
# Detection of Rail Surface Defects based on Axle Box Acceleration Measurements: A Measurement Campaign in Sweden

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# Outline:

- Axle Box Acceleration (ABA) system
- Detection methodology
- Measurement campaign
- Results
- Conclusions
- Outlook

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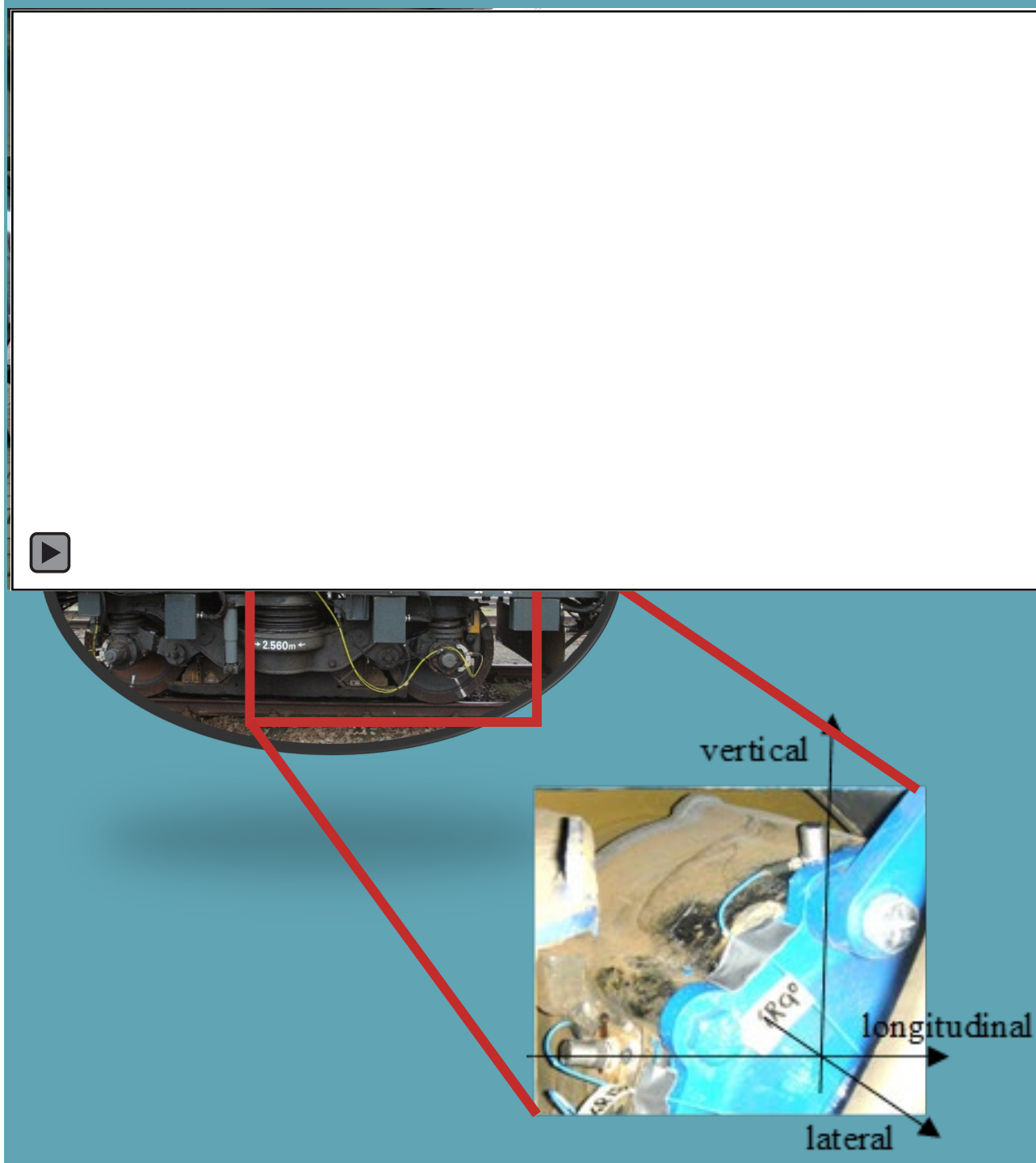
# ABA system

- To make use of the dense operation, access to the whole infrastructure conditions, including rail defects, can be achieved within a few minutes.

If all the trains are instrumented with sensors!

installed at the axle box of a train.

- The ABA measurement system consists of 3 main components:
  - acceleration sensors, a one-directional accelerometer attached to an axle box of the wagon
  - speed and positioning sensors
  - data acquisition system (DAQ) unit

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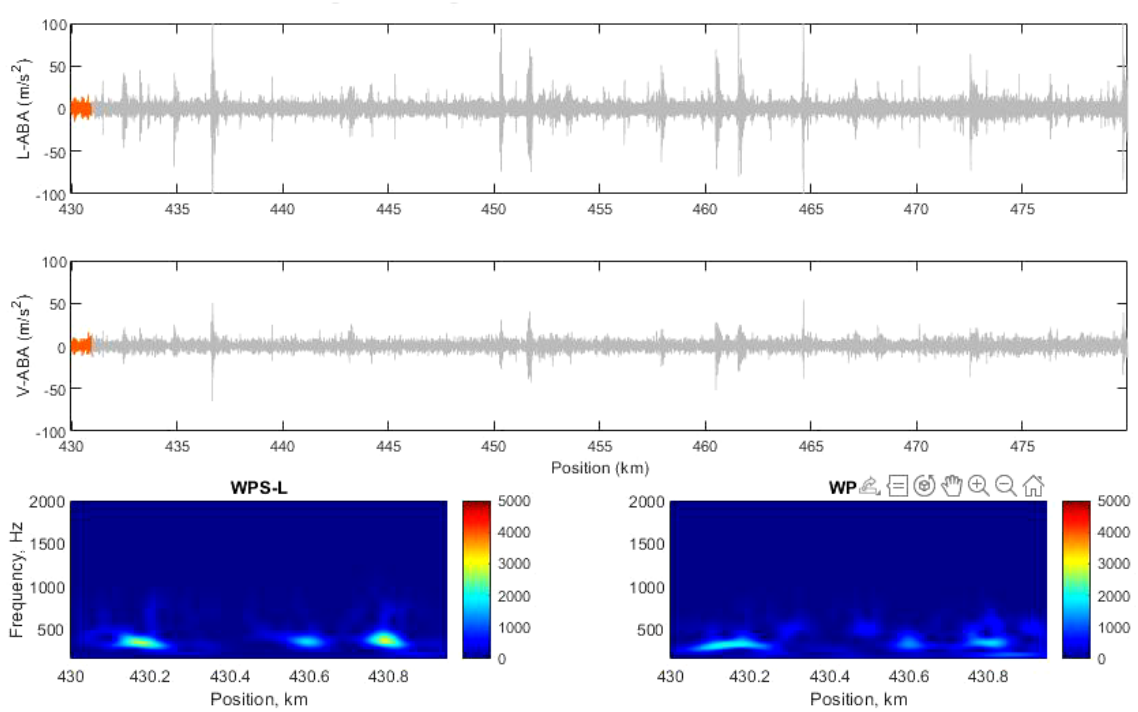
# ABA system

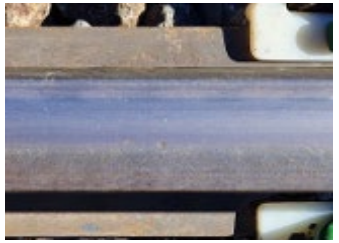



Principle:

Investigate the deviated dynamic response measured by accelerometers at axle boxes.

Squat

Light squat



Small defect

Weld

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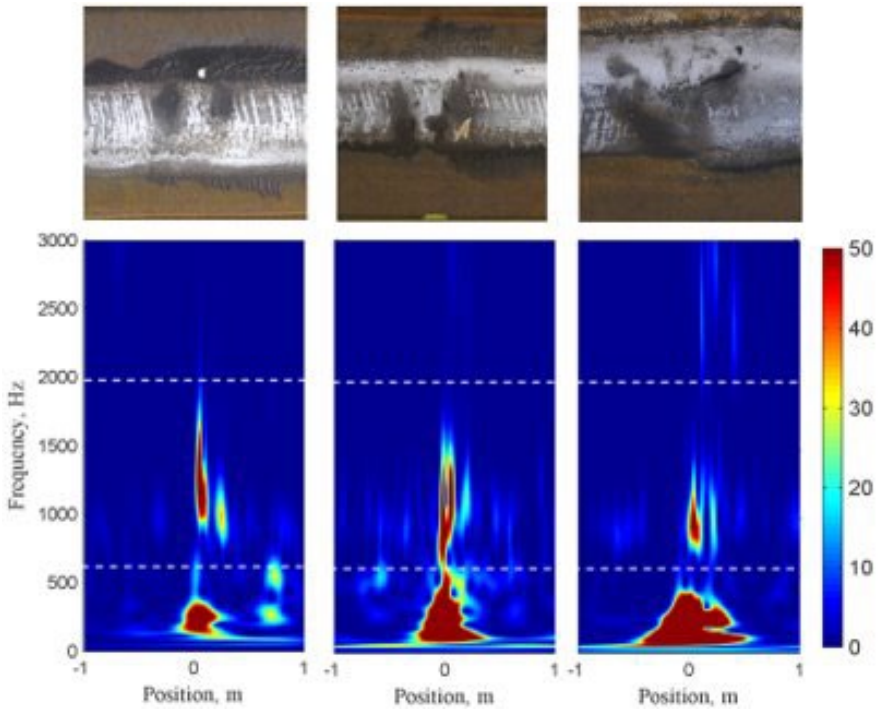
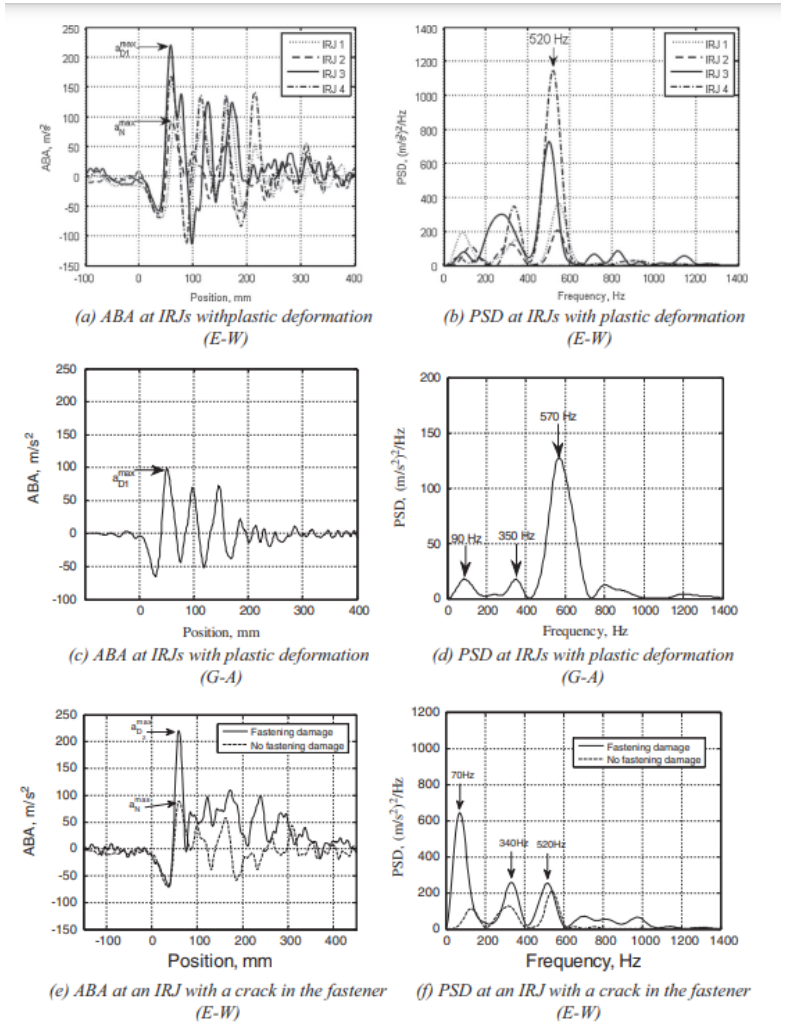
# Examples of our publications




Z. Li, M. Molodova, A. Núñez, and R. Dollevoet, “Improvements in axle box acceleration measurements for the detection of light squats in railway infrastructure”. IEEE Transactions on Industrial Electronics 62(7): 4385-4397, 2015.




(a) ABA at IRJs withplastic deformation (E-W)

(b) PSD at IRJs with plastic deformation (E-W)

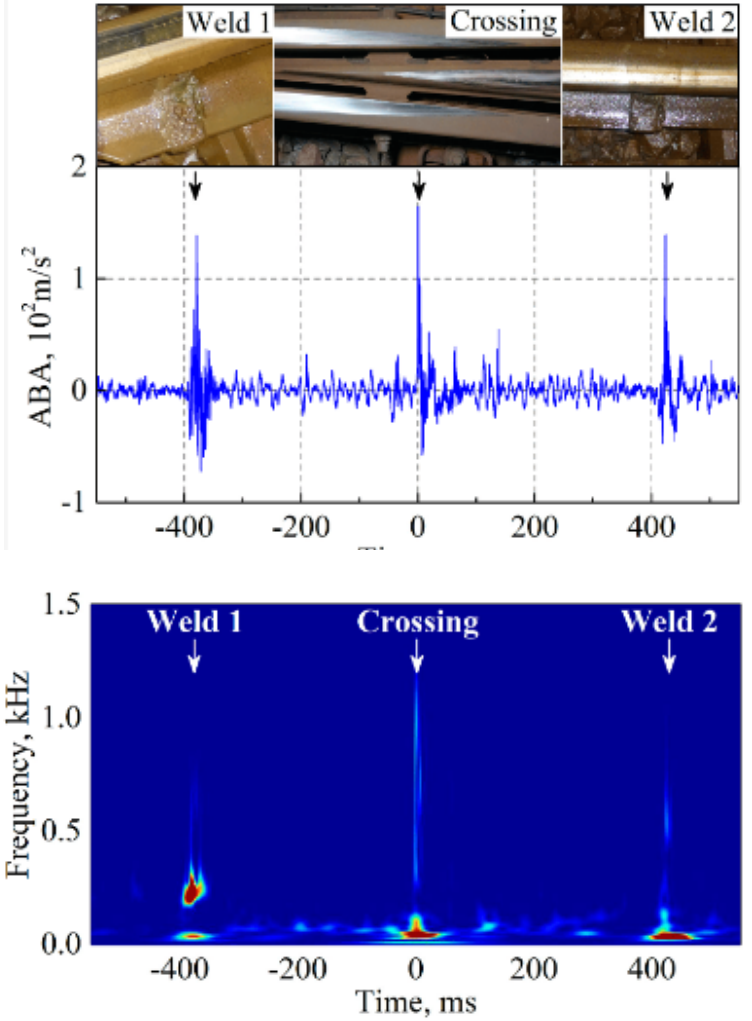
(c) ABA at IRJs with plastic deformation (G-A)

(d) PSD at IRJs with plastic deformation (G-A)

(e) ABA at an IRJ with a crack in the fastener (E-W)

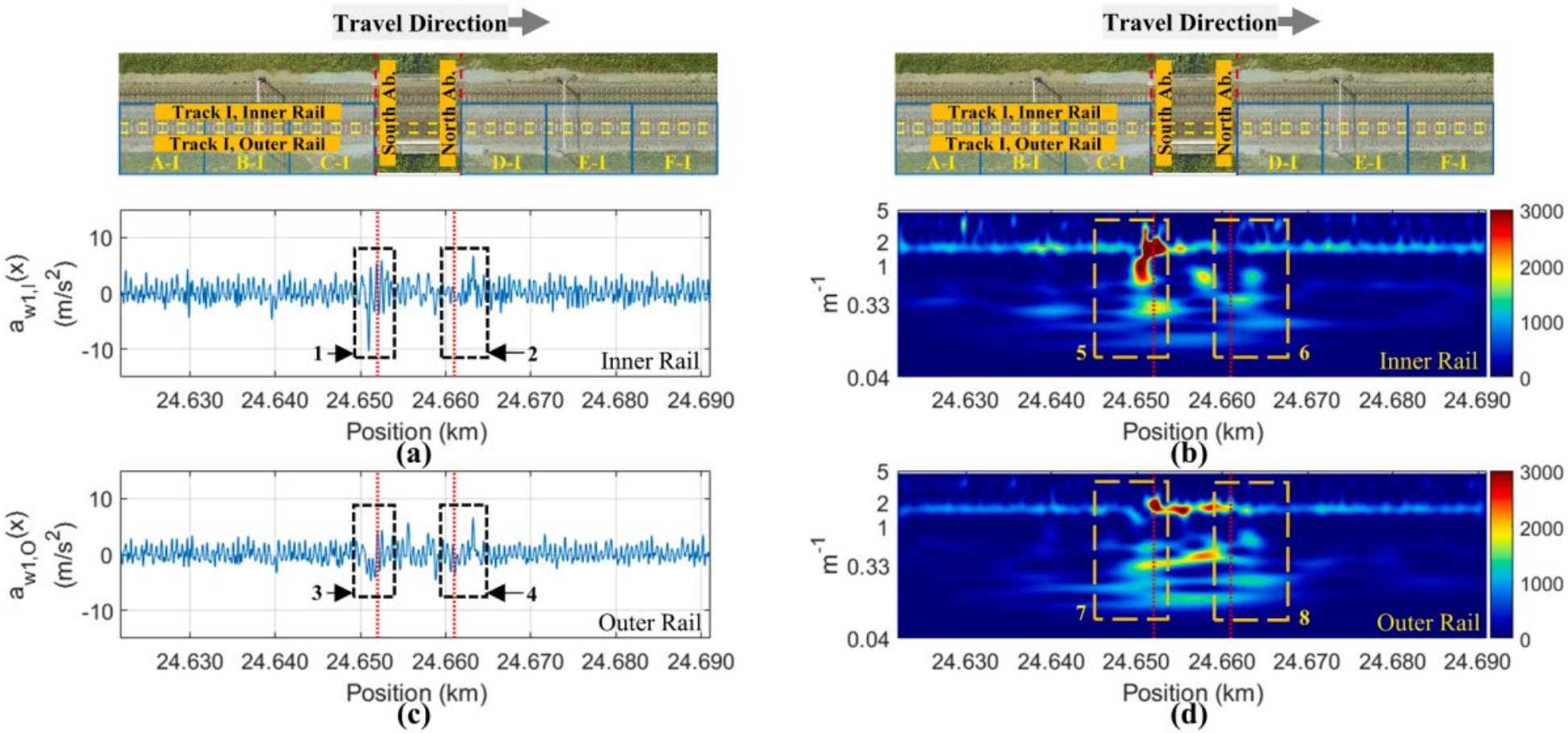
(f) PSD at an IRJ with a crack in the fastener (E-W)

M. Molodova, M. Oregui, A. Núñez, Z. Li, R. Dollevoet. (2016). Health condition monitoring of insulated joints based on axle box acceleration measurements, Engineering Structures 123.




Z. Wei, A. Núñez, Z. Li and R. Dollevoet. (2017). Evaluating degradation at railway crossings using axle box acceleration measurements. Sensors, Volume 2017, Issue 17(10), 2236, September 2017.

# Examples of our publications

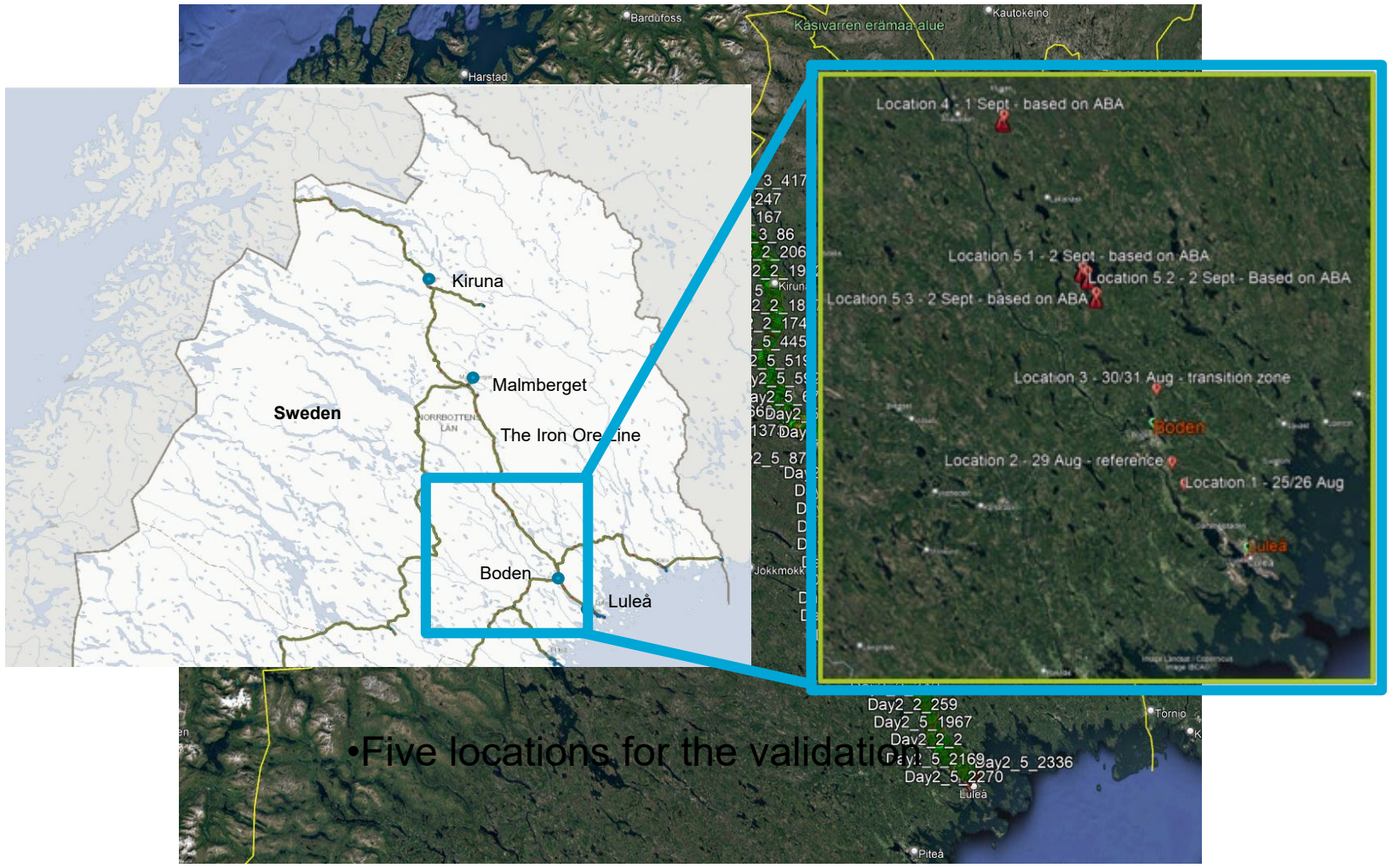



S. Unsiwilai, L. Wang, A. Núñez, Z Li, (2023). Multiple-axle box acceleration measurements at railway transition zones. Measurement 213.

# Measurement campaign

Measurements are from a comprehensive environment:

- Iron Ore Line (Lulea-Narvik)
- Single track
- Passenger-freight mixed traffic
- Heavy axle load, freight-dominated (~31 t)



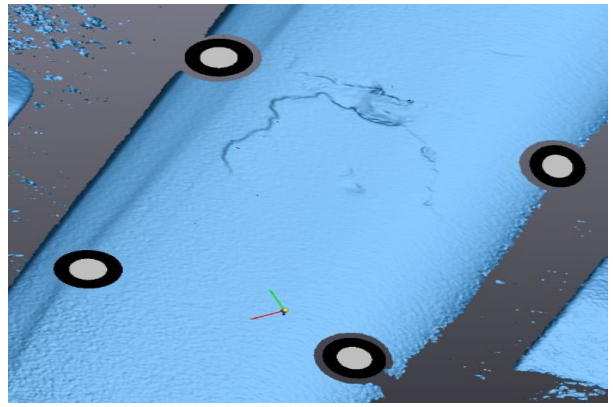
# Visual inspections

# Other measurement techniques

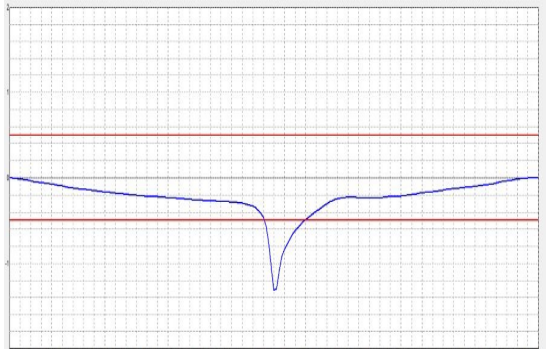
In2Track3

Track geometry profile measurements

3D scanner



Railprof



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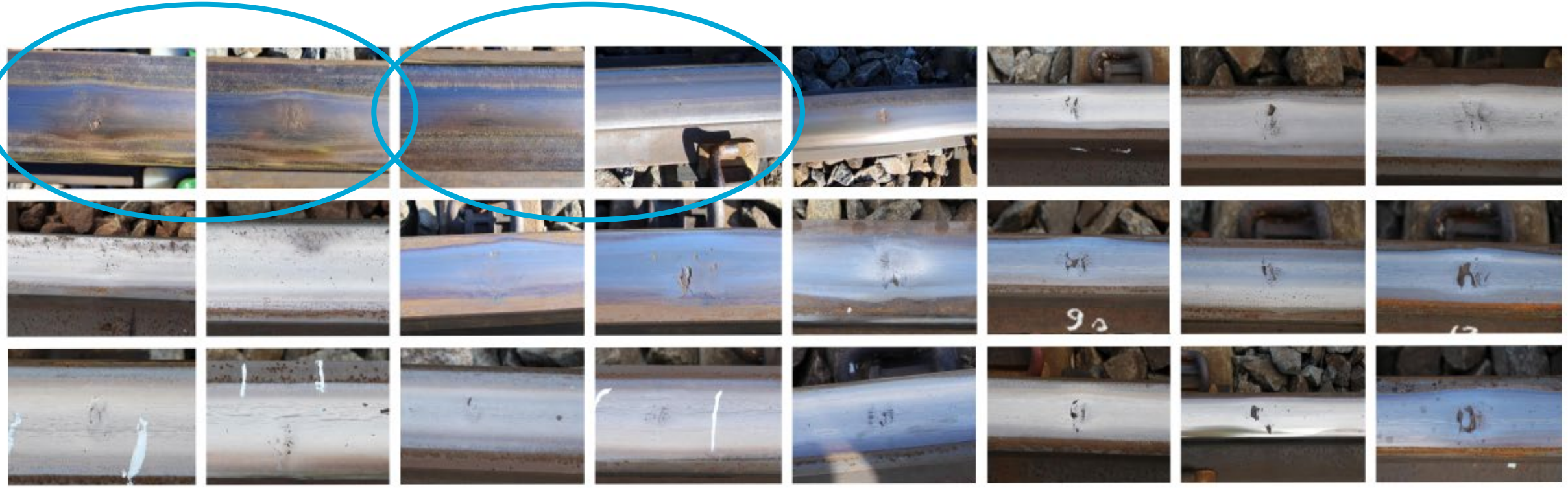
# Other measurement techniques

Track stiffness measurements

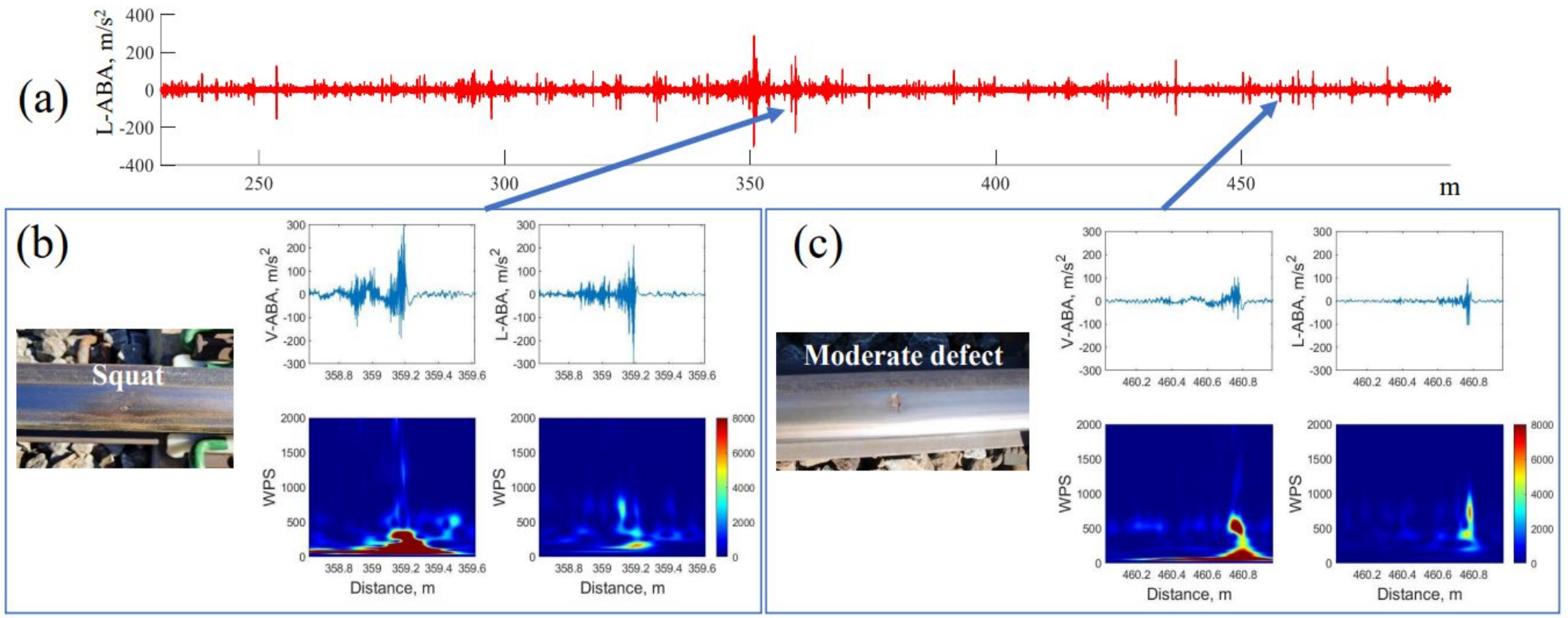
# Photos of some squats and other defects from the field inspection.



# Detection methodology

- The ABA measurements are from the vertical and longitudinal directions.
- The time-frequ
- A threshold is defined according to energy variations beyond local average values.

So, how do we detect rail defects?



# Results

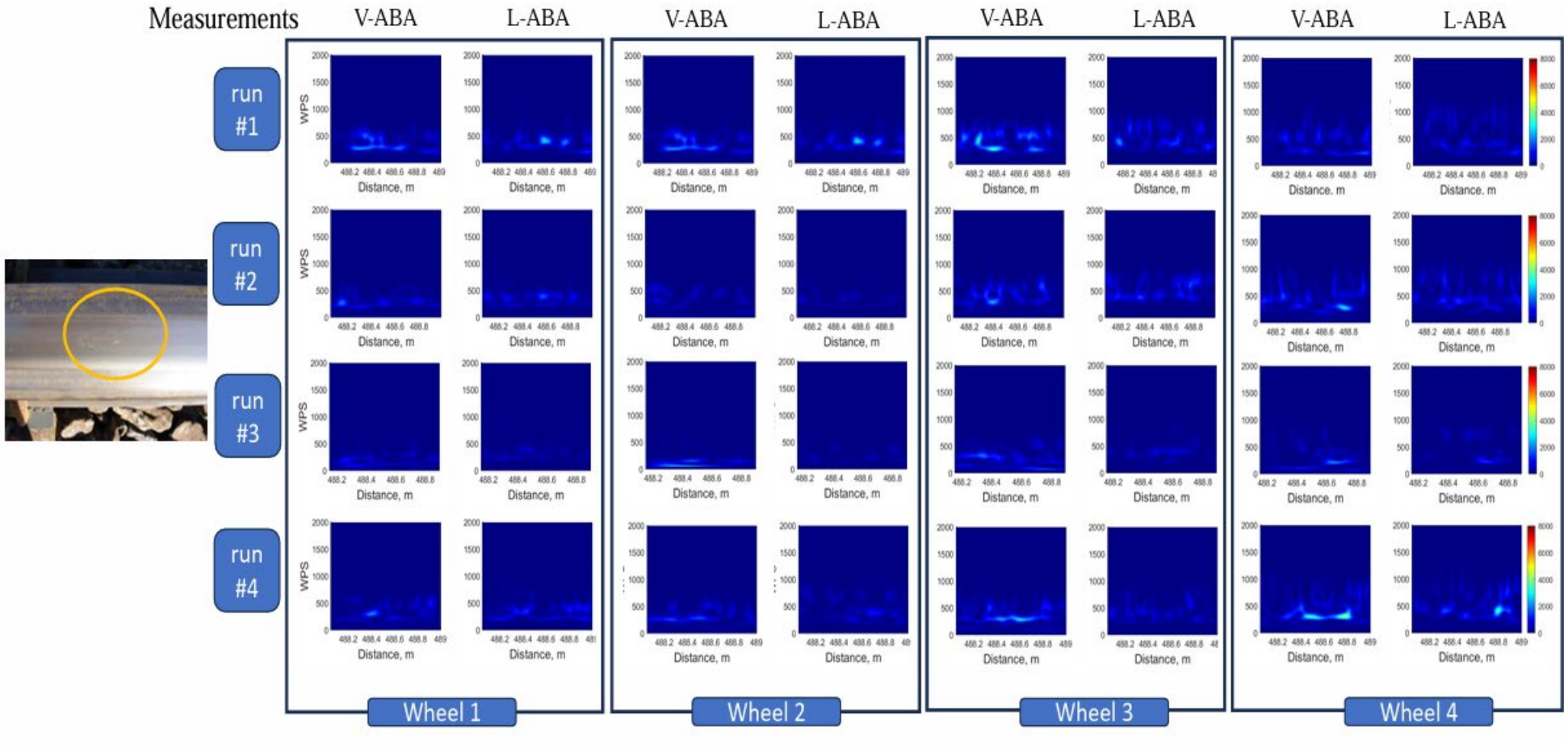
- 100% of moderate and severe defects were detected.
- Detection of moderate and severe defects was almost obtained in real-time.
- All insulated joints and some locations of welds and small defects were also detected.

| | Location 1 | | Location 2 | |
|---|---|---|---|---|
| | Field inspection | ABA detection | Field inspection | ABA detection |
| Insulated joint | 1 | 1 | 3 | 3 |
| Squat | 5 | 5 | 2 | 2 |
| Other severe defects | 1 | 1 | 0 | 0 |
| Weld | 14 | 6 | 30 | 17 |
| Small defect | 29 | 14 | 9 | 2 |

| | Location 3 | | Location 4 | | Location 5 | |
|---|---|---|---|---|---|---|
| | Field inspection | ABA detection | Field inspection | ABA detection | Field inspection | ABA detection |
| Insulated joint | 1 | 1 | 0 | 0 | 0 | 0 |
| Squat | 3 | 3 | 34 | 34 | 9 | 9 |
| Other severe defects | 0 | 0 | 4 | 4 | 1 | 1 |
| Weld | 12 | 6 | 24 | 13 | 17 | 3 |
| Small defect | 27 | 1 | 65 | 10 | 10 | 1 |

# Discussion

A trade-off between setting the threshold and the number of benign defects detected




An example of an undetected small defect

# Conclusions

- ABA measurements demonstrate the capability of rail defect detection.
- ABA measurements allow identification of priority locations in tracks for maintenance actions.
- ABA measurements can be used to assess the condition of welds and monitor small defects.

# Outlook

- ABA can be embedded into existing railway track information systems to continuously monitor the ABA energy at defects and components such as welds, S&Cs, insulated joints, transition zones, bridges, etc.

- As various measurement techniques were used to collect data, information from those different data types can be extracted and integrated with ABA data to enhance the effectiveness and interpretability of the continuous monitoring of track components and defects.

# Acknowledgements

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# Thank you for your attention

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