*UIC TRAIN-TRACK INTERACTION (TTI)*
*SECTOR PLENARY MEETING*
*Málaga, 17 Sept. 2025*

# *InterActive Pads for monitoring the interaction Wheel-Rail (Train-Track)*

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# CONTENT

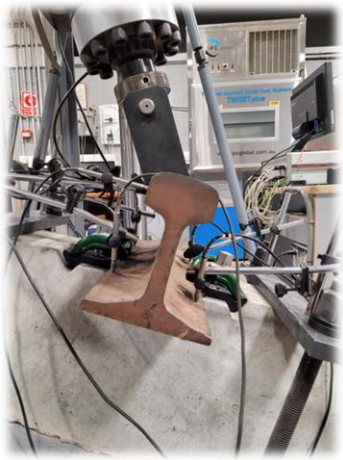
I. What is InterActive Pad (IA Pad)

II. Benefits and advantages

III. Applicability

IV. Experiences: validation and demonstration

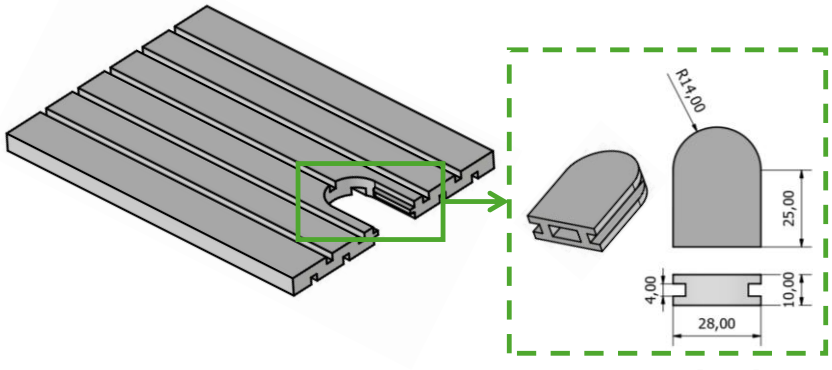
V. Conclusions



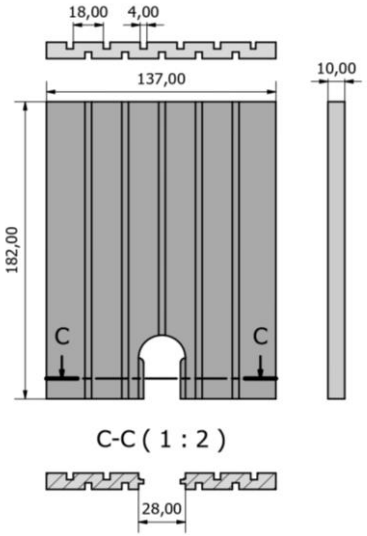
# *What is InterActive Pads*

The InterActive Pad (IA Pad) is an innovative rail pad **including a sensor-insert allowing the inclusion and extraction of diverse type of sensors** for continuous and versatile monitoring.

Prototype design




Sensing technology



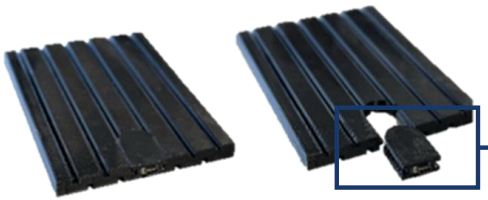

InterActive Pad

# *What is InterActive Pads*

A **specific Data Acquisition System** has been designed and developed to provide a versatile and economical solution for **continuous and real time recording of data and wireless communication.**

Similarly, a **specific software** is applied to visualize and analyze the data.

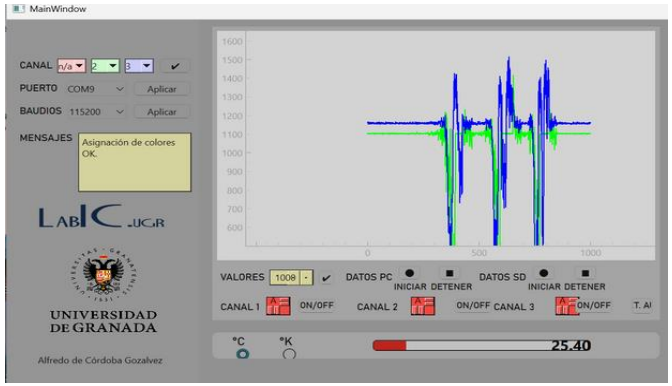
InterActive Pad



Sensor Device

Data Acquisition System

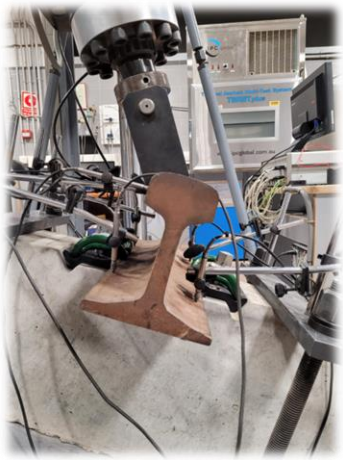
Data Software



# *What is InterActive Pads*

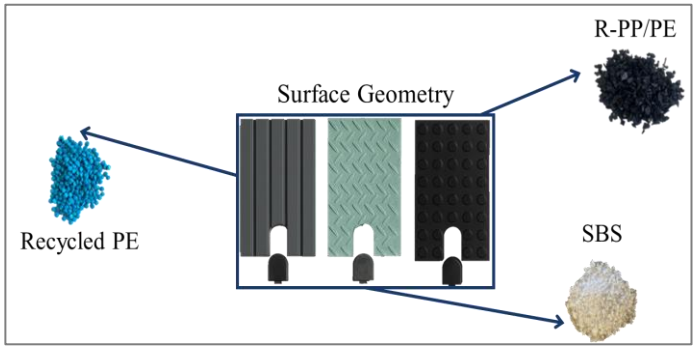
# CONTENT

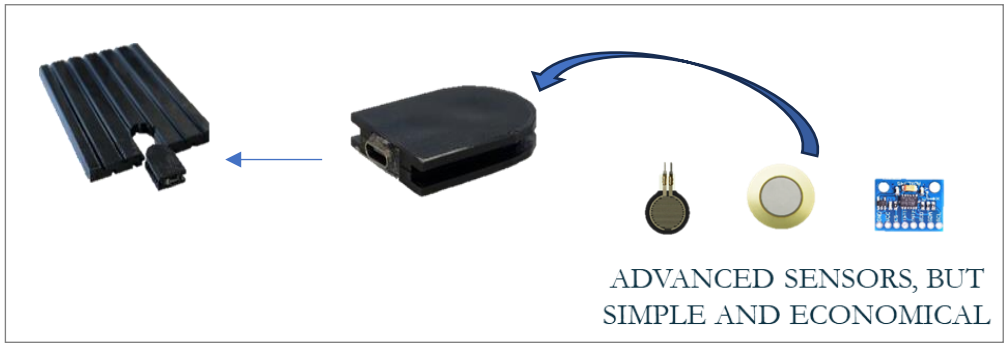




# *Benefits and Advantages*

- IA Pad is a customizable rail pad, designed to **adapt to different railway applications**.
- Its **material composition is tailored to meet the specific requirements** of customers or railway operators.
- Can be manufactured from different polymers, including the **recycled ones**.
- **Compatibility with any fastener system** for various environments and vehicle types, from subways to high-speed trains.
- The **innovative sensor-insert allows for modifying the type of sensor for an adaptative system**, while allowing for technology up-date and/or reparation.



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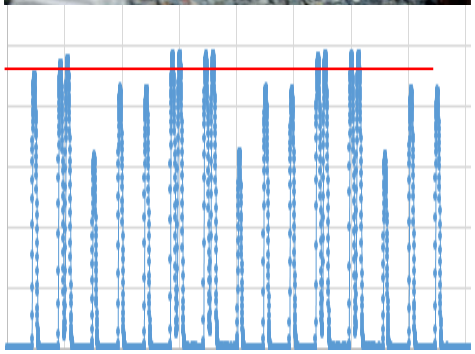
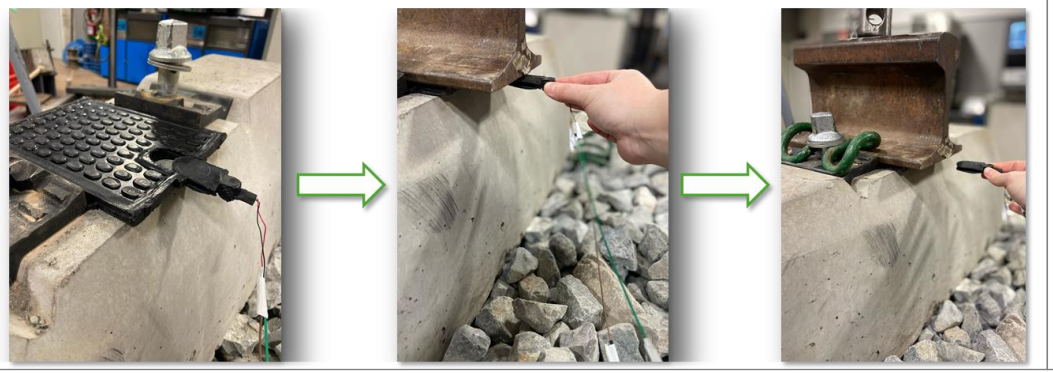
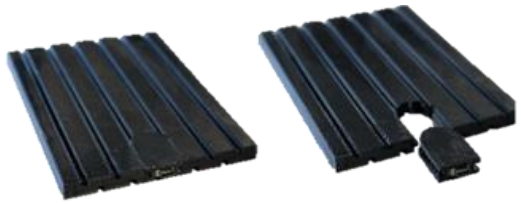
# *Benefits and Advantages*

- **Continuous and real time monitoring**.
- Allowing for **measuring diverse parameters** by including various types of sensors.
  Examples: temperature of rail;
  oscillation of rail-sleeper;
  pressure in rail-sleeper contact;
- Sensitivity analysis of **diverse operation parameters**.
- Allowing for stablishing limits to communicate irregularities: **predictive maintenance and managing**
- **Remote control and communication**.

*Cotinuous and real time monitoring of diverse parameters*







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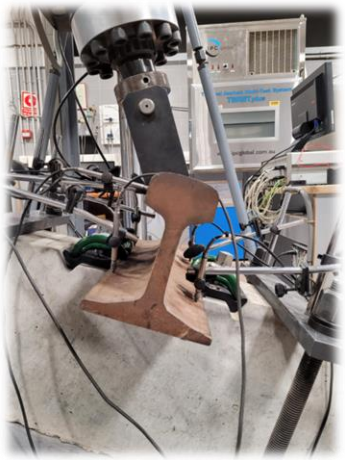
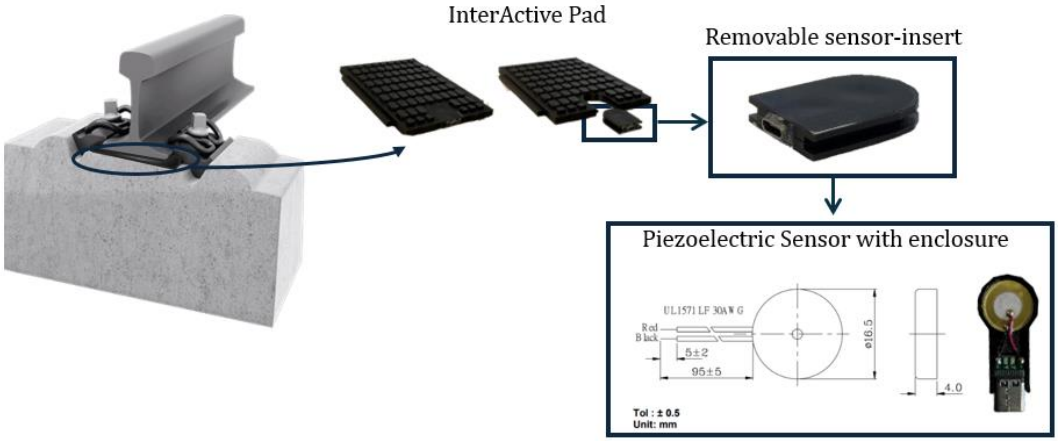
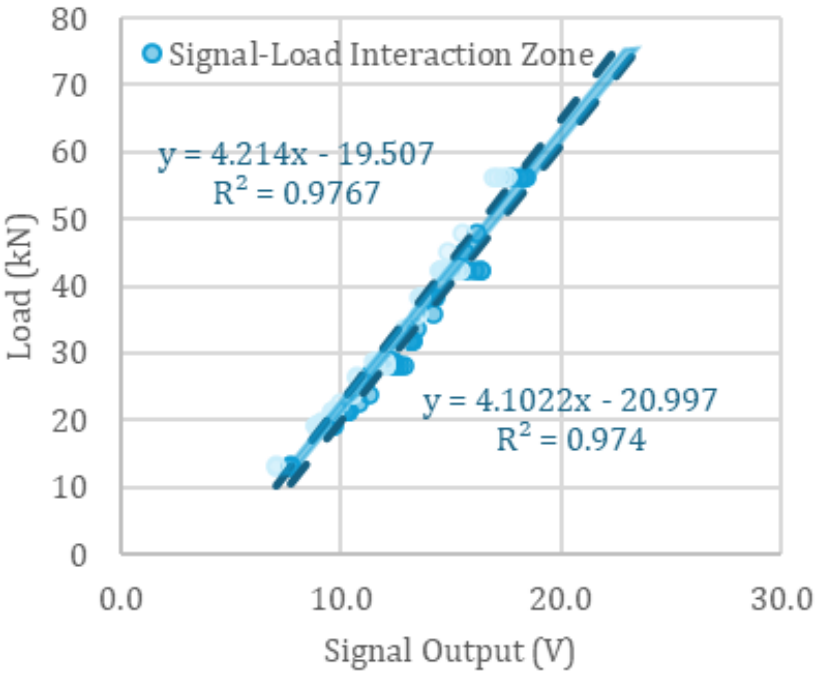


# *Applicability*

- **Example of using piezoelectric as main sensor**
- **Some practical applications:**

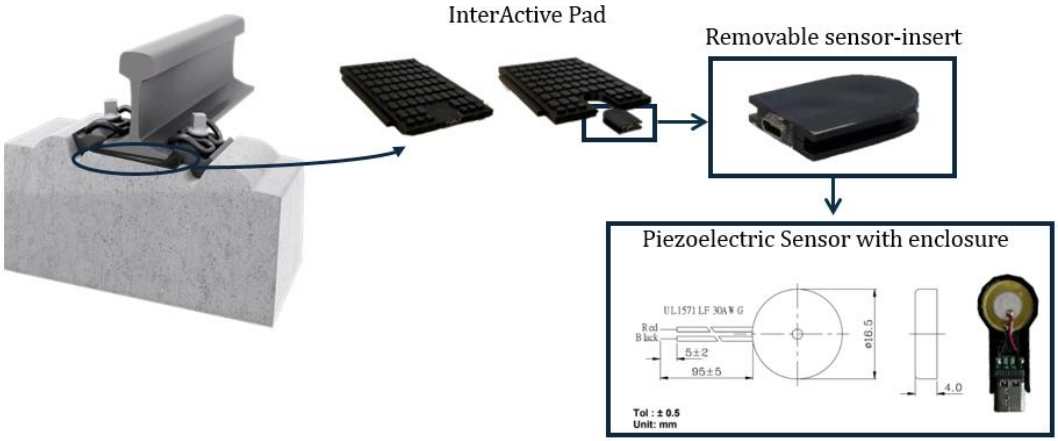


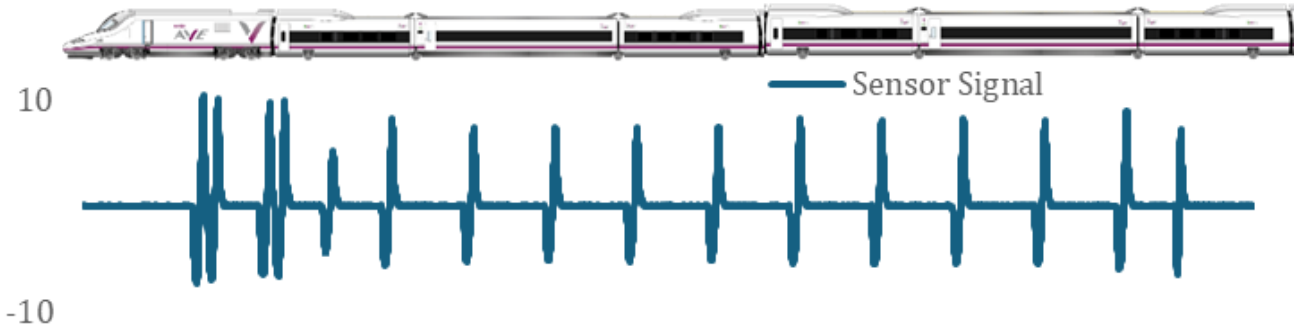




- Dynamic Weighting of Trains

# *Applicability*

- **Example of using piezoelectric as main sensor**
- **Some practical applications:**

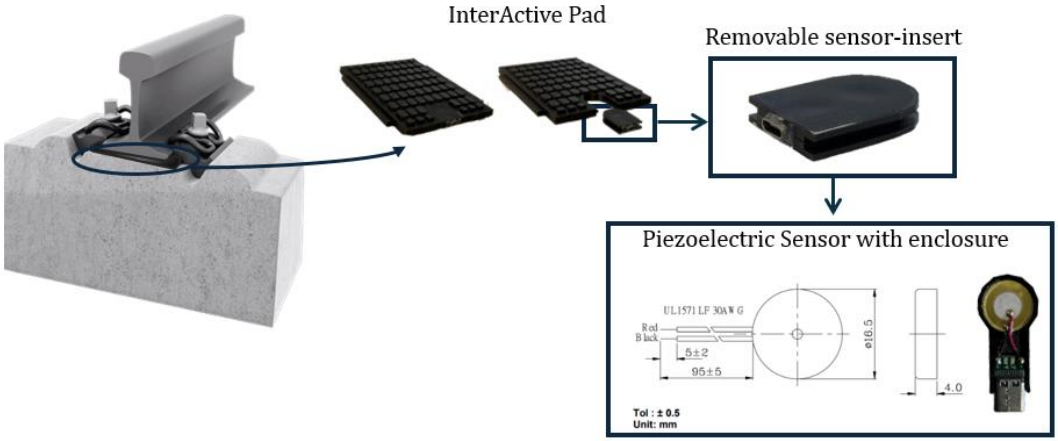


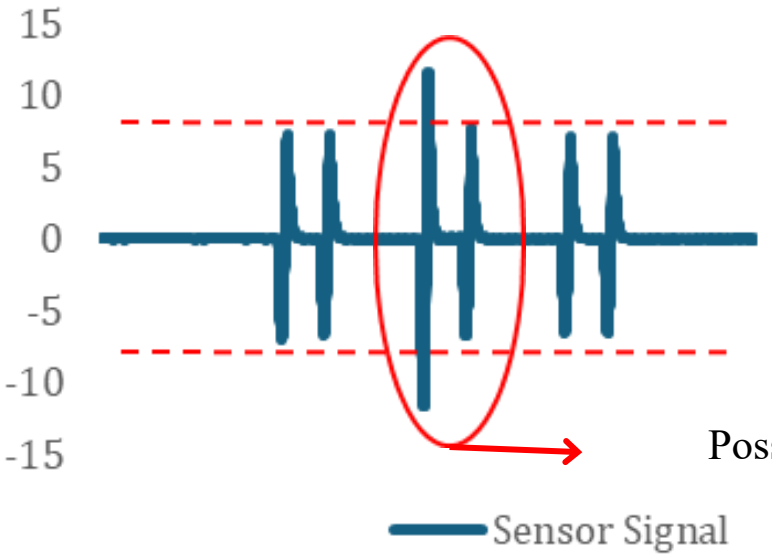




- Load Level on Track components

# *Applicability*

- **Example of using piezoelectric as main sensor**
- **Some practical applications:**



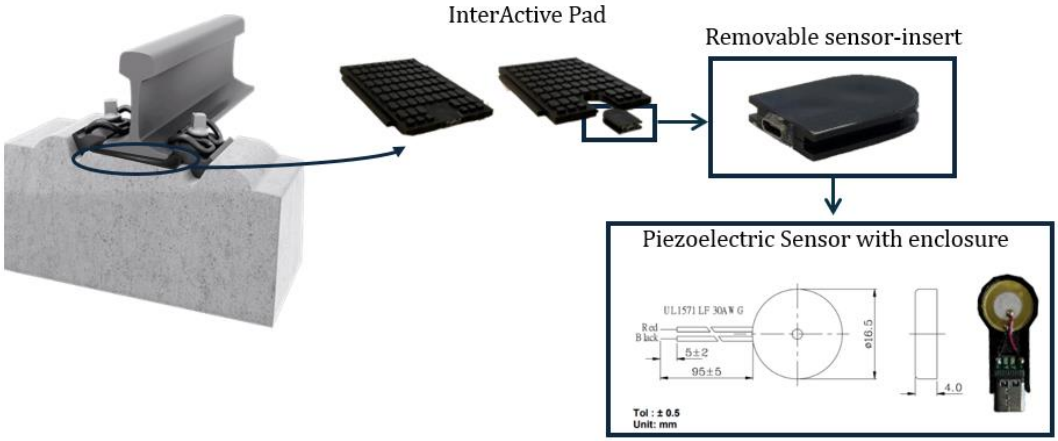




- Control of state of train-track contact

Possibility of detecting anomalous loads.

# *Applicability*

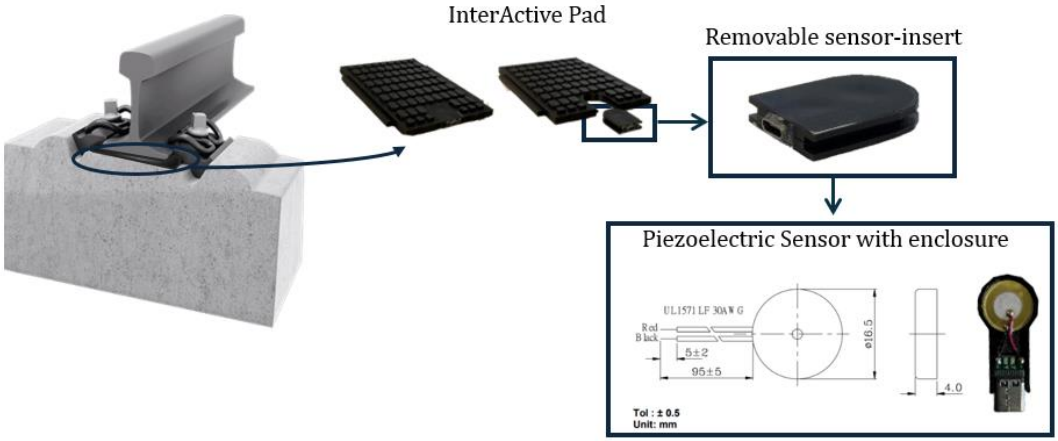
- **Example of using piezoelectric as main sensor**
- **Some practical applications:**

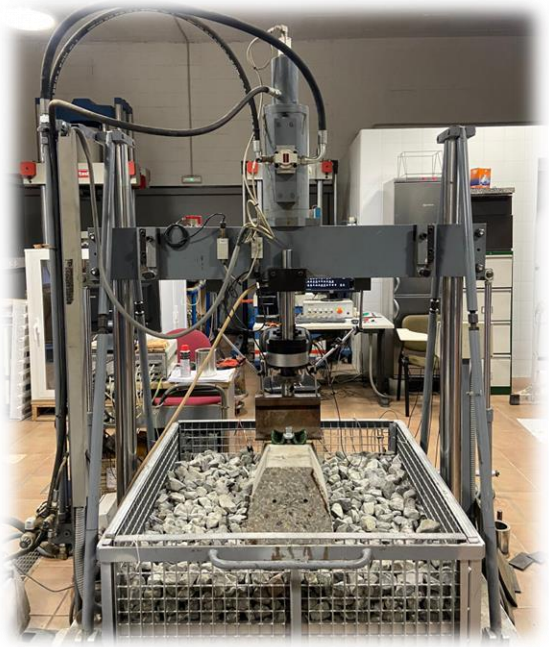



- Component Temperature Change Control.

# *Applicability*

- **Example of using piezoelectric as main sensor**
- **Some practical applications:**

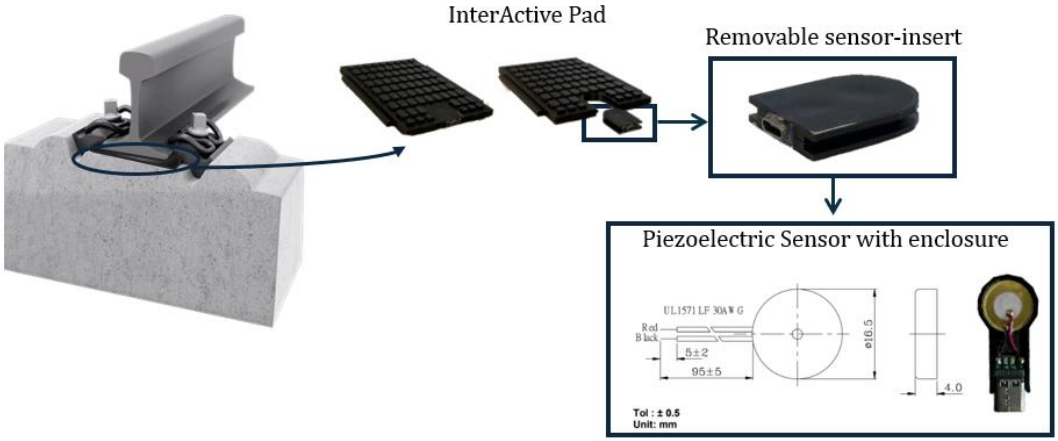


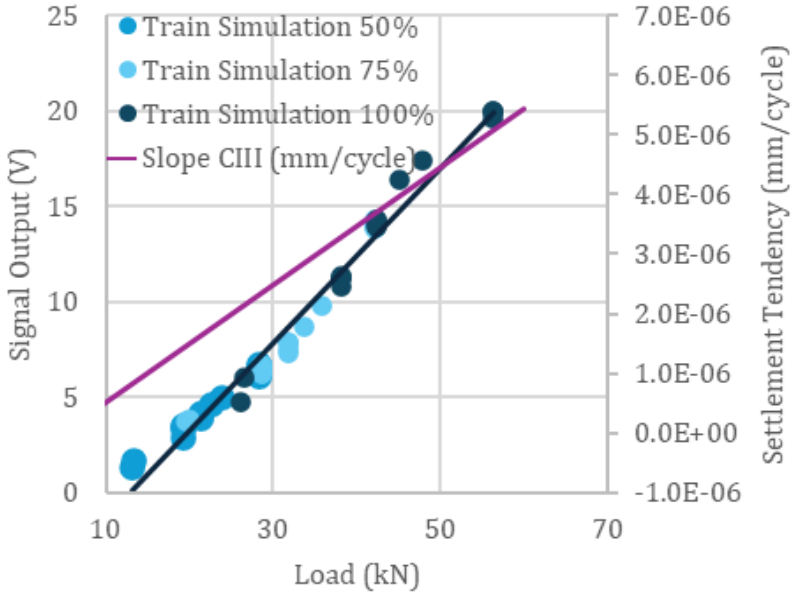
- Behaviour in Critical Sections (curved sections, track changes, transition sections, etc.)

# *Applicability*

- **Example of using piezoelectric as main sensor**
- **Some practical applications:**




- Settlement Prediction.

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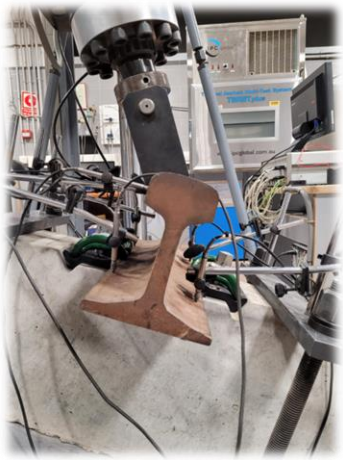
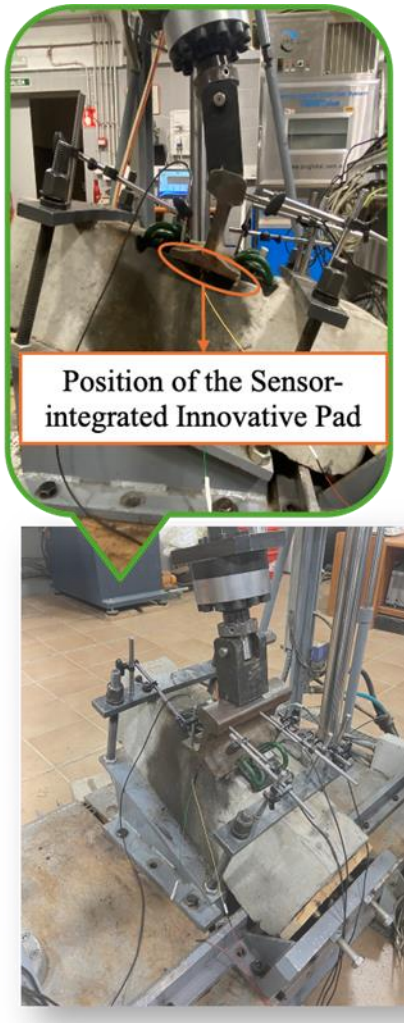


# *Experiences: validation and demonstration*

## Laboratory validation EN 13146 / Tech. Esp.

**Static and Dynamic Stiffness test**


**Impact Mitigation test**




**Fatigue test**

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## Technical DataSheet

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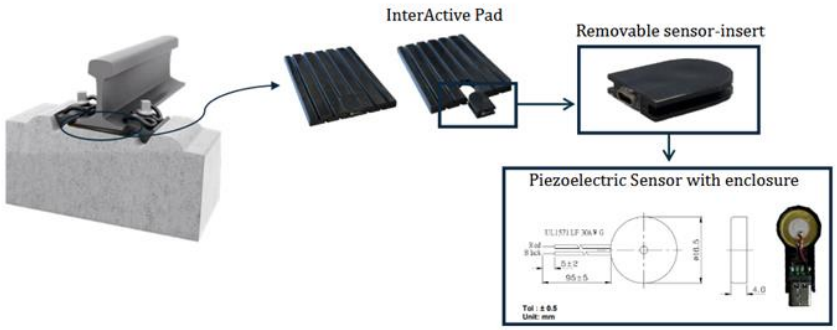
InterActive Pad

### i. General Rail Pad Properties

The Interactive Pad is a customizable rail pad with a variable thickness of 7 to 10 mm, designed to adapt to different railway applications. Its material composition is tailored to meet the specific requirements of customers or railway operators, ensuring compatibility with various environments and vehicle types—from subways to high-speed trains. Additionally, both its overall and surface geometry are adjustable to fit the required model.

| Property | Typical Value |
|---|---|
| **Colour** | Black/White but adjustable |
| **Thickness** | 7-10 mm |
| **Bottom Surface** | Line Geometry |
| **Dimensions** | 180 mm x 140 mm |
| **Material Density** | 1160 kg/$m^3$ |
| **Weight** | 0.22 kg |
| **Environmental impact** | 100% recyclable |

### i. Model **IAP – MT – 10** characterization




This pad is positioned between the rail and the sleeper and features a removable piezoelectric sensor. The sensor can be inserted or removed as needed during the application/service. It functions by deforming under mechanical stress, converting this deformation into voltage signals. These signals are then collected and stored by a data acquisition system, which may be either a dedicated external device designed for this InterActive Pad supporting wireless functionality or a PC with specialized software for data processing.

*Sensor Specifications*

| *Item* | *Unit* | *Specification* |
|---|---|---|
| Operating Voltage | V | Max. 12 |
| Operating Temperature | ºC | -30 - +85 |
| Storage Temperature | ºC | -40 - +95 |
| Weight | gr | 1 |



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Technical DataSheet

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InterActive Pad

### IAP – MT – 10

ii. Field of application

| Track category | Typical axle load |
|---|---|
| **Subway track** | 100 kN |
| **Main-line railway** | 225 kN |
| **Freight trains** | 280 kN |

iii. System Stiffness – Following UNE-EN 13146-9

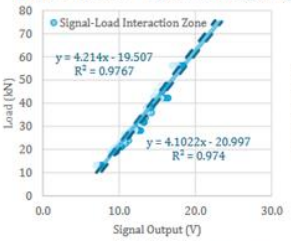
| Type of Stiffness | Temperature (ºC) | Value |
|---|---|---|
| **Static** | 20 | 198 |
| | 30 | 193 |
| | 40 | 192 |
| **Dynamic** | 20 | 229 |
| | 30 | 223 |
| | 40 | 220 |

iv. Mechanical Properties

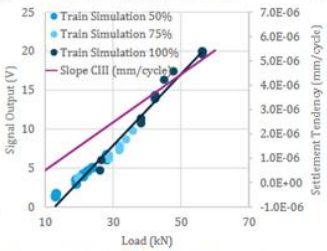
| Parameter | Method | Result |
|---|---|---|
| **Fatigue resistance** | UNE-EN 13146-4 | $D^C \leq 1$ mm<br>$D^P \leq 0{,}5$ mm<br>$K_{est\ after\ fatigue} < 1.15 * K_{est}$<br>$K_{din\ after\ fatigue} < 1.15 * K_{din}$ |
| **Impact Mitigation** | UNE-EN 13146-3 | a > 25% |

v. InterActive Pads applications

Load Detection – Dynamic Weighting

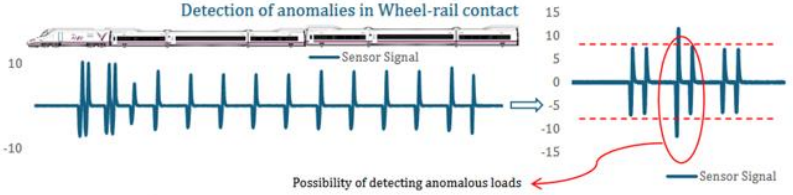



Settlement prediction



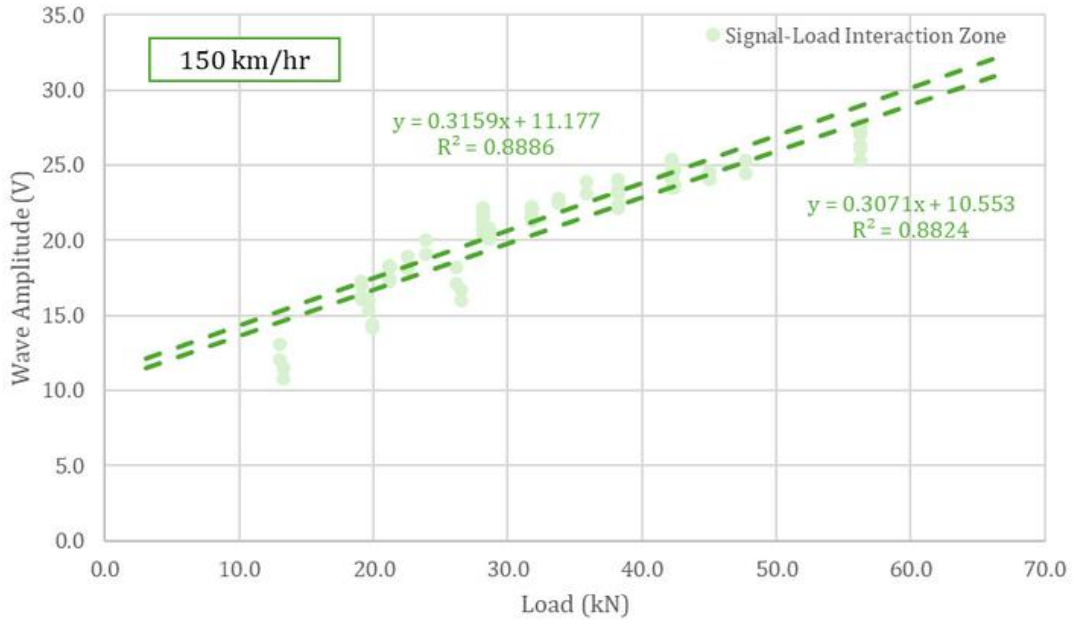

Component Stress Monitoring

Detection of anomalies in Wheel-rail contact



## Sensor calibration

Prior to the field trials, laboratory calibration of the sensors was performed to establish a **direct relationship between the track loads and the speed of the passing train.**

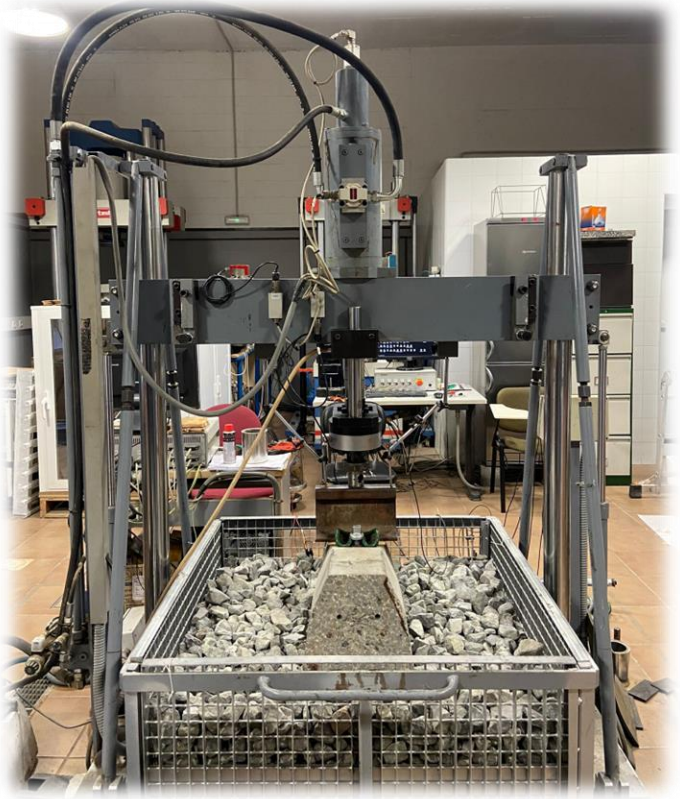


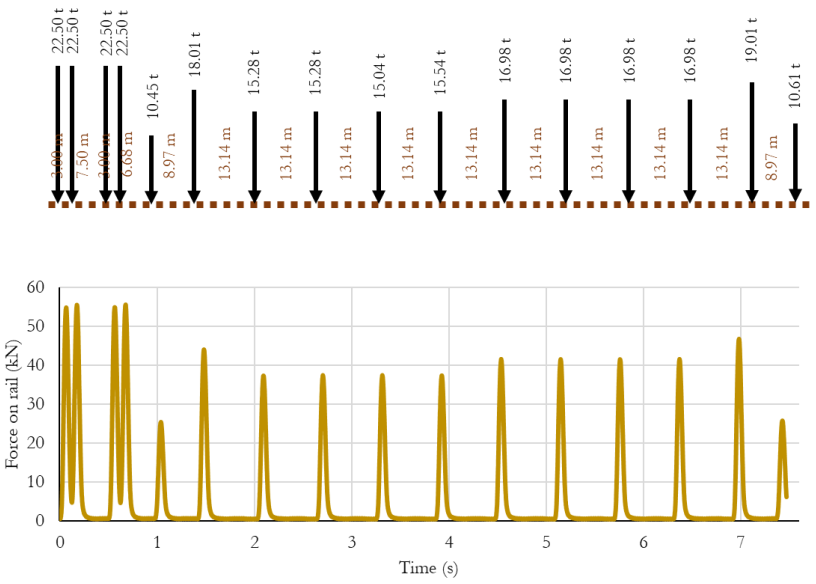

### Calibration Table

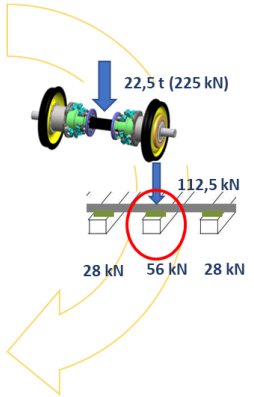
| | 50 km/hr Signal | | 100 km/hr Signal | | 150 km/hr Signal | |
|---|---|---|---|---|---|---|
| Rail pad load applied (kN) | MAX | MIN | MAX | MIN | MAX | MIN |
| 13 | 7.70 | 7.03 | 11.89 | 11.31 | 11.46 | 10.79 |
| 19 | 9.64 | 8.92 | 15.41 | 14.83 | 17.01 | 16.10 |
| 20 | 9.60 | 9.12 | 14.83 | 14.70 | 14.40 | 14.18 |
| 21 | 10.34 | 9.75 | 16.32 | 15.90 | 18.31 | 17.38 |
| 23 | 10.84 | 9.99 | 17.36 | 16.64 | 18.92 | 18.11 |
| 24 | 11.26 | 10.58 | 17.88 | 17.53 | 19.99 | 19.11 |
| 26 | 11.25 | 10.72 | 17.12 | 16.55 | 16.69 | 16.03 |
| 28 | 12.53 | 12.04 | 19.44 | 19.12 | 21.49 | 20.44 |
| 29 | 12.38 | 12.03 | 18.97 | 18.84 | 20.79 | 20.20 |
| 32 | 13.29 | 12.59 | 20.28 | 20.04 | 22.27 | 21.52 |
| 34 | 13.48 | 12.87 | 21.26 | 21.04 | 22.82 | 22.51 |
| 38 | 14.26 | 13.64 | 22.23 | 20.92 | 24.05 | 22.28 |
| 42 | 16.37 | 15.11 | 23.29 | 22.19 | 25.34 | 23.51 |
| 48 | 16.22 | 15.54 | 23.17 | 22.88 | 25.28 | 24.46 |
| 56 | 18.17 | 16.93 | 25.09 | 24.01 | 27.14 | 25.33 |

## Demonstration: Full-scale tests

**Full-scale tests in controlled conditions at laboratory, assessing diverse parameters** under the simulation of train passage to correlate track performance and sensor measurements

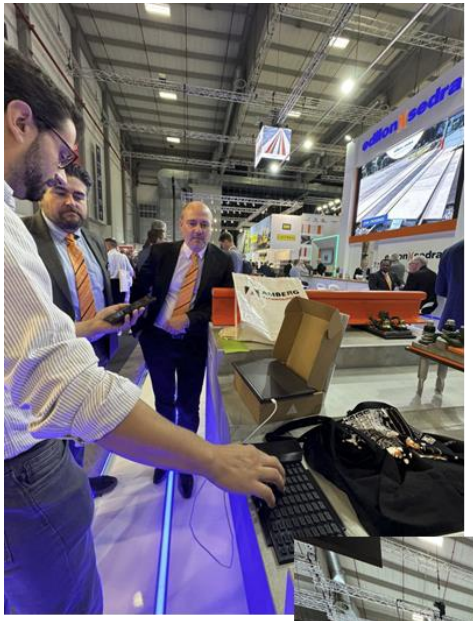


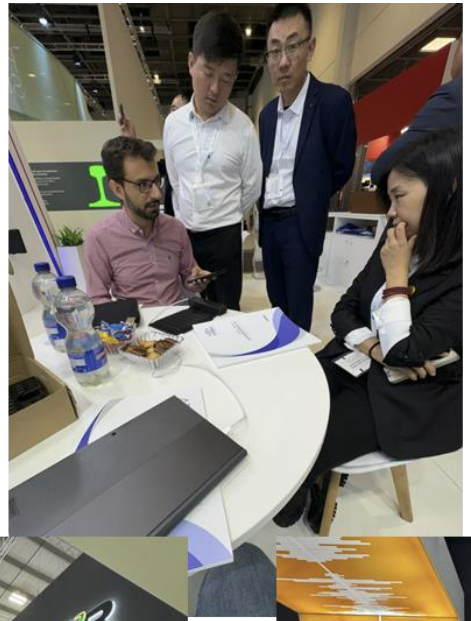


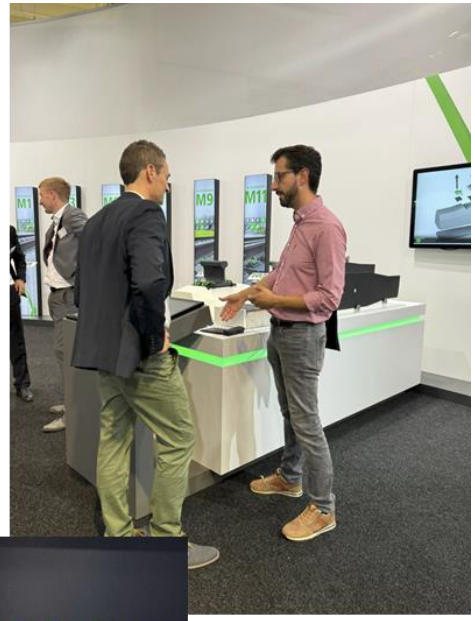



# *Experiences: validation and demonstration*

## Promotion







# Experiences: validation and demonstration

## Promotion



**II JORNADA TÉCNICA "I+D+i en Materiales y Tecnologías para la Construcción y Mantenimiento de Vías Ferroviarias", Granada 2024**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AC Ingenieros LADICIM ArcelorMittal edilon sedra AGENCIA ESTATAL DE INVESTIGACIÓN CT
ANTRASA guamar Innerspec Railway Innovation Hub
KONUX ayesa
IDOM UAX renfe ineco lantania
eurecat TECSA MOBILITY ADO ctcon POLITÉCNICA INSTITUTO EDUARDO TORROJA COMSA CORPORACIÓN

## Promotion



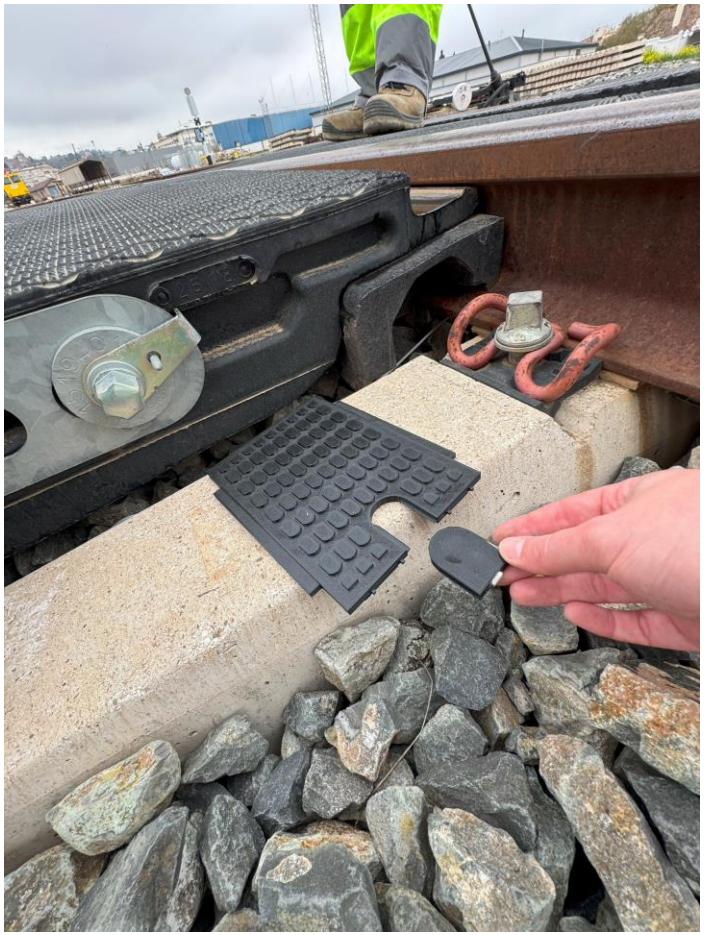
# *III JORNADA TÉCNICA "I+D+i en Materiales y Tecnologías para la Construcción y Mantenimiento de Vías Ferroviarias"*

## ***October-November, Granada 2026***

## Pilot – Real Track

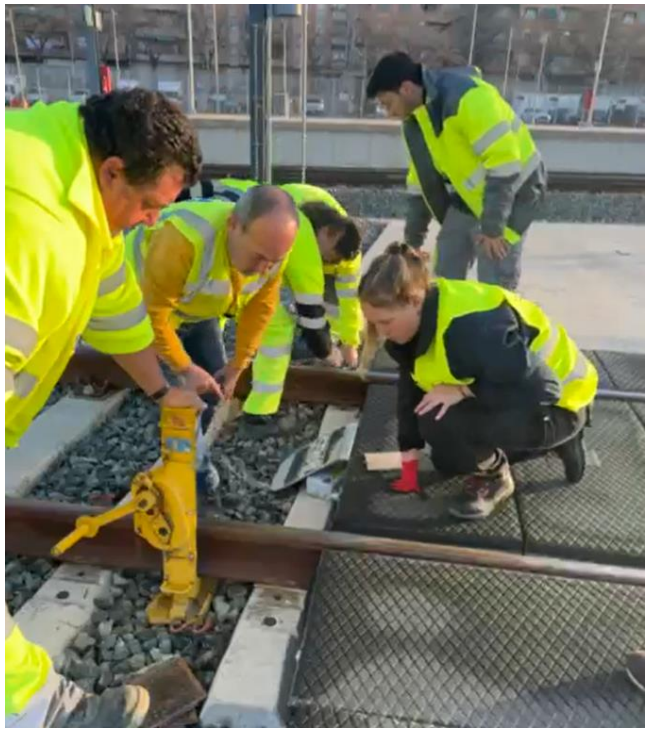

PUBLIC-PUBLIC/PRIVATE COLLABORATION

## Pilot – Real Track

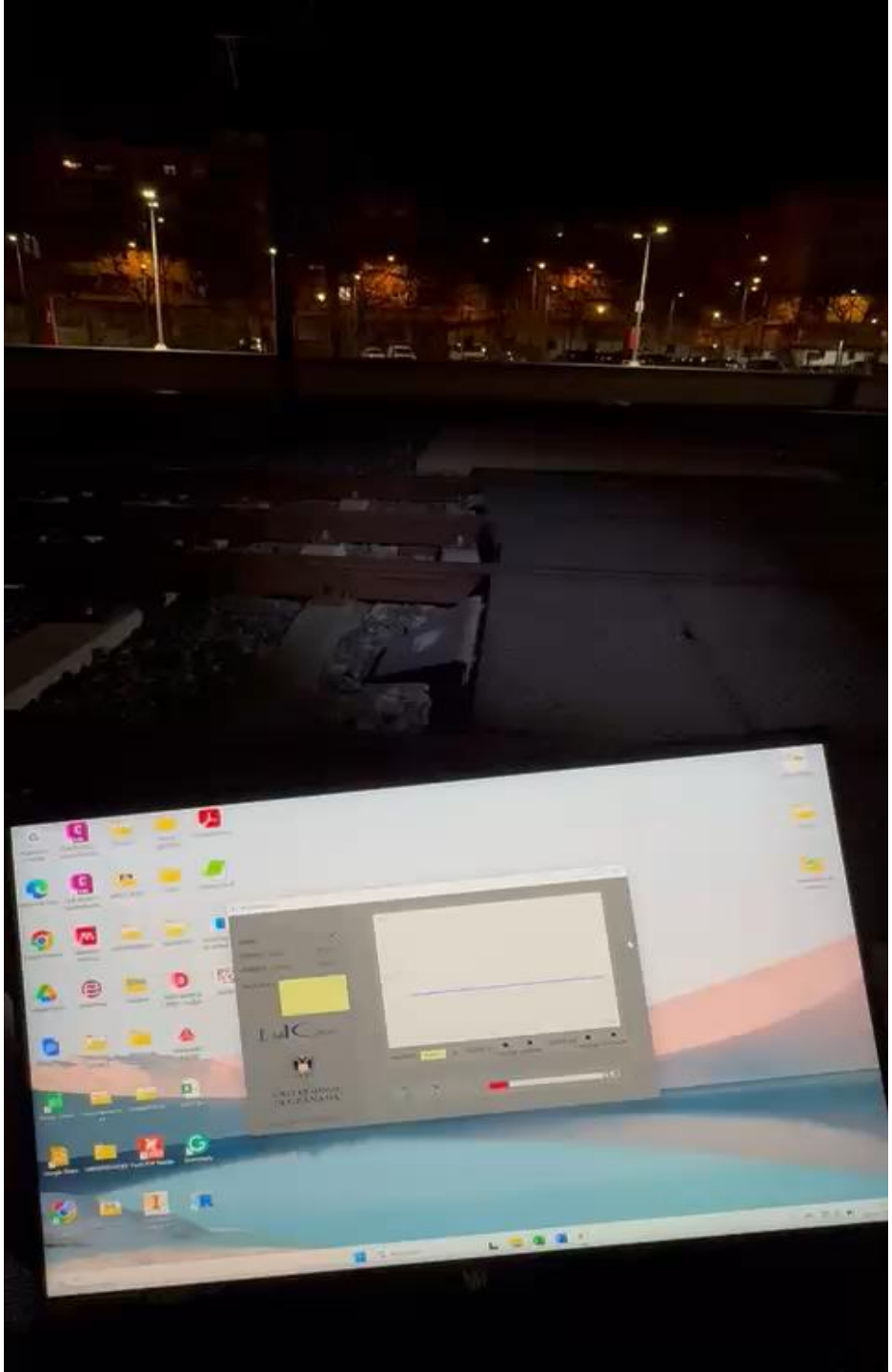
# *Experiences: validation and demonstration*

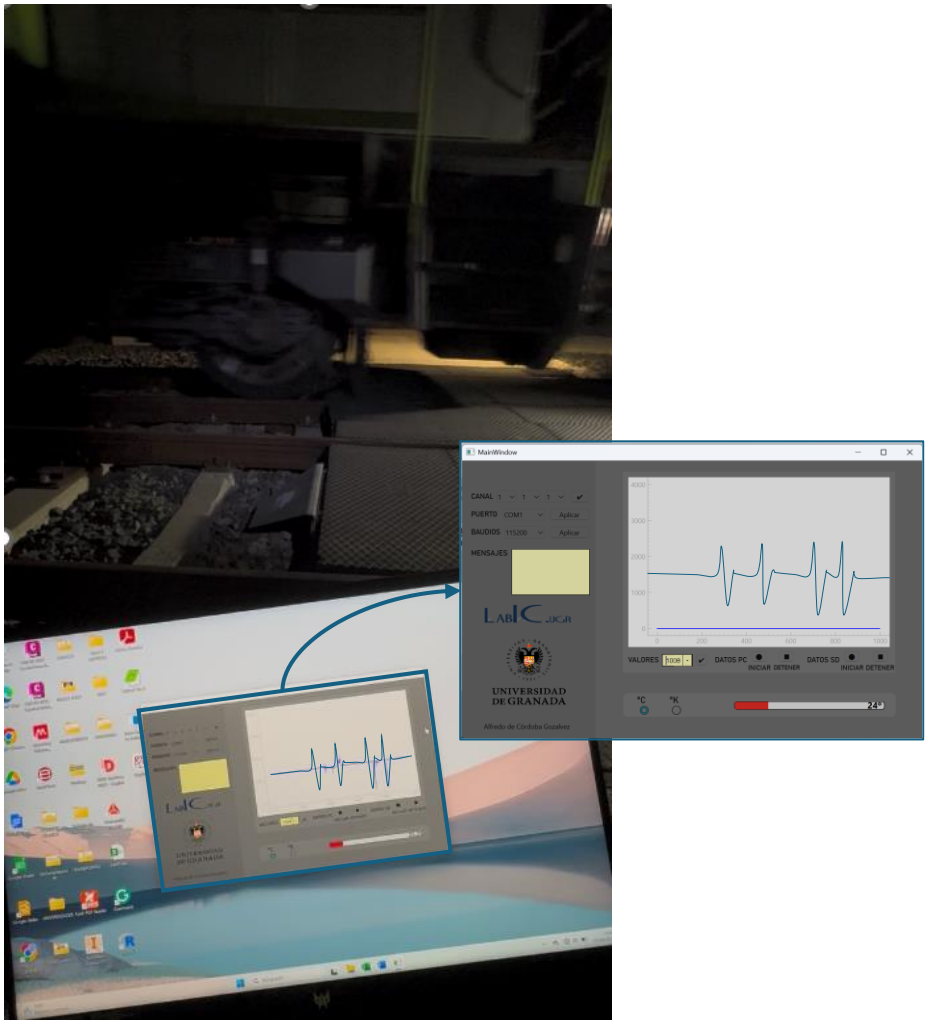
## Pilot – Real Track




***ESAD***

***Internal view***




MainWindow
CANAL
PUERTO
BAUDIOS
MENSAJES
VALORES
DATOS PC
DATOS SD
INICIAR
DETENER
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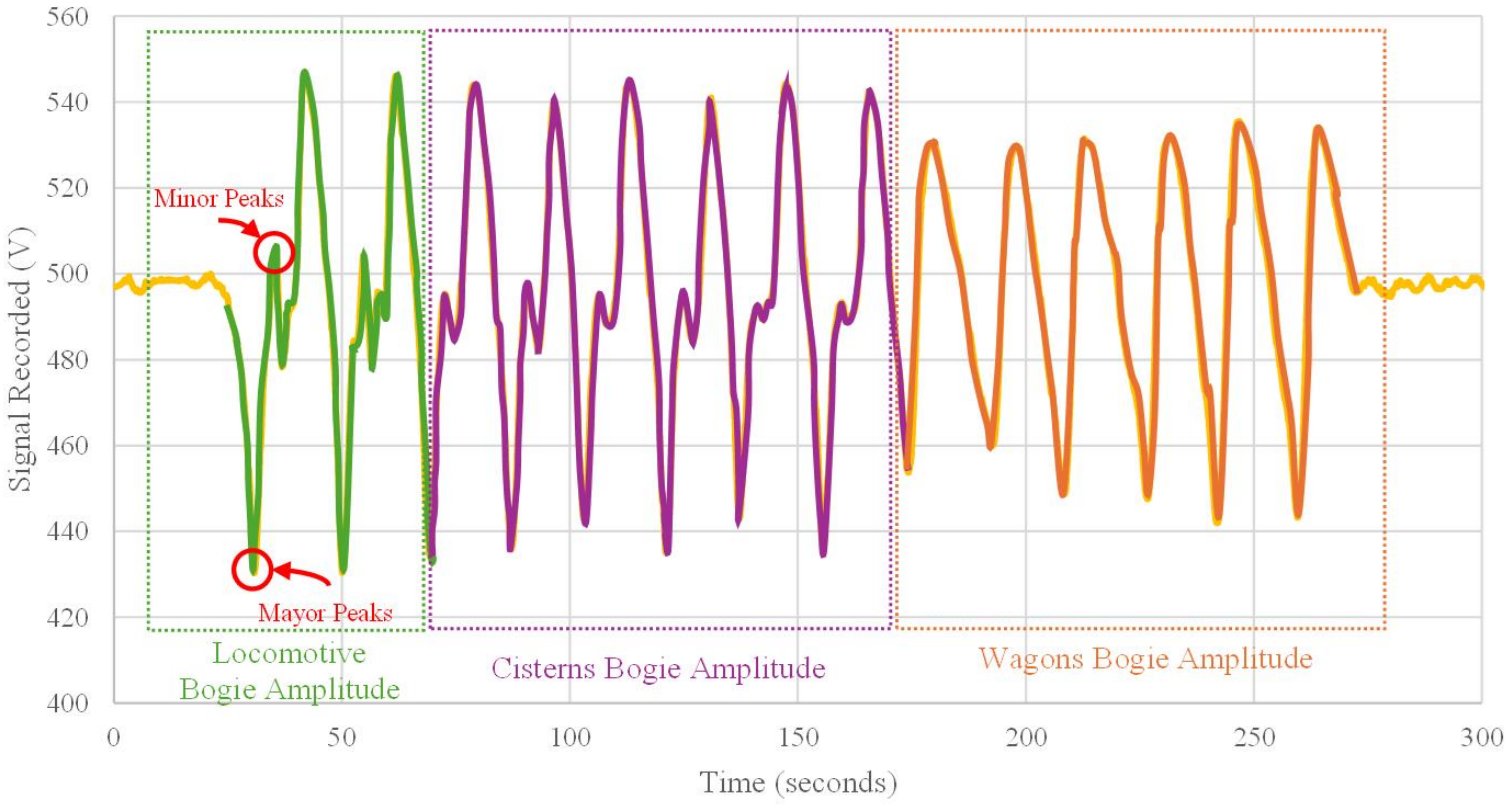
## Pilot – Real Track

## Pilot – Real Track

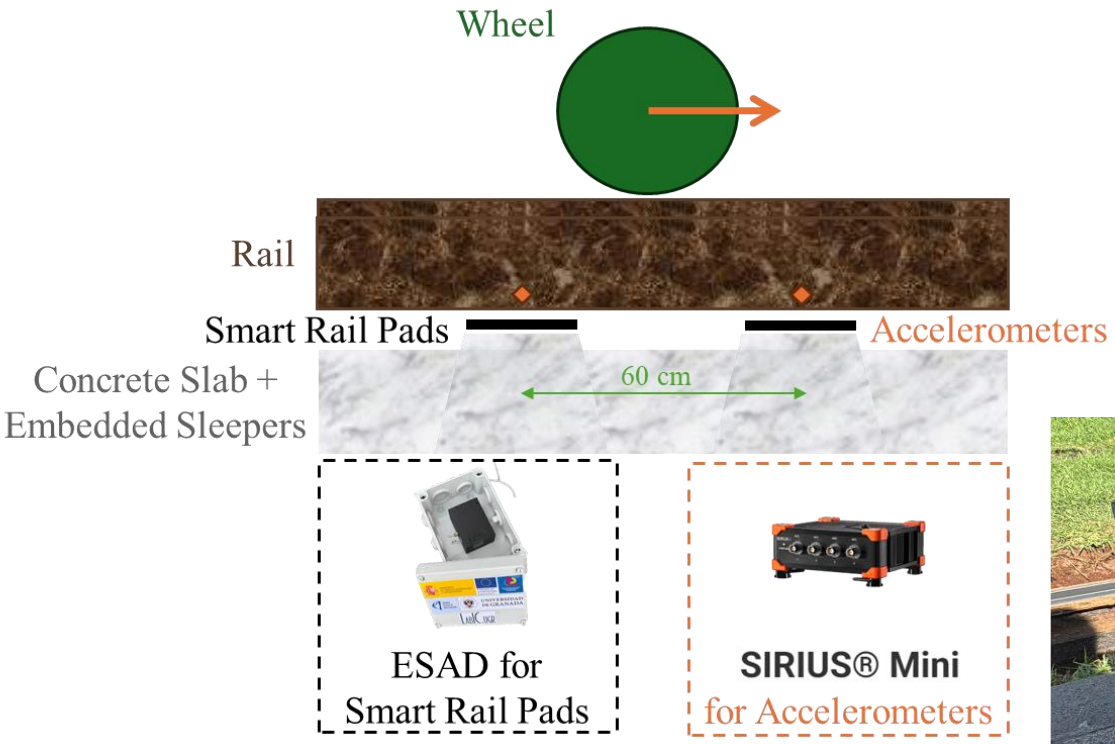

PUBLIC-PRIVATE COLLABORATION

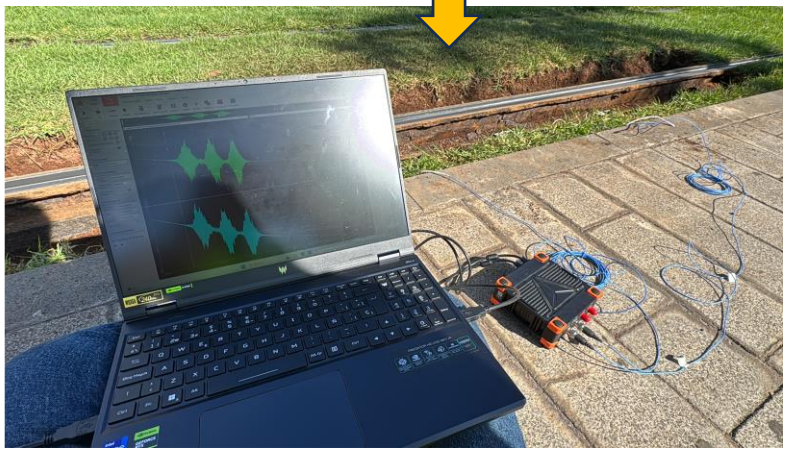

metrotenerife

## Pilot – Real Track

## Pilot – Real Track

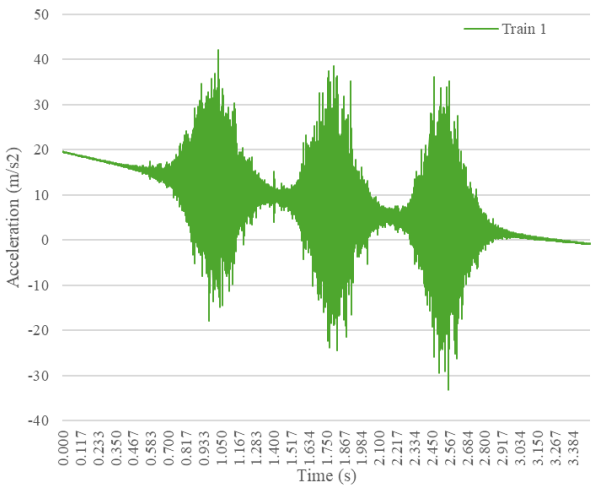
Comparing InterActive Pads with Standard devices, like accelerometers



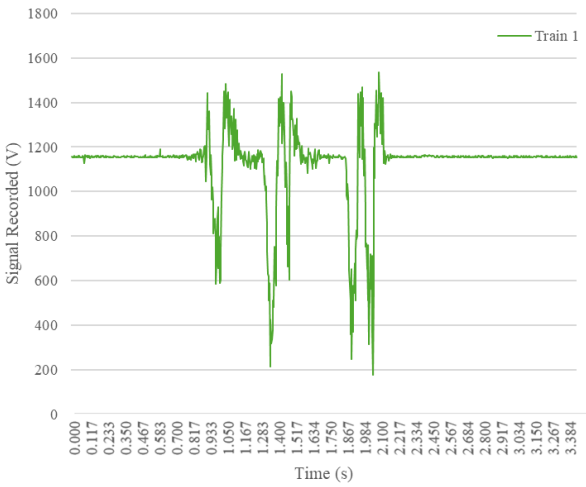
## Pilot – Real Track

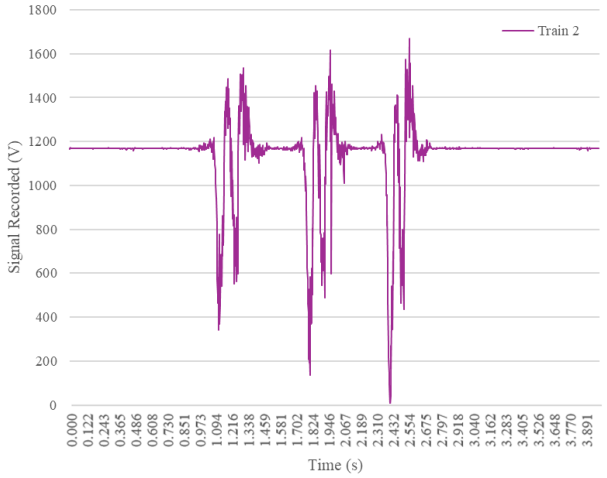
### Accelerometers



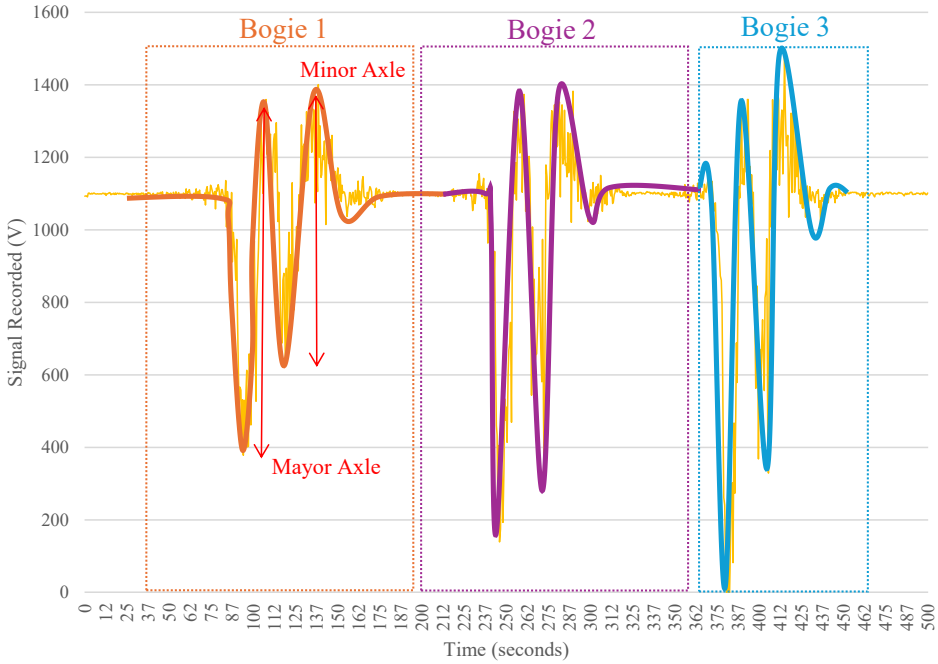


### InterActive Pads

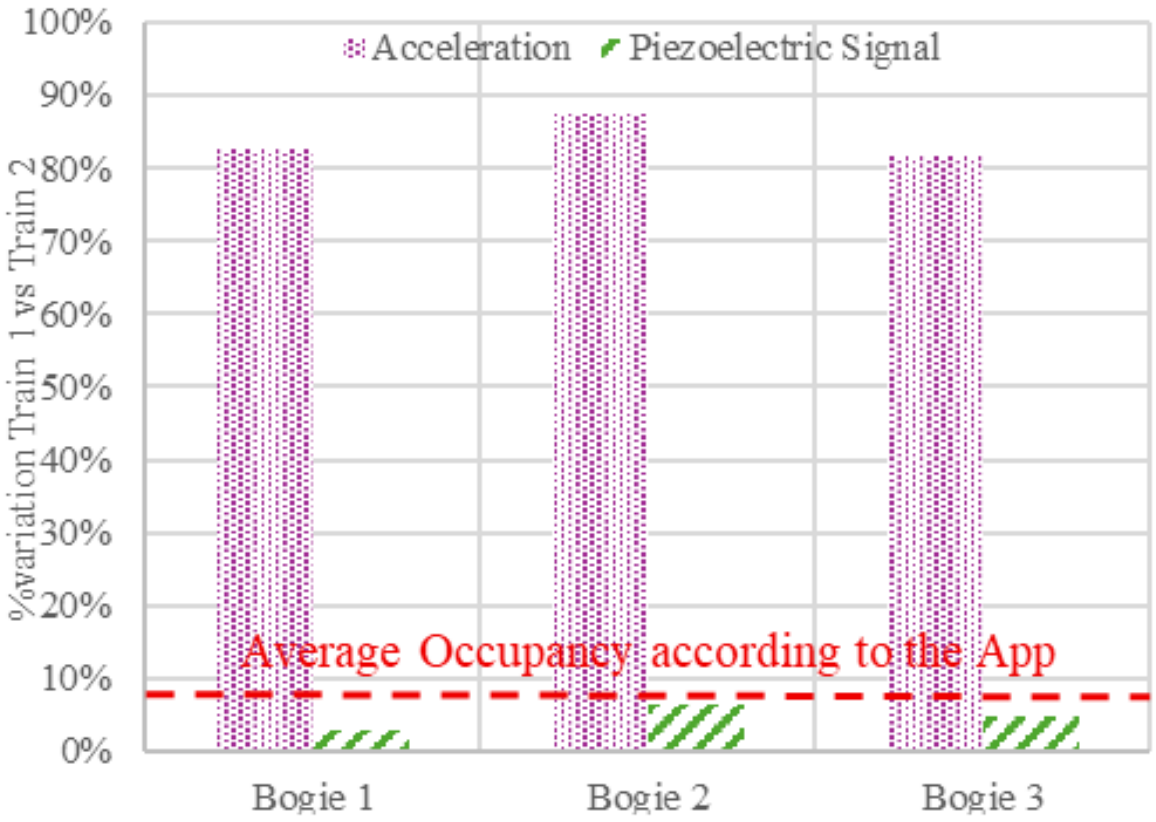


## Pilot – Real Track

## Pilot – Real Track

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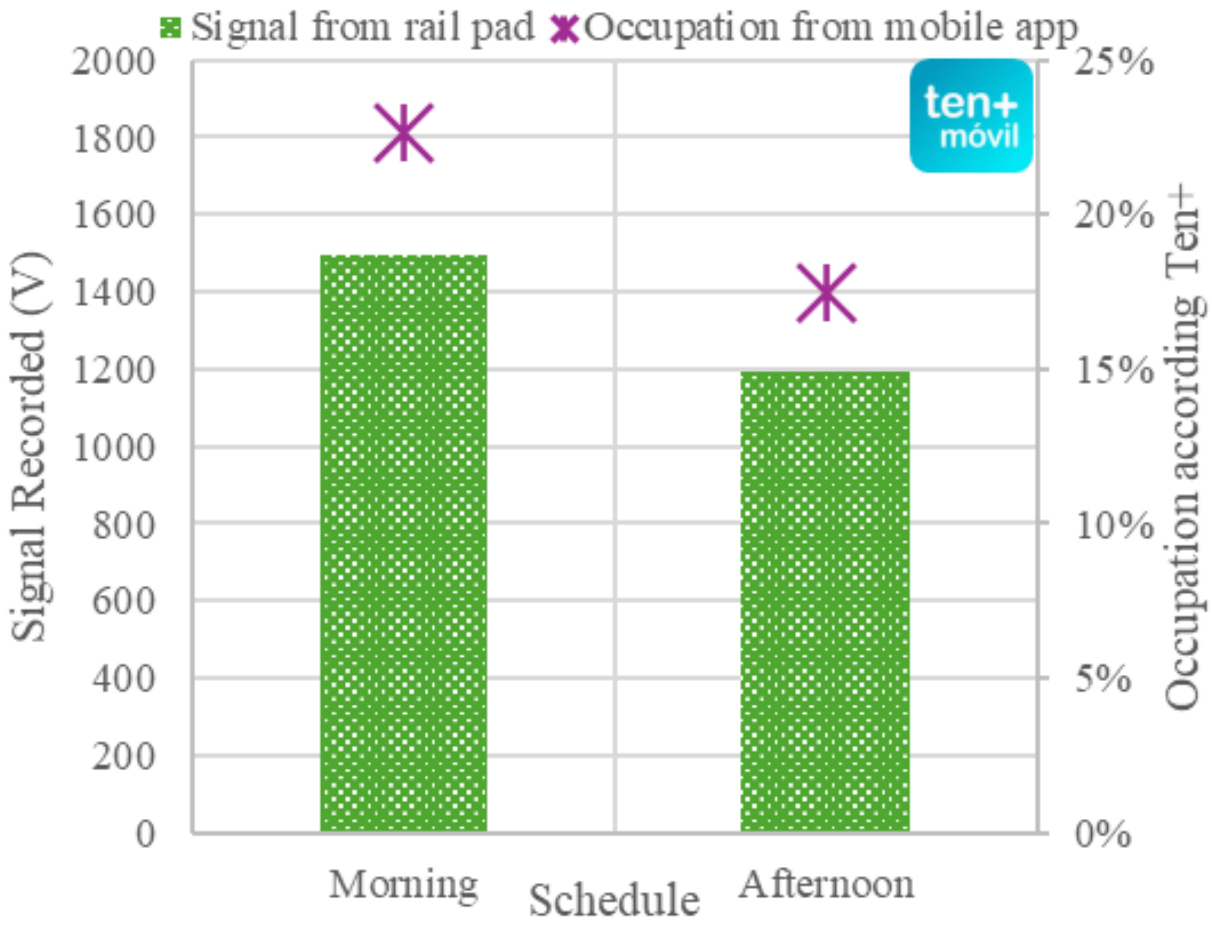
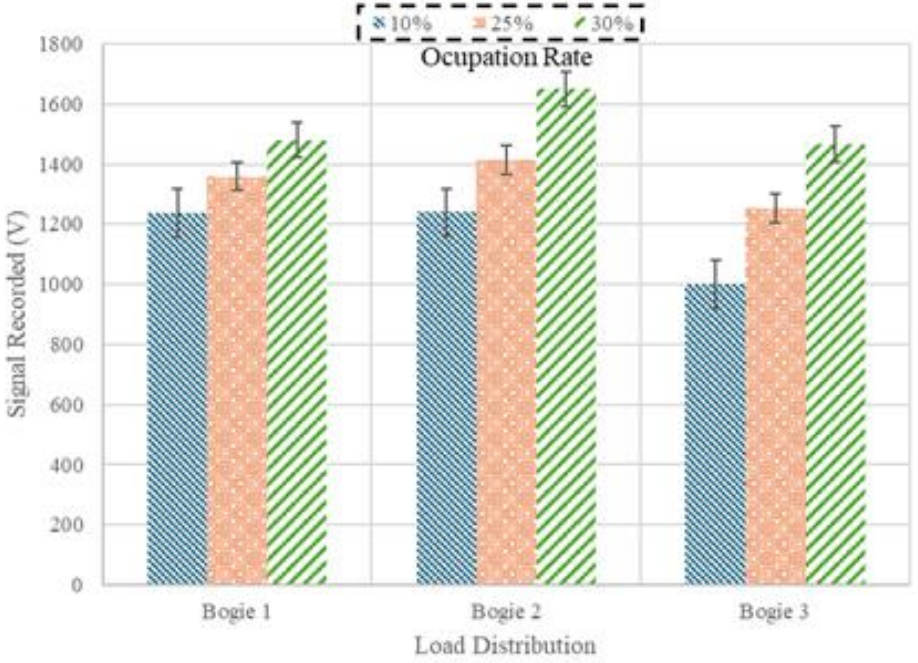
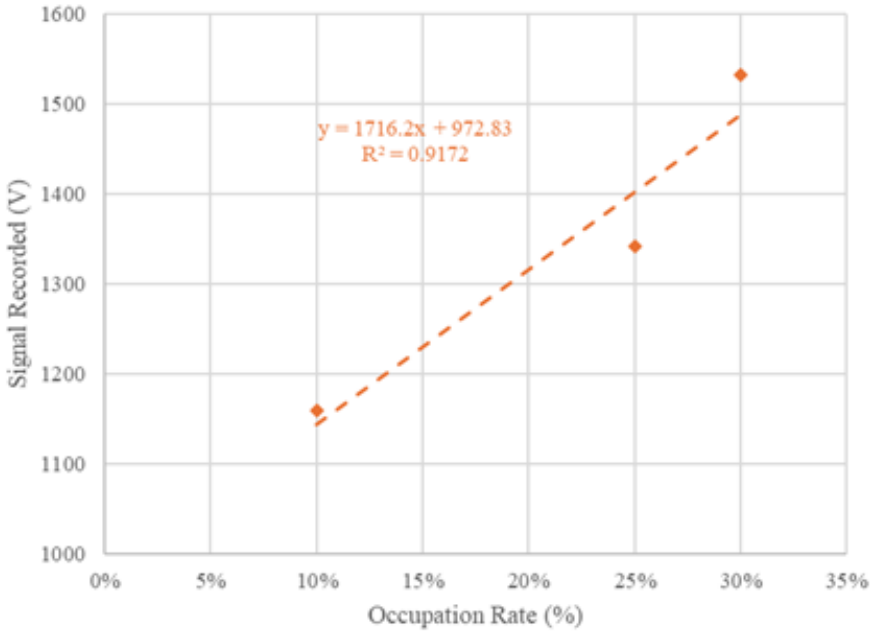
## Pilot – Real Track

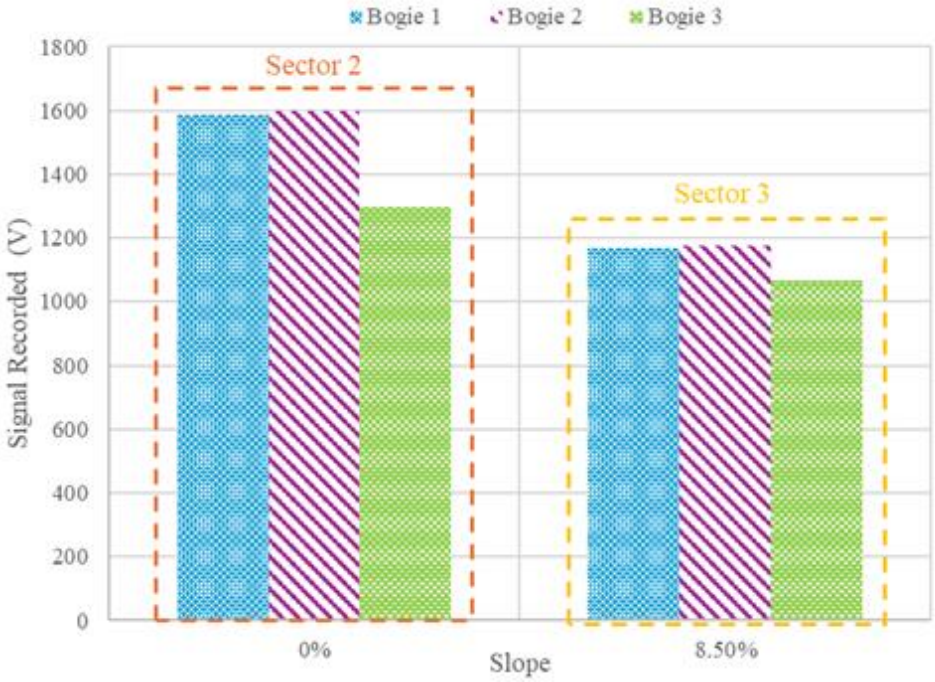


## Pilot – Real Track

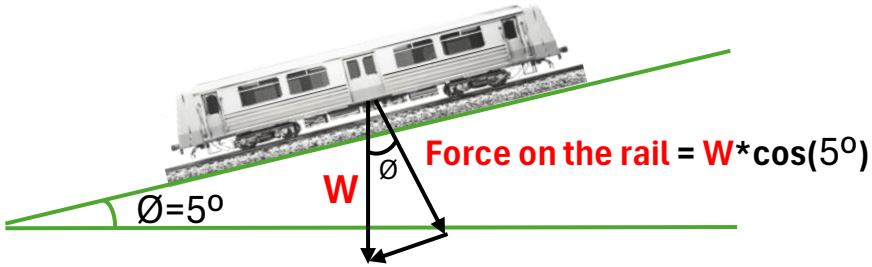


## Pilot – Real Track

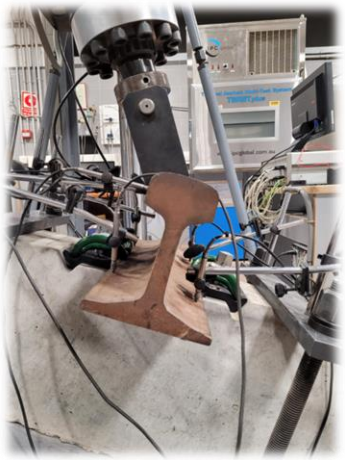



Sector 3 - Slope: 8,5 %



# CONTENT





# *Conclusions*

- InterActive Pads are smart rail pads allowing **for continuous and reliable monitoring of railway tracks**

- Measuring of **diverse operation parameters**: **adaptable system** by changing type of sensor

- IA Pads have been **successfully validated and demonstrated through full-scale laboratory tests**

- IA Pads have been **successfully demonstrated at real tracks: slab and ballasted track; light and heavy traffic**

# *ACKNOWLEDGEMENTS*

**PROJECT** PDC2022-133966-I00 **FUNDED BY**


Project "Proof of Smart Pads for Monitoring Vehicle-Track Interaction" (PDC2022-133966-IOO), funded by the Ministry of Science, Innovation and University of Spain (MICIU/AEI /10.13039/501100011033) and by the European Union – Next Generation (EU/ PRTR)

**PhD Student** Amparo Guillén

# *THANKS FOR YOUR ATTENTION*