

Data Analytics and Co-Simulation for Smarter and More Resilient Rail Systems

Supervision team

Main Supervisor: kenneth.pierce@newcastle.ac.uk

Co-supervisors: david.golightly@newcastle.ac.uk, roberto.palacin@newcastle.ac.uk, matthew.forshaw@newcastle.ac.uk

Research project

Rail networks face increasing demand, with even small disturbances often escalating into significant reactionary delays. Traditional performance measures, based on station arrival and departure times, are too coarse to capture the subtle but critical variations that destabilise services. Recent work at Newcastle University has introduced *Time Signal at Red (TSAR)* — a novel, fine-grained performance metric — and demonstrated its potential through large-scale data analysis and co-simulation.

This PhD project will advance this research by combining *data-driven analytics* with *high-fidelity co-simulation*. The aim is to validate and extend TSAR-based methods for diagnosing and mitigating delays, accounting for factors such as heterogeneous traffic, driver behaviour, and operational policies. Potential areas of investigation include:

- Extending TSAR analysis to complex junctions and multi-directional routes.
- Building and validating co-simulation models incorporating realistic driver behaviour, signalling systems, and train dynamics.
- Using TSAR-informed models to support timetable optimisation, capacity planning, and resilience to seasonal effects.

The successful candidate will join a multidisciplinary team spanning computing, engineering, and transport systems. The project provides opportunities to work with real-world rail data, advanced simulation platforms, and industry stakeholders, with significant scope to shape the research direction.

Applicant skills/background

This project requires:

- A strong background in computing, engineering, mathematics, or related discipline.
- Skills in one or more of: data analytics, simulation/modelling, or transport studies.
- Programming experience (e.g. Python, Java, C++).
- Interest in transport systems, human factors, or applied AI for infrastructure.
- Ability to work independently and collaboratively across disciplines.

References

Bhattacharyya, A., Forshaw, M., Golightly, D., Merricks, S., Palacín, R., Pierce, K., & Pinto da Silva, P. (2025). *Using Time Signal at Red (TSAR) as a tool for analysing rail network performance*. Journal of Rail Transport Planning & Management, 33, 100505. <https://doi.org/10.1016/j.jrtpm.2025.100505>.

Pierce, K., Bhattacharyya, A., Golightly, D., Pinto da Silva, P., Merricks, S., Palacín, R., & Guo, Z. (2024). *Using Co-Simulation and Time Signal at Red (TSAR) to Determine Impact of Driver Behavior on Rail Network Performance*. In *Proceedings of the 2024 Annual Simulation Conference (ANNSIM'24)*.