



# Current Developments in Rigid Catenary-Pantograph Wear Reduction: Insights from the University of Málaga

Rail Vehicle Dynamics Research Group of the University of Málaga

Department of Mechanical, Thermal and Fluids Engineering, University of Málaga, Spain

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## Rail Vehicle Dynamics Research Group of the University of Málaga

Analysis of contact forces between the pantograph and the overhead conductor rail using a validated finite element model. *Engineering Structures*, 2020

A procedure for validating rigid catenary models using evolutionary techniques. *Computers and Structures*, 2020

Evaluation of the influence of the speed, preload and span length on the contact forces in the interaction between the pantograph and the overhead conductor rail. *Engineering Structures*, 2021

Influence of main operating conditions on contact wire wear of rigid catenary lines. *Tribology International*, 2024

A study on the dynamic response of the double pantograph interaction with rigid catenary. *Engineering Structures*, 2025

## Research Projects:

**"Detection of irregular wear zones in rigid catenary of Malaga Metro and their decrease based on wear models validated with tunnel measurements."**

**Ref: PROYEXCEL\_00379**

**"Prediction of wear in rigid catenary with experimental validation on track"**

**Ref: PID2023-148854OB-C22**

- Ministry of Science and Innovation
- University of Malaga
- Andalusian Regional Government
- Mechanical Engineering Department of Malaga
- Vehicle dynamics laboratory

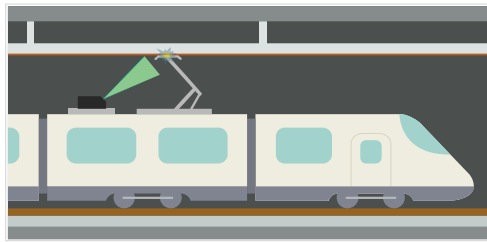
Study the behaviour of the rigid catenary-pantograph contact and analyse the resulting wear of both parts

To be able to carry out predictive maintenance of both elements

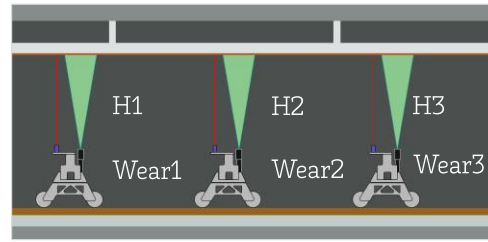


## Field work

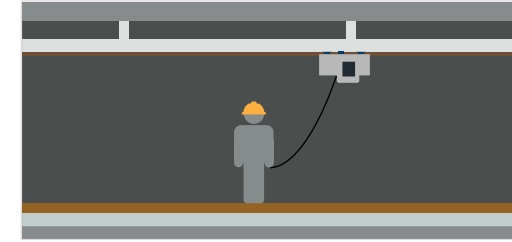
Locate contact  
wire wear areas



Extra information  
of the facility



Create a wear  
register

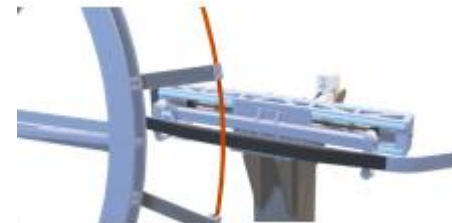


## Laboratory work

Simulate contact  
behaviour



Development of  
wear models



- **Locate contact wire wear areas**

## On-board electric arc detection device

Locate electric arc  $\approx$  locate wear areas

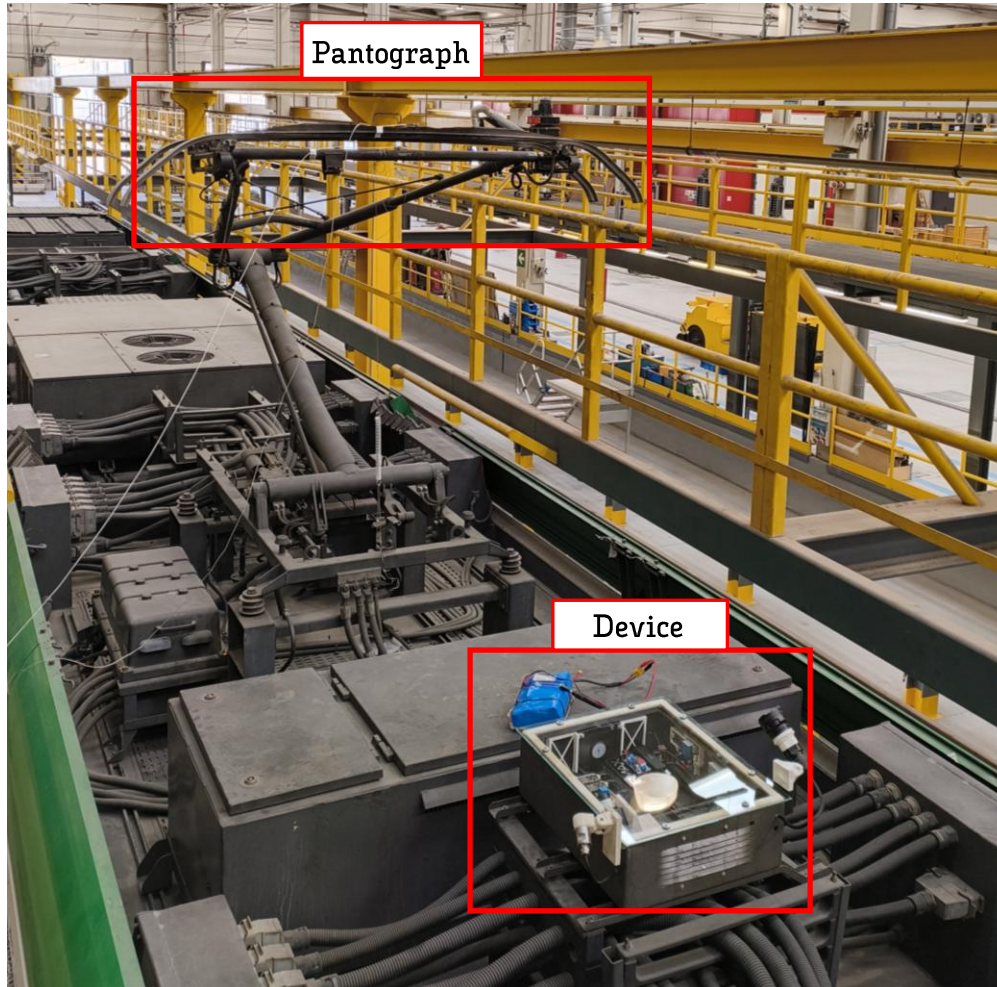
Remote control device

Video recording of the tunnel vault

Get additional information with sensors



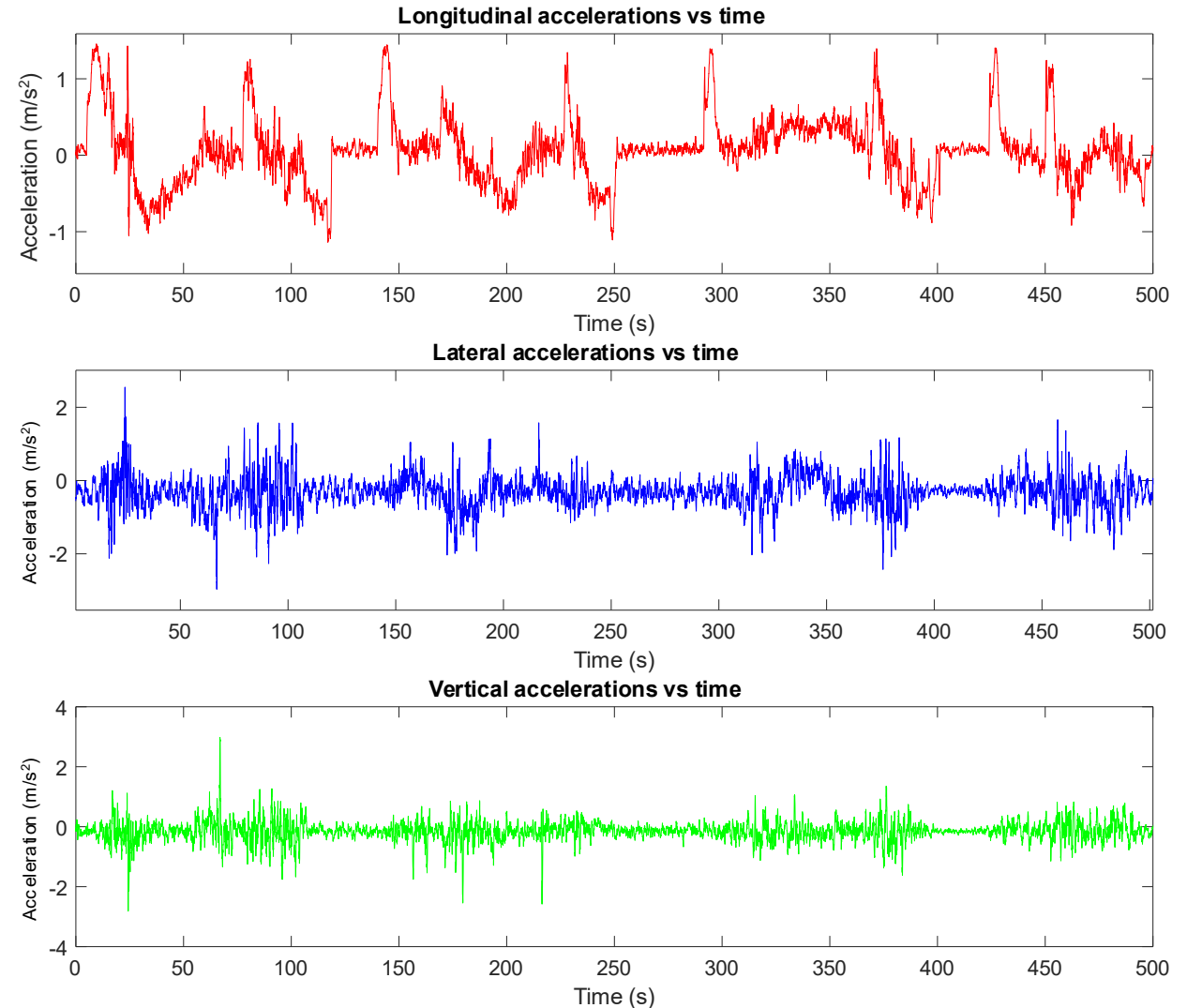
# ON-BOARD ELECTRIC ARC DETECTION DEVICE



## Additional information

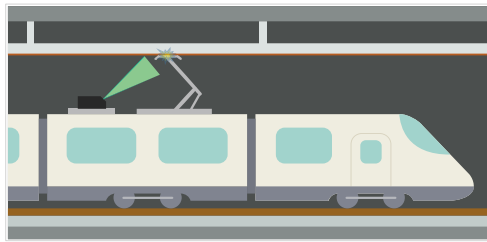
Data on starts, stops and  
track gradients

Location of irregularities  
on the track

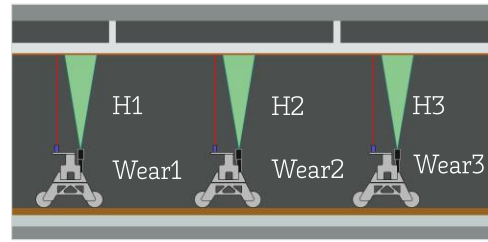


## Field work

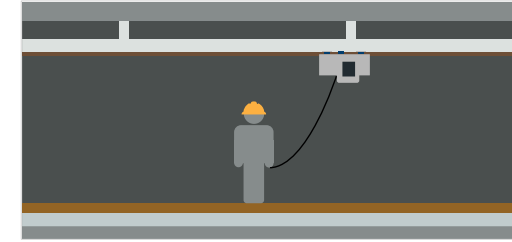
Locate contact  
wire wear areas



Extra information  
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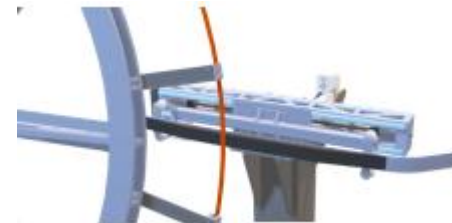


## Laboratory work

Simulate contact  
behaviour



Development of  
wear models

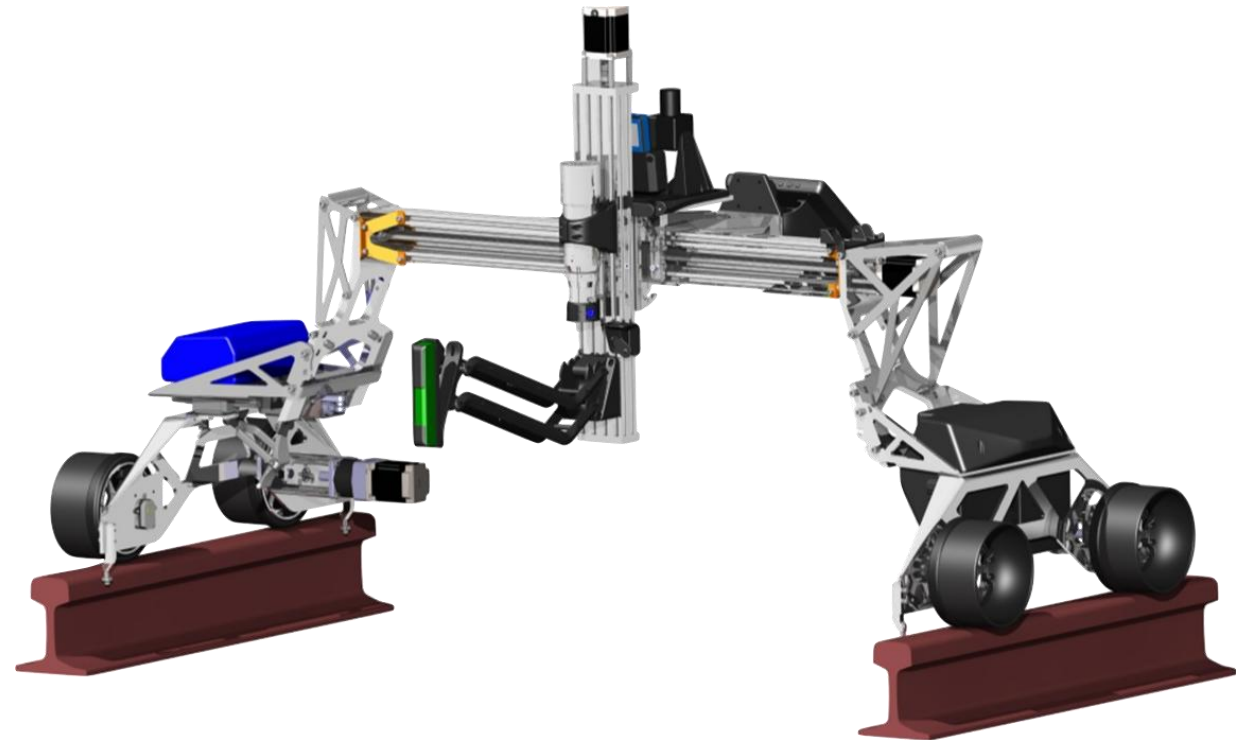


- Obtain extra information of the facility

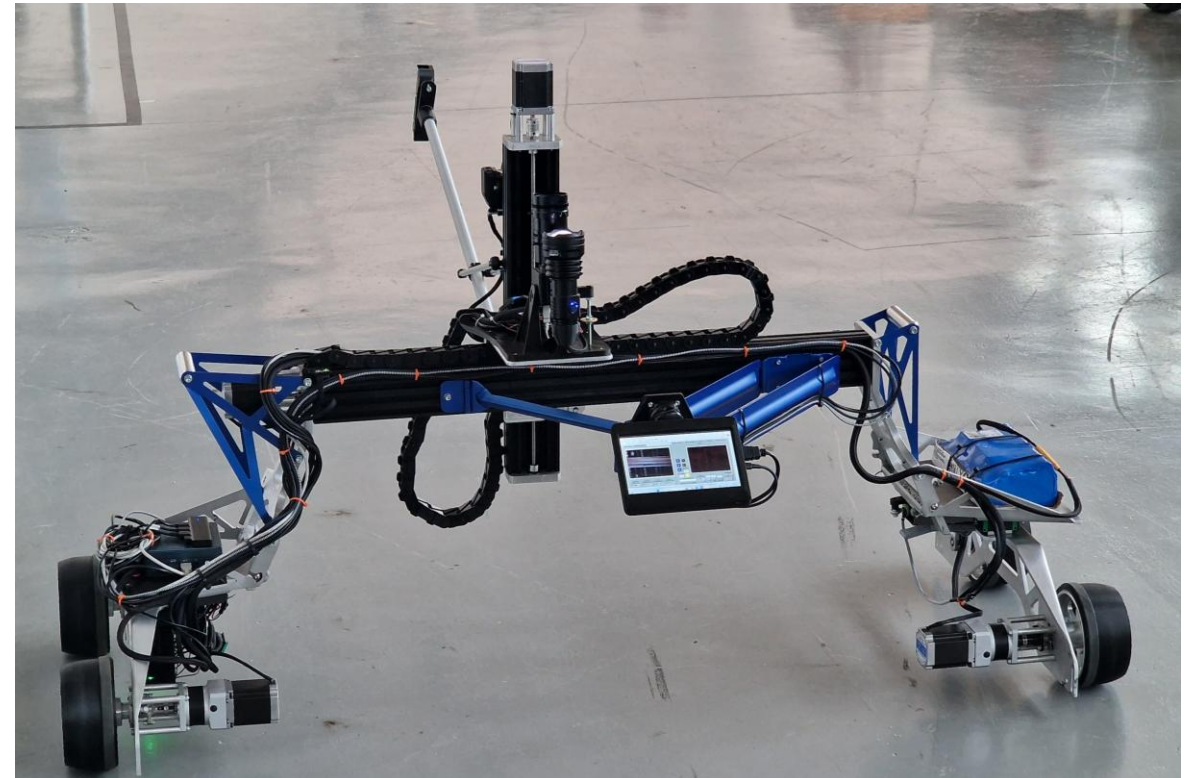
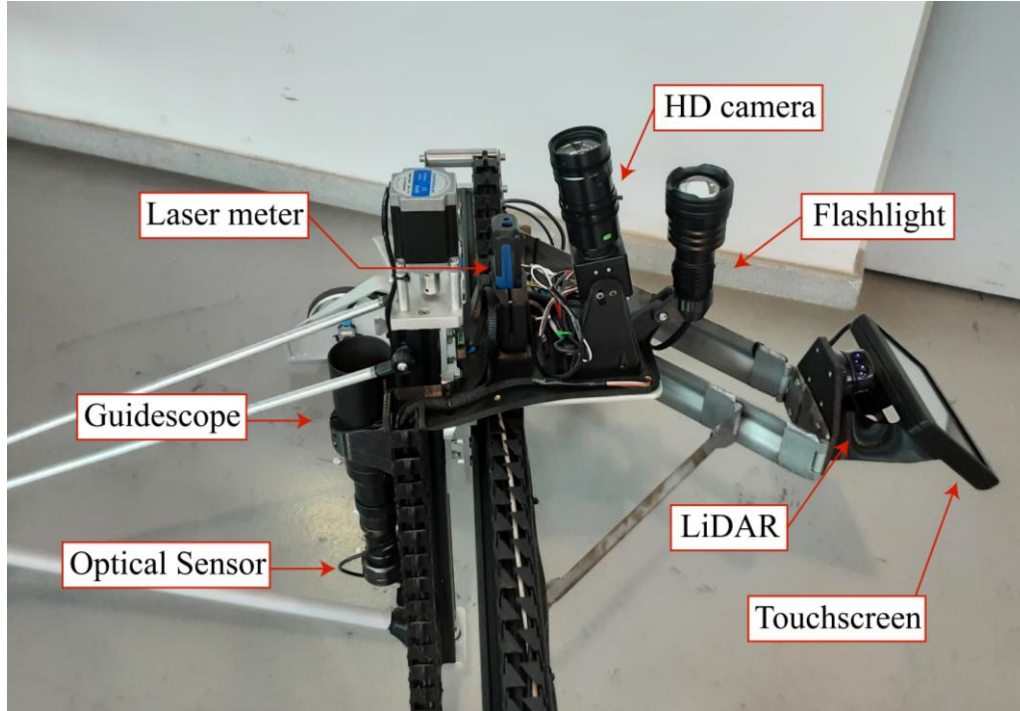
## Optical data collection device

Ability to measure:

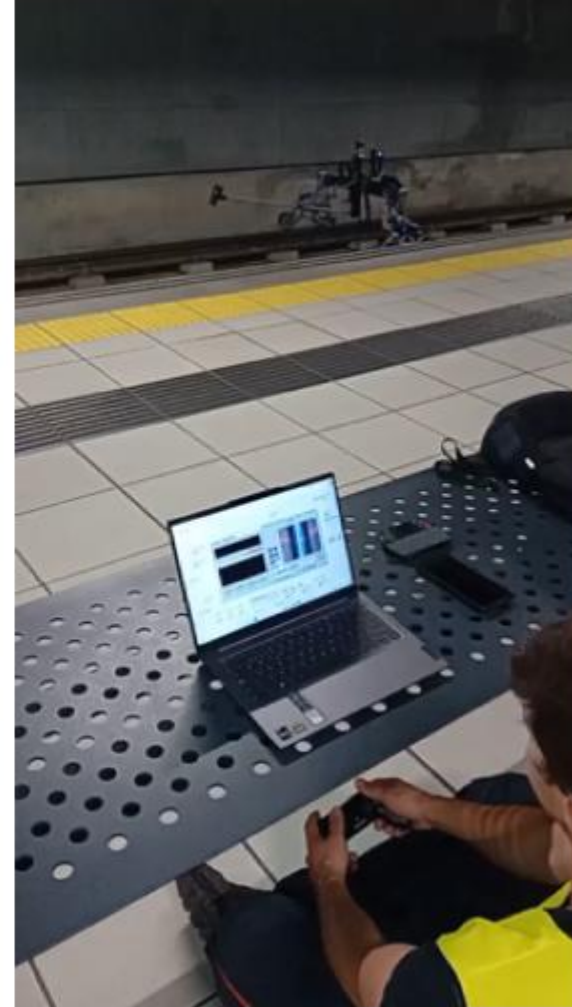
- Contact wire wear
- Rail gauge
- Travelled distance
- Rail irregularities
- Catenary height and offset



## Laser and camera measuring technique



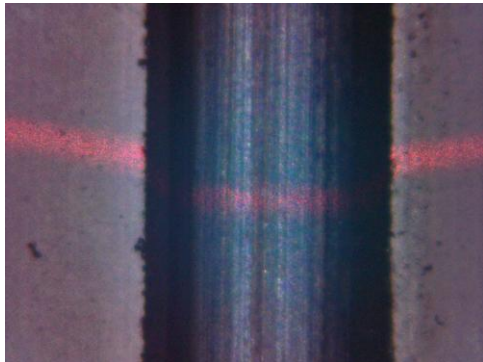
# OPTICAL DATA COLLECTION DEVICE



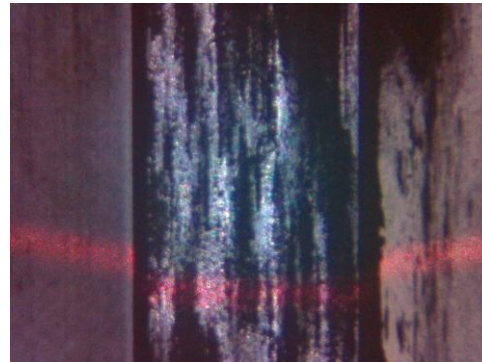
# OPTICAL DATA COLLECTION DEVICE

## Contact wire wear comparison

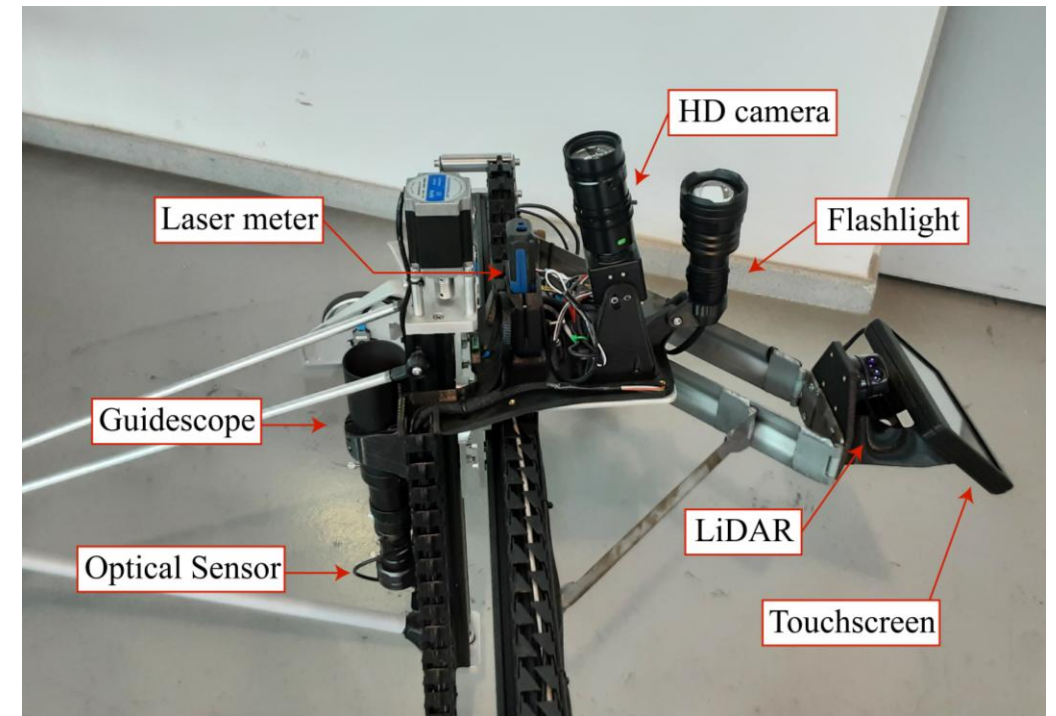
Low wear

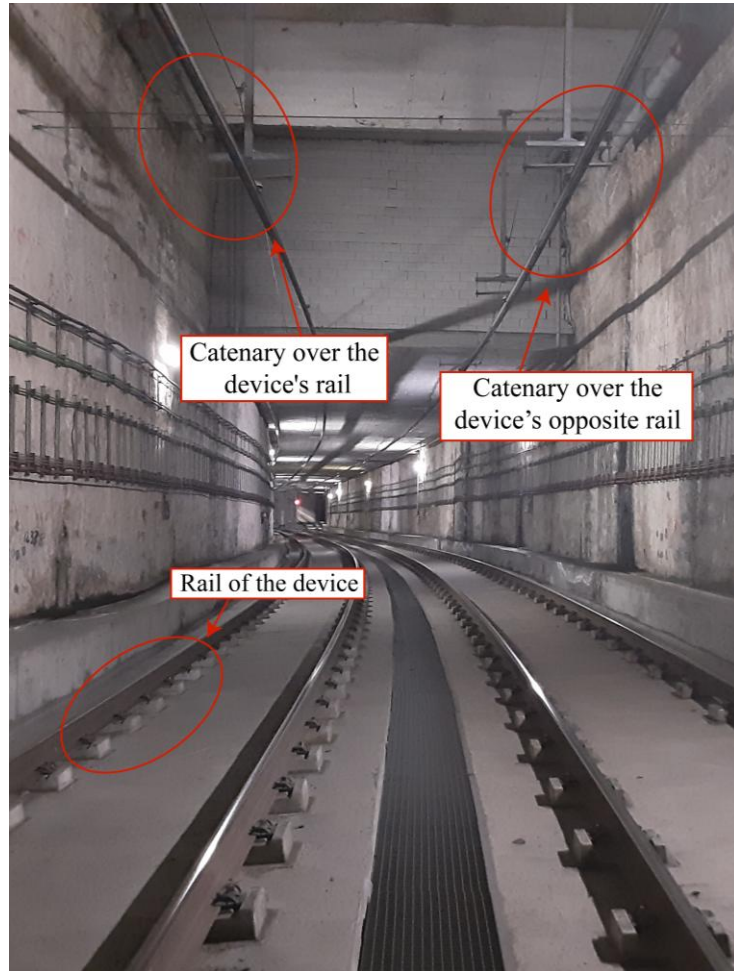


High wear

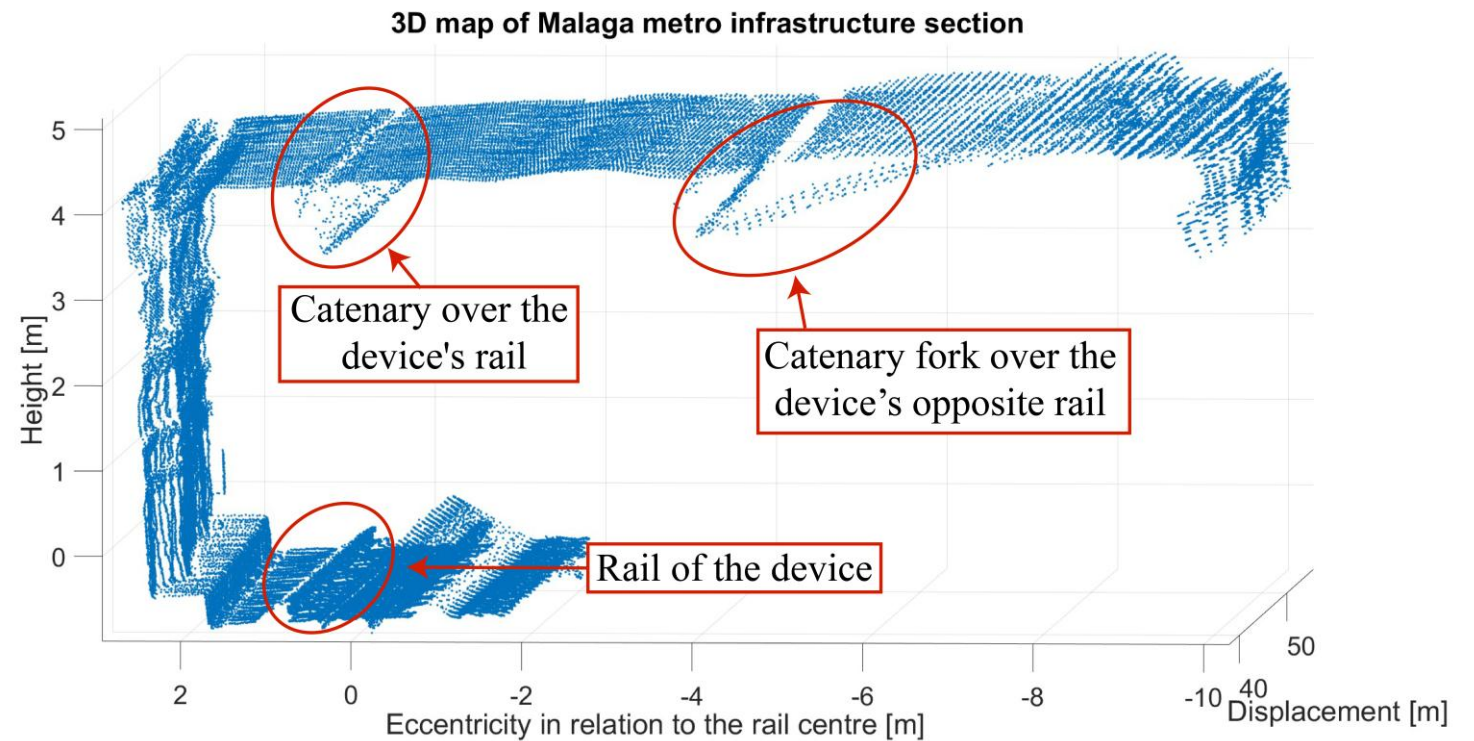


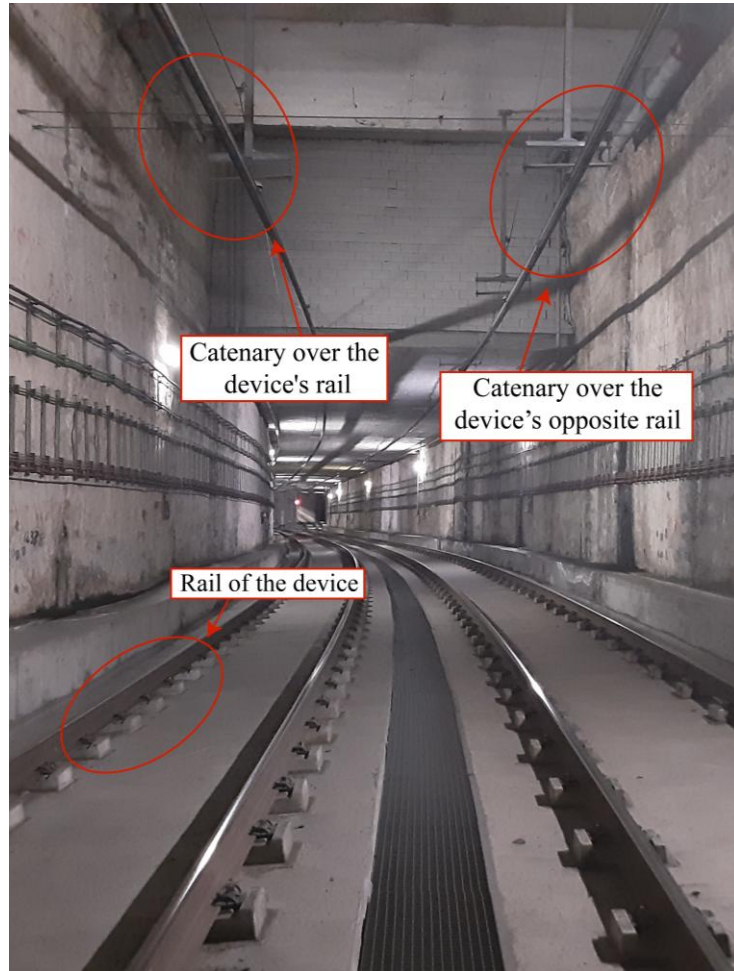
## Laser and camera measuring technique



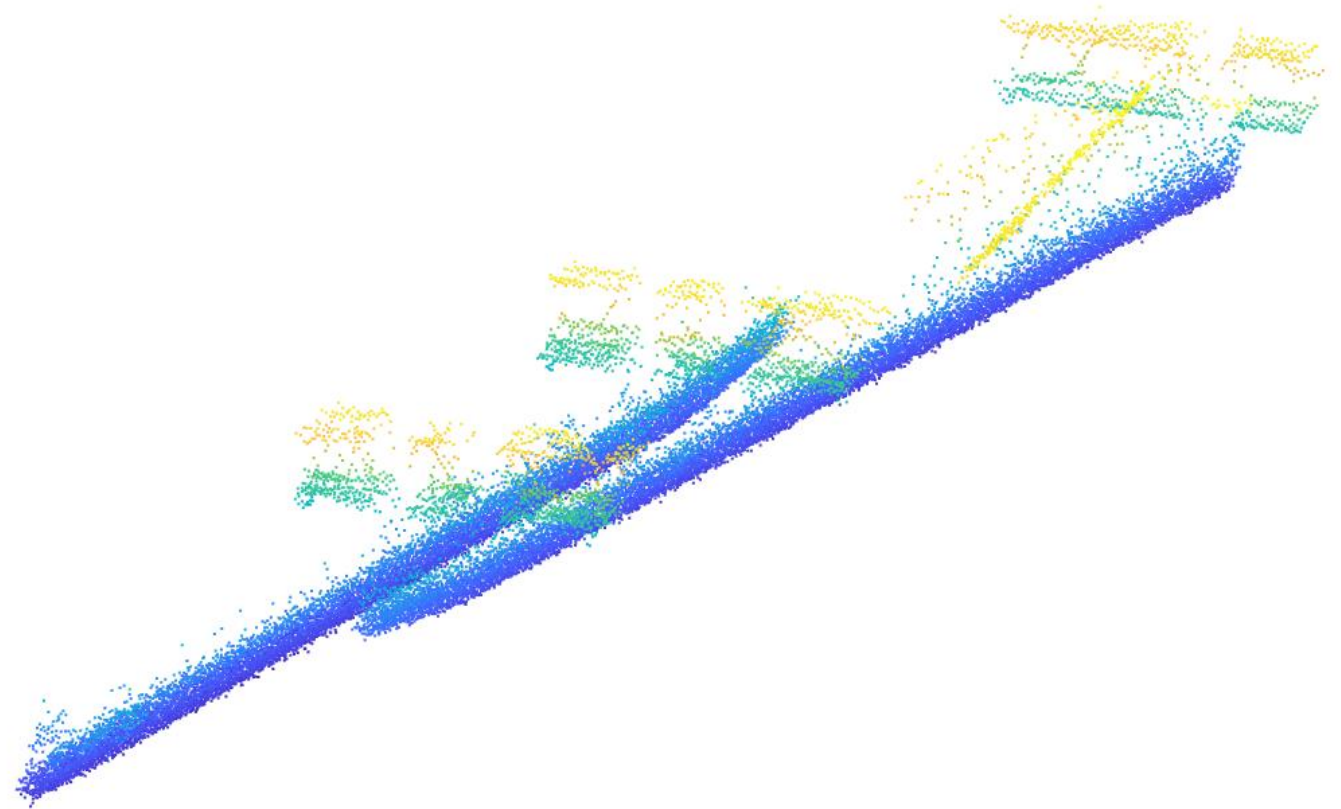


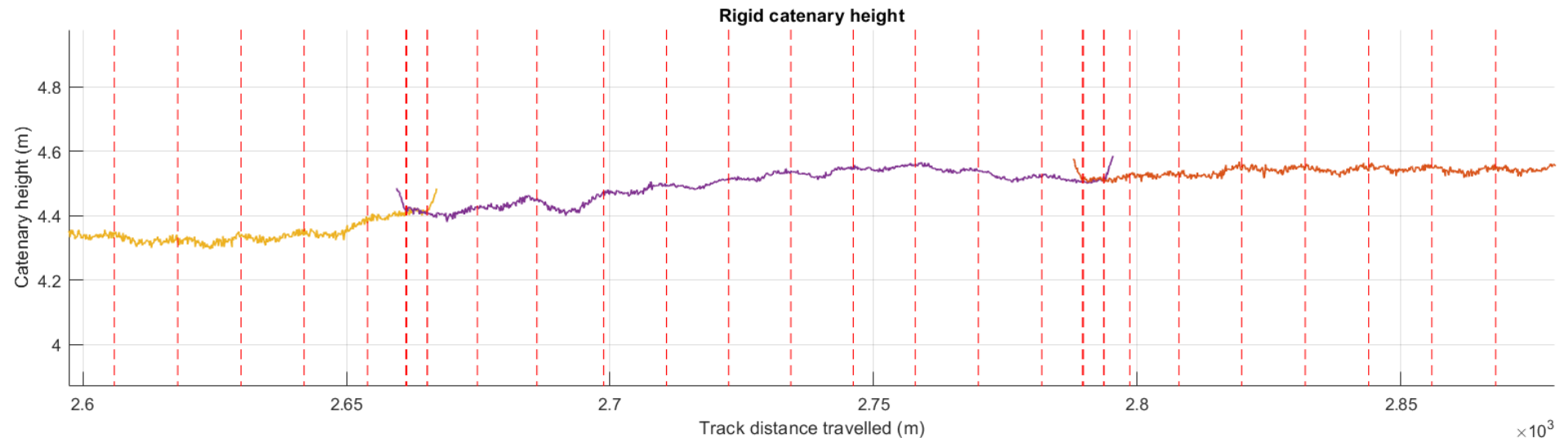
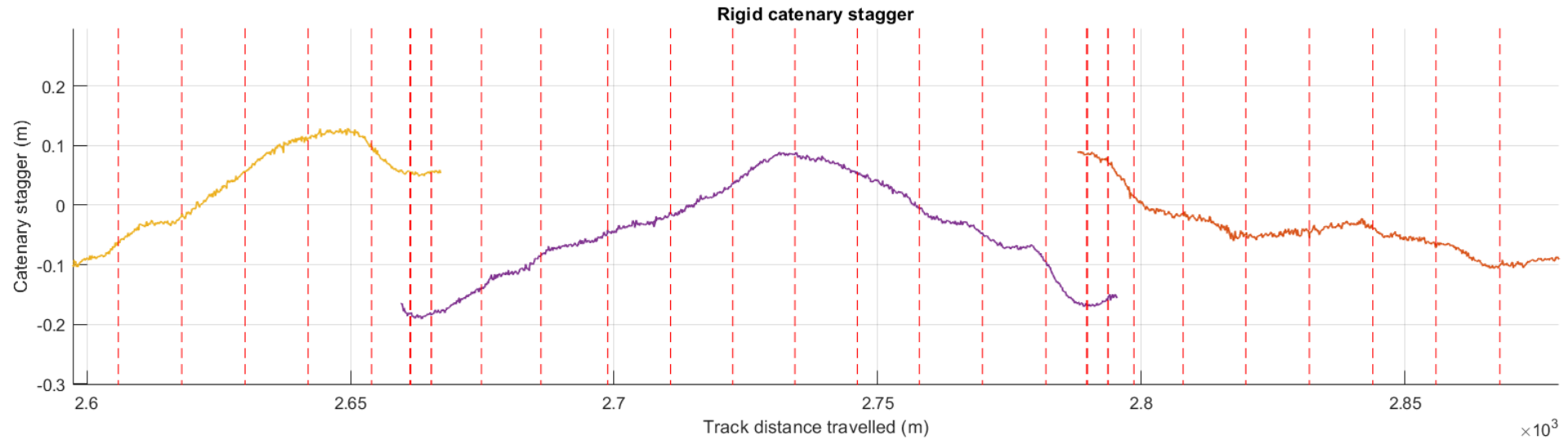
## View of data provided by LiDAR





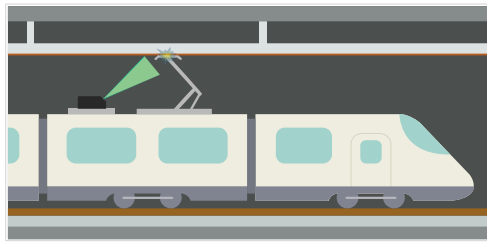
View of data provided by LiDAR



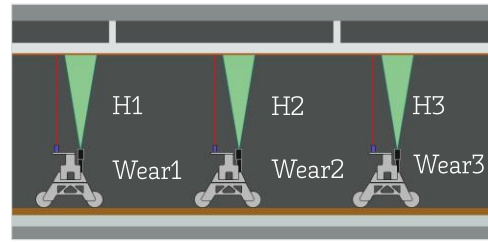


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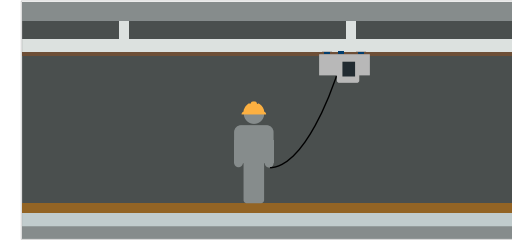
Locate contact  
wire wear areas



Extra information  
of the facility



Create a wear  
register

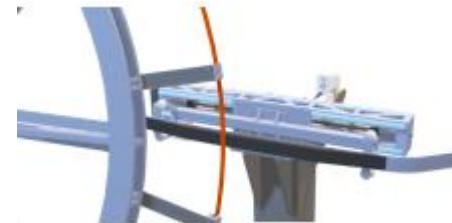


## Laboratory work

Simulate contact  
behaviour



Development of  
wear models



- Periodical wear measurements



Pantograph strip



Contact wire

- Periodical wear measurements



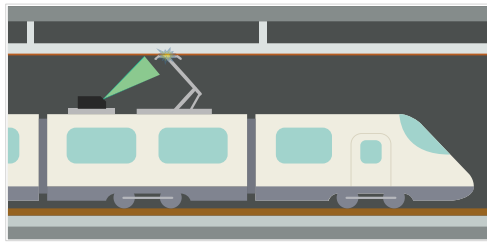
Pantograph strip



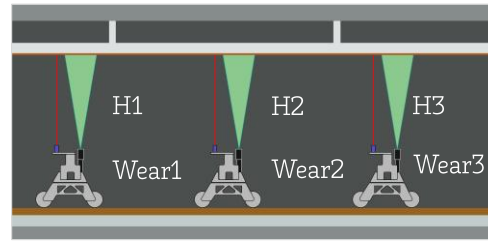
Contact wire

## Field work

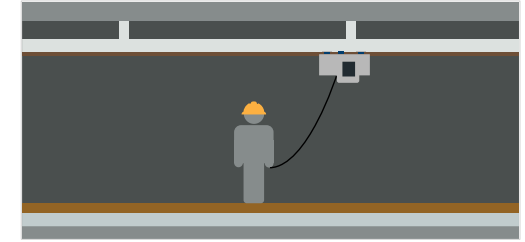
Locate contact  
wire wear areas



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of the facility



Create a wear  
register



## Laboratory work

Simulate contact  
behaviour



Development of  
wear models



- **Simulate contact behaviour**

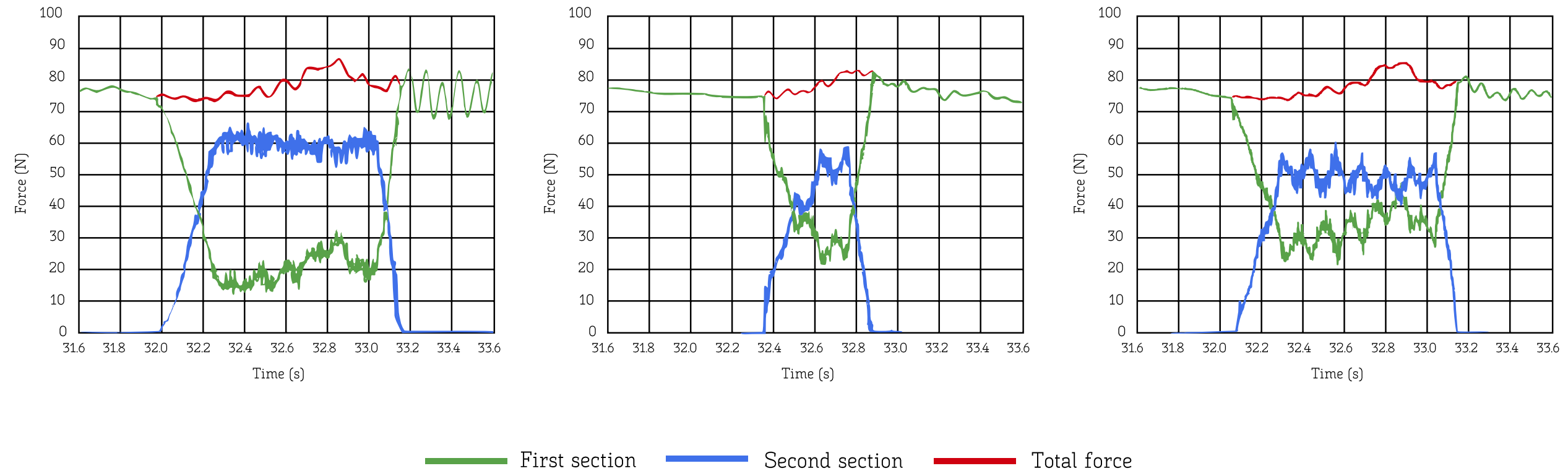


## Dynamic analysis

Simulations at section joints:

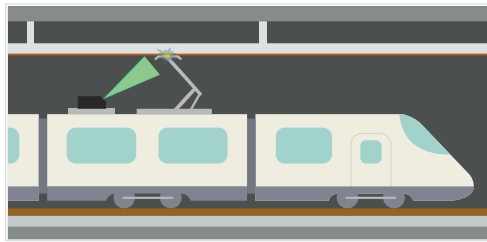
- Evolution of force on each catenary section
- Different installation configurations

- Simulate contact behaviour

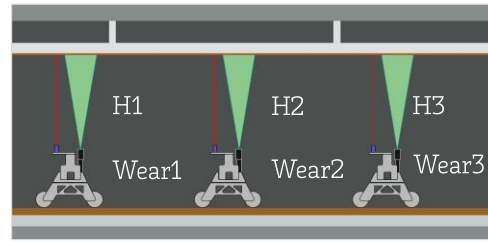


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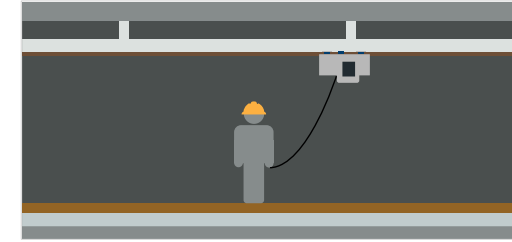
Locate contact  
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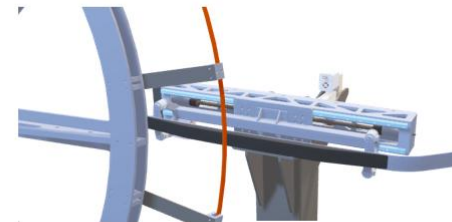


## Laboratory work

Simulate contact  
behaviour



Development of  
wear models



- **Development of wear models**

## Ring test bench

Obtain wear model for:

- Contact wire
- Pantograph strip



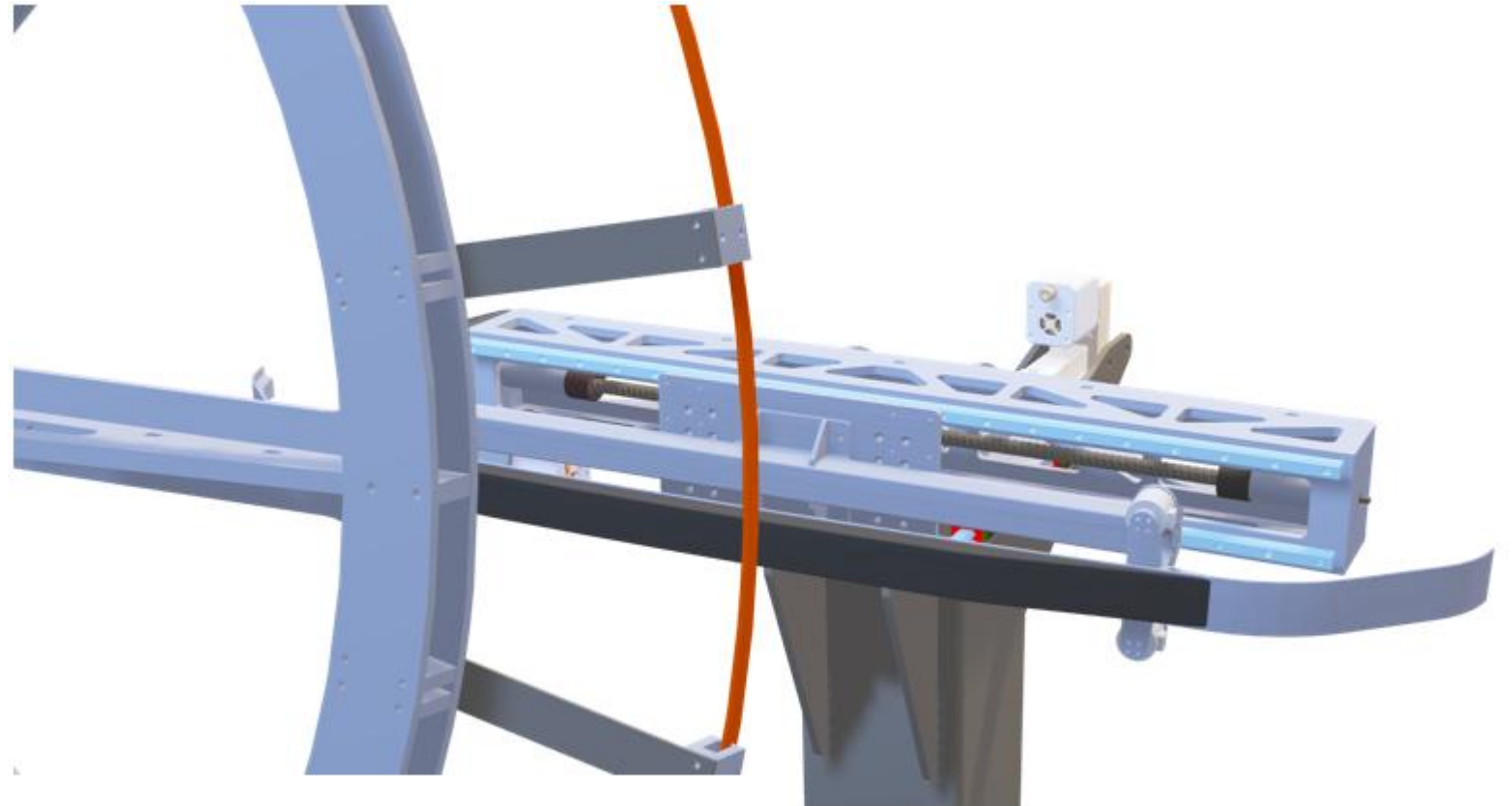
- **Development of wear models**

## Ring test bench

Obtain wear model for:

- Contact wire
- Pantograph strip

Possibility to study  
the effect of zigzagging



- **Development of wear models**

## Ring test bench

Obtain wear model for:

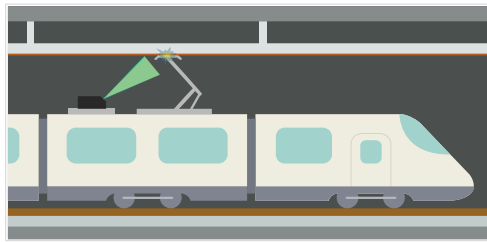
- Contact wire
- Pantograph strip

Possibility to study  
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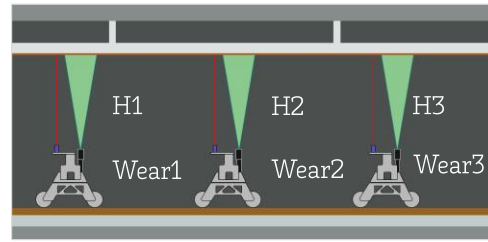


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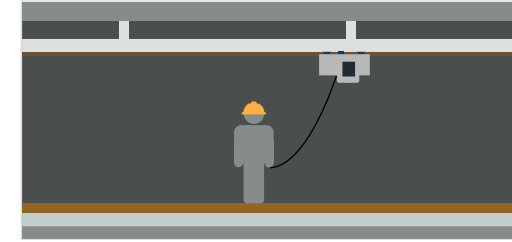
Locate contact  
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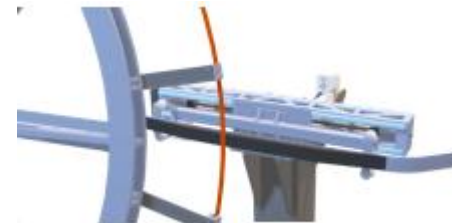


## Laboratory work

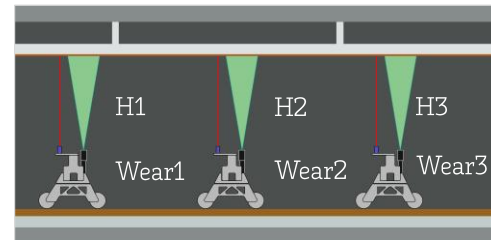
Simulate contact  
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Development of  
wear models



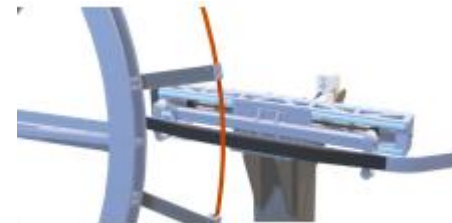
Extra information  
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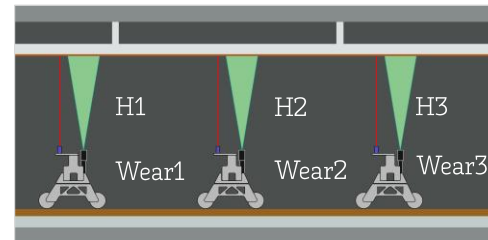
Simulate contact  
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Development of  
wear models



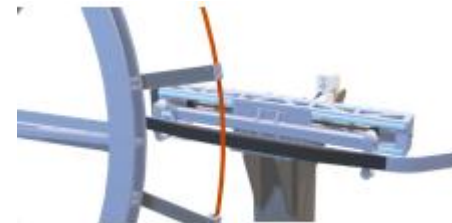
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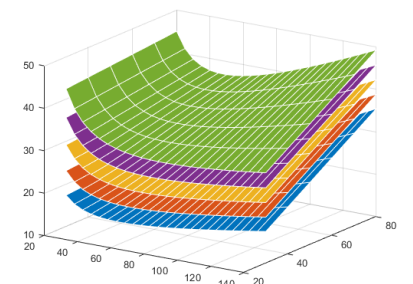
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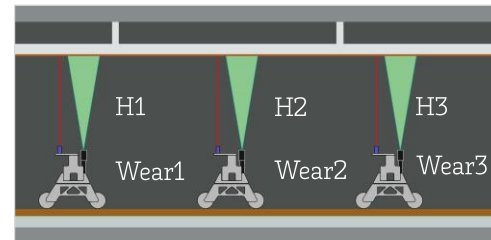
Development of  
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Wear models



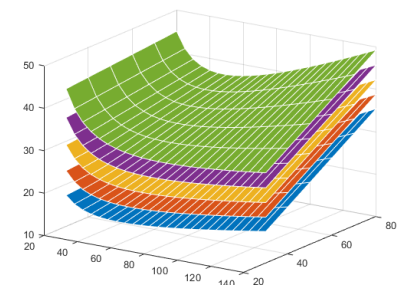
Extra information  
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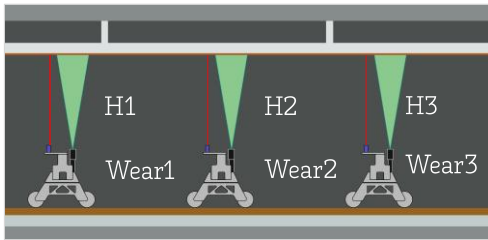
Simulate contact  
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Wear models



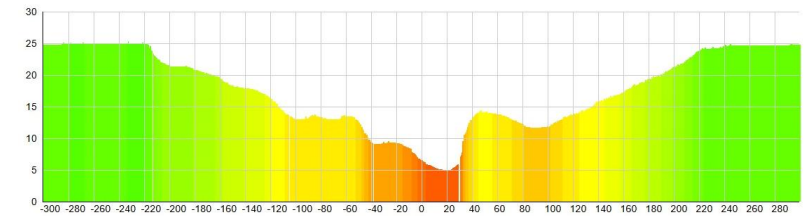
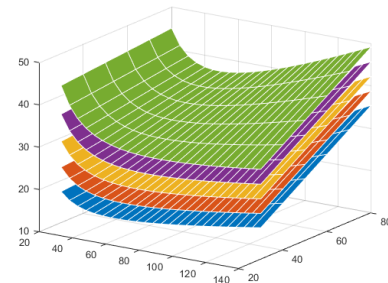
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Simulate contact  
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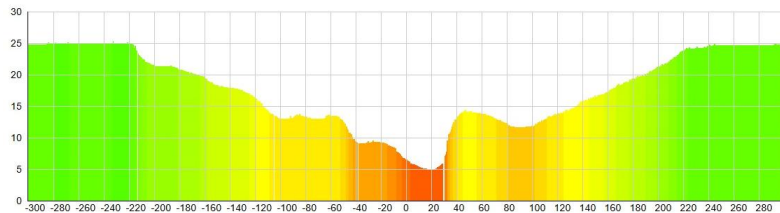


Wear models



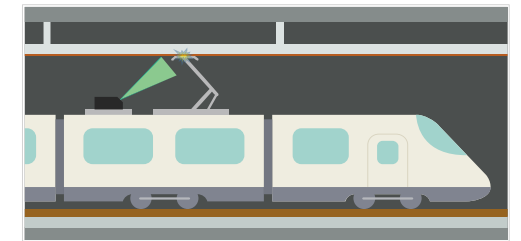
Estimated wear

# FUTURE WORK

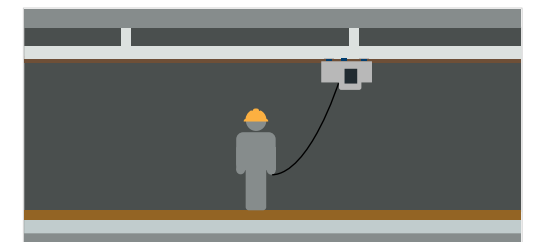


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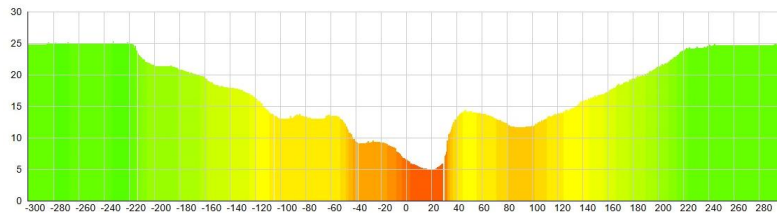
Locate contact  
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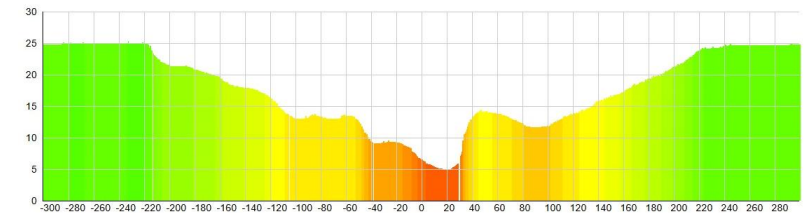
Create a wear  
register



# FUTURE WORK

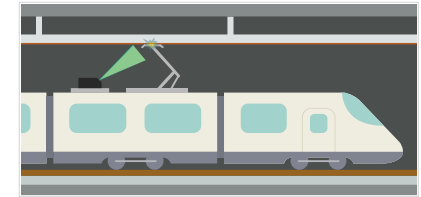


Estimated wear

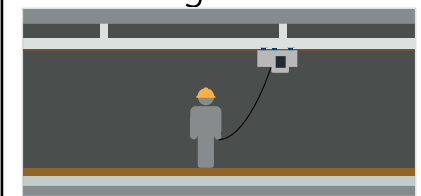


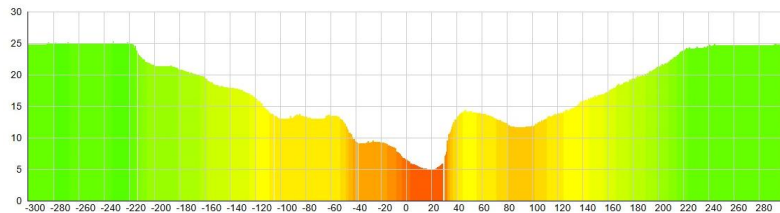
Real wear

Locate contact  
wire wear areas

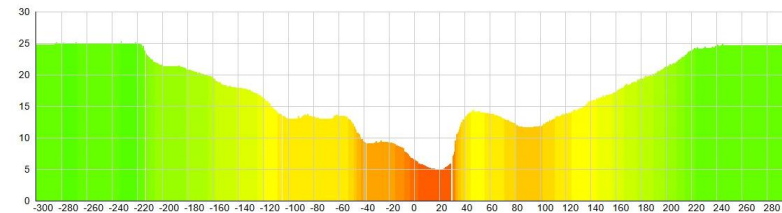


Create a wear  
register





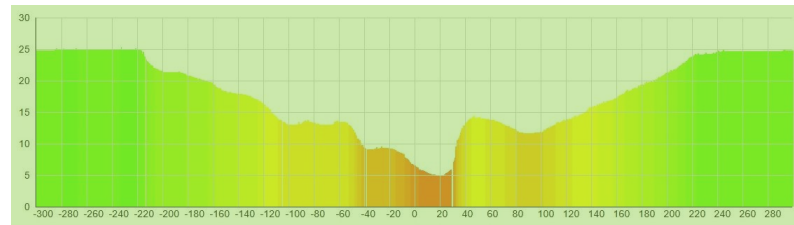
Estimated wear



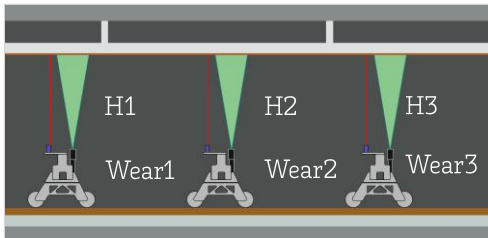
Real wear



# FUTURE WORK



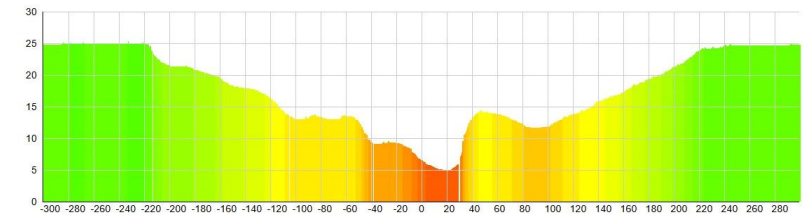
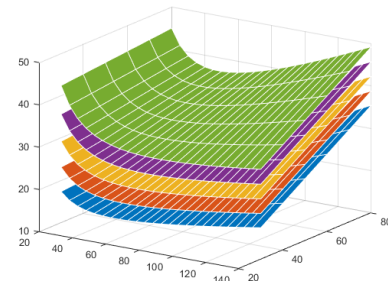
Extra information  
of the facility



Simulate contact  
behaviour



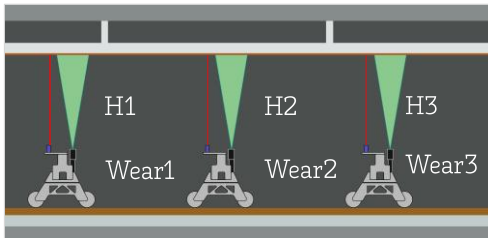
Wear models



Estimated wear

# FUTURE WORK

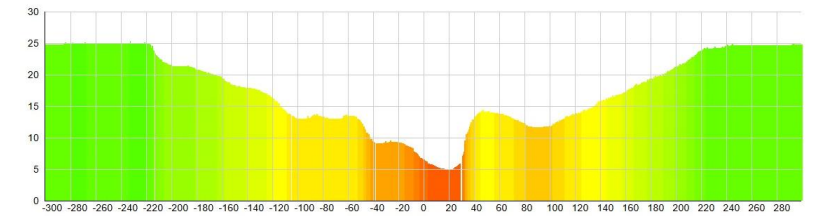
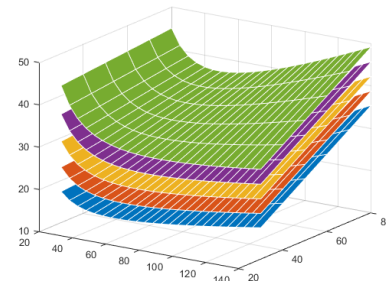
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Simulate contact  
behaviour



Wear models



Estimated wear



**Predictive  
maintenance**





# Current Developments in Rigid Catenary-Pantograph Wear Reduction: Insights from the University of Málaga

Rail Vehicle Dynamics Research Group of the University of Málaga

Department of Mechanical, Thermal and Fluids Engineering, University of Málaga, Spain