Assessment of a steel bridge using magnetic methods

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Ageing Bridges and Related Issues

- Railway steel bridges in Europe are > 80 years old in average; oldest German bridge 175 years
- Operational conditions changed
- Environmental conditions changed
- Standards changed
- No adquate material data available
- Damage degree only observed visually with respect to corrosion
- Enhanced inspection effort required

Photos: www.dieolsenban.de
www.fotocommunity.de .

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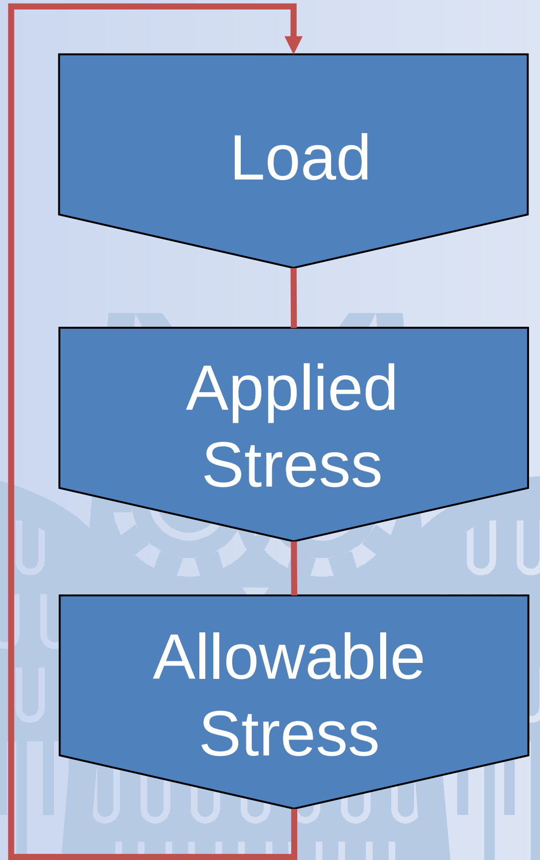
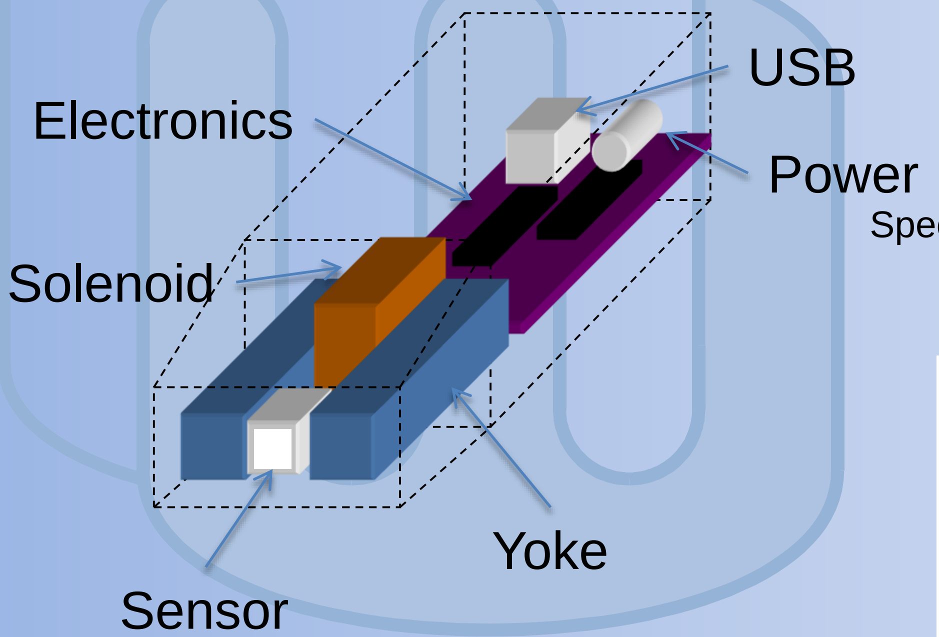
Key Elements in Structural Design

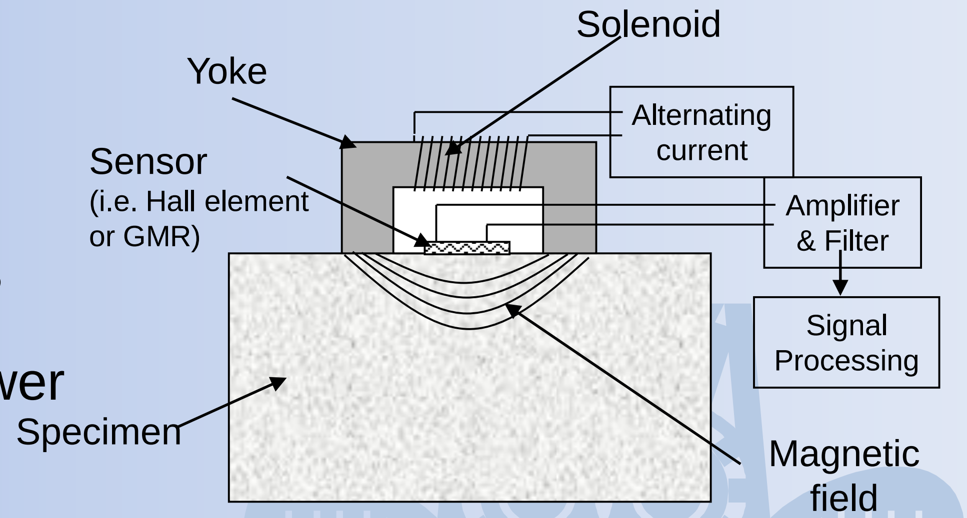
- Load (assumed)
  - Static Load: Ultimate Load
  - Fatigue Load:
    - Constant Amplitude Load
    - Random Load (Service Load)
- Geometry (given)
  - Notches
  - Stress States/Multiaxial Loading
- Material (to be selected)
  - Strength
  - Ductility



Allowable Stress > Applied Stress ?

MicroMach Monitoring Device





Figures left & bottom: Fraunhofer IZFP

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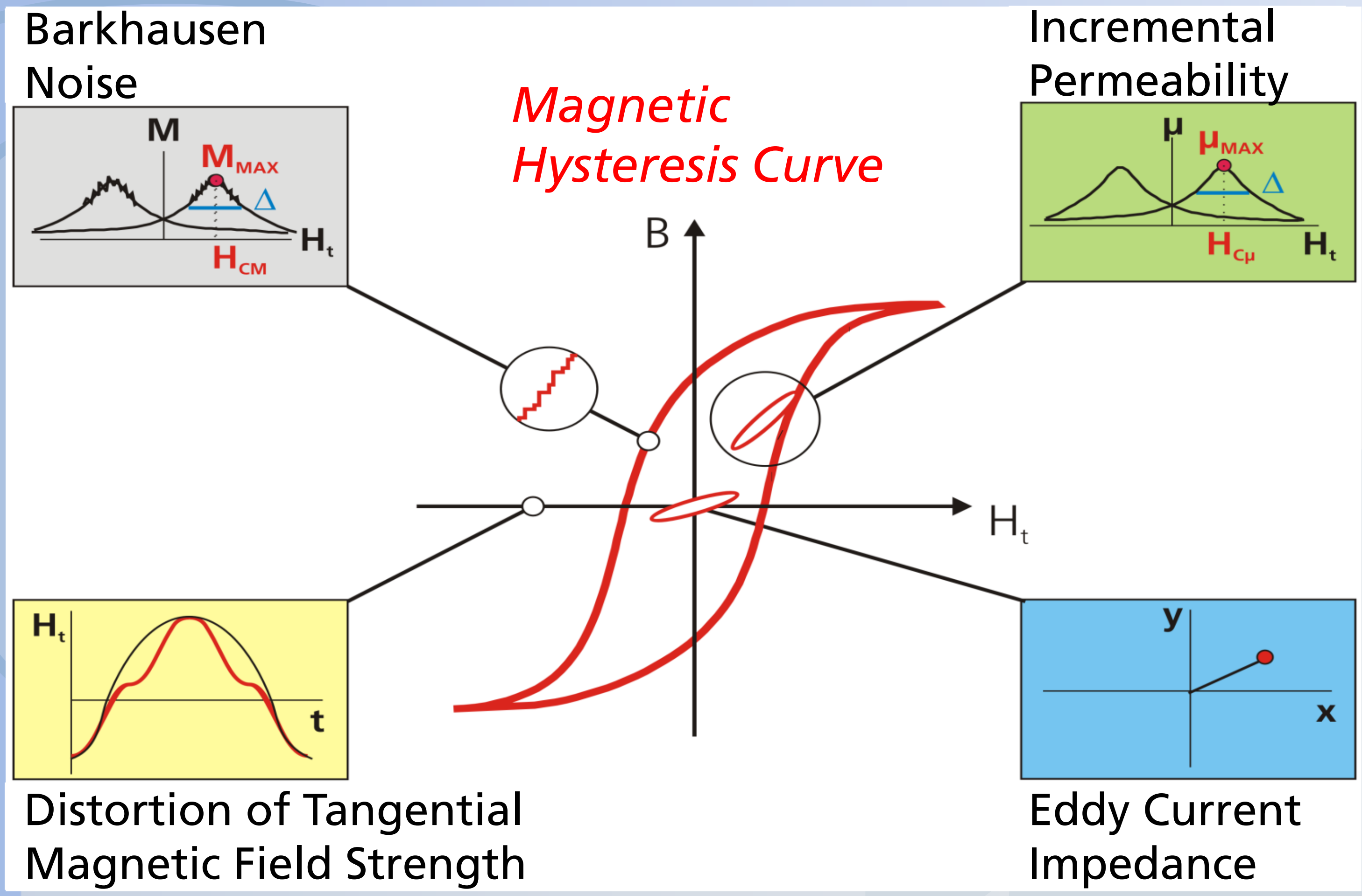
Electromagnetic Techniques and their Potential for Data Fusion (3MA Approach)



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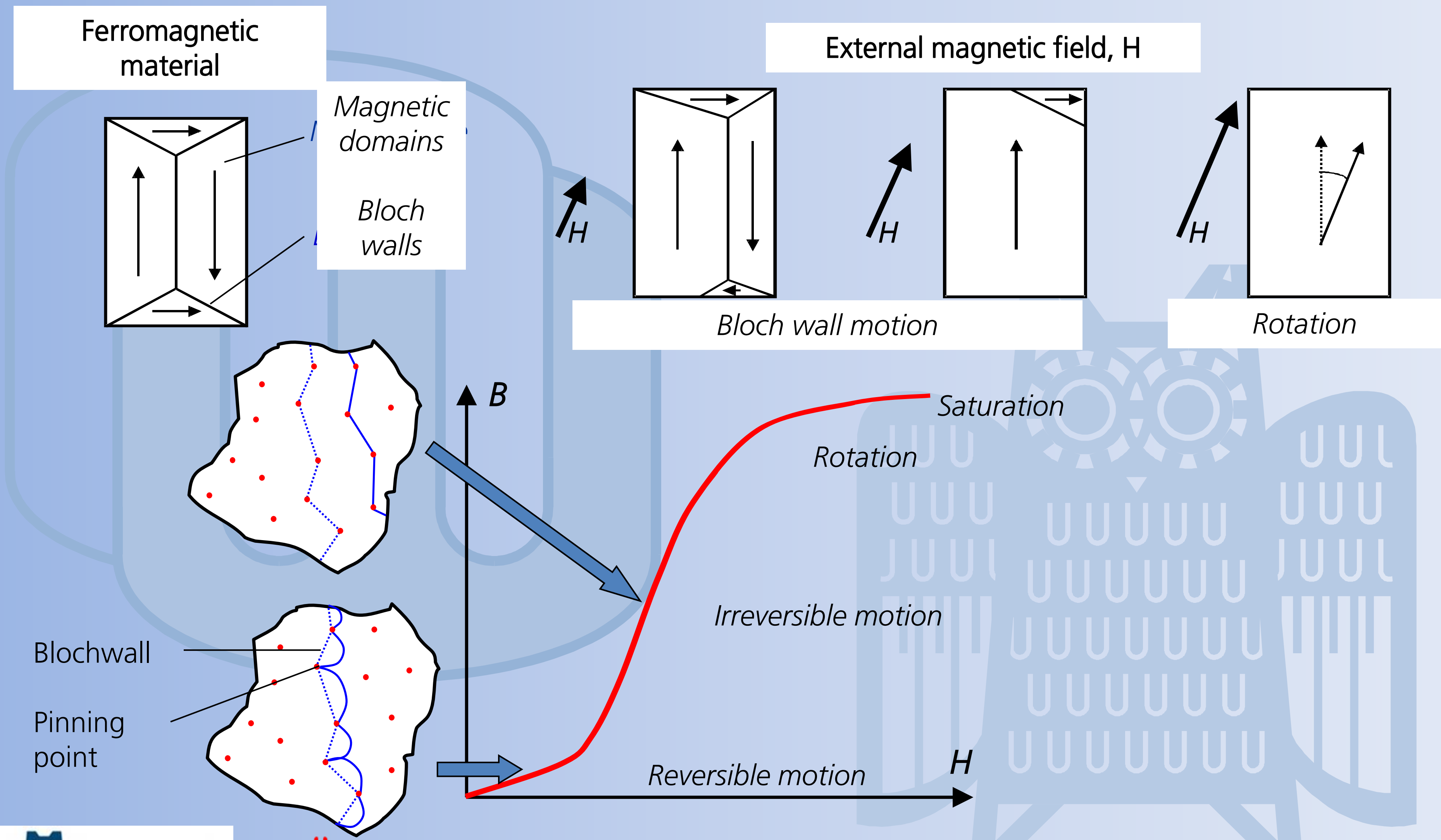
Magnetisation in Ferromagnetic Materials



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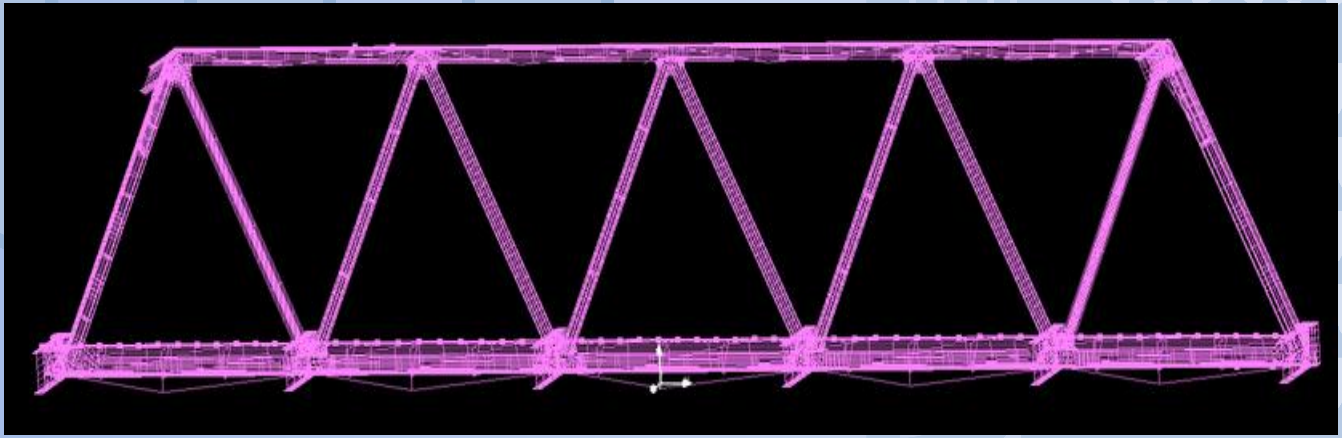
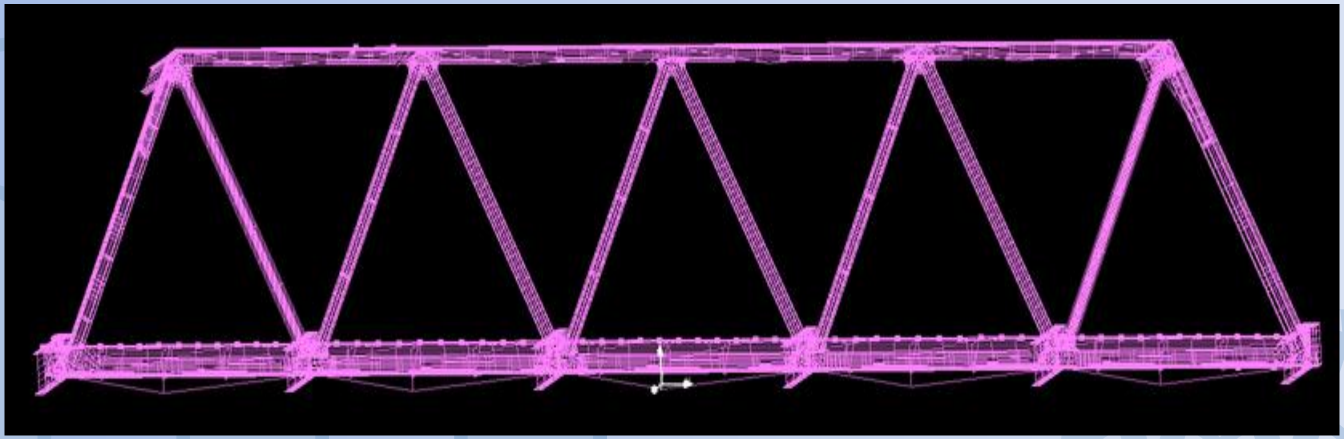
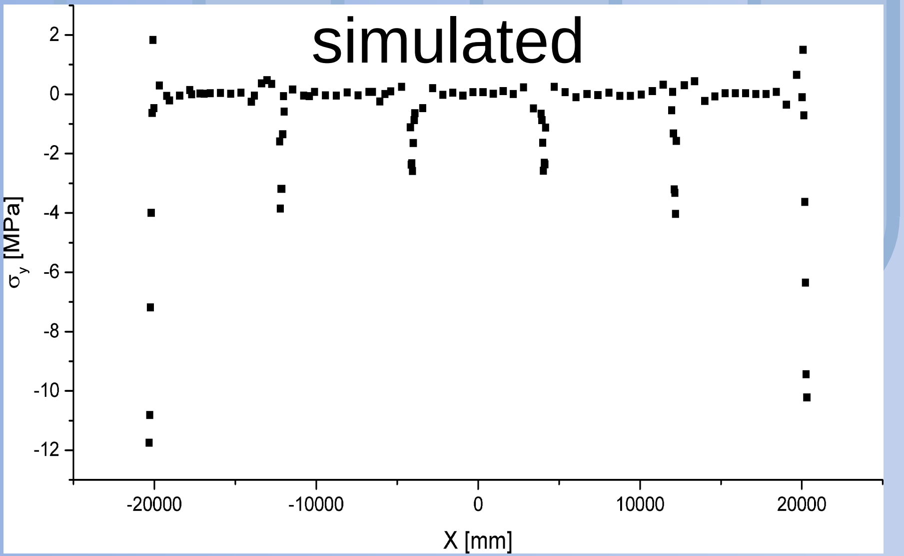
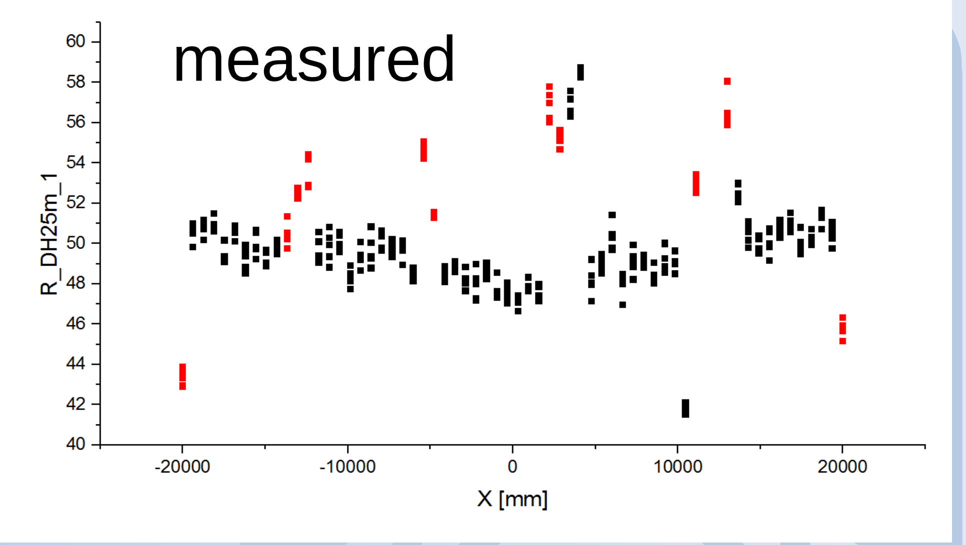
Steel Railway Bridge to be Inspected



Stress Distributions along Lower Girder Beam







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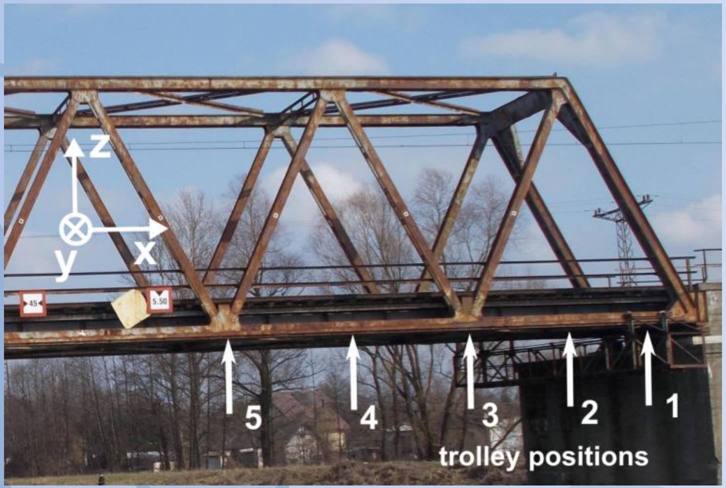
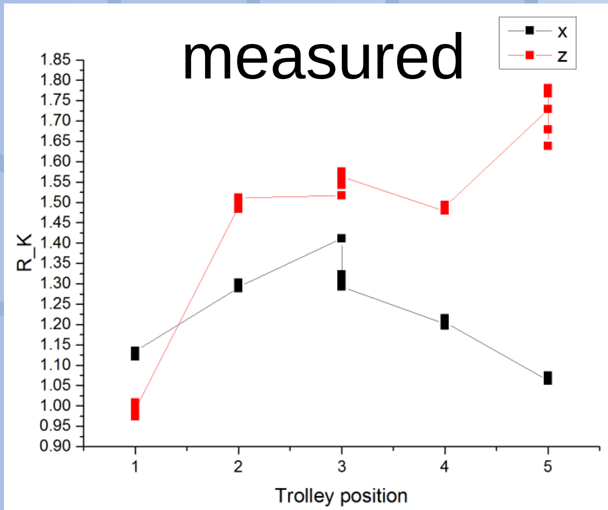
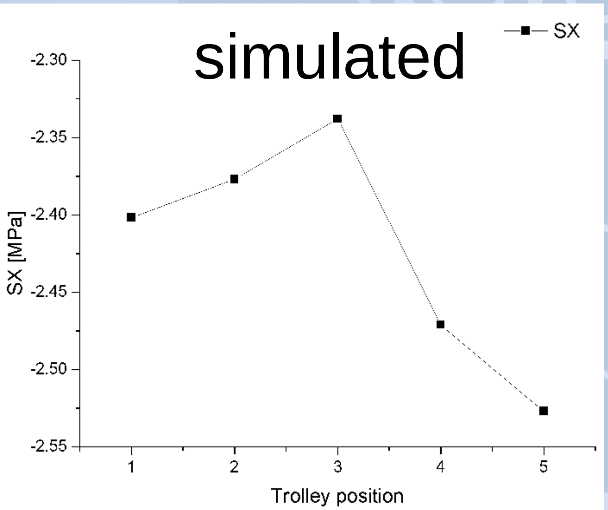
Measured and Simulated Stress Data for Different Loading Conditions







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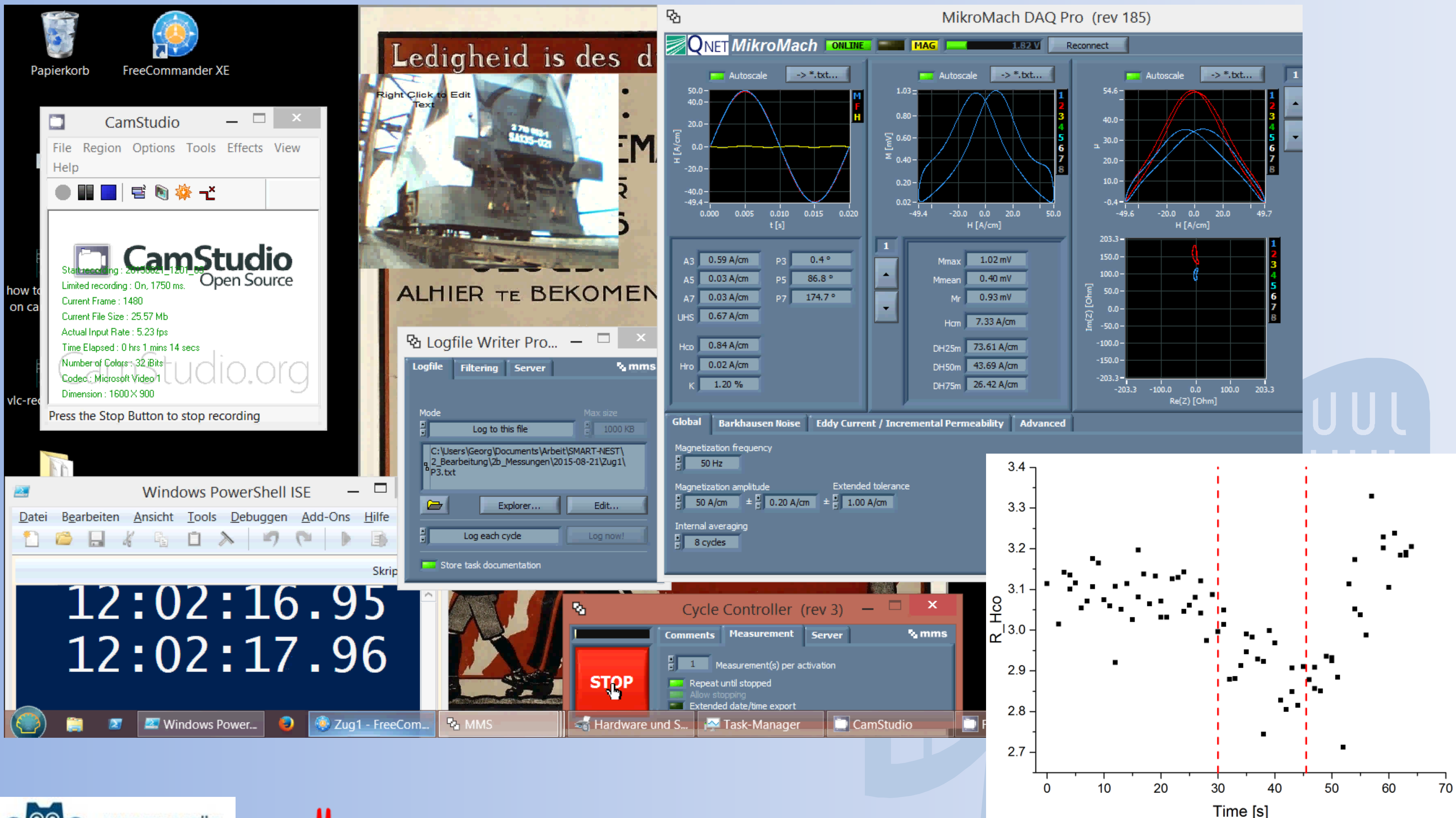
Monitoring of Train Crossing over Bridge



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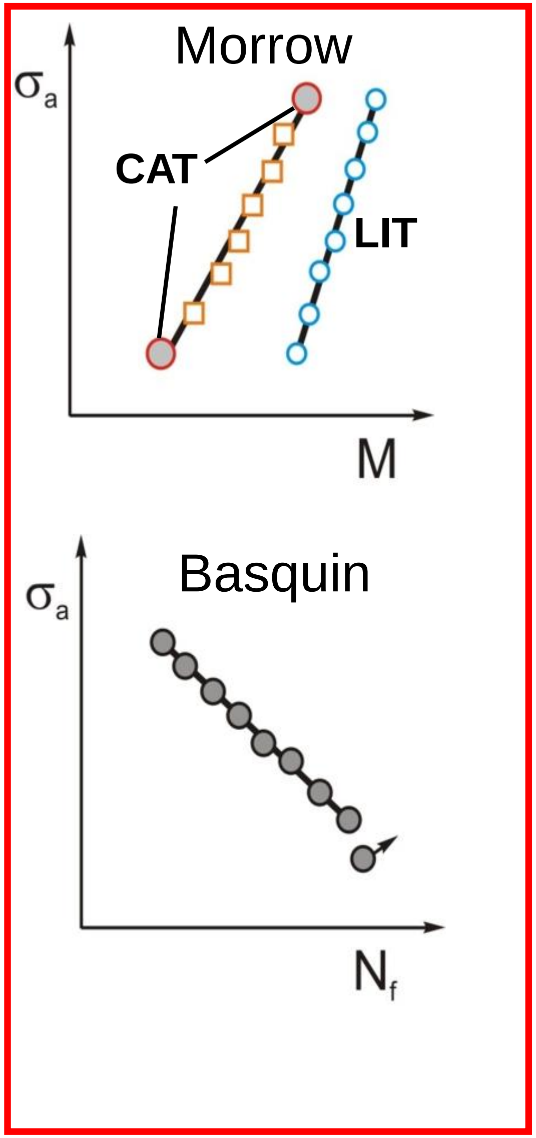
Fatigue Life Calculation Method “PHYBAL“



$$\sigma_a = K' \cdot \left(\varepsilon_{a,p}\right)^{n'}$$

$$\sigma_a = K'_M \cdot (M)^{n'_M}$$

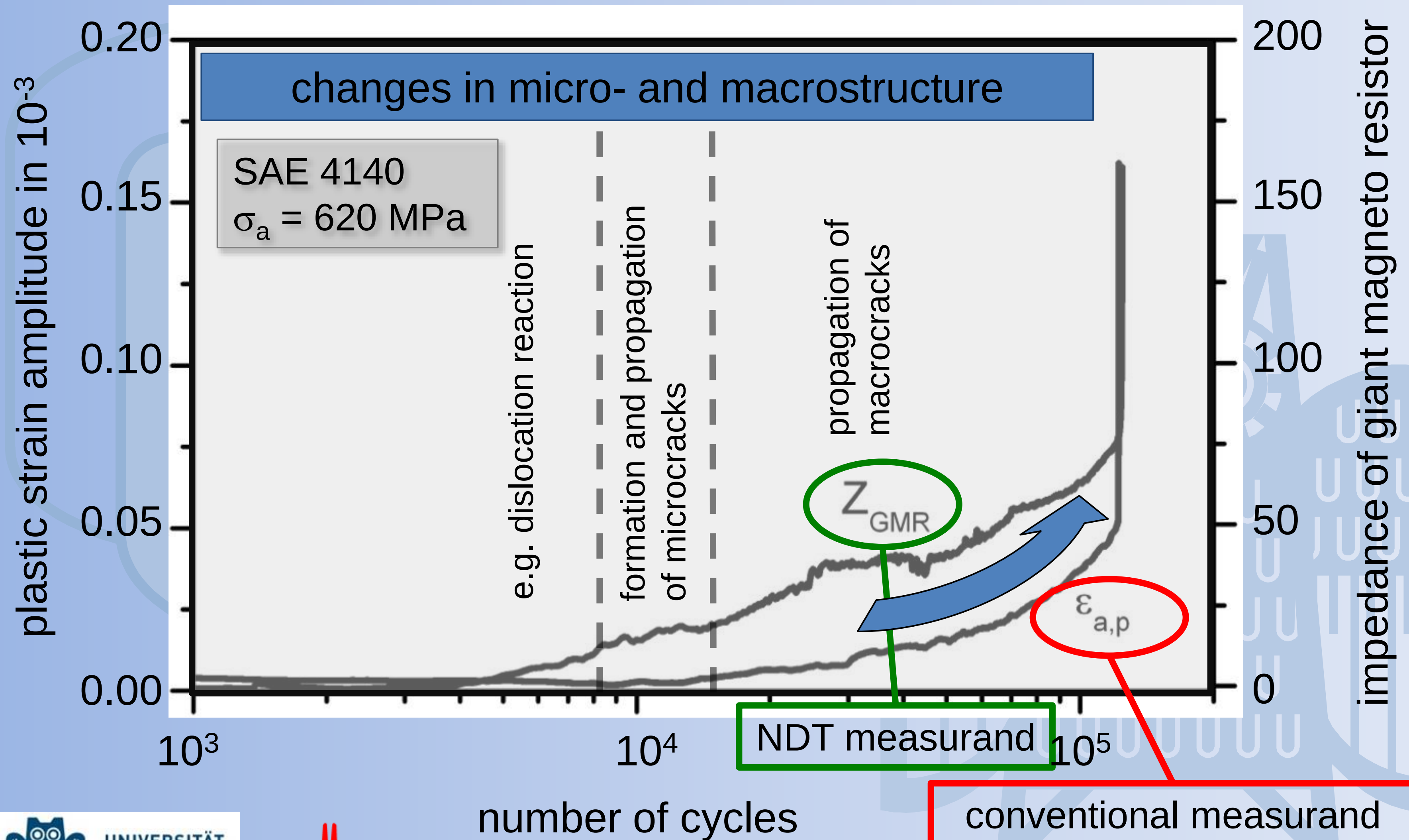
$$b_M = \frac{-n'_M}{5\,n'_M + 1}$$

σ_a and N_f of one CAT

$$\sigma_a = \sigma'_{f,M} \cdot \left(2N_f\right)^{b_M}$$

$$N_f = 0.5 \cdot \left(\frac{\sigma_a}{\sigma'_{f,M}}\right)^{\frac{1}{b_M}}$$

Cyclic Deformation Behavior



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Conclusions

- Life cycle management of ageing steel infrastructure can be made more efficient with NDT and associated structural technologies
- The NDT and associated technologies are:
  - Magnetics or other technologies to measure actual stress, strain and loading conditions
  - Damage tolerance ‚redesign‘
  - Material residual fatigue life assessment with PhyBaL
  - Magnetics for the assessment of the damage and stress condition in the pre-cracked phase.
  - Prognostics for the assessment of residual fatigue life.

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Parts of the research leading to these results has received funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement n° 284995

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