5. Improved environment

How can the railway limit noise and vibrations in a situation when traffic volumes increase? How can the railway adapt to climate changes? Some examples of how the project tackles these issues are presented.
Effective Drainage Management

Phil Winship
Network Rail
Challenge addressed

Problem
– The UK experiences a significant amount of rainfall, and effective drainage systems are essential to prevent water accumulation on railway tracks. Adequate drainage helps mitigate the risk of flooding, which can lead to track damage, erosion, and even track bed instability. Effective drainage management is essential in lowering whole life cycle costs of railway infrastructure whilst also minimising safety and performance risks of many assets. Loss of drainage system performance can result in a range of failure mechanisms in parent assets such as the track and earthworks.

Approach
– By using a broader range of data, self-organising maps (SOMs) based analysis identified more relevant data derived parameters (e.g. asset condition scores for whole systems, local rainfall volumes) that were more strongly linked to the occurrence of particular types of failure events than the data derived parameters in the earlier In2track2 work. Once these improved data-derived parameters were identified, they were used to develop enhanced supervised Machine Learning (ML) algorithms that were trained (calibrated) using more up-to-date data, and then validated using an independent set of data not used in the training.
Results In2Track3

- In the In2track3 project, the ML approach from In2Track2 has been enhanced markedly by considering larger and broader data sets, and developing better data preparation protocols especially considering system-based organisation of asset datasets.

- Based on the progress in the In2track3 project, with better understanding of uncertainty and the role of data preparation in the training and validation phases, the ML based codes and data processing protocols have now been developed to TRL 7. This has involved the development of strict data preparation protocols and supporting code, and the re-coding of the ML code to include training and validation functionalities (to allow for updating as new asset and environmental data as it becomes available), output methods to present failure risk in three formats and also the ability to use short term rainfall forecasts to estimate the failure probability of assets in the near future.

Figure 1: Total probability of earthworks failure based on rainfall values between 10 and 100 mm
Recommendations for future research

– The accuracy of the asset data, especially data indicating the location of assets was often poor and this limited the ability to co-locate assets accurately and so investigate the interactions between different assets. The introduction of a system to accurately locate individual assets, and their condition record, so that the interaction between drainage assets and other types of assets can be investigated, would solve this problem.

– There is further work needed to fully integrate the failure risk models into NR decision support systems. Once this has occurred an evaluation of how NR updates the risk models can be done.

– Further research is needed to better identify wet bed failure mechanisms. Initially it would be advisable to determine whether there are different forms of wet bed, that can be characterised by different physical factors. Currently wet bed data is limited, with date of occurrence and location poorly defined in the data.
Mitigation of Noise and Vibration

Phil Winship
Network Rail
Challenge addressed

Problem
- The noise produced by vehicle operations on slab tracks is typically louder compared to ballasted tracks. One main reason for this is that the stiffness of the rail pad is typically lower on slab tracks. This is necessary to compensate for the higher mechanical impedance of the concrete support structure compared to the sleepers in a ballast bed. The lower rail pad stiffness also lowers the rate at which the vibrational energy decays along the rail, leading to higher noise levels.

Approach
- The objectives of this task are three-fold: Firstly, one possibility to reduce both noise and vibration on slab track operation is researched. Secondly, a measurement campaign on an In2Track3 demonstrator in Gransjö is carried out, comparing noise radiated from a slab track section to noise from a ballasted track section. A third additional work was carried out in 2022 on the modelling of noise radiation from the railway wheel.
Milling appears to reduce acoustic roughness in the longer wavelengths, but significantly increases the roughness at short wavelengths.

Grinding and polishing of the rail after milling can reduce the acoustic roughness at short wavelengths.

Milling does not appear to be capable of achieving TSI compliance only using a defined set of parameters.

Milling can be applied strategically (on a site-by-site basis) to reduce acoustic rail roughness.

In some cases, this application may not be cost-effective when treatment requirements are considered.
Future work on the topic

- Future work recommendations to improve:
  - The analysis of the measurements, which is ongoing, can bring more insight into the effect of the In2Track3 - GA 101012456 48 | 177 track construction on the noise radiation. It is suggested to research changes in the track design using numerical models, such as the ones developed in this work, before implementation in the field. The developed time-domain model for sound radiation from railway track can provide an insightful tool for researching, among others, human responses to railway noise and especially the temporal patterns in the signals.
Mitigation of ground-borne vibrations

Aires Colaço, Pedro Alves Costa, Paulo Soares, Alexandre Pinto
Faculty of Engineering, University of Porto
The prediction and control of ground-borne vibrations represent significant environmental challenges for railway exploration in urban areas.

The challenge within sub-task 7.2.6 involves exploring two distinct mitigation measures: i) in the transmission path — through an innovative solution based on a seismic metamaterial concept; ii) at the receiver — by employing a base-isolated building.
Results In2Track3

- Mitigation measure based on seismic metamaterial concept
  - Metastructure: periodic association of individual structures

  Acoustic concept: the periodic characteristics produce a mitigation effect known as the “sonic-crystal”, which is responsible for the introduction of a band gap.

  Applying the same concept to elastodynamic problems
Base-isolated building

- A library located near a shallow underground metro line in the vicinity of Barcelona

Due to the building’s proximity to the tunnel and its sensitivity, a vibration (and re-radiated noise) mitigation measure was recommended during the design phase.

Experimental calibration of the numerical model
Future work on the topic

- What happens next?
  - Developing an expedite tool for predicting ground-borne vibration levels in nearby buildings

- Integrating mitigation measures into the prediction tool

IntRAIL Intelligent prediction tool for ground-borne noise and vibrations induced by railway traffic
Reducing noise after rail machining

Urs Schönholzer
Swiss Federal Railways SBB CFF FFS
Challenge addressed

- Grinding of rails is an important part of normal rail maintenance. Damage caused by rolling contact fatigue needs to be removed to maintain a safe and cost-effective operation of railway tracks.
- One of the drawbacks of rail grinding is a temporary increase of perceived noise emission and corresponding complaints from lineside residents.
- In our work, we tried to assess the surface quality after different rail grinding procedures and quantify their impact on pass-by noise.
Results In2Track3

- Rail roughness has been improved after grinding with an optimized acoustic grinding process.
- However, this did not translate into a significant difference in the pass-by noise measurements according to ISO 3095.
Future work on the topic

- Current measurement standards, as ISO 3095, do not account for tonal differences in pass-by noise. This can lead to an underestimation of tonal annoyance in noise measurements.
- Future work will look for better measurement parameters for acoustic rail roughness and for tonal composition of noise signals.
- A respective project is currently being set up by an international group of rail infrastructure managers.
- More information can be found in the respective chapter of the final report.
Predict and mitigate curve squeal

Astrid Pieringer, Wolfgang Kropp, Jannik Theyssen
Chalmers University of Technology

Leevi Toratti, Matti Rantatalo, Florian Thiery, Johan Odelius, Praneeth Chandran, Matthias Asplund
Luleå University of Technology
Challenge addressed: Railway curve squeal

- Highly disturbing tonal sound in tight curves
- Self-excited vibrations of the railway wheel during ‘imperfect curving’
- Challenging to model, to measure and to mitigate

Source: Peter Torstensson, VTI
Advances in modelling:
- State-of-the-art time-domain model WERAN to study realistic curving scenarios
- Captures transient effects
- Evaluates squeal occurrence and amplitudes

Advances in mitigation:
- Squeal occurs in a certain range of contact positions on the wheel tread
- Measures that move the contact position outside this range have a potential to mitigate curve squeal (e.g. optimised rail profile).
Future work on the topic – Subtask 1

Mitigation methods for curve squeal

- Influence of track design
  
  *Project:* National project funded by Trafikverket (TRV 2020/49829)

- Influence of wheel design
  
  *Project:* Rail4Earth, WP 3, Task 3.5

Publications in Subtask 1


Results In2Track3 – Subtask 2

- Study of real curve in simulation environment
- Parametric studies of train curving and risk for squeal
  - Track gauge does not affect curving significantly
  - Increased cant deficiency improves the radial alignment of train
  - Longer bogie wheelbase increases the angle of attack
- Highest angle of attack when leading wheelset enters the curve
Future work on the topic – Subtask 2

- Development of curve squeal monitoring system in the squeal location, Project: Rail4Earth WP3

- PhD project research
  - Study on how worn wheel- and railprofiles affect the curving performance
  - Field tests with friction modifiers
Thank you!