

Railway Operation Control and Simulation Research at University of Birmingham

Prof Lei Chen (L.Chen.3@bham.ac.uk)

Professor of Railway Operation and Control

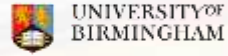
Lead for CoE in Digital Systems UKRRIN

The University of Birmingham

Outlines

- ❖ Introduction to BCRRE and UKRRIN
- ❖ Introduction to railway operation control simulation research at University of Birmingham
- ❖ Case study 1: West Midlands network operation Digital Twin
- ❖ Case study 2: HS2 Operation Modelling and Simulation
- ❖ Case study 3: SMRT Power System Simulation for Energy Saving

University of Birmingham Centre for Rail Research and Education



Top 100
university



Established
1971



140+ people



Collaborative



Broad focus



... and reach

UK Rail Research & Innovation Network

Hub of UKRRIN

UNIVERSITY OF
BIRMINGHAM



UKRRIN Academic Founding Partners

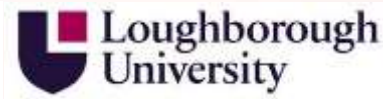
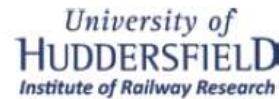
UKRRIN Lead



Digital System



Rolling Stock



Infrastructure



Testing



Network with 31 industry partners and 19 universities

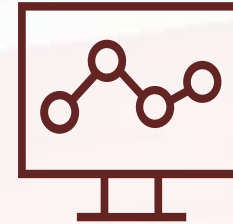
Centre of Excellence in Digital Systems



**Future Railway
Operations and
Control**



**Data Integration
and Cyber Security**

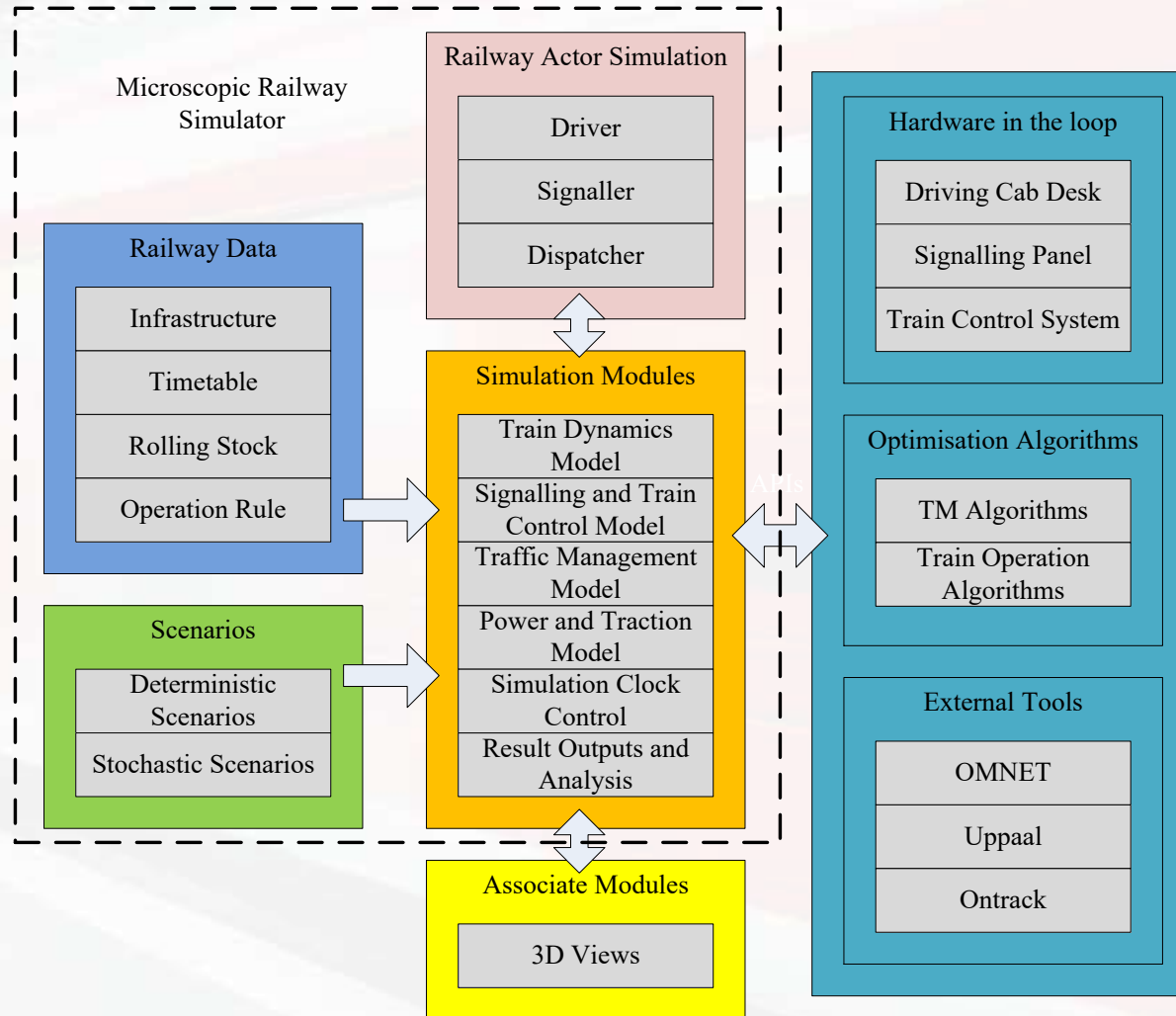


**Smart Monitoring
and Autonomous
Systems**

Leading expertise in railway operations and control for digitalisation
Data-driven railway, Internet of Railway Things, cybersecurity
New-generation smart monitoring, smart systems, sensor-based systems
Supporting the adoption of technology into innovation

Railway Operation Digital Twin

- Inhouse railway operation digital twin research and development
- Conventional signalling, ETCS, CBTC etc
- Modular architecture
- APIs to link other simulation modules, hardware-in-the-loop and real-time data feed
- Completely extensible
- Used on a number of projects worldwide



Man in the loop simulation

- Simulation driving cab with speed controllers and touch screens including ETCS DMI;
- Signalling panel for manual/automatic route settings in control centre.
- Flexible configuration



3D visualisation integration



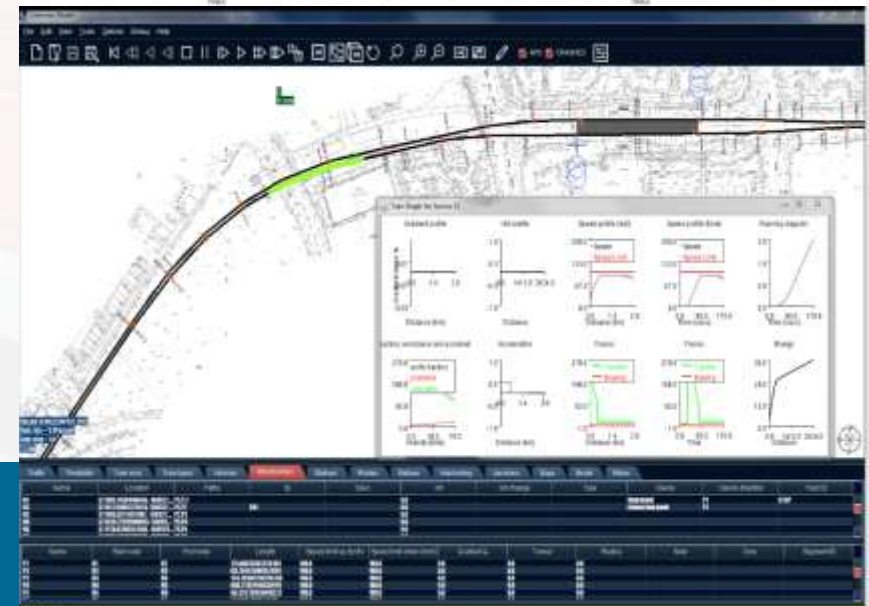
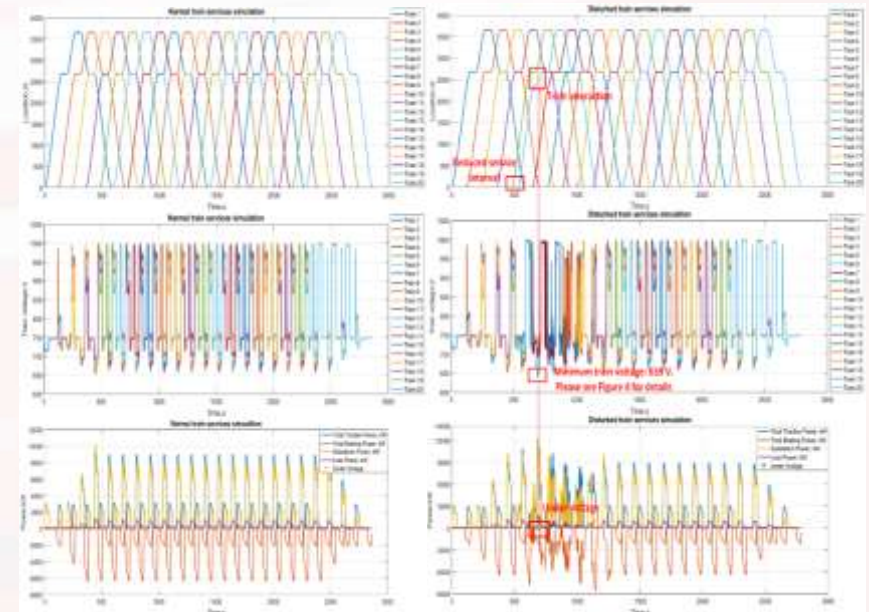
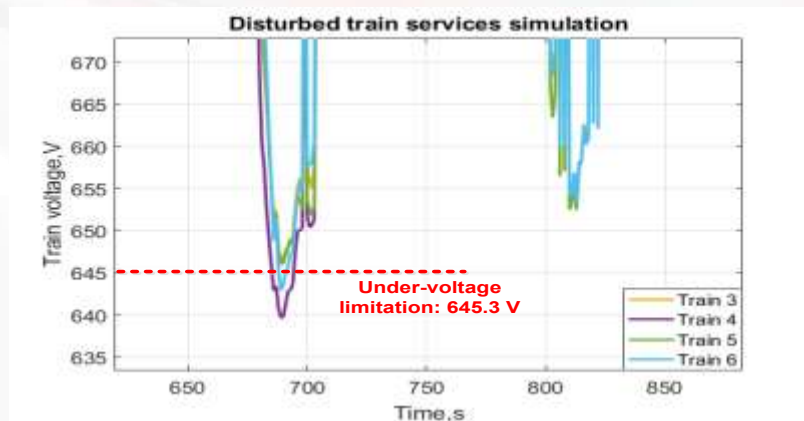
Railway Power System Analysis

AC and DC simulations

Understand dynamic conditions, e.g. during perturbations

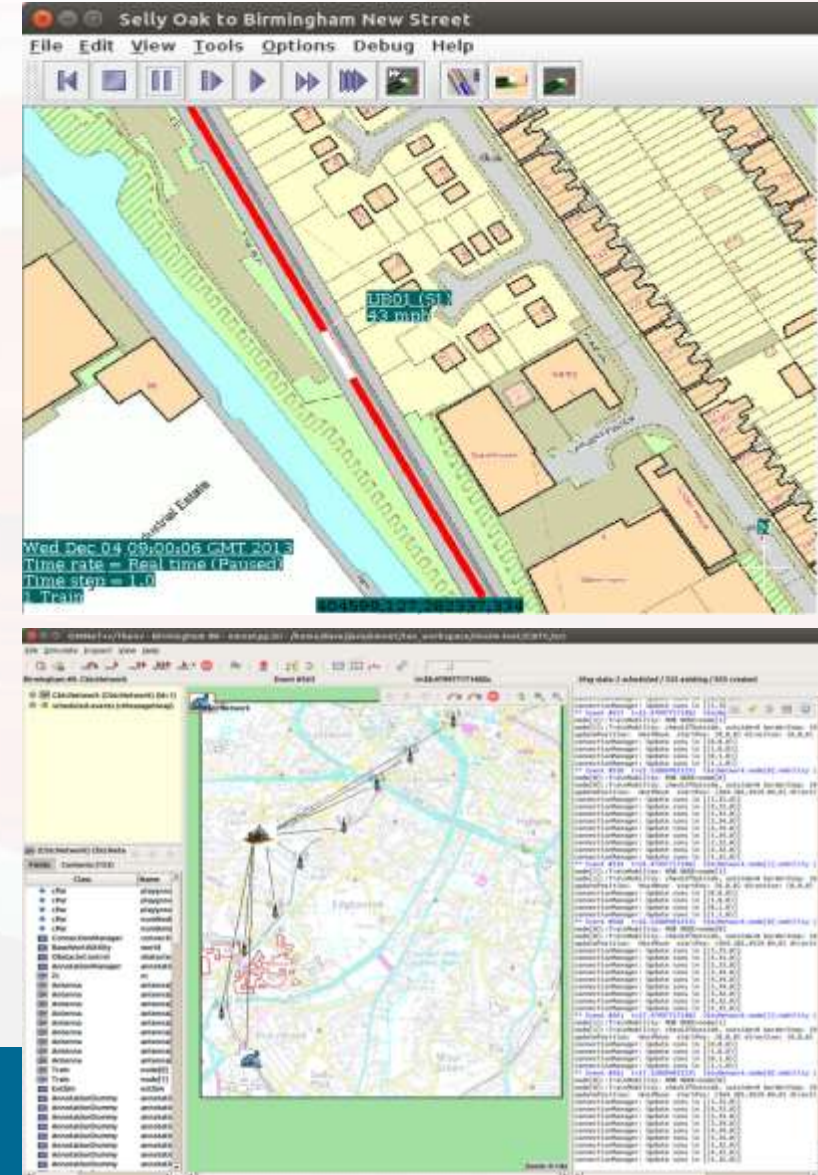
Helping to specify increased resilience through focussed introduction of technology

De-risk technology introduction



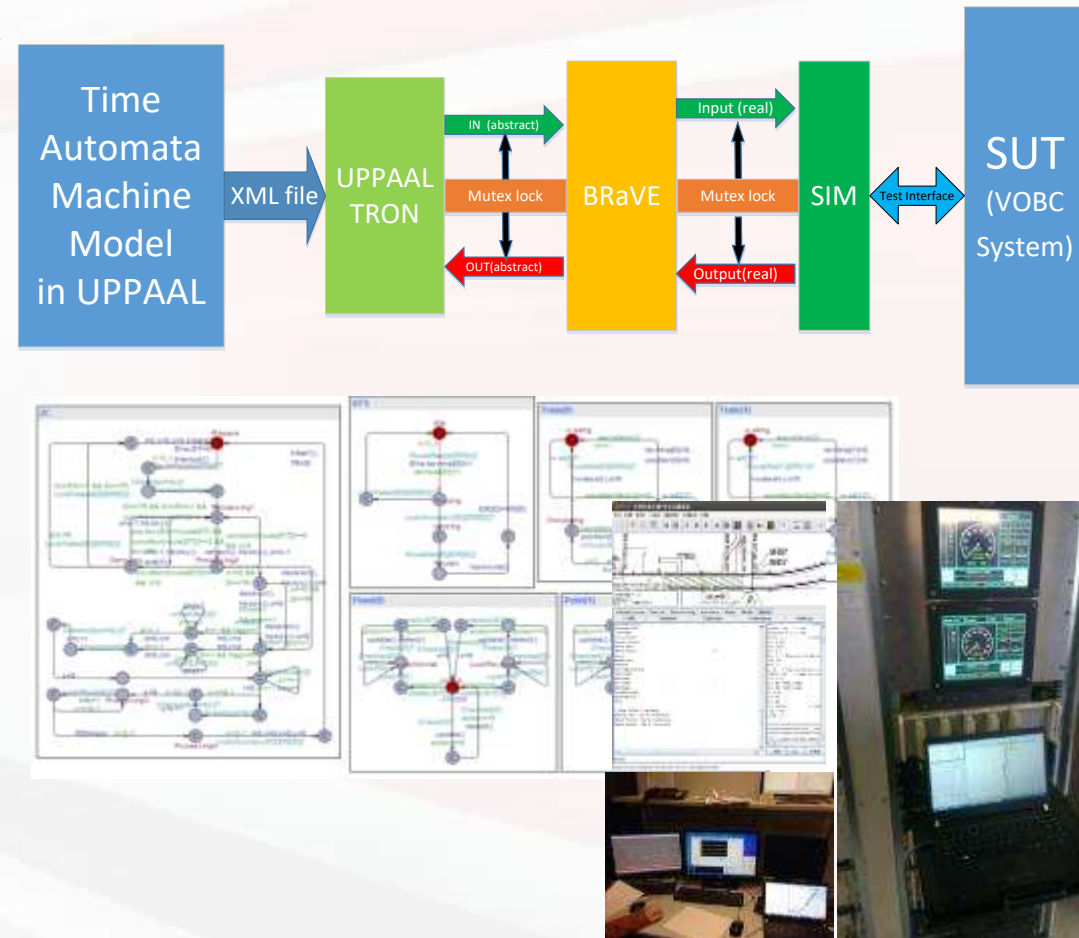
Railway Communication Simulation

- Railway data communication system modelling and optimisation
 - Integrate OMNET and Simcat
 - Modelling and simulation of DCS of CBTC
 - Modelling and simulation of GSM-R of ETCS
 - Communication configuration optimisation
 - TVWS application to railways (QinetiQ)
 - Safety and Security
 - Future technologies e.g. LTE, 5G



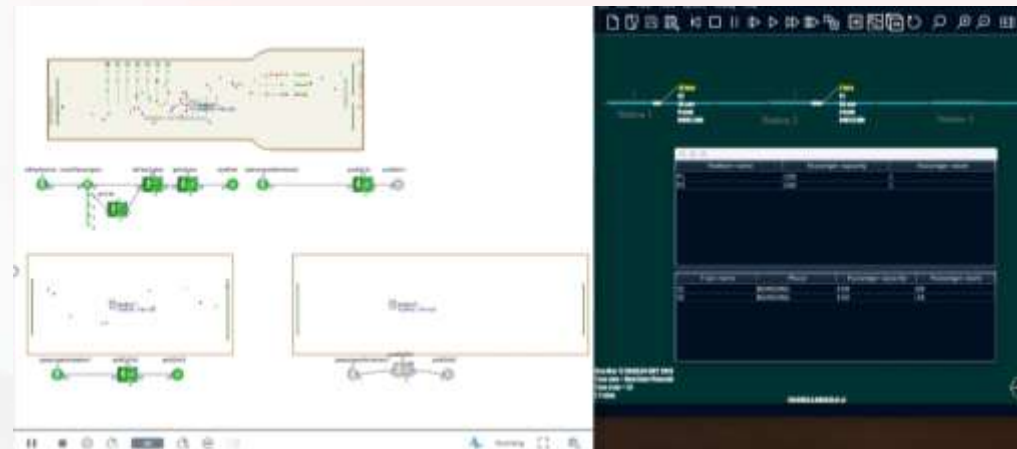
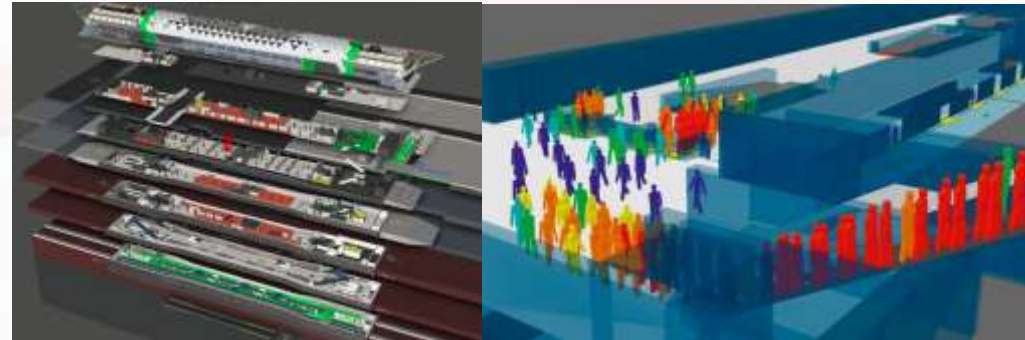
Railway system testing and validation

- Railway system function testing integrated with UPPAAL
 - Integrate Timed Automata Machine modelling tool **UPPAAL**
 - Generate generic test cases using formal method
 - Online system function testing
 - System function testing for **CBTC** and **ETCS**



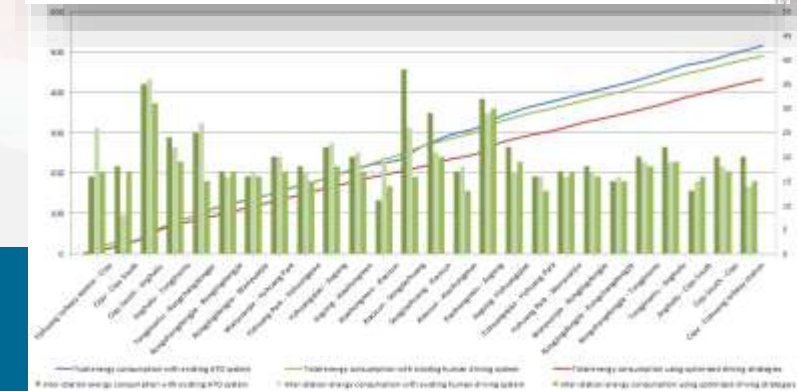
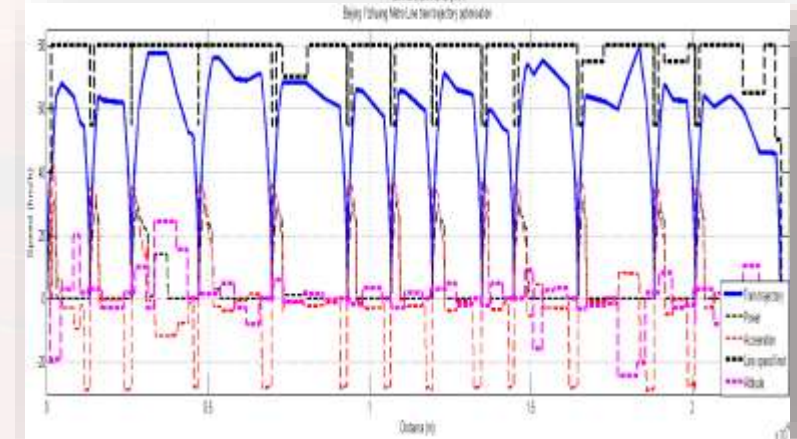
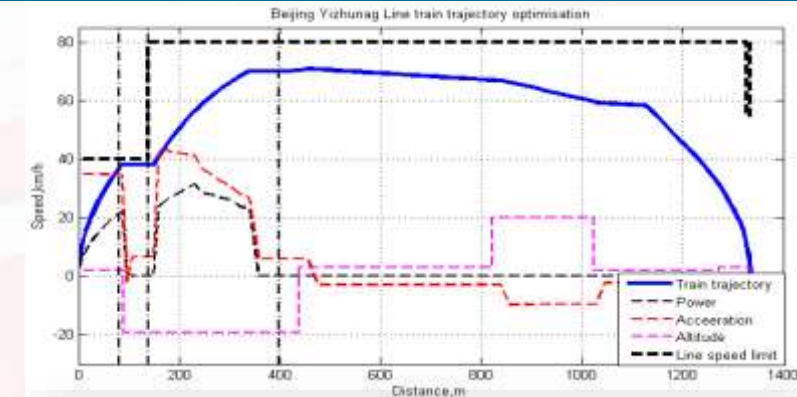
Integration of Passenger Movement

- Integration of system dynamics simulator Anylogic to understand passenger flows through stations and on to trains
- Analysis of passenger flow related impact with railway operations
- Real-time data or statistical data can be integrated



Railway Operation Optimisation

- Railway system operation optimisation
 - Dynamic train running trajectory optimisation for drivers / DAS / ATO
 - Braking energy re-generation strategy
 - Dynamic timetabling
 - Resource management
 - Integrated optimisation for railway traffic management, timetable design, power and traction system etc
 - Beijing Metro / Guangzhou Metro/ SMRT



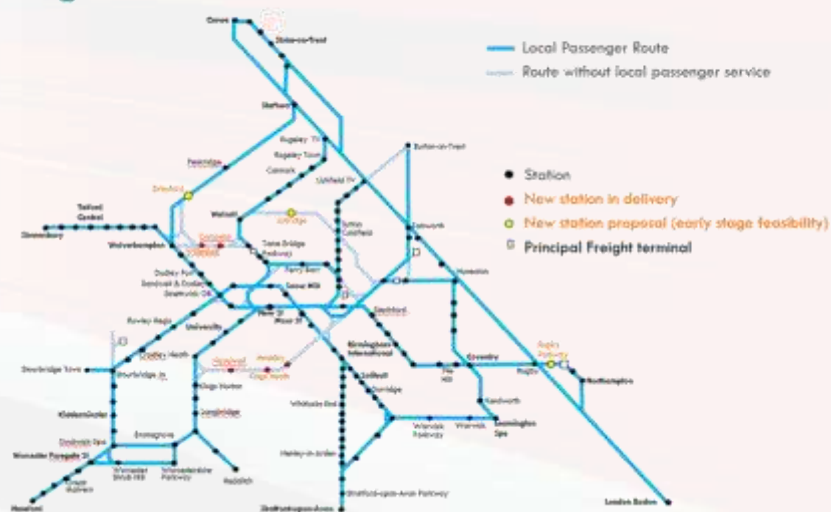
West Midlands Digital Twin

- Develop a Digital Twin model of the West Midlands network that can accurately replicate the railway operation in the area.
 - Identification of the bottleneck of current network performance;
 - Improvement of the current timetable to improve the network operation resilience;
 - Reduction of time and effort for the implementation of new/revised timetables.

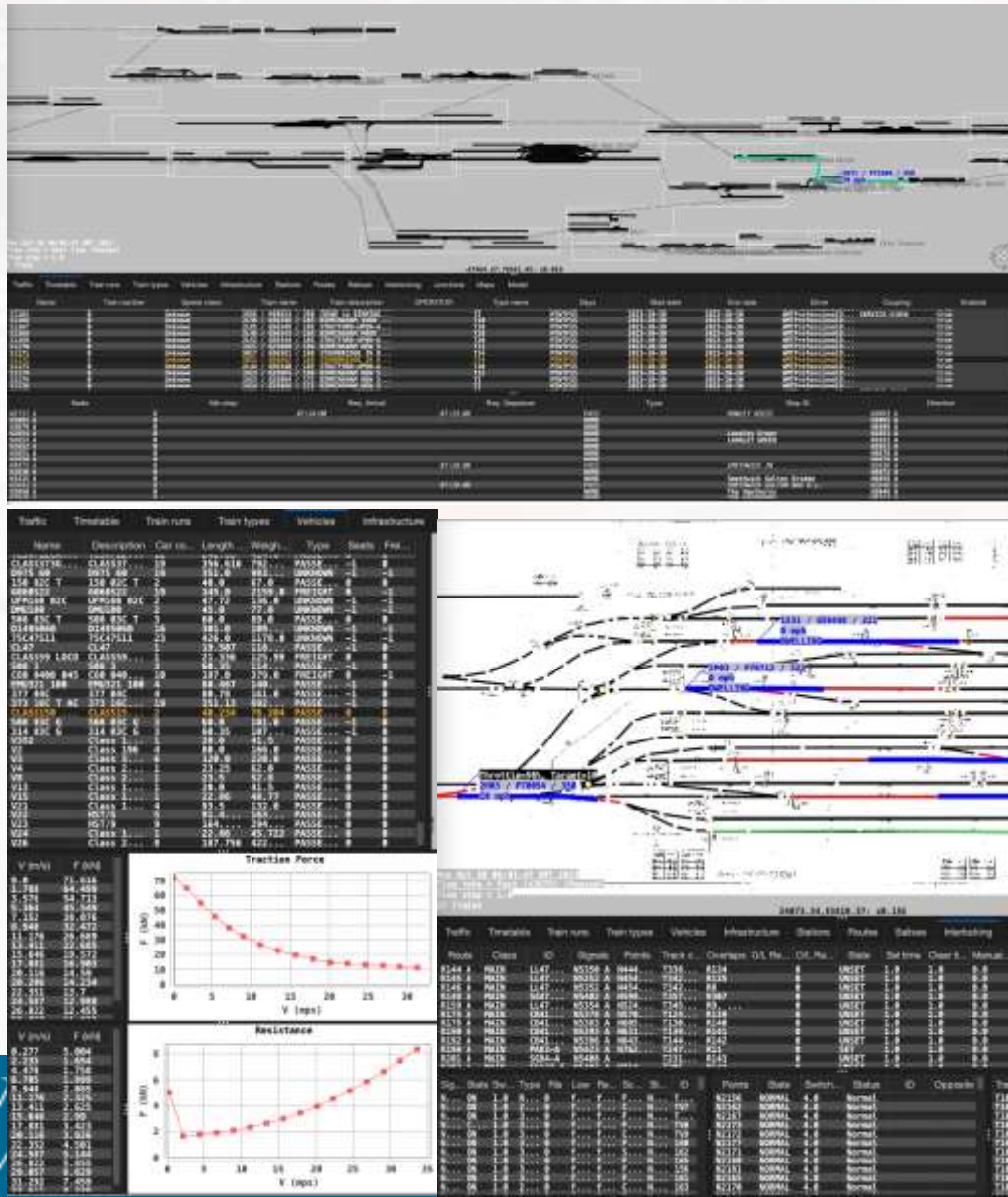
The Digital Twin system contains:

- An accurate infrastructure and signalling model of the WM railway network;
- Automatic report analysis to evaluate operational performance;
- Simulation of professional driving rules in different companies and weather conditions;
- Timetable import tool for passenger and freight services;
- Simulation of multiple disruption scenarios;
- Real-time data feed.

Digital Twin Model Area



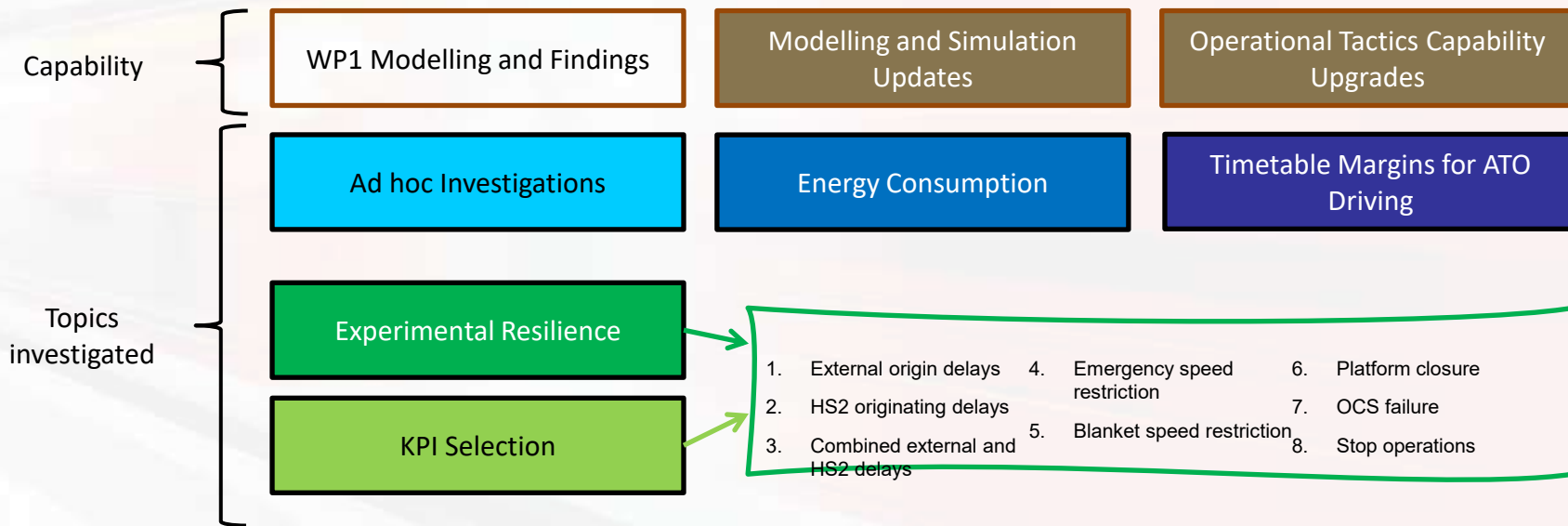
West Midlands Digital Twin



- Successfully developed a digital twin system that can represent the network
- Enabling to simulate the timetable
- Enabling to simulate the disruptions
- Improvements with the Class 730 train fleets
- Simulation of Camp Hill passenger and freight services
- Further timetable validations.

HS2 modelling simulation and optimisation

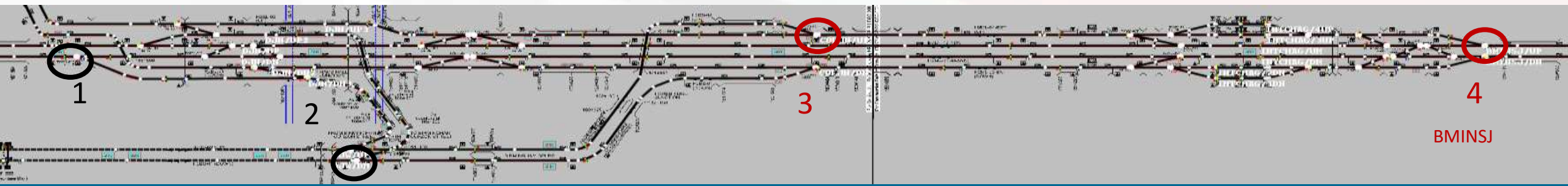
- Develop Microscopic detailed HS2 integrated system model (infrastructure, rolling stock, timetable)
- Validation of timetable
- Validation of infrastructure



DJN (nearest)

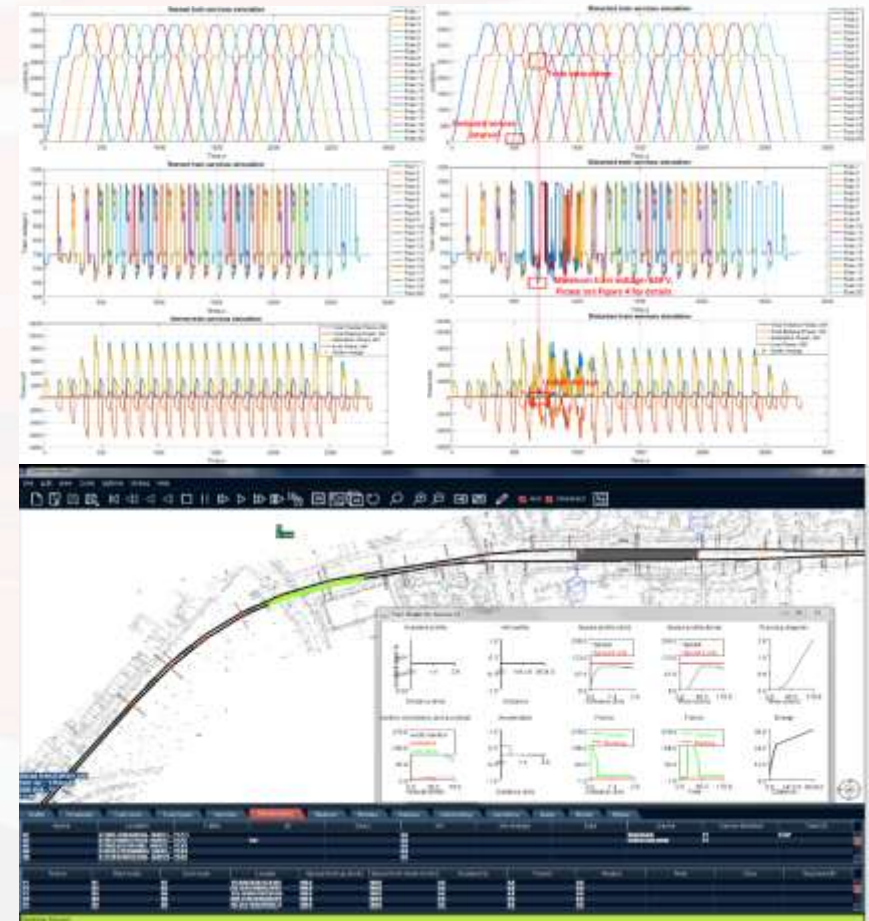
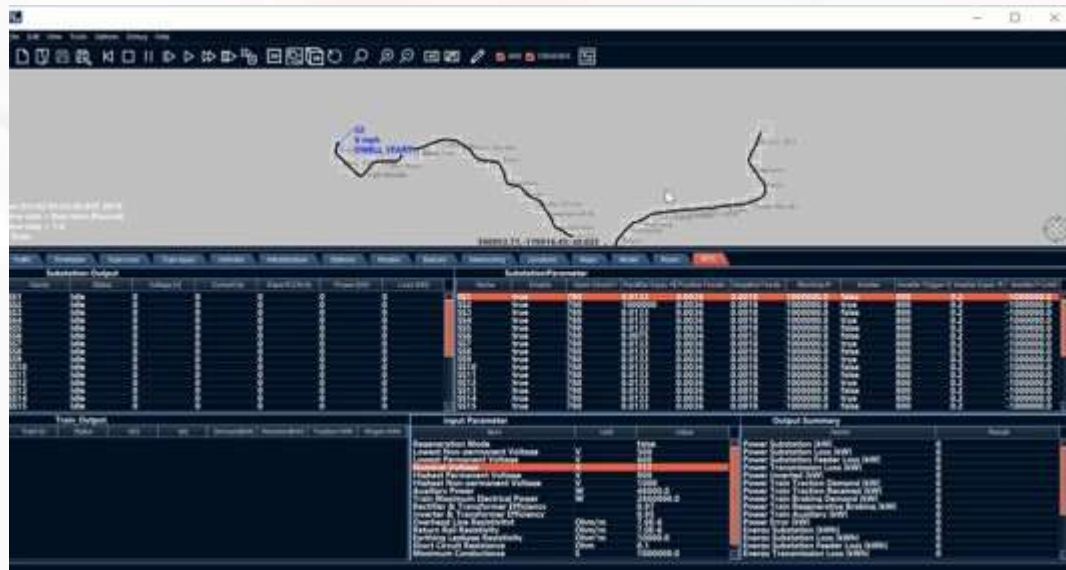
COLJN

BMINSJ



SMRT Power System Simulation for Energy Saving

Simulate and optimise the SMRT operation control and traction power system for energy saving





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