REDUCING THE OCCURRENCES AND IMPACT OF FREIGHT TRAIN DERAILMENTS

D-Rail Final Workshop
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Monitoring and supervision concepts and techniques for derailments' investigation

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SEVENTH FRAMEWORK PROGRAMME

Inspection and monitoring techniques

Objectives:

- Provide critical and detailed assessment of current and emerging inspection and monitoring techniques,
- Examine prevention and mitigation for the 'total freight system' (vehicle, track and their interaction),
- Develop from previous findings suitable cost effective technical improvements,
- Provide forward functional and operational requirement specifications.
- Pilot testing of new technologies

Methodology

- Survey about monitoring techniques to provide a detailed review of current inspection and monitoring techniques related to derailment prevention and mitigation.

- These technologies have been further investigated and assessed regarding derailment main causes (WP1), Cost analysis (WP2) and most relevant parameters (WP3) to determine suitability to capture key derailment parameters.

- A matrix with causes to derailment v.s. preventive inspection and monitoring techniques has been formed (commented by different railway experts).

- By means of a gap analysis, missing technical functions or functions that could be improved have been highlighted.

- Among potential technological improvements efficient to monitor critical derailment parameters, some selected promising technologies have been tested and validated .

Assessment matrix for monitoring systems

- Results:
  - Causes related to Infrastructure : High effectiveness of existing technologies
    - Rail failure
    - Track geometry parameters
  - Causes with highest potential for technological improvements:
    - Wheel failure
    - Spring & suspension failure
    - Skew loading

Assessment matrix for monitoring systems

- Experts general comments
  - Development of information handling systems gathering data from different systems
  - Analysis and sending an alarm to the right user
  - Harmonization of limit values.
  - Develop international standards for each detection method is necessary to support interoperability.
- Starting point for technology enhancement
  - Overall effectiveness
  - Potential for improvement

Improvement of monitoring techniques

Which functionalities in existing systems require further development?

=> Identification and proposition of potential improvements of existing systems:

Axle load checkpoints, Hot box detectors, Wheel profile and diameter systems, Track geometry measurement systems…

Which functions in existing systems are missing today?

=> Identification of missing functions by means of gap analysis

- Analysis done for scenarios from WP3: Wheel failures, Flange climbing in line operations, S&C, Rail failures
- Proposition of promising techniques or innovative solution to meet these gaps and improve the derailment detection:

  Ex: Reinforce, complement and integrate onboard systems with ground systems

DRAIL innovative propositions – Selection and testing

- Link between WP4 results (functional specifications for system application) and WP6 (validation through testing of derailment prevention technology)
- The purpose is to provide an industrial and critical point of view of the following innovations validation.
- Among all innovative technologies efficient to monitor critical derailment parameters, DRAIL focused on, tested and validated the following:
  - MERMEC: Wheel checker
  - FAIVELEY: Derailment Prevention Device
  - DAKO: Derailment detection
- Cross-border testing by DB and Trafikverket

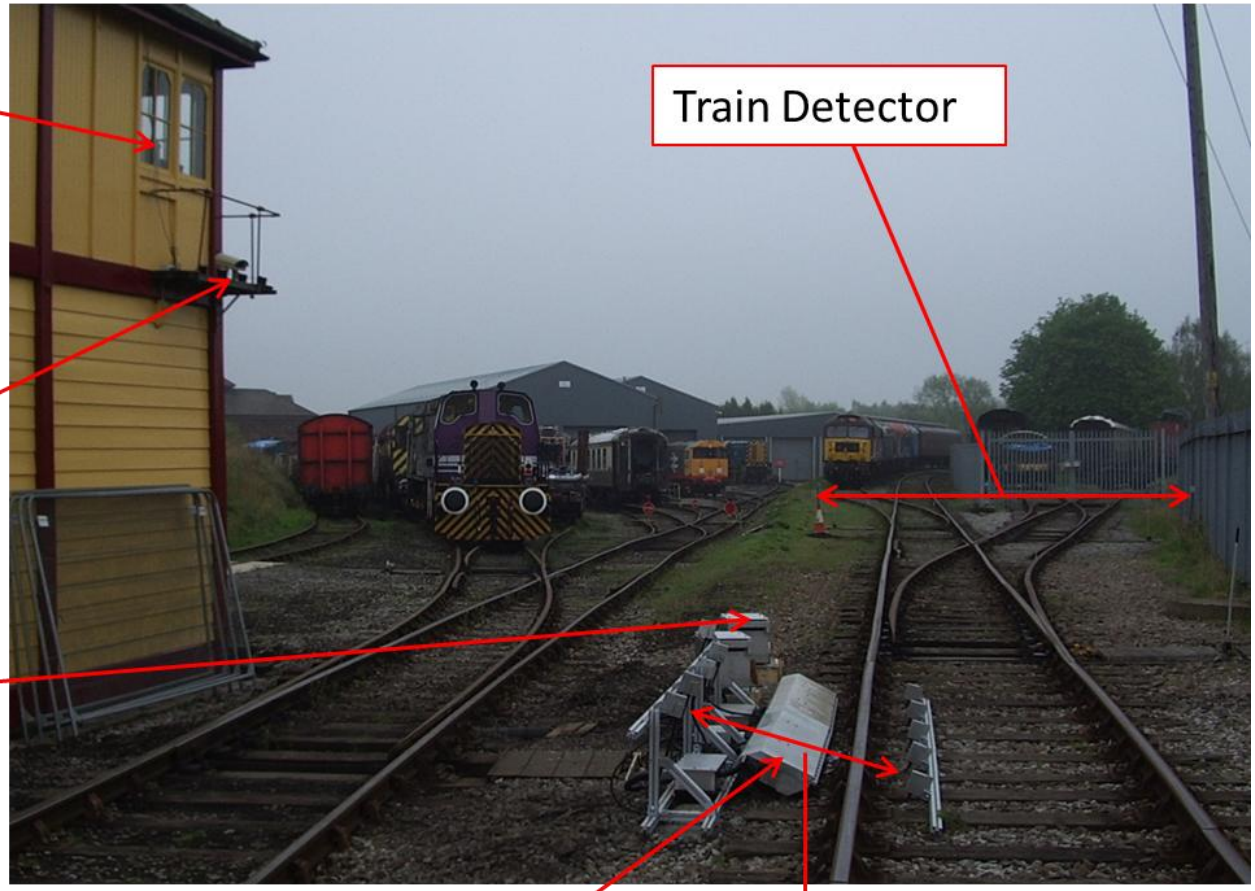
MERMEC – Wheel Checker

MERMEC wheel surface defects inspection system was tested in Barrow Hill

- Non-contact wheel surface inspection system able to perform an automatic visual inspection of the wheelsets in service,
- Automatically detect and identify surface defects on the wheels of trains passing in revenue service (also cracks on the tread of the wheel shelling, spalling, flat spots…),
- Derailment cause: Wheel breaks.
- Proposed adaptation for DRAIL: Focus on **flange defects**
- Physical principle: high definition cameras.

MERMEC – Wheel Checker

Test equipment

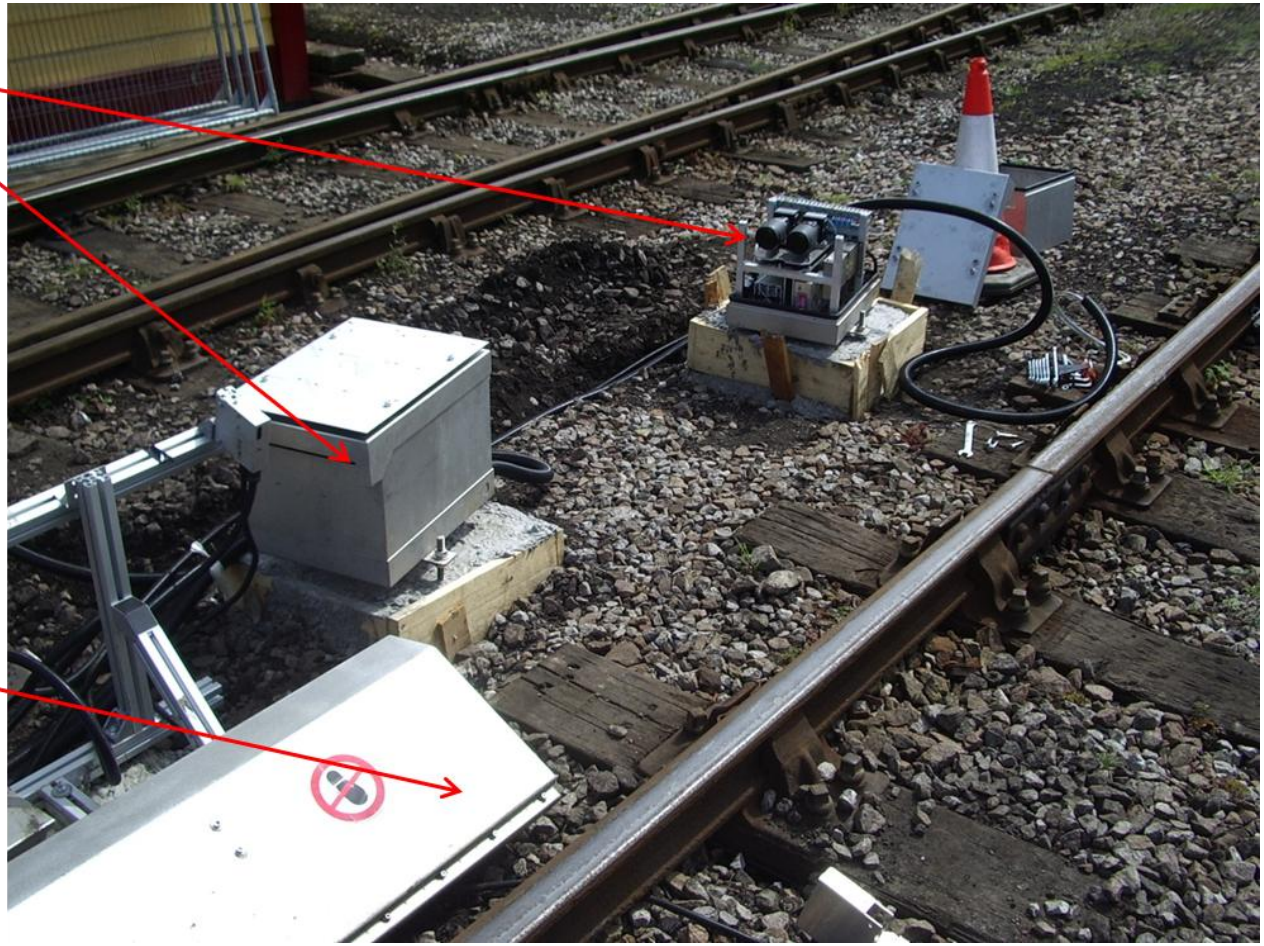


MERMEC – Wheel Checker

Test equipment

Wheel Checker Cameras

Wheel Lighting Boxes (Protective cover over lights)

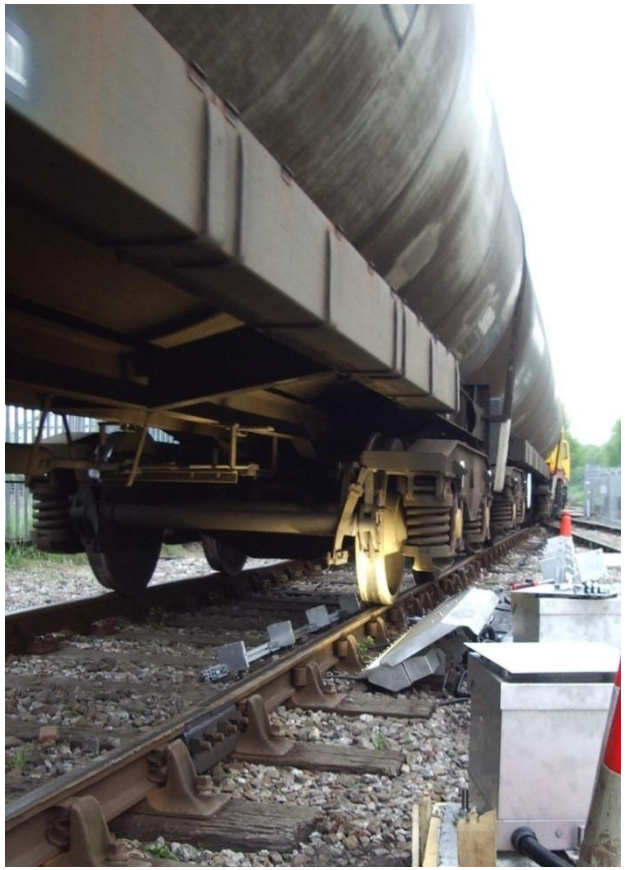


Wheel checker installation and tests

Installation, then leave the system running to capture data automatically for a period of months and tune the image processing

Capture data from traffic between depot and national network for a period of months, including capturing vehicles which visit repeatedly

- Including a group of 8 class 20 locos and tank wagons which visit between regular periods operating on the network
- Different background lighting and environmental conditions

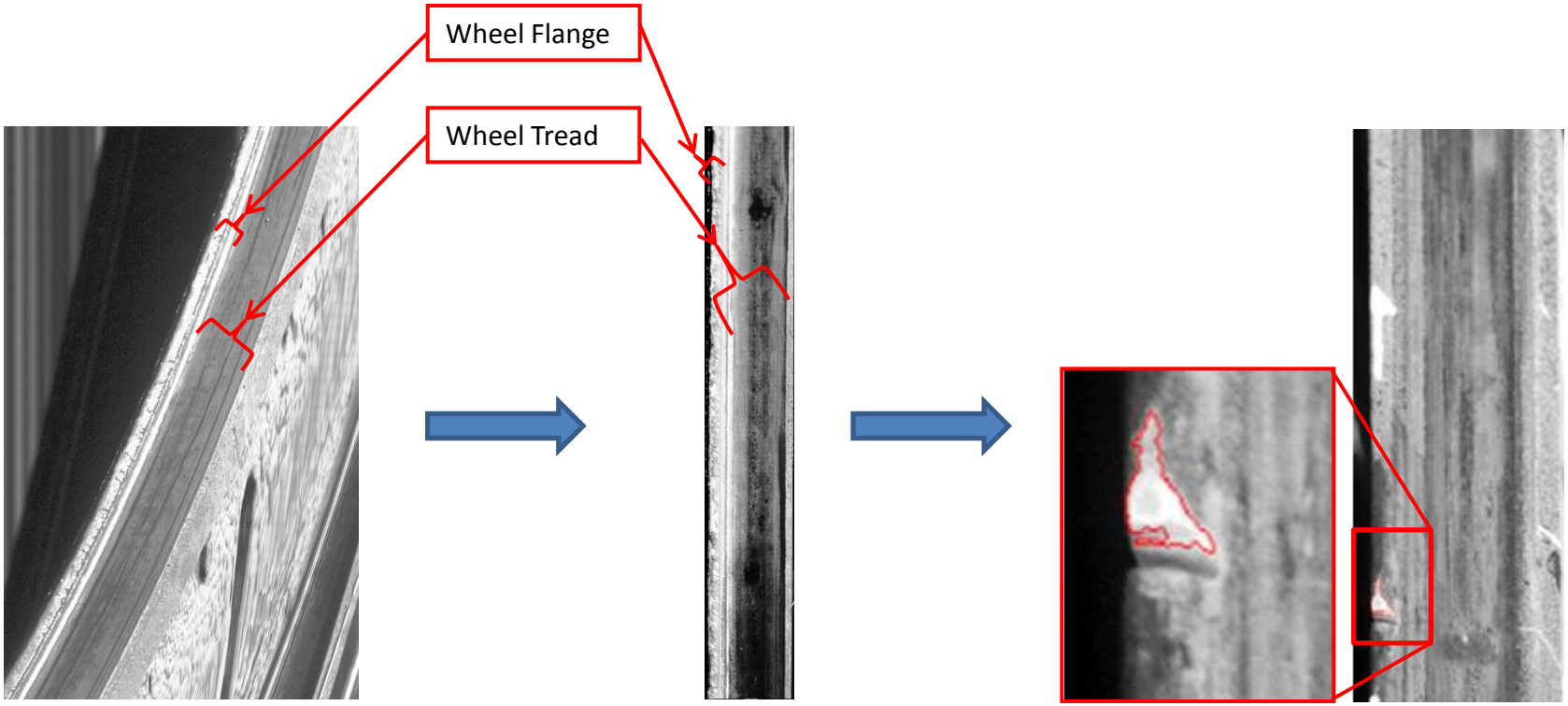


Wheel checker installation and tests

Flange defects have been artificially created on the wheel of a vehicle to replicate a flange broken in service. To run this vehicle through the system, to capture data and tune the image processing.

Results of the test sessions

The system has acquired detailed images of the wheel tread and flange and has successfully detected the artificial defects on the wheel flange



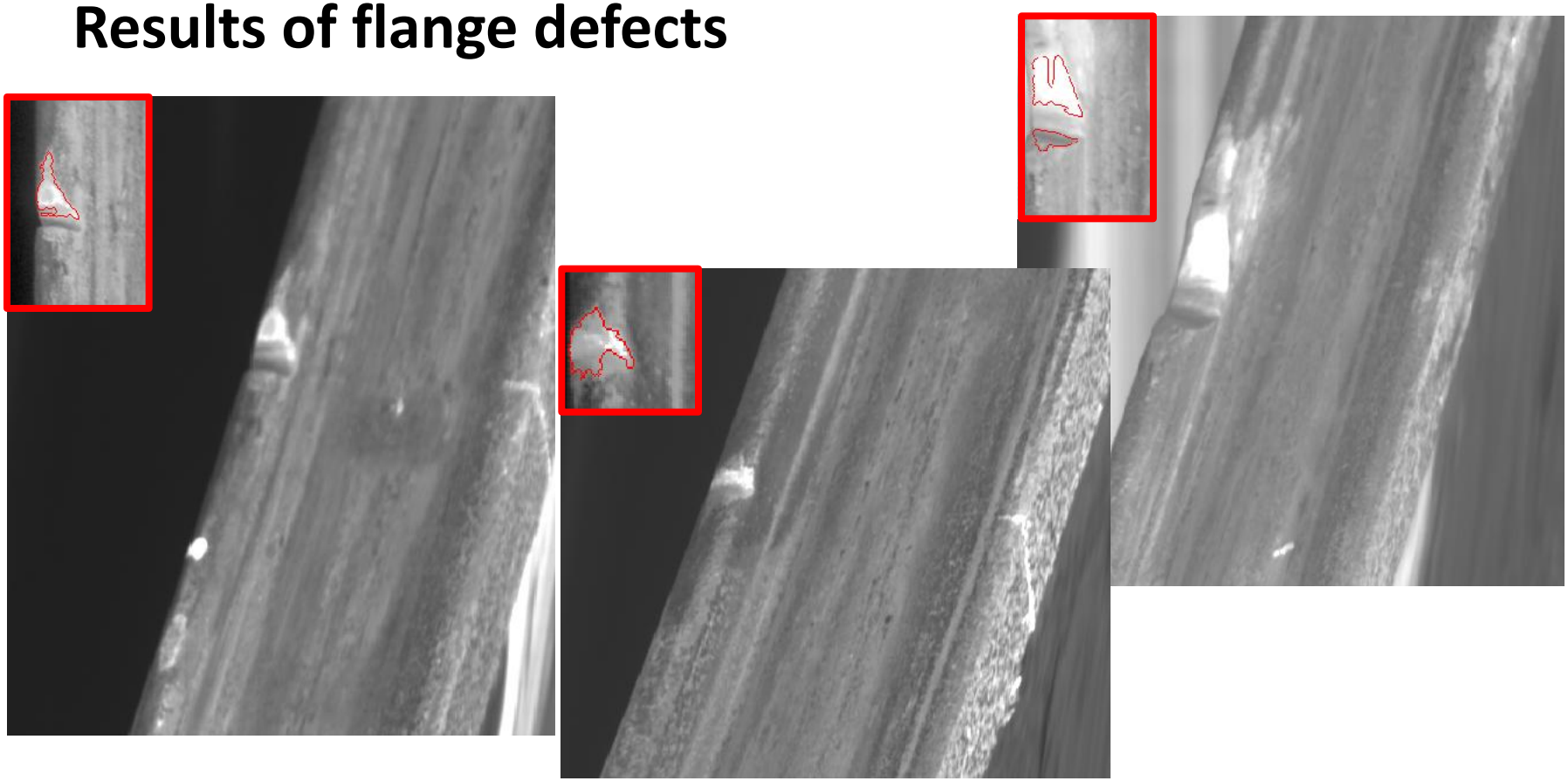
Raw Picture of the wheel

Straightened picture

Processed picture with detected flange defect

MERMEC – Wheel Checker

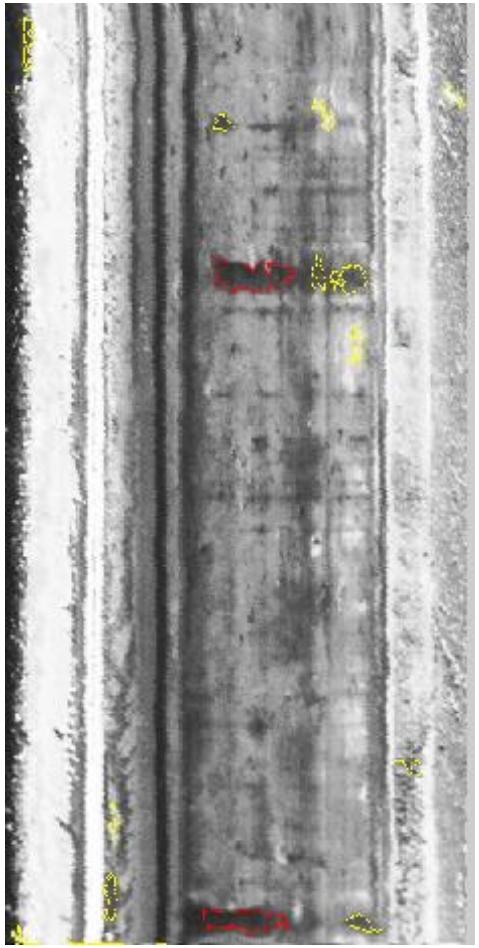
Results of flange defects

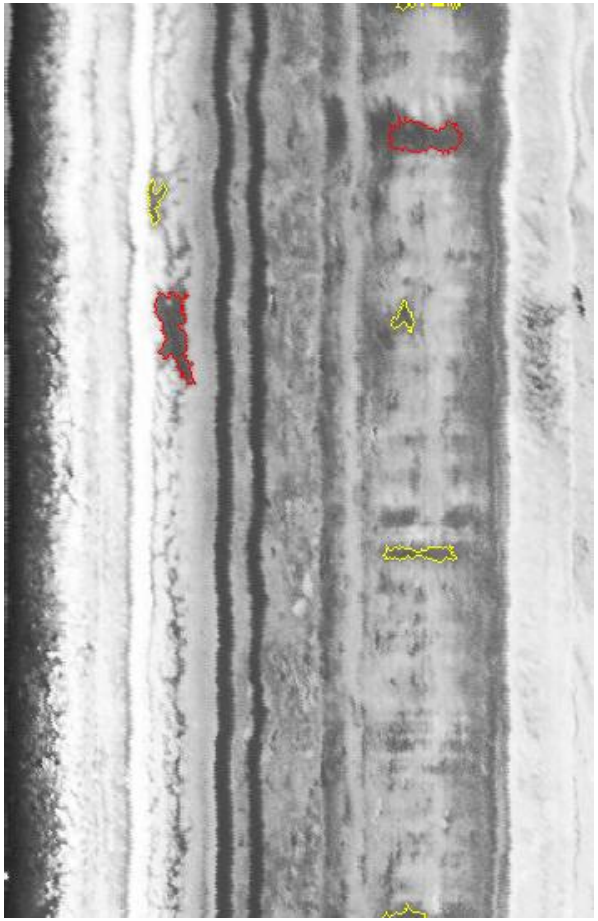


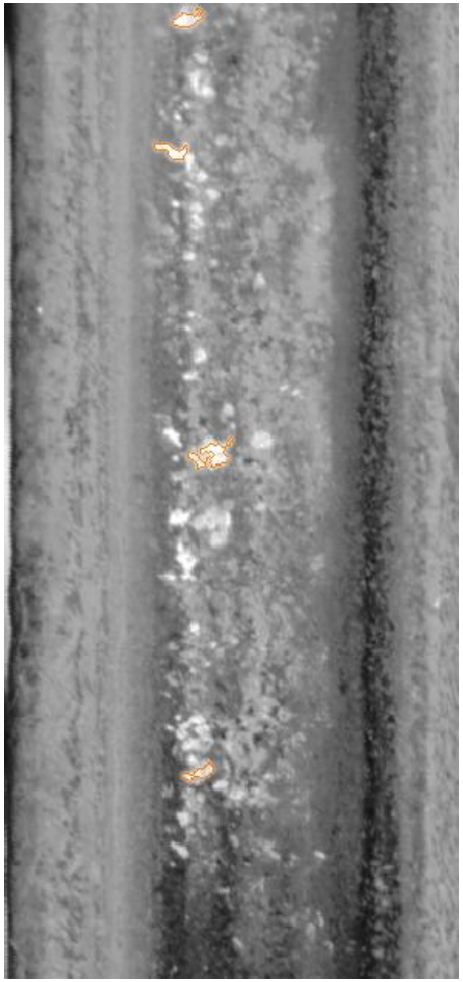
Raw pictures of the wheel and processing results

MERMEC – Wheel Checker

Other results







Straightened pictures and processing results

MERMEC – Wheel Checker

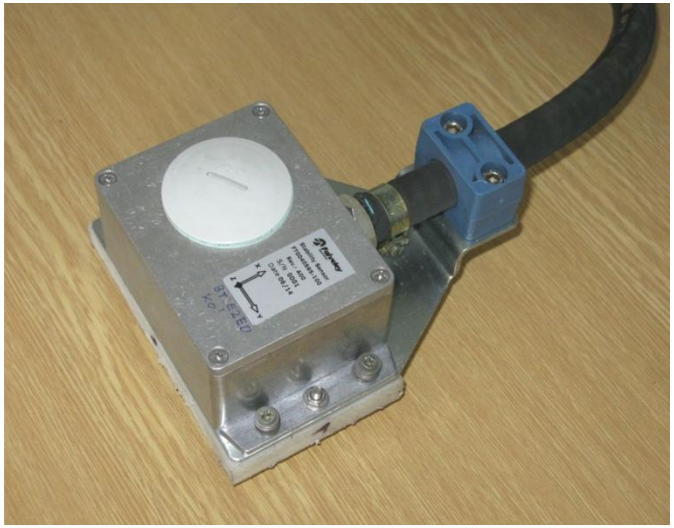
Conclusions

- The system was successfully integrated into a railway site
- No special adaptations to vehicles or operations were required
- The system successfully captured images and detected defects, especially broken flange defects.
- Future testing and validation
  - Other kind of defects on the wheel wear.
- Exploitation and future improvements:
  - *Improve robustness of the system*
  - *Improving the image processing for automatic defect identification and creating alerts*

FAIVELEY instability sensor

- on-board prevention device aiming at detecting abnormal conditions of vibration and/or shock. At the actual design level the sensor is able to log the 3 axis acceleration rates and to detect high acceleration pattern in time domain
- one possibility to detect conditions for derailment is to equip each car with a scrutiny device, organised to take the best for range of signals of accelerometers and gyroscope, and to establish comparison rules, algorithms and tables in order to detect the moment when the conditions turn from normal to abnormal
- the proposed device is an intelligent safety sensor designed to be installed on the bogie frame and on the car body

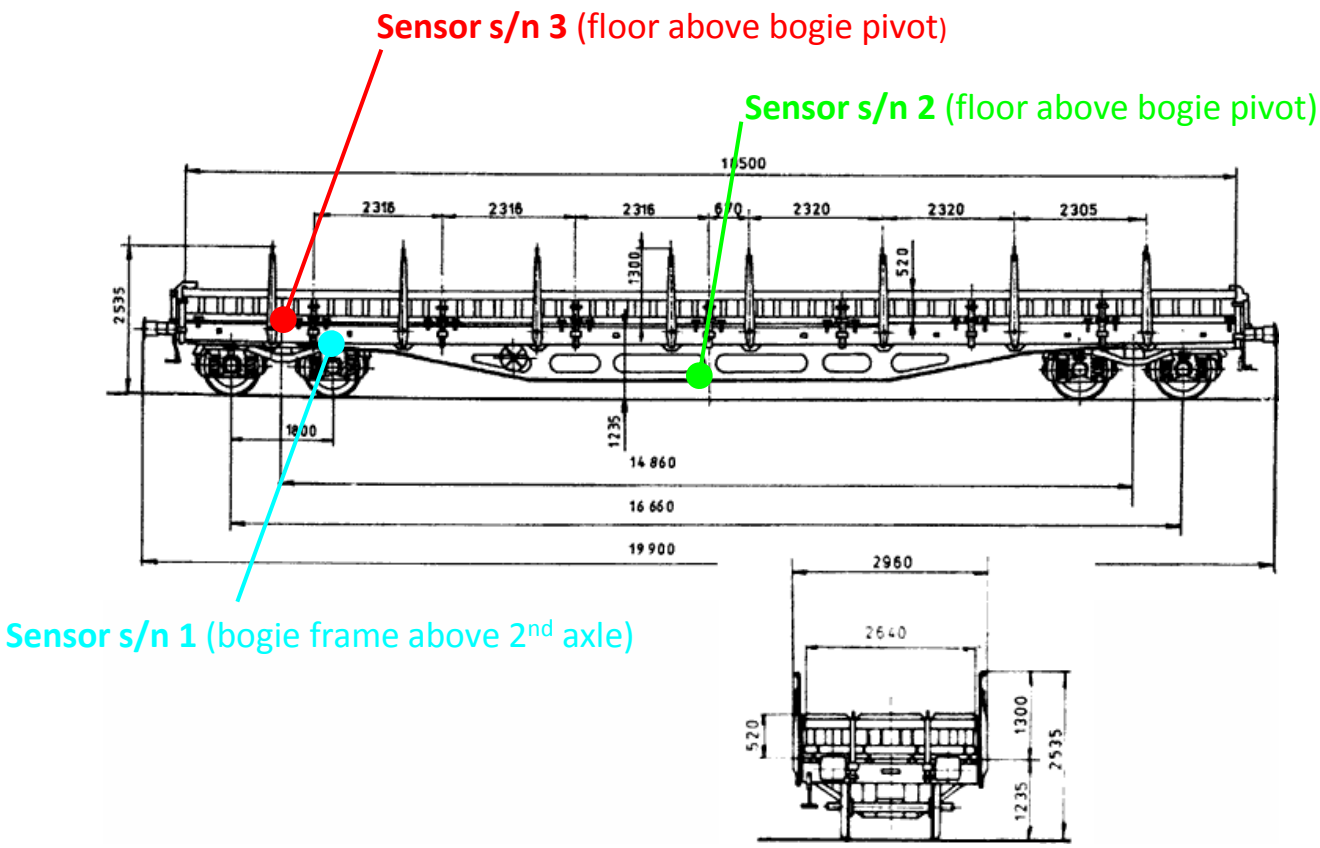
FAIVELEY instability sensor



FAIVELEY – BOGIE STABILITY SENSORS

FAIVELEY instability sensor

- three sensors were installed on the flat car – one on the bogie frame and two on the car body – and were left running to simulate both normal operation and abnormal conditions



FAIVELEY – BOGIE STABILITY SENSORS

FAIVELEY instability sensor

Test objectives

- To record the bogie and body acceleration levels in normal wagon operation including stressing track section as bad line junction, track switches, not frequently used section etc.
- To set up the detection parameter according to the previous point from tests logged data. And to test the detection by simulating bogie abnormal acceleration values, including derailment.
- To analyse off line the logged data to verify that:
  - the detector works correctly
  - acceleration sampling filtering and span is well suited for the detection
  - compare the bogie and body vibration levels to be able to estimate if one unit mounted on body is enough to check both bogies.

FAIVELEY instability sensor – test conditions

- **Normal operation test** - several test runs at different speeds were performed on the small test circuit
- **Test runs with not well tightened coupler** - the test train was prepared by releasing the coupler links between the test and VUZ measuring car. Test runs were performed on the small test circuit

FAIVELEY instability sensor – test conditions

- **Coins test** - on the left rail 5 round flat metal pieces, about 25 mm x 1 mm in size were placed 10 m from each other. Test runs were performed on the small test circuit
- **Wheel flat** - A flat of about 2 cm length on the wheel under sensor 1 was produced by manual abrasion tool. The flat was checked to be well audible . Test runs were performed on the small test circuit

FAIVELEY – BOGIE STABILITY SENSORS

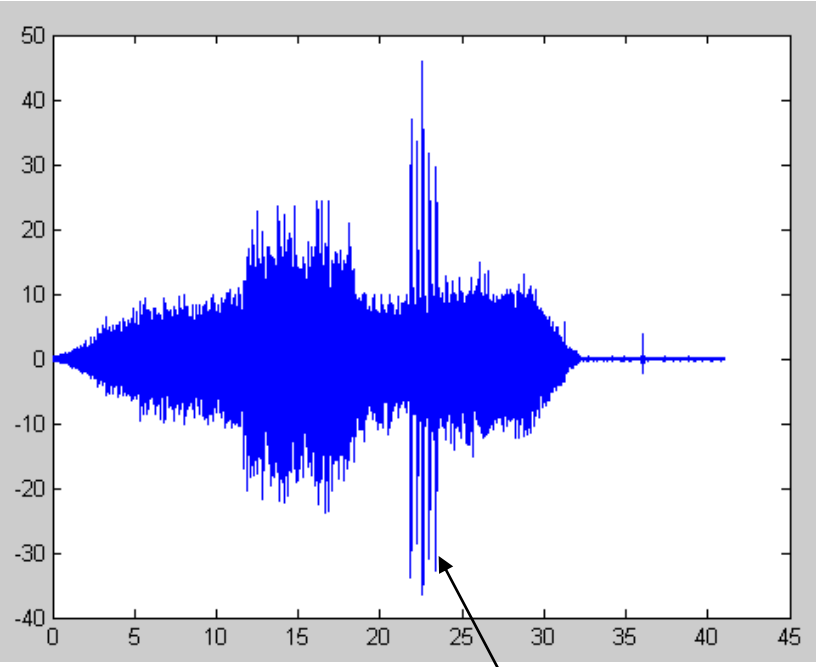
FAIVELEY instability sensor – test conditions

- **Derailmentest** - two real derailments were performed using the derail device. During the test the wagon was being pushed by VUZ diesel locomotive at very low speed (about 8 km/h). Tests performed on the auxiliary yard in the VUZ test centre.

FAIVELEY instability sensor – test results

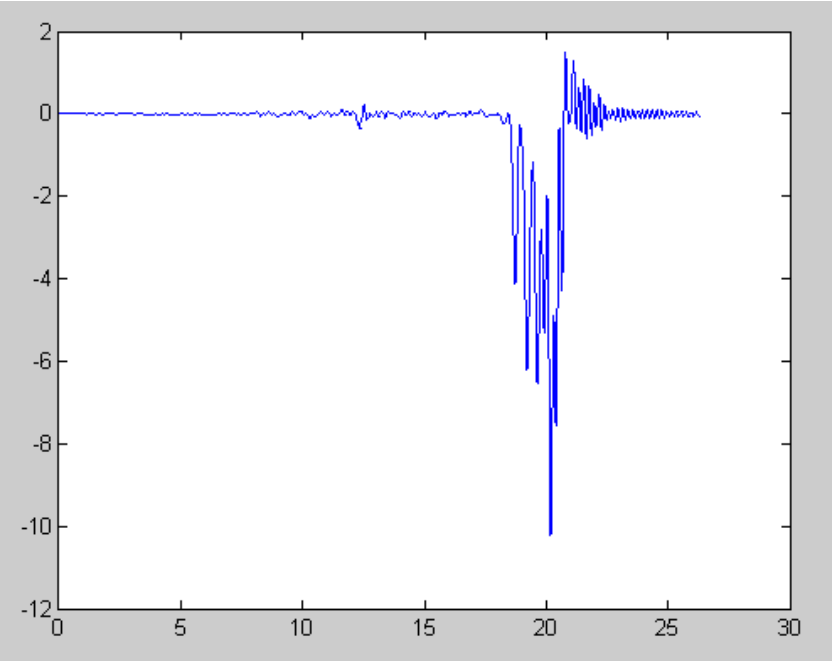
Examples of acceleration signal from the sensor

Coins test



coins

Derailment (filtered 5 Hz)



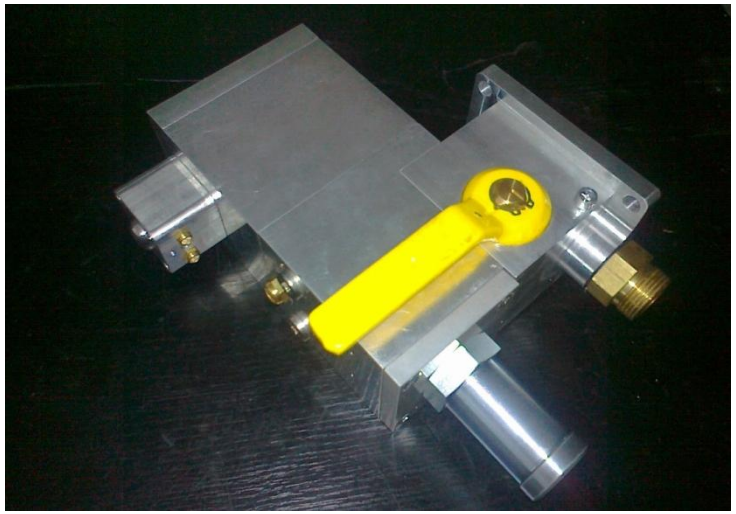
Conclusions – Exploitation perspectives

- The device was easily implemented on a wagon
- Lots of recordings have been gathered at different speeds, reflecting real running conditions and providing a solid database
- FT has confirmed his confidence for the sensitiveness of the sensors.

- Future improvements
  - *Use the Velim tests recordings as input data to simulate real running conditions*
  - *Optimize the algorithm and the fine tuning of the instability sensor*
  - *Determine if body installation is sufficient or if bogie installation is necessary*
  - *Develop wireless transmission to locomotive*
  - *FT system could be mixed with GPS and GSM-R systems in order to provide important messages for maintenance (vehicles and track)*

DAKO DETECTING SYSTEM

- DAKO detecting system is a newly developed device which is designed to detect derailment and significantly reduce the impact of derailment
- integrated sensor is able to detect high acceleration values in time domain
- two sensors have been installed on both headstocks of a tank wagon and connected to the brake pipe. In addition one accelerometer was attached next to the detector in order to measure the acceleration of wagon headstock where the detector was installed. The value of vertical acceleration at which the detector is activated was set on **9.5 g**.



DAKO DETECTING SYSTEM

Test objectives

- to check if the detector is not activated during normal operation running including stressing track section as track switches, not frequently used section etc.
- to check if the detector is activated when the vertical acceleration of wagon headstock reaches value of 9.5 g. For this purpose the wagon was running over wedges of various heights

DAKO DETECTING SYSTEM

The tests were carried out under two load conditions:

- unladen (25,6 t)
- laden (77,5 t)

- **normal operation test** - several test runs at different speeds were performed both on the small and large test circuit at unladen and laden condition
- test speeds: 50, 60, 70, 80, 90, 100, 120, 132 km/h
- during normal operation test at unladen and laden condition none of the detectors was activated
- maximum value of acceleration measured by the parallel accelerometer at unladen weight was **2.6 g**
- maximum value of acceleration measured by the parallel accelerometer at laden weight was **4.4 g**

DAKO DETECTING SYSTEM

- **test runs over wedges** - test wedges of various heights were put on both rails and the test wagon ran over them at different speeds at unladen and **laden weight**. The wagon was pushed by the locomotive until the first wheelset ran over wedges
- wedge height: 4, 6, 15, 30 mm
- test speed: 5, 10, 15, 20, 25, 30, 40 km/h

DAKO DETECTING SYSTEM

- during runs over wedges at unladen weight none of the detector was activated
- during runs over wedges at laden weight the detector above the first wheelset was activated for wedge height 30 mm and speed 20 km/h

DAKO DETECTING SYSTEM

Test runs over wedges – results

Wedge height [mm]	Speed [km/h]	Vertical acceleration
4	10	1.1 g
	20	1.3 g
	25	2.3 g
6	20	1.5 g
	40	2.6 g
15	5	1.3 g
	15	2.0 g
30	10	2.0 g

Wedge height [mm]	Speed [km/h]	Vertical acceleration
4	10	1.8 g
6	20	2.8 g
15	5	5.5 g
30	10	7.0 g
	15	7.1 g
	20	9.3 g

- **After successful tests the DAKO device is ready for a trial operation.**

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THANK YOU
FOR YOUR ATTENTION

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