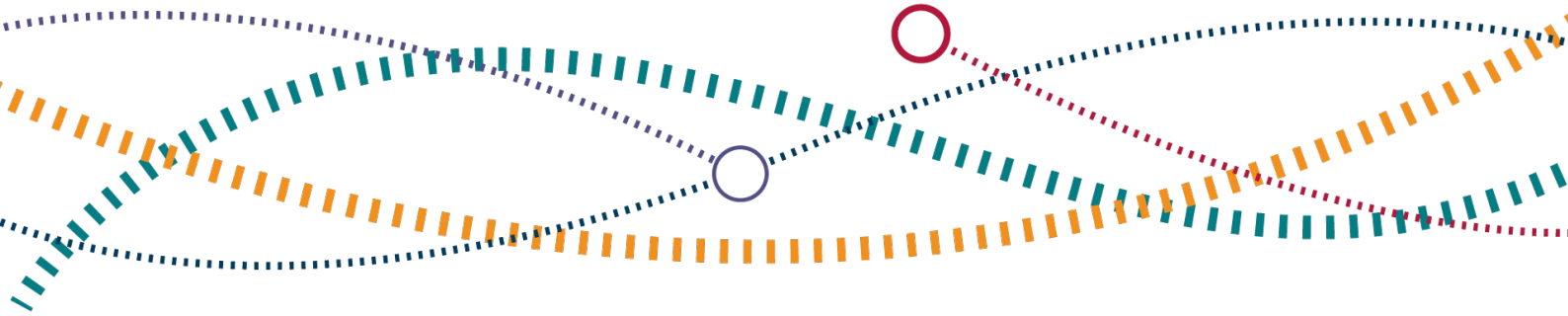
OFFICE OF RAIL AND ROAD

Technology Adoption in Network Rail

Targeted Assurance Review

23 June 2023



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Acronyms and Abbreviations

CP6 - Control Period 6

ORR – Office of Rail and Road

TAR – Targeted Assurance Review

R,D&I – Research, Development and Innovation

RIRL – Rail industry readiness level

IOMSL – Interfaced overlay miniature stop light

PLPR – Plain line patter recognition

STE - Safety, Technical and Engineering

TSR – Temporary speed restrictions

PSR – Permanent speed restrictions

Definitions

Descriptor	Detail
Technology adoption	In this review, technology adoption refers to implementation of new technologies and new methods of working.
Control Period	Control Periods are the 5-year timespans into which Network Rail, works for financial and other planning purposes.
Safety, Technical and Engineering (STE)	A technical authority for Network Rail that leads policy, providing support and delivering assurance for the safe, reliable and effective functioning of assets.
Whistle boards	Train Drivers are required to sound their horns when they pass a “whistle board” sign on the approach to a level crossing and this provides users with an understanding of whether or not it is safe for them to cross the railway.
Boots on Ballast	The term refers to railway workers having to walk around the railway to do some of the fundamental tasks of checking and measuring.
False positive	A test result which wrongly indicates that a particular condition or attribute is present.

1. Executive Summary

The CP6 determination provided Network Rail with funds to undertake research, development, and innovation (R,D&I) projects that were to provide future benefits to the operation and maintenance of the assets controlled by Network Rail.

Network Rail was allocated £245 million for R,D&I portfolio in CP6. The benefits would typically be expected to take the form of improved outcomes such as efficiency, improved asset management, reductions in disruption or reductions in safety risk. For the research and development (R&D) investment to offer good value for money for funders, it has to develop technology that are adopted by the business and deliver its intended benefits.

Therefore, we wanted to seek assurance that the investment in R&D by Network Rail is delivering new technologies and that they are being embedded into business. We therefore carried out a Targeted Assurance Review (TAR) by looking at the adoption of new technologies developed, this report summarises the findings.

Network Rail's R,D&I portfolio has a number of projects on in progress in CP6. By year 4 of CP6, seven projects have matured for deployment. This review focused on a sample of three out of seven deployed technologies. Based on the projects reviewed, we found that all three technology solutions have been adopted for use by Network Rail.

The feedback from the users were positive and confirmed that the technology solutions fulfils its' intended purpose and will help realise the benefits.

All three projects have been developed in collaboration with suppliers and/or universities:

- The Interfaced Overlay Miniature Stop Light (IOMSL) can be considered as a bespoke refinement of an existing product by a supplier in Europe, to address the specific requirement of Network Rail.
- Plain Line Pattern Recognition (PLPR) deep learning is a refinement of an algorithm developed earlier by a supplier in collaboration with Network Rail.
- The approach to reduced clearances for electrification was conceptualised by the suppliers to address a challenge on the Great Western electrification, which was further developed and validated by Network Rail in collaboration with an university.

On the basis of this review, we are assured that the technology research and development undertaken by Network Rail for the three examples reviewed have resulted in viable technologies, and they are being adopted by the business and industry. This review does not propose any recommendation, however we will continue to monitor the technology adoption of future projects through our routine monitoring with the R,D&I programme and the regions.

2. Introduction

2.1 Purpose

The aim of this review is to seek assurance that investment in R&D by Network Rail results in technology development that are successfully being adopted into business and achieve the intended benefits.

2.2 Objectives

For the five yearly funding cycle CP 6, running from 2019 to 2024, Network Rail was allocated **£245 million** for R,D&I . When combined with investment from other sources, Network Rail's R&D Portfolio equates to **£357 million**, focused on improving the quality and value for passengers and freight customers of the rail network.

The CP6 determination provided NR with funds to undertake R&D projects that were to provide future benefits to the operation and maintenance of the assets controlled by NR.

https://www.orr.gov.uk/sites/default/files/om/pr18-final-determination-review-of-network-rails-proposed-costs.pdf (Pages 83 to 89)

These benefits would typically be expected to take the form of improved outcomes such as efficiency, improved asset management, reductions in disruption or reductions in safety risk.

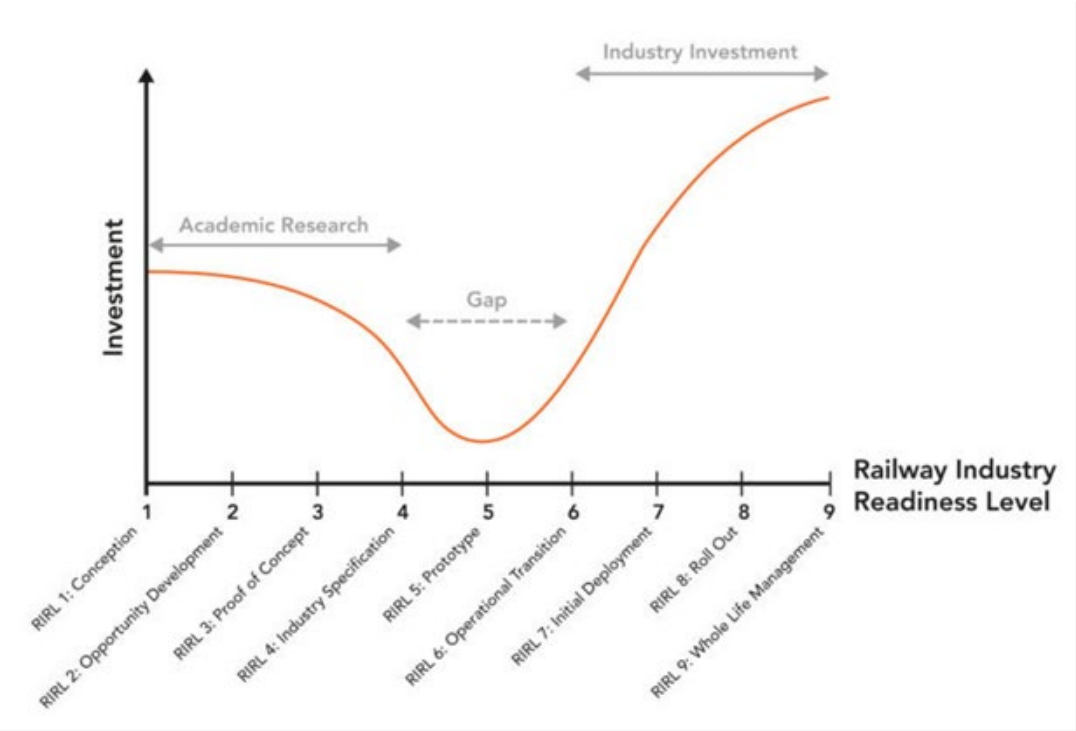
For the R&D investment to offer good value for money for funders, it has to develop technologies that are adopted by the business and deliver its intended benefits.

Therefore, ORR wanted to assure that the investment in R&D by Network Rail is delivering new technologies and that they are being embedded into business.

3. Background and Scope

3.1 Technology Adoption Process

Network Rail uses the RIRL as a stage-gate process for technology readiness and it has nine levels as shown in figure below.



The research stage is RIRL 1-3 and Development stage is RIRL 4-6. After these stages, the outputs must ultimately be used within the day-to-day operations for the intended benefits to materialised.

Network Rail's R&D portfolio funds are used to take ideas to RIRL 6 with work to support Initial deployment (RIRL7). This review focuses on projects progressed to RIRL 7-8.

3.1 Technology Development in Network Rail

In Network Rail, technology development is undertaken by different business units within the organisation.

R,D & I Programme

NR's R&D portfolio aims to bring together research & development in one place and unlocks benefits across Network Rail. The R&D portfolio is reflected in regional plans to help improve outcomes including safety, efficiencies, and benefits to customers.

Network Rail's R,D&I unit acts as a sponsor and offers governance for the development of technology projects. The projects are generally delivered through collaboration and partnerships, either by the Technical Authority (NR's technical authority), national delivery programmes, industry suppliers and/or universities.

R&D portfolio is sometimes linked to national delivery programmes that offers routes for new products and services to be brought into use.

National Delivery Programmes

Route Services:

Route Services is a division of Network Rail that supplies critical services for the wider business. It includes business and technical services, commercial and procurement, engineering services, IT services, telecoms, supply chain operations, finance and business support, and HR.

Route Services seek opportunities to identify and develop innovation. It undertakes R&D programmes to deliver innovation services and disruptive technologies, this includes Digital Railway and Intelligent Infrastructure.

Intelligent Infrastructure:

Intelligent Infrastructure (II) is a five-year transformation programme (2019-2024) focused on turning data into intelligent information. This programme looks at how Network Rail can maximise the value from the data it has whilst working closely with the research and development programme to be at the forefront of technology introduction.

Working with the regions and industry partners, Intelligent Infrastructure uses existing and emerging digital technology to deliver technology projects.

System Operator:

This nation-wide function focuses on the railway 'system' level opportunities to deliver more capacity, better timetables, longer and more trains and new technology.

System Operator is undertaking technology projects, mainly around the use and quality of data, since data underpins all its activities. Some of the projects are linked to the R,D&I programme as it has sought funding from R&D portfolio for further development of its programme.

Regional Initiatives :

Network Rail's devolved regions may also initiate and deliver technology projects separate from the R&D portfolio.

Scope of Review

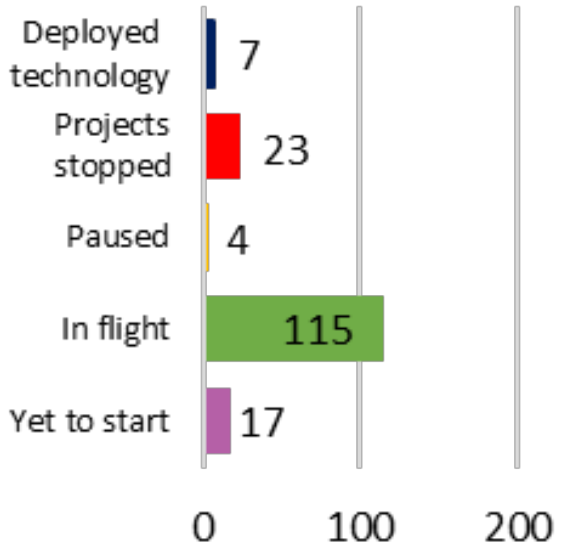
Although technology projects are undertaken by different business units within Network Rail, this review focused only on the R&D portfolio and only the projects that were funded from CP6 determination.

For the purpose of this review, a sample of projects that has been progressed up to deployment stage were selected for assessment. Sample projects were chosen to represent different disciplines, customers, and delivery partners.

4. Observation & Findings

4.1 Status of CP6 R&D Programme:

The status of R&D projects as of March 2023.



No. proven and purchasable technologies - 7

No. of projects maturing for deployment – 9

No. of projects reaching RIRL6 by end of CP6 – 24.

4.2 Evidence of Adoption:

Interfaced Overlay Miniature Stop Light System:

The intended purpose was to find an automatic solution to improve the safety of sighting-only crossings and protecting users of high-risk footpath, bridleway and user-worked level crossings.

Overlay miniature stop light (OMSL) systems has been used in the UK since CP5 which is suited for a level crossing at a simple plain line location. However, for the more challenging sites, IOMSL is a new solution developed in CP6 through the R&D programme.

Features:

The IOMSL is a level crossing that interfaces with the signalling so it can provide the user with more information to make a safer crossing.

This technology was developed by Schweizer Electronic, in close co-operation with Network Rail.

IOMSL is based on Schweizer's level crossing system known as Flex Control at its core but it was developed for a bespoke UK application to meet Network Rail's requirements. The new system also includes Network Rail designed interface circuit.

End user views:

According to Network Rail three installations has been completed to date (April 2023), with six more planned for CP6 (2023-24) and five in Year of CP7 (2024-25).

We interviewed the route level crossing managers from two routes to obtain their feedback on the installation and benefits.

Dibleys, Kent:

IOMSL has been installed at Dibleys level crossing which is a public footpath crossing with whistle boards.

This site has insufficient user sighting and is located very close to a railway station and a crossing. There has been a speed limit on the line since 2015 due to lack of technology in place to resolve issue like this.

The key objective of this installation was to remove the speed restriction.

Adoption and benefits:

At the time of the interview, this technology installation was still under the trial – in a data gathering mode to understand driver behaviour over this level crossing. The planned commissioning date was in late March 2023. Installation of this equipment was funded by Network Rail level crossing safety fund with an anticipated budget of £647K.

Since the installation of IOMSL in Dec 2022, the crossing remains closed (for trial period) and speed limit restored from 45mph to the original 50-mph for freight and 70-mph for passenger trains.

In addition to restoring speed limit, the other objective of installing IOMSL at this location is also linked to the opening of Thanet parkway station. By removing TSRs and PSRs, it provides 31seconds of journey time improvement along this line of route.

Following the installation of IOMSL, the risk profile of the level crossing was reduced for fatality weighted injuries.

This technology is expected to provide the following benefits - safer crossing, faster services, removal of whistle boards (environmental benefit), and provides train performance for Thanet parkway.

Smiths, Wessex Route

On the Wessex route, there are 60 user-worked level crossings, these are crossings that require the user to call a signaller who will let them know if it's safe to cross.

Smiths level crossing at Wokingham is one of the user-worked crossing with poor sightings. There has been a speed limit on the line for 3-5 years to reduce the risk. Local residents found the whistle board warning noise made for each of the 123 trains a day using this piece of track very disruptive.

The key objective of this installation was to remove the speed restriction and whistle boards.

Adoption and Benefits:

IOMSL was installed in January 2021 and after undergoing acceptance testing it has been operating as business as usual from January 2022.

This kind of crossing would cost £800K but the R&D team have helped to identify a way to install a crossing like this one for about £250K.

The crossing has allowed to remove a speed restriction on this line and thus reducing the travel duration for the train users. Also, removing the need for trains to whistle.

As a result of this technology the region hopes that it can improve more level crossings within their budget and it has plans to install 2 or 3 more of these in the next couple of years and many more in the years after that.

PLPR Deep Learning:

The intended purpose was to enhance the algorithm to improve the results (better detect false positives) from the automatic track inspection using PLPR technology.

PLPR is a technology that monitors and records track condition information, and can find issues such as missing fasteners, excess ballast and ineffective rail clamps. Every year there are over 130,000 rail clamp inspections where damage

is suspected. Of these, nearly 50% are false positives, caused by debris. This results unnecessary time of “boots on ballast”, causing delays and safety risk.

End user view:

PLPR is run as a service offered by Network Rail’s Asset Information team to the individual routes.

We interviewed the head of delivery for Data collection within Network Rail’s Information Services regarding the PLPR deep learning project. We discussed about the intent and features of the new technology, its adoption and implementation, customer satisfaction and benefit outcomes. A summary of the responses provided are given below:

Features:

This project was an improvement to the PLPR technology using Artificial Intelligence (AI) based deep learning model to better detect ‘false positives’ from the machine data.

PLPR was originally developed as joint venture between Balfour Beatty, Omnicom and the University of York.

PLPR is used for assessment of different track asset components (eg.clamps, fasteners). There are separate projects for the development or refinement of their algorithm and are funded through various sources.

The deep learning model for rail clamps was developed by Network Rail through a performance-based supplier contract with R&D funding.

Omnicon Balfour Beatty worked in collaboration with Network Rail to introduce a deep-learning model for the classification of rail clamps to operate within the PLPR processing environment.

Adoption and Benefits:

The model was developed, tested and implemented in eleven months. It has been adopted as business as usual for over 18 months and has successfully reduced false positives.

During the trial, Inspectors from the Information Services team were involved in the validation of the algorithm. The algorithm has exceeded the Inspectors’ expectations; they aimed for 85% reduction, but it has resulted in 95-98% reduction.

The trial resulted in sustaining the accuracy of detection levels whilst significantly reducing the levels of candidates (false positives) being presented to an Examination Inspector.

The use of new algorithm has resulted in a 98% reduction of false positives which has significantly increased the efficiency of PLPR inspections freeing up both time and capital for alternative projects. However, the customers (routes) got the same results.

Reduction in false positives means less candidates being presented and hence reduction of team size. During this period, Network Rail Asset Information team has been able to reduce the number of examiners by six.

Cost-Efficient Electrification - Reduced Clearances

The Cost-Efficient Electrification project (Phase 1) which aims to reduce the unit rate for new overhead line electrification is made up of ten workstreams. Electrification Clearance (voltage-controlled[1] clearances) is one the workstreams which according to Network Rail has already generated significant efficiencies.

The intended purpose of this workstream was to develop ability to install overhead line equipment (OLE) with lower clearances to fixed infrastructure (structures, tunnels etc) and thus reduce the cost of electrification.

Electrifying a railway with restricted gauge that were constructed in the early 19th century can be challenging and expensive. The need to create clearance for overhead line equipment (OLE) often means majority of existing structures, like bridges, need to be reconstructed before electrification is installed. Civils work – especially bridge reconstructions – can make up around a third of the electrification cost. The challenges to the cost of electrification led to the search for innovative solutions to reduce clearances.

The need to achieve reduced clearances resulted in formalising and validating existing methods of surge arrestors, contact wire covering and insulating coatings in various combinations. This was achieved by testing the flash over distances for the various combinations and differing environmental conditions at Southampton University. Following this testing Network Rail concluded that clearances could be reduced.

[1] Note: Although the approach of reduced clearances using the combination of surge arrestors, contact wire covers and an insulating covering is often referred to as voltage-controlled clearance, it does not control the voltage but it does reduce the chance of flash over.

End user view:

Reduced clearances have been adopted by electrification projects, including TransPennine and in Scotland.

We interviewed the Chief Engineer from Eastern Region and Project Manager from North West Central region to confirm adoption of this approach on TransPennine Route upgrade. We discussed the context and features of the new approach its adoption and implementation and benefit outcomes. A summary of the responses provided are given below:

Features:

On the Great Western Electrification project, to address a complex clearance challenge, the concept of reduced clearance was developed for application. A wide range of stakeholders were involved in this development.

Network Rail Technical Authority then developed and tested the technology with the University of Southampton for deploying[2] it nationally across a wide range of bridges.

Adoption and Benefits:

Both the interviewees confirmed that reduced clearances are being adopted in the OLE design for TransPennine route upgrade. The adoption involved design and installation of OLE according to the standard which has been updated following the trial and validation of this approach.

The use of this approach has helped overcome many of the OLE installation problem locations on TransPennine route upgrade. By avoiding the need for bridge reconstruction, the technology has already delivered its intended benefits.

[2] Note: According to ORR's policy on electrical clearance, since the use of contact wire covers and insulating covering are novel solutions not proven over time and should only be used where it is grossly disproportionate to meet the minimum clearance required by the published standards.

5. Conclusion

5.1 Network Rail's R&D portfolio has a number of projects in progress in CP6. By year 4 of CP6, seven projects have matured for deployment.

5.2 This review focused on a sample of three out of seven deployed technology. Based on the projects reviewed, we found that all three technology solutions have been adopted for use by Network Rail. The technologies reviewed are given below:

- PLPR deep learning has been fully deployed as business as usual.
- IOMSL has been deployed in three sites.
- The development of reduced clearance approach for electrification has led to the new standards and formalisation of approach, which is being adopted on a major electrification programme.

5.3 The feedback from the interviewees were positive. They confirmed that the developed technology solution fulfils its intended purpose and enable to realise the planned benefits.

5.4 The end users have been involved during the trial and validation of the technology, and there was opportunity to provide feedback to the developers.

5.5 All the three projects have been developed in collaboration with the suppliers and/or universities.

- The IOMSL can be considered as a bespoke refinement of an existing product by a supplier in Europe, to suit the specific requirement of Network Rail.
- PLPR deep learning is a refinement of a technique developed earlier by a supplier in collaboration with Network Rail.
- The approach to reduced clearances for electrification was conceptualised by the suppliers to address a clearance challenge, which was then developed, formalised and validated by Network Rail.

5.6 On the basis of this assurance review, we are assured that the technology research and development undertaken by Network Rail for the three examples reviewed have resulted in viable technology and they are being adopted by the business.

5.7 To address the adoption challenges and facilitate deployment and scaling-up of the new technology in the regions, R,D&I has set up a dedicated 'first in class' deployment support team.

5.8 This review does not propose any recommendation, however will continue to monitor the technology adoption of future projects through our routine monitoring with the R,D&I programme and the regions.

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