tasks**

#1: Investigation on the most probable damage scenarios and key PI for bridge structures (reinforced and prestressed concrete)



#2: Application of damage identification to a full-scale case study – Lezíria bridge



#3: Quantification of the value of information (voi) by using lezíria bridge as a case study (demonstrative prototype)

Planned for Aug/Sep 2018



## INDEX

### 1. Decision scenario

- The structure, monitoring system and FE model
- Damage scenarios & Performance Indicators

### 2. Methods applied

- Response Surface Modelling
- Explanatory power of (single/multiple) PI for damage identification

### 3. Results obtained

### 4. Value of the SHM information for the owner/concessionaire

### 5. Open question addressed to decision makers



## 1. Decision scenario

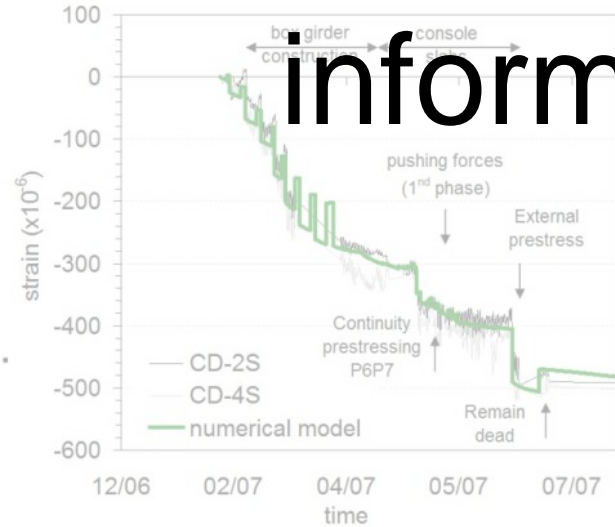
- **Monitoring system**
  - Permanent monitoring system (construction + operational life)
  - Monitoring project (as part of the bridge project)
  - $\cong$  400 sensors (10 different type of sensors)
  - 3 different acquisition systems (static, dynamic, optic)
  - > 10km cable length
  - sampling-rate up to 100 Hz
  - $\cong$  1 000 000 records / year



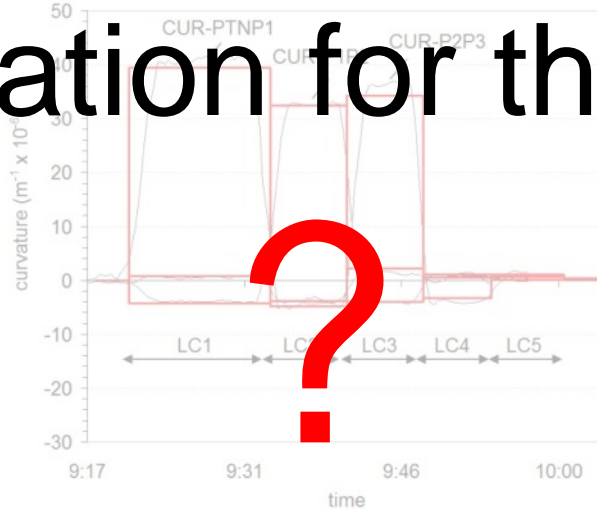
## 1. Decision scenario

- FE modelling (vs. measurements)

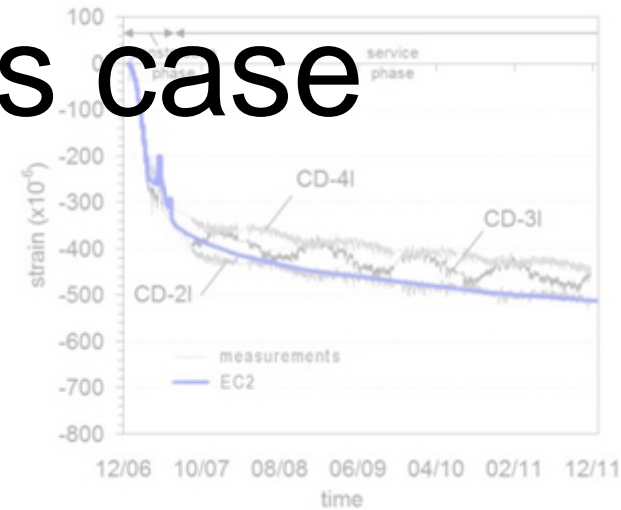
# How to take advantage of such information for this case



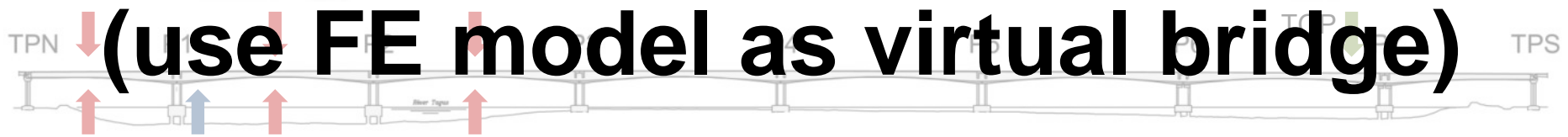
Loading: Self-weight, prestressing and traffic loads



Load test at the end of the bridge construction



Lifetime predictions based on the updated model



**(use FE model as virtual bridge)**

BOTTOM

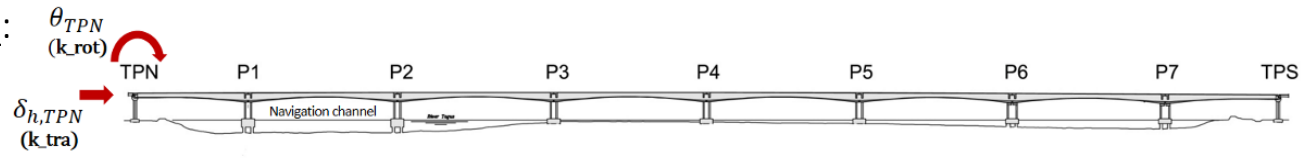


# 1. Decision scenario

- Damage scenarios (exploratory approach)

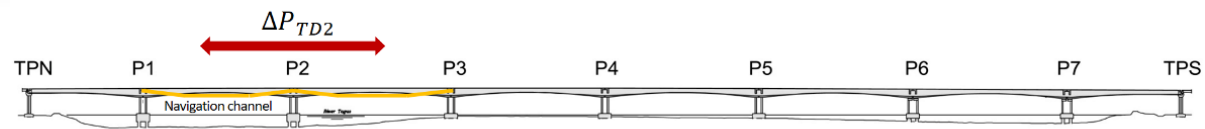
DAMAGE SCENARIO 1:

Deterioration of bearing devices



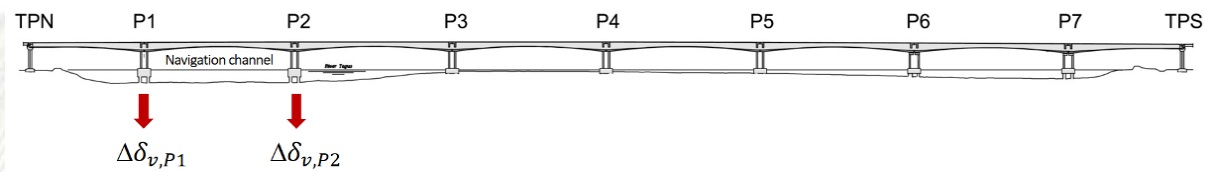
DAMAGE SCENARIO 2:

Prestress loss due to failure of external tendons



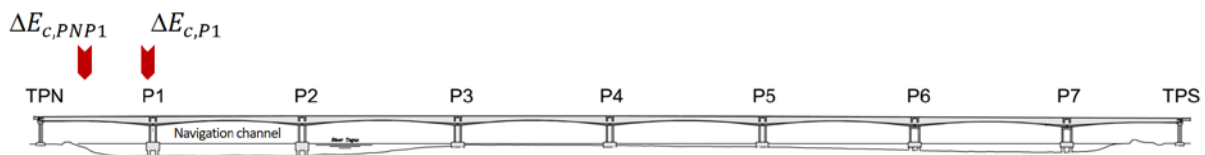
DAMAGE SCENARIO 3:

Pier settlements due to liquefaction of the foundation soil



DAMAGE SCENARIO 4:

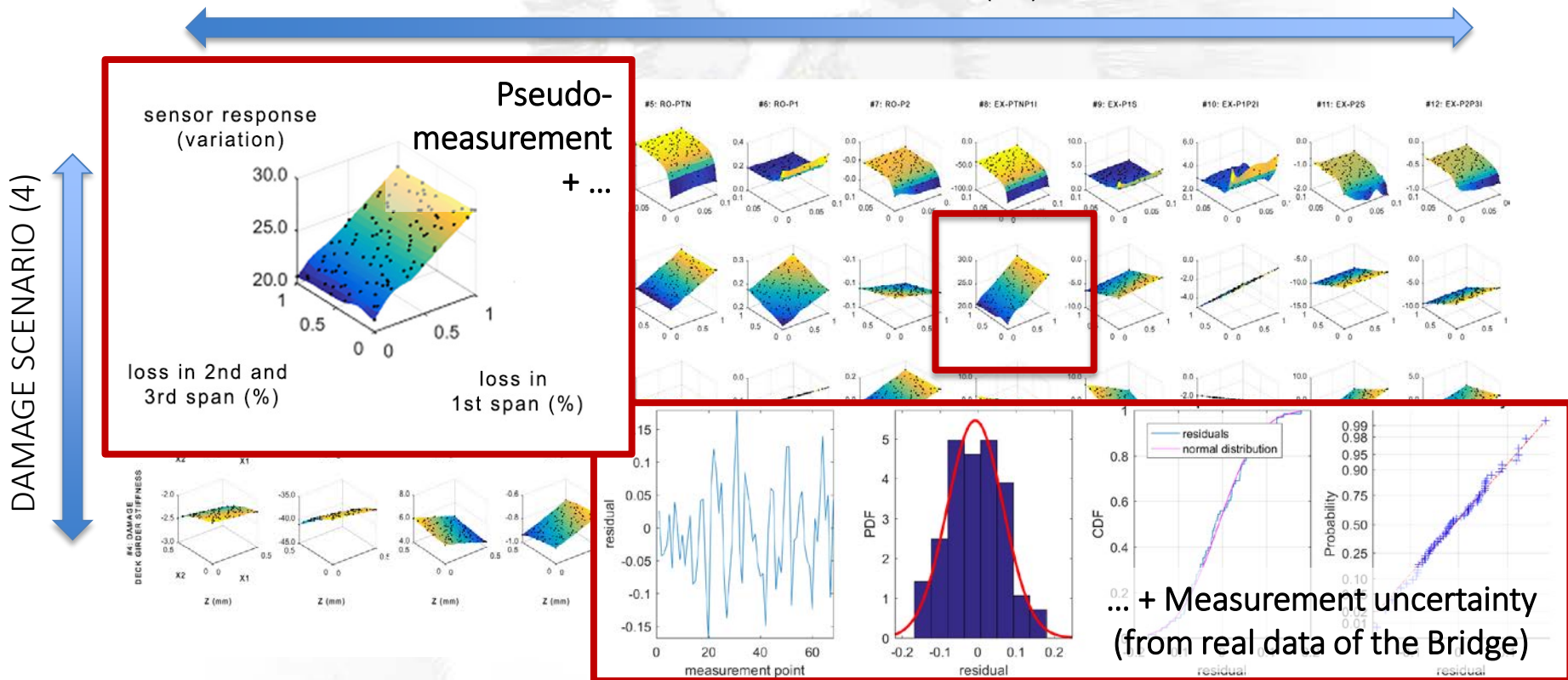
Loss of stiffness on the deck girder above the piers



### 3. Results obtained

#### STEP 1: Generation of a comprehensive database with pseudo-measurements (supported by refined FE modelling)

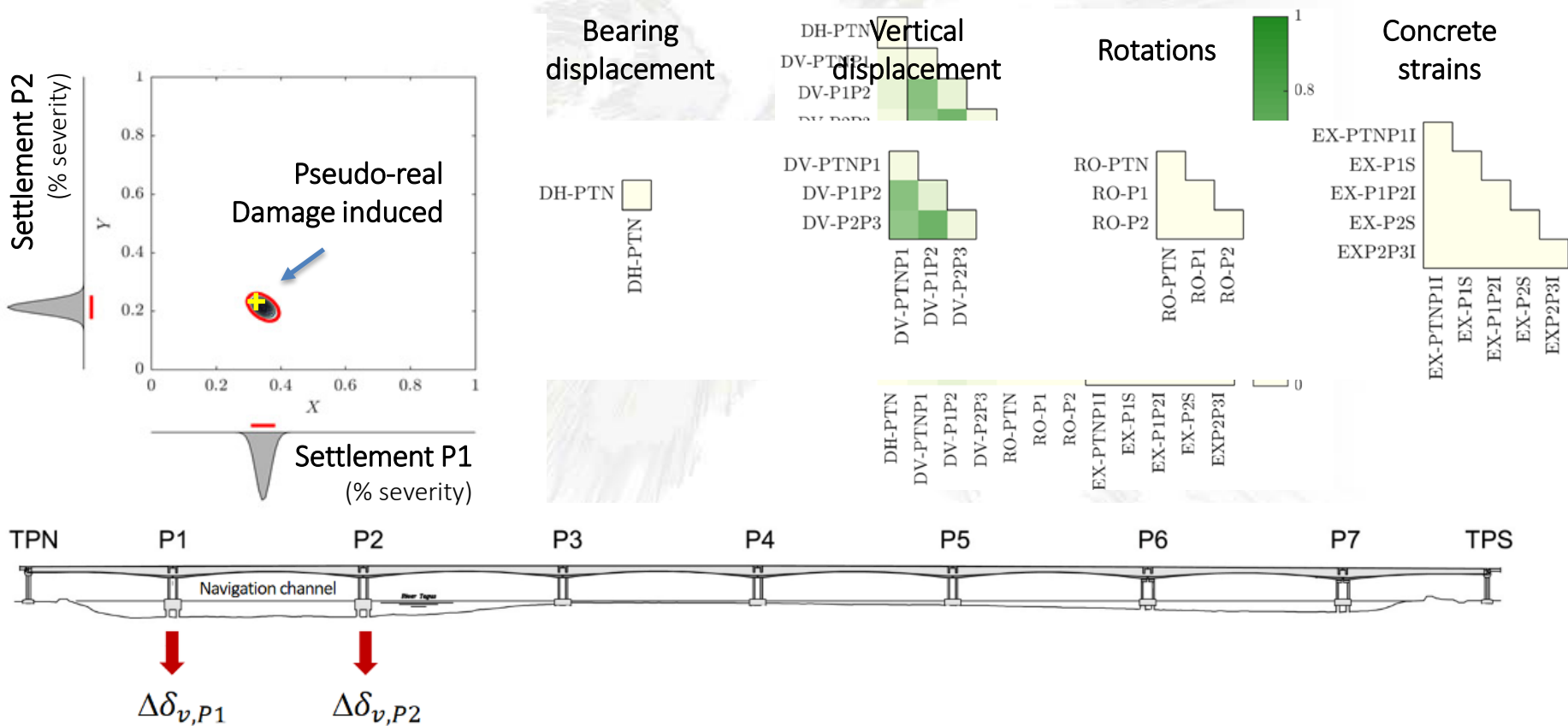
SENSOR MEASUREMENTS (12)



### 3. Results obtained

#### STEP 2: Automatic probabilistic damage identification in the Bayesian framework

- Damage A: Pier settlement





## 4. Value of the SHM information for the owner/concessionaire

### STEP 3: Quantification of the Value of Information (Vol of a CATALOGUE)

– DAMAGE SCENARIO 1:

Det. bearing devices

– DAMAGE SCENARIO 2:

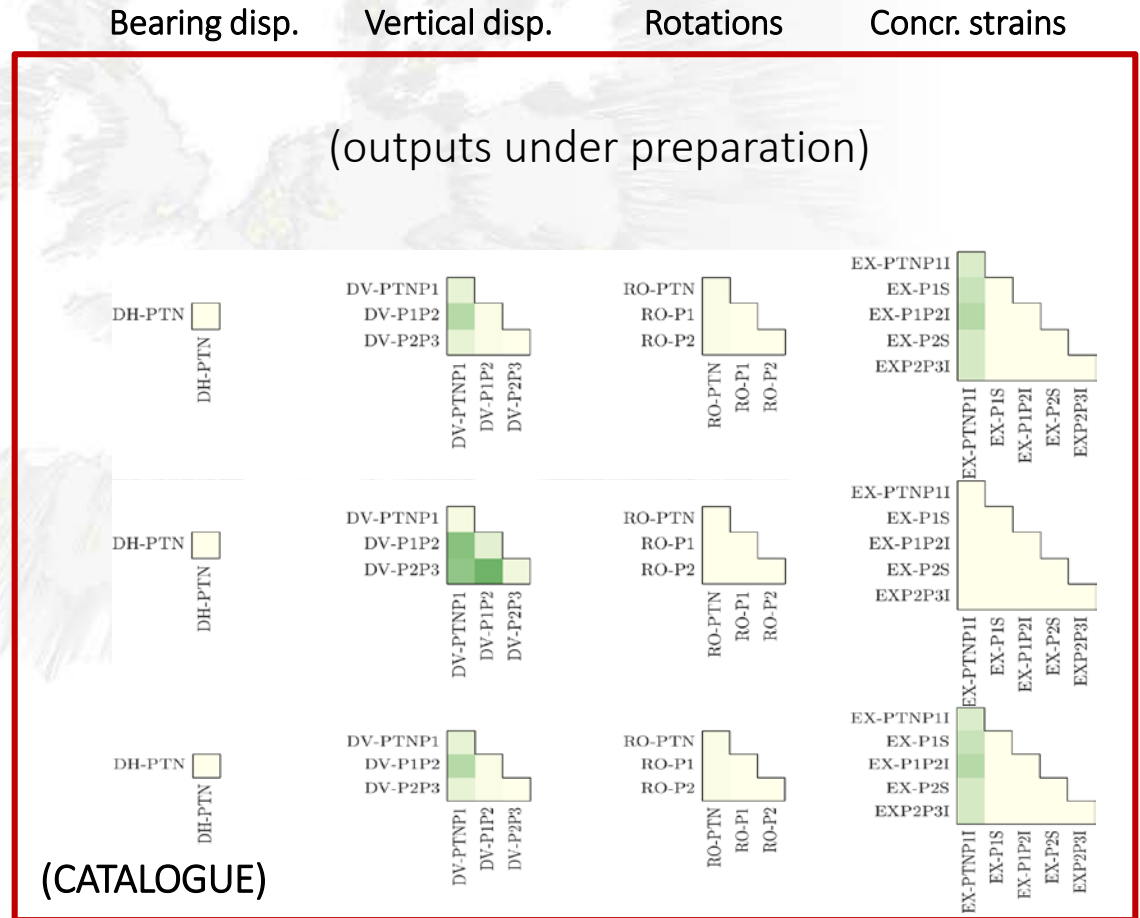
Prestress failure

– DAMAGE SCENARIO 3:

Pier settlements

– DAMAGE SCENARIO 4:

Loss of girder stiffness

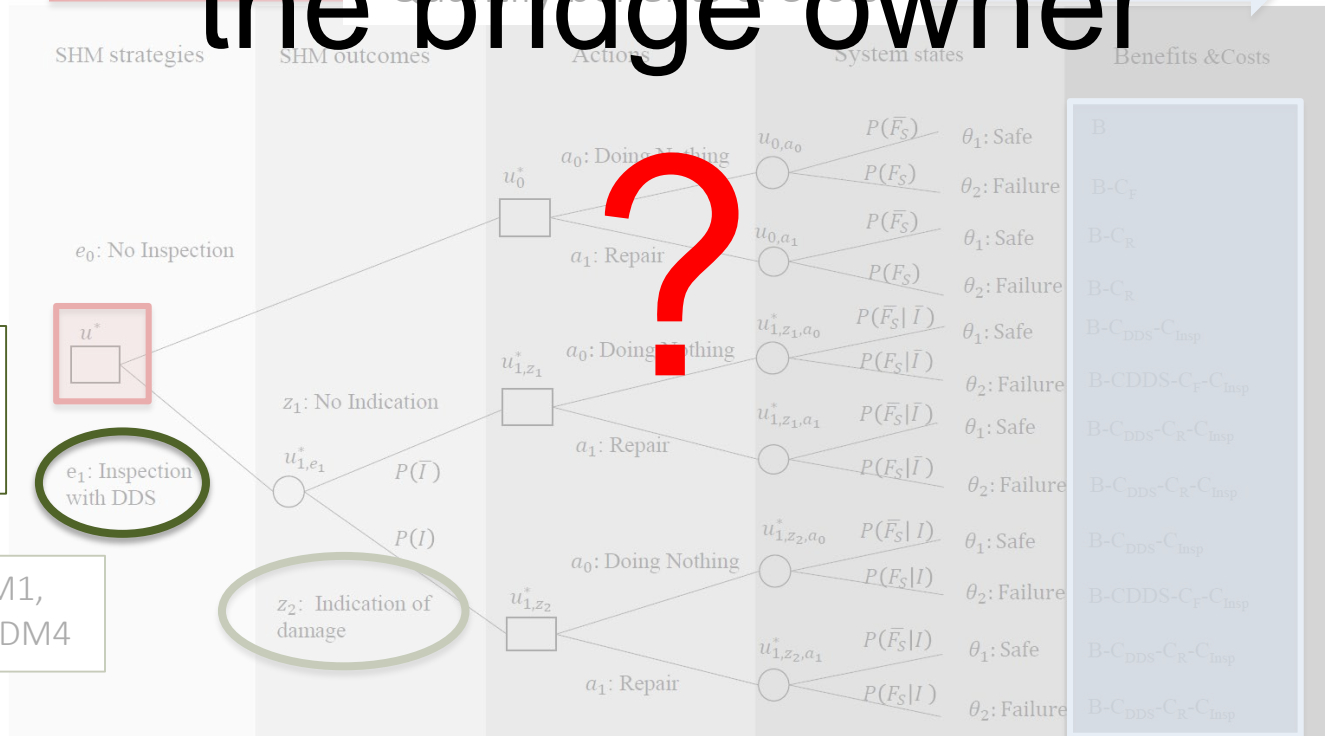


4. Value of the SHM information for the owner/concessionaire

# How to deliver this information to the bridge owner

STEP 3: Quantification of the Value of Information (Vol of a CATALOGUE)

## Quantify Benefits & Costs



with the support of SHM of the bridge

Test for DM1, DM2, DM3, DM4

# (CATALOGUE FOR DECISION)

Quantify Value of SHM strategy for each damage scenario



## 4. Value of the SHM information for the owner/concessionaire

### STEP 3: Quantification of the Value of Information (Vol of a CATALOGUE)

Value of SHM

$u_{DM1}$

– DAMAGE SCENARIO 1:  
Det. bearing devices

$u_{DM2}$

– DAMAGE SCENARIO 2:  
Prestress failure

$u_{DM3}$

– DAMAGE SCENARIO 3:  
Pier settlements

$u_{DM4}$

– DAMAGE SCENARIO 4:  
Loss of girder stiffness

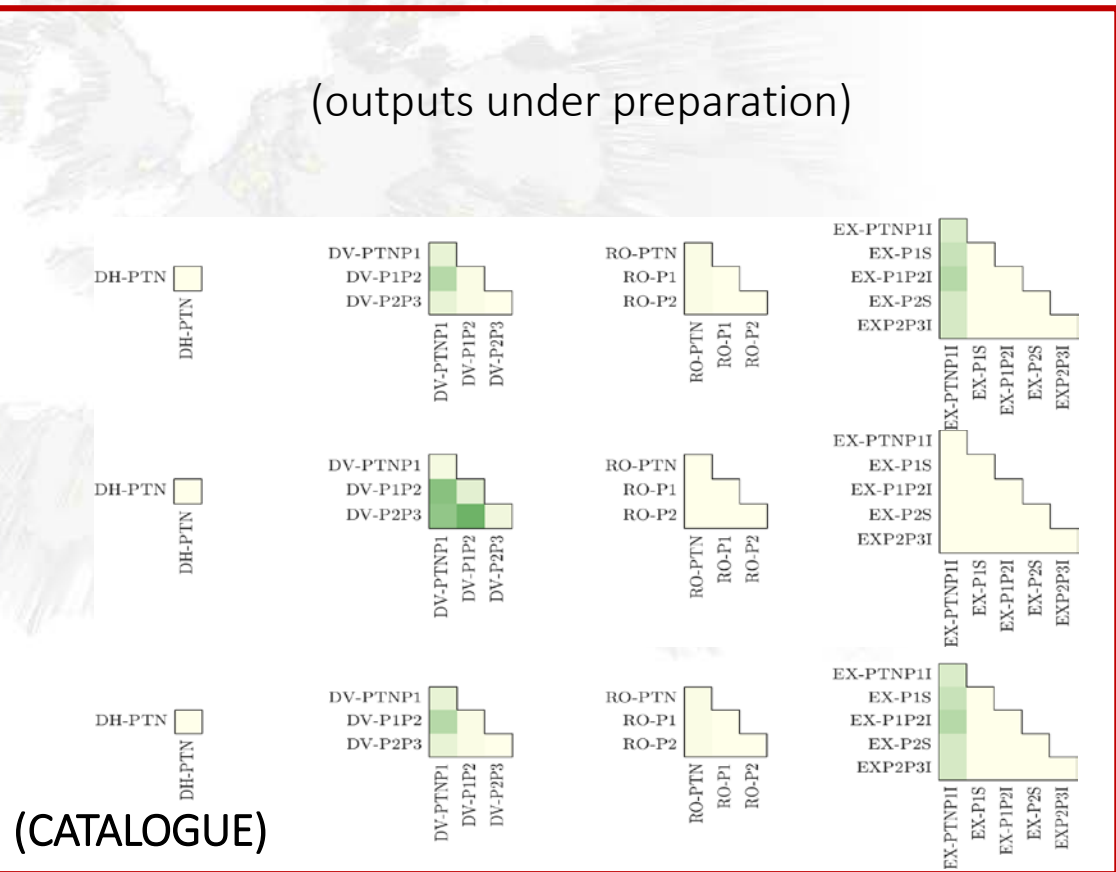
Bearing disp.

Vertical disp.

Rotations

Concr. strains

(outputs under preparation)



## 5. Open question addressed to decision makers

- Is this relevant to complement the visual/maintenance operations for Lezíria Bridge?
- What type/magnitude of costs are involved here (e.g. maintenance, repair, reputation, others)?
- What are the order of magnitude of those costs, which is vital for an accurate assessment of the Value of SHM in the big-picture of asset management?
- How relevant is this for a decision maker (e.g. BRISA):  
, i.e. having a CATALOGUE of SHM solutions for tackling/support the most likely damage scenarios

mainly from the point of view of managing an infrastructure park (scalability effect)?

Thank you for your attention

<http://www.cost-tu1402.eu/>

