The University Of Sheffield.

RAIL SAFETY AND STANDARDS BOARD

Predicting Railhead Friction levels Using Artificial Intelligence (AI)

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Overview

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  - How data is collected
  - Prediction tool
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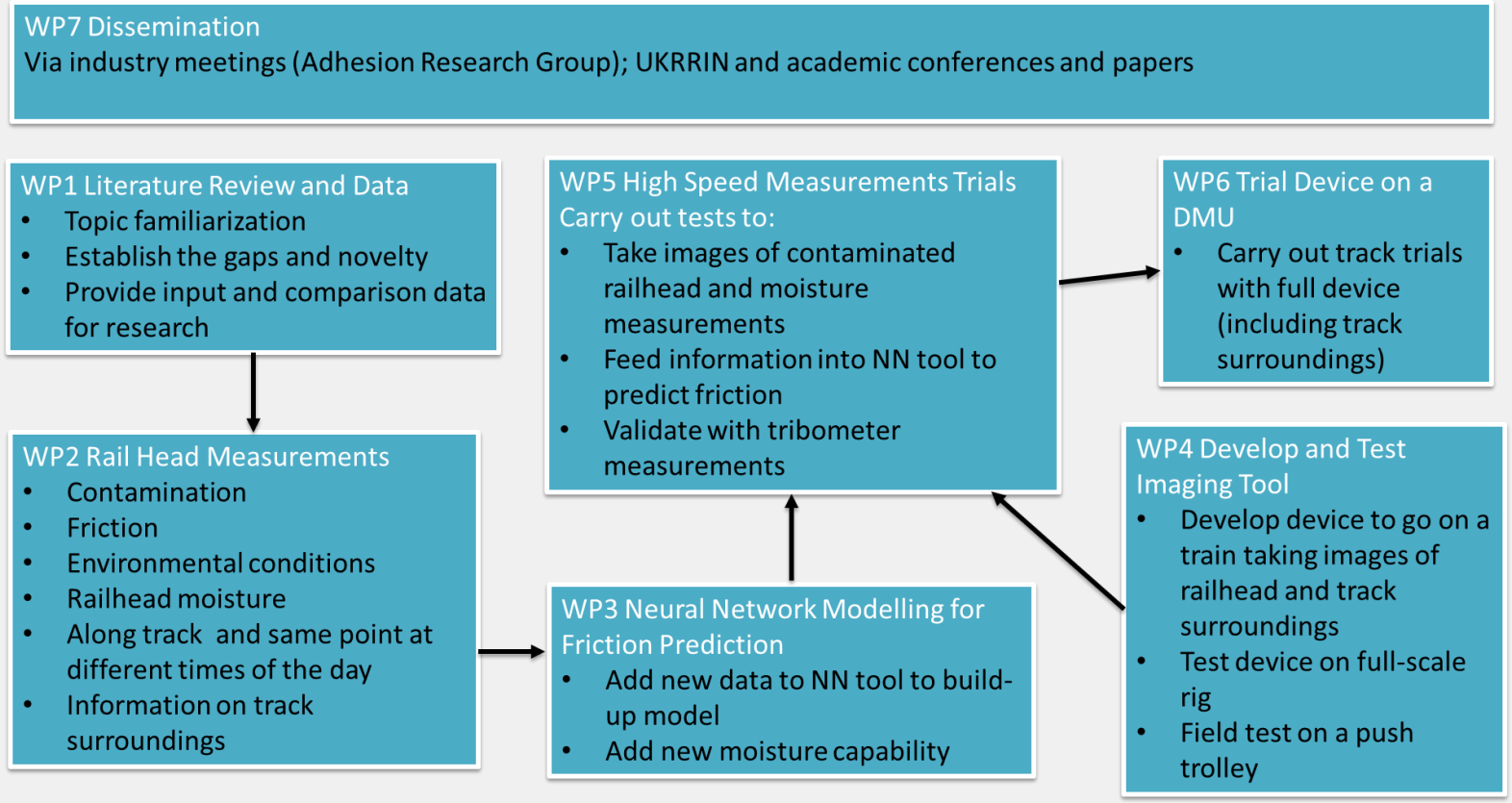
  - Validation and Retraining of the NN tool
- Image Sensitivity test for NN tool
- Future work plan

Aim and Objectives

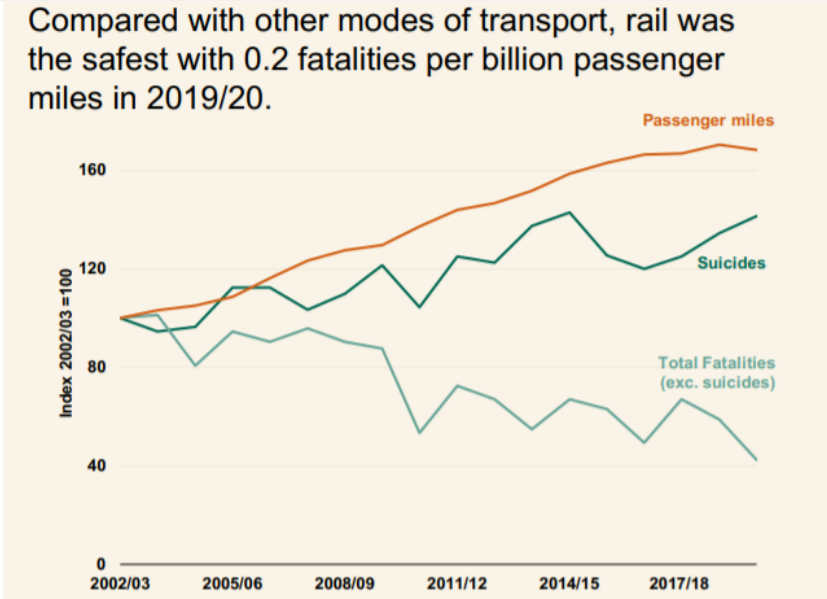
The aim of the project is to improve the understanding of wheel/rail interface low adhesion friction transience and to use it to improve adhesion forecasting and validation approaches.



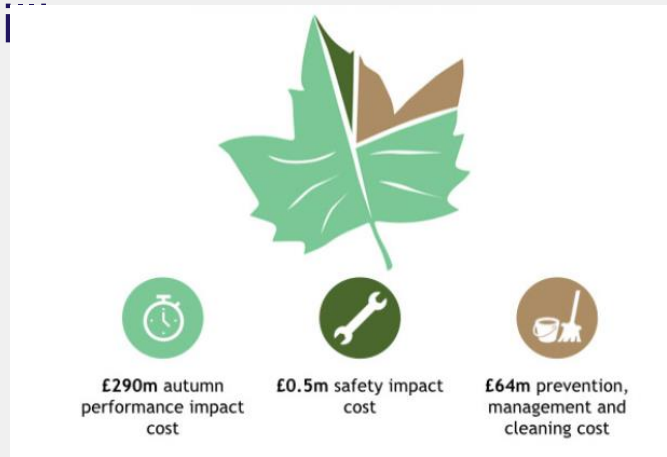
Introduction

- Electrified rail provides greener modes of transportation

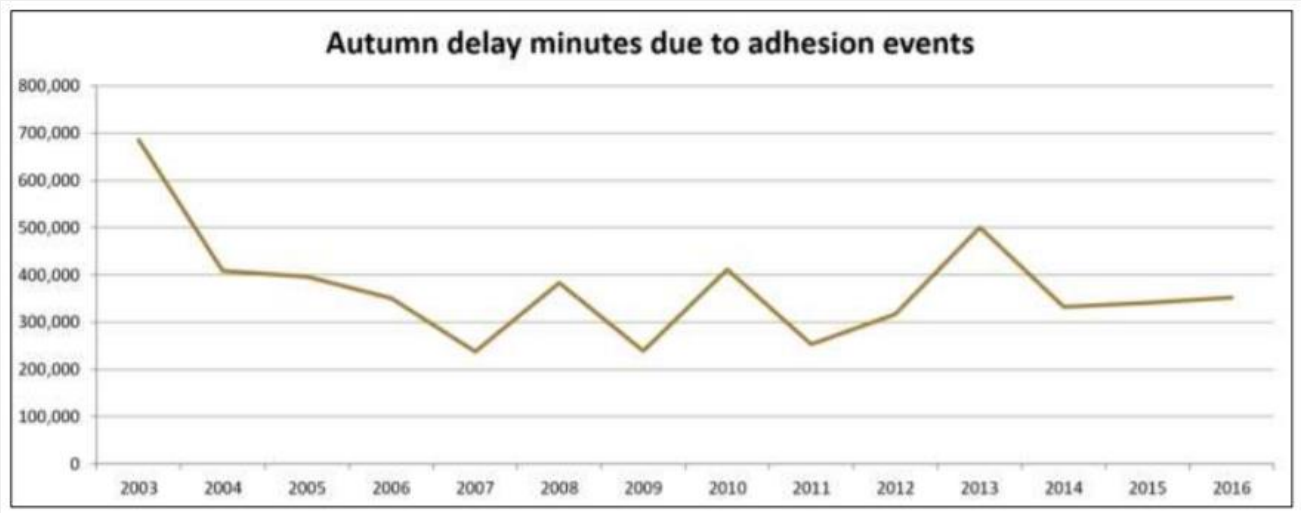
- Rail provides safer travel with only 40 incidents recorded in 2018/19 in the UK



- Low Adhesion costs the UK rail industry approximately £355 mi



- Low adhesion between wheel/rail contact is one of the major causes of trains delays in the UK

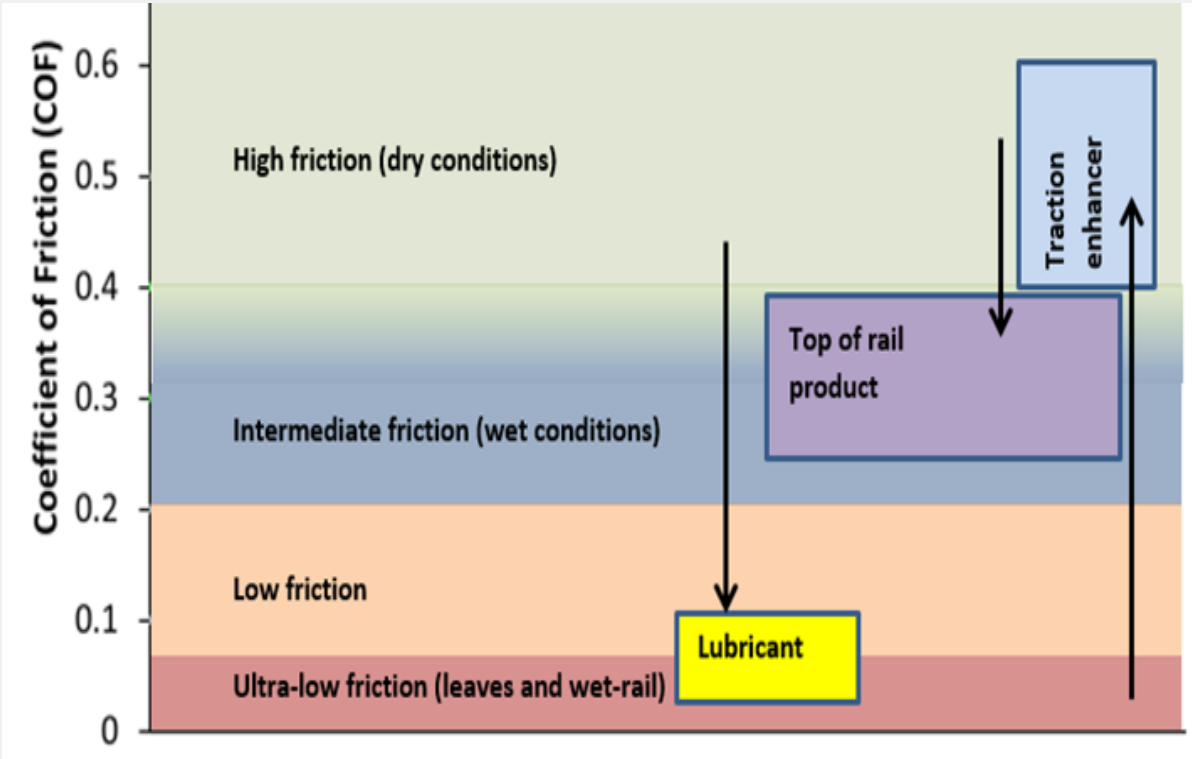


Introduction to Low Adhesion

- What is Low adhesion?

According to the AWG “Adhesion is the measure of slipperiness or grip between the wheel/rail contact.

It is measured as coefficient of friction, *Mu*.



Introduction to Low Adhesion (cont'd)

- Occurs majorly in autumn and winter due to low temperatures, fallen leaves and increase in humidity
- It has two major causes which are;
  - Wet-rail Phenomenon – mixture of oxides and moisture
  - Leaf contamination – creates a black Teflon-like coating on the railhead

  - Others like oil and/or hydraulic fluid leakage, coal dust presence

Methodology: Data collection

- Data Collection
  - Data has been collected over Autumn and Winter of 2019 and 2020. This data was collected from over 8 railway tracks in the UK.
  - Data collected include:
    - Railhead friction
    - Air and railhead temperature
    - Dewpoint temperature
    - Contamination thickness layer
    - Relative humidity
    - Railhead and forward-facing images

  - The data collected was used to train the Neural network (NN) tool and analyzed to further understand the mechanisms of low adhesion

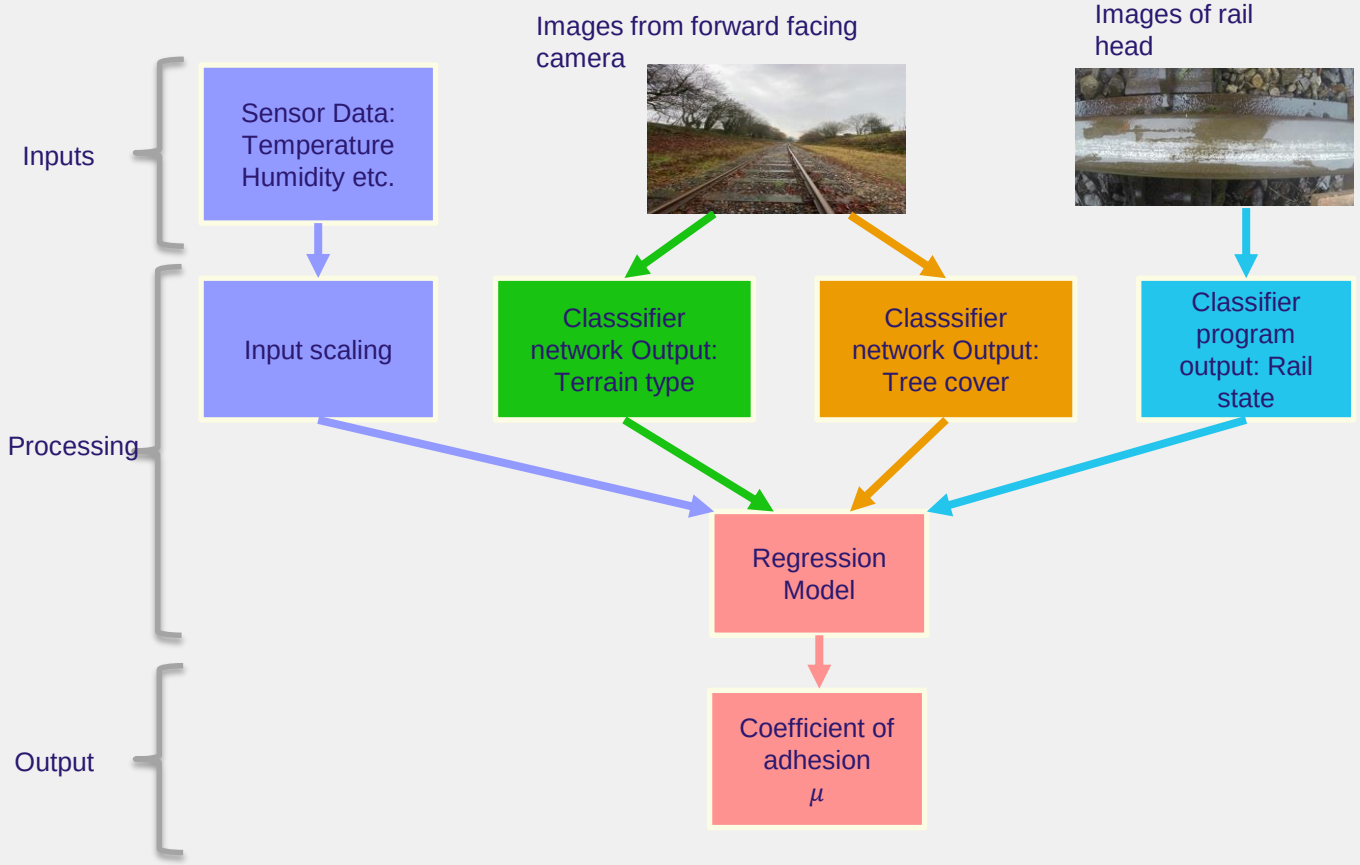
Methodology: Data collection

- Train track sites were visited to collect data

Information Collected	Tool used
Pendulum Test Value (PTV)	Pendulum Tribometer
Railhead and Air temperature	Infrared Thermometer
Relative Humidity	
Dew point	
Railhead and forward Images	GoPro Camera (Hero 8 & 9)
Contamination layer thickness	Eddy current thickness gauge

Methodology: Prediction tool

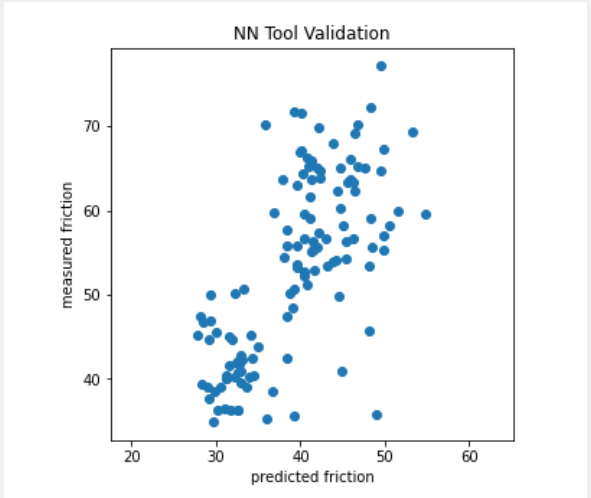
- A prediction tool has been designed to boost train driver confidence, passengers and railway industry safety
- Real-time on-board train friction prediction tool leads to high precision forecasts
- **Neural network** is used to process the images
- Relationship between environmental data and railhead friction is non-linear, hence the need of **Gaussian process** to predict **adhesion levels** as they flexible for non-linear relationship.

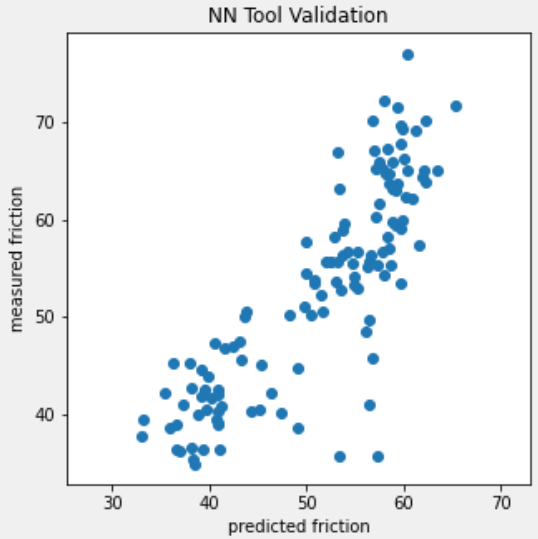


Neural network (NN)

Validation of the prediction tool

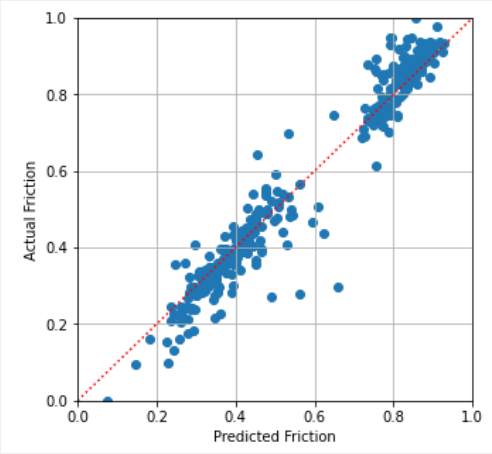
- The prediction tool was tested on a unique set data that was not involved in the training
  - The tool under predicted friction (left)
  - It was retrained with relevant data (right)





Results from the prediction tool's regression model (Gaussian model) before and after retraining

- Normalised data from first training using data collected in 2019 (left) and
- second training with inclusion of data collected in 2020 (right)



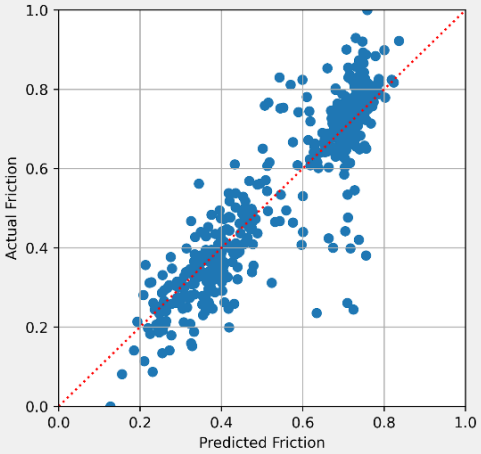


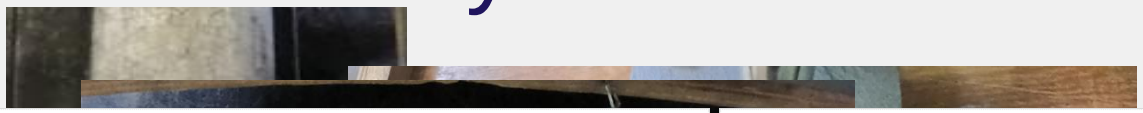
Image sensitivity test for NN image processing

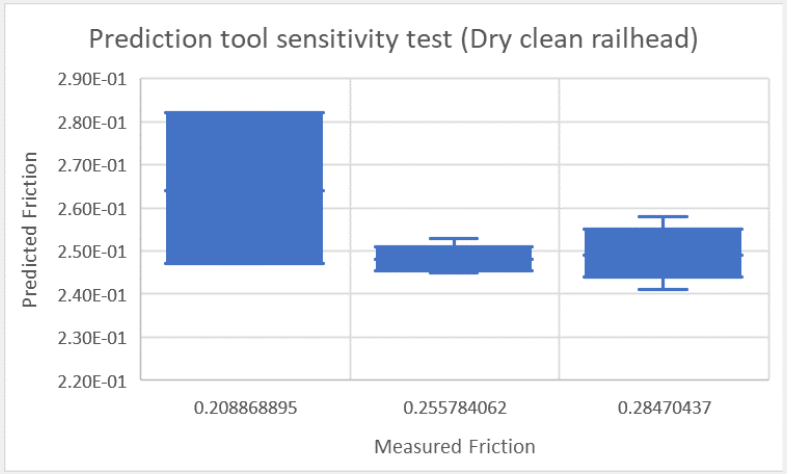
A number of tests and analysis on the image sensitivity of the NN tool has been done to determine the impact on the NN tool's friction prediction.

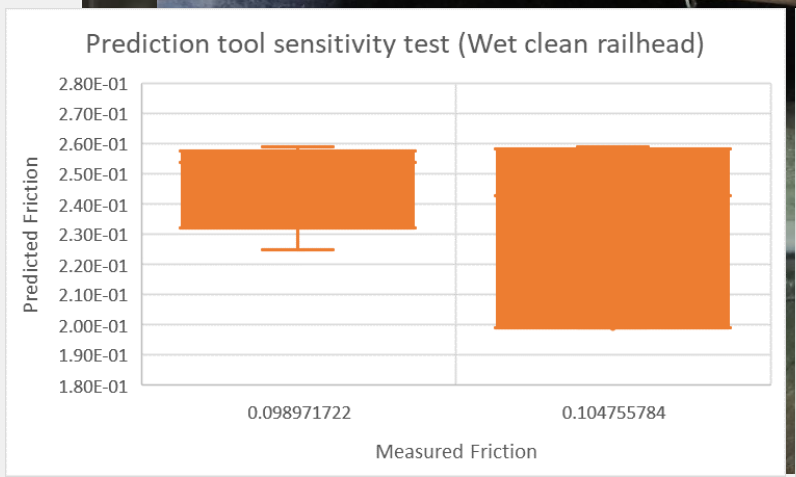
- Images of the railhead from varying:
  - Angles
  - Distance
  - Lighting contrast

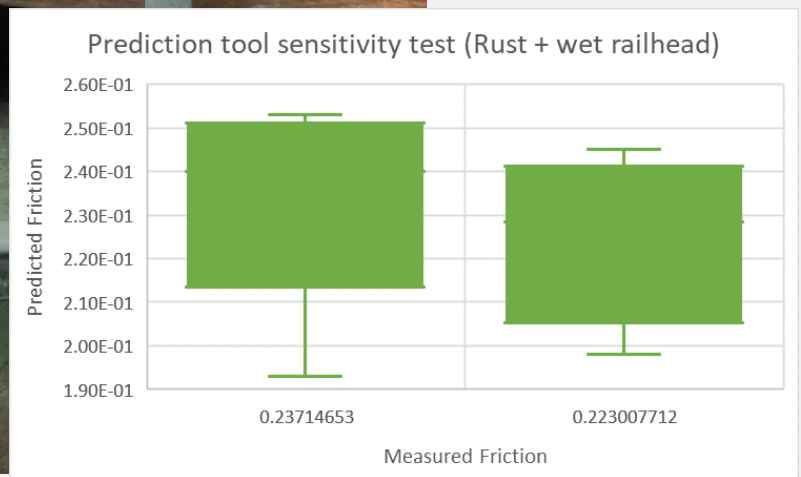
- The images have been tested by processing them through the NN and comparing the similarity or difference in friction prediction

Results from sensitivity tests





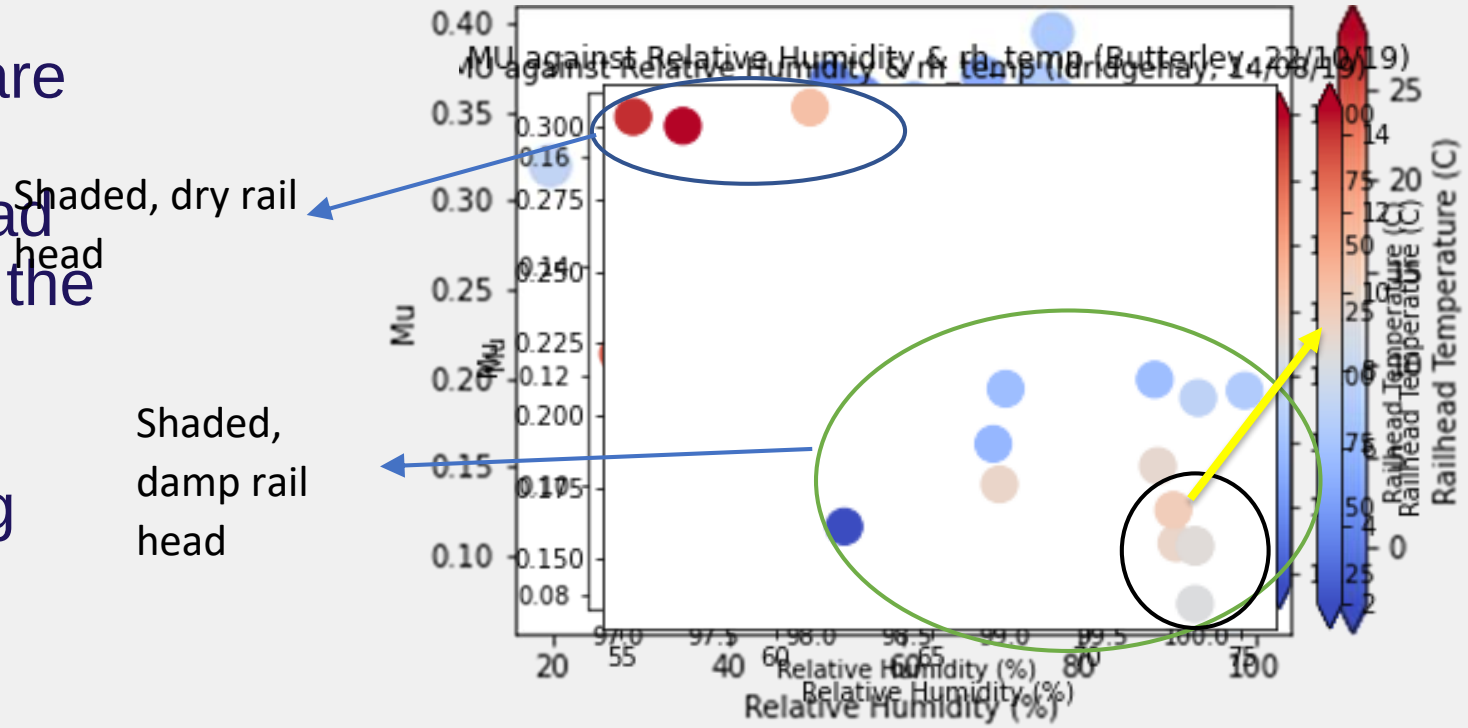




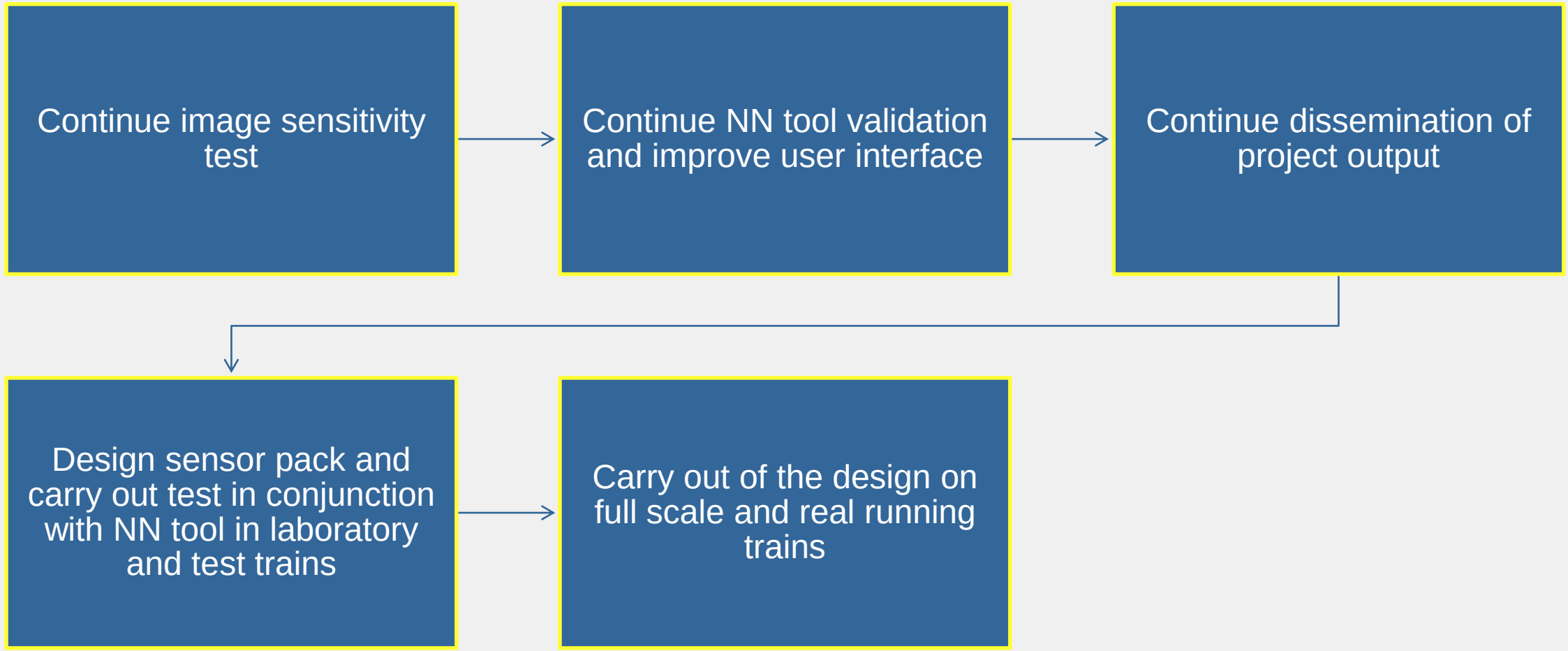
Analysis of Friction and environmental data

Data collected over the period of Autumn and Winter, 2019 and 2020 are been analysed to improve the understanding of the effects of railhead temperature and relative humidity on the friction level.

- General trend noticed is that high relative humidity (>70%) can bring about a decrease in friction level



Future work plan



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