JCSS

Joint Committee
on Structural Safety

Workshop on Assessment of Existing Structures

28th and 29th January 2021

Monitoring Bridges Using Bridge Weigh-in-Motion Technology

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ZAG
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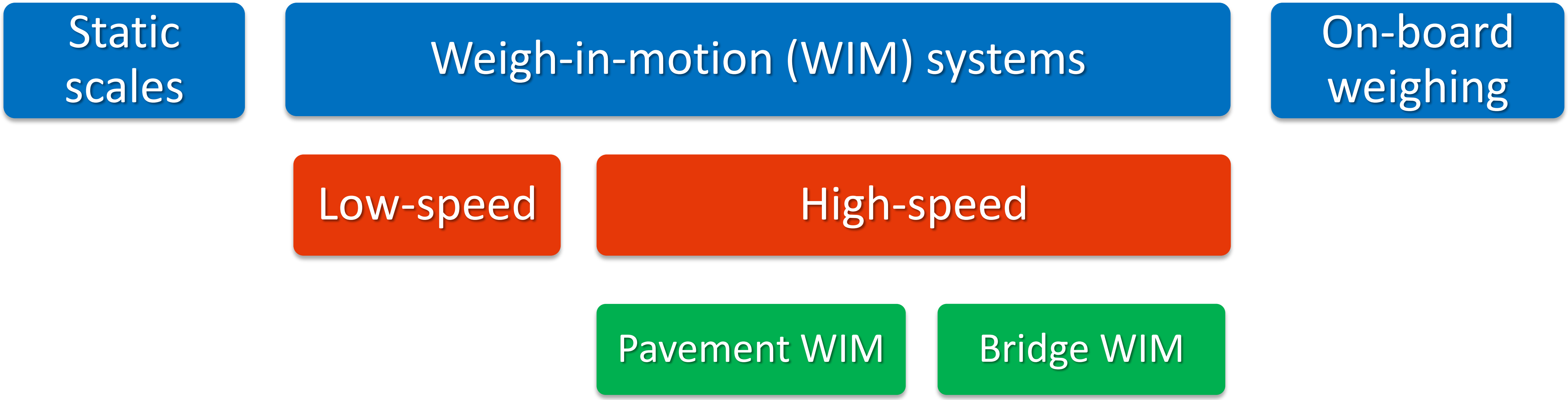
Content

1. Traffic Load Monitoring and Bridge-WIM
2. Modelling traffic load effects on bridges
3. Monitoring bridge performance indicators with B-WIM
4. Way forward

Traffic loading

Measurements of traffic loading

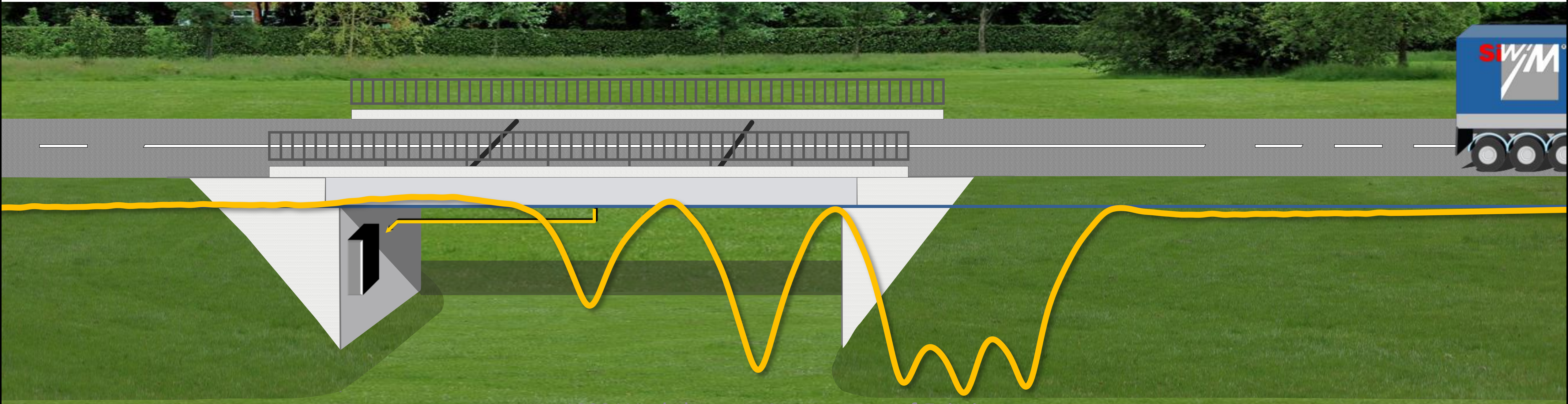
- traffic counters – no information about axle loads
- weighing devices



Weigh-in-motion systems

Bridge WIM system…

… or **B-WIM** is a measuring device that uses an existing instrumented structure – a bridge or a culvert – to *‘weigh‘* road vehicles or trains in motion, at normal operating speed.



Bridge WIM system

- since 1979
- research in Europe from 1993 to 1999
- SiWIM® system since 2000
- over 5000 installations around the globe
- strain measurements
- developments and applications in Europe, USA, Japan, Korea…
- main benefits:
  - portable, does not disturb traffic
  - measure bridge performance under traffic

COST 323

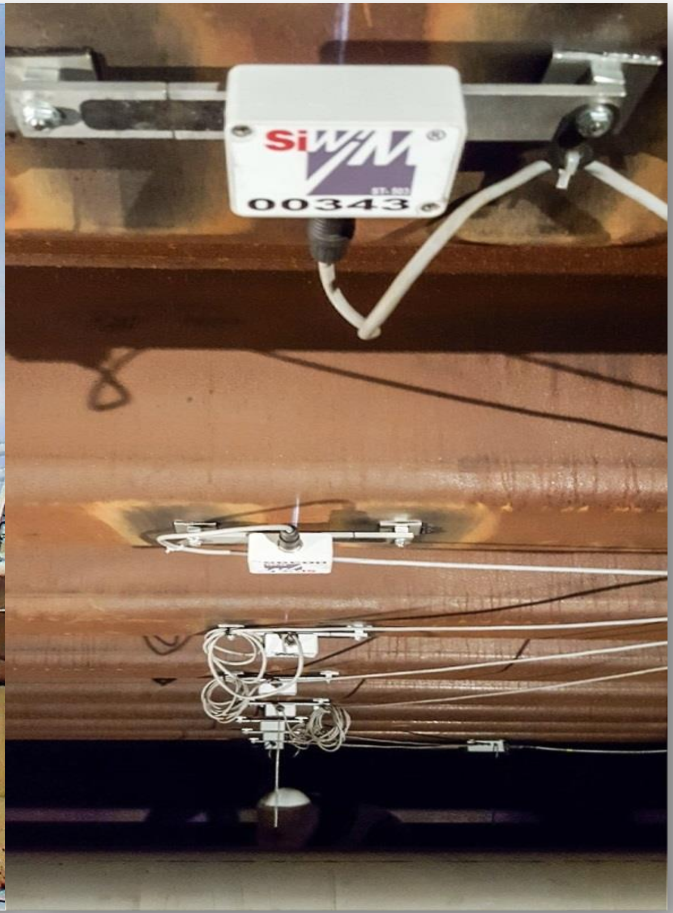
WAVE

SAMARIS ARCHES TRIMM BRIDGEMON

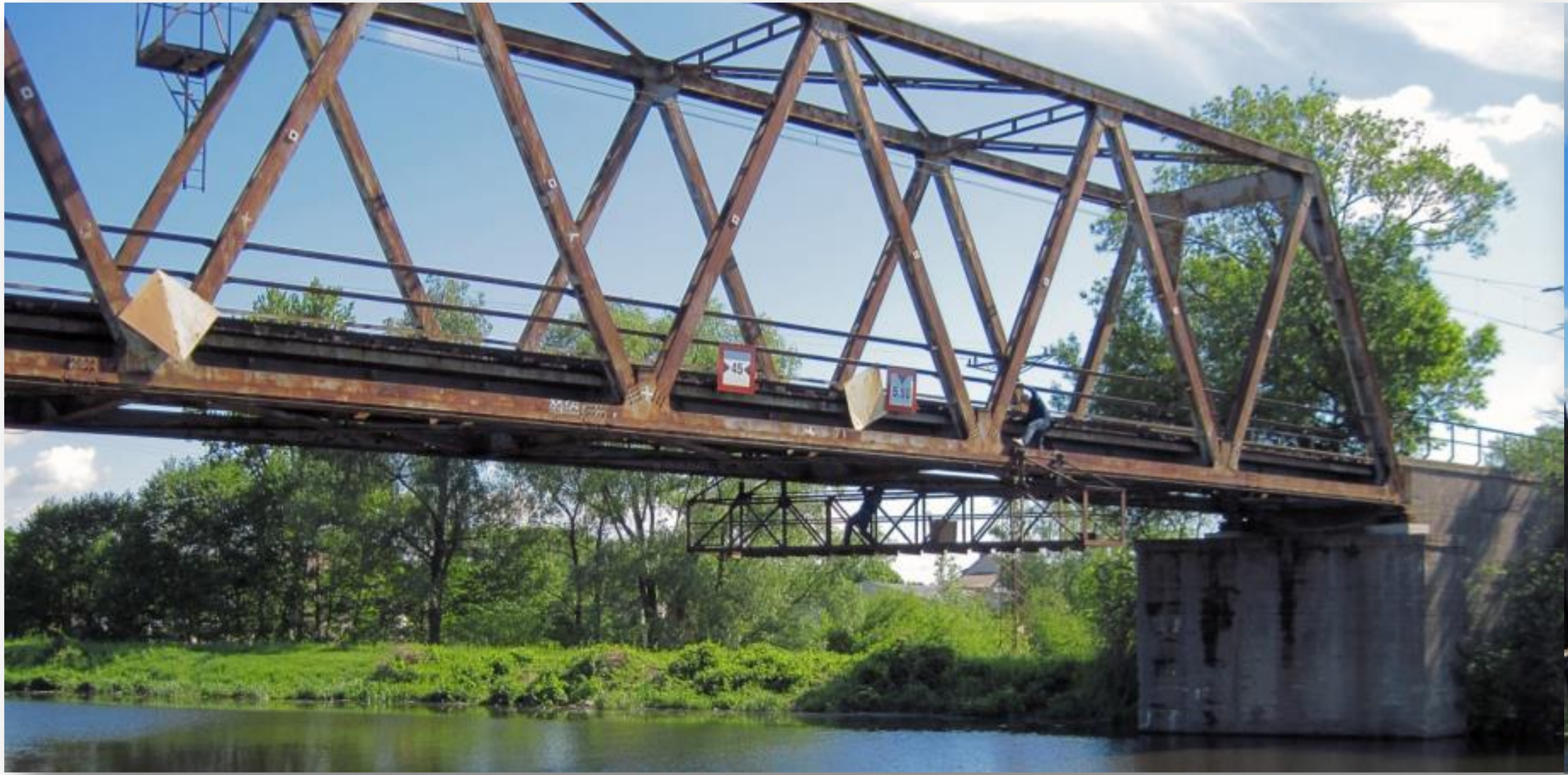
Žnidarič, Kalin, Kreslin. Improved accuracy and robustness of bridge weigh-in-motion systems, *Structure and Infrastructure Engineering*, Volume 14, 2018 - Issue 4

Typical bridges

Viaduc de Millau – France

Neiporet railway truss bridge – Poland



Traffic loads on bridges

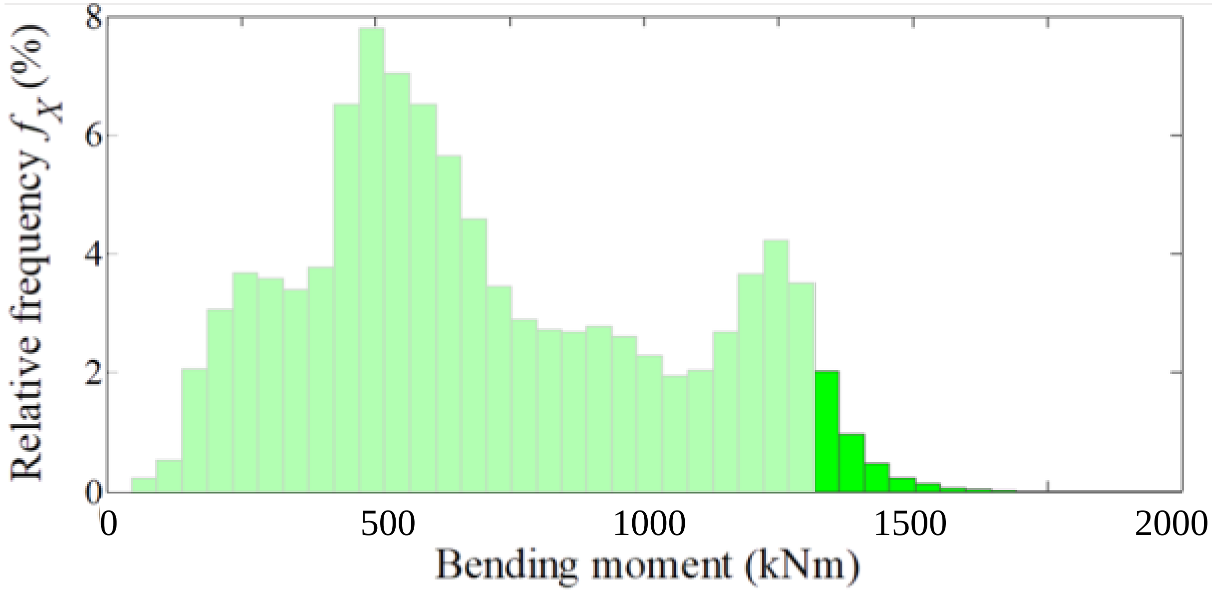
- Change over time
- Important considerations:
  - What are the actual traffic loads?
  - How traffic loads are transformed into load effects / stresses / strains?
  - How traffic loads are distributed across the structure?
  - What is the dynamic amplification?

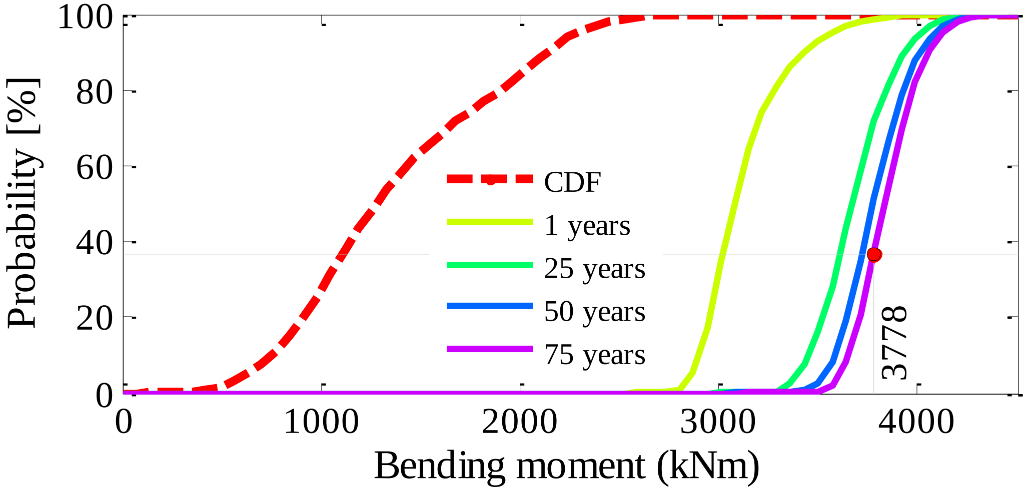
REALISTIC LOADS

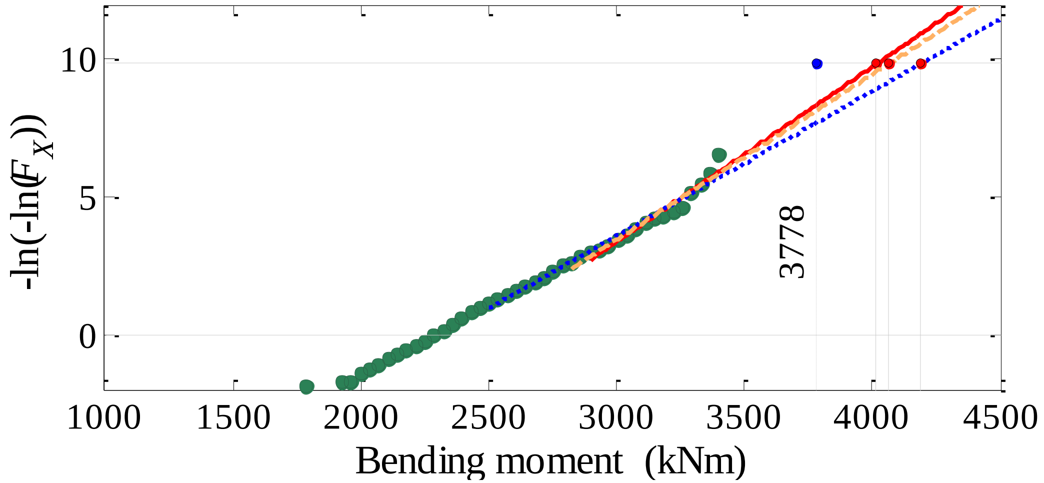
+

MODEL UPDATING

Modelling traffic load effects on bridges







Long-term simulations

Bridge performance under traffic

Numerical models

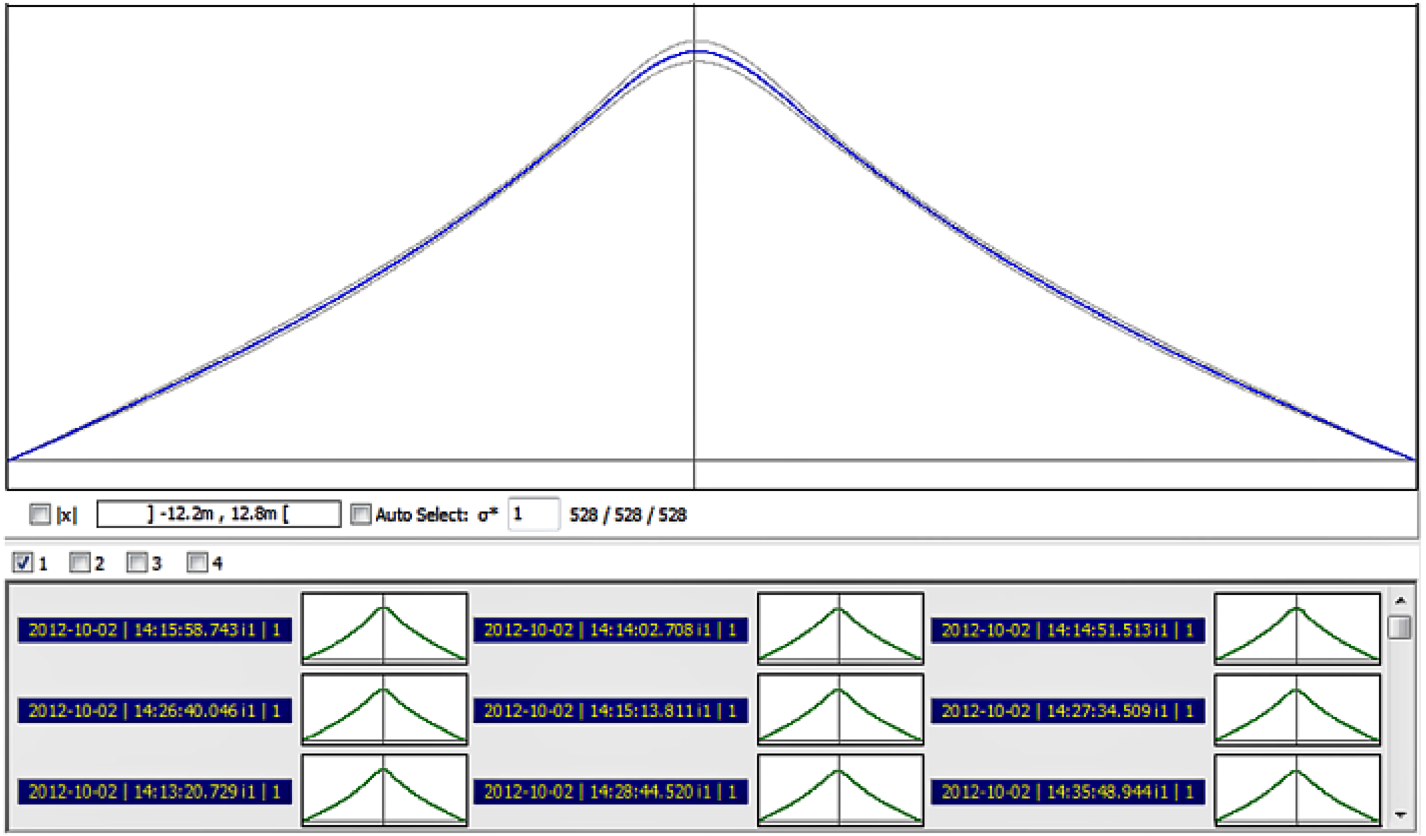
Load tests:

- with pre-weighed vehicles
- with B-WIM system:
  - Influence lines
  - LF/GDF
  - DAF

On bridges with IL < 40 m

Measurement of bridge KPIs – Influence line

- IL measured from each loading event
- mean IL (+STD) used to calibrate structural model

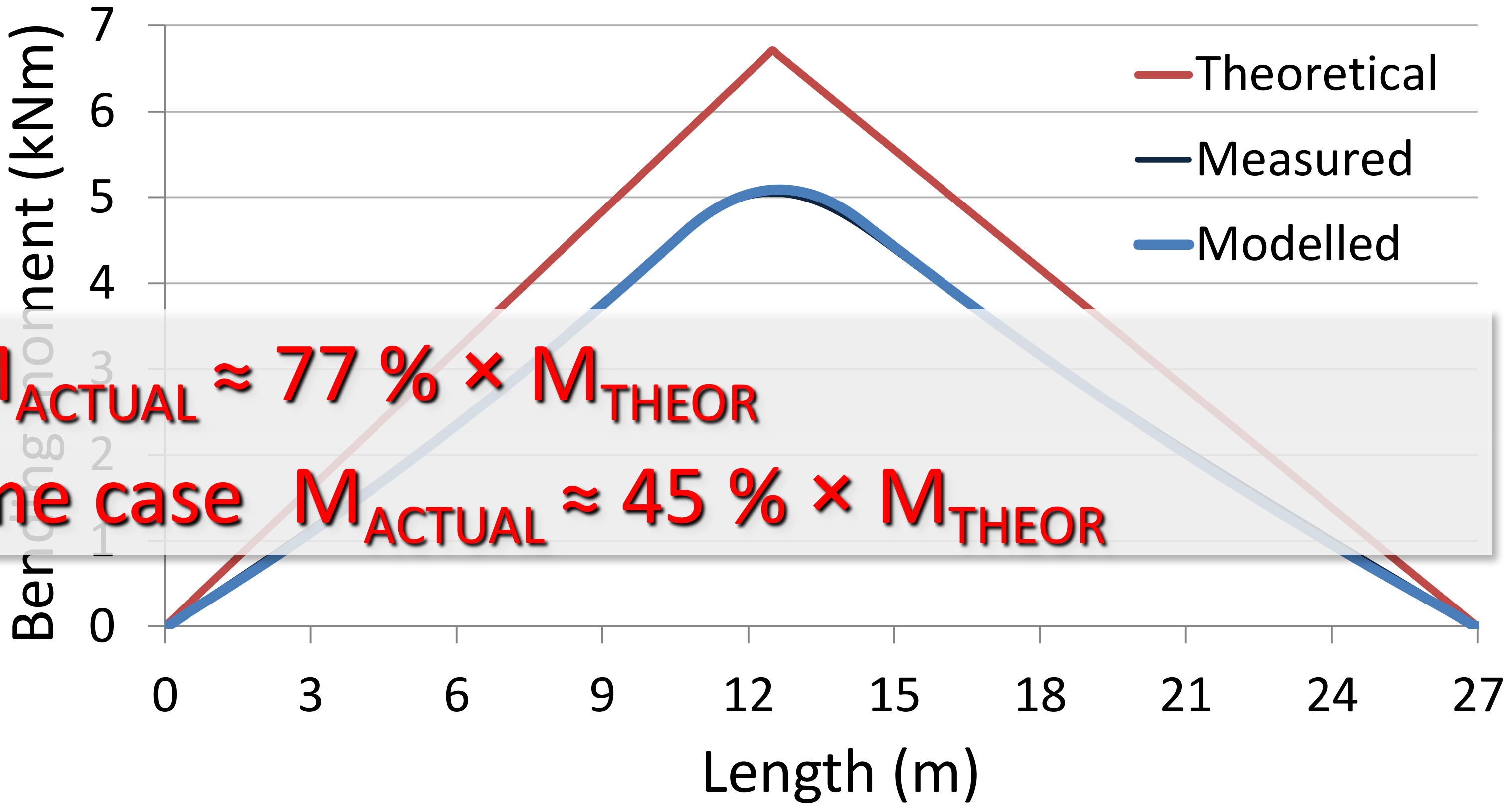


Žnidarič, Kalin. Using bridge weigh-in-motion systems to monitor single-span bridge influence lines. *Journal of Civil Structural Health Monitoring* (2020) 10:743–756

27-m long New Jersey underpass

Measurement of bridge KPIs – Influence line

- IL measured from each loading event
- mean IL (+STD) used to calibrate structural model
- always different than in theory



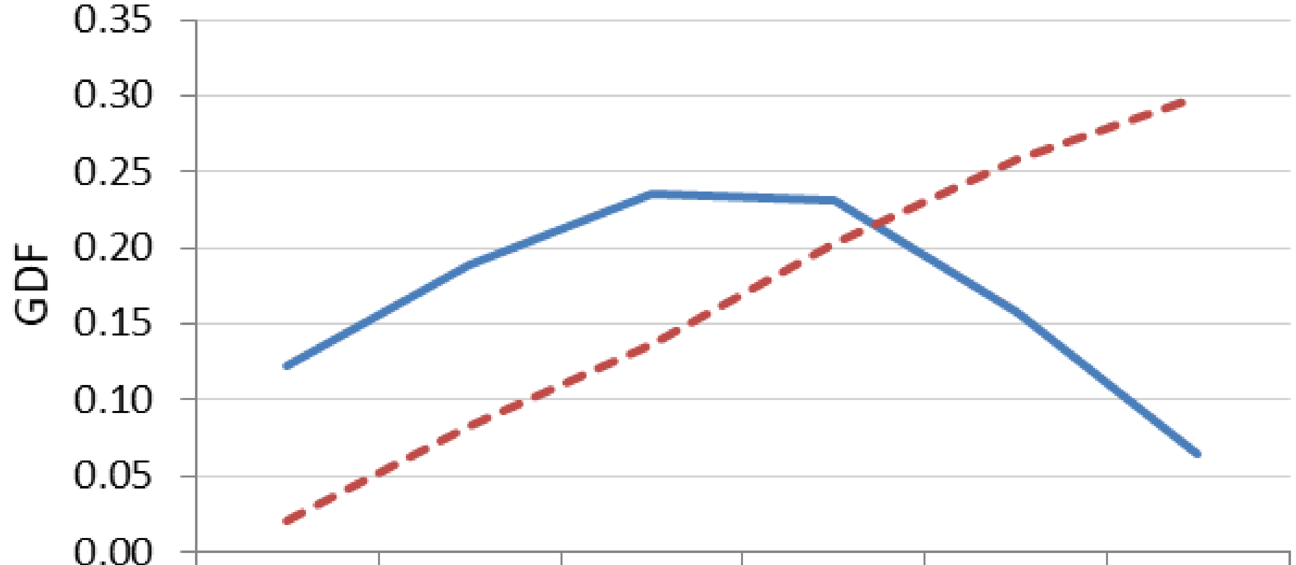
$M_{ACTUAL} \approx 77\ \% \times M_{THEOR}$

In an extreme case $M_{ACTUAL} \approx 45\ \% \times M_{THEOR}$

Žnidarič, Kalin. Using bridge weigh-in-motion systems to monitor single-span bridge influence lines. *Journal of Civil Structural Health Monitoring* (2020) 10:743–756

Measurement of bridge KPI – GDF

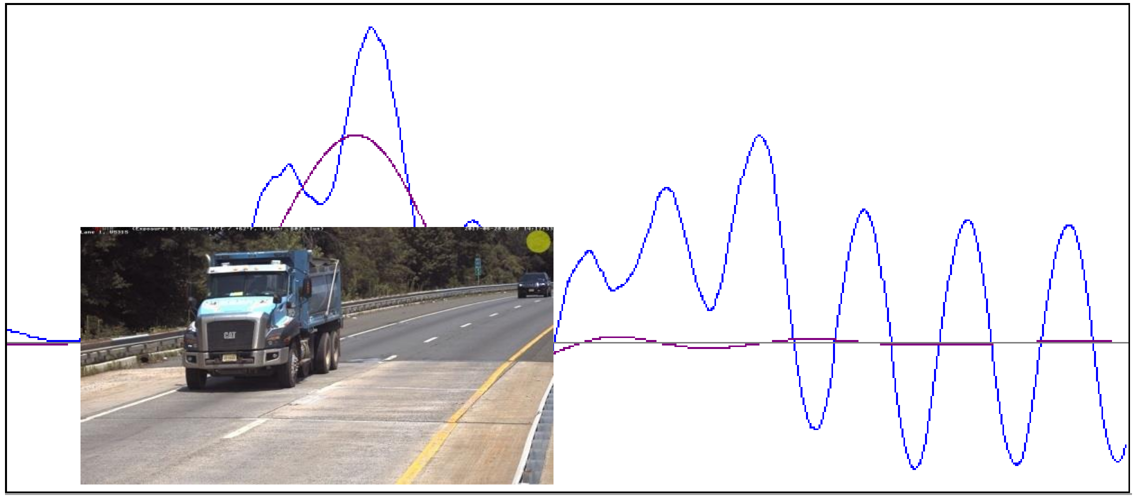
- measured & statist. evaluated (mean & STD) of:
  - Girder Factors – GDF
  - Lane Factors – LF
- substantial differences btw. bridges

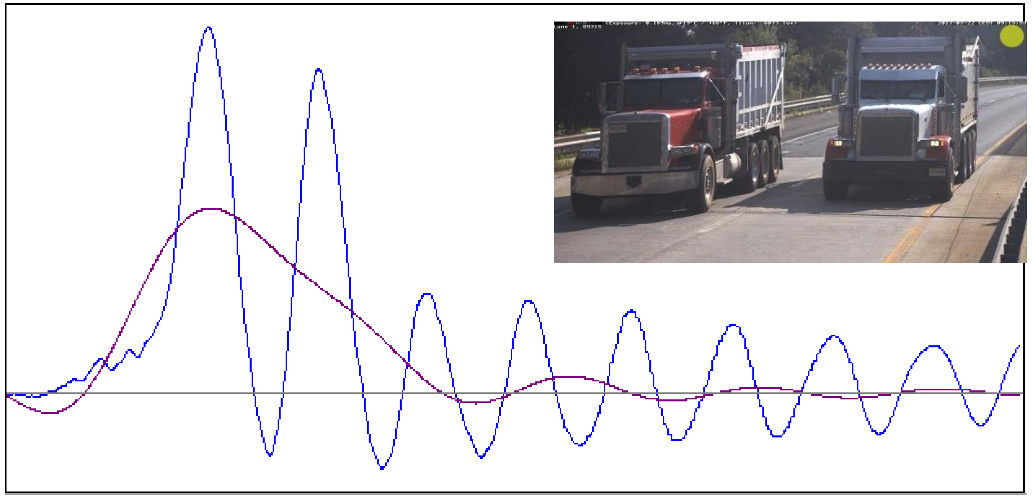


	1	2	3	4	5	6
Driving lane	0.12	0.19	0.24	0.23	0.16	0.07
Fast lane	0.02	0.08	0.14	0.20	0.26	0.30

Žnidarič, Kalin. Using bridge weigh-in-motion systems to monitor single-span bridge influence lines. *Journal of Civil Structural Health Monitoring* (2020) 10:743–756

Dynamic response of a bridge

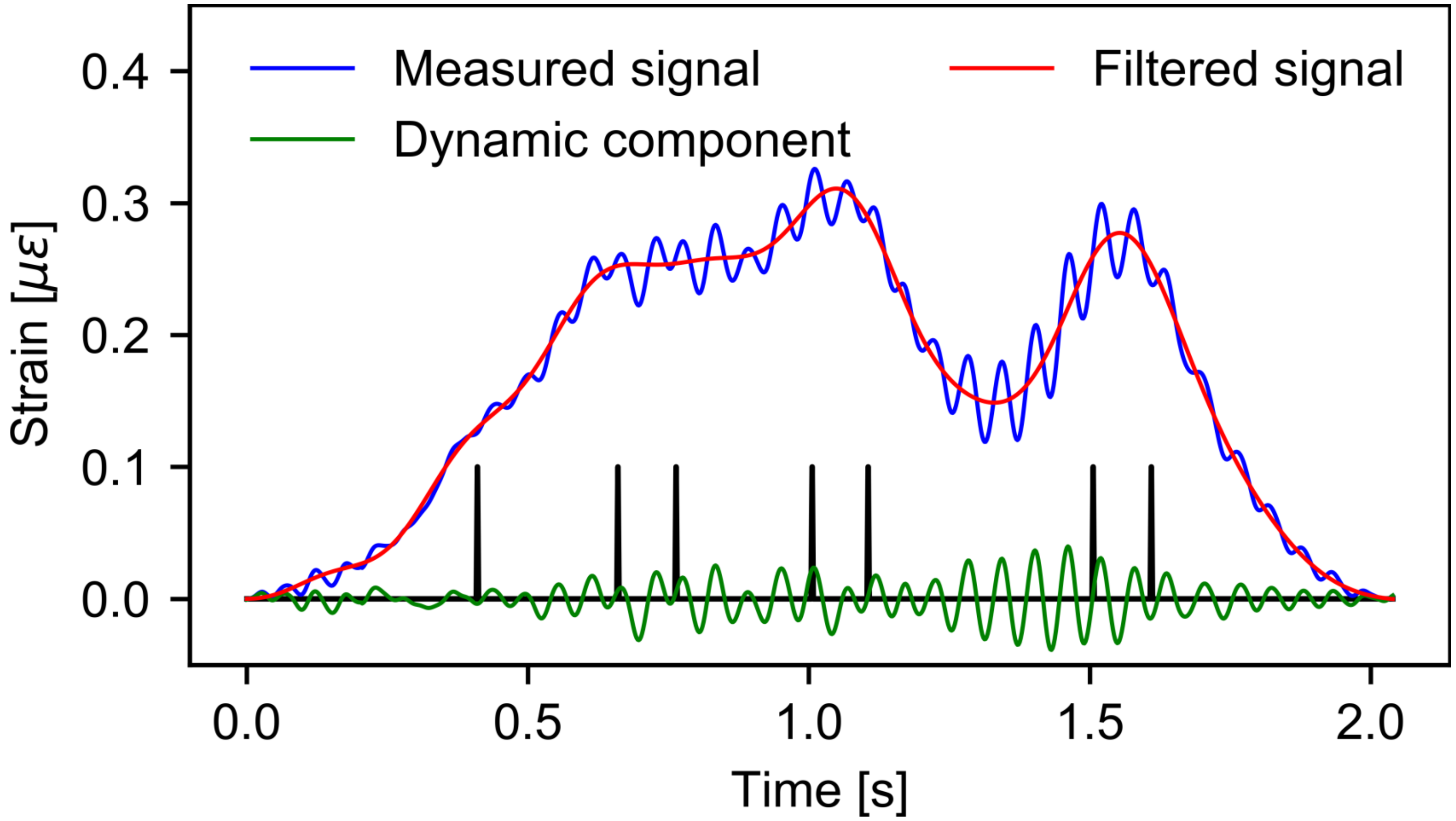




Dynamic amplification

$$DAF = \frac{S_{total}}{S_{static}}$$

- 10 000s bridge responses



Kalin, Anžlin, Kreslin, Žnidarič. *Measurements of Bridge Dynamic Amplification Factor Using Bridge Weigh-in-Motion Data*, accpt. for publ. in Structure & Infrastructure Engineering

Dynamic amplification

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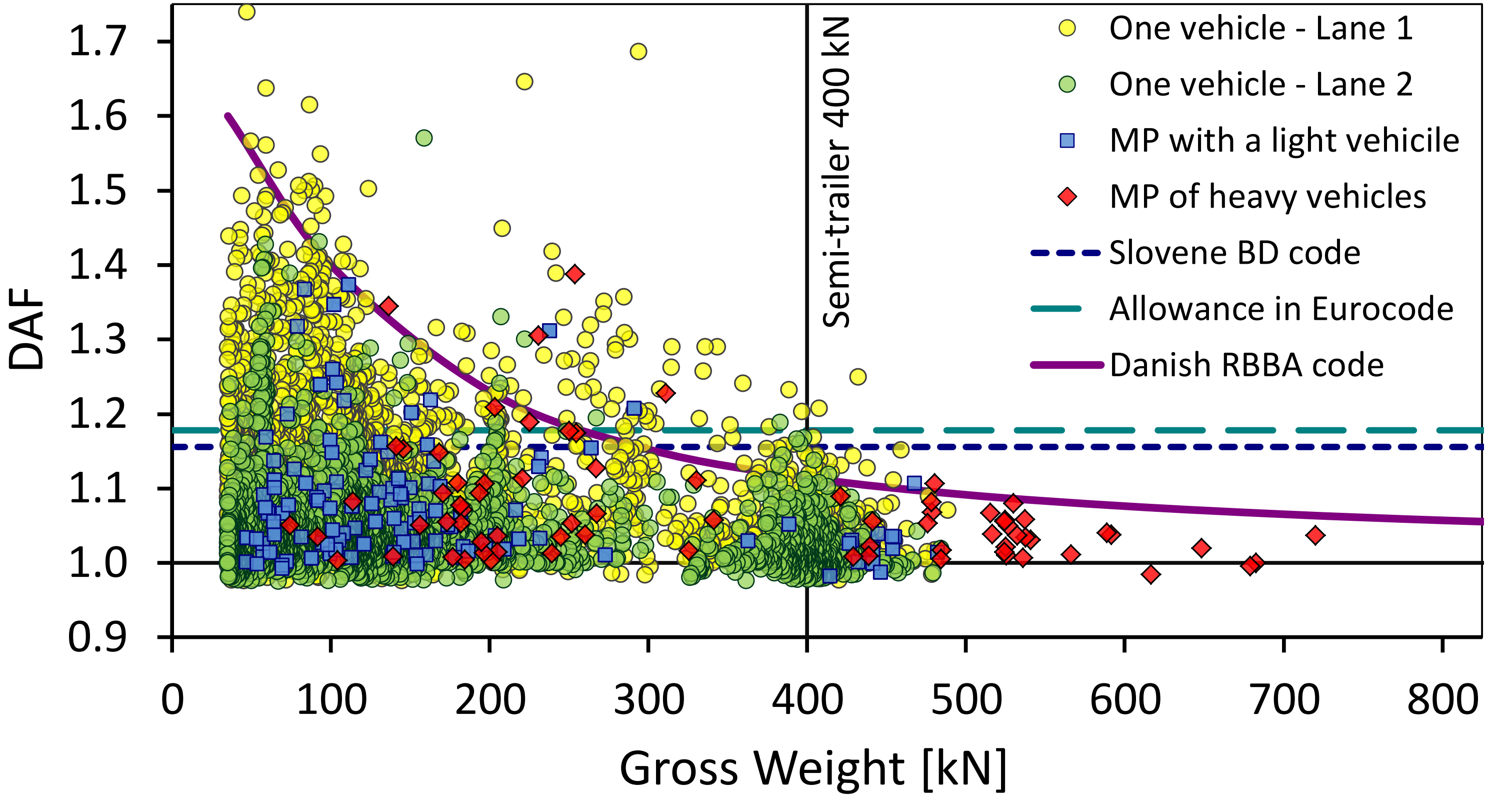
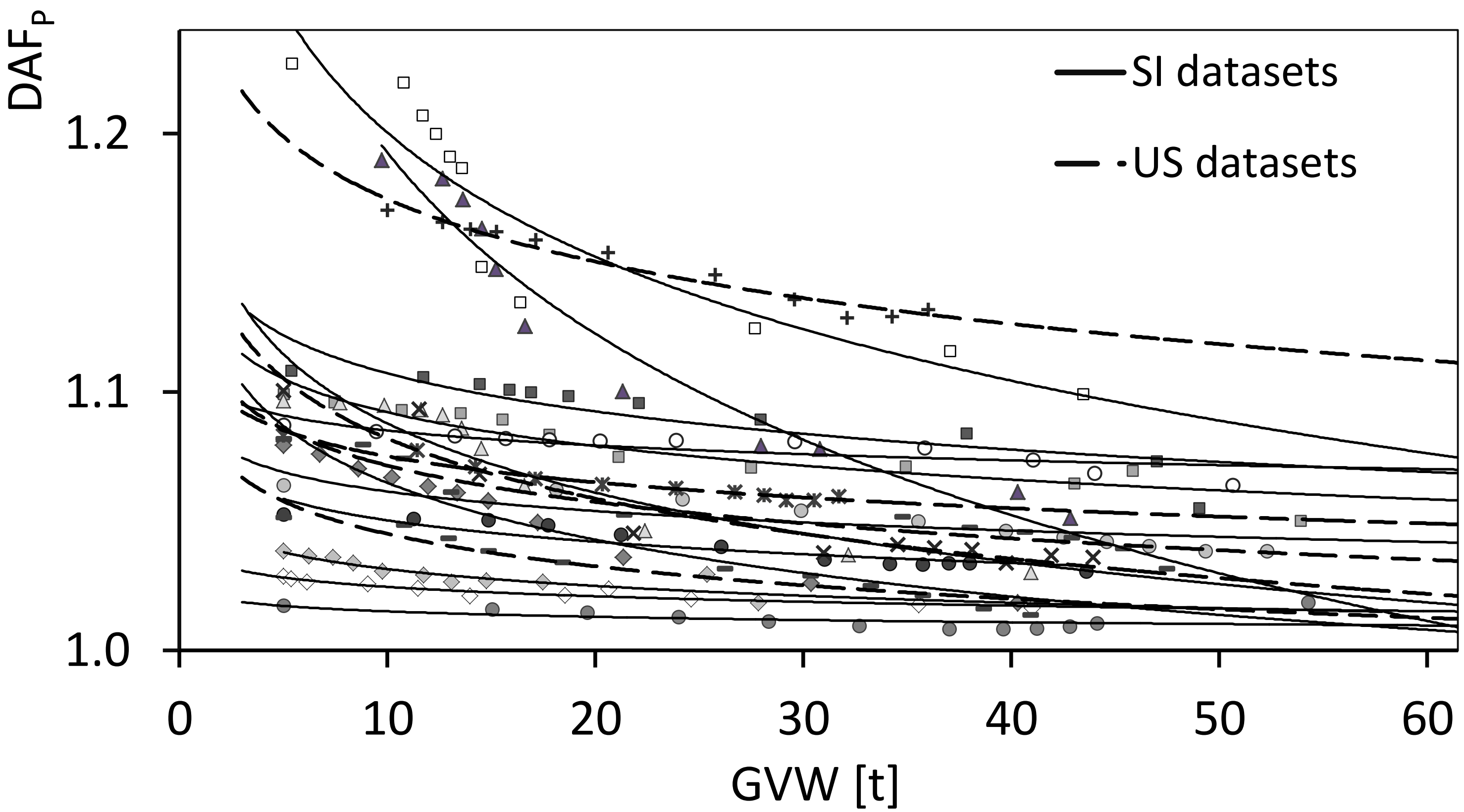


34-m bridge – 5004 measured DAF values

Dynamic amplification

$$DAF = \frac{S_{total}}{S_{static}}$$

- 10 000s bridge responses
- analysis of 5 US and 12 SI bridges

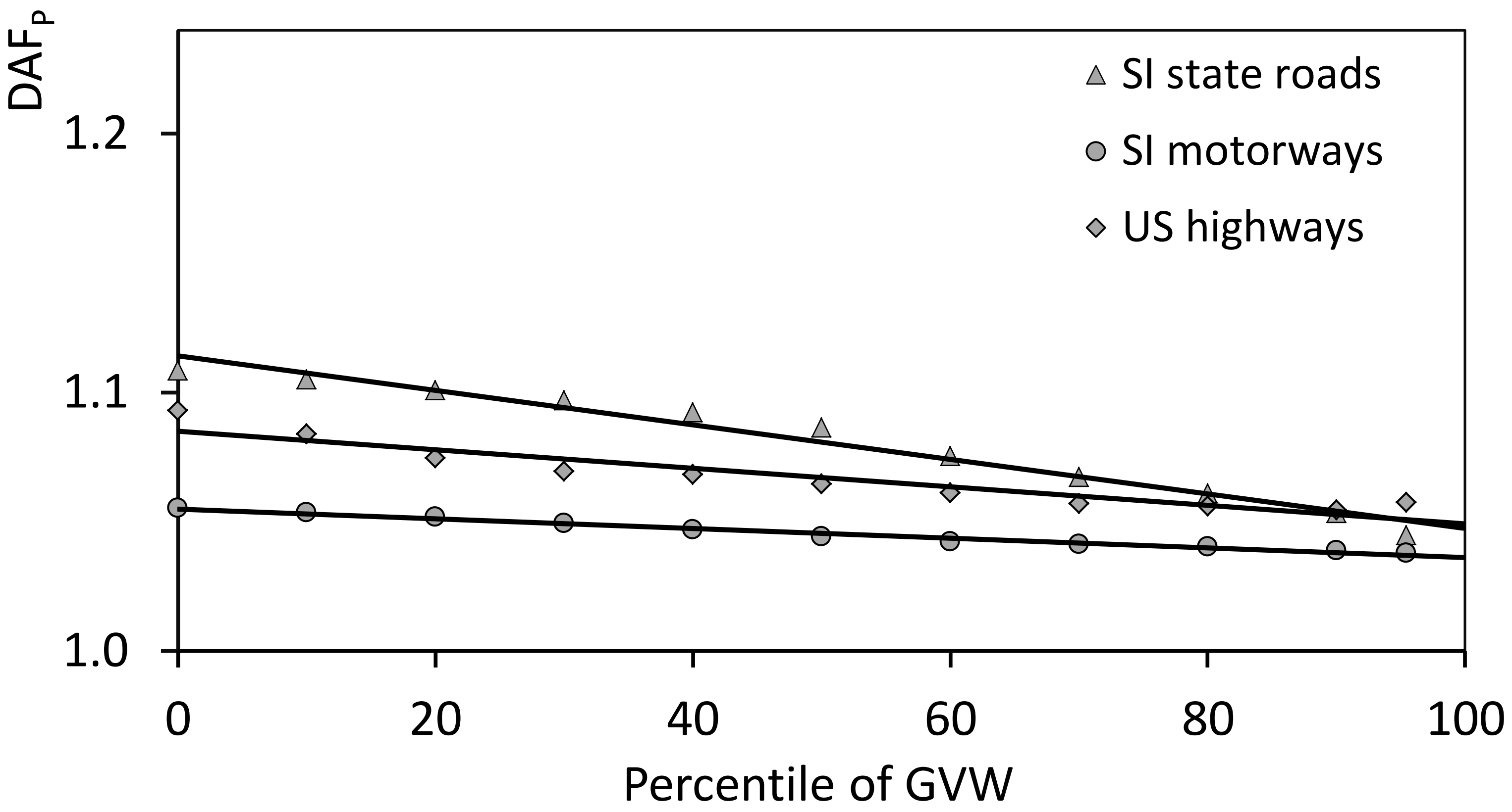


17 datasets, 202 to 747 000 DAF values

Dynamic amplification

$$DAF = \frac{S_{total}}{S_{static}}$$

- 10 000s bridge responses
- analysis of 5 US and 12 SI bridges
- in line with theory, how to implement it in codes?



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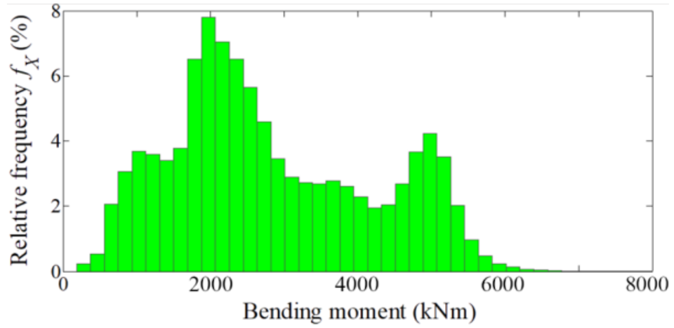
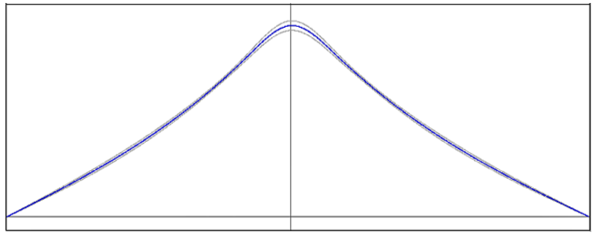
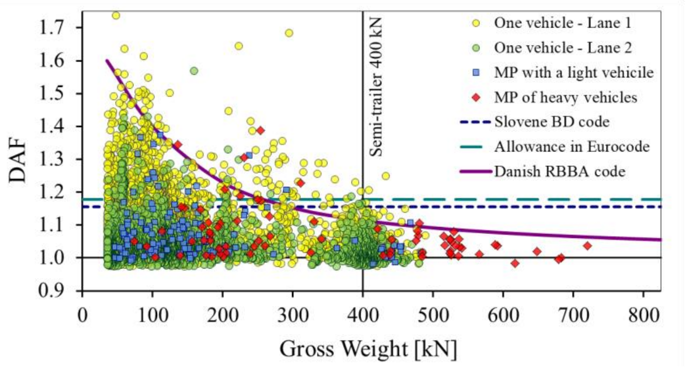
Optimised safety assessment of bridges







Traffic Loading

Moments

Shear forces

Dynamic loading

site-specific
time-dependant

More reliable information, less uncertainties

Way forward…

- all questionable bridges cannot be replaced, rehabilitations should be as optimal as possible
- quality data crucial:
  - (almost) any measured data is better than no data
  - B-WIM data reduces uncertainties, substantial savings in BM
  - a lot of data already available, need for more
- should be included in assessment guidelines and codes, in particular for site-specific optimisations

Thank you for listening!

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