The Söderström Bridge

COST Action TU1402 – Case study

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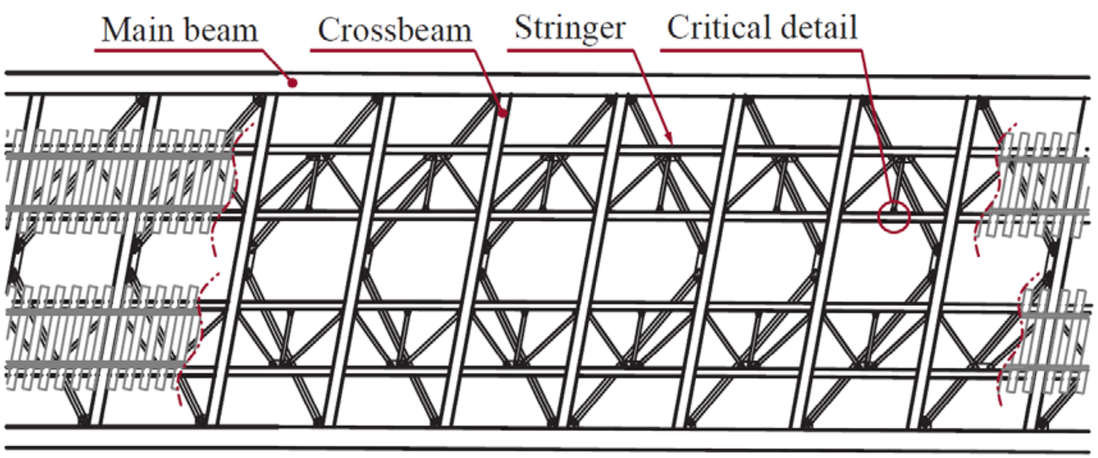
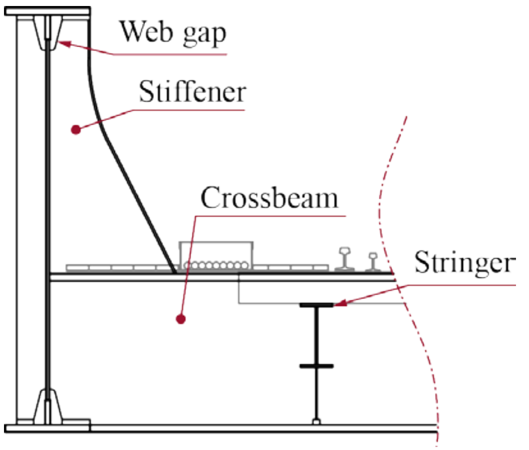
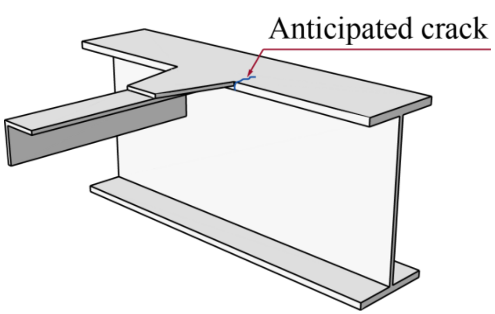
The Söderström Bridge

Source: www.trafikverket.se

The Söderström Bridge



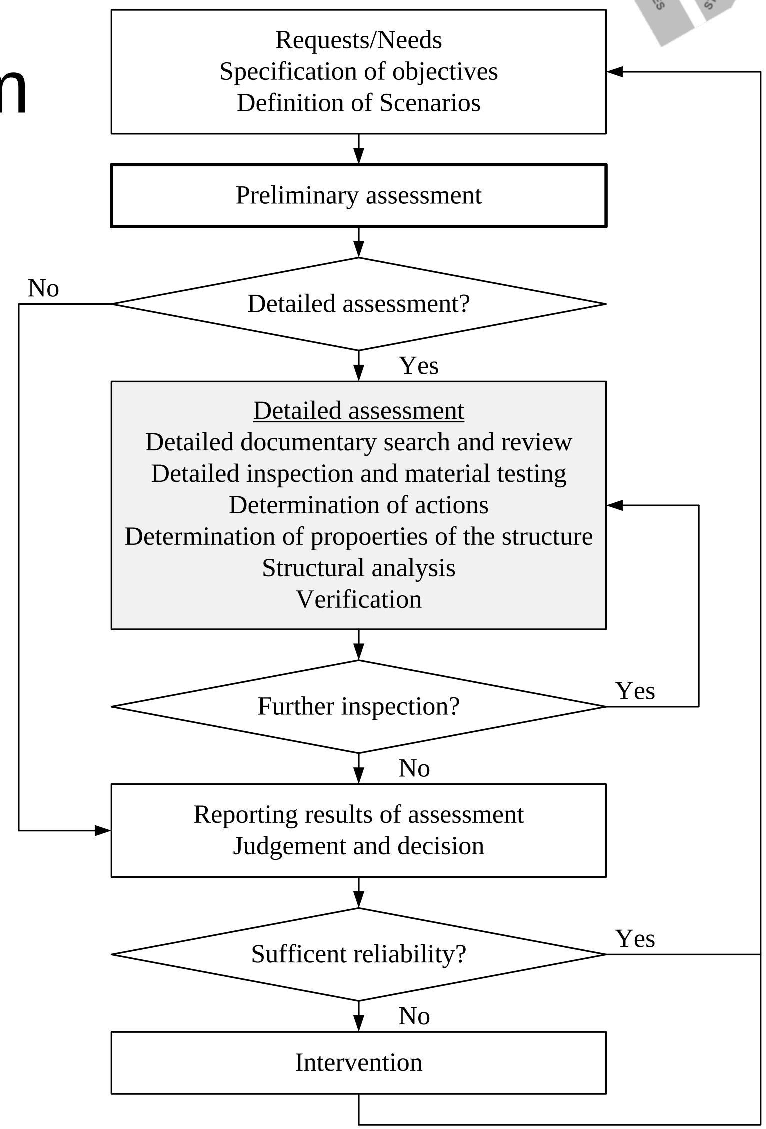




- This case study is focused on the connection between the lateral bracing and the stringer beams.
- Previous assessments have shown an exhausted fatigue life.
- However, no signs of cracks have been found during inspections.
- So what?

Condition assessment problem

- What methods should be used to assess the condition of the detail?
- Worth to do further assessment?
- How?
    - Inspect more/better?
    - Improve structural analysis?
    - Improve consideration of uncertainties?
    - All?



ISO 13822

Levels of condition assessment

Modelling sophistication (M)

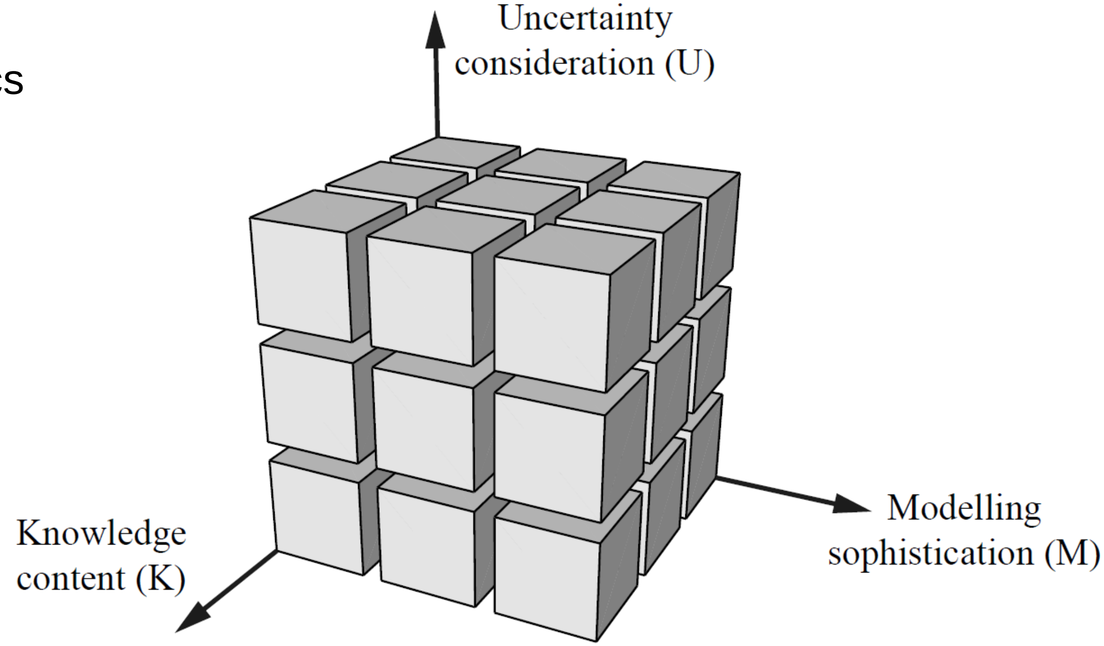
- Simple checks
- Linear damage accumulation
- Linear elastic fracture mechanics

Uncertainty consideration (U)

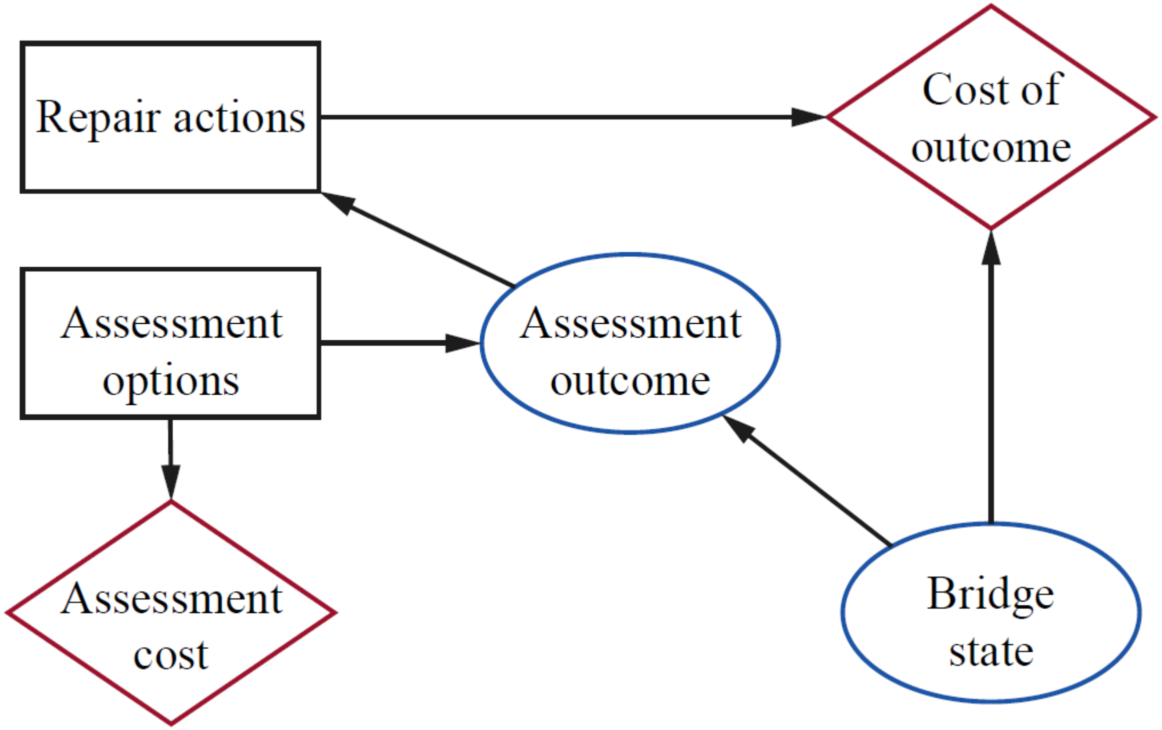
- Deterministic
- Reliability-based
- Risk-based

Knowledge content (K)

- Desktop assessment
- Inspections and testing
- Monitoring

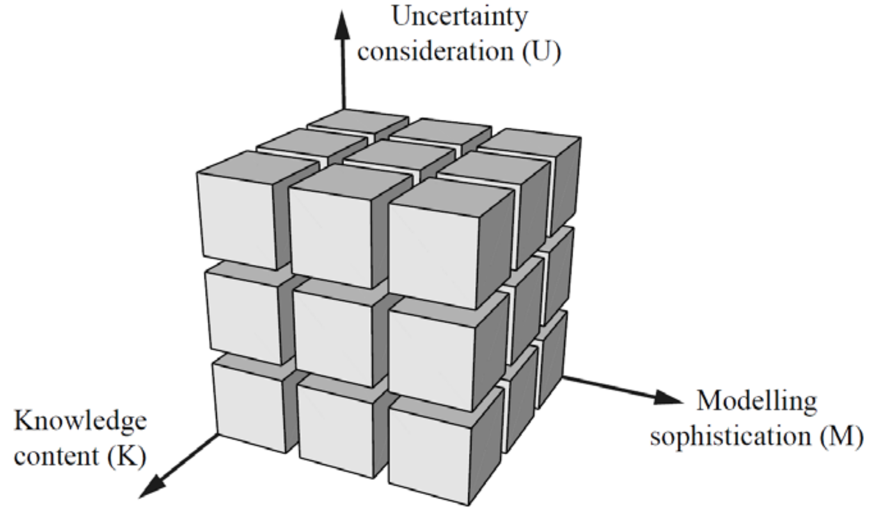


Influence diagram

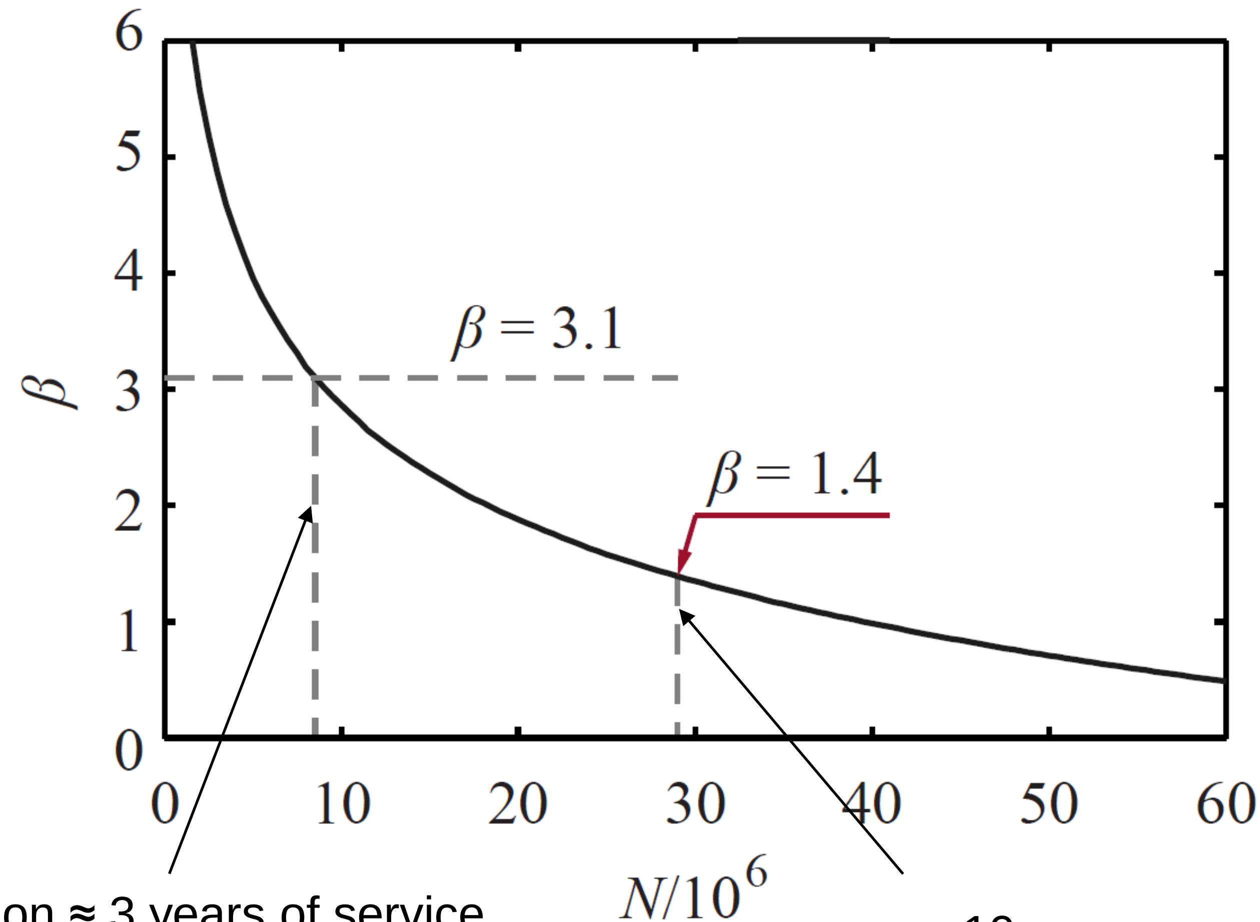


Assessment options

- Preliminary deterministic assessment
- e_0 – Prior reliability-based assessment using measured stresses
- e_1 – Assessment based on LEFM without inspection
- e_2 – Assessment based on LEFM with visual inspection (VT)
- e_3 – Assessment based on LEFM with magnetic particle testing (MT)



Prior reliability



8.6 million ≈ 3 years of service

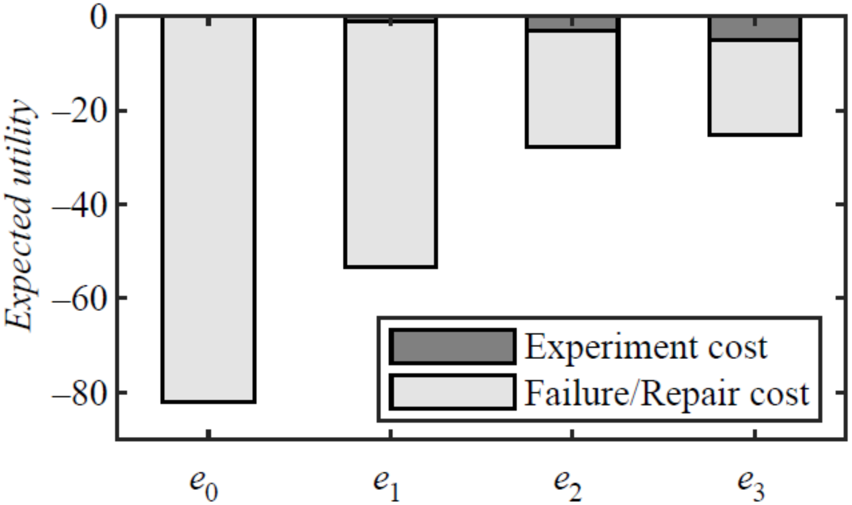
≈ 10 years, p_f = 8.2 ×10^{-2}

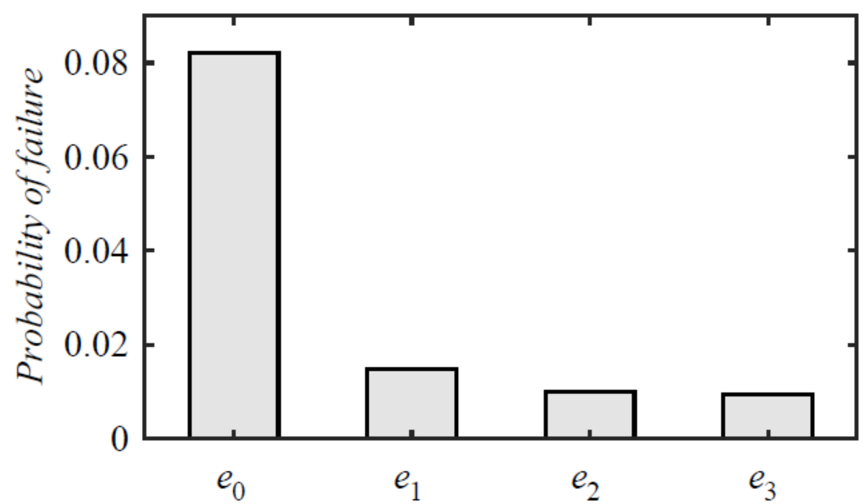
Sample likelihoods and costs

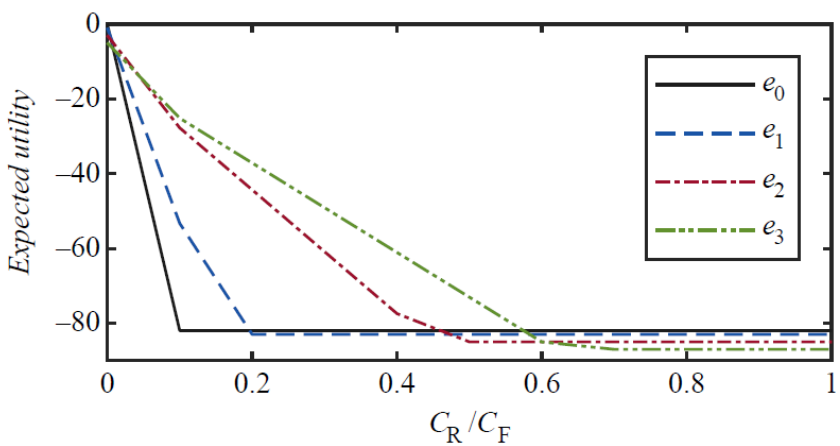
	Assessment e_1		Assessment e_2		Assessment e_3	
	Detail state		Detail state		Detail state	
Assessment result	θ_0	θ_1	θ_0	θ_1	θ_0	θ_1
Indicates damage	0.6	0.1	0.9	0.1	0.95	0.1
Indicates no damage	0.4	0.9	0.1	0.9	0.05	0.9

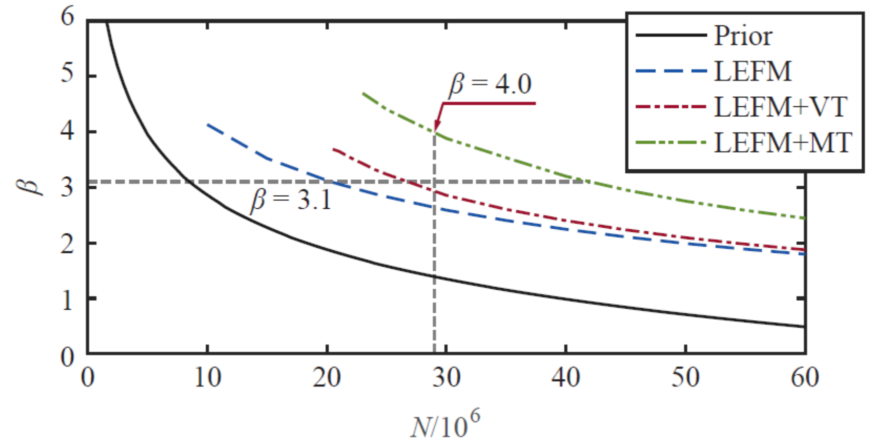
Assessment costs				Cost of outcome			
				No failure, θ_0		Failure, θ_1	
e_0	e_1	e_2	e_3	No repair	Repair	No repair	Repair
0	-1	-3	-5	0	-100	-1 000	-100

Results


Expected utility
0
−20
−40
−60
−80
Experiment cost
Failure/Repair cost
e_0
e_1
e_2
e_3


Probability of failure
0.08
0.06
0.04
0.02
0
e_0
e_1
e_2
e_3


Expected utility
0
−20
−40
−60
−80
0
0.2
0.4
0.6
0.8
1
C_R / C_F
e_0
e_1
e_2
e_3


β
6
5
4
3
2
1
0
0
10
20
30
40
50
60
$N/10^6$
$\beta = 4.0$
$\beta = 3.1$
Prior
LEFM
LEFM+VT
LEFM+MT

Open questions and obstacles

- Obtain realistic cost estimates
- Include direct and indirect costs
- Include successive assessment
- Consider correlations
- Consider system reliability

To be standardized…

Perhaps not to standardize, but to provide guidance first…

- Determination of priors when starting with deterministic verification format which is typically the starting point of traditional bridge assessments
- Include the option and make clear the possibility for advanced probabilistic fatigue assessments in Eurocode (approved by transportation authorities)
- Provide/develop PoD curves for fatigue crack detection for different NDT methods

Related publications

Leander J, Andersson A, Karoumi R, 2010. Monitoring and enhanced fatigue evaluation of a steel railway bridge. *Engineering Structures*, Vol 32(3), pp. 854-863.

Leander J, Karoumi, R, 2012. Quality assurance of measured response intended for fatigue life prediction. *Journal of Bridge Engineering*, Vol. 17(4), pp. 711-719.

Leander J, Norlin B, Karoumi R, 2015. Reliability-based calibration of fatigue safety factors for existing steel bridges. *Journal of Bridge Engineering*, Vol. 20(10).

Leander J. and Selén E. (2017) The applicability of reliability-based inspection planning for steel bridges based on fatigue crack detection, Proc. ICOSSAR 2017, Vienna, Austria.

Honfi D., Leander J. & Björnsson Í. (2017) Decision support for bridge condition assessment. 4th International Conference on Smart Monitoring, Assessment and Rehabilitation of Civil Structures (SMAR 2017), Zürich, Switzerland, 13-15 September, 2017.

Leander J., Honfi D., & Björnsson Í. (2017) Risk-based planning of assessment actions for fatigue life prediction. Procedia Structural Integrity, Vol. 5, pp. 1221-1228.

Honfi D., Leander J., Björnsson Í., Larsson Ivanov O., Plos M., Zandi K., Magnusson J., Lechner T. & Gabrielsson H. (2017) Decision support for maintenance and upgrading of existing bridges, 39th IABSE Symposium – Engineering the Future, Vancouver, Canada, 21-23 September 2017, pp. 336-345.

Leander J., Honfi D., Björnsson Í. & Larsson Ivanov O. (2018) A decision support framework for fatigue assessment of steel bridges, Engineering Failure Analysis (submitted).

Björnsson Í., Larsson Ivanov O., Honfi D. & Leander J.,, (2018) Decision support framework for bridge condition assessments, Structural Safety (submitted).

Thank you for your attention!