



Cloud-based data analytics enables Network Rail to improve the performance of its network

Executive Summary

Network Rail produces the UK rail timetable, which schedules the movements of over 22,000 trains every weekday across approximately 19,000 miles of track; over 4 million passengers a day. With demand increasing and problems of overcrowding on the busiest lines intensifying, Network Rail needed to consider making use of any spare capacity in the system and adding services to the timetable. To achieve this, it needed to improve both the accuracy of the existing timetable and the performance of services against it.

However, the multiplicity of sources of data and the complexity of the planning rules governing train movements has led to a volume of data that is simply too vast and unwieldy for Network Rail to validate with sufficient accuracy to form the basis for performance improvement.

Deloitte has worked with Network Rail's timetable planners to develop a cloud-based data analytics system that utilises the billions of rows of data generated by the railway signalling system about the movement of trains across the network and validates the timetable planning rules. The firm's analysis allows the data to be slimmed down to produce a more accurate timetable, which in turn will support not only improved performance but also the ability to maximise rail capacity.

Network Rail anticipates £7m of direct benefits from this project. The combined operational savings for Network Rail and the rail operators are expected to be in the tens of millions, while the indirect benefits of improving the performance and capacity of the railway are estimated in hundreds of millions of pounds, with UK rail travellers benefitting from improved punctuality.

"Working with Deloitte Analytics, Network Rail's Delivering a Better Timetable programme has identified that existing operational data could be utilised to improve the rules used to create future timetables. Deloitte has taken these disparate data sources, aligned the information contained, and developed a powerful analytics system that uses observed data that introduces new capability in analysing timetable rules.

Previously validation of the rules was a laborious process that could only be undertaken on targeted areas. This new system automates this process, allowing nationwide validation to be undertaken systematically for the first time. Once fully implemented, this system will lead to changes to timetables that will improve punctuality of over 1.6m passenger journeys per year and provide a significant return on investment through reduced delay payments."

Mark Foster, Senior Analyst, Network Rail's Delivering a Better Timetable Programme

Deloitte worked with Network Rail to develop a **cloud-based data analytics system** which will deliver improved performance on



 **7,200** services per year and approximately

 **1.6m** more passenger journeys on time.

The system **integrates data** from 10 sources to **improve the accuracy** of the national rail timetable by:

 Analysing **9m+** train services on demand, with

 **18 months** of data facilitated and prepared in minutes,

 saving **1.3m** hours of manual data processing.

Project and approach



Background

Network Rail's current national Public Performance Measure (PPM) – a measure of the degree to which trains run to timetable – is less than 90%. As part of the company's Control Period 5 settlement, which sets out funding for 2014-19, Network Rail has been mandated by the rail regulator to deliver 92.5% PPM by March 2019. Delivery of this improvement in performance will require changes across many aspects of Network Rail's business, including developing new and innovative ways of thinking, analysing performance data and simulating timetable options in order to improve the timetable.

Investigation into the causes of PPM failures has identified that between 3.1-3.6% of trains fail to achieve PPM due to errors in the rules used in compiling timetables: a cause known as the 'specification' of the timetable. These are trains that, even on the best days for the network, fail to achieve PPM. Within Network Rail's Capacity Planning department, the Timetable Rules Improvement Programme (TRIP) has been tasked with delivering a 0.46% improvement in PPM by focusing on these trains and the causes for their PPM failure.

Delivery of this 0.46% improvement in PPM incorporates a programme of works all focused on driving performance improvement and Deloitte was commissioned to support one of these workstreams by looking at the analysis of actual train and network running data.

Tackling this requires the production of a set of timings and analysing them against existing values, known as Timetable Planning Rules (TPRs) – which are the timing 'assumptions' that drive the construction of the timetable. This analysis will inform recommendations on how the TPRs can be revised, allow Network Rail to accurately recast the timetable and take advantage of spare capacity by allowing train operators to run more trains.

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The challenge

The complexity, incompatibility and inaccessibility of the data has meant that Network Rail has been unable to validate around one million timetable planning rules with actual train network and running data.

Deloitte brought together a team combining transport experts, data scientists and big data and visualisation experts to understand Network Rail's challenges. Its first step was to run an Innovation Lab session to brainstorm ideas and conceive some potential solutions. Using agile methodology, the team then developed a rapid proof of concept to test and model the ideas based on sample data sets provided by the client. This generated a prototype which, with visualisation of the analysis, fed into further Lab sessions with the client in order to structure and confirm the scope of an implementation project. The Deloitte team also provided assistance to the client developing the business case for the implementation project.

The objectives for the project were defined as:

- Develop a web-accessible system that would host three years' worth of data from 10 sources, including timetable planning rules, planned timetable and actual train running times
- Integrate data sources into a cloud-based single central repository that is accessible using analysis software to allow analysis of the integrated dataset
- Develop an analytics suite of tools that enable data-mining and visualisation of the integrated data to validate Timetable Planning Rules.

The resulting solution also had to deliver a key set of functionalities, which included:

- capacity for approximately 2 billion records
- accessible through the web
- capability for a user group to run bespoke reports on request
- raw data to be extracted in a standardised format, such as csv
- automated upload of future data.

Implementation

Deloitte worked very closely with Network Rail to gather the large and complex datasets from across multiple storage servers; perform data cleansing activities; and transform the multiple sources into single data storage to be used for retrieval and analysis.

Deloitte integrated data from 10 separate sources across Network Rail's Capacity Planning department and its Network Operations Business Units into a central "single source of truth". The resulting big-data store is accessible via the web, governed and enhanced with tools to allow review of the actual train running times data using PPM, service performance, train specification, timetable and other dimensions. This has delivered:

- Standardisation of multiple data sources
- Single version of the truth
- High data quality
- Referential integrity
- Automatic integration of future data into the system.

All data is stored on and managed by Deloitte Cloud, which is also responsible for upgrades, maintenance, operations, IT infrastructure and support for Network Rail. The cloud also provides the automated functionality to add new data to the central system from Network Rail's legacy systems.

Using agile development methodology, Deloitte has also delivered a bespoke suite of analytics tools (Figure 1). Built with intelligent algorithms, these tools support data mining allowing users to visualise and validate TPRs. These tools provide a number of benefits to Network Rail:

- Transparency of output
- Insights in 3-6 weeks
- End-to-end systems view
- Improved performance
- Operational efficiency
- Analytics capability building.

Figure 1: Analytics suite

The Deloitte team held weekly meetings with Network Rail stakeholders to familiarise them with the system, answer any queries and incorporate their feedback. This approach helped to establish and build trust. Deloitte also modelled a series of case scenarios to both ensure and demonstrate that the data integration was reliable, and eliminate any surprises when the system was deployed. The solution drew together Deloitte's expertise in analytics, visualisation and user interface to deliver a system that is both robust and user-friendly (Figure 2). On testing the system, Thomas Blann, a performance analyst from Network Rail, said: **"I was really impressed with how quickly it calculated and displayed the data, and how it looks visually."**

Figure 2: User interface

Deloitte's suite of analytical tools allows Network Rail to:

- Automatically retrieve all relevant information
- View and compare intervals between two adjacent services
- View features and routes of selected services
- Retrieve all track sections between two locations
- Search by operators, train details, PPM, coach type, stock weight, location and track section in the network
- Train stopping patterns for all sections along a journey
- Compare expected and actual journey times
- View the real variation in running a block of trains and analyse the step-by-step train movement between two locations
- Automatic ordering of track sections between two locations
- Compare services with each other and distinguish journeys by direction of the train.

Figure 1. Analytics suite

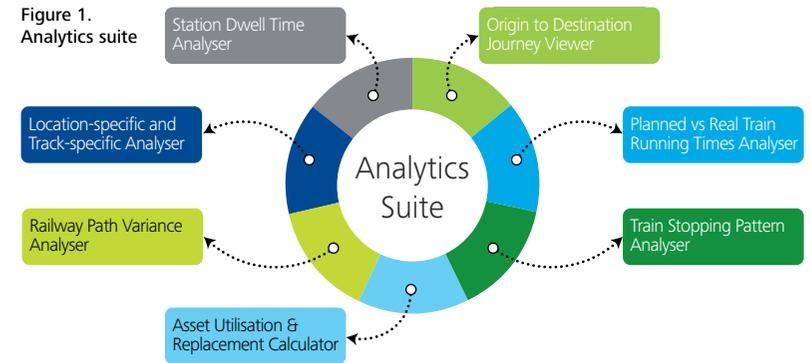


Figure 2. User interface



"Collaborating with Deloitte has brought expertise in handling large datasets, particularly high-quality visualisation, with an ability to quickly grasp difficult railway terminology and processes. Well-structured weekly meetings enabled thorough two-way feedback of the product and quick development of ideas into practice. The suite of tools provides efficient, effective and detailed analysis, which will ultimately benefit passengers – analysis which previously took five days is now completed in five hours."

Thomas Blann, Performance Analyst, Network Rail's Delivering a Better Timetable Programme

Outcomes

Deloitte's data analytics project has exceeded all expectations in terms of accuracy, ease of use and enhanced functionality.

The magnitude of the project's achievement and success can be measured in three dimensions:

Automated data processes

The system:

- has saved approx. 1.3 million hours of manual data processing. Operational planners and performance analysts have seen their time switched from 90% data manipulation and only 10% value adding analysis, to needing to spend only minimal time manipulating data and the vast majority of their time undertaking business changing analysis

- combines multiple sources of data so that the data being analysed is much richer facilitates preparation of up to 18 months of data in minutes, allowing more comprehensive and far reaching analysis; previously it took up to 20 hours to prepare data for a two-week sample
- analyses over 9 million (95%) train services on demand; previously this took multiple days
- analyses over 1 million TPRs that govern the timetables for passenger and freight services.

Enhanced performance

The system:

- will deliver improvement in train punctuality of 0.1% on PPM, which equates to improved performance on 7,200 services per year and approximately 1.6 million more passenger journeys on time
- will facilitate timetable changes that will improve punctuality and capacity – approximately 14 million minutes of train delays cut by December 2018
- fully automates the analysis between trains that would previously be done on site with stopwatches in real time. The capacity to combine multiple data sets has removed the need for site visits and allows a full year of observations to be analysed instantaneously.

Clever decision making

The new system:

- provides new and enhanced capability for large-scale data analysis
- identifies existing unused capacity on the railway network allowing potential for additional services to be run
- identifies where trains consistently do not perform to the timetable and support investigation of root causes
- supports business decisions on future investment
- will deliver a return of investment of 8-1 through reduced delay payments.

Deloitte's data analytics system has provided Network Rail and rail operating companies with demonstrably accurate and easy-to-use data tools and visualisation. For the first time, all the data from disparate and seemingly

incompatible systems has been drawn together to offer a clear picture of how trains all over the UK are performing against the timetable, of where problems occur and of where there is potential to expand rail capacity without building new lines. Understanding in detail the current situation is the key to critical decision making for Network Rail in meeting its mandated target of 92.5% PPM and Deloitte Analytics' new system has provided a powerful tool that will deliver wide-ranging benefits:

- Passenger and freight operators will have access to the data that will allow them to perform detailed analysis of their train performance, understand delays, and optimise their services, including adding more trains at peak times to increase capacity
- Network Rail Strategic Planning and the Department for Transportation will be able to develop long-term plans and policies on the basis of accurate and detailed analysis of UK train performance
- UK rail passengers will see more trains on time and the identification of extra capacity will allow additional services to operate in future timetables leading to less-crowded trains at peak times.

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