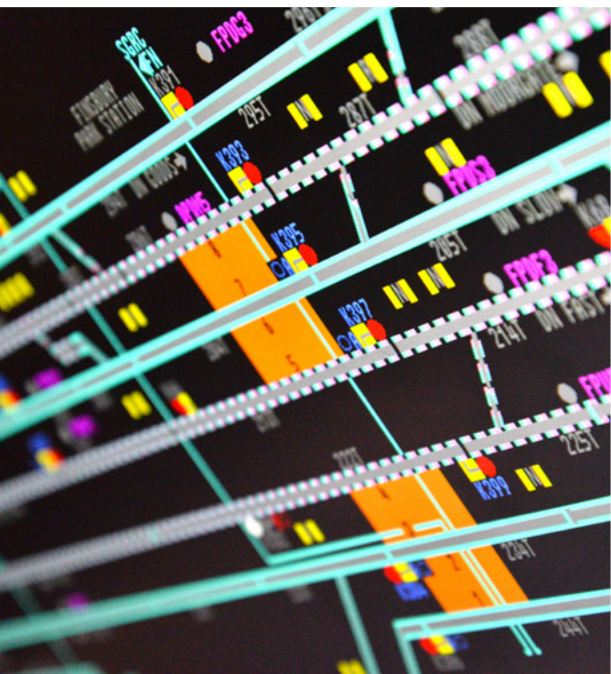


*Our Systems Modelling
Capability and Experience*





We know how to run a railway because we do it every day

Network Rail

Network Rail owns and operates Britain's rail infrastructure network – one of the world's most intensively used rail networks. Our network is the fifth busiest rail network in the world and the second busiest in Europe. We:

- ▶ Provide a safe and efficient national railway network that carries over 1.8 billion passenger journeys, 16.6 billion tonne kilometres of freight and 7 million train movements every year;
- ▶ Own, maintain and operate 20,000 miles of track, 30,000 bridges, tunnels and embankments and thousands of signals;
- ▶ Operate 20 major stations which handle 800 million passenger journeys and own 2,500 other stations, which are leased to train operators;
- ▶ Employ 42,000 people in asset management, operations, maintenance, renewals, and enhancement projects; and
- ▶ Have an annual turnover of over £8bn, with capital expenditure of over £5bn per annum.

Network Rail Consulting

Network Rail shares its expertise with the world's rail owners and operators through Network Rail Consulting (NRC). We understand the institutional, regulatory, technical, policy and strategic issues of running a railway in the 21st century. We know how to operate a network, manage its assets, and deliver renewal and enhancement programme whilst minimising the disruption to passenger and freight services.

What makes us different from other consultants is that our people have genuine hands-on experience in solving the challenges you face in the real world of rail operations. We are rail professionals operating and maintaining one of the world's leading railway systems who want to share their expertise, experience, and passion for the job.

Our advice covers the full range of the project life cycle, from concept, project development and delivery through to operations and maintenance.

Network Rail Consulting in Australia, the Middle East and North America

We have been active in the Australian, the Middle East and North American markets since 2013 and have successfully delivered more than 150 consultancy contracts for government, public and privately owned companies; and for passenger and freight owners and operators.

Whilst our unique selling point is our access to Network Rail's expertise in the UK, we are committed to developing our local workforce through a structured training and development programme using Network Rail's award winning training capability. This will ensure that we continue to provide our clients with leading edge technical and management advice delivered by a blend of local and British experts.

Our Approach to Systems Modelling

How We Have Applied Our Approach

Background

Computer modelling of rail systems and projects can make a critical contribution to informed decision making through all stages of development.

Many projects which have been successfully delivered and are in operation today have achieved that outcome in part due to the modelling that has been done to support project development and delivery.

Rail systems modelling in its various forms can provide a level of progressive assurance against performance requirements that cannot be achieved any other way, and can support optimised design development. Effective rail systems modelling can make a significant contribution to your project achieving all of its objectives.

The Challenge

Like many other technical specialist functions on the railway, doing systems modelling well can bring significant benefits, but applying it ineffectively can be expensive and time-consuming, and gives poor value.

In order for systems modelling to deliver best value it should be planned, delivered, and presented by specialists whose expertise spans engineering and operations. Without this level of understanding, there is always the risk that the modelling that is delivered is not what is required, or that the correct conclusions will not be recognised.

How We Can Help

Our team have extensive experience of successful application of systems modelling through all stages of the lifecycle on major UK rail projects.

We understand that the value of systems modelling is in providing assurance against project performance requirements. This could be a standalone study to demonstrate performance of a single aspect of a project, or progressive assurance throughout a major project. For these and anything in between, it is not enough to know how to run modelling tools. Our team are systems engineers and rail operations specialists who can provide relevant and insightful assurance of the correct performance requirements for your project, to help you achieve your programme objectives.

Network Rail's experience as UK rail infrastructure owner gives our team an almost unique perspective on project delivery for rail operator clients.

This experience has taught us valuable lessons about the benefits of applying the right tool for the job, informed by client and project needs. These lessons have since proven invaluable in informing effective modelling support for a variety of projects of all sizes and levels of complexity.

Our Corporate Experience

Major UK Enhancement Programmes

Our experience includes the provision of extensive and trusted analysis to most major enhancement programmes in the UK in the last 25 years.

Our involvement in these programmes has ranged from being embedded in the project teams and having responsibility for all aspects of performance assurance and modelling, to delivering and/or assuring individual packages of analysis.

Thameslink

Major Rail Infrastructure Programme involving removal of track bottlenecks and extending platform lengths, along with ETCS implementation to increase train frequencies.

We led and delivered all aspects of systems modelling throughout the development and delivery of this programme. This included scheme simulation, operational modelling, and performance & reliability modelling plus reliability analyses; station dwell time analysis; and maintainability assessment.

Crossrail

We undertook scheme simulation work to demonstrate the technical capability of the scheme during its development, as well as assurance of analysis completed by others.

Other Projects

Our experience on a portfolio of other projects has included performance requirements definition and performance assurance planning; train simulation modelling ranging from simple line speed or train supervision changes through to complex multi-train simulations of busy commuter corridors; scheme design support for signalling technologies from token block and absolute block to ETCS and ATO; studies of driving profiles; development and modelling of concept train plans; and support for business case development.

Our Systems Modelling Service Offerings



Performance Requirements Definition



Design Development Support



Performance Assurance Planning



Concept Train Planning



Performance Assurance Reporting



Timetable Optimisation



Analytical Assurance



Timetable Performance Evaluation



Concept Evaluation



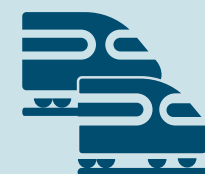
Operational Scenarios



Planning Margin Development



Performance Resilience Modelling



Capacity Assessment

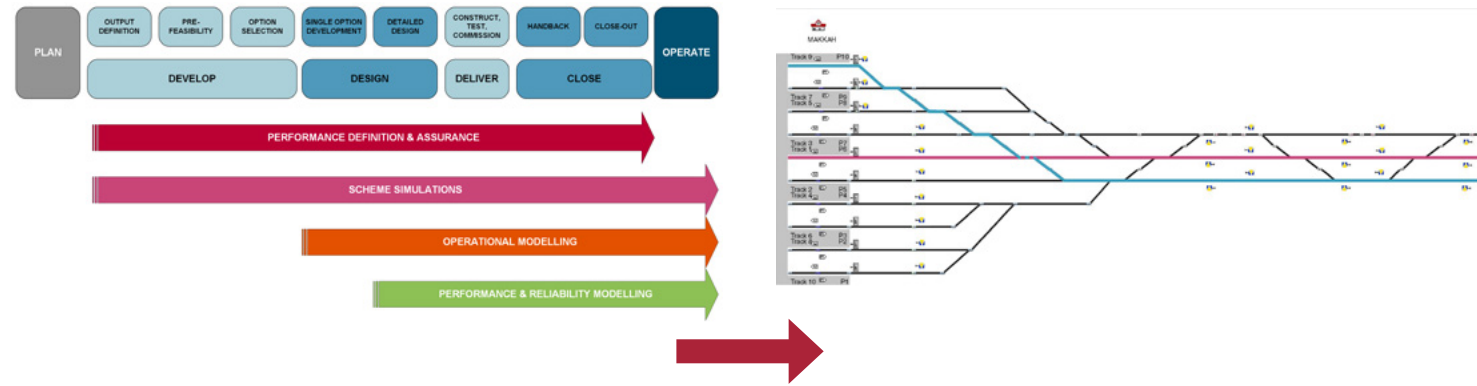


RAM Target Validation & Iteration

Systems Modelling Overview

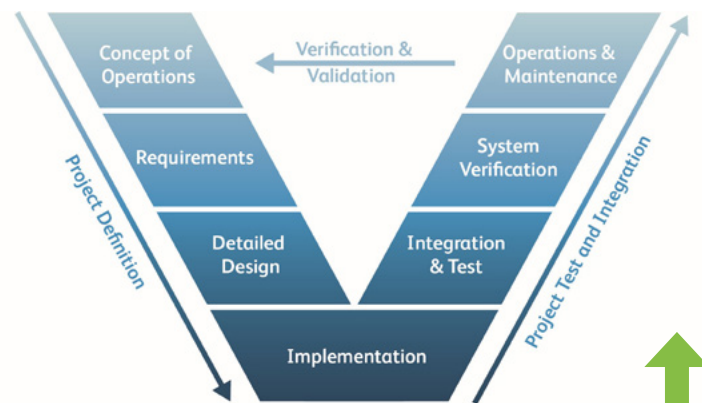
Performance Definition & Assurance

- ▶ Performance Requirements Definition
- ▶ Performance Assurance Planning
- ▶ Performance Assurance Reporting
- ▶ Analytical Assurance

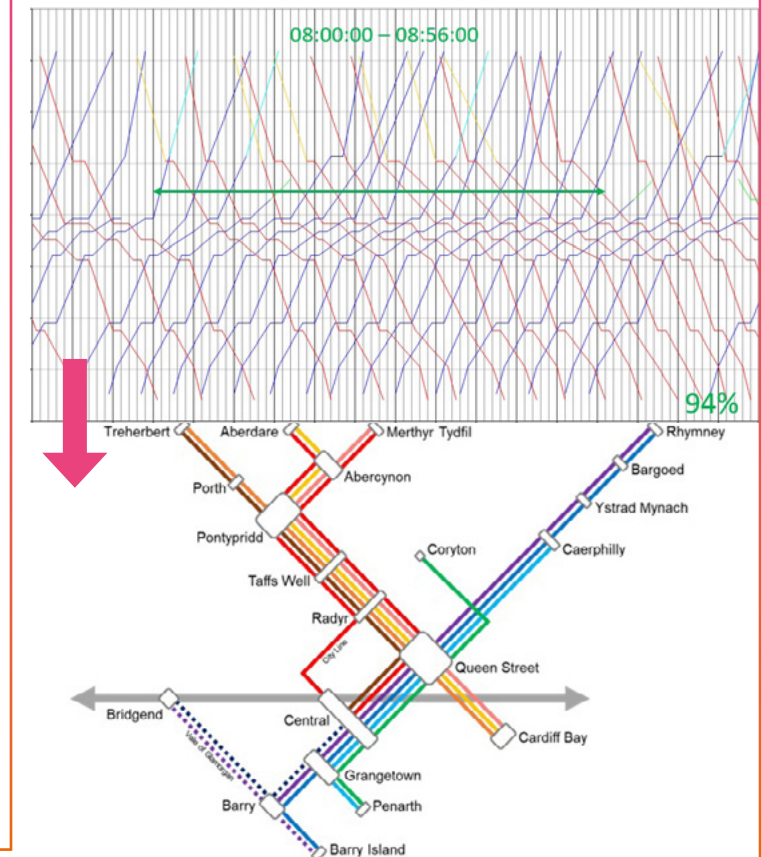
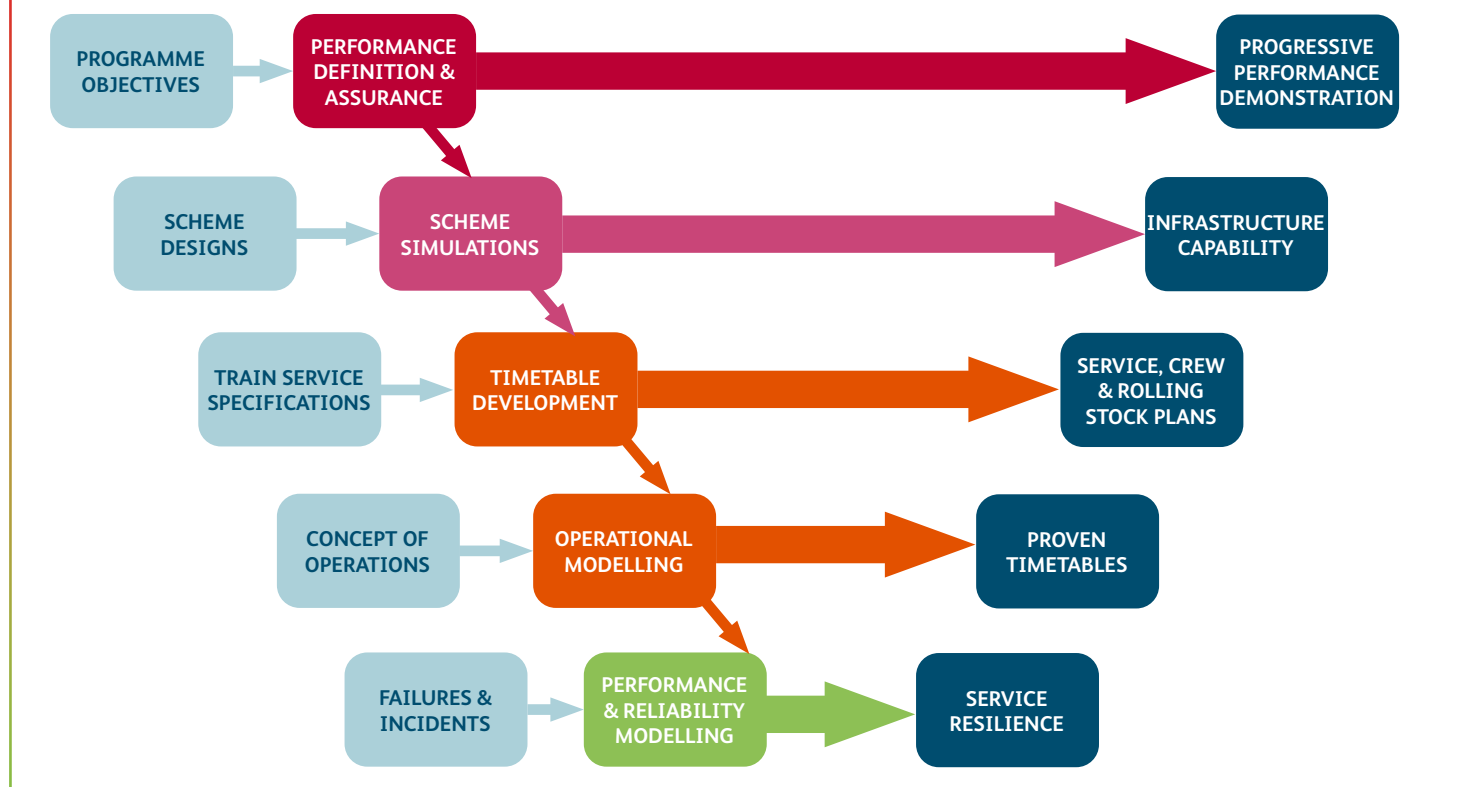


Scheme Simulations

- ▶ Concept Evaluation
- ▶ Planning Margin Development
- ▶ Capacity Assessment
- ▶ Design Development Support

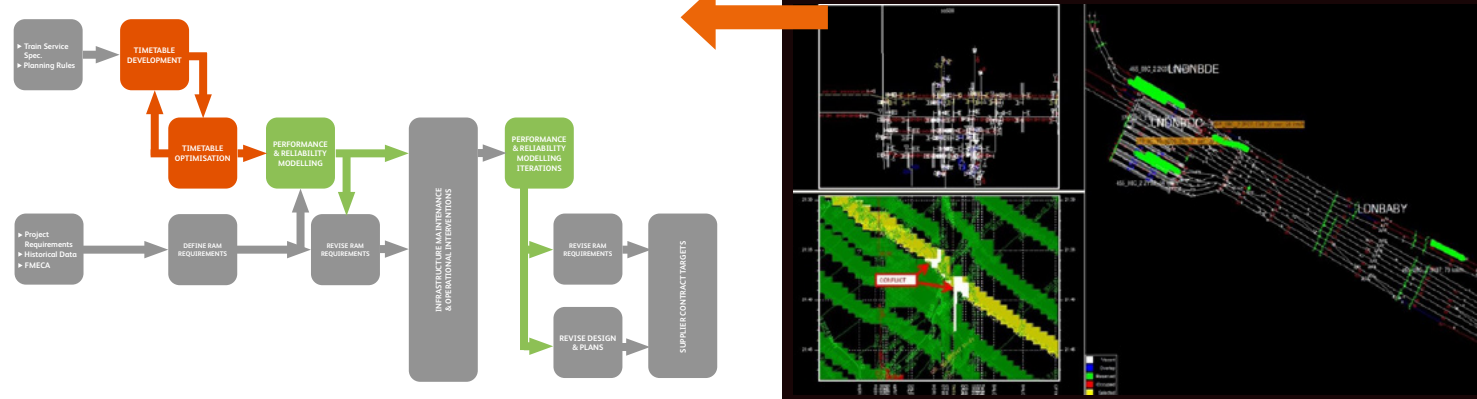


INTEGRATED MODELLING PROCESS



Performance & Reliability Modelling

- ▶ Performance Resilience Modelling
- ▶ RAM Target Validation & Iteration



Timetable Development and Operational Modelling

- ▶ Concept Train Planning
- ▶ Service Schedules, Crew and Rolling Stock
- ▶ Timetable Optimisation
- ▶ Timetable Performance Evaluation
- ▶ Operational Scenarios

Performance Definition & Assurance

Background

Railway performance covers many factors that rail customers would see as defining success. Any rail system or project which does not understand its performance requirements is therefore unlikely to be successful.

The Challenge

Defining a valid and comprehensive suite of railway performance requirements is not easy. To do this effectively requires a combination of railway operations and systems engineering expertise that can only be developed by varied experience of multiple rail projects. Effective planning and delivery of progressive assurance against those requirements also requires specialist skills which most rail operators do not have the opportunity to develop or maintain.

How We Can Help

We have extensive experience of performance definition and assurance on a varied portfolio of projects. Our modelling team is comprised of experienced systems engineers who understand railway operations and performance.

Our expertise can help you to maximise the likelihood of your project meeting its objectives. With our help you can understand and mitigate performance risk throughout the development and implementation of your project.

Performance Requirements Definition

We can develop and validate a comprehensive suite of project performance requirements from your programme objectives.

- ▶ Develop performance requirements from programme objectives;
- ▶ Validate performance requirements;
- ▶ Remove spurious or inconsistent performance requirements; and
- ▶ Improve project performance specification to inform optimal design solutions.

Performance Assurance Planning

We can develop a plan to optimise the application of analytical and modelling techniques to provide progressive assurance of performance requirements for your project.

- ▶ Optimise modelling schedule to inform project development;
- ▶ Provide visibility of level of performance assurance throughout project lifecycle;
- ▶ Facilitate effective decision planning, early risk identification and mitigation opportunities; and
- ▶ Maximise likelihood of successful delivery of programme objectives.

Performance Assurance Reporting

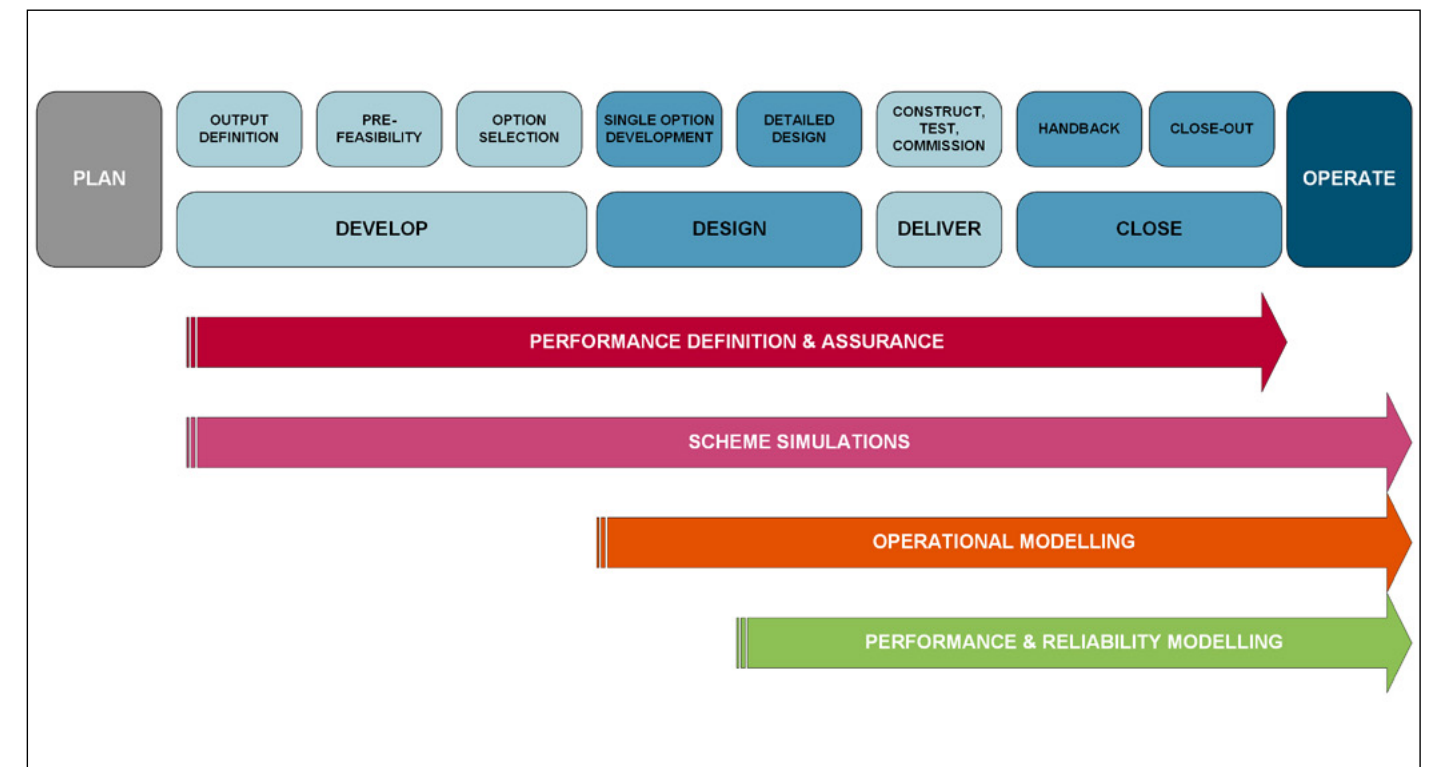
We can act as an expert interface between the client team and modelling practitioners, to maximise the value of the modelling outputs.

- ▶ Optimise modelling remits to maximise value;
- ▶ Review modelling outputs to maximise volume of valid conclusions;
- ▶ Satisfy requirements and intent of performance assurance plan; and
- ▶ Improve stakeholder engagement with modelling.

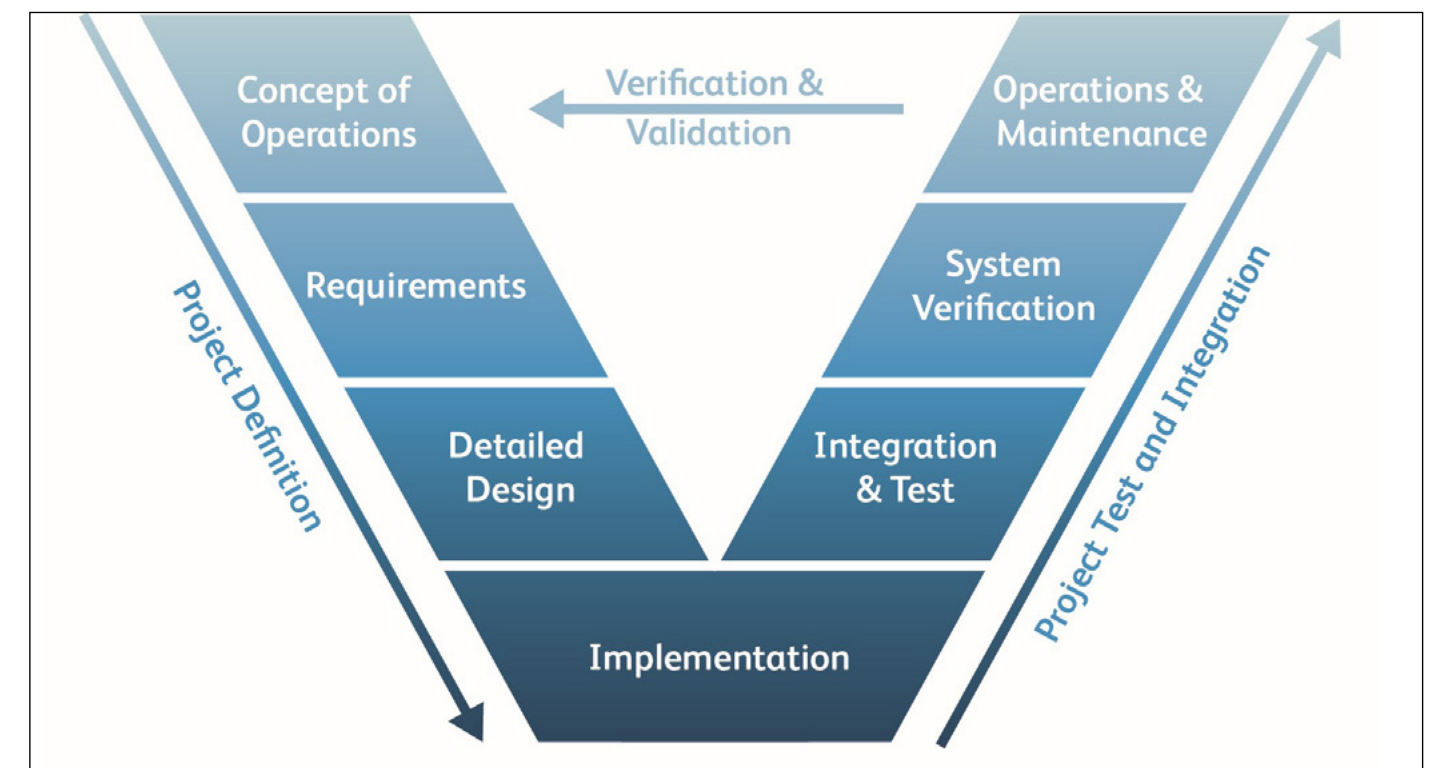
Analytical Assurance

We can provide independent assurance of performance analysis and modelling.

- ▶ Increase credibility of modelling and analytical outputs;
- ▶ Provide independent assurance of performance analysis and modelling; and
- ▶ Develop and implement analytical assurance policies and processes.



Project Modelling Lifecycle, Illustrating the Project Development Phases During Which the Various Categories of Modelling Can Support Informed Decision Making



Systems Engineering V-Lifecycle. An Integrated Systems Modelling Process Forms Part of a Comprehensive Application of Systems Engineering to a Rail Project

Scheme Simulation

Background

Many railways operate without a comprehensive understanding of the capacity or capability of their system. When there is no pressure to make efficient use of the available capacity this situation is perfectly reasonable, but if questions such as “how many more passengers can we carry?” and “what are the constraints on our system?” are being asked, the only way to provide informed answers is to understand the system capability.

The Challenge

Defining the capacity of anything but the simplest of existing rail systems can be challenging. Different signalling and control systems, track layouts, rolling stock types and configurations all influence the capacity, and operational factors like service routing and station workings impact how much of the theoretical capacity is actually accessible.

Once additional variables arising from improvement options are considered, the picture can appear to be very complicated.

How We Can Help

Scheme simulation modelling can capture all of the features that define the capability of your current and future railway.

We have extensive experience of successful application of scheme simulations on major UK projects, both as part of an integrated lifecycle and as a standalone assessment.

Our expertise can help you to maximise the likelihood of your project meeting its objectives, and enable you to get the best value from your investment in improvements.

Concept Evaluation

We can help in identifying improvement concepts worthy of being progressed, and inform the development of programme objectives into performance requirements.

- ▶ Test programme objectives;
- ▶ Define programme objective assessment criteria;
- ▶ Define and apply appropriate high level assessment methods; and
- ▶ Supply substitute data for system features yet to be defined.

Planning Margin Development

We can calculate planning margins consistent with your processes, or we can assist you with developing a robust process.

- ▶ Calculate train planning values;
- ▶ Running Times;
- ▶ Headways;
- ▶ Platform Reoccupation Times; and
- ▶ Junction Margins.

Capacity Assessments

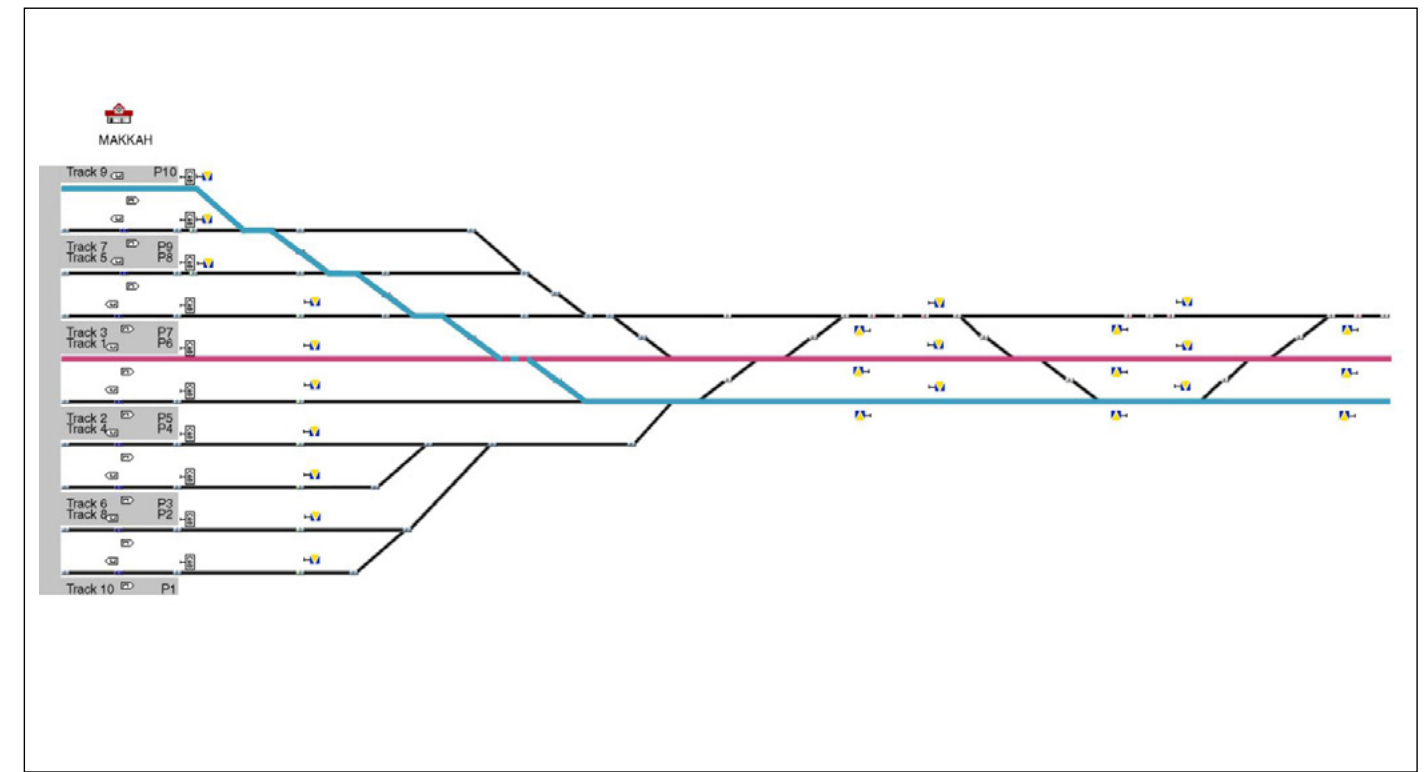
We can identify your system’s capacity constraints, and identify where changes will provide greatest value in performance improvements.

- ▶ Quantify the existing capacity and utilisation;
- ▶ Identify capacity constraints;
- ▶ Demonstrate capacity of improvement options;
- ▶ Provide measure of service robustness for future timetable on proposed infrastructure; and
- ▶ Application of UIC-406 methodology.

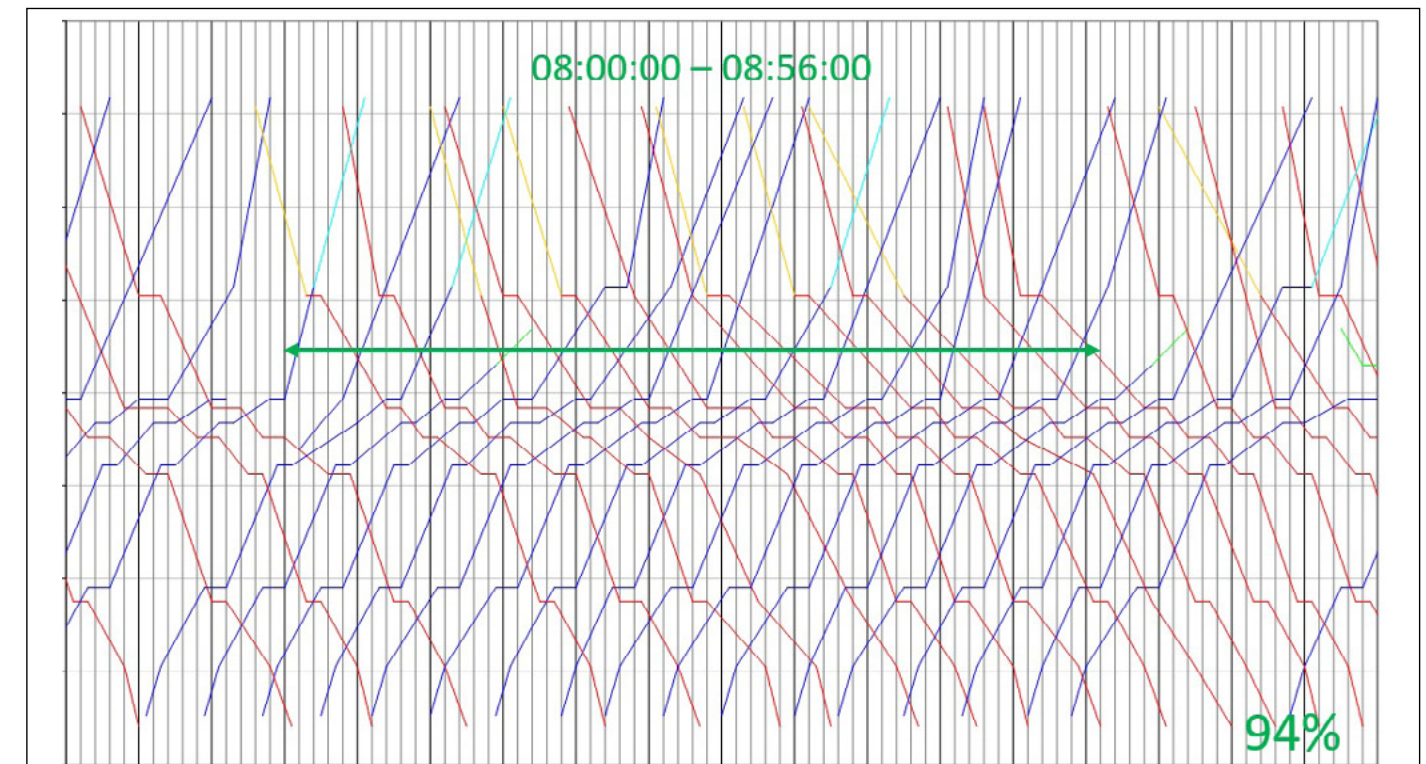
Design Development Support

We can support your design engineers to optimise scheme designs to meet programme objectives, enabling them to see the wider impact of their design choices.

- ▶ Demonstrate system-level impacts of design options;
- ▶ Facilitate informed design development decisions;
- ▶ Support optimisation of design to meet programme objectives;
- ▶ Encourage multi-discipline thinking by designers; and
- ▶ Promote focus on programme objectives between project gate reviews.



Representation of a Junction Margin in a Scheme Simulation Model. Junction Margins are Key Components of Rail Infrastructure Capability, Particularly on Highly Utilised Networks



Capacity Utilisation Analysis on a Train Graph. Capacity Utilisation is an Internationally Recognised Technique to Establish Rail Service Resilience

Timetable Development and Operational Modelling

Background

Running a proven timetable on established and reliable infrastructure provides not only a good train service for your customers, but also a wealth of experience for your staff.

If you make only minor changes to your system or timetable then you might reasonably expect that service quality and staff expertise will also only experience minor changes.

Significant improvements to train services are likely to require similarly significant changes to your infrastructure or timetable. Implementing these changes without proving them first, and expecting your passengers and staff to get to grips with them at the same time, is fraught with risk.

The Challenge

How do you maximise the quality of your future timetables, and embed some operational experience before the infrastructure and service changes are implemented on your rail system?

How We Can Help

Operational modelling enables you to prove and improve your future timetable on your system so that when it goes into service the risk of disruption to customers is minimised.

We have extensive experience of successful application of operational modelling on major UK projects, both as part of an integrated lifecycle and as a standalone assessment.

Timetable Development

We can develop train plan segments to prove service concepts, timetables to demonstrate planning capacity and for performance evaluation in multi-train simulation models, and service quality timetables ready for operation.

- ▶ Develop and demonstrate train planning options to meet programme objectives;
- ▶ Produce train plan segments bound by time or geography to test planning concepts and facilitate modelling; and
- ▶ Undertake service timetable development including crew and rolling stock planning.

Timetable Optimisation

We can use multi-train simulation tools to optimise your timetables so they are of proven high quality before being introduced to operational service.

- ▶ Identify issues with planning values and provide solutions;
- ▶ Optimise platform and line assignments;
- ▶ Mitigate risk of introducing unproven timetable into service; and
- ▶ Provide better quality timetables for quicker and more accurate performance evaluation.

Timetable Performance Evaluation

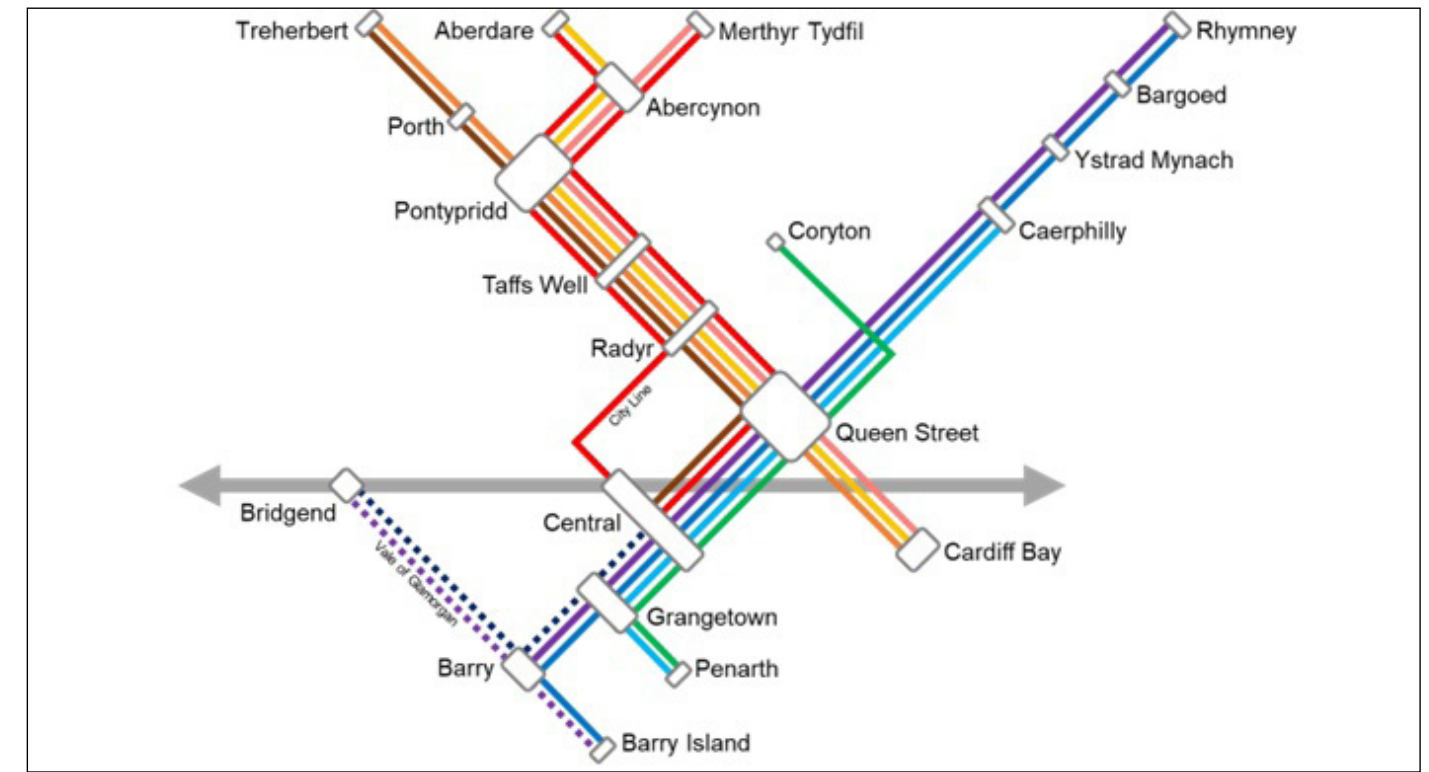
We can demonstrate whether your current or planned infrastructure can support your future timetable, what performance you can expect, and what improvements you should consider.

- ▶ Demonstrate whether the rail infrastructure can support resilient operation of the timetable;
- ▶ Provide train service projections to support business case development;
- ▶ Compare timetable options and inform selection decisions; and
- ▶ Inform future in-service operation.

Operational Scenarios

We can model critical perturbation incidents, to inform and test your infrastructure and operational responses.

- ▶ Test infrastructure layout options to identify optimal balance of flexibility and simplicity;
- ▶ Inform operating practise to minimise disruption caused by failures and incidents; and
- ▶ Provide a tool to examine response to actual events, and derive maximum benefit from lessons learnt.



Train Service Specification Schematic

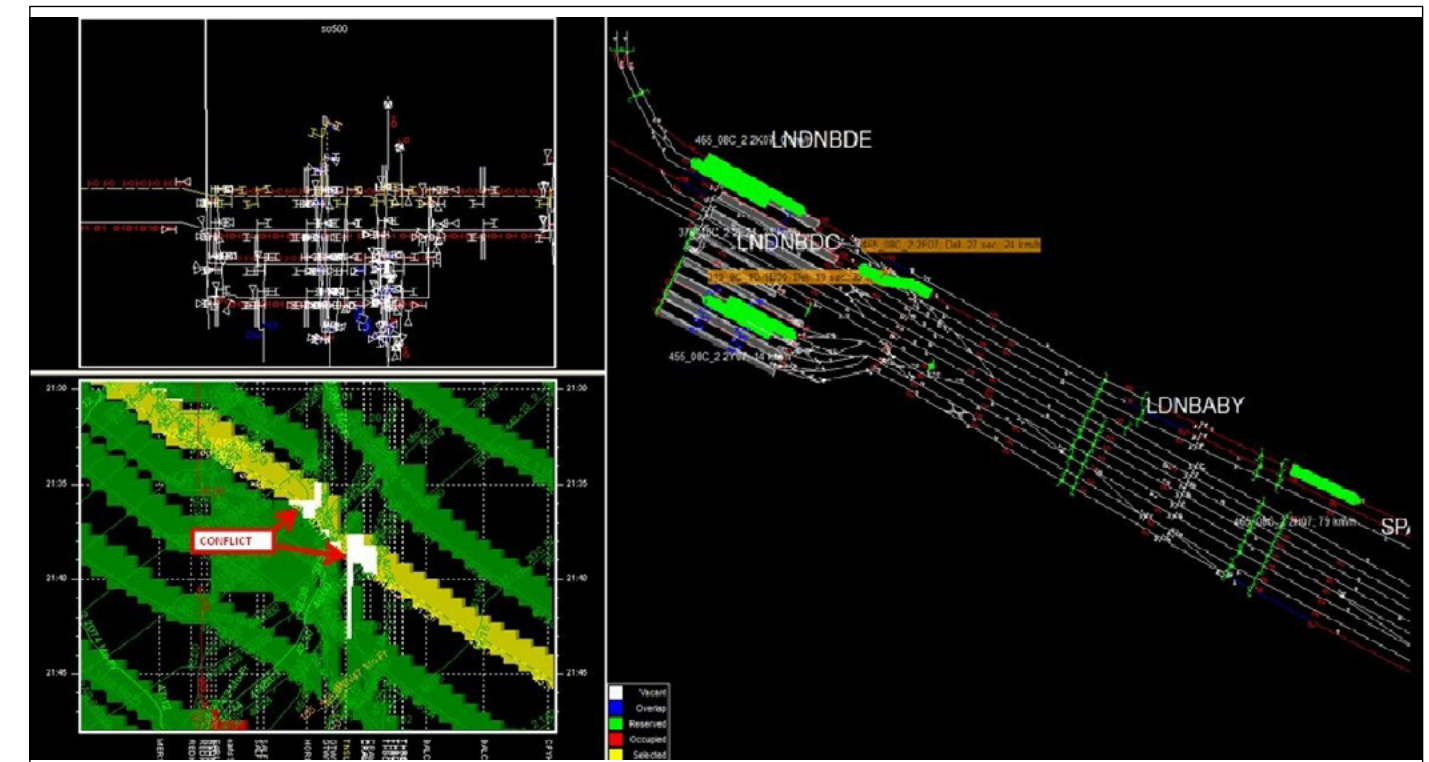


Illustration of Timetable Optimisation Process in Operational Modelling Tool

Performance & Reliability Modelling and Other Modelling

Background

For many railways, performance constraints due to operational incidents or asset failures are a regular occurrence. The mitigations necessary to continue operational service in these circumstances are often reactive.

Reliability, Availability, and Maintainability (RAM) analysis and operational modelling are familiar tools used to understand and predict railway performance, but rarely are they integrated to facilitate a proactive approach to address these issues.

The Challenge

Exhaustive modelling of all possible failure scenarios and operational incidents on a complex railway is significant commitment. The alternative solution is to identify critical scenarios and concentrate expert analytical resource where it can deliver the best value.

How We Can Help

We have extensive experience of using modelling to demonstrate performance impact of failures and incidents, and to inform and optimise operational mitigations, so that the performance impact of such events on the railway is minimised.

Our expertise encompasses the full range from comprehensive performance & reliability modelling on major programmes to targeted analysis of critical scenarios, and includes validation and iteration of RAM targets as well as performance resilience modelling.

Performance Resilience Modelling

We can undertake modelling of critical scenarios and operational responses to inform improvements and mitigations. Performance sensitivity to asset technology and maintenance regime change can also be modelled.

RAM Target Validation & Iteration

We can validate RAM targets, provide RAM target performance sensitivity testing, and support iterative reapportionment of RAM targets.

Other Modelling and Analysis

To complement our in-house capability, we can call on Network Rail's expert resource in other areas of modelling and analysis.

Station Capacity Modelling

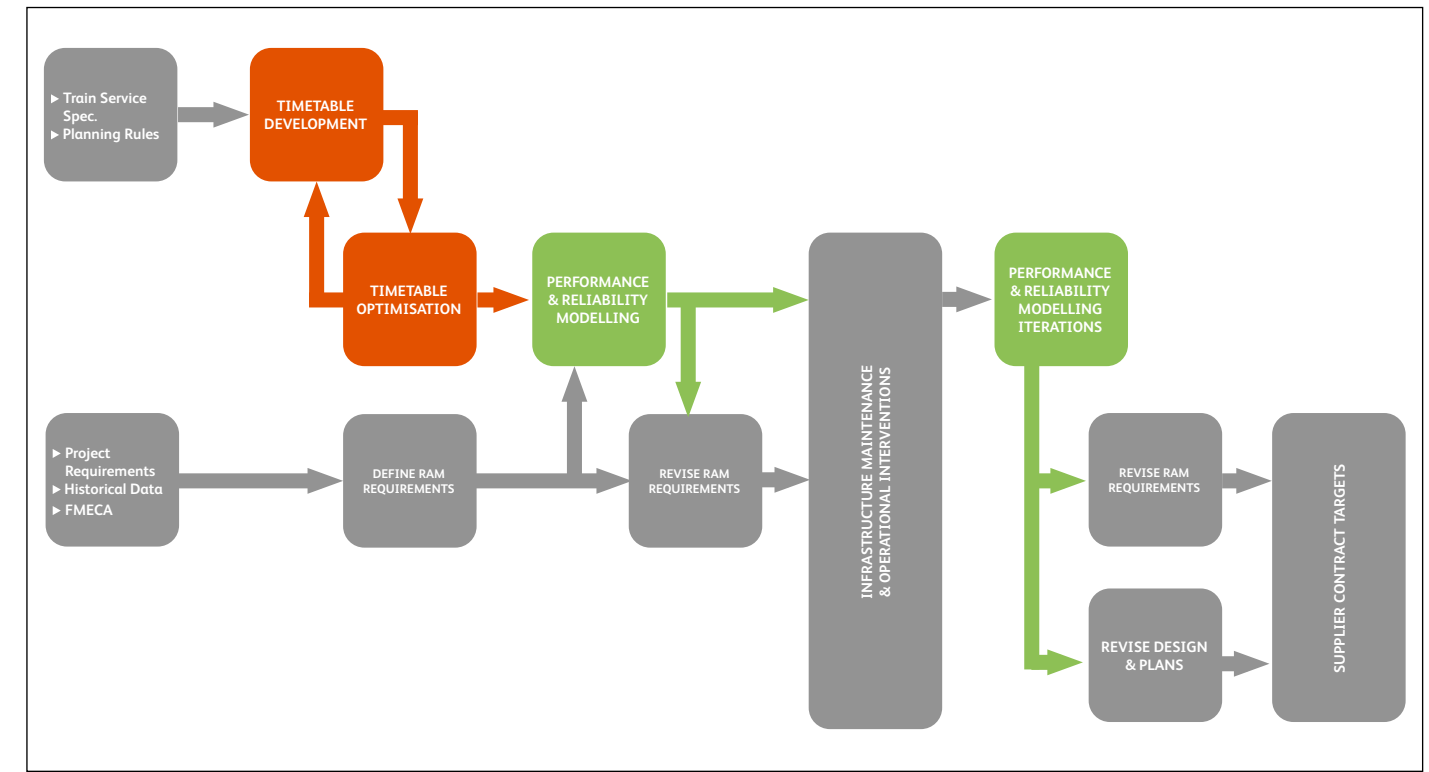
We can provide station planning, pedestrian analysis, passenger safety, and crowd monitoring expertise.

Traction Power Modelling

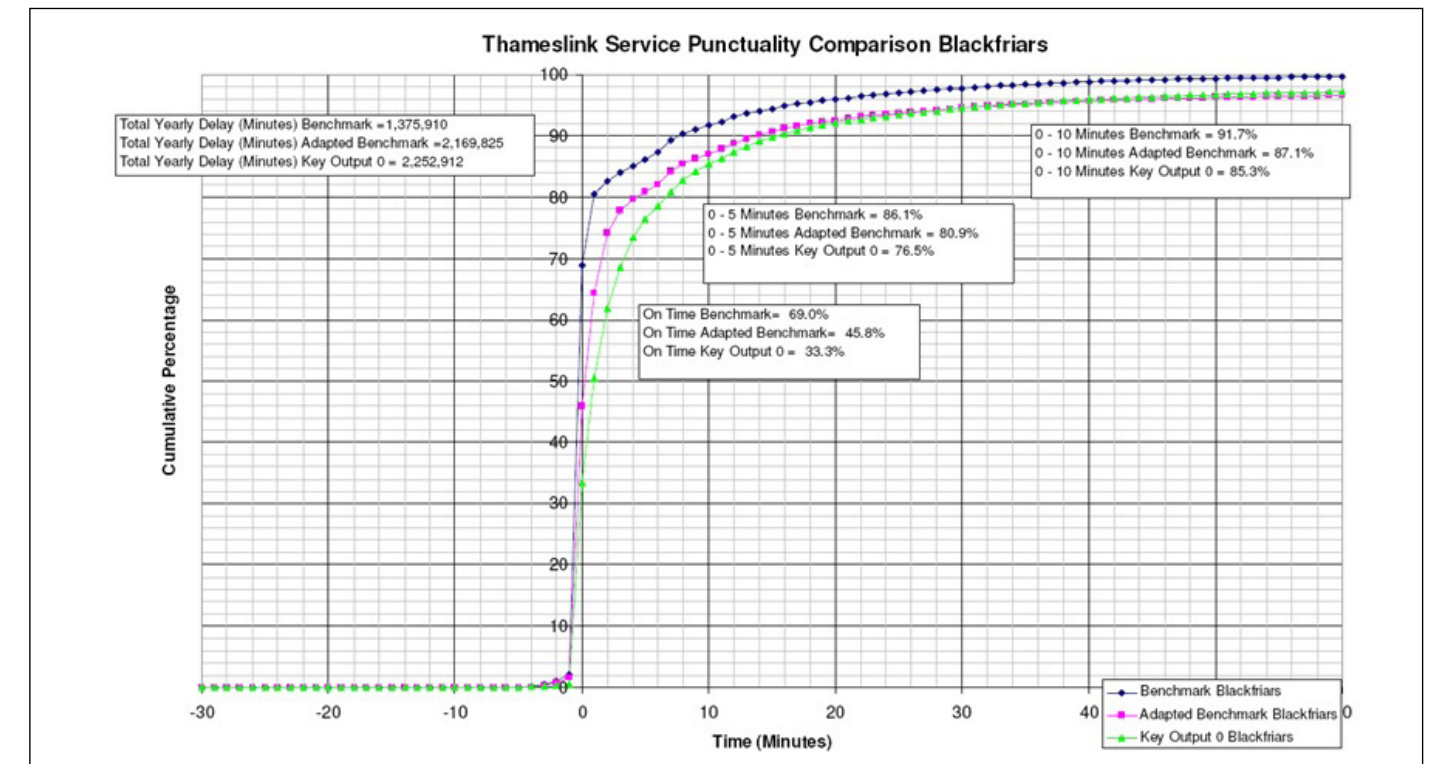
Our capability includes modelling of AC and DC electrified, diesel, battery and other traction technologies to analyse traction power system capacity and journey time calculations.

RAM Analysis

We can undertake a broad range of RAM analyses including FMEA & FMECA, DRACAS, reliability growth, and fault tree analysis.



How RAM Analysis and Modelling Work Together to Inform RAM Targets



Punctuality 'S-Curve' Showing Performance Comparisons in a Range of Operational Conditions



Transport for NSW, Sydney Trains



SAR Passenger Train, Saudi Arabia



Acela Express at Washington, DC, USA



Amtrak at Moorpark, California, USA

Local presence - international expertise

Our approach is to provide the right blend of international best practice expertise coupled with local rail experts who are familiar with the local operating, regulatory and political context, so that we provide advice that is appropriate and implementable for local circumstances. We draw our core expertise from Network Rail, the owner and operator of Britain's rail infrastructure. Together with locally based experts a key part of our offer is our ability to reach back to our colleagues in the UK to access the latest advice, get access to world class expertise and provide additional technical resources during periods of peak workload demands.

Our local teams are able to provide rail owners and operators a wide range of advice covering:

Advisory and Strategic Planning

- ▶ Benchmarking, Auditing and Due Diligence
- ▶ Appraisal, Cost Benefit Analysis and Forecasting
- ▶ Institutional Advice
- ▶ Organisational Change and Transformation Management
- ▶ Performance Regime Design and Management
- ▶ Rail Franchising – Bidding, Specification and Evaluation
- ▶ Policy Development

Stations and Commercial Development

- ▶ Station Design Principals
- ▶ Station Scoping and Requirements Setting
- ▶ Operations and Maintenance and Asset Management Plans
- ▶ Retail and Space Optimisation
- ▶ Customer Information Development

Maintenance

- ▶ Access Optimisation
- ▶ Design and Implementation of Training
- ▶ Design, Modification and Implementation of Maintenance Management Systems
- ▶ Design of Outsourced Operations and Maintenance (O&M) Contracts
- ▶ Planning Maintenance Facilities
- ▶ Systems Automation

Major Projects

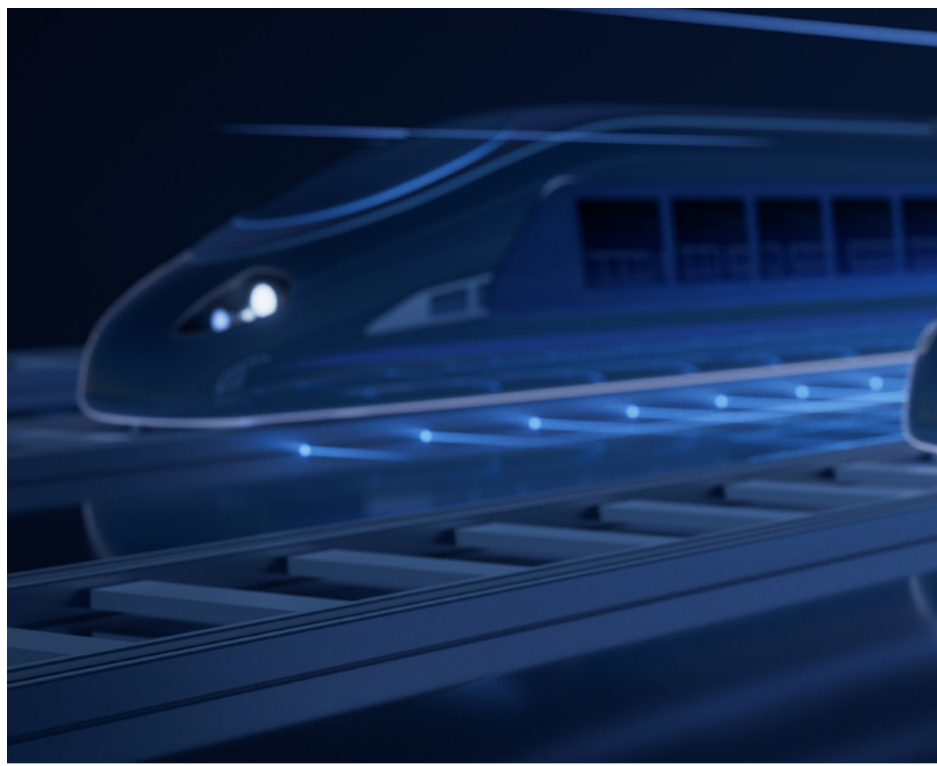
- ▶ Access Planning
- ▶ Client Side Delivery Partner
- ▶ Construction Management & Operations Planning
- ▶ Development and Roll Out of New Digital Train Control Systems
- ▶ Project & Programme Management
- ▶ Reporting & Documentation
- ▶ Risk Management
- ▶ Scheduling
- ▶ Stakeholder Management
- ▶ Systems Integration
- ▶ Value Engineering

Rail Operations

- ▶ Operational Infrastructure Planning and Optimisation
- ▶ Operations Control and Management Systems
- ▶ Performance Analysis and Modelling
- ▶ Shadow Operator Services
- ▶ Simulation Modelling and Timetabling

Asset Management

- ▶ Asset Degradation Modelling
- ▶ Conceptual Design of Asset Management Plans
- ▶ Data Capture
- ▶ Enterprise Asset Management Systems
- ▶ Remote Condition Monitoring
- ▶ Risk Based Maintenance
- ▶ Route Asset Management Plans
- ▶ Whole Life Evaluation



International Presence

- ▶ *Boston*
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- ▶ *Sacramento*
- ▶ *Toronto*
- ▶ *Brisbane*
- ▶ *New York*
- ▶ *San Francisco*
- ▶ *Washington, D.C.*
- ▶ *London*
- ▶ *Riyadh*
- ▶ *Sydney*

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