TRANSPORT RESEARCH ARENA
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Condition monitoring of railway transition zones using acceleration measurements on multiple axle boxes

Case studies in the Netherlands, Sweden, and Norway

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Background

What is a railway transition zone?

Segments

between

normal embankment

and

civil structures,

bridges, culverts, tunnels…

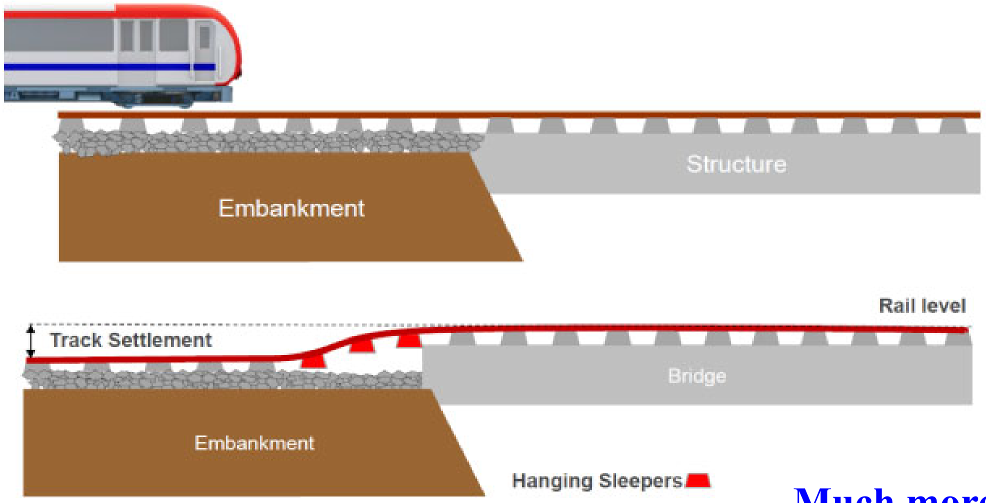
Background

What is the problem?

Broken tension clamp

Basirat et.al, 2017

Broken sleeper



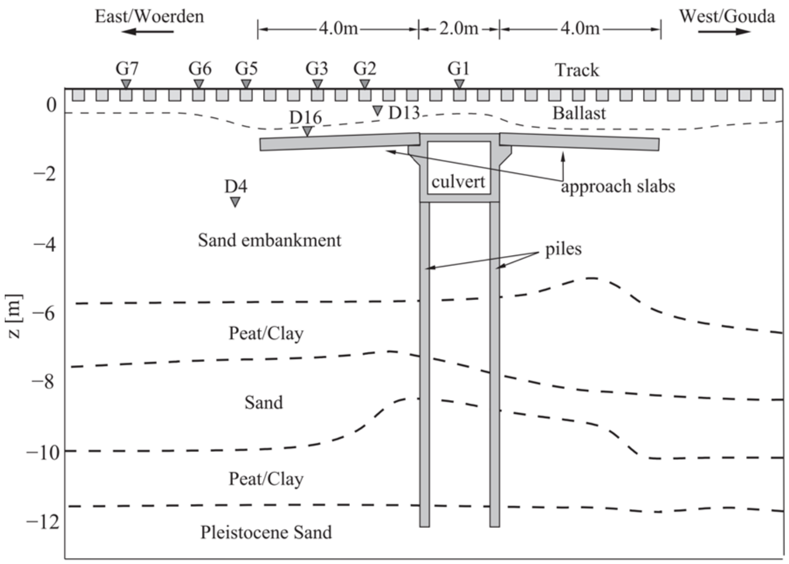
IN2ZONE D2.1 report, 2021

Track geometry degrades fast

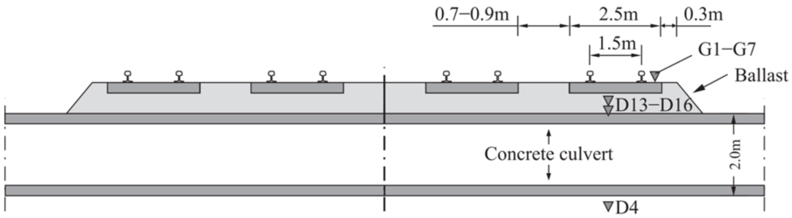
Much more maintenance, in case safety problem, such as derailment

Background

Reasons behind? – complex and case dependent



a) Track longitudinal view



b) Track transverse view

DIC Device

DOI: 10.3390/s18020413

LVDT

DOI: 10.1016/j.engstruct.2017.02.020

Accelerometer

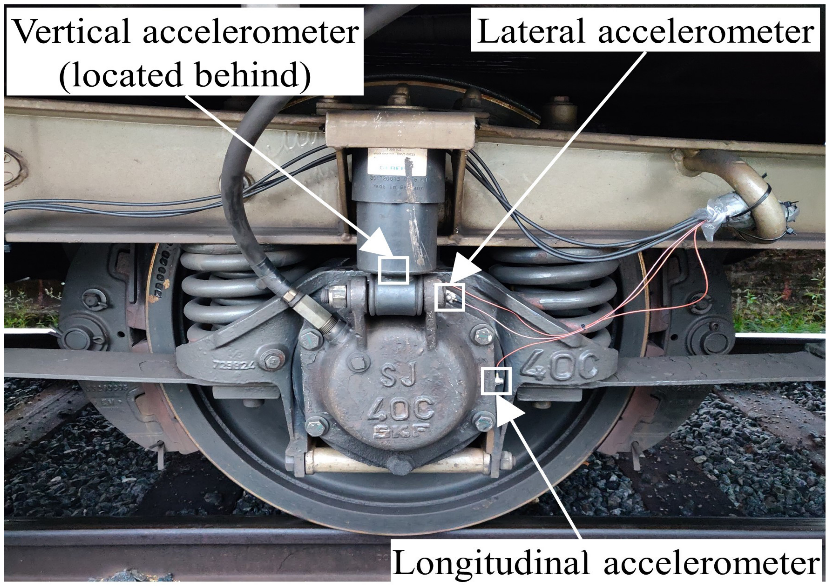
DOI: 10.1115/JRC2015-5645

- **Generally, it is because of significant variation in track support conditions - uneven track stiffness/damping**
- **But could be quite complex/different in cases**

Trackside monitoring is Not possible for network-level monitoring

ABA measurements

Axle box accelerations - efficient solution



DOI: 10.1007/s13349-024-00766-0

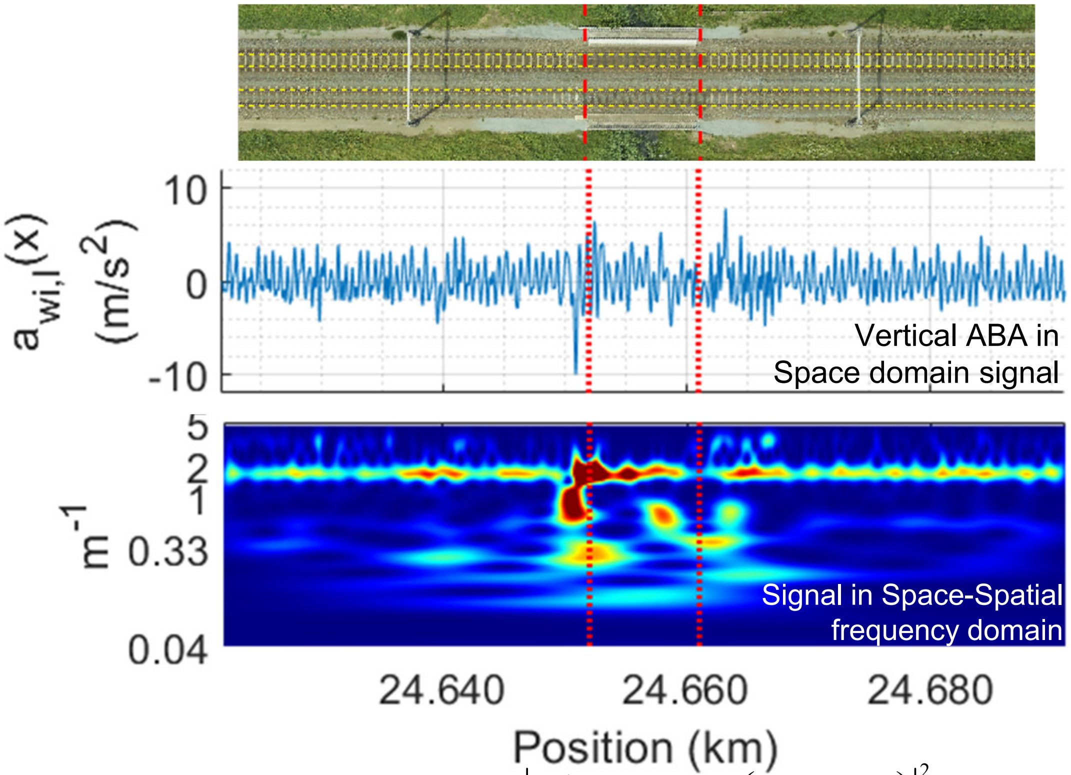
- **Accelerometers** → **Vertical, lateral and longitudinal accelerations [On 4 wheelsets thus 8 wheels]**
- **GPS**
- **Tachometer**

GPS and **Tachometer** → **Locate the wheels, thus the defects**

Onboard measurements – special measuring wagon or equipped on normal vehicle

ABA measurements

Wavelet analysis and various indicators



Vertical ABA in Space domain signal

Signal in Space-Spatial frequency domain

$$WPS_{w,r}\left(x,s\right)=\left|\sum_{n'=0}^{N-1}a_{w,r}\left(n'\right)\psi^{*}\left(\frac{(n'-n)\delta_t}{s}\right)\right|^2$$

- **WPS**

$$WPS_{w,r}\left(x,s\right)=\left|\sum_{n'=0}^{N-1}a_{w,r}\left(n'\right)\psi^{*}\left(\frac{(n'-n)\delta_t}{s}\right)\right|^2$$

- **GWPS**

$$GWPS_{w,r}\left(s\right)=\frac{1}{n_2-n_1}\sum_{n=n_1}^{n_2}WPS_{w,r}\left(x_n,s\right),\quad x_{n_1}<x_n<x_{n_2},$$

Global wavelet power spectrum is used to evaluate an average of the *WPS* within a particular segment of positions

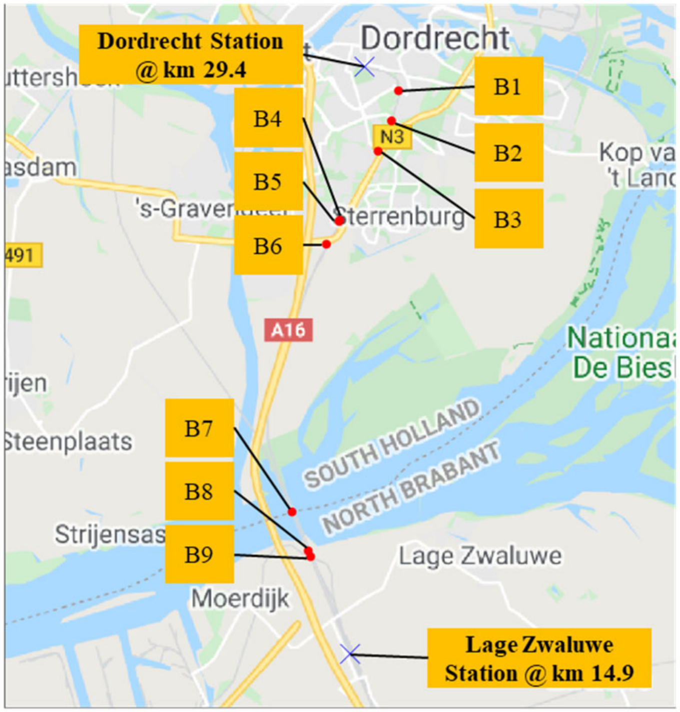
SAWP

$$SAWP_{w,r}\left(x\right)=\frac{\delta_j\delta_t}{C_\delta}\sum_{j=j_1}^{j_2}\frac{WPS_{w,r}\left(x,s_j\right)}{s_j},$$

scale average wavelet power is used to investigate the *WPS* within a considered spatial frequency range

Possible specific indicators for specific track/substructure defects

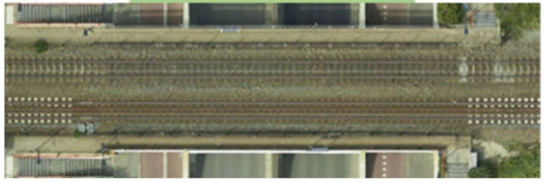
Case studies – the Netherlands



Aerial Photo of B2

Google Street View of B2

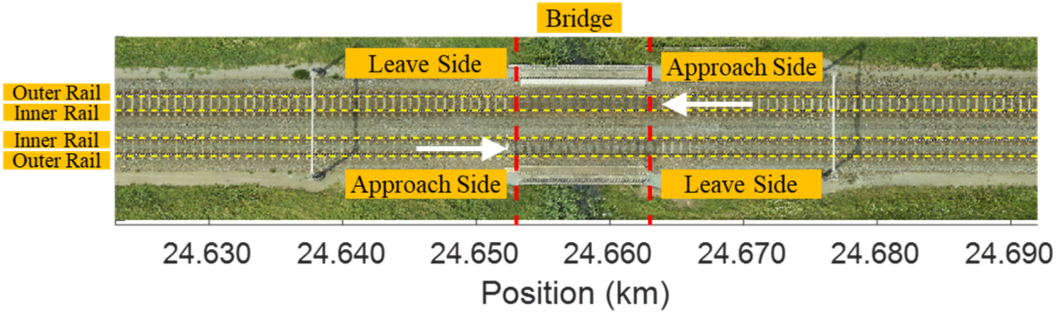
Aerial Photo of B3



Google Street View of B3

Aerial Photo of B4

Google Street View of B4



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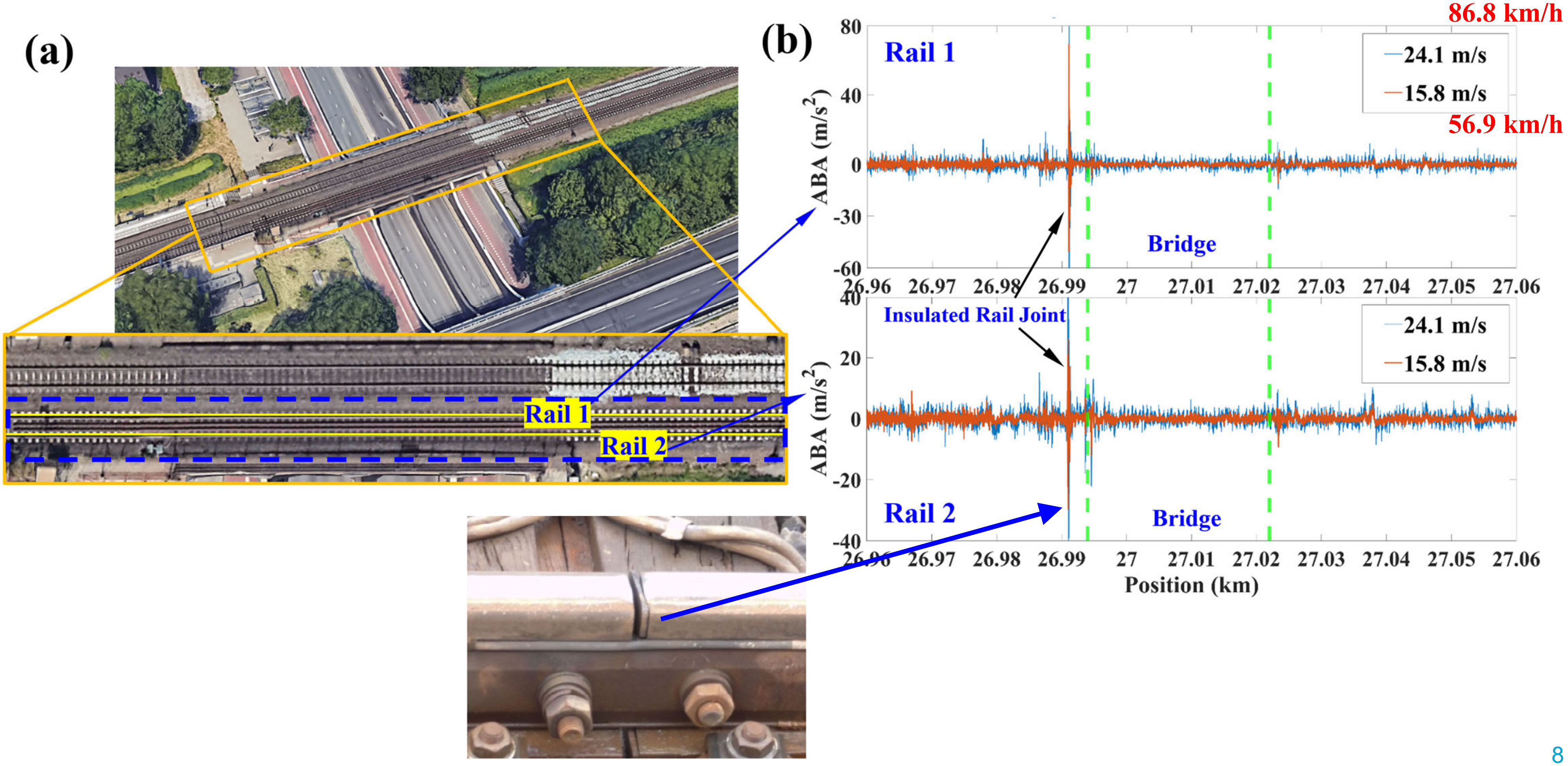
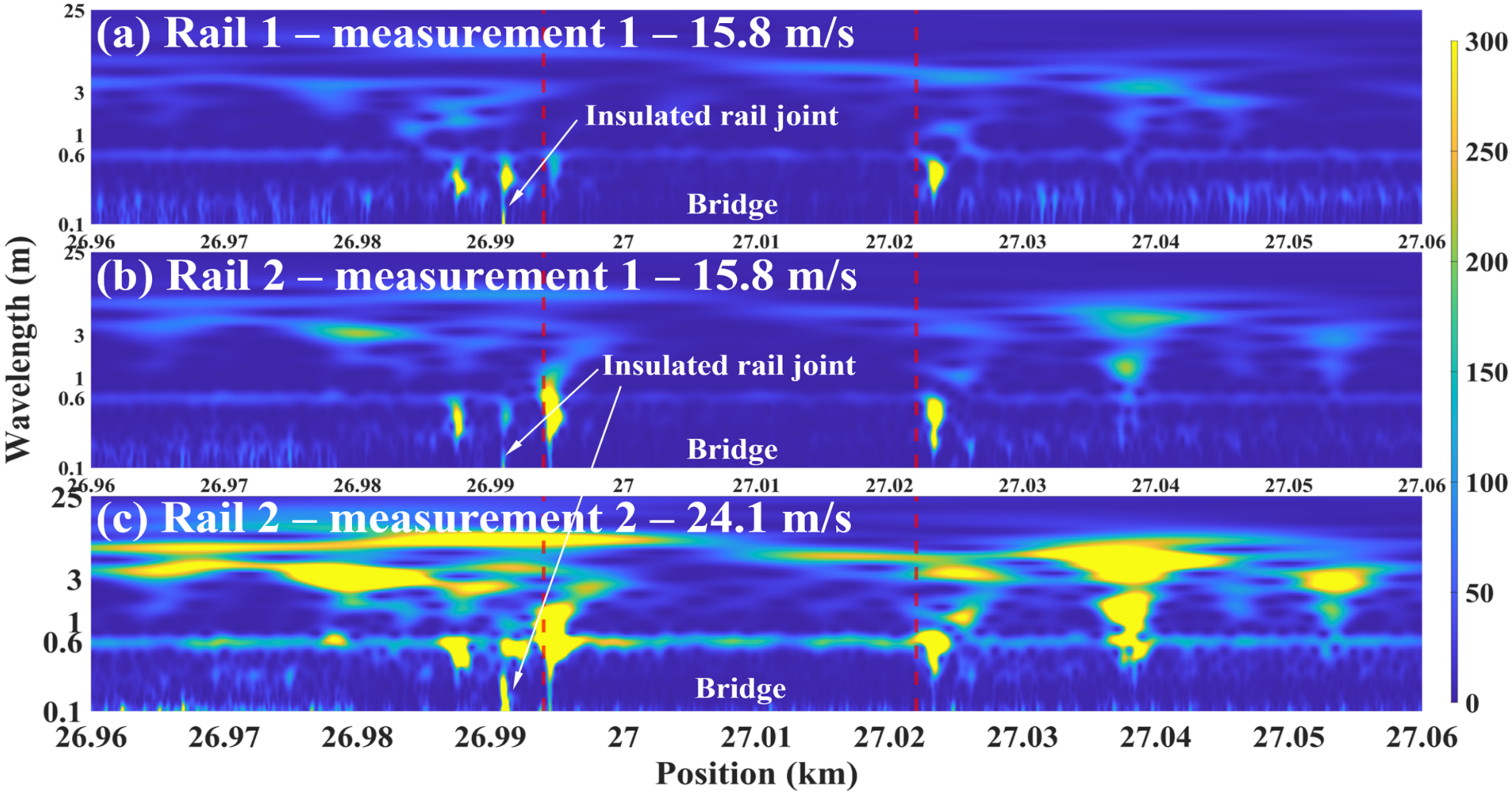
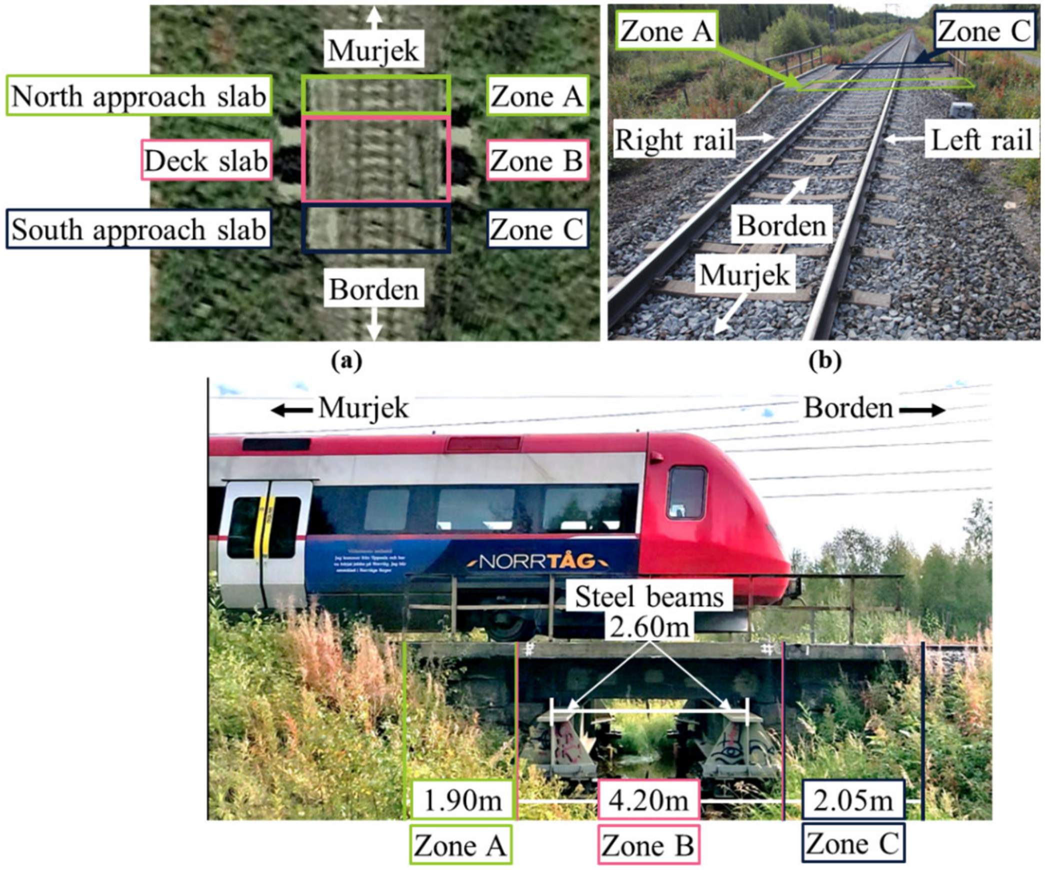


Case studies – the Netherlands



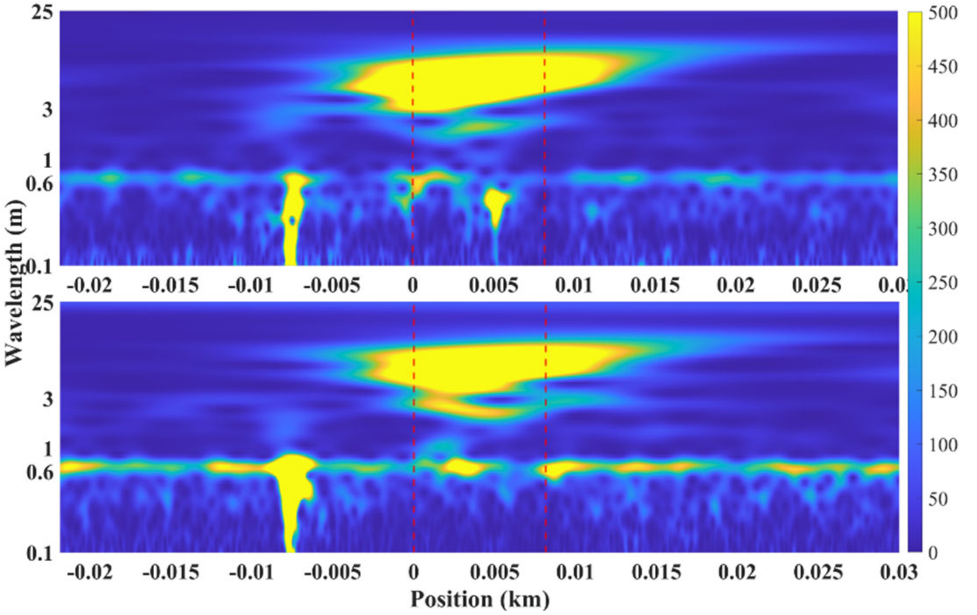
- *Identify defects from rail surface to substructures*
- *Speed independent – faster train speed makes signal more pronounced*

Case studies – Sweden



(a) (b)

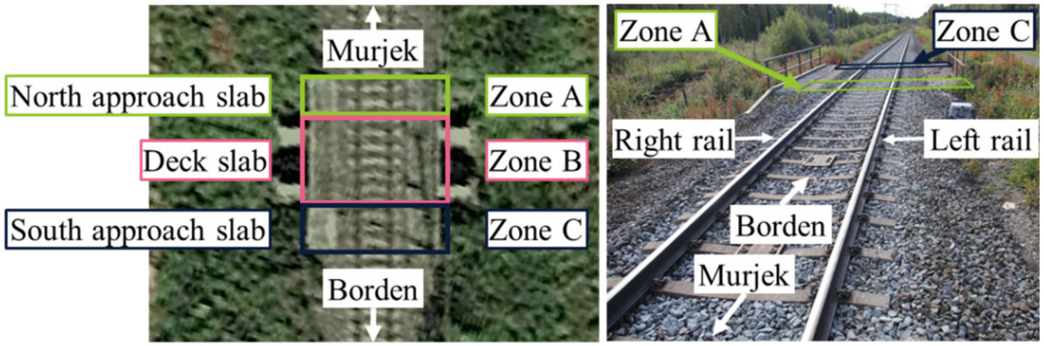
(c)



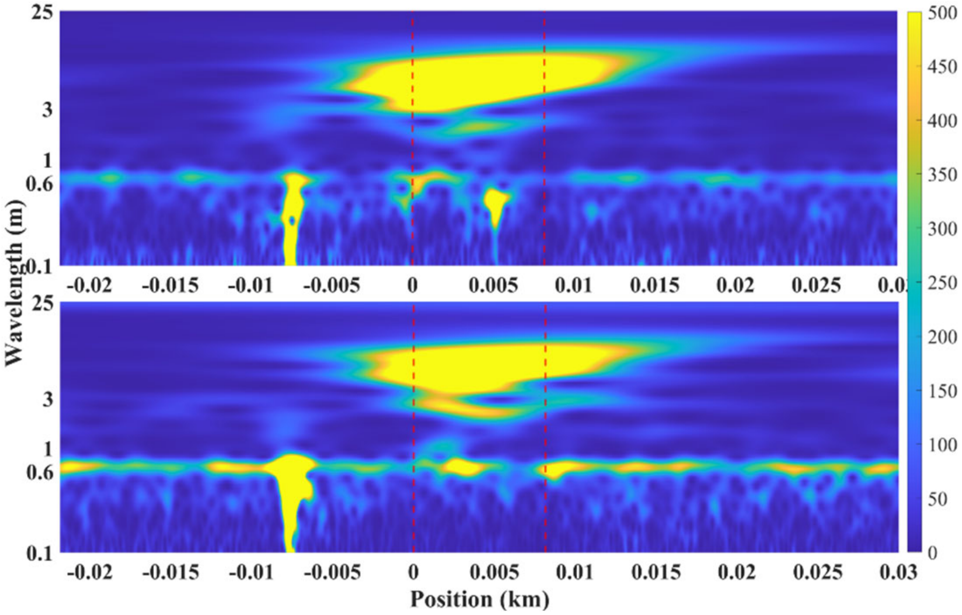
- The effects of the welds can be identified easily
- The responses are obvious at 0.65 m

  → sleeper interval in Sweden

Case studies – Sweden



(a) (b)



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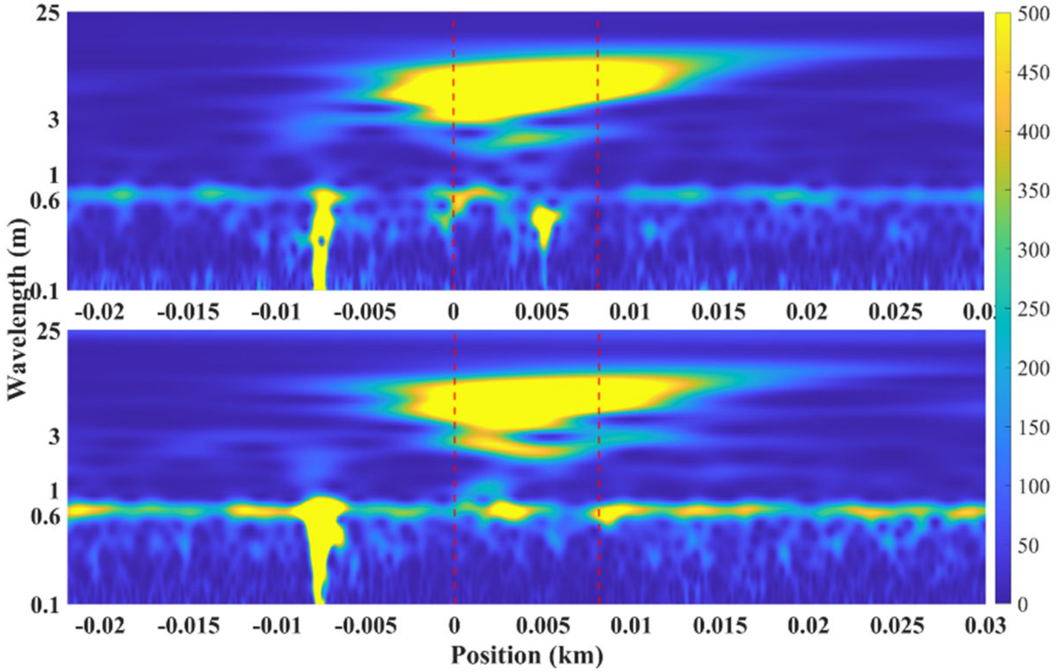
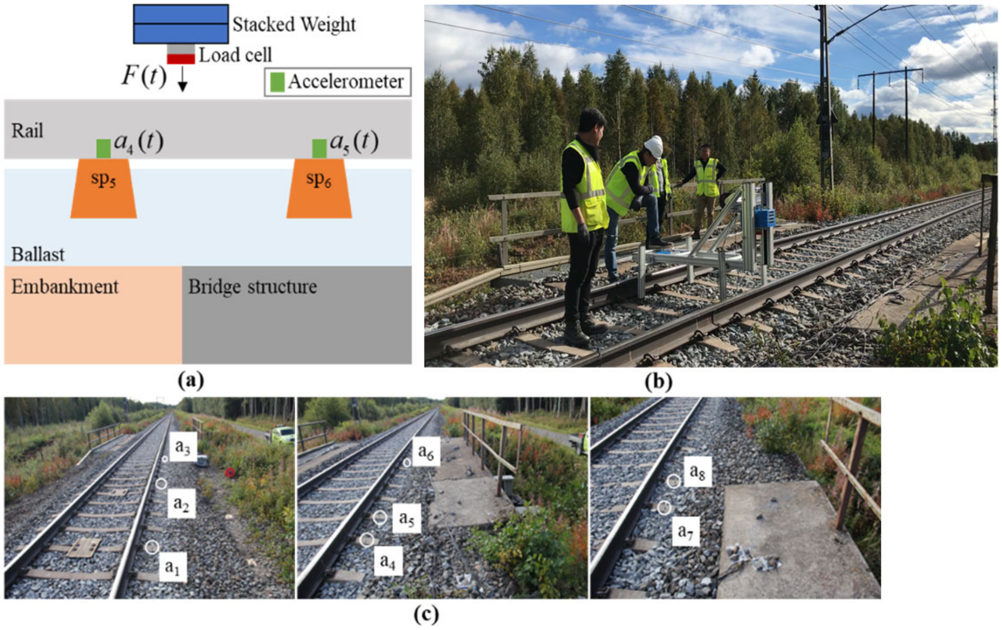
Case studies – Sweden





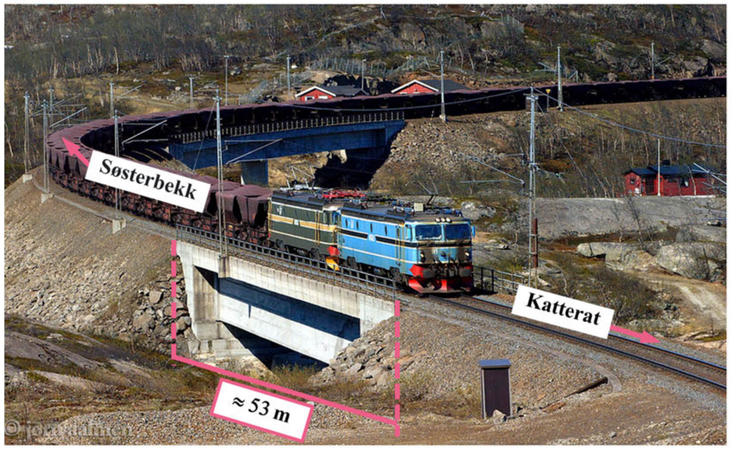
The strong responses on the culvert is found in the wavelength from about 3 – 10 m.

→ Probably due to dynamic characteristics of the degraded structure

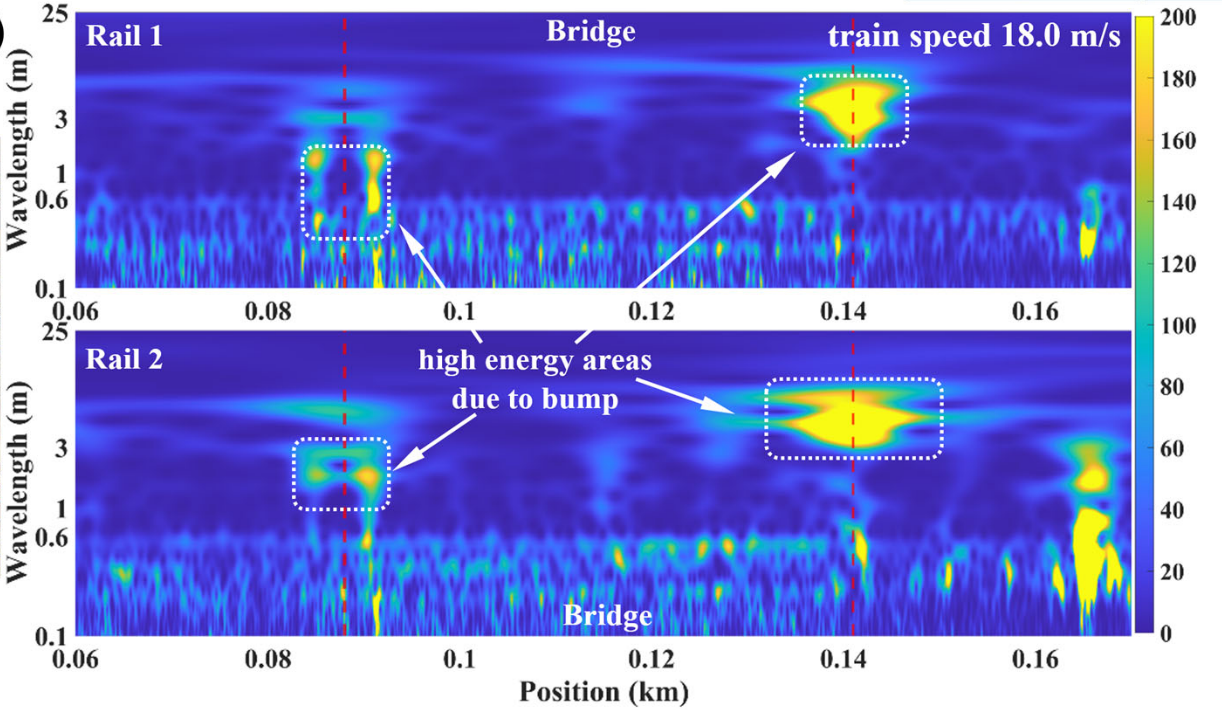
Further analysis of falling weight tests data and hammer tests data will confirm this

Case studies – Norway

(a)



(b)



- Differential settlement was found at transition zones due to the large variation in track support.
  - High-energy areas in the range 1-10 m, indicated by the white dash boxes, are found due to bumps caused by differential settlement.
- The responses due to sleeper interval are observed but not so distinguishable from other short wavelength responses.
  - Probably due to short sleeper interval of 0.52 m, making discrete rail support effect less pronounced.

Conclusion and future works

- **ABA is promising in health condition monitoring at transition zones**
- **Case studies in the Netherlands, Sweden, and Norway prove this.**
- **ABA has the potential to evaluate transition zones health conditions:**
  - ***Different transition zones and railway bridges provide unique characteristics of ABA signals.***
  - ***Differences in dominant wavelengths and energy distribution of ABA signals are found.***
- **ABA responses are more pronounced at higher train speed.**

➢ **Trackside measurements and numerical studies are needed to further interpret the ABA measurement results.**

Acknowledgements

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Thanks!

Welcome any suggestions, comments and question!

If any following discussion:

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