



**ORDINE DEGLI INGEGNERI
DELLA PROVINCIA DI FIRENZE**



**Collegio Ingegneri Ferroviari Italiani
sezione di Firenze**

IMPIANTO DINAMICO POLIFUNZIONALE “OSMANNORO”

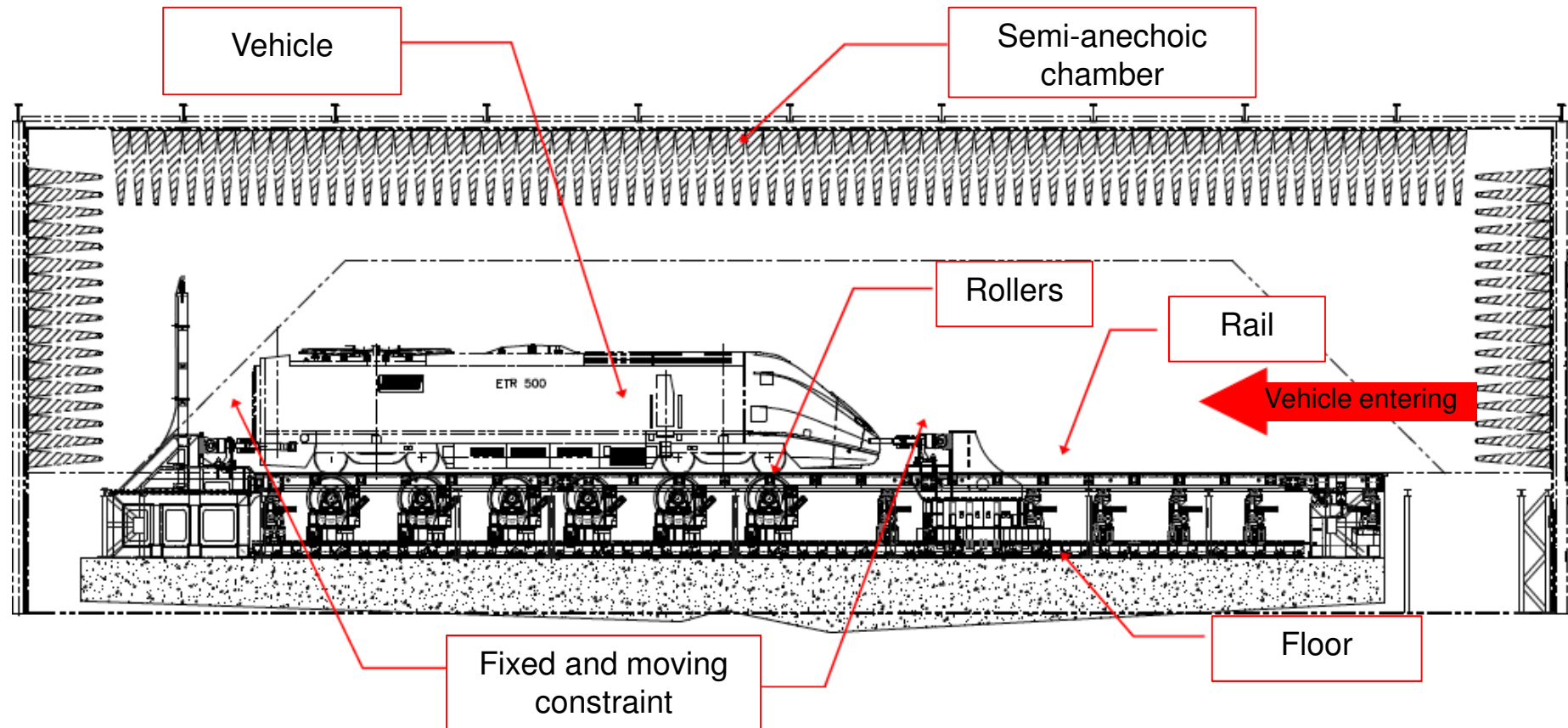
**Il mondo universitario.
Sia progettisti che utilizzatori**

Prof. G. Diana



**POLITECNICO
MILANO 1863**

Full scale roller rig



Full scale roller rig

The full scale roller rig includes:

- six rollerstes (rollers, motors, sensors, etc.)
- a semi-anechoic chamber (50m x 25m x 12m)
- the vehicle under test (wagon or locomotive)
- a control room (8m x 4m x 3m)

Aim of the roller rig is:

- to verify traction systems of locomotives up to 6 axes
- to test anti-slip/anti-skid control systems
- to identify braking performance
- suitable for performing electromagnetic tests (radiated emissions and immunity) on the locomotive
- **to study and test diagnostic systems to prevent derailment conditions**

Full scale roller rig

Roller rig main characteristics

Max. axle number	[-]	6
Max. bogie number	[-]	3
Gauge	[mm]	1450
Max. wheel diameter	[mm]	1350
Bogie wheelbase	[mm]	1600÷3200
Max. speed	[km/h]	400
Max. traction power	[MW]	10
Max. traction force	[kN]	500

In the test bench are present 6 rollersets, one for each possible axle

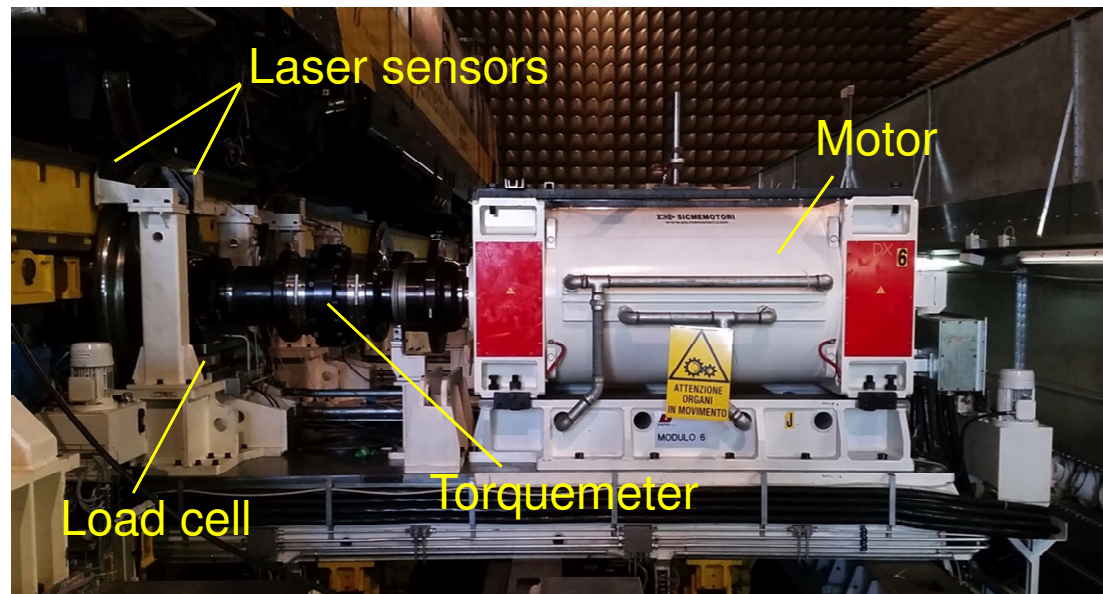
The roller rig allows to test vehicles having up to 6 axes and 3 bogies



Full scale roller rig

Each rollerset is constituted of:

- two 950 kW electric motor (one per wheel);
- four tri-axial load cells to measure rail-roller contact forces;
- two torquemeters to measure torques transmitted by the shafts of the roller motors;
- three encoders to measure the angular speeds of the rollers and of the vehicle axle;
- six laser sensors to measure the distance of the wheels from the roller in the longitudinal, lateral and vertical direction.

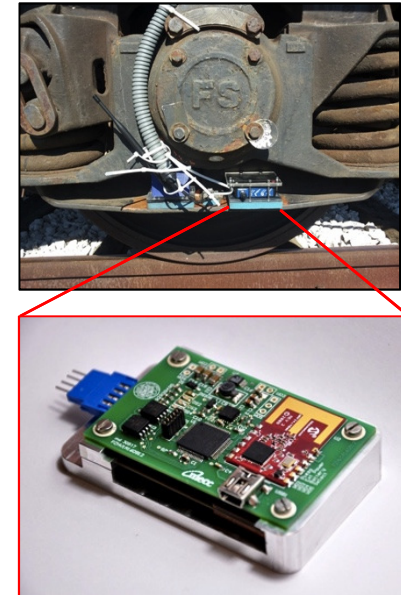


Diagnostic device

Application of the roller rig to develop a diagnostic system for freight trains

The roller rig allows

- to study, develop and test **diagnostic systems** able to identify downgraded conditions (cracks in train axles, etc.), which may lead to derailment
- overcoming limitations characterizing on-line testing:
 - safety concerns
 - low reproducibility of experiments
 - several parameters may affect the results

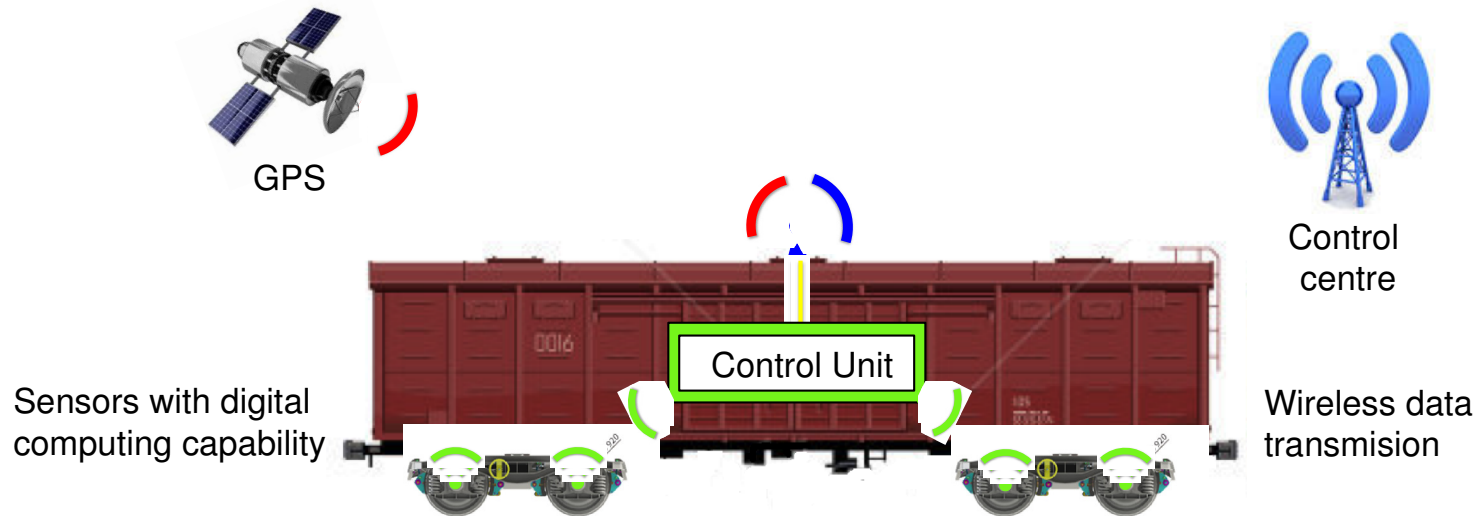


JRC (Joint Research Centre) is developing a **diagnostic device** for **freight trains** based on **acceleration measurements**, which should be integrated within an **information network** allowing communication between train wagons, locomotive and infrastructure.

Diagnostic device

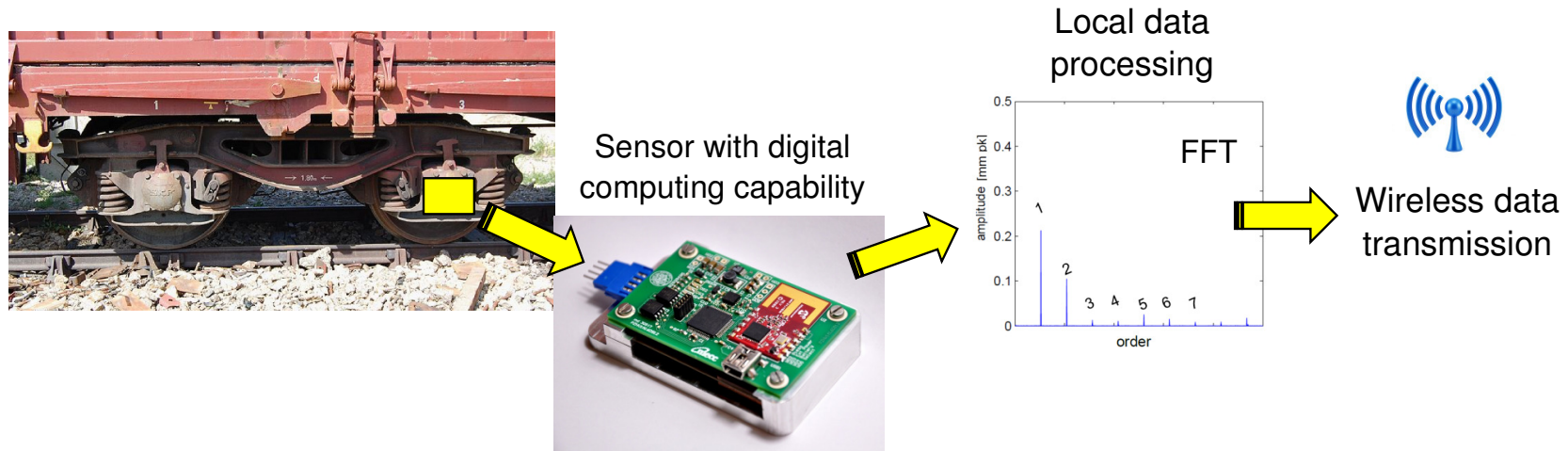
On-board diagnostic device requirements:

- autonomous from an energetic point of view
- digital-computing capability for local processing of acquired data
- capability of transferring information to the locomotive (operator)
- wireless communication
- easy to install
- applicable to mixed freight trains (tanks, goods, etc.)



Diagnostic device for crack detection

Diagnostic device



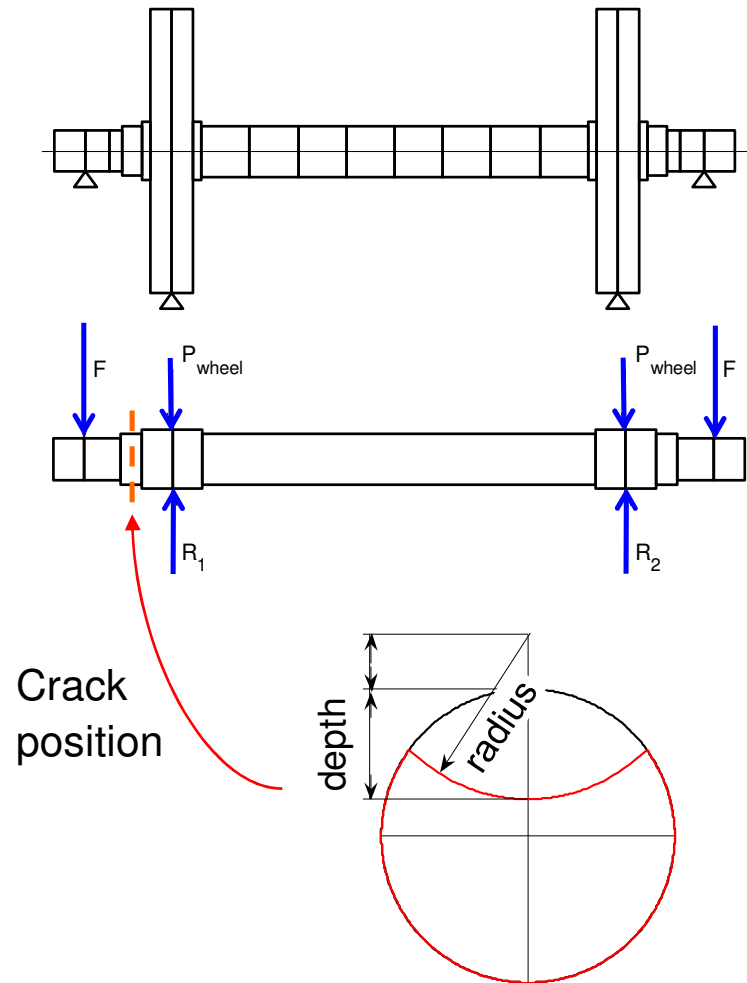
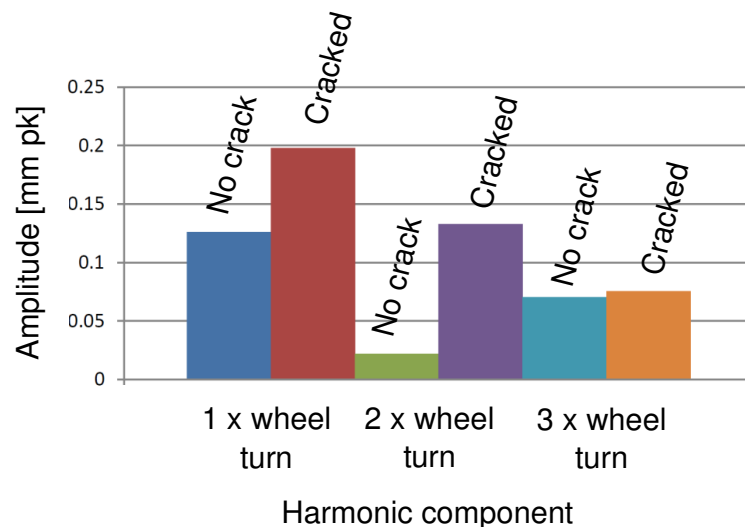
- The sensor is based on acceleration measurements
- A support was designed to filter out high frequency disturbances and amplify 1x, 2x and 3x vibration components
- The device is able to process acquired data (frequency domain analysis)

Diagnostic device for crack detection

Algorithm

Frequency domain analysis of FE simulations and laboratory tests showed that:

- presence of cracks increases the amplitude of the first three harmonics of vibration amplitude spectrum
- depth of the crack should be about 20mm (10-15% of cross section cracked) to be detected due to measurement and environmental noise (e.g. track irregularity)



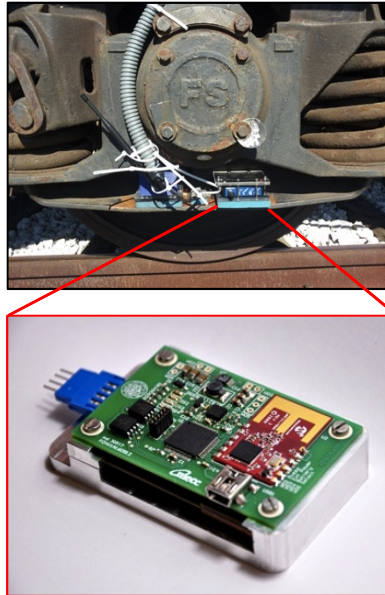
Finite Element (FE) model



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Detection of downgraded running behaviour

Detection of downgraded running behaviour



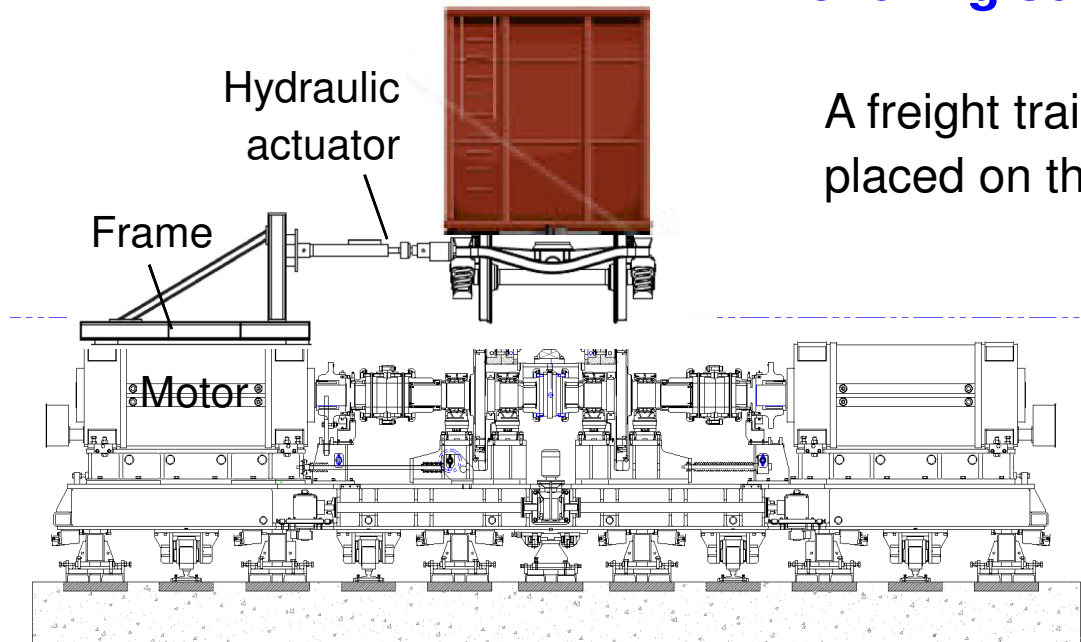
The sensor node also includes an accelerometer to measure bogie lateral acceleration

Lateral acceleration sensor is included for detection of downgraded running behaviour

Downgraded running behaviour when the rms of bogie lateral acceleration (filtered at 20 Hz) overcomes a threshold

Diagnostic device for crack detection

Roller rig setup for diagnostic device testing



A freight train equipped with a **cracked axle** is placed on the roller rig

Controlled hydraulic actuators allow to vary wheelset-roller relative lateral position

This setup allows to:

- test freight train wagons with **cracked axles**, whilst maintaining **safety**
- vary **noise** affecting measurements
- obtain **reproducible results**
- simulate turns and straight lines



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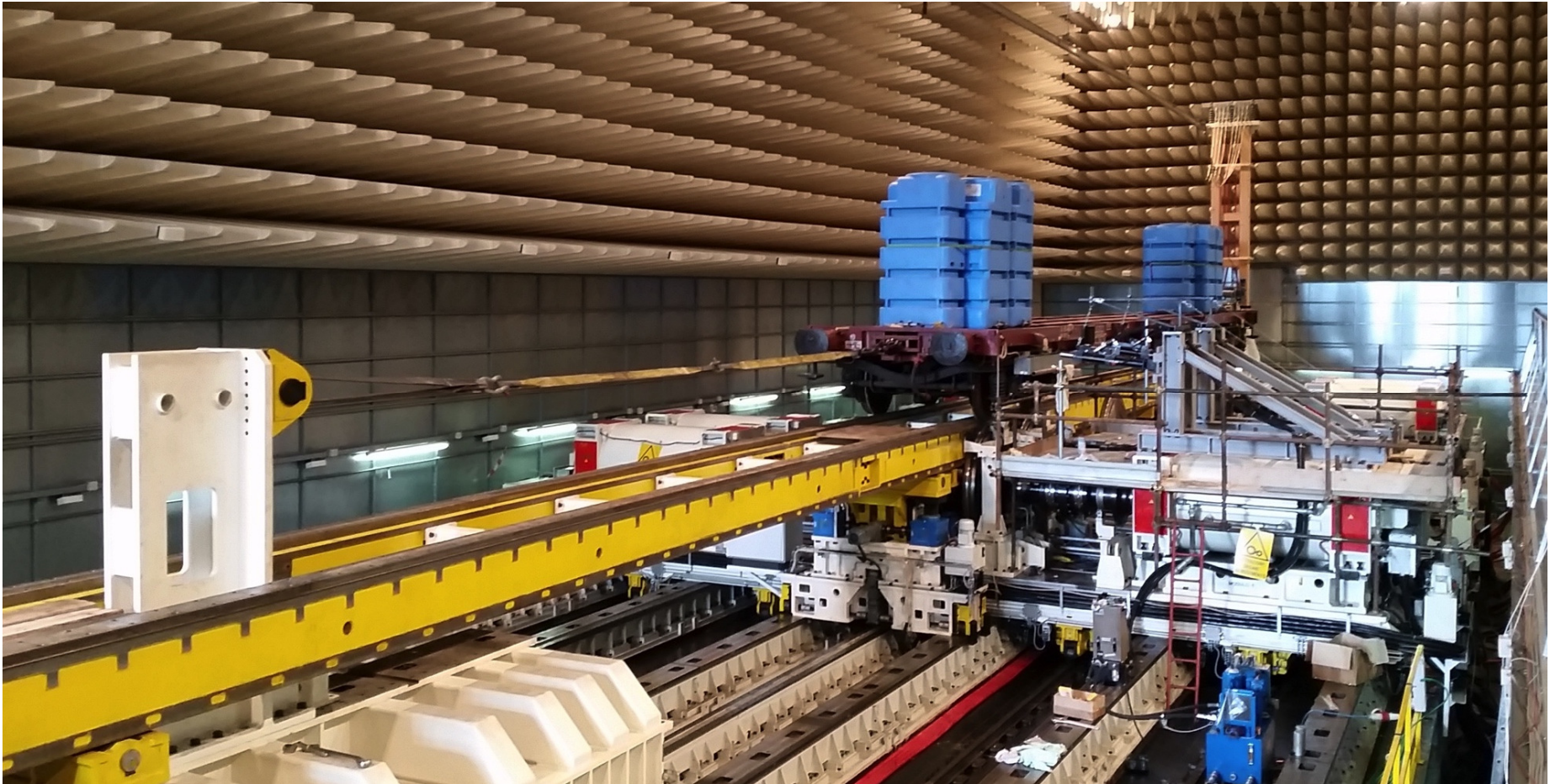
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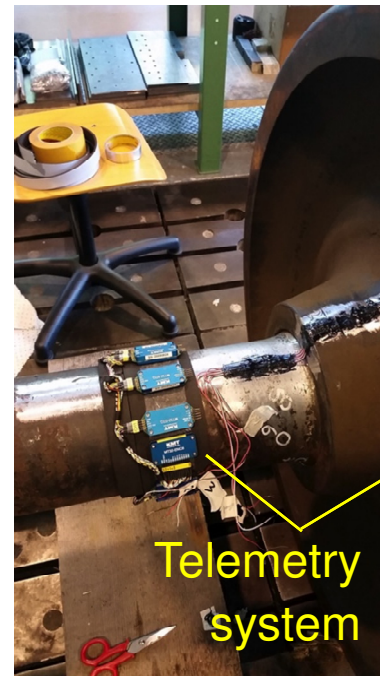
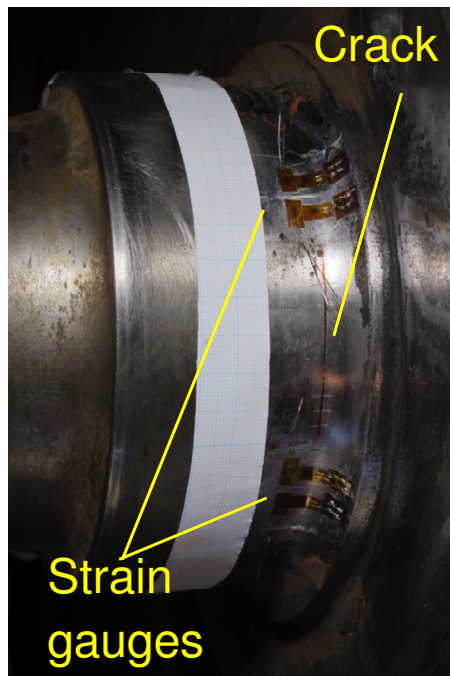
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Experimental setup

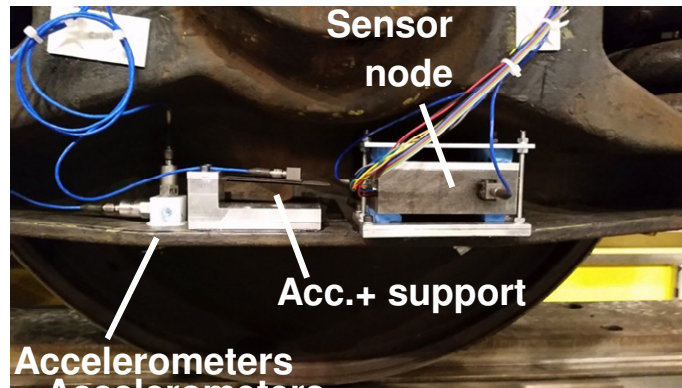


Experimental setup

Strain gauges are placed on the axle to monitor crack propagation and thus maintain safety

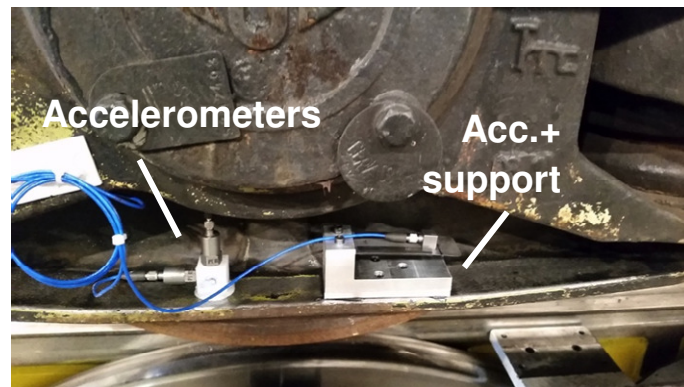


Experimental setup



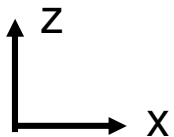
Cracked axle

- Sensor node
- 1 single axis accelerometer (z) + support
- 2 single axis accelerometers (x,z)



Not-cracked axle

- 1 single axis accelerometer (z) + support
- 2 single axis accelerometers (x,z)



Constant speed: 80 km/h

FFT of longitudinal acceleration (x-axis)

