# The Development of an Integrated Computing Platform for Measuring, Predicting and Analyzing Profile-specific Fixity of Railway Tracks

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## I INTRODUCTION

### What is "track fixity"?

**Track fixity refers to the degree to which the position of a railway track remains unchanged over time; it is one of the key measures used to calculate clearances between rolling stock and structures.**

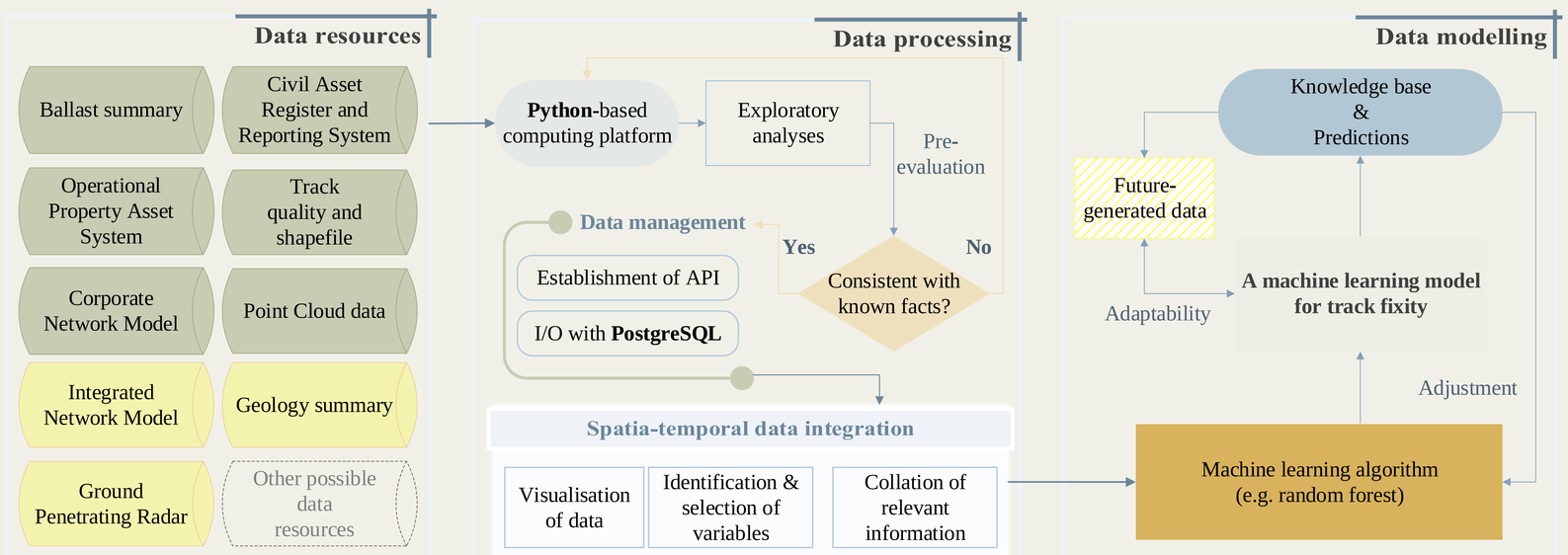
### Motivation

- **The UK's current measurement of the track fixity remains at a low level of granularity.**
- **There is a lack of predictive tools that can provide more detailed information about the movement of tracks through a continuously updated, ongoing automated process.**

## II OBJECTIVES

1. **Propose an effective metric and method of calculating track movements using LiDAR (Laser imaging, Detection, And Ranging) data.**
2. **Create an integrated data model with a machine learning model (e.g., a random forest model), which is trained on the calculated track movements and the data of a selection of the factors influencing track movement.**
3. **Verify the key factors that can cause the track movements.**

## III METHODOLOGY




### 1 Calculation of track movement

**Propose a new metric for calculating the displacement of rail heads in terms of both rate and direction.**

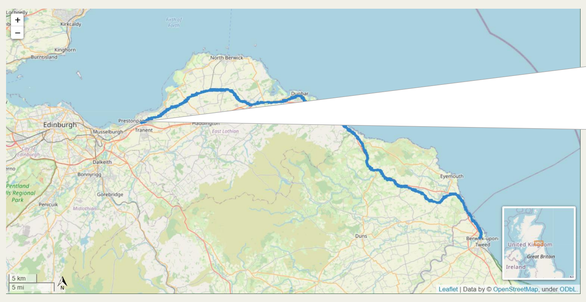
### 2 Data integration

**Cross-reference the track fixity measures with data of identified influencing factors, given the availability of the data resources.**

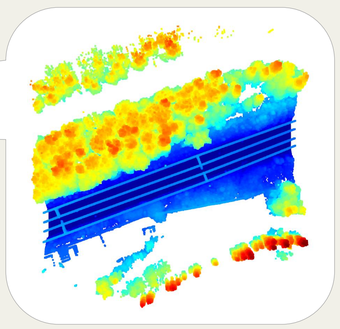
### 3 Predicting track movements

**Create a comprehensive data set, with which a prototype machine learning model was developed and applied to predict and analyze track fixity.**

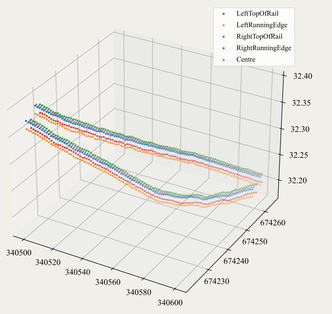
## IV A CASE-STUDY EXAMPLE



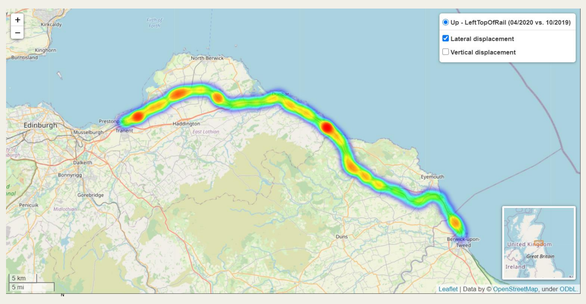

**We demonstrate the feasibility of the prototype with data from an approximately 80-km section of the East Coast Main Line south of Edinburgh in Scotland.**



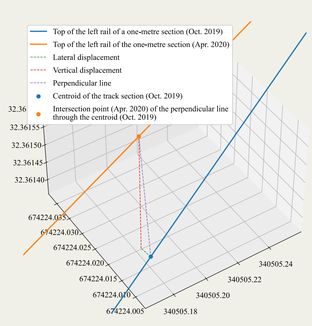
**LiDAR data in a 100m×100m grid (April 2020)**



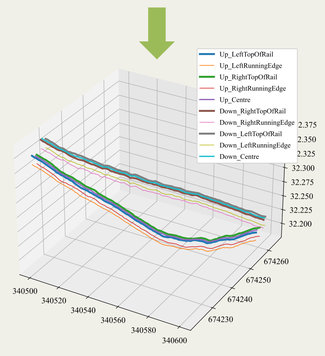

**Point cloud of rail heads in the grid**




**Average lateral track movement (mm per 10-meter length) of the top surface of rail head of the left rail in the up direction (October 2019 vs. April 2020)**

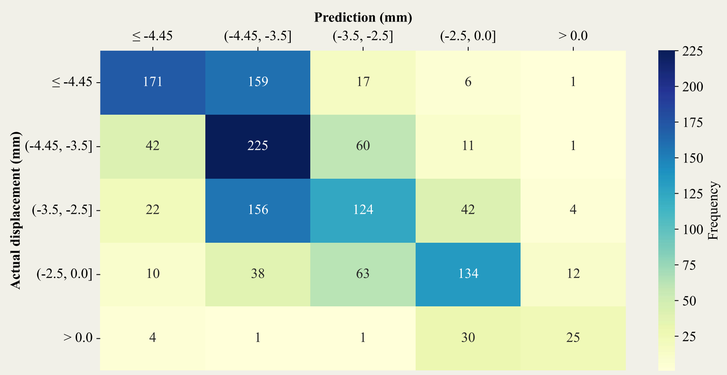



**The movement of the top surface of a 1-m length of rail head of the left-side rail in the up direction**




**Polylines using the point cloud in the grid**

### Modelling results (based on a random forest model)




| Factor | Relative importance |
|---|---|
| Curvature | 0.3887 |
| Cant | 0.3725 |
| Maximum speed | 0.2016 |
| Presence of underline bridges | 0.0095 |
| Presence of over-line bridges | 0.0073 |
| Maximum axle load | 0.0067 |
| Presence of retaining walls | 0.0060 |
| Presence of tunnels | 0.0058 |
| Presence of stations | 0.0019 |

- **Curvature** and **cant** proved to be the most important among all that were considered in the model. **Axle load** and **train speed** would also be expected to significantly impact track fixity.
- In terms of the presence of structures,
  - track fixity of ballasted track can be more vulnerable to movement than fixed structures such as **retaining walls** and **tunnels**.
  - Track sections within **station** areas are much less likely to suffer from fixity issues given a much slower train speeds and lack of track curvature.

## V CONCLUSION

- **We designed and tested the most comprehensive integrated computing framework (prototype) to date for track fixity in the context of the UK's railway system.**
- **With the established workflow, we propose a new metric for assigning track fixity values to a given track profile in terms of its movement relative to the plane of rail within a given period.**

### Further development of the framework

1. **Improved quality reference data over the different location identifiers across different data sources.**
2. **The comprehensive data set should be extended to include additional line sections with differing reference curves and speed profiles.**
3. **Using data from additional measurement campaigns to enable the existing model to be further developed, leading to improved accuracy and greater confidence in the results produced by the model.**
4. **Would require a more harmonized and unified data codification system across the rail industry to accelerate the development and implementation of a full-fledged, automated computing platform to be integrated into the railway track system.**

### ACKNOWLEDGEMENT

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