Department for Transport

An Independent Retrospective evaluation of the Rail Safety & Standards Board Research & Development Programme

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Department for Transport
Great Minster House
33 Horseferry Road
London
SW1P 4DR

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Glossary

Acronym	Long form
APM	Association for Project Management
BCR	Benefit Cost Ration
DfT	Department for Transport
DVRS	Double Variable Rate Sanders
ETT	Economic Tyre Turning
FOAK fund	First of A Kind innovation fund
FOC	Freight Operating Company
GB	Great Britain
NR	Network Rail
ORR	Office of Rail and Road
PIF	Performance Innovation Fund
R&D	Research & Development
RAATS	Red Aspect Approaches to Signals
RDG	Rail Delivery Group
RIA	Rail Industry Association
ROSCO	Rolling Stock Company
RSSB	Rail Safety and Standards Board
RTS	Rail Technical Strategy
SIC	System Interface Committee
SME	Subject Matter Expert
SPAD	Signal Passed at Danger
SPARK	RSSBs research repository
TCA	Track Circuit actuator
TOC	Train Operating Company
TRL	Technology readiness levels
UKRRIN	UK Rail Research and Innovation Network
VTISM	Vehicle Track Interaction Strategic Model
WSPR	William-Shapps Plan for Rail

Executive Summary

Introduction

The Rail Safety and Standards Board (RSSB) is a non-profit organisation which supports the rail industry to deliver a better, safer railway. Its Research and Development (R&D) Programme has been running since 2001 and aims to promote cross-industry collaboration and to encourage the adoption of research for the benefit of the wider rail sector. The Programme aims to address key industry challenges that cannot be tackled in isolation, and which need a long-term, whole-system approach. The Department for Transport (DfT) has funded the Programme providing approximately £10 million per year to conduct research.

The context within which the RSSB R&D Programme currently exists will change significantly because of the Williams-Shapps Plan for Rail, which was published in May 2021. This includes a commitment to simplify research, development, and innovation funding, with Great British Railways to become the primary public funder.

In January 2022, DfT commissioned PA Consulting to conduct an independent retrospective evaluation of the RSSB R&D Programme – the first of its kind. The evaluation was completed over 10 weeks from 10th January to 21st March 2022.

There are three strands to this evaluation:

- **Impact.** What difference has the RSSB R&D Programme made to the rail industry indirectly or directly, and has it achieved its expected outcomes?
- **Value for Money.** Is the RSSB R&D Programme delivering value for money in financial terms, and is it a good use of public funding?
- **Process.** How well does the RSSB R&D Programme's structures and governance facilitate delivery of its aims and objectives, and what lessons can be learned from the Programme on R&D in the Rail sector?

Each of these strands contains several research questions agreed with DfT, which this report addresses individually to provide an overall assessment of the Programme.

High Level Findings

Impact

a) To what extent has the Programme achieved its expected outcomes?

The RSSB R&D Programme **has achieved its strategic outcome of addressing a market failure** where there is no clear accountability or stakeholders are unincentivised to solve issues which they do not directly benefit from. All case studies and stakeholder interviews provide evidence that the Programme has been fundamental in addressing this market failure by facilitating cross-industry collaboration and solving challenges that would not be addressed elsewhere.

Whilst the Programme has adapted its focus to meet industry challenges, **stakeholders are not always clear on its strategic direction and overall focus.** Some interviewees raised concerns or did not understand the Programme's priorities, future direction, and alignment to current industry priorities. The Programme typically delivers R&D at lower technology readiness levels (TRL). Interviewees identified the Programme as providing 'low TRL' research or 'blue sky thinking' and some expressed frustrations that the Programme does not deliver industry-ready solutions.

Most stakeholders **perceive Programme outputs to be good quality**. Likewise, most agree that the Programme had led to new insights or better understanding of future research areas. However, dissemination of outputs across industry could be improved.

b) What evidence is there that the outcomes were caused by the Programme and not by other factors (e.g. similar interventions including wider regulations and rail policies, or positive contextual conditions)?

Interviewees provided many examples where **RSSB research directly informed standards changes** or provided industry with a new tool or capability (particularly in the case of 'safety'). The role of the Programme in **supporting ORR investigations following safety-related incidents** is a clear example of how it drives industry outcomes and has led the industry to act on its recommendations.

c) What direct and indirect impacts has the Programme had so far (e.g. economic, commercial, environmental, social)?

Interviewees agreed that **there has been positive industry change,** particularly in the areas of safety, sustainability, and optimisation. The R&D Programme was fundamental to those changes by building knowledge and creating tools to facilitate data-driven decision making and help the industry to navigate new technologies and trends.

A key theme to emerge from interviews was the culture shift towards, and emphasis now placed on, safety in the industry. Having historically focused on safety, **the RSSB R&D Programme is recognised by many as a critical factor in the development of the current safety culture** in the industry. Interviewees now perceive a similar trend in relation towards sustainability in the industry.

Many **interviewees identified collaboration as a key benefit of the Programme**, and the importance of the RSSB's independence in enabling this. The Programme provides a mechanism to understand and investigate fundamental challenges and build knowledge within the industry.

The Programme is recognised internationally as a rail research centre of excellence and has **helped to position the UK as a global leader of rail R&D**, creating a pool of subject matter experts.

d) To what extent have the Programme's outputs led to real world applications of research?

All interviewees identified areas where research had led to real world applications and directly influenced or created change. Similarly, the case studies highlighted examples of where the research was being used by industry or in the process of delivering impact.

Challenges exist in relation to implementation and monitoring. Despite engagement with RSSB, organisations are prevented from implementing Programme outputs by resource limits, documentation complexity, lack of clarity on value, lack of incentives and changing priorities. Similarly, projects classified by RSSB as 'non-significant' but which go on to have real world applications may be missed and successes not communicated.

e) To what extent have the Programme's outputs influenced relevant senior decision makers (e.g. Rail Strategy Board, senior civil servants)?

Programme outputs indirectly influence senior figures by providing an evidence base for decision making. Interviewees cited the use of research as evidence to support new policies, business cases, investment papers, industry strategies and quantifying benefits, risks, and opportunities.

Outputs are **more likely to influence senior decision makers directly when the underpinning research is 'event-driven'** – for example, when it has been produced in response to safety-related incidents or media articles.

Value for Money

f) What is the estimated benefit-cost ratio of the Programme so far?

It was not possible to calculate a benefit-cost ratio for the overall Programme. This was due to challenges quantifying the overall expected benefits stemming from incomplete and inconsistent data.

RSSB is developing new Programme-level benefits realisation timelines for projects starting from 2020, which will enable future Programme-level cost benefit analysis.

g) What is the estimated value-for-money of the Programme so far (including additionality of policy impacts)?

Despite the absence of an overall benefit-cost ratio, **evidence from case studies and stakeholder interviews suggests that that the Programme does provide value for money.** Case study findings are shown below (see page 53 for more detail on the assessment of case studies' value).

- 8 out of 13 case studies were considered good value for money at the time of this evaluation.
- 4 out of 13 case studies were unclear or too early in the implementation stage to make a meaningful value for money assessment at the time of this evaluation.
- 1 out of 13 case studies was not considered good value for money at the time of this evaluation.

The RSSB R&D Programme brings unique value to the rail industry as it is currently structured – through its independence, cross-industry structure and input, technical expertise, and academic focus. Without the Programme there would be a significant loss in these areas. **Co-funding partners across the Programme reduce its overall financial risk exposure** and drive private sector investment in R&D.

Process

h) How well does the Programme align with the Rail Technical Strategy and DfT's strategic priorities?

There was no evidence that the RSSB R&D Programme was explicitly designed or formally mapped to the Rail Technical Strategy (RTS) and DfT strategic priorities. For example, the RTS is listed on the RSSB R&D website, but there is no information as to how the Programme aligns with it. Similarly, during familiarisation interviews, participants were unclear how the Programme had been formally aligned.

Nevertheless, an exercise undertaken to map the RTS and DfT priorities against the research groupings devised for this evaluation suggests that **the RSSB R&D Programme does support the RTS and DfT priorities** (see Table 11 on page 65).

i) How well does the Programme's governance model facilitate the delivery of its aims and objectives?

We adopted an R&D process benchmarking approach to evaluate the Programme's governance model. We present the main findings below. For more detail, please see page 64.

- **The Programme has an effective entry management process** which includes generating ideas from multiple sources, selecting, and involving industry sponsors, assessment of projects against key criteria and reviewing existing research. Projects tend to be adopted or implemented more effectively when the end customer is involved from the outset. Benefits management could be improved.

- **The Programme has strong project-level management,** with a defined project life cycle and good capabilities for delivery. Projects are typically well scoped and delivered on time and on budget, with strong stakeholder involvement. The Programme learns lessons from previous projects and stops or alters projects which are not meeting expectations. As projects are often designed in stages and managed separately, **there is a risk that costs and benefits are not effectively monitored.**

j) What lessons have been learnt from the Programme about what works well and less well in supporting R&D in the rail sector?

Several lessons can be learnt from the Programme.

1. An early-stage R&D capability within the rail industry is important because it provides an evidence base to help industry make informed, data-driven decisions about new technologies, market trends, industry challenges and where to focus further R&D work.
2. There is an important role for an independent body within the current industry structure to provide credibility and trustworthiness for key decisions to be based on.
3. Collaboration across industry, both with private and public organisations, should be central to R&D because of the current structure of the industry.
4. Academic partnerships can bring strength and value to rail sector R&D in the form of flexibility to complete follow on research and shape requirements, the ability to take on projects which may not be delivered commercially as they are too uncertain and helping build subject matter expertise.
5. Customer-led research, in which customers are involved and engaged in the research from the outset, are more likely to be impactful and easier for industry to adopt.
6. Benefits should be clearly articulated so that ensure the research is a good investment and to incentivise stakeholders to implement/adopt outputs.
7. The need for clarity in understanding and communicating the wider R&D rail ecosystem so stakeholders know how research moves through the Technology Readiness Levels and which organisation is best suited to support.

k) What lessons can be learnt from the Programme about monitoring and evaluating R&D in the rail sector?

We have identified the following lessons.

1. Aligning Programme structure around strategy and purpose is important because it helps articulate and document the rationale, objectives and intended outcome of the Programme. Without this, it is challenging to understand the success measures and therefore complete an evaluation.
2. Establishing consistent data frameworks and collection methods provides the ability to make data usable and relevant for the purposes of evaluation. They should be

aligned to the success measures of the Programme to help monitor and understand if it is having the desired effect.

3. Programme evaluation should be planned and executed during and after programme delivery. A more effective feedback loop and regular monitoring should be established to incorporate feedback and lessons learnt into the Programme on an ongoing basis.

Conclusions

We have drawn the following conclusions based on the evidence collected and analysis carried out across the impact, value for money, and process evaluation strands.

Impact

- The Programme is delivering impact and driving positive change against its overall purpose to:
    - Enhance the safety, sustainability, and optimisation of the rail network, addressing key challenges which cannot be tackled in isolation, need a 'system thinking' approach or have long-term time horizons.
    - Benefit the entire rail ecosystem, including system interfaces, not individual stakeholders.
    - Address a market failure where there is no clear accountability or stakeholders are unincentivised to solve issues which they do not directly benefit from, including long-term issues.
- Most outputs that are produced are high quality and have a direct causal link to subsequent outcomes, with some external factors additionally contributing to change.
- The Programme has encouraged, facilitated, and supported industry collaboration.
- The strategic direction of the Programme is sometimes unclear and partially reactive.
- Not all outputs are implemented by industry and sometimes engagement can be low, with missed opportunities to communicate the value of R&D effectively to support implementation.

Value for Money

- Analysis across case studies suggests projects are generally value for money and, in most cases, appropriate assumptions are used when estimating project level benefits and value for money.
- It has not been possible to calculate a benefit-cost ratio for the overall Programme, as benefits have been tracked differently for different types of projects. This is mainly due to the way data is currently collected at project level. RSSB is currently changing its processes in a way that should make it possible in the future.
- The Programme provides additional value to the rail industry, improving industry collaboration, representing an independent viewpoint, providing technical subject matter expertise, and improving the UK's rail research status.

- Co-funding is increasing the value for money of the Programme, driving private sector investment in R&D.

Process

- There was no evidence that the RSSB R&D Programme was explicitly designed or formally mapped to the Rail Technical Strategy and DfT strategic priorities. However, there is broad alignment, although this appears to be more of a reactive process rather than by design.
- Project-level governance throughout the project lifecycle is generally effective. Programme-level governance such as prioritisation (strategic alignment) and monitoring is less effective.
- The RSSB R&D Programme has provided key lessons for the rail sector as it is currently structured across early-stage R&D, independence, collaboration, academic strategic partnerships, customer-led research, articulating benefits and understanding the wider rail ecosystem.
- The RSSB R&D Programme has provided key lessons for monitoring and evaluating in the Rail sector including defining the purpose and theory of change of the Programme from the outset, consistent data collection and ongoing reviews.

1. Introduction

1.1 Introduction

In January 2022, PA Consulting were commissioned by the Department for Transport (DfT) to retrospectively evaluate the Rail Safety and Standards Board (RSSB) managed Research and Development (R&D) Programme. The evaluation was completed over the course of 10 weeks, from the 10th January to the 21st March 2022.

The report has been structured in the following way:

- **Introduction** – Background to the RSSB R&D Programme and need for evaluation.
- **Evaluation approach, design, methods, and data sources** – How the evaluation was conducted, methodology and justification for this approach.
- **Findings** –
    - *Overview of Projects* – an overview of projects delivered through the RSSB R&D Programme.
    - *Impact* – analysis and evidence to answer the impact evaluation questions.
    - *Value for Money findings* - analysis and evidence to answer the value for money evaluation questions.
    - *Process findings* - analysis and evidence to answer the process evaluation questions.
- **Conclusions** – The overall conclusions of the evaluation.
- **Annexes** – Supporting evidence and information relevant to the evaluation.

1.2 The Rail Safety & Standards Board Research & Development Programme

The RSSB is a non-profit organisation which supports the rail industry to deliver a better, safer railway. Its R&D Programme has been running since 2001 and aims to promote cross-industry collaboration and to encourage the adoption of research for wider Rail sector benefit.

While there are multiple organisations investing in research and development across the UK rail industry, including independent operating companies and industry bodies, typically this is focused on generating a direct return on investment to their business. Due to the current operational structure of the railway industry, it was recognised that there is a market failure when it comes to investing in research that will benefit the system but not the asset owner directly. The RSSB R&D Programme aims to address this key industry challenge, investing in R&D that cannot be tackled in isolation, and which need a long-term, whole-system approach.

DfT funds the RSSB R&D Programme, providing approximately £10 million per year in recent years to conduct research. Projects funded through the Programme are required to be:

- Cross-industry.
- Supported by cross-industry groups and senior industry representatives.
- Consisting of research and / or development activities.
- Aligned to industry strategies.

Since its inception, the Programme has evolved from having a pure safety focus to a broader remit. It operates alongside and complements other R&D departments such as Network Rail's R&D portfolio, UK Rail Research & Innovation Network (UKRRIN), and other supply chain research.

The overall purpose of the RSSB R&D Programme is:

- To enhance the Safety, Sustainability, and Optimisation of the rail network, addressing key challenges which cannot be tackled in isolation, need a 'system thinking' approach or have long-term time horizons.
- To benefit the entire rail ecosystem, including system interfaces, not individual stakeholders.
- To address a market failure where there is no clear accountability or stakeholders are unincentivised to solve issues which they do not directly benefit from, including long-term issues.

These objectives were identified based on the latest RSSB R&D spending review[1] information and insights from familiarisation interviews with the RSSB R&D Programme and DfT stakeholders. These were later agreed with DfT and RSSB during the development of this evaluation.

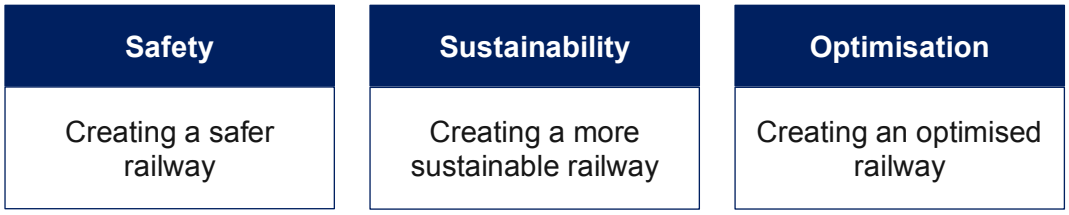


Figure 1: RSSB's R&D Strategic Objectives.

[1]RSSB request for funding, 1 April 2022 – 31 March 2025.

Underpinning this overall purpose, the Programme has three strategic objectives as shown in Figure 1.

Several inputs have influenced the focus of the Programme including the RTS and changes to government policy. There have also been updates to internal processes and delivery frameworks with the aim to improve the effectiveness of how the Programme delivers projects. Figure 2 shows the evolution of the Programme since its inception:

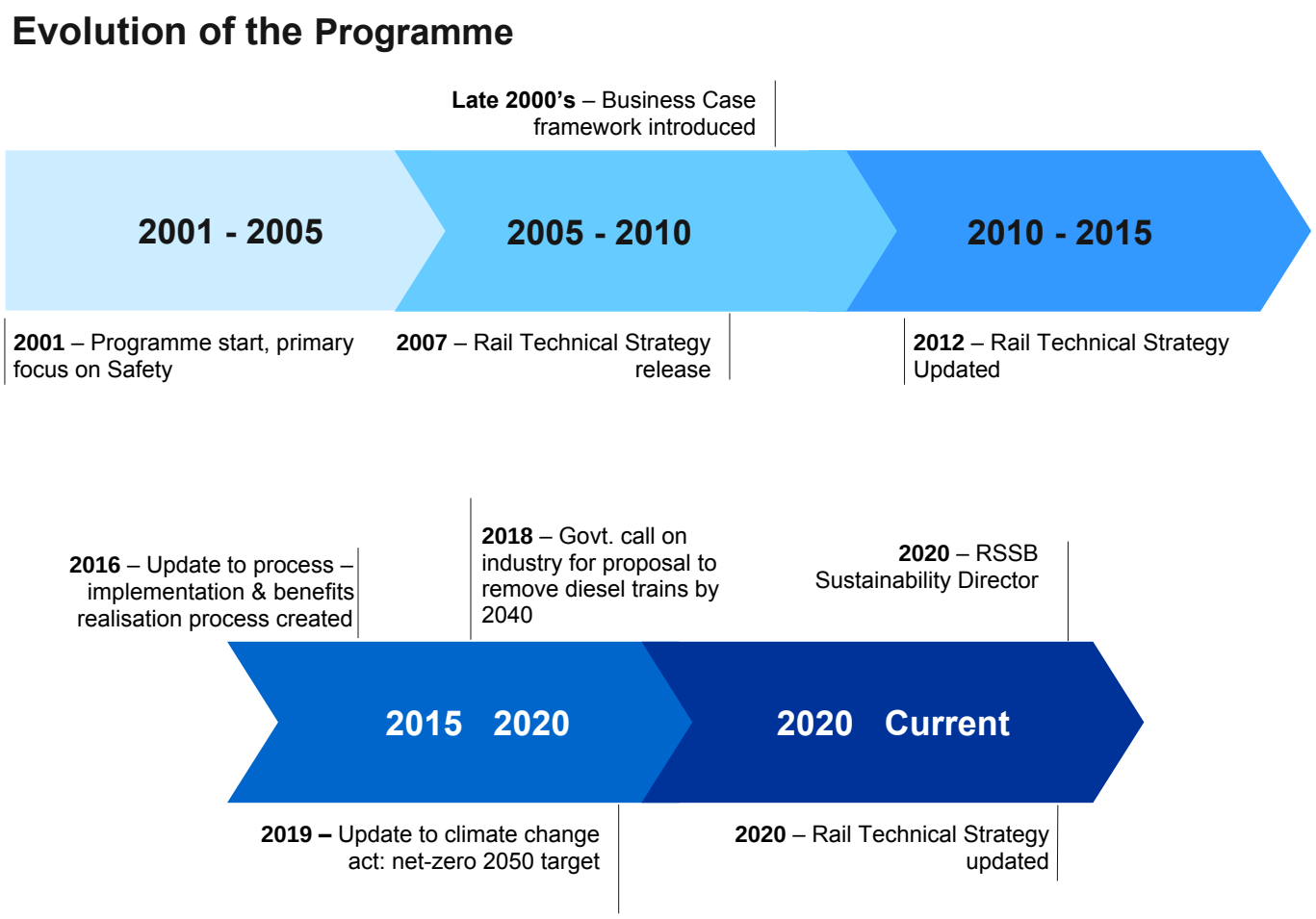


Figure 2: Evolution of the RSSB R&D Programme since its inception.

The Programme has a broad range of beneficiaries due to the nature of the research. The key stakeholder groups and beneficiaries of the Programme which have been identified (not exhaustive) are:

- Department for Transport (DfT).
- Office of Rail and Road (ORR).
- Network Rail (NR).
- Train Operating Companies (TOCs) / Freight Operating Companies (FOCs).
- Rolling Stock Companies (ROSCOs).
- Supply Chain Companies.
- Representative Bodies (Rail Industry Association (RIA), Rail Delivery Group (RDG)).

- UK Rail Research & Innovation Network (UKRRIN).
- System interface / industry working groups.

The context within which the Programme currently exists will change significantly as a result of the Williams-Shapps Plan for Rail[2], which was published in May 2021. This includes a commitment to simplify research, development and innovation funding, with Great British Railways to become the primary public funder.

1.3 Need for Evaluation

At the date of this evaluation there had been no previous independent evaluations of the Programme's impact and value for money. With this exercise, DfT are seeking to understand more about how the Programme operates, outcomes and ultimately the level of impact on industry the Programme has had, while considering the changes which will result from the Williams-Shapps Plan for Rail.

The overall purpose of this evaluation is to provide robust, defensible, and evidence-based answers to questions across three strands:

- **Impact** – What difference has the RSSB R&D Programme made to the rail industry directly or indirectly, and has it achieved its expected outcomes?
- **Value for Money** – Is the RSSB R&D Programme delivering value for money in financial terms, and is it a good use of public funding?
- **Process** – How well does the RSSB R&D Programme's structures and governance facilitate delivery of its aims and objectives, and what lessons can be learned from the Programme on R&D in the Rail sector?

Each of these strands contain several research questions agreed with DfT at the start of the evaluation. These can be found in Section 2.2.

[2] Great British Railways: The William-Shapps Plan for Rail, May 2021, Department for Transport

2. Methodology

This section of the report details the approach, design and methods used to complete this evaluation. The methodology is broken down into the following areas:

2.1 Scope – Objectives and purpose of evaluation, full evaluation questions to be addressed, timescales and delivery of evaluation.

2.2 Research Methods – Overview of design and approach, RSSB R&D Programme Theory of Change, detail of methods and analysis used to answer impact, value for money, and process evaluation questions.

2.3 Data Collection – What data was included in the evaluation and how this data was collected.

2.4 Evaluation Limitations – Key considerations and challenges of the current evaluation.

2.1 Scope

Evaluation Objective

To date, there has been no previous external independent assessment of the RSSB R&D Programme's impact and value for money. Through this evaluation, DfT sought to understand, in detail, how the Programme operates, the outcomes it has delivered and the overall level of direct and indirect impact on industry the Programme has had.

The overall objective of this evaluation is to provide robust, defensible, and evidence-based answers to questions across three strands:

- **Impact** – What difference has the RSSB R&D Programme made to the rail industry directly or indirectly, and has it achieved its expected outcomes?
- **Value for Money –** Is the RSSB R&D Programme delivering value for money in financial terms, and is it a good use of public funding?
- **Process** – How well does the RSSB R&D Programme's structures and governance facilitate delivery of its aims and objectives, and what lessons can be learned from the Programme on R&D in the Rail sector?

Evaluation Questions

Within the three strands of impact, value for money, and process, the evaluation sought to provide robust, evidence-based answers to the research questions, as defined and agreed with DfT at the start of the evaluation:

Impact

a) To what extent has the Programme achieved its expected outcomes?
b) What evidence is there that the outcomes were caused by the Programme and not by other factors (e.g., similar interventions including wider regulations and Rail policies, or positive contextual conditions)?
c) What direct and indirect impacts has the Programme had so far (e.g., economic, commercial, environmental, social)?
d) To what extent have the Programme's outputs led to real world applications of research?
e) To what extent have the Programme's outputs influenced relevant senior decision makers (e.g., Rail Strategy Board, senior civil servants)?

Value for money

f) What is the estimated value-for-money of the Programme so far (including additionality of policy impacts)?
g) What is the estimated benefit-cost ratio of the Programme so far?

Process

h) How well does the Programme align with the Rail Technical Strategy and DfT's strategic priorities?
i) How well does the Programme's governance model facilitate the delivery of its aims and objectives?
j) What lessons have been learnt from the Programme about what works well and less well in supporting R&D in the Rail sector?
k) What lessons can be learnt from the Programme about monitoring and evaluating R&D in the Rail sector?

Delivery of this Evaluation

The evaluation was completed retrospectively, from the 10th of January to the 21st of March 2022, with interviews and workshops conducted remotely. The methodology was shaped with these considerations in mind to ensure robust, evidence-based answers could be provided to the specific research questions. These can be found in Section 3 of this report (pages 37-74).

2.2 Research Methods

Overview of Design and Approach

This evaluation was based on a theory of change (logic map) which can be thought of as a set of underlying hypotheses, to be tested through the research, drawing on the available data to determine the extent to which there is evidence to support the intervention logic.

The evaluation used a retrospective, mixed-methods design, underpinned by the overall theory of change (logic map). Research & analysis methods were tailored across impact, value for money, and process evaluation areas, with a mix of qualitative and quantitative methods to ensure it was fit for purpose given the context, availability of data and resources. Analysis included group review and case study review to provide breadth and depth of assessment considering the evaluation timescales. Figure 3 provides an overview of the overall design and methods used. These are explained in more detail in the subsequent sections.

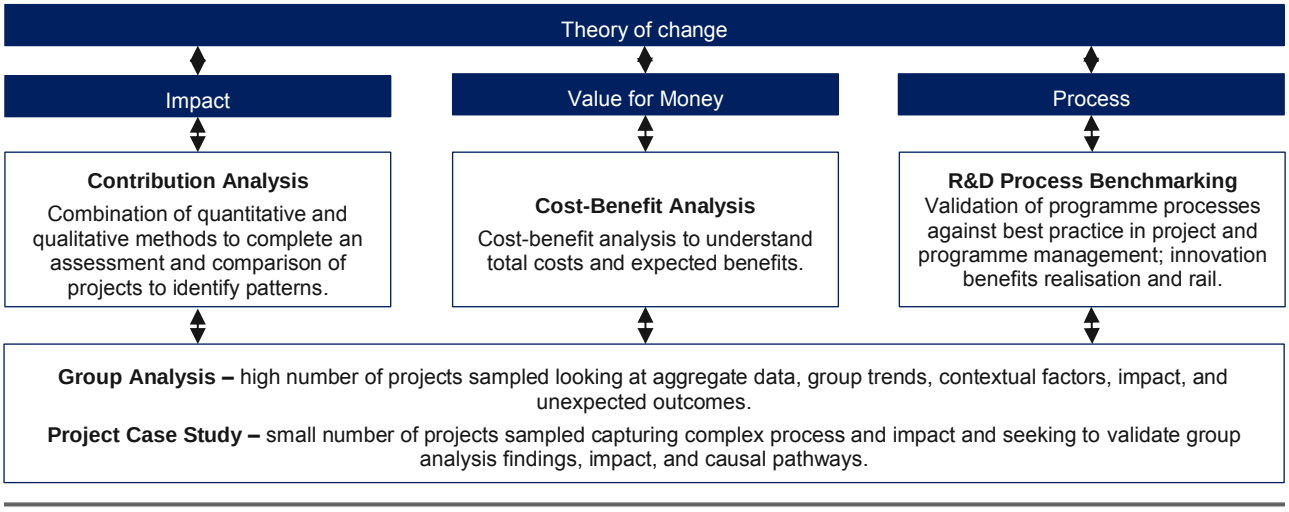


Figure 3: Overview of design and methods used to conduct the programme evaluation

This approach was selected due to the 'complex setting' that the RSSB R&D Programme exists in and that the intervention is trying to change the behaviour of groups of individuals and involves 'emergent outcomes' (Forss et al (2011), p. 57). RSSB is uniquely placed in a complex network of Rail stakeholders and looks to inform senior decision making on the adoption or scaling up of new technologies, standards, and policies with a lack of a clear counterfactual.

The theory of change approach was appropriate to use, as it would not have been possible to create a baseline or control group for the RSSB R&D Programme. This approach allows a theory of change to be developed retrospectively, which was required in the case of the RSSB R&D Programme.

A literature review of evaluation approaches and research quality can be found in Annex A.

RSSB R&D Programme - Theory of change

The theory of change is a model used to describe the processes by which a Programme expects or assumes to have caused change. This can be thought of as a set of underlying hypotheses, which can be tested, drawing on available data, to determine the extent to which there is evidence to support an assertion that the intervention caused change.

In this evaluation, a theory of change was used to:

- Create a systematic and visual way of presenting the 'story about how the RSSB R&D Programme works'.
- Identify what features of the Programme contributed to outcomes.
- Identify what progress has been made along an anticipated path towards the final impacts.
- Create a shared understanding and support communication.
- Simplify complexity where possible.

The RSSB R&D Programme theory of change is presented in Figure 4. The theory of change was developed at the start of the evaluation in collaboration with DfT and RSSB synthesising evidence from documentation, familiarisation interviews, and workshops. Establishing the RSSB R&D theory of change allowed a set of hypotheses to be created which could be tested through the evaluation.

The RSSB R&D Programme theory of change was established based on RSSB outputs, outcomes, and impact and aims to represent the relationship between the research Programme output and the rail industry outcomes, along with consideration of enablers, barriers, and wider context:

- Inputs are a research theme, category, or challenge with a common overall objective and/or common group of stakeholders.
- Outputs are what projects produce and have been aligned to TRL where possible.
- Outcomes are changes that have occurred due to outputs. These will be short-term and long-term outcomes and both direct and indirect.
- Impacts are long-term benefits that align to the Programme’s aims and strategic objectives.

Full details of theory of change development and assumptions can be found in Annex B.

Levels of Analysis

In evaluating the Programme impact, value for money and process, two levels of data collection and analysis were undertaken to provide a balance of breadth and depth of analysis within the evaluation time limitations:

- **Group Analysis**– 304 projects meeting the criteria described in Section 2.4 (e.g., completed projects starting after January 2016), were grouped according to main research areas (Adhere, Clear, Decarb, Freight, Perform, Staff Health &

Wellbeing, Engineering Interface Optimisation, Safety Insights & Analysis Tools, and Other). Analysis was conducted at group level to assess trends, contextual factors, impact, unexpected outcomes and testing theory of change hypothesis. Findings were used to evaluate the impact, value for money, and process across the groups. This provided breadth to the analysis.

- **Project Case Study**– A targeted selection of (13) projects were reviewed in depth, including 5 projects starting prior to January 2016, with the remaining 8 post January 2016. Qualitative and quantitative analysis was conducted to assess causal pathways, validate detailed benefits, and cost data, and review processes. Findings validate and provide examples of the group analysis findings, for impact, value for money, and process. This provided additional depth to the analysis.

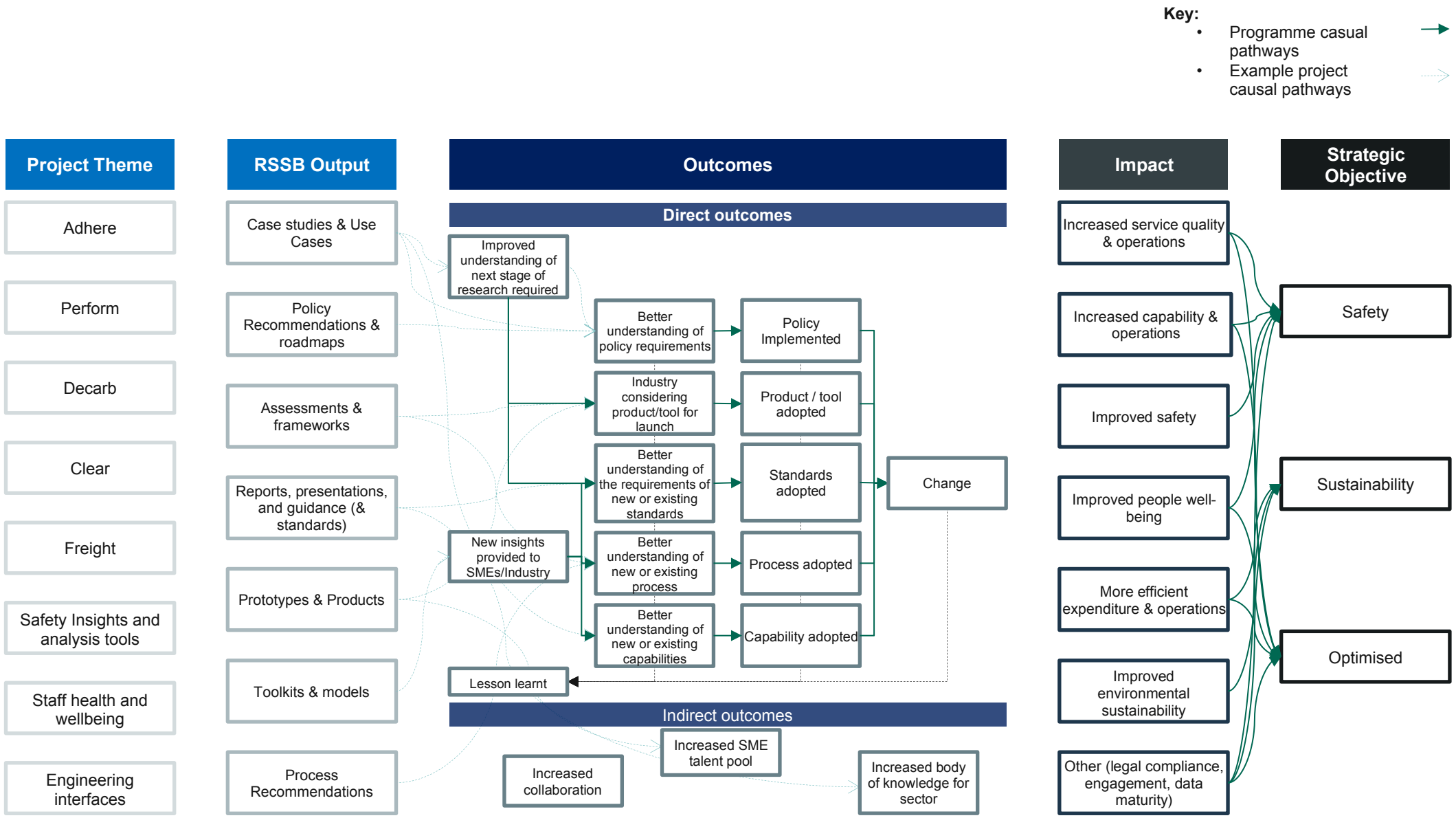


Figure 4: Baseline RSSB R&D Programme Theory of Change. This was developed at start of evaluation in collaboration with DfT and RSSB.

Impact – Contribution Analysis Approach

To address the impact the RSSB R&D Programme had on its objectives of safety, sustainability, and optimisation in the rail network, a contribution analysis was used. This approach aims to describe and then test the contribution an initiative has had to a wider change, using a transparent, systematic approach to testing, structured around the theory of change – it "sets out to verify the theory of change behind a programme and, at the same time, takes into consideration other influencing factors" (Mayne, J., (2008)).

Six steps are taken as part of contribution analysis to produce a credible contribution story. These are laid out below, describing how the evaluation identified and tested the RSSB R&D Programme's contribution to the outcomes derived from theory of change and impact within the rail industry (Further detail on methods can be found in Table 1):

1. ***Set out the 'attribution problem' to be addressed*** – Impact evaluation questions defined and agreed with DfT at the start of the evaluation.
2. ***Develop of a 'theory of change'*** – RSSB R&D Programme theory of change developed collaboratively through workshops with DfT & RSSB (as detailed in previous Section). For each impact evaluation question, a series of hypotheses were produced, based on the overall theory of change established for the RSSB R&D Programme.
3. ***Gather existing evidence on theory of change –*** Group analysis included a review of project data, and interviews with key programme stakeholders / beneficiaries was conducted.
4. ***Assemble and assess contribution narrative –*** Thematic analysis was used to build evidence case to support, or change hypotheses developed and produce overall contribution narrative.
5. ***Seek out additional evidence*** – Project case study analysis involved conducting a small number of deep dive project reviews, providing examples of causal pathways, test assumptions, and support the evidence collected group analysis level
6. ***Revise and strengthen contribution narrative –*** Evidence from group analysis and case study reviews were synthesised to build an evidence base to support or challenge each of the hypotheses produced for each evaluation question. This produced an overall contribution narrative of the RSSB R&D Programme against its aims and objectives and overall impact of the Programme.

Research and Analysis Methods

	Research Methods	Analysis Methods
Group Analysis	• Review of project data and publicly available data. • Semi structured interviews with key stakeholders/ beneficiaries for each research group.	• Qualitative - Thematic analysis of research group activities and outputs. • Qualitative - Thematic analysis & coding of interview transcripts against evaluation question hypotheses (perceived outcomes impacts, contribution).

Project Case Study	• Review of project documentation e.g., 'case for research', 'Post Project Reviews', implementation data. • Semi structured interviews with key project stakeholder / beneficiary.	• Qualitative - Identifying presence of logic chain components at project level (short term and long-term outcomes, direct & indirect impacts).

Table 1: Research and analysis methods used to evaluate impact.

Value for Money – Cost Benefit Analysis

Value for money assessment is used to compare the cost of an investment and its inspected impact or value. This is one of the key considerations of any decision involving the use of public funds across government. To evaluate the value for money for the RSSB R&D Programme a cost benefit analysis approach was taken.

A cost benefit analysis approach looks to quantify the overall costs and overall benefits of an initiative and use this to calculate a benefit-cost ratio (BCR). The BCR provides a representation of the relative relationship between benefits and costs, indicating how much benefit is expected for each unit of cost.

The BCR is defined as:

$$\text{BCR} = \frac{\text{Present Value of Benefits}}{\text{Present Value of Costs}}$$

This evaluation estimated the overall RSSB R&D Programme cost, based on aggregated individual project costs, stored across multiple RSSB R&D Programme databases spanning the lifetime of the Programme.

The evaluation also aimed to estimate the overall RSSB potential and actual benefits, through aggregating project benefits data. However, based on the data available it wasn't possible in practice to quantify the overall benefits, as benefits had been monitored differently across projects, with many projects not having benefits data fed into the central data bases.

Without being able to quantify the overall Programme benefits, the evaluation was not able in practice to calculate an overall benefit-cost ratio for the Programme, though BCRs were calculated for the projects included in case study review.

The evaluation sought to address this limitation in quantifying overall Programme value for money, through qualitative analysis of stakeholder interviews, conducting thematic analysis of broader benefits stakeholders recognised across the Programme.

Further detail on method can be found in Table 2.

Research and Analysis Methods

	Research Methods	Analysis Methods
Group Analysis	• Review of RSSB project database; including cost data, benefits tracking, implementation tracking. • Semi structured interviews with key stakeholders/ beneficiaries for each research group.	• Quantitative - Estimation of overall Programme costs, benefits, and BCR created. • Qualitative – Understanding any additional benefits and value from the Programme.
Project Case Study	• Review of project documentation - 'case for research', 'post project reviews' implementation data.	• Quantitative - Test the assumptions and calculations of benefits for specific projects.

Table 2: Research and analysis methods used to evaluate value for money.

Process – R&D Programme Bench Marking

To evaluate the R&D Programme's processes and address the evaluation questions, an R&D process benchmarking approach was used. The model shown below in Figure 5 is based on PA Consulting's understanding of best practice in R&D project and programme management, innovation, and benefits management. Further detail on method can be found in Table 3 below.

Figure 5: Process bench marking approach.

Research and Analysis Methods

	Research Methods	Analysis Methods
Group Analysis	• Review of project data and publicly available data. • Semi structured interviews with key stakeholders/ beneficiaries for each research group.	• Qualitative – Identifying strengths and weaknesses against the benchmarking model.

Project Case Study	• Review of project documentation e.g., 'case for research', 'Post Project Reviews', implementation data. • Semi structured interviews with key project stakeholder / beneficiary.	• Qualitative – Identifying strengths and weaknesses against the benchmarking model.

Table 3: Research and analysis methods used to evaluate process.

2.3 Data Collection

RSSB R&D Project Selection

1802 projects were initially shared from the RSSB R&D Programme's project database, spanning the lifetime of the Programme. Out of these 113 were initially excluded as they were management activities or fully funded through other sources and therefore out of scope for this evaluation.

From the remaining 1689 projects, a multi-stage sampling approach was used to select projects for group analysis and the project case study, detailed in the following sections.

The multi-stage approach used stratified sampling, with a preselection criterion applied – this provided the sample for group analysis. The next stage was purposive sampling which selected projects against a set of defined project characteristics – this provided the sample for case study analysis.

A breakdown of the 1689 projects, and full list of projects included in group analysis and project case study can be found in Annex D.

Group Analysis Sample - Pre-Selection & Research Grouping

A stratified sampling approach was used to select of projects for group analysis, with a preselection criterion applied. 304 projects were selected for inclusion based on a defined selection criterion:

PRE-SELECTION CRITERIA:	JUSTIFICATION:
Start date from 1st Jan 2016 onwards	For projects pre-2016, there is a known lack of data including project documentation and stakeholders available for interview (the majority likely to have moved roles).
Project status of 'completed' or 'closed'	As this is a retrospective evaluation focusing on impact and value for money, inflight projects will not provide the evidence needed to answer the evaluation questions.
Must not relate to management activity	The project list includes management activities which are not relevant to the evaluation.
Projects funded by other sources	This evaluation is focused on the DfT grant. Therefore, must include DfT funding (this includes co-funding).

Table 4: Preselection criteria for group analysis sample.

The 304 projects meeting the pre-selection criterion were categorised into nine 'research groups' where projects addressed a common theme, industry challenge or had a common stakeholder group. These were: Adhere, Clear, Decarb, Freight, Perform, Staff Health &

Wellbeing, Engineering Interface Optimisation, Safety Insights & Analysis Tools, and Other. Table 5 below shows the definition of the groups and number of projects from within each group.

RESEARCH GROUP	NUMBER OF PROJECTS	PRIMARY PROJECT AIMS OR INDUSTRY CHALLENGE
Adhere	31	Projects primarily aimed at achieving adhesion conditions that are unaffected by the weather & climate - through modelling of adhesion & braking, rail cleaning & re-contamination, driver behaviours, changes to train design, and forecasting of adhesion.
Clear	6	Projects primarily aimed at improvement of air quality - through development of air quality targets for rail industry, and assessment and monitoring of rail emissions.
Decarb	15	Projects primarily aimed at reduction of carbon levels in the rail industry. This is typically through development of industry action plans, research on designing out carbon in trains, and research into supply chains.
Freight	8	Projects primarily aimed at supporting freight growth aspirations and reducing safety risk relating to freight traffic. This is being developed through improved evidence and modelling feeding into loads and speed limits, freight pathing, freight accessibility to the rail network, and freight derailment.
Perform	41	Projects primarily aimed at achieving performance improvements and to run more trains on time. This is typically through operational rules & standards, effective management of passenger & staff behaviours, disruption and using data to improve decision making.
Staff Health & Wellbeing	14	Projects primarily aimed at improvement of staff health & wellbeing. This is typically through occupational health & cultures, mental wellbeing, as well as reducing risk of fatigue through guidance for management and drivers.
Engineering Interfaces Optimisation	70	Projects primarily aimed at optimising engineering interfaces across industry. This is typically through data analysis, modelling, and development of innovative solutions
Safety Insights & Analysis Tools	84	Projects primarily aimed at reducing risk and improving safety. This is typically through data modelling, analysis, developing tools, and frameworks.
'Other'	35	Projects which did not comfortably align to one of the above research groupings.
Total Projects	**304**	

Table 5: Evaluation research groups – number of projects per group and definition. (See Annex D for full list of group analysis sample projects).

Project Case Study Sample

For the project case study analysis, purposive sampling was used to select 13 projects for in depth review. A purposive approach selects projects against a set of defined project characteristics. For this evaluation three main characteristics were used to select projects for case study review:

- Date Project Started – Whether projects start pre or post 1st January 2016
- RSSB Reported Significance – Some projects were flagged by RSSB R&D Programme leads as being particularly 'significant'. This was reported in RSSB project databases.
- RSSB Reported Implementation Status – Some projects had implementation status reported in RSSB project databases. For those with implementation status reported – the status options were 'Further R&D' needed, 'Planning', 'Initial', 'Advanced', or 'Full' Implementation

For projects starting prior to the 1st of January 2016; a targeted sample of 5 projects were selected which had long term implementation or benefits tracking, and that which were considered high value by RSSB.

Project type (pre-2016)	Number of projects in group	Number of case studies Selected
Total	464	5

Table 6: Selection of case study sample for pre-2016 projects.

For projects starting after 1st January 2016, 8 projects randomly selected; with 4 that were 'not significant', 2 that were 'significant' but not 'fully implemented', and 2 that were both 'significant' and 'fully implemented'.

Project type (2016 onwards)	Number of projects in group	Number of case studies selected
Not significant	218	4
Significant, not fully implemented	75	2
Significant, fully implemented	11	2
Total	**304**	**8**

Table 7: Selection of case study sample for projects from the beginning of 2016 onwards, against criteria of significance and implementation.

When selecting projects to review at case study a purposive sample approach was chosen for the following reasons:

- A limited number of case studies could be completed within the time and resource available to this evaluation. Applying parameters to case study selection ensures projects with different characteristics are reviewed, which might not be achieved through fully randomised selection. This enables valuable insights to be gained from a small number of studies, to supplement the broader group analysis.
- For projects pre-216 data is limited, processes have since changed, and contacts may not be available. As pre-2016 projects represent around 60% of the completed projects in the Programme the evaluation couldn't exclude them. Non-randomly selecting key high-value projects for the pre-2016 sample, which have long term benefits tracking, enabled the evaluation to focus where data is available, and where analysis will provide insight on broader impact delivered.
- For projects post 2016 an equal number of 'significant' and 'non-significant' were selected. this allowed to evaluate the full breadth of projects including project that

may be perceived as “low impact” but may develop foundations for further or rule out research areas.

- Ensuring the case study sample included 2 projects which RSSB recognised as fully implemented, enabled the evaluation to provide insight into the impact and value of projects where benefits should be expected to have been delivered.
- Within the post-2016 case study selection parameters, projects were randomly selected, to provide a level research rigour to the assessment, whilst ensuring value can be gained from the projects selected.

Evaluation Data sources

The evaluation collated findings from the following data sources:

- RSSB project data – total of 1802 projects across three internal data bases. All historic, and current projects, information on status, dates, topic, cost information, key sponsors, key stakeholders.
- RSSB implementation database – 324 projects, logging of projects deemed significant, monitoring of project implementation where deemed significant.
- RSSB project documentation – case for research, business cases, post project reviews, implementation reports, project reports/outputs, any other relevant project information.
- 10 familiarisation interviews with RSSB & DfT programme stakeholders.
- 20 semi-structured interviews with leaders and representatives of relevant industry working groups for group analysis (at least 2 per research group).
- 13 semi-structured interviews with specific project beneficiaries for project case study analysis.
- Publicly available data – standards, policy documents and strategies.

An overview of the stakeholders who were engaged with for interviews can be found in Annex C.

2.4 Methodological limitations

We acknowledge several limitations in the design and method of this evaluation. Below are some of the key limitations which should be considered when reviewing the findings and conclusions.

- The theory of change was produced retrospectively for the purposes of the evaluation, rather than as part of the Programme’s set-up and structuring. This means it does not reflect elements of the Programme which have changed since its initiation.
- The RSSB R&D Programme and rail industry context is complex – the theory of change attempts to simplify this by taking a linear perspective of causal pathways.

- Contribution analysis is based on assumptions and aims to build evidence for or against the hypothesis to produce an overall narrative. It does not enable the evaluation to prove direct causal links between initiatives and outcomes.

- The evaluation has been conducted within a limited timeframe meaning not all projects within the Programme could be reviewed, although the evaluation has aimed to address this through group and case study analysis.

- Purposive sampling has been used to select case studies which may reduce the ability to generalise the findings across the whole Programme. With additional time, a higher number of case studies could have been reviewed, with random sampling employed to ensure representativeness.

- Whilst 20 stakeholder interviews are enough to provide a comprehensive data set for review, due to the complex nature of the rail industry, additional interviews or focus groups would have increased the reliability of findings.

3. Findings

This section describes the findings drawing on overall Programme data, group analysis and project case study review to answer the evaluation questions. The findings section is broken down into:

3.1 Overview of Projects – An overview of the projects delivered through the RSSB R&D Programme, including an overview of the projects reviewed within the group analysis.

3.2 Impact Findings – An overview of the Programme impact, addressing the impact evaluation questions by presenting evidence for or against the theory of change. An overall summary of the contribution narrative is provided at the end of this section.

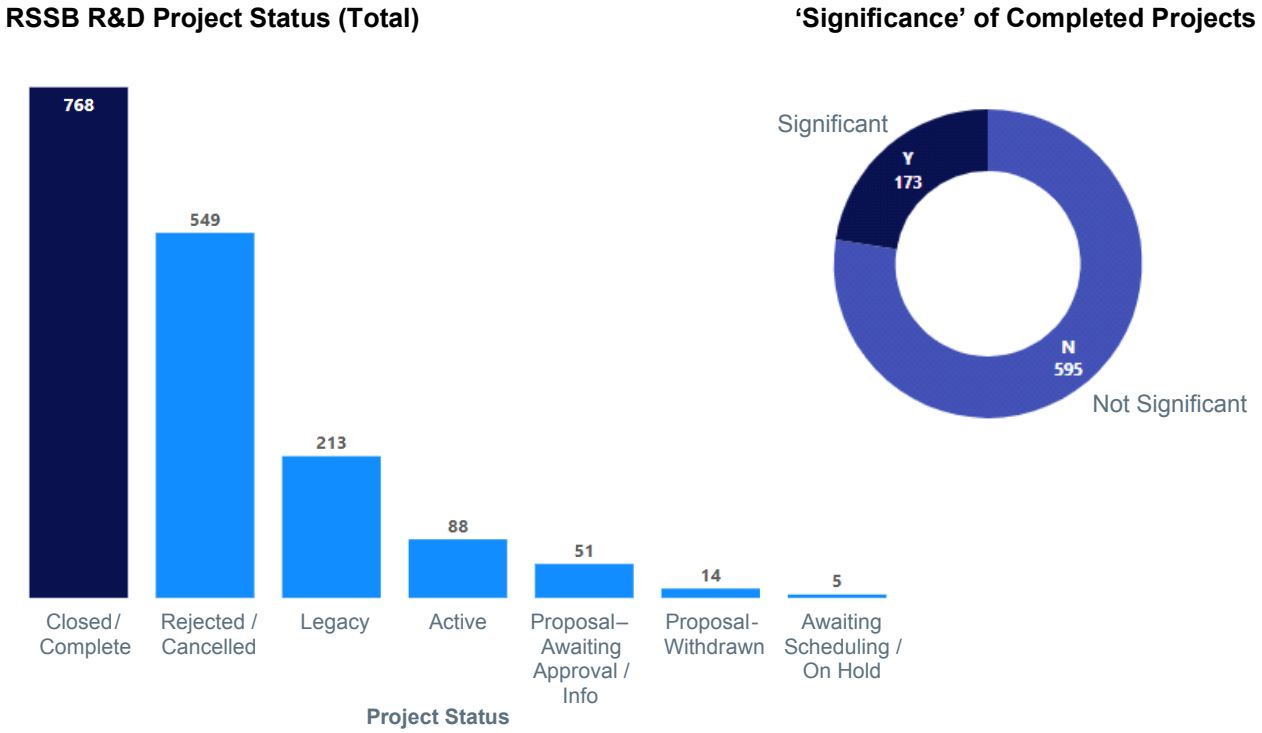
3.3 VfM Findings – An overview of the value for money for the Programme, breaking down the estimated cost / benefit ratio of the Programme and overall value of Programme. Findings are estimations, based on data available, and where assumptions have been made, these have been clarified.

3.4 Process Findings – This section provides a breakdown of the RSSB R&D Programme against the R&D benchmarking model key stages.

3.1 Overview of RSSB R&D Projects

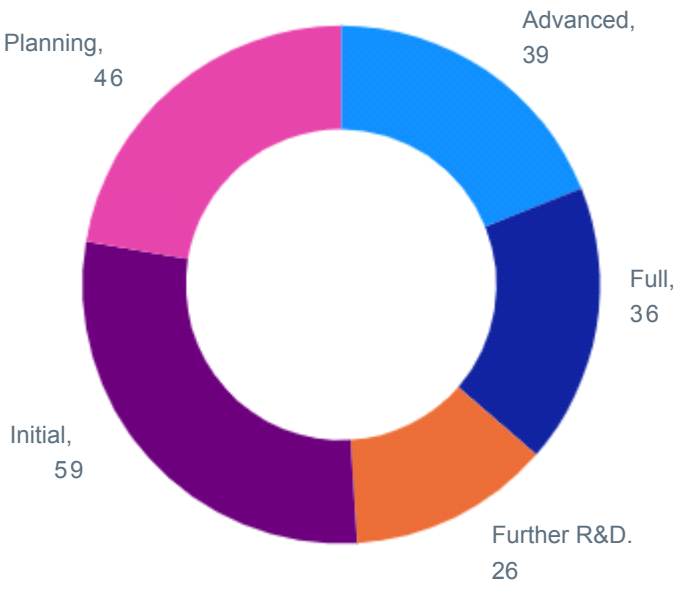
All RSSB R&D Projects

Across the RSSB R&D Programme's lifetime, a total of **768 projects were completed**, with **549** projects **rejected**. Out of projects completed, **173 (around a quarter)** were reported by RSSB to be 'significant' as shown in Graph 1; these were projects deemed by RSSB R&D Programme leads to be the most impactful. This is in line with expectations of an R&D Programme of this nature, that only a proportion of projects will deliver high impact.



Graph 1: Total of R&D projects by completion status, and by RSSB reported 'significance' of completed projects.

Completed projects varied in level of implementation. The RSSB R&D Programme started monitoring and reporting implementation of select projects, from 2013. A review of implementation tracking data found 75 projects were reported to have been fully or in advanced stages of implementation, 105 were in initial stages or in planning, and 26 required further research. This is shown in Graph 2.



Graph 2: Implementation status of projects closed from 2013 onwards.

Group Analysis

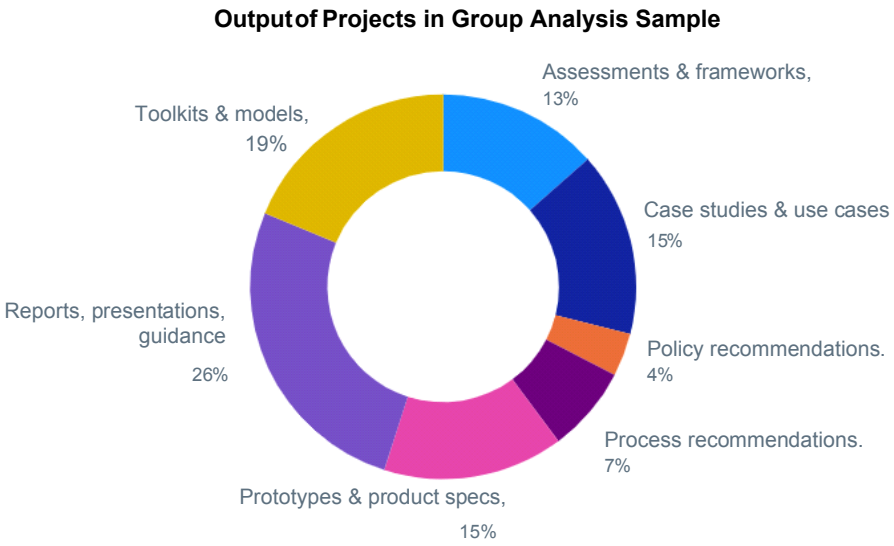
For those 304 projects included in the group analysis (i.e., commencing from 2016, & status closed) – just over half fell into either the 'Safety Insights & Tools' or 'Engineering Interfaces Optimisation' research groups and nearly a quarter fell into either 'Perform' or 'Adhere' research groups. The number of projects in each research group is shown in Graph 3 below.

Graph 3: Number of projects within each research group, for group analysis sample.

The breakdown of projects across research groups is broadly reflective of the proportion of funding allocated to these research groups. Out of £25.71 million spent across these 304 projects – 'Safety Insights & Tools' made up £5.27 million (20%), 'Engineering Interfaces Optimisation' made up £5.46 million (21%), 'Perform' made up £4.71 million. (18%), and 'Adhere' made up £3.29 million (13%). Further breakdown on the Programme cost can be found in Section 3.3

As part of the group analysis, project output was reviewed to build understanding of how projects may be delivering short and long-term outcomes and delivering impact across different causal pathways predicted in the RSSB theory of change. Projects outputs were categorised based on key information captured in the main RSSB R&D databases, such as project descriptions, abstracts, and implementation data. Definitions of the output types can be found in Annex B.

The most common output type produced in the group analysis sample was 'knowledge reports, guidance, or standards' (26%), followed by 'Tool kits & models' (19%), with 'case studies & use cases' and 'prototypes & product specs' separately making up 15% each.



Graph 4: Group analysis sample – output types.

Further breakdown of the group analysis sample groups' outputs and outcomes can be found in Annex E.

3.2 Impact Findings

Key Findings for Impact

- The Programme is delivering impact and driving positive change against its overall purpose
- Most outputs that are produced are high-quality and cause subsequent outcomes.
- The programme has encouraged, facilitated, and supported industry collaboration.
- The strategic direction of the Programme is sometimes unclear and partially reactive.
- Not all outputs are implemented by industry and sometimes engagement can be low, with missed opportunities to communicate the value of R&D effectively for implementation.

To assess the impact of the Programme, hypotheses were produced to address each evaluation question, based on the theory of change for the RSSB R&D Programme. An assessment was made of the extent to which the evidence (group analysis and interviews, and case studies) supports these hypotheses. The following structure has been used:

Theory of Change Hypothesis: *hypothesis derived from the theory of change.*

- ✓ Evidence broadly supports above hypothesis
- ❖ Evidence partially supports above hypothesis or is not always clear
- x Evidence broadly challenges above hypothesis

Summary of findings: *overall summary from the evidence.*

a) To what extent has the Programme achieved its expected outcomes?

Theory of Change Hypothesis: The RSSB R&D Programme addresses a market failure, where there is no clear accountability or stakeholders are unincentivised to solve issues which they do not directly benefit from, including long-term issues.

Summary of findings:
There was clear evidence that the RSSB R&D Programme addresses a market failure, where there is no clear accountability or stakeholders are unincentivised to solve issues which they do not directly benefit from. Whilst the Programme has adapted its focus to meet industry challenges, there is a general lack of clarity on the overall strategic direction, and many stakeholders do not understand how its focus and the portfolio of projects aligns to industry's key challenges. Regarding the types of research, the Programme has evidently undertaken work across various stages of R&D, yet there was confusion across stakeholders with some expecting to see early stage, low TRL R&D while others expect higher TRL research and ready to implement solutions.

- ✓ **Evidence supporting hypothesis:** The Programme addresses cross-industry challenges (described by 15/20 of interviewees); and addresses challenges which would or could not be picked up elsewhere by themselves or independent organisations (identified by 11/20 of interviewees).

  "Initiatives across the supply chain, … across the Rail Industry Association, the freight groups, operators"
  "Addresses things that industry probably wouldn't be able to solve that well individually"
  "That breadth of looking both within rail and looking across industry"
  "Not economically viable for [train operators] to pick up"
  "It's not in our sphere of influence, or it is research and development that is actually better undertaken by a third party for the overall benefit of the industry"
  "Challenges which have multiple system interfaces such as track and vehicle"

- ✓ **Evidence supporting hypothesis:** All case studies (13/13) reviewed demonstrated that they addressed a market failure, had multiple beneficiaries or were cross-industry challenges. Several covered a system interface such as track/vehicle. Others addressed a cross-industry challenge such as sustainability metric or improving safety.

- ✓ **Evidence supporting hypothesis:** The Programme has changed its focus to be in line with broad needs and future needs of the industry. Historically it focused on safety (in line with initial Programme remit) but more recently there has been increased focus on sustainability, in line with broader cultural and industry shifts. Interviewees referred to sustainability as following a 'similar trajectory' to safety.

  "Sustainability I think is following not a dissimilar trajectory to safety. I think it's a very good parallel to use about how the focus is changing".
  "Obviously, there's a lot of other stuff on sustainability now, which I think is appropriate - it's an area that has been particularly weak historically"

- ❖ **Evidence partially supporting hypothesis, or unclear:** Interviewees were often not clear on the Programme's overall strategic direction and the alignment of research focus & priorities to industry challenges. Whilst many interviewees (15/20) mentioned routes for industry groups to contribute to research, some (7/20) raised concerns or confusion around its priorities and alignment to industry, citing missed industry opportunities, lack of clarity on current & future focus of Programme, and appropriate involvement with industry. The DECARB Programme was an example where it was aligned well with industry and prioritised effectively to meet industry needs.

  "I struggle to know whether it's tailored sufficiently in the way they're looking it. I'm not quite sure if it's spread so thinly, whether it's delivering stuff appropriately that we can take on. I still feel like we struggle on working health, transparent management, and depot management. There is still weakness in risk management".
  "I do sometimes struggle with the scope of RSSB work … bearing in mind safety and standards was where it started and that was the reason it got set up in the first place."
  "You could say a lot of the work does fit into the remit in a broad way. So, you know, they're doing things in the performance management world now, but it feels like it is probably work that I don't think they should be doing and looking at how control managers work is quite niche."
  "Sometimes they're not clear on the real issue. Risks & opportunities in the Programme and not always clear. It's lost a bit of direction, & alignment to industry"

"I think it does need to be more directed and steered more by industry and how we try and commit the right level of resource and capability to it"
"Missed opportunities where they could align a bit more with what industry might need to build a business case for"
"The Programme goes off and does its own thing as well, so they don't exclusively work for their customers"
"Sometimes feels like it's a drip feed. I don't feel particularly aware of what is coming up in the future...in the next sort of year, three years, five years"

- **Evidence partially supporting hypothesis, or unclear:** The RSSB R&D Programme delivers R&D across a range of TRLs but typically at the lower stages. Evidence and examples demonstrated this and RSSB have an entry criterion to prioritise early-stage R&D. That said, it is not clear to interviewees the type of research the Programme aims to address, or what it is best placed to deliver. Only 7/20 of interviewees identified the Programme was providing 'low TRL' or 'blue sky thinking' relatively far from market. Some interviewees (4/20) expressed some frustrations with the Programme in delivery of solutions.

"RSSB is in a prime position to provide the direction to industry for early-stage research"
"To conduct blue sky thinking, which is relatively far from market - low TRL"
"Works best with low end TRL"
"Program should be delivering research that's immediately useful and solves the industries problems now… though I think there is longer term value. Often it's easy to overlook that"
"Some of the more science research that goes into this Programme can be underplayed because it doesn't allow a managing director somewhere to take a decision tomorrow"
"There's also frustration where RSSB have looked at very blue sky thinking, and it wasn't about is anyone adopting this? and I think it's quite frustrating when you're in industry"
"Sometime research has compromised in order to deliver something useful for industry".
"As an industry player, you just want the answer and want RSSB just to give the answer. But actually, as the duty holder, I should be coming up with the answer myself. RSSB can often providing the missing bits of the jigsaw puzzle or provide the overall picture – sometimes need to manage expectations with industry about what it is RSSB is providing"
"Less field trails but maybe they aren't the right people to do it"

Theory of Change Hypothesis: The RSSB R&D Programme has provided new insights to SMEs/Industry and improved the understanding of the next stages of research required.

Summary of findings: There was clear evidence that the research is of high quality and provided new insights to industry both in the UK and globally. Outputs were shared at a minimum with sponsoring industry working groups, however the effectiveness of wider industry communication insights was mixed - with some stakeholders saying content is 'lost' and opportunities can be missed, where outputs are sometimes not tailored for the end customer.

- ✓ **Evidence supporting hypothesis:** There was evidence across evaluation research groups that programme outputs were initially shared through industry; the majority of stakeholders (18/20) referenced sharing via industry groups, presentations, or sharing through RSSB website, research catalogue, or Spark data base. All case studies (13/13)

reviewed in this evaluation also demonstrated that outputs were shared back, at a minimum, with the sponsoring working group.

- ✓ **Evidence supporting hypothesis:** The outputs of the research programme were generally perceived to be good quality research, with the majority of stakeholders (17/20) positive about research quality. Across research groups, stakeholders identified that the Programme had provided new insights to industry or improved the understanding of the next stages of research (identified by 15/20 stakeholders).

  "RSSB outputs are by far the most high-quality research outputs across industry"
  "They produce brilliant technical reports"
  "My views from a very broad point of view is that the research is always helpful. It's insightful, it's informative."
  "The work that I have seen coming out of RSSB has, to my mind been thorough and it has been focused."

- ✓ **Evidence supporting hypothesis:** The research has not only provided insight to the GB rail industry but also globally. Academic stakeholders (3) referenced international colleagues using RSSB research. They also referenced a pool of SME experts due to the research programme providing consistency and certainty.

  "I know colleagues in Europe who use it and find themselves on the RSSB database"
  "It's increased the academic status of the UK and encouraged more people into research, by providing funding leading to improved SME knowledge and expertise"

- ✓ **Evidence supporting hypothesis:** In all relevant case studies, it was demonstrated that the research had improved the next stages of required R&D. For example, in case study 3, two follow-on research projects were identified and subsequently delivered by RSSB. In case study 5, the need for further product development was identified and evidence of completed operational trials provided.

- ❖ **Evidence partially supporting hypothesis, or unclear:** There was a mixture of views from stakeholders about the effectiveness of sharing insights, making outputs digestible to industry, and ensuring they are addressing the industry challenge. Where end users, 'customers' and working groups were involved from the outset, research was more effective.

  "The projects are well scoped and clear remit, and they're endorsed by the relevant Standards or technical committees"
  "Always sought to answer the problem statement in the first place"
  "I think they're really well formatted …. produce really engaging looking documents that give you the sort of headline you need to know."
  "A very simple short document, but actually written in such a way that it engages the target audience. It makes it really easy to use"
  "it's given in headlines of what you need to know - why you need to know it and some top tips for delivering it."
  "We sometimes struggle to try and interpret what they do in a practical sense and understand how we make it work for our business, limited in finding the space to even review some of the documentation that comes through from the research."
  "Whilst the research is informative, it's not always contextualised, and it's not always real world helpful. Where I think the research often misses a trick is understanding the operating environment and constraints held by those that will benefit from the research."
  "Up to about five years ago programme paid little attention to a business case and focused on solving the technical challenge; but actually those projects haven't been taken

up and haven't had impact in industry as much. More recently where more effort has been put into identifying the potential end user and business case - the end material is able to better help them make a case to their board or investors"

x **Evidence challenging hypothesis:** There were significant challenges highlighted in the wider dissemination of findings outside of immediate industry groups (cited by 11/20 stakeholders) and missing opportunities. These mainly included:

- Attendance at industry events
- Visibility & promotion of benefits within industry
- Knowledge being 'lost' within the research data base or internal systems
- Content not being tailored to end customer and not 'user friendly'

"Biggest problem is dissemination with organisations across the industry"
"I don't think they're all aware of the sort of literature and support that's there for them and the research. I mean, some of them will probably never attend an RSSB meeting or never look at the website"
"Some outputs just sit on sit in their repository on their website on Spark and no one notices it and doesn't go anywhere."
"I think there's a lot of good stuff gets done, but I think it's under promoted - it's not publicised enough"

Theory of Change Hypothesis: The RSSB R&D Programme creates a better understanding of policies, products/tools, standards, processes, and capabilities which were subsequently adopted.

Summary of findings:
There was evidence that the Programme created better understanding in industry providing a knowledge base and developing toolkits and frameworks (lower TRL products). Whilst there was evidence of industry making use of these early-stage products, and of industry standards being updated following RSSB R&D recommendations; there was less evidence of industry implementation of later stage products (higher TRL) and an overall challenge from industry where significant change or investment was required.

✓ **Evidence supporting hypothesis:** Through its innovation, the Programme has developed early-stage knowledge toolkits and capabilities. Across evaluation group analysis, the most common output of projects was 'knowledge reports, guidance & standards (26% of outputs in group analysis), 'toolkits & models (19% of outputs in group analysis)']; and there was strong consensus across stakeholders that there had been an improved understanding of products or tools (identified by 11/20) standards (identified by 11/20) and process (identified by 8/20).

"We wouldn't have been there without some independent people coming in and looking at this problem, surfacing the information and knowledge that's needed to manage it."
"Identifying problems which the industry didn't know about"
"It increased the general awareness, pushing people's imagination… now we have specific research that demonstrates air quality challenges"
"It's doing things differently, innovating …. the research program is about innovation, problem solving and highlighting issues, the research isn't always about finding a solution to a problem. It's finding out what those problems are in the 1st place"

"It's unintended outcomes in that it often highlights other areas of weakness when you start doing this thing, you start to think well, actually, if we knew a lot more about X, we could also help with some other problems"

✓ **Evidence supporting hypothesis:** Interviewees most frequently cited successful adoption of programme outputs in relation to products (cited by 7/20 interviewees) and standards (cited by 5/20 interviewees) - this was particularly where the Programme provided data, frameworks and toolkits and demonstrated early-stage use-cases.

"There's lots of use cases where a model or tool has been created and then used for something else as well"

"How we approach SPADs and investigate, the research that's gone on to try and help us understand some of the organisational, but also individual issues. How we recognise fair culture and can now put a level of quantification around human error. The tools that we use to investigate and understand things like train accident risk.

"Has improved the level of understanding of maturity we have for platform risk training - understanding what our responsibilities are as a duty holder for everything from wheeled buggies and pushchairs that roll into the path of freight trains."

"We are now looking at what we can do to improve that situation on board, we would not have been in a position to do that previously because we just wouldn't have had the facts behind it"

✓ **Evidence supporting hypothesis:** Four case studies provided recommendations to update industry standards (3, 9, 10, 13). In these cases, standards were subsequently updated and adopted across industry. These changes also had a clear link to improvements across industry. Case study 7 demonstrated full adoption (for relevant users) of a tool created from RSSB research. This has over 350 users and is actively being used to make more informed safety decisions to reduce Signals Passed at Danger (SPADs).

❖ **Evidence partially supporting hypothesis, or unclear:** There was less evidence where the Programme had driven adoption of policies. Analysis of the evaluation research groups output identified only 4% of projects producing policy recommendations – and only 3/20 stakeholders identified examples of Policy implementation.

"For policy work, you need options. Some projects do not give the different options and only provided the final solution. From a policy perspective, this is not helpful. DfT will be asked 'why' they are choosing this answer. "

"Sometimes RSSB don't understand how policy works from a government perspective "

x **Evidence challenging hypothesis:** Many stakeholders (9/20) did identify a challenge with industry adoption and implementation; this was particularly evident around later TRL product adoption or where significant change was required to facilitate implementation. Interviewees identified specific industry challenges around:

- Unclear line of responsibility / duty holders [TOCs]
- Lack of industry incentive to adopt or implement
- Lack of industry funding or other resources to adopt or implement

"The ability of the industry to take on board and implement is much harder and much slower than I would have imagined and that is a real paradox, there's so much good learning, but the ability to implement is a bottleneck".

"Once reports get published - in many cases industry doesn't adopt or implement"

"Often a failure to adopt and implement from industry. Would be good to see an increase in incentivisation of operators in picking up research."

> *"A lot of the stuff gets written off before it's even read - it's we just haven't got the money right now. We're delivering our license obligations. We can't afford to go beyond our license obligations right now."*

Theory of Change Hypothesis: The RSSB R&D Programme shares lessons learnt with the industry and learns from previous research.

Summary of findings: There was evidence that the Programme has taken on feedback from the industry and learnt from previous research. These lessons have been shared with industry stakeholders.

- ✓ **Evidence supporting hypothesis:** The Programme has taken feedback from industry and stakeholders onboard; 7/20 stakeholders described improvements frequently referencing increasing quality of outputs and research scope areas addressed.

  "I think they certainly tightened up on the scope of work which has been asked for and understanding what's specifically being asked"
  "It's becoming more useful and more practical"
  "The quality of products has matured"

- ✓ **Evidence supporting hypothesis:** Where research was not progressed or was stopped, stakeholders described where the Programme had shared learnings with industry and applied it to further research.

  "There are instances, of course, and that's the beauty of having a portfolio approach where individual projects within the portfolio will fail. They will fail in the sense that they won't come up with a conclusion that is useful. They don't address the problem that we thought they were going to address, or they address it in a way that isn't tractable or amenable. We basically archive it as a report, but we also kind of put it in our register of, that didn't work, and this is why it didn't work."

- ✓ **Evidence supporting hypothesis:** Case Study 2 demonstrates RSSB sharing lessons learnt from research. Though the technology in the research was not progressed, it provided industry with an evidence base to pursue alternative solutions.

- ✓ **Evidence supporting hypothesis:** Several case studies build on previous research or are follow-on research projects. This demonstrates lessons and insights are being fed back into industry and the research programme.

b) What evidence is there that the outcomes were caused by the Programme and not by other factors (e.g., similar interventions including wider regulations and Rail policies, or positive contextual conditions)?

Theory of Change Hypothesis: There is evidence that outcomes are directly caused by the Programme, with other factors also contributing.

Summary of findings: There was strong evidence that the Programme contributed in significant part to outcomes across industry, though other factors played a part (including policy, other research bodies, and external events in the industry).

- ✓ **Evidence supporting hypothesis:** There is evidence across research groups that many outcomes are caused by the RSSB R&D Programme rather than other factors. This is particularly evident within Safety, where the Programme has led to new process and standards, improved understanding, and provided toolkits that are used in industry. There is further evidence that the RSSB R&D Programme laid foundations which significantly contributed to outcomes.

  "These projects often start off wider changes. You know when they actually get adopted and started to come into use then people will realise that these innovations have had a real impact and have made a significant difference in terms of reducing cost, increasing performance, increasing capacity, reducing the need for maintenance those sort of things"

- ✓ **Evidence supporting hypothesis:** In some cases, there is evidence external events have in part contributed to outcomes of the RSSB R&D Programme. Safety-related incidents have led to investigation or recommendations from the ORR. However, by providing industry with knowledge to inform decisions, often facilitating these investigations, and developing tools and standards to improve safety; the research Programme significantly drives broader outcomes. The external event contributes to industry drive to make a change, and the RSSB R&D Programme provides the information and tools required. For example:
  - Case study 3 responded to an ORR enquiry into freight derailment and research subsequently produced the information needed to reduce poorly loaded containers.
  - Following media reports on unnecessary tree felling on the railway, DfT commissioned an environmental strategy review from the RSSB R&D Programme. Case study 8 demonstrates how this research has now been incorporated into several environmental strategies across industry.

- ❖ **Evidence supporting hypothesis: I**n some cases, there is evidence that policy has driven research rather than research driving policy. An example of this is the 2018 challenge to the rail industry from the transport minister (Jo Johnson), to remove all diesel-only trains by 2040. Whilst not primarily being the driver of change, it is clear R&D by RSSB has contributed to outcomes through development of toolkits & benchmarks as well as research into hydrocarbon trains.

  "I think what has helped is having policy statements from government like net zero carbon by 2050. That's what should be happening. We should be having policy set by government research done by either individuals or in the industry, and then the private sector delivering against that. …. I think we are almost in a virtuous circle certainly on sustainability."

- ✓ **Evidence supporting hypothesis:** There are several other entities conducting rail research that were mentioned by stakeholders. Largely these focus on different areas

such as later stages of implementation or delivery, or are not cross-industry / independent:

- Network Rail R&D (including the Performance Innovation Fund (PIF)) – more focused on implementation, NR specific projects, higher stage TRL and less cross-industry focused.
- First of A Kind (FOAK) innovation fund (including Innovate UK) – usually product based rather than research.
- UK Rail Research & Innovation Network (UKRRIN) - focused on delivery, later stage field trials, connecting industry, universities, SMEs, infrastructure owners.

❖ **Evidence partially supporting hypothesis, or unclear:** Where there are similar interventions – it is not always clear to stakeholders the roles different organisations play in relation to each other, and there may be some areas where there is overlap.

> "[*implementation] should probably sit elsewhere [not in the R&D programme] …. there's got to be a clear path to implement and who is supporting when and where"*
> *"It's not always clear who's doing what and where we need to go for funding"*
> *"Industry risk groups are looking at specific chapters of the safety chart and their safety strategy - all these groups are trying deliver the key aims of the strategy … but they are overlapping in a lot of activities and collaboration, but still needs improvement. But it is a lot better than what I would say 2-4 years ago"*
> *"The overlap is not huge - the main area of overlap is between Network Rail because of the system interfaces. For me it's very much driven by the fact that RSSB hosts the vehicle track System Interface Committee and is therefore working across the whole range of duty holders for that interface, not just for one. There's always a debate with those particular types of projects should we [RSSB] be funding this or should Network Rail be funding it?".*

c) What direct and indirect impacts has the Programme had so far (e.g., economic, commercial, environmental, social)?

Theory of Change Hypothesis: The RSSB R&D Programme has improved the safety, sustainability and optimisation of the GB rail network (direct).

Summary of findings: There was evidence the Programme has significantly improved Safety in the GB rail network over the last 10-15 years, as well as significantly improving Sustainability more recently (last 5 years). There was evidence that the Programme has improved optimisation in the rail network. This was less an overall cultural shift and more due to enabling improvements through products and increased knowledge base.

✓ **Evidence supporting hypothesis:** There was consensus that the RSSB R&D Programme directly and indirectly led to a significant industry wide improvement in safety over the last 10-15 years. All interviewees who referred to safety changes in the industry identified direct and indirect impacts that the RSSB R&D Programme had achieved (9/20). Specific impacts cited included:

- A cultural shift within safety and improved fundamental understanding of risk
- Development of risk-focused standards
- Building significant knowledge and source of data which has been drawn on across industry

- Identifying previously unknown industry issues, and quantifying safety benefits
- Increased focus on reducing SPADs
- Improved understanding of derailment
- Improved understanding of human error

✓ **Evidence supporting hypothesis:** There was a perception that the RSSB R&D Programme is now building a more comprehensive understanding of sustainability and what it means for the industry. Previously there was a perception that rail was very 'green' and could do no harm, which led to a general complacency within industry about sustainability. 5/20 stakeholders discussed the direct and indirect impacts of the Programme on industry wide sustainability. Specific impacts cited included:

- Increasing focus & understanding on scale of the challenge
- Building a knowledge base and identifying problem areas in the industry
- Providing a central focus & "rallying cry" to tackle sustainability
- Influencing DFT & ORR to embed sustainability benchmarks in various contracts
- Key areas the Programme focused with Sustainability included: Decarbonisation, Air Quality, Noise pollution, Biodiversity and Circular Economy

✓ **Evidence supporting hypothesis:** The Programme has improved optimisation in the rail network. This has been less of a significant cultural shift, and more due to improvements in knowledge, benchmarking, and products. Specific impacts cited by stakeholders included:

- Building understanding of industry issues and identifying opportunities to improve performance
- Providing evidence through benchmarking
- Vehicle Track Interaction model – used by Network Rail & others

✓ **Evidence supporting hypothesis:** In 9 case studies, there was evidence that the research has contributed towards the RSSB R&D Programme's strategic goals of safety, sustainability & optimisation and driven positive change across industry. The remaining four case studies showed there was a clear link to benefits across industry, but due to the time that the research was completed, it was too early to evidence this.

Theory of Change Hypothesis: The RSSB Programme has increased collaboration, increased the SME talent pool, and increased the body of knowledge (indirect).

Summary of findings: There was evidence the RSSB R&D Programme has led to indirect improvement within the UK rail network – through improving the general body of knowledge, improving collaboration and to some extent developing the talent pool in the industry.

✓ **Evidence supporting hypothesis:** The majority of stakeholders (15/20) stated the RSSB R&D Programme had led to the significant increase in the body of knowledge within the UK. The RSSB R&D Programme was fundamental in setting up UKRRIN - improving the academic status of the UK.

"They're often not quick wins, they are feeding the body of knowledge"
"RSSB R&D was a founding and fundamental member of UKRRIN"
"Identifying unknown industry problems"
"Highlighting connected areas of weakness, multiple payoff areas"
"I know colleagues in Europe who use it and find themselves on the RSSB database"

- ✓ **Evidence supporting hypothesis:** The RSSB R&D Programme has led to increase in collaboration across industry. This was commented on by many stakeholders (12/20).
  "Industry working better together, rallying cry around decarbonisation"
  "Bringing in ROSCOs to talk to operators, suppliers, infrastructure owners."
  "RSSB has made it, so we are more joined up in a professional way"
  "We were never collaborating like this before"

- ✓ **Evidence supporting hypothesis:** The Programme has led to some increase in the talent pool – with 5/20 of stakeholders commenting on this.
  "There is definitely an indirect impact in that you are making railways just a little bit more exciting … I think some of the innovations do look interesting and you know whatever exposure we can get on that it does then attract young people to see a career in railways"
  "Increased the academic status of the UK and encouraged more people into research by providing funding and improved SME knowledge and expertise. The support that RSSB gives to our university and others does mean that it supports our role in educating people and educating the next generation of Engineers and other people that are needed to work in the rail industry. It's a quite a challenge for the rail industry now, the skills shortage"

d) To what extent have the Programme's outputs led to real world applications of research?

Theory of Change Hypothesis: Several key programme outputs have led to tangible real-world applications.

Summary of findings: There was evidence that several programme outputs had led to a number of significant real-world applications, however there was a gap in the level of implementation of products, standards, processes by industry, as well as a gap in programme monitoring of where there has been real world application.

- ✓ **Evidence supporting hypothesis:** All stakeholders interviewed identified key areas where research had led to real world applications. Some significant examples cited by stakeholders included (but were not limited to):
  - Double Variable Rate Sanders – projects trialling, evaluating, and quantifying the impacts of double variable rate sanders on braking & traction during low adhesion. (IMP-T1107, COF-UOH-46, T1107, T796).
    "The benefits were drawn out quite clearly and tested. The methodology was fantastic. Ricardo Rail work very closely with Great Western and RSSB. RSSB did a brilliant job of pulling it all together, it was professionally done. … We have now had double rate variable sanders in existence, or certainly the proof of concept now, for at least 2 autumn seasons if not 3"
  - Air quality mapping framework & standards – projects mapping air quality, producing emissions mapping tool, and providing freight & passenger sectors with data, leading to benchmarking against standards (T1186, T1232, T1160).
    "The air quality mapping tool, and updates to things like the emissions inventory. The assessment was carried out nationally looking at the impact of rail… research was carried out looking at what is the reality. So, we need to reduce the impact of these assets based on research… we've had some tangible impact"

- Hydrocarbon Train Research - providing industry with better understanding of operational considerations & constraints and providing a route map to entry into service (T1172, T722, T1160).
  "I can sell my board a hydrogen train now because I've got a wealth of information from the research and development RSSB, and others have done. I've seen prototypes of it. I am now at the point where I'm ready to invest in productionisation"
- Freight Derailment – Research into uneven freight wagon loading & track geometry (T1112, COF-UOH-17).
  "We had some work done on uneven loads and track geometry to understand how the two come together and where there's a potential of a freight train derailment …. that was something that they were helpful in providing data analysis, where there was uneven load against a piece of track geometry and the risk that goes with that…. so that was beneficial, certainly for us"
- Colour Visions Standards – Identification of robust colour vision testing (T924).
  "*We were able to draw on that piece of research, make sure that our guidance was in line with it and use it to actually defend a case, defend our position…. It's been shared with our learning and development team to incorporate into training."*
- Speed differential - Development of criteria for assigning differential speed categories (T1163).
  "That's got huge potential. For more capacity, more benefits for passengers without necessarily requiring lots of investment."
- SPADs insights tool – Development of Signal passed at Danger (SPAD) risk management tools (T435).
  "The RAATS SPAD tool has over 350 users and it's largely train operators and Network Rail sort of performance and planning teams."

✓ **Evidence supporting hypothesis:** Outputs from 10/13 case studies led to tangible real-world applications. A summary of their application can be seen below. For more detailed information, please see Annex F.

- *Case study 1 - T1173 Identifying measures to prevent customer-on-staff work-related violence in the GB rail industry* – framework used as the basis for the industry strategy and used by TOCs.
- *Case study 3 - T1112 - Quantify the distribution of unevenly loaded container wagons* – Informed update to Railway Group Standard GMRT 2141. Across all freight types there's a clear reduction in risk, which can be linked to the actions of the research.
- *Case study 5 - COF-TAR-03 - Adhesion Riddle Feasibility Study on the use of Dry-ice for Rail Head Cleaning* – Industry has taken the product forward using FOAK and PIF funding. Expected product will be in service in 2023.
- *Case Study 7 – COF-UOH-07 - Red Aspect Approaches to Signals* – Tool produced which is used by over 350 users and risk, modelling and analysis teams using the output to make more informed decisions and improve safety.
- *Case Study 8 – T1153 - Lineside Vegetation Management Review* - Review has been referenced by NR's environmental strategy and accelerated targets such as no net-loss by 2024 and net-gain by 2035.
- *Case Study 9 – COF-UOH-09 Economic Tyre Turning (ETT)* – Report has caused an update to Railway Group Standards GMRT2466 allowing ETT on GB railways.
- *Case Study 10 – T1005 – Enhancement of the TCA Risk Advisor Tool to include on-track machines* – New functionality added to TCA risk tool. Update to the Rule Book and the Railway Group standards was completed to allow operators to make gains from tool.
- *Case Study 11 – T797 – Performance and installation criteria for sanding systems* – The initial project has resulted in a standard change which allowed train operators to make changes to the existing sanding parameters. This research has formed the basis of

several other high-profile projects which has ultimately led to the application of funding for an entire fleet to be retrofitted with Double Variable Rate Sanders.

- *Case Study 12 – T792 – Vehicle Track Interaction Strategic Model (VTISM)* - Enhanced tool which extended the capability of the VTISM and improved the user interface. Savings have been realised by using VTISM in the tender evaluation for the InterCity Express and Thameslink rolling stock projects, strategic business planning for track maintenance and renewal, and evaluation of track access charges.
- *Case Study 13 –T978 – Development of Passenger Standard Vehicle Gauge*s - new gauges were updated in GE/RT8073 and EN15273 allowing operators to quickly and easily determine whether their rolling stock will be able to operate on a certain route and avoid the need for expensive gauging studies when moving stock between routes.

x **Evidence challenging hypothesis:** There was a significant amount of missed opportunity where industry had not adopted outputs from research. Challenges with implementation and adoption from industry were raised by many stakeholders interviewed (9/20). Evidence of this can be found under the evaluation question 'a) To what extent has the Programme achieved its expected outcomes?'.

e) To what extent have the Programme's outputs influenced relevant senior decision makers (e.g., Rail Strategy Board, senior civil servants)?

Theory of Change Hypothesis: Programme output have indirectly influenced key senior decision makers.

Summary of findings: There was evidence that outputs from the Programme indirectly influenced senior decision makers across industry, by providing a data backed evidence base, which has been used to support cases for change and drive further industry focus.

✓ **Evidence supporting hypothesis:** Programme outputs indirectly influence senior decision makers within industry groups, through providing an evidence base to build 'a case for change' and quantification of challenges to gain early traction. Many stakeholders (13/20) mentioned the indirect influence of programme outputs, frequently citing:

- Evidence taken to board for further research or focus
- Feeding business cases for change or investment
- Quantifying benefits, risks, or opportunities

"I've used this evidence to make a case to TfL to say we should increase the number of people that were randomly tested based on this new guidance"
"Rare for it to be taken directly to a very senior forum … it's more likely to be sort of assessed and digested and discussed as to what scope there is at a local forum and then maybe escalated up to one of those more important forums"
"Taking the evidence to the board as well as all of the savings which can be made from making the change.
"Utilised for producing business cases for change"

✓ **Evidence supporting hypothesis:** When the research is 'event driven', such as in response to a safety related incident or media article, the outputs are much more likely to directly influence senior decision makers. For example, case study 8 was delivered in response to media reports about tree felling on the railway. The output was shared with senior decision makers and subsequently environmental policies and targets were updated.

- **Evidence partially supporting hypothesis, or unclear:** The was no evidence from stakeholders or case studies that demonstrated the Programme had influenced the Rail Strategy Board or senior civil servants, indirectly or directly. However, there was no evidence that this was not the case. Outputs from the RSSB R&D Programme were used to feed the RTS route maps for achieving its functional priorities, particularly in early scoping of challenges and options with RSSB being cited at least 21 times in the RTS November 2021 roadmap progress updates.

3.3 Value for Money Findings

Key Findings for Value for Money

- Analysis of case study benefit-cost ratio suggests projects are generally value for money.
- The programme provides additional value such as improved industry collaboration, an independent viewpoint, technical subject matter expertise and improving the UK's rail research status.
- Co-funding is increasing the value for money of the programme and drives private sector investment in R&D.
- Benefits and value are not always tracked consistently or accurately.

f) What is the estimated benefit-cost ratio of the Programme so far?

The figures provided in this section have been calculated using data provided by RSSB. Calculations and figures should be used as guidelines rather than absolute figures, due to the following factors:

- **Quality of data** – since the Programme began, the ability to capture data has dramatically changed and quality has improved. This has been driven by changes in technology allowing digital storage and easier access.
- **Process changes** – changes to how the Programme and projects are delivered have changed the requirements on what data is collected. This has led to inconsistent datasets such as differences in how funding is reported and monitored.
- **Multiple system extracts** – due to the age of the Programme, multiple systems have been used to capture and store data. This has resulted in different values, column headings and misalignment between data sets.
- **Analysis resource and time** – due to the time constraints on this evaluation, aggregate level analysis was completed to provide breadth, accompanied by case studies (13) to provide depth. Although this provides a good representation of the overall Programme, extensive data analysis of every individual project was not completed.

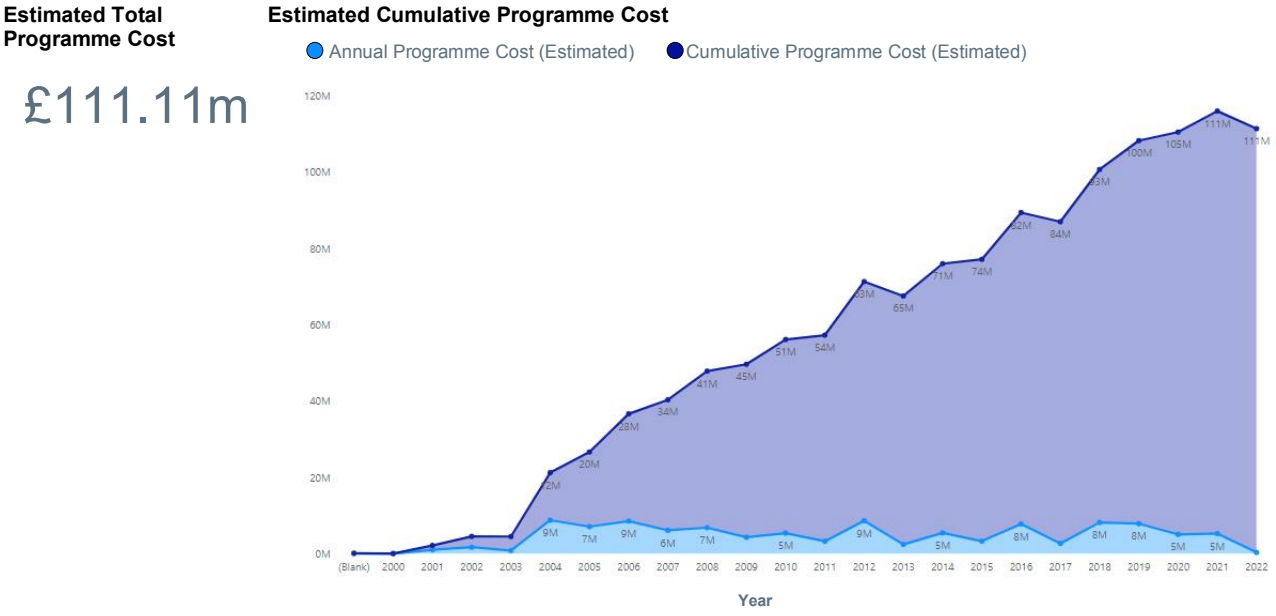
These factors are not uncommon when evaluating retrospectively and would be expected given the age of the Programme.

Estimated Programme Costs

The total cumulative cost of the Programme since its inception is estimated to be £111,110,000. Graph 5 below, shows the annual and cumulative cost of the Programme.

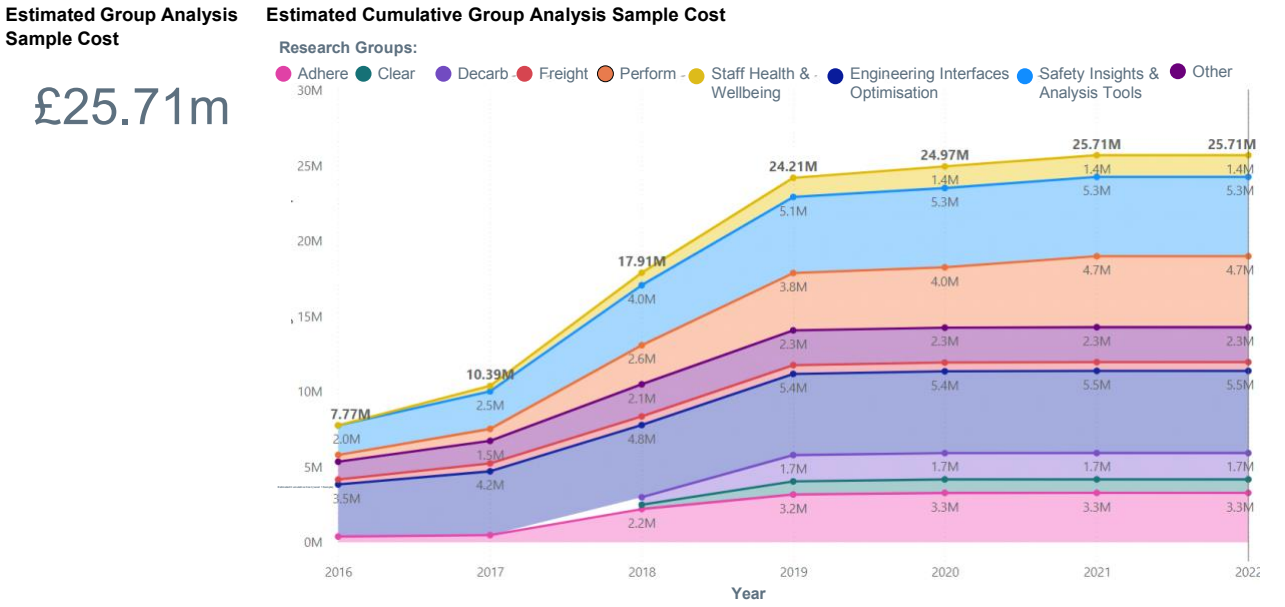
Cost figures were calculated based on data provided by the RSSB – this calculation included consolidating and aggregating the data of all projects conducted throughout the Programme, drawing on three separate data bases (current and legacy) which tracked

external (supplier) and internal costs. These figures should be considered an estimated rather than absolute value.



Graph 5: Total programme costs.

The group analysis sample (i.e. completed projects starting from January 2016) had a total cost of £25,710,000 which is 23% of the total estimated Programme cost. The highest cost research groups were 'Engineering Interface Optimisation', 'Safety Insights & Tools' and 'Perform' (See Graph 6 below).



Graph 6: Programme cost for group analysis, overall and by research group.

Estimated Programme Benefits

Benefits refer to the positive impact an initiative has had; and may include social, financial, environmental, or other benefits. 'Potential benefits' are those impacts that can realistically

be expected to be gained because of the initiative, and 'actual benefits' are those that have been realised and achieved.

Since 2009 RSSB have grouped R&D projects based on the output produced, to appropriately monitor benefits. These three benefits categories are:

- **Tangible Products** – For projects which develop or deliver a new product or service, where realistic expected benefits (weighted benefits) as well as implementation costs can be quantified, allowing a project BCR to be calculated. (Referred to internally within RSSB as Category 1).

- **Knowledge Products** – For projects which deliver knowledge or facilitate industry decisions, where potential benefits can be estimated to some extent but not always quantified. (Referred to internally with RSSB as Category 2).

- **Non-Quantifiable Products** – For projects where the specific output is unclear or unknown, and benefits (potential or expected) cannot yet be quantified to any degree. (Referred to internally with RSSB as Category 3).

The above groupings enable RSSB to calculate cost benefits ratios for those projects where actual benefits and implementation costs are known and quantifiable, whilst capturing broader potential benefits for those projects where is it not possible to fully quantify the level of benefits that are likely to be realised.

Table 8 below shows the specific benefits measures captured by the RSSB for each of the three benefits categories:

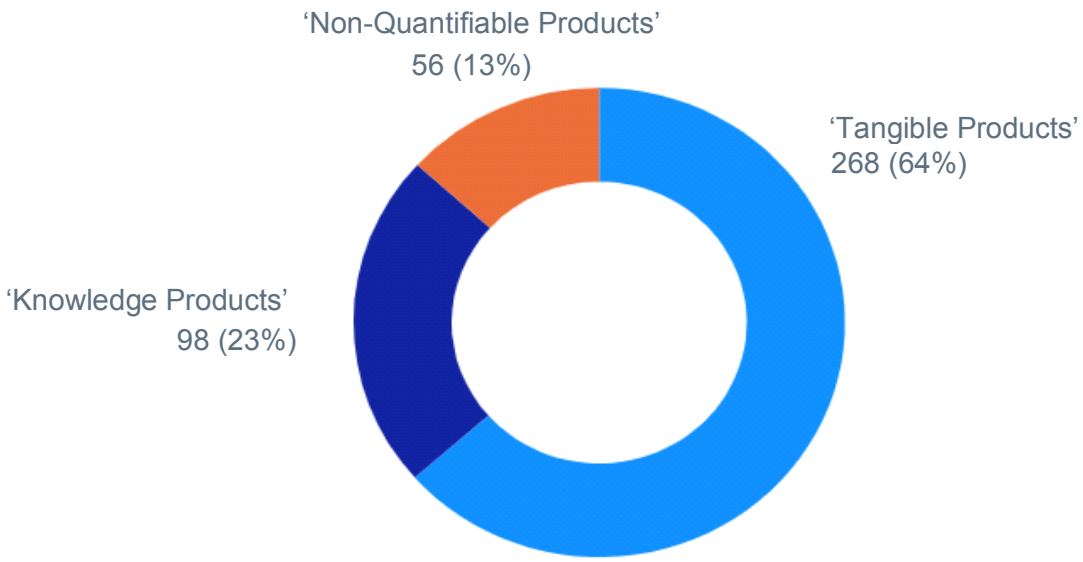
Benefits Monitored	Tangible Products	Knowledge Products	Non-Quantifiable Product
Potential Benefits (Unweighted) – estimate of the possible benefit to the rail industry if envisaged change is implemented.	Yes	Yes	No
Expected Benefits (Weighted) – calculated by weighting factor (as determined case-by-case by expert judgement of benefits realistically achievable) against unweighted benefits.	Most	No	No
Implementation Costs – Cost required to implement output & realise benefits (In addition to research delivery costs)	Yes	No	No
benefit-cost ratio – calculated at project level	Yes	No	No
Benefits Timeline Data	Some	Some	No

Table 8: RSSB R&D benefits categories & captured.

Out of 768 total closed projects, 418 projects had benefits categorised with 350 projects not being categorised due to being legacy projects or closed when categorisation was implemented in 2009.

Out of the 418 projects that were categorised; 64% of these were categorised as 'Tangible Products', 23% as 'knowledge products' and 13% as 'Non-Quantifiable products' (see Graph 7 below).

'Types of Benefits (Where Benefits Categorised)



Graph 7: Types of benefits (418 projects with benefits categorised)

As only 64% of projects (Tangible Projects) had actual expected benefits monitored; it was not possible to quantify overall RSSB R&D Programme benefits.

Estimated benefit-cost ratio

It was not possible in practice to calculate an accurate reflection of the Programme's overall benefit-cost ratio.

The minimum data to calculate an overall programme benefit-cost ratio is research & implementation costs, expected benefits and benefit timeline. The main challenges we faced with the data were:

- **Research and implementation costs** – the project data is provided in different formats depending on the system used at the time of project. It was possible to aggregate this to calculate the estimated overall programme research cost. However, implementation data was not consistently available and there was a lack of data with older projects.
- **Expected benefits** (Weighted) – Within the 'Tangible Products' projects, benefits where weighted to calculate actual expected benefits, however this project data was

provided in different formats depending on the system used at the time of project, and only 197/268 'Tangible Product' projects actually had a weighting provided within the database.

- **Benefit timeline** – A review of benefits data reported by the Programme found inconsistent timelines are used across the Programme to calculate benefit-cost ratios. To provide an aggregate benefit-cost ratio for the Programme we need to have certainty that the same assumptions on benefit realisation timelines have been utilised. Benefits timelines have only been reported on within individual project documentation, and not at programme level, which means it is not possible to easily aggregate and provide a consistent benefit-cost ratio across the whole programme. RSSB is collecting programme level benefit realisation timelines for more recent projects (starting in 2020) which will more easily allow a cost benefit analysis at a programme level to be made, though timelines are expected to vary due to the nature of different areas of project focus.

Overall summary for estimated benefit-cost ratio of the Programme so far

It has not been possible to calculate a benefit-cost ratio for the overall Programme due to incomplete and inconsistent data across the Programme. Changes have subsequently been made (2020) which should allow a benefit-cost ratio to be calculated in the future.

g) What is the estimated value-for-money of the Programme so far (including additionality of policy impacts)?

Value for Money Case Study Analysis

This section used RSSB's project data, primarily from business cases and Post Project Reviews, to understand the projected benefits and assumptions. Assumptions and calculations were tested with SMEs from across industry to understand their accuracy and validity. The projects were given an assessment as to if they were likely to be value for money at the time of delivery and subsequently at the time of evaluation using the evidence provided. The full details of this analysis per case can be found in Annex F.

Table 9 provides a summary view of the value for money findings. This is split by category and uses the following key:

- ✓ Considered value for money.
- ❖ Unclear or too early to determine if it is value for money.
- x Not considered value for money.

A case study was considered value for money using the following guidelines:

- 'Tangible products' (where benefits are quantified, and project Benefit Cost Ratio is reported) – benefit-cost ratio is greater than 1 and positive stakeholder feedback.
- 'Knowledge Products' (where potential benefits are estimated) – Expert review on 'size of opportunity' and positive stakeholder feedback.

- 'Non-Quantifiable product' (where no benefits are estimated or quantified) – Positive stakeholder feedback.

Value for money was assessed at two occasions: at the time of delivery and at the time of this evaluation:

- At the time of delivery – this assessment considered if a project was value for money at the time it was delivered.
- At the time of evaluation - this assessment considered if a project was value for money at the time of this evaluation, reviewing if the implementation is delivering expected outcomes & benefits.

Case Study Categorisation	VfM assessment at time of delivery	VfM assessment at time of evaluation
Tangible Products	✓ 7/8 x 1/8	✓ 6/8 ❖ 1/8 x 1/8
Knowledge Products	✓ 4/4	✓ 1/4 ❖ 3/4
Non-Quantifiable Products	✓ 1/1	✓ 1/1

Table 9: Summary view of case study value for money analysis.

Summary of case studies

An overview of the value for money findings for case studies is shown in Table 10 below. Full details on case studies conducted can be found in Annex F

- ✓ Considered value for money.
- ❖ Unclear or too early to determine if it is value for money.
- x Not considered value for money.

Case Study	BCR	Project Outcomes / Impact Overview	Value for Money Evaluation Summary
Case Study 1 - T1173 - Identifying measures to prevent customer-on-staff work-related violence in the GB rail industry	6.9	Research provided insight for industry on the most effective interventions for work-related violence and provided tools for companies to make the case for interventions within organisations. It is likely this project will deliver impact in the industry though due to the research completing in 2021, it is difficult to evidence this.	❖ No post-R&D implementation costs were included in the business case, although there is sufficient margin of error in the BCR (6.9) to suggest value for money.
Case Study 2 - COF-G18-01 - Automated collection of train consist information	1.0	The initial research provided industry with knowledge on whether progress the technology further, helping inform industry decisions. Although the original use case is unlikely to be realised, lessons have been fed back into the RSSB R&D Programme and parts of the technology are to be commercialised for different use cases.	x The assumptions used in the benefits case are not a true reflection of the benefits associated with this project. Additionally, the BCR (1) only breaks even if fully successful. Therefore, this project would not be considered value for money or a good use of resources.

Case Study 3 - T1112 - Quantify the distribution of unevenly loaded container wagons	N/A	This project has contributed to RSSB's strategic objective of creating a safer railway. Across all freight types there has been a reduction in risk, which can be linked to the actions taken by Freight Operating Companies and initial work by RSSB. Most striking was the significant drop in the most severe category of exceedance of loading limits. Given that most severe exceedances were the most likely to derail, it is reasonable to conclude this project has delivered significant impact. As this project was part of responding to an ORR enquiry it is possible the investment would have been mandated is industry had not responded.	✓ The relatively small cost of the project suggests it was value for money given the possibility of large fines across industry and direct impact it has on reducing risk. Quantifying this is not possible due to influence of other projects and lack of information at time of evaluation.
Case Study 4 - T1198 - DECARB - Interim and long-term targets to achieve decarbonisation strategy	N/A	This project directly inputs into key industry strategies such as the Transport Decarbonisation Plan, though due to recent commencement there is less evidence of actual impact. It has not been possible to contact the 'customer' of the project (DfT) to understand how they are using the outputs of the project to set industry targets – a key aim of the project	❖ The size of opportunity is large enough to suggest it is likely to be value for money given the relatively small research cost, though there are no implementation costs included so a BCR could not be calculated to assess if this project is value for money.
Case Study 5 – COF-TAR-03 - Adhesion Riddle Feasibility Study on the use of Dry-ice for Rail Head Cleaning	N/A	This project produced a feasibility study which was used to facilitate industry decisions on what technology to pursue for improving rail head adhesion. Industry stakeholders have used this initial piece of research to further develop this technology and are beginning to realise the benefits as more trials are complete. The product is expected to enter service in 2023.	❖ Having spoken to key stakeholders (Train Operating Companies), more comprehensive business cases have now been created thought it has not been possible to review these do to commercial sensitivities. Based on the organisation progressing the technology further, it could be inferred the product is commercially viable and is proving value for money.
Case Study 6 – COF-DSP-03 – IntelliDwellTime Demonstrator Project	N/A	The implementation of this project has been significantly impacted by COVID-19 and the associated reduced passenger numbers. This has led to dwell times at stations no longer being an industry priority in the short-term. Due to the interest from industry and IP ownership by a 3rd party, it is likely once passenger numbers increase and dwell times become a higher priority, an impact will be observed.	❖ There are no implementation costs included so a BCR cannot be used to assess if this project is value for money. Yet given the size of opportunity and subsequent commercial interest, it is likely this project was value for money.

Case Study 7 – COF-UOH-07 - Red Aspect Approaches to Signals (RAATS)	15.9	This project has had a positive impact on industry and the causal link from the RAATS tool through to RSSB's strategic objective of improving safety is clear and can be evidenced. The RAATS tool was highlighted by several stakeholders during interviews as a 'real world' example where their risk, modelling and analysis teams were using the output from RSSB to make more informed decisions and improve safety.	✓ Reasonable assumptions were made for the BCR (15.9) calculation, and this project would be considered value for money.
Case Study 8 – T1153 - Lineside Vegetation Management Review	N/A	This project has had a significant impact on senior decision makers updating policies, guidance and driving change across the industry. These changes can clearly be evidenced as they have been published and are being tracked by industry. Although the industry was aware of some of these challenges, this project acted as an evidence base and catalyst to kick-start the industry into action. As Network Rail begins to report on this issue annually, it may be possible to further evidence the impact.	✓ Given the size of opportunity, this is likely to be considered value for money.
Case Study 9 – Pre-2016 COF-UOH-09 Economic Tyre Turning (ETT)	40.0	The output from this project can be directly linked toe updated standards and subsequently more efficient expenditure and operations creating a more optimised railway	✓ The analysis used for business case has been verified, reasonable assumptions were made, and this project would be considered value for money.
Case Study 10 – Pre-2016 T1005 – Enhancement of the Track Circuit Actuator (TCA) Risk Advisor Tool to include on-track machines	4.7	The output has contributed to more optimised rail –through reduced delays and cancellations. Standards and the Rule Book were changed which led to a direct benefit for industry.	✓ The analysis used for business case has been verified, reasonable assumptions were made, and this project would be considered value for money.

Case Study 11 – Pre-2016 T797 – Performance and installation criteria for sanding systems	1.3	The initial project has resulted in a standard change which allowed train operators to make changes to the existing sanding parameters. This research has formed the basis of several other high-profile projects which has ultimately led to the application of funding for an entire fleet to be retrofitted with Double Variable Rate Sanders. This has significant impacts on improved safety, savings on delay minutes due to overruns and savings on overruns investigation costs.	✓ The analysis used for this business case was comprehensive and assumptions reasonable. This project would be considered value for money.
Case Study 12 – Pre-2016 T792 – Vehicle Track Interaction Strategic Model	25.0	This piece of research had an impact across the industry and contributed towards the strategic objectives of creating a more optimised railway Savings have been realised by using VTISM in the tender evaluation for the InterCity Express and Thameslink rolling stock projects, strategic business planning for track maintenance and renewal, and evaluation of track access charges.	✓ The analysis used for this business case was extremely comprehensive and the most thorough seen in this evaluation. This project would be considered value for money.
Case Study 13 – Pre-2016 T978 – Development of Passenger Standard Vehicle Gauges	7.4	Through changing of standards that this project has had an impact across the industry and contributed towards the strategic objectives of creating a more optimised railway.	✓ The analysis used for business case has been verified, reasonable assumptions were made, and this project would be considered value for money.

Table 10: Summary of value for money findings for case studies

Tangible Products

Value for Money assessment at time of delivery

- ✓ 7 out of 8 case studies were considered value for money at the time of delivery and had benefit-cost ratios greater than 1. Generally, these calculations were based on robust information and assumptions. In two cases, a full value for money assessment was not possible as implementation costs post R&D investment were not included. Where this was the case, the benefit-cost ratio was large enough to allow for considerable margin of error for implementation costs to be included and the project to still demonstrate a positive benefit-cost ratio.

- x 1 out of 8 case studies had a benefit-cost ratio of 1, thus only just covering the cost of development and inaccurate / unsubstantiated assumptions made within the business case. This project would not be considered value for money or good use of resources.

Value for Money assessment at time of evaluation

- ✓ 6 out of 8 case studies were considered value for money at the time of evaluation. There was clear evidence that the outputs had contributed to beneficial change within industry.

- ❖ 1 out of 8 case studies was unclear or too early in the implementation stage to make a significant value for money assessment at the time of this evaluation.

- x 1 out of 8 case studies did not realise the desired benefits and thus is not value for money.

Knowledge Products

Value for Money assessment at time of delivery

- ✓ The size of opportunity calculation only provides assumptions on the baseline data for the opportunity, but no projected improvement or implementation cost post R&D stage. A full BCR could not be calculated, however, the size of opportunity can provide an indicator towards value for money. In 4 out of 4 case studies, the size of opportunity was considered large enough to assume that it was probably worth investing in even with the lowest confidence level for improvement applied.

Value for Money assessment at time of evaluation

- ✓ While 'Knowledge Products' projects do not have quantified benefits, they aim to improve industry knowledge and understanding. 1 out of 4 case studies were considered value for money at the time of evaluation and stakeholders evidenced qualitative benefits such as outputs being referenced in strategy documents.

- ❖ 3 out of 4 case studies were unclear or too early in the implementation stage to make a significant value for money assessment at the time of this evaluation.

Non-Quantifiable Products

Value for Money assessment at time of delivery

- ✓ 1 out of 1 case studies was considered value for money at the time of delivery. This project was part of responding to an ORR enquiry. Had the industry not responded, it is possible the investment would have been mandated to maintain legal compliance with the regulator. The relatively small value of the project also suggests it was value for money to support the regulator build evidence across the industry from an independent party.

Value for Money assessment at time of evaluation

- ✓ 1 out of 1 case studies was considered value for money at the time of evaluation. There was clear evidence that the outputs had a direct benefit on reducing risk.

Summary of Value for Money Case Study Analysis

Overall, the case studies would generally be considered value for money.

- ✓ 8 out of 13 case studies were considered value for money at the time of this evaluation.
- ❖ 4 out of 13 case studies were unclear or too early in the implementation stage to make a significant value for money assessment at the time of this evaluation.
- x 1 out of 13 case studies was not considered value for money at the time of this evaluation.

Interestingly, pre-2016 case studies tended to have more robust calculation and assumptions with sensitivity analysis, adjustments for inflation and implementation costs included. This could be due to resource focus moving elsewhere as the Programme has developed.

Implementation costs required following R&D investment are key to completing an accurate value for money assessment, and across case studies were often missed from the analysis. An example of where they were considered effectively was in case study 12 (Vehicle Track Interaction Strategic Model), with the scope of the project to produce an enhancement to an existing tool and assumed implementation costs of £10,000 to create training material were provided in the calculations.

'Knowledge Products' projects lacked a benefit-cost ratio which RSSB linked to the early stage of the research and lack of clear route to implementation. While this is often the case with early-stage research, techniques such as sensitivity analysis to calculate minimum improvement required to achieve a positive benefit-cost ratio or creating specific use case boundaries within the size of opportunity, would help provide confidence that the investment is value for money.

Additional value of the Programme

In reviewing the value for money of the Programme, in addition to the projected and weighted benefits, the evaluation identified areas of additional value unique to the RSSB R&D Programme in its current context. This was based qualitative analysis of stakeholder interviews.

Independence & transparency – 5/20 stakeholders raised the critical value the RSSB R&D Programme provides through its independence and cross-industry perspective that could not be found elsewhere in the current industry structure.

- *"There is nowhere else in the industry that you have the representation and the independence."*
- *"It has that degree of independence and transparency… RSSB brings a huge benefit through its transparency and openness and cross-industry engagement and sharing of research."*
- *"RSSB is an incredible tool for this industry to have. Because of that total cross-industry perspective."*
- *"I don't think we would have been there without some independent people coming in and going, you know what, we'll look at this problem for you… we'll try and surface some of the information and knowledge that you need to manage it."*
- *"The only representative body for the whole of the rail industry. There are trade bodies, their trade associations, etc. But to the best of my knowledge, RSSB is the only place where the whole of the rail industry is independently represented."*

Cross-industry structure – All stakeholders highlighted the unique value the RSSB R&D Programme provides through its structure, by providing a forum for bodies across industry to collaborate and address issues. While the R&D Programme is not necessarily essential to the structure and forums, the funding it provides means industry can understand their challenges more effectively.

- *"RSSB does have that clear, tangible structure there in place… without the funding it brings and the structures it has, these groups would just be talking shops."*
- *"The R&D Programme allows us to work together to understand our challenges and provides a mechanism to do this"*
- *"I think there's some really good collaboration going on, it's bringing in ROSCOs to talk to operators to talk to suppliers or talk to infrastructure owners and operators … I think RSSB have really, really got that right"*
- *"I can't think of another organisation actually that does it as well as RSSB. (I still think there's lots of opportunities to do it better)"*
- *"It's just a very good forum to talk about lots of different things … that's probably about 60% of what I get back from these forums, you have these discussions, and you learn about what others are doing"*
- *"They contain many of the industry stakeholders who can come together, and we can sort of talk fairly freely about what the industry needs in a fairly broad way"*

- *"Where you have a system which is really collectively owned across the industry. Then that's the point at which RSSB brings in the value, because they can look at the system which sits across the various industry stakeholders"*

Technical Expertise – 8/20 stakeholders discussed the level of technical expertise and deep understanding of rail that the RSSB R&D Programme and professional leads within the Programme provided to industry. This level of expertise was highlighted as a unique attribute of the RSSB.

- *"Big concern that there isn't a group of technical expertise who can help with specific issues post the rail reform"*
- *"The R&D function is filling the gap on knowledge that we don't have"*
- *"RSSB have an understanding of how the railway works in all its grungy bits … something like that which is quite technical rail and actually is modernising the railway by using innovation rather than fundamental research"*
- *"We've got 2 technical specialists in the role …having that support from them has helped me get up to speed in the area and helped to drive some of these improvements in terms of the projects that they're doing. And I don't think we would be setting targets if it wasn't for their expertise"*

Academic focus & partnerships model – Academic stakeholders suggested that the RSSB R&D Programme has positioned the UK as a leading rail institute and has raised the profile of UK rail research. The partnership model is unique and has allowed a more flexible approach to research.

- *"The partnership model works really well; it gives us quite a lot of flexibility. We have quite a few examples of taking on projects that RSSB could not get done commercially because they were too uncertain. Whereas we can do stuff, we can tackle it and tackle it in stages, and you can say, well, that's really working out."*
- *"The flexibility of the partnerships model and the longevity means that we're committed to that, and we have a reason to promote our research to people in industry. RSSB has good governance, and it does allow more value and more flexibility than you would get otherwise"*
- *"Raising the profile of UK as an innovative heavy weight …. increased the academic status of the UK."*
- *"One of the real strengths of the partnership approach is that you can follow up, can keep promoting that work, you can do in implementation projects … that's just something that really isn't available if you're just doing a commercially tendered piece of R&D."*

Co-funding

Across the RSSB R&D Programme, there are several co-funding partners, including universities and commercial partners. This reduces the overall risk exposure of the Programme and is seen to drive private sector investment in R&D. The extent of this co-

funding has not been extensively explored in this evaluation and it is not easily accessible from the existing data.

Overall summary for value for money

Although it has not been possible to calculate an overall benefit-cost ratio of the Programme to inform this evaluation question, given the evidence available it is likely that the Programme is providing value for money and a positive return on investment.

When reviewing individual case studies:

- 8 out of 13 case studies were considered value for money at the time of this evaluation.
- 4 out of 13 case studies were unclear or too early in the implementation stage to make a significant value for money assessment at the time of this evaluation.
- 1 out of 13 case studies was not considered value for money at the time of this evaluation.

The RSSB R&D Programme brings unique value to the rail industry as it currently exists – through its independence, cross-industry structure and input, technical expertise, and academic focus. As the current rail industry structure stands, without the RSSB R&D Programme there would be a significant loss in these areas.

Across the RSSB R&D Programme, there are several co-funding partners, including universities and commercial partners. This reduces the overall risk exposure of the Programme and is seen to drive private sector investment in R&D. The extent of this co-funding has not been extensively explored in this evaluation and it is not easily accessible from the existing data.

3.4 Process Findings

Key Findings for Process

- There was no evidence that the RSSB R&D Programme was explicitly designed or formally mapped to the RTS and DfT strategic priorities. However, there is broad alignment – although this appears to be more of a reactive process than by design.
- Project-level governance throughout the project lifecycle is generally effective. Programme-level governance such as prioritisation (strategic alignment) and monitoring is less effective.
- The RSSB R&D Programme has provided key lessons across early-stage R&D, independence, collaboration, academic strategic partnerships, customer-led research, articulating benefits and understanding the wider rail ecosystem.
- The RSSB R&D Programme has provided key lessons for monitoring and evaluating in the Rail sector including defining the purpose and theory of change of the programme from the outset, consistent data collection and ongoing reviews.

h) How well does the Programme align with the Rail Technical Strategy and DfT's strategic priorities?

The RSSB R&D Programme has three main strategic priorities: 'safety', 'sustainability' and 'optimisation'. Within these areas, there is a mixture of major research groups (Adhere, Clear, Decarb, Freight, Perform) which have a clear set of specific objectives, and other individual projects which have been loosely grouped together for this evaluation (Staff Health & Wellbeing, Engineering Interfaces Optimisation, Safety Insights & Tools and Other) and have a less formal set of objectives.

There was no evidence that the RSSB R&D Programme was explicitly designed or formally mapped to the RTS and DfT strategic priorities as set out in the DfT Outcome Delivery Plan[3]. For example, the RTS is listed on the RSSB R&D website, but there is no information as to how the RSSB R&D Programme aligns to this. Similarly, during familiarisation interviews, it was unclear from stakeholders how the Programme had been formally aligned to RTS.

However, a mapping exercise between the RTS and DfT priorities and the research groupings used for this evaluation was completed and results shown in Table 11. Broadly, this suggests that the RSSB R&D Programme supports the RTS and DfT priorities through its research with some research groups such as Clear and Decarb aligning to very clear specific objectives and other groups such as Perform addressing multiple industry priorities.

[3] DfT Outcome Delivery Plan: 2021 to 2022, July 2021, https://www.gov.uk/government/publications/department-for-transport-outcome-delivery-plan/dft-outcome-delivery-plan-2021-to-2022#priority-outcomes-delivery-plans

		Department for Transport Priority Outcomes[4]					Rail Technical Strategy Functional Priorities [5]			
	Research grouping	1. Improve connectivity across the UK and grow the economy by enhancing the transport network, on time and on budget	2. Build confidence in the transport network, improve experience, ensuring that the network is safe, reliable, & inclusive	3. Tackle climate change and improve air quality by decarbonising transport	4. Increase global impact	1. Easy to use for all	2. Low emissions	3. Optimised train operations	4. Reliable and easy to maintain	5. Data driven
Already defined before evaluation	**Adhere** - aims to achieve adhesion conditions that are unaffected by and independent of the weather and climate		✓		✓			✓	✓	
	Clear – aims to improve air quality across the network			✓			✓			
	Decarb – aims to decarbonise the network			✓			✓			
	Freight – aims to improve routes & speed of freight, monitoring, maintenance, and decarbonisation	✓		✓	✓		✓	✓		
	Perform – aims to improve performance to run more trains on time today, and future rail performance	✓	✓			✓		✓	✓	
Defined for the purpose of this evaluative	**Staff Health & Wellbeing** - aims at improving occupational health & cultures, mental wellbeing, passenger & public wellbeing & risk of fatigue for drivers		✓			✓				
	Engineering Interfaces Optimisation – aims to optimise engineering interfaces across the industry				✓			✓	✓	
	Safety Insights & Analysis Tools – aims to produce data, insights and analysis to improve the safety of the network		✓		✓	✓				
	Other – a mixture of projects which do not clearly fit into other groupings	No clear overall alignment. Each individual project has its own focus area								

Table 11: Alignment of RSSB R&D Programme to DfT and RTS Strategy

[4] DfT Outcome Delivery Plan: 2021 to 2022, July 2021, https://www.gov.uk/government/publications/department-for-transport-outcome-delivery-plan/dft-outcome-delivery-plan-2021-to-2022#priority-outcomes-delivery-plans

[5] Rail Technical Strategy, October 2020 - https://railtechnicalstrategy.co.uk/

i) How well does the Programme's governance model facilitate the delivery of its aims and objectives?

To evaluate the RSSB R&D Programme's governance model and evaluation questions, an R&D process benchmarking approach was used. The model shown below in Figure 5 is based on PA's understanding of best practice in R&D project and programme management, innovation, and benefits management.

Figure 5: Process bench marking approach.

For each section of the model, an expectation, strengths, weaknesses, and an overall summary has been provided:

Strategic Objective

Expectation: The RSSB R&D Programme has a clear purpose which is understood by its stakeholders. There is clear strategy and defined set of objectives which are aligned to relevant industry strategies and trends.

Strengths:

- The Programme addresses a market failure where there is no clear accountability or where stakeholders are unincentivised to solve issues which they do not directly benefit from. This purpose was described by the majority (15/20) of stakeholders.
- At a high level, stakeholders recognised there is alignment of the Programme to strategic objectives of 'safety' 'sustainability', 'optimisation'. These are the primary drivers for research and evidence is also backed up by the Impact assessment.

Challenges:

- Interviewees were sometimes unclear what type of TRL research the Programme aims to address. Some (4/20) expressed frustration that the Programme wasn't delivering "solutions" or "trials". RSSB delivers a mixture of TRL research (typically lower end). Due to the expensive nature of high TRL research, the RSSB R&B Programme is more suited and impactful with low TRL research.
- It is not always clear how the overall portfolio of projects is balanced to deliver against its strategic objectives. Interviewees do not always understand the 'bigger picture', the direction of the Programme or breakdown of projects within each strategic objective. Throughout the evaluation it took considerable effort and data manipulation to get a clear view of the distribution of the projects across the Programme.
- The Programme is not explicitly designed or formally mapped to the RTS, DfT strategic priorities and industry priorities. For example, the RTS is listed on the RSSB website but there is no information as to how the RSSB R&D Programme aligns to this. However, when reviewing the research groupings, analysis shows there is broad alignment.
- 'Client' visibility (e.g., towards DfT) on the Programme's priorities, spending breakdown, prioritisation of research and decision making is less clear. No overall programme level dashboard was observed or clear documentation explaining the overall programme structure.

Summary: There is a common understanding of the purpose of the Programme. It addresses a market failure where there is no clear accountability, where stakeholders are unincentivised to solve issues which they do not directly benefit from, it benefits the entire rail ecosystem and enhances safety, sustainability, and optimisation of the rail network. However, there is a lack of clarity on the strategic objectives and direction of the Programme and therefore how the Programme is structured to support this. It is not straightforward to obtain a clear view of the distribution of projects across the Programme.

R&D Entry Management

R&D Entry Management 2

Expectation: The RSSB R&D Programme has clear processes to identify ideas from steering groups, test the value through key criteria, reject low value propositions, prioritise a pipeline of projects, set up high potential projects and, assign sponsors and budgets for delivery.

Strengths:

- Stakeholder interviews confirmed there were multiple mechanisms to input new ideas and generate challenge statements such as industry working groups, research competitions, academic partnerships, collaboration events. Details of these mechanisms can also be found on the RSSB website.
- Project lifecycle documentation has been reviewed which shows a comprehensive entry and selection process to assess eligibility, attractiveness, and timing of research ideas to guide decisions on which project to progress.

- As part of the Idea Generation Meeting, existing research is reviewed to avoid duplication and incorporate lessons learned. A delivery plan and risks are also presented and discussed.
- Often industry sponsors and 'end customers' are engaged from the outset to develop project requirements. Stakeholder interviews indicated that in these cases research is more likely to be implemented/adopted.

Challenges:

- Interviewees are sometimes unclear how projects are prioritised. Sometimes it was felt "RSSB drives prioritisation rather than being industry led". This is linked to clarity over the strategic priorities with 35% raising concerns or confusion with alignment. Project documentation shows the use of a 'strategic fit' criterion, but it is unclear how this aligns to the RTS and industry priorities and used in the selection process.
- Projects always have an industry sponsor, but sometimes the 'end customer' is not involved in the research to help shape the project requirements. Where this is the case, projects are less likely to be implemented/adopted.
- Visualising and articulating project benefits is less effective. Communication aids such as benefit maps or benefits hierarchy are not produced during the project life cycle.
- 'Knowledge Products' projects lacked a benefit-cost ratio which RSSB linked to the early stage of the research and lack of clear route to implementation. While this is often the case with early-stage research, techniques such as sensitivity analysis to calculate minimum improvement required to achieve a positive benefit-cost ratio or creating specific use case boundaries within the size of opportunity, would help provide confidence that the investment is value for money.

Summary: The Programme has an effective entry management process which includes generating ideas from multiple sources, selecting, and involving industry sponsors, assessment of projects against key criteria and reviewing existing research. Although research is assessed using a 'strategic fit' stakeholders found it was less clear how this aligned to wider industry priorities and what it meant for prioritisation. Where the end customer is involved at the outset of the project, the projects tend to be adopted/implemented more effectively. Benefits management could be improved using techniques such as sensitivity analysis to calculate minimum improvement required to achieve a positive benefit-cost ratio or creating specific use case boundaries within the size of opportunity.

R&D Delivery

R&D Delivery 3

Expectation: The RSSB R&D Programme has a clear, consistent delivery lifecycle which is aligned to best practice (e.g., Association for Project Management (APM) and TRLs). There are multiple delivery mechanisms, continuous engagement and communication with stakeholders, governance and stage gate reviews, and risk and issue management processes.

Strengths:

- Comprehensive project life cycle management including defined gate process for delivery. This was evidenced in the project documentation and flow charts for delivery.
- Approval and change process in place with varying levels of authority.
- Multiple delivery mechanisms such as strategic partnerships, internal delivery, open procurement – one stakeholder interviewed who delivered the research said the Programme was “by far the best research programme” in terms of delivery and governance.
- Skills, expertise, and support in place to deliver high quality outputs.
- Projects address project aims and answer research challenges. All case studies demonstrated that the research met their intended aims.
- Effective communication of progress to stakeholders. All stakeholders interviewed and involved in research mentioned receiving updates on the progress of the project.

Challenges:

- Projects are often designed in stages and managed separately. There is no clear way to link projects together so there is a risk of losing track of what projects are related. Also, this means the tracking of risk, costs and benefits is less clear due to the separate management.

Summary: The Programme has strong project level management, with a defined project life cycle and good capabilities for delivery. Projects are typically well scoped and delivered on time and on budget. Interviewees who are involved in the project have clear visibility and are engaged with throughout the process. As projects are often designed in stages and managed separately, there is a risk that costs, and benefits are not effectively monitored.

R&D Exit Management

R&D Exit Management 4

Expectation: The RSSB R&D Programme effectively closes successful projects and communicates value to stimulate implementation or terminates failing projects early and learns lessons effectively. The Programme effectively monitors implementation and benefits realisation.

Strengths:

- A lessons learnt process is in place for inputting into future project selection and sharing of lessons to industry. Several case studies demonstrate knowledge being fed back into the Programme and informing future research.
- Capability and processes are in place to stop projects not delivering their expected outcomes.
- Research outputs communicated and shared to industry (at a minimum the sponsoring industry working group). All case studies evidenced the research was shared with the relevant working group.
- All projects are stored on SPARK, RSSB's online database of research.
- Implementation and benefits realisation process in place

Challenges:

- Although the outputs are generally communicated with stakeholders, the ability to adopt/implement was identified as a challenge by 9/20 of stakeholders. It was found the communication of the benefits was less effective and incentives/roadmap for industry to adopt were sometimes unclear.
- There is no ability to link related projects together and complete follow-on projects without setting up a new project. This means there is a risk that benefits could be double counted or overestimated. Given the timescale and focus of the evaluation, we have not been able to validate this.
- Unable to track and monitor all projects and support implementation which is driven by lack of resource. Out of 444 RSSB R&D projects that were closed from 2013 (when implementation tracking commenced) 72 projects were reported by the Programme to have been implemented in full or be in advanced stages of implementation, and 102 were in initial stages or in planning of implementation. This means some projects which go on to have real world applications may be missed and success not communicated with key stakeholders. This is currently driven by resource restraints.

Summary: The Programme can learn lessons from previous projects and stop or alter projects which are not meeting value or expectations. Although research outputs are always shared with the industry sponsors, the Programme is less effective at communicating the benefits, making the outputs more accessible to industry, and stimulating implementation. Tracking projects through implementation is a challenge due to resource restraints.

j) What lessons have been learnt from the Programme about what works well and less well in supporting R&D in the Rail sector?

This evaluation has identified several lessons from the RSSB R&D Programme which can help support and inform future R&D in the Rail sector. We have used findings from across stakeholder interviews and case study analysis to highlight the key learnings. These are summarised below:

Early-stage R&D - The evaluation has highlighted the importance and need of early-stage R&D capability within the rail industry – this is currently being fulfilled by the RSSB R&D Programme. The rail industry requires an evidence base to make informed, data-driven decisions about the future technologies, market trends and industry challenges. For example, the Programme is creating new knowledge, insights and an evidence base for the topic of sustainability. This is helping shape the industries response.

Independence – The presence of an independent body in the current industry context such as RSSB that can drive research into areas that may not be immediate priority for individual organisations and creating a source of non-proprietary knowledge across organisations was seen as key by stakeholders. Independence was also viewed as a source of credibility and trustworthiness for key decisions to be based on.

Collaboration – Due to the structure of the rail industry, collaboration is essential for R&D. Cross-industry working groups are key to facilitating collaboration which the RSSB R&D Programme has demonstrated. While having funding for cross-industry working groups is not essential, it allows them to test, research, and understand industry challenges more effectively. Some stakeholders felt working groups would become “talking shops” if there was no mechanism to research industry challenges.

Academic strategic partnerships – The RSSB R&D Programme has established several strategic partnerships with universities. This model has been very effective at delivering impactful research with multiple real-world examples delivered by this model being cited by stakeholders. Similarly, the University of Huddersfield (a strategic partner) is using 3 projects from the RSSB R&D Programme in their Research Excellence Framework submission – a UK wide academic assessment of research impact. Benefits of the partnership model are:

- Flexibility of being able to complete follow on research and easily shape requirements.
- Ability to take on projects which could not be delivered commercially as too uncertain.
- Longevity and certainty to help build up SME knowledge and expertise.

Customer-led research – When there is clear focus on the end customers/users and they are involved in the research from the outset, stakeholders felt projects were more impactful and easier for industry to adopt. This highlights the need for R&D to be customer-led and ensure it meets their requirements. Early engagement of industry sponsors and end customers in project scoping and research specification, facilitates effective direction and focus of resources.

Articulating benefits – Implementation and adoption of research was identified as a key challenge by stakeholders. Poor communication of value and benefits of research leads to low incentivisation from industry to adopt or implement change. R&D needs to be able to clearly articulate the benefits to firstly ensure the research is a good investment and

secondly incentivise stakeholders to implement/adopt the research by effectively communicating.

Understanding the wider ecosystem – There was a lack of clarity from stakeholders on 'who does what' across various organisation delivering R&D in the Rail sector. It is important to map out the ecosystem to ensure stakeholders are aware about how research moves through the Technology Readiness Levels and which organisation is best suited to support. The requirements of late-stage research, for example operational trials, is very different to 'blue sky thinking'.

k) What lessons can be learnt from the Programme about monitoring and evaluating R&D in the Rail sector?

Three key lessons about monitoring and evaluating R&D in the Rail sector have been identified from the RSSB R&D Programme:

Need for aligned Programme structure around strategy and purpose: At the start of the evaluation, a theory of change was developed collaboratively with DfT and RSSB. This was the first time this exercise had been formally completed and it helps articulate and document the rationale, objectives and intended outcome of the Programme. Without this it is challenging to understand the success measures and therefore complete an evaluation.

Need for consistent data frameworks and collection: Being able to reliably provide consistent data against agreed frameworks across the portfolio. At times it has taken considerable effort and manipulation to make data usable and relevant for the purposes of evaluation. For example, it has not been possible to complete a programme level value for money assessment of the RSSB R&D Programme due to gaps in benefit data and inconsistent framework for benefit realisation timelines. Similarly, due to not linking related and follow-on projects, it was challenging to trace projects from start to finish and their subsequent impact.

Need for programme evaluation before, during and after programme delivery: This is the first formal evaluation since the RSSB R&D Programme began in 2001. A more effective feedback loop and regular monitoring should be established to incorporate feedback and lessons learnt into the Programme ongoing. Government best practice suggests evaluations should take place before, during and after to ensure that interventions are as effective as possible.

4. Conclusions

The evaluation was completed from the 10th January to the 21st March 2022.

The research questions (specified in Section 2.2) were answered based on a comprehensive dataset, including review of over 1800 projects' data, 10 semi-structured familiarisation interviews with DfT and RSSB, 20 semi-structured interviews with leaders and representatives of relevant industry working groups, 13 case study deep-dive interviews with project beneficiaries and a review of publicly available documents such as standards, policies, and strategies.

Based on this evidence, the research questions have been answered as follows:

Impact

a) To what extent has the Programme achieves its expected outcomes?

- The Programme has achieved its strategic aims of addressing a market failure in industry, and it has adapted to meet industry challenge. However, there is a lack of clarity on overall strategic direction, and alignment across the Programme to industry priorities, with no clearly articulated and published strategic purpose.
- There is no consensus from stakeholders on expectations of the level of TRL that should be delivered within the Programme.
- Outputs are broadly high quality and provide new insights to industry. Outputs are shared with sponsoring industry working groups, but wider industry communication is not as effective as it could be, and some outputs are not tailored for end customer implementation.
- The Programme has improved industry understanding of research challenge areas, especially when providing a knowledge base, developing toolkits and frameworks (lower TRL products) with evidence of these being utilised and delivering the desired impact. There was less evidence of implementation of later stage products (higher TRL).
- The Programme has taken on feedback from the industry and learnt from previous research. These lessons have been shared with industry stakeholders.

b) What evidence is there that the outcomes were caused by the Programme and not by other factors?

- The Programme has been a significant cause of change, contributing and enabling outcomes across industry. Other factors have also played a critical role such as these factors include policy decisions, outputs from other research bodies, and wider industry events.

c) What direct and indirect impacts has the Programme had so far?

- The Programme has directly improved safety in the GB rail network over the last 10-15 years; driving a cultural shift and providing data, tools, and knowledge to enable change. It has been seen as one of the main contributors of the current safety culture and maturity in the network.
- More recently, the Programme has also significantly improved sustainability in the industry (last 5 years), through increasing awareness, insight and focus on key challenge areas. Multiple stakeholders have highlighted that without the contribution of the RSSB R&D the railway would not be as mature or able to deliver against its sustainability commitments as it is today, quoting carbon costing and air quality monitoring as success stories. It was even highlighted how their impact on sustainability in rail today is comparable to the work they led in rail safety in the past.
- The Programme has also enabled significant improvements to optimisation through products and process, though this was of a cultural shift in comparison to safety and sustainability.
- The Programme has indirectly led to significant improvements across the UK rail network, improving the general body of knowledge, collaboration and building skills in the industry to some extent developing the talent pool.

d) To what extent have the Programme's outputs led to real world applications of research?

- Many Programme outputs have led to significant real-world applications, which were cited across stakeholders. There are wider challenges facing the implementation of products, standards, and processes by industry, with some inconsistencies in monitoring of implementation. However, to some degree this is outside of the remit of the RSSB R&D Programme, as their responsibility ends once successful R&D is delivered.

e) To what extent have the Programme's outputs influenced relevant senior decision makers?

- Outputs from the Programme have indirectly influenced senior decision makers across industry, most notably when providing data backed insights, to support cases for change, business case development and drive further industry focus.

Value for Money

f) What is the estimated benefit-cost ratio of the Programme so far?

- It has not been possible to calculate a benefit-cost ratio for the overall Programme, and there were challenges in accurately quantifying the overall expected benefits from the Programme due to incomplete and inconsistent data across the Programme. This is in part due to the way the Programme is currently structuring and recording its data which does not enable to easily create a programme level benefit-cost ratio.
- Changes to the Programme have subsequently been made (2020) including collecting programme level benefit realisation timelines, which should allow a benefit-cost ratio to be calculated in the future at least for projects with 'Tangible Products'.

g) What is the estimated value-for-money of the Programme so far?

- Case study evidence indicates it is likely that projects across the Programme do provide value for money and a positive return on investment, although it has not been possible to quantify this at programme level.
- In its current context, the Programme brings unique value to the rail industry through its independence, technical expertise and academic focus, and cross-industry structure and input. Without the Programme there would be a significant loss of value in these areas.
- The Programme has co-funding partners, including universities and commercial partners, which reduces its overall risk exposure, and is seen to drive private sector investment in R&D.

Process

h) How well does the Programme align with the Rail Technical Strategy and DfT's strategic priorities?

- The RSSB R&D Programme has three main strategic priorities: 'safety', 'sustainability' and 'optimisation'. We found no evidence that the RSSB R&D Programme was explicitly designed for, or formally mapped to, the RTS and DfT strategic priorities. However, our mapping broadly suggests that the Programme supports the RTS and DfT priorities through its research.

i) How well does the Programme's governance model facilitate the delivery of its aims and objectives?

- There is a common understanding of the purpose of the Programme. It addresses a market failure where there is no clear accountability, where stakeholders are unincentivised to solve issues which they do not directly benefit from. There is, however, a lack of clarity across stakeholders on the Programme's strategic objectives and direction, and limited visibility on how the structure of the Programme supports these.
- The Programme has an effective entry management process which includes generating ideas from multiple sources, selecting, and involving industry sponsors, the assessment of projects against key criteria and reviewing existing research. It was less clear to stakeholders how the prioritisation approach aligned with wider industry priorities. Where the end customer is involved at the outset of the project, projects tended to be adopted or implemented more effectively. Benefits monitoring

and reporting could be improved to ensure appropriate balance of investment, as well as clear communication of research value to stakeholders.

- The Programme has strong project-level management, with a defined project life cycle and good capabilities for delivery. Projects are typically well scoped and delivered on time and on budget. Project stakeholders have clear visibility and are consulted throughout the process. As projects are often designed in stages and managed separately, there is a risk that costs and benefits are not effectively monitored, with overlap of projects leading to miscalculations.
- The Programme learns lessons from previous projects and has process to stop or alter projects which are not value for money. Although research outputs are always shared with the industry sponsors, the Programme is less effective at communicating the benefits, making the outputs more accessible to industry, and stimulating implementation.

j) What lessons have been learnt from the Programme about what works well and less well in supporting R&D in the Rail sector?

The following lessons can be learnt from the evaluation of the Programme:

1) The need for early-stage R&D capability within the rail industry,
2) The importance of an independent body in the current structure,
3) The requirement for collaboration,
4) The strength & value of academic partnerships,
5) The value of customer led research,
6) The need for clear articulation of benefits and,
7) The need for clarity in understanding the wider R&D rail ecosystem.

k) What lessons can be learnt from the Programme about monitoring and evaluating R&D in the Rail sector?

We have identified three lessons about monitoring and evaluation for R&D in the Rail sector:

1) Need for aligned Programme structure enabling balance of projects and focus areas to be monitored, in relation to strategy objectives,
2) The need for consistent data frameworks and collection and,
3) The need for Programme evaluation before, during and after programme delivery.

Annexes

Annex A: Justification of Methods

Literature Review of Research & Development Evaluation Approaches

A review of methods was conducted in order to select the most appropriate method for evaluation of the RSSB R&D Programme impact. Impact evaluation approaches explore how knowledge, products or services generated from the research and development, disseminate amongst its target population, and more widely approaches assess the value generated by the knowledge, products, or services. A wide variety of approaches are used to evaluate the impact of research and development, which make use of both experimental and non-experimental methods. Common research and development, outputs that are used to form the basis of evaluations include “(1) bibliometrics; (2) patents; (3) peer-review; (4) economic and financial metrics; and (5) process-outcomes.” (Geisler, E. (2002)).

Ruegg and Jordan provide a comprehensive summary of research and development evaluation using quasi-experimental and theory-based approaches (Ruegg, R. and Jordan, G., (2007)). Their summary describes quasi-experimental econometric methods that compares impact with a constructed counterfactual, to estimate effect size and prove attribution. For example, Ruegg and Jordan describe a research study that constructs a production function using inputs such as the number of patents generated by firms, firm-level research and development spending and intensity of participation in research consortia to measure the impact on research productivity of participation in government-funded research. Such approaches can provide valuable insight into the scale of impact. However, they treat the intervention as a black box which does not provide the opportunity to explore how change is generated and its potential range of causes.

By contrast, theory-based approaches to impact evaluation provide more opportunity to learn not only whether an impact has been caused, but how an intervention has caused the impact. Theory-based methods summarised by Ruegg and Jordan include peer review, bibliometric methods, and network analysis, to show that knowledge has been created and disseminated. Technology commercialisation tracking and historical tracing methods as well as cost-benefit methods, are described to estimate the cumulative net benefits of the program. The case study method is identified as valuable “to shed light on how innovation occurs, why certain decisions are made, and why some processes work better than others” ((Ruegg and Jordan (2007), p.61).

For the purpose of the current evaluation, the theory-based approach of contribution analysis was used to evaluate impact. Two considerations on using contribution analysis with the RSSB evaluation are: (Simister, N. et al. (2017)).

1. The method is supposed to be iterative to refine the assumed theory of change and explore alternative explanations behind the outcomes that occur. The RSSB Evaluation has a fixed timescale and therefore theory of change iterations are limited. Evaluators are managing this challenge by testing findings with stakeholders and conducting internal evaluation reviews within the timescale available.
2. The method does not aim to develop alternative theories of change and so is less useful for experimental interventions.
    - Evaluators do not expect to need to develop alternative theories of change for the RSSB Evaluation. The theory of change for the Programme as a whole assumes an expected causal pathway to increase knowledge and innovation, even though the RSSB Research and Development Programme projects research experimental interventions and approaches.

Research Quality & Level of Confidence

Mayne, the developer of contribution analysis, argues the level of confidence behind addressing the cause-effect question "needs to 'fit the purpose', i.e., be what is needed for the purpose at hand" (Forss et al (2011), p.65).

To increase confidence in the research findings, evaluation research techniques have been employed to establish trustworthiness in the research findings. Trustworthiness, or the degree to which findings can be trusted and used for qualitative research as an alternative to 'rigour', is devised of four criteria that can be compared to the concepts of internal and external validity (Lincoln and Guba (1985), Cameron (2011)). These criteria are:

- **Credibility**: Confidence in how congruent the findings are with reality.
- **Transferability:** Availability of sufficient data and context to show the findings apply in other contexts.
- **Dependability:** Documentation of methods sufficient so the findings can be replicated.
- **Confirmability:** Documentation of findings and analysis sufficient to show the basis of the conclusions is the available evidence instead of researcher bias.

Table 12 summarises strategies employed to strengthen the RSSB evaluation against these four criteria (Korstjens and Moser (2018)).

Trustworthiness criteria	Strategies to improve research quality and trustworthiness
Credibility	• Data triangulation – Data gathered from different types of stakeholders: RSSB staff, DfT staff & industry as well as project documentation and publicly available sources. • Investigator triangulation – at least two researchers were making coding, analysis and interpretation decisions following interviews. • Method triangulation – Process evaluation and Cost-Benefit analysis to provide alternative perspectives on impact evaluation. • Member checking throughout interviews (i.e., respondent validation). – validating stakeholder responses through re-stating or clarifying to determine accuracy and improve credibility. • Findings, interpretations, and conclusions are fed back to DfT to assess adequacy of data and preliminary results.
Transferability	• Sampling approaches. • Randomised sampling for project selection. • Purposive sampling for interviewee selection.
Dependability	• Transcription of all Interviews using Microsoft Teams. • Fully referenced data sources.
Confirmability	• Audit trail of logs and records from research. • Transcription of all interviews using Microsoft Teams. • Fully referenced data sources.

Table 12: Strategies to improve research quality and trustworthiness.

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Annex B: RSSB R&D Programme Theory of Change - Assumptions & Details

The RSSB R&D Programme theory of change was established and developed in collaboration with RSSB and DfT stakeholders drawing on strategic documentation of the Programme, early reviews of programme output, and through several remote workshop sessions with RSSB and DFT stakeholders.

The theory of change is based on RSSB outputs, outcomes, and impact and aims to represent the relationship between the research programme output and the rail industry outcomes, along with consideration of enablers, barriers, and wider context. As part of establishing the theory of change, the following headings were used to identify, develop, and refine the assumed causal journey from programme output to impact delivery:

Theory of change headings	Description	Evaluation Assumptions or considerations
Project Themes	Research theme category, or challenge area with a common overall objective and/or common group of stakeholders.	• Level 1 sample provides adequate representation of projects to appropriately define the research themes for purpose of logic mapping. • All themes/categories deliver all types of outputs.
RSSB Output	Outputs produced by RSSB research projects.	• Outputs based RSSB project data bases of reported output – and for purposes of evaluation grouped into broader categories. • Where possible categories have been aligned to Technology Readiness Levels (TRL). • Definitions are as follows of the different outputs: ○ **Case studies & Use Cases** – a descriptive and exploratory analysis of a person, group or item or a description of

		how a person who uses a process or system will accomplish a goal. ○ **Policy recommendations & Roadmaps** – Information which government will use to inform policy or roadmaps which show how a technology or process will develop over time. ○ **Frameworks** – an established system of rules, ideas, or beliefs that is used to plan or decide something. ○ **Assessments** – an evaluation using an established system of rules, to determine an outcome. ○ **Reports, presentations and guidance** – 'a written account of something that one has observed, heard, done, or investigated. A verbal report disseminated with illustrative material. ○ **Prototypes and Products** – An original, full-scale, and usually working model of a new product or new version of an existing product. ○ **Toolkits and models** – a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. Or a set of tools/activities to achieve a goal/objective. ○ **Process Recommendations** – a method or technique that has been generally accepted as superior to any alternatives because it produces results that are superior to those achieved by other means.
Outcomes	Changes that have occurred due to outputs (after roughly 1 – 3 years).	• Outcomes include both direct (e.g., change to standards) and indirect outcomes (e.g., increase collaboration) • Outcomes include short term outcomes (e.g., increase in understanding) and long-term outcomes (e.g., new capability adopted).
Impact	Long term benefits that have been delivered (after roughly > 3 years).	• Impacts have been tailored from the best practice Network Rail R&D portfolio and aligned with the RTS.

Strategic Objectives	Overall strategic objectives of the programme (safety, sustainability, optimisation).	• Strategic objectives of programme based on document review and familiarisation interviews with RSSB and DfT stakeholders at start of evaluation.

Table 13: RSSB R&D theory of change headings, descriptions, and assumptions.

Annex C: Stakeholders Interviewed & Questions

Stakeholders Engaged

Below is a list of the number of stakeholders who were engaged with throughout this evaluation. This was through the familiarisation interviews, Level 1 interviews, or case study interviews.

Stakeholder group	No. of stakeholders
DfT	8
RSSB	11
Network Rail	7
Industry Bodies (RDG, RFG, etc.)	3
Train Operating Companies / Freight Operating Companies	8
Rolling Stock Companies (ROSCOs)	4
Academia	3
Other (e.g., TfL, rail scheme delivery)	2

Table 14: Stakeholders engaged with through the evaluation.

Familiarisation Interview Questions

Strategy – *Understanding the RSSB cross-industry rail research programme's 'research focus and journey', strategic objectives and broader industry alignment*

1. What are the Programmes strategic outcomes / primary research drivers and how are these formed?
2. How does the Programme align with the RTS & DfT & customer's strategic priorities?
3. Are there any other inputs into the strategic outcomes & high-level direction of research?
4. How is the portfolio of projects balanced across strategic outcomes?

5. How has the Programme evolved since its inception? (Considering Programme maturity etc.)

Governance – *Understanding the governance processes in place, both at a programme level and project level*

6. What is the Programme structure and how does it align to strategic objectives?
    - What are the key Programme workstreams?
    - How do you decide on continued workstreams, growth workstreams and new workstreams?
7. What is the project lifecycle within the Programme?
    - What is the entry & selection process for projects?
    - How are projects prioritised both initially and during delivery?
        - Is there an exit process for projects which are not delivering value?
    - How do you capture and embed lessons learnt from projects?
    - How do projects progress to implementation?
    - What monitoring is currently in place to track through their lifecycle?
8. How do you manage accountabilities and responsibilities throughout the project lifecycle?
9. How do the rail industry Readiness Levels impact the project lifecycle?
10. What tools are used to support the process (across governance)?

Frameworks, Data & Metrics – *Understanding how the Programme identifies, quantifies, and tracks benefits*

11. How do you estimate, quantify and track impact/benefits?
12. How do you track and monitor and track implementation?
13. How does Value for Money and Impact influence programme governance, prioritisation and balancing the portfolio?

Stakeholder Interview Questions

Introduction & Role
What is your name, role, and involvement with the RSSB Programme, both present and historically?

Expected outcomes

1. What is the purpose of the RSSB R&D Programme?
2. What kind of challenges is the RSSB R&D Programme suited to the address?
3. How does your working group engage with RSSB and influence which projects to pursue?
4. What are typical outputs which you receive from RSSB? (e.g., Knowledge reports, frameworks, toolkits & prototypes etc.)

5. Who decides and how do you receive the outputs?
6. What happens once you receive them?
7. Why do are do you feel some RSSB projects are more impactful than others?
8. What happens to the outputs in the longer term?
9. Do you think the outputs had any influence on your research group? Why do you think that (what changes observed?)
10. Have any of the outputs led to any unexpected outcomes? (Examples welcome)
11. How (effective) is receiving information and updates about relevant research projects from the Programme? –Have you received info and updates about relevant research projects? Were these updates used, and if so, how?
12. How do you provide feedback on the research projects?

Influence on decision making

1. How do research outputs get shared with senior stakeholders across industry?
2. Is the research used by industry stakeholders to make decisions? If so, what kind of decisions, and by whom?

Direct and indirect impacts

1. What kind of changes have you observed in the Rail Network in:
    - Safety.
    - Sustainability.
    - Optimisation.
2. What have been the main drivers for these changes?
3. Do you feel there has been increase in collaboration, an increase in the talent pool and increased body of knowledge or any other indirect impacts

Real world research applications

1. Are there any examples of RSSB research or projects which have had a significant impact in your industry and/or real-world application (e.g., key decision making, policy adoption, process adoption etc.)? What was the size of this impact?

Contributing factors

1. What other entities besides RSSB conduct Rail Network Research, and how do they compare to RSSB?
2. Can you describe some of the relevant major developments in the UK Rail Network relevant to your research grouping over the last 10 years – (how has RSSB impacted those developments?)

Do you have any further comments about the RSSB R&D Programme?

Annex D: Projects Selected for Evaluation

Overview of RSSB R&D Projects

Project Status	Projects starting pre 2016	Projects starting post 2016	Total
Closed or completed	464	304*	768
Active / In progress		88	88
Awaiting schedule / contract / on hold		5	5
Evaluation		1	1
Legacy	213		213
Proposal - awaiting approval / Pending info		51	51
Proposal Withdrawn by applicant		14	14
Rejected, not approved, cancelled	484	65	549
Grand Total	1161	528	1689
*Minus 113 initially excluded where management activities or funded elsewhere. (304 projects selected for group sample)			

Table 15: Total RSSB Projects Reviewed.

Group Review – Selected Projects

The below table shows all projects included within the group analysis component of this evaluation. Group level analysis and findings can be found in Annex E.

EVALUATION RESEARCH GROUP: ADHERE

Project Reference Number	RSSB Database Source	Project Name	Project Start	Project Finish	Output Category (grouped for evaluation)	Implementation Data Output	RSSB Rated as Significant	Furthest Implantation Status
T1153	BPL	T1153 - Lineside Vegetation Management Review	07/06/2018	28/05/2019	Process recommendations	Lineside Vegetation Management Review	Significant	Full
COF-AUT-02	BPL	COF-AUT-02 - ADHERE - Extended use of moisture sensors	01/04/2019	21/02/2020	Case studies & use cases	ADHERE: Autumnsense - Extended use of moisture sensors	Significant	Advanced
COF-DART	BPL	COF-DART - ADHERE - Quantifying the effects of Railhead Treatments on adhesion	04/01/2019	10/05/2019	Case studies & use cases	ADHERE: Quantifying the effects of Railhead Treatments on adhesion	Significant	Initial
COF-TAR-03	RMC-C	Adhesion Riddle Feasibility Study on the use of Dry-ice for Rail Head Cleaning	22/03/2016	30/06/2015	Case studies & use cases	Adhesion Riddle Feasibility Study on the use of Dry-ice for Rail Head Cleaning (UoS)	Significant	Initial
COF-LAD	BPL	COF-LAD Correlating low adhesion and dwell times	29/06/2020	26/03/2021	Reports, presentations, guidance & standards	Correlating low adhesion and dwell times	Significant	Further R&D
COF-TAR-02	RMC-C	Feasibility study into non-contact ultrasonic cleaning to address the Adhesion Riddle	22/03/2016	17/12/2015	Case studies & use cases	Feasibility study into non-contact ultrasonic cleaning to address the Adhesion Riddle (UoSS)	Significant	Planning
IMP-T1107	BPL	IMP-T1107 - Piloting Double Variable Rate Sanders on the GB mainline	01/01/2018	19/03/2021	Prototypes & product specs	ADHERE: Piloting DVRS on the GB mainline	Significant	Initial
COF-E14-02	RMC-C	High resolution leaf fall monitoring and low adhesion forecasting	22/03/2016	19/07/2019	Toolkits & models	High resolution leaf fall monitoring (Linked to COF-TAR-01)	Significant	Planning
COF-E14-01	RMC-C	Using tribo-chemistry analysis to understand low adhesion in the wheel/rail contact	22/03/2016	31/05/2018	Reports, presentations, guidance & standards	Tribo chemistry analysis to understand low adhesion in wheel rail contact	Significant	Further R&D
T1149	BPL	T1149 - ADHERE - Further Development of Modelling the Effects of Low Adhesion Mechanisms	01/01/2018	05/06/2020	Toolkits & models	ADHERE: Further Development of Modelling the Effects of Low Adhesion Mechanisms	Significant	Planning
T1181	BPL	T1181 - ADHERE - In-service benefits to railhead treatments	01/04/2019	19/03/2021	Prototypes & product specs	ADHERE - In-service benefits to railhead treatments	Significant	Initial
COF-UOH-48	RMC-C	ADHERE: LABRADOR model validation and improvement	19/12/2018	17/01/2020	Toolkits & models	ADHERE: LABRADOR model validation and improvement	Significant	Initial
COF-UOH-12	RMC-C	Development of a Low Adhesion Braking Dynamic Optimisation for Rolling Stock (LABRADOR)	22/03/2016	10/03/2018	Toolkits & models	Low Adhesion Braking Dynamic Optimisation for Rolling Stock (LABRADOR)	Significant	Advanced
COF-BRP	BPL	COF-BRP - ADHERE - Use of step 2 brake applications in low adhesion	01/04/2019	26/03/2021	Case studies & use cases	ADHERE - Use of 2-step brake applications in low adhesion		Not Monitored
COF-UOH-63	RMC-C	ADHERE: Improved wheel rail adhesion calculation using the sander trial data	05/05/2020	22/01/2021	Case studies & use cases			
COF-UOH-35	RMC-C	Incorporation of WILAC low adhesion contact model in LABRADOR	05/04/2017	21/09/2018	Toolkits & models			
COF-TAR-01	RMC-C	Towards a high resolution 'Internet of Things' moisture detection system for railways	22/03/2016	15/05/2015	Case studies & use cases			
COF-FCA-03	RMC-C	Feasibility of integrating operational data with adhesion forecasts	16/01/2019	31/07/2020	Assessments & frameworks	Feasibility of Integrating Operational Data with Adhesion Forecasts		Further R&D

COF-FCA-02	RMC-C	Setting the Verification Standard for Adhesion Forecasting - Case Studies: Stagecoach Supertram and Arriva Rail North	14/01/2019	28/02/2020	Reports, presentations, guidance & standards	Setting the Verification Standard for Adhesion Forecasting - Case Studies: Stage Coach Supertram and Arriva Rail North	Not Monitored
COF-DART-01	RMC-C	ADHERE: Quantifying the effects of Railhead Treatments on adhesion	30/08/2018	29/03/2019	Assessments & frameworks		
COF-BIO-01	RMC-C	PhD Studentship: Biochemistry of Leaves	21/02/2017	29/11/2019	Reports, presentations, guidance & standards	PhD Studentship: Biochemistry of Leaves	Not Monitored
COF-AUT-01	RMC-C	ADHERE: Autumnsense - Wet rail monitoring using a network of sensors to improve autumn resilience	18/07/2018	31/12/2019	Prototypes & product specs	ADHERE: Autumnsense – Wet rail monitoring using a network of moisture sensors to improve autumn resilience	Further R&D
COF-ARW-12	RMC-C	Rail Adhesion Monitoring System	22/03/2016	30/04/2015	Assessments & frameworks		
COF-UOH-32	BPL	COF-UOH-32 - Dependable Speed Measurement for Improved Low Adhesion Braking	26/07/2021	06/01/2022	Reports, presentations, guidance & standards		
COF-UOH-46	BPL	COF-UOH-46 - Sanders trial data analysis	01/01/2018	06/01/2022	Prototypes & product specs	Sanders trial data analysis	Not Monitored
COF-UOS-02	BPL	COF-UOS-02 - ADHERE - Neural Network-Based Regression for Local Adhesion Estimation	01/05/2019	08/05/2019	Toolkits & models		
COF-UOS-03	BPL	COF-UOS-03 - ADHERE - Sand consist changes for improved track circuit performance	27/02/2020	27/03/2020	Reports, presentations, guidance & standards		
T1156	BPL	T1156 - ADHERE - Managing driver behaviours through adhesion-related information flows	06/08/2018	24/06/2019	Reports, presentations, guidance & standards	ADHERE: Managing driver behaviours through adhesion-related information flows	Initial
T1159	BPL	T1159 - ADHERE - Evaluating variability in train driving under different adhesion conditions	14/08/2018	02/09/2019	Assessments & frameworks	ADHERE: Evaluating variability in train driving under different adhesion conditions	
COF-ITR-01	BPL	Lubrication and friction modifier optimisation	26/07/2021	26/07/2021	Process recommendations		
COF-TAR-04	RMC-C	Improving rail wettability	22/03/2016	24/12/2015	Assessments & frameworks	Improving rail wettability (TRL)	Not Monitored
EVALUATION RESEARCH GROUP: CLEAR							
Project Reference Number	**RSSB Database Source**	**Project Name**	**Project Start**	**Project Finish**	**Output Category (grouped for evaluation)**	**Implementation Data Output**	**RSSB Rated as Significant**	**Furthest Implantation Status**
T1122	BPL	T1122 - Research into air quality in enclosed railway stations	30/04/2018	26/04/2019	Reports, presentations, guidance & standards	Research into air quality in enclosed railway stations	Significant	Initial
T1186	BPL	T1186 - CLEAR - Rail air quality mapping	21/06/2019	22/04/2021	Toolkits & models	CLEAR - Rail air quality mapping	Significant	Initial
T1187	BPL	T1187 - CLEAR - Fleet wide assessment of rail emissions factors	17/06/2019	25/03/2021	Assessments & frameworks	CLEAR - Fleet wide assessment of rail emissions factors	Significant	Initial
T1232	BPL	T1232 - CLEAR - Rail standards review for air quality	24/05/2020	29/09/2021	Reports, presentations, guidance & standards			
T1190	BPL	T1190 - CLEAR - Assessment of air quality at depots	21/06/2019	04/01/2022	Assessments & frameworks			
T1191	BPL	T1191 - CLEAR - Air quality personal monitoring	21/06/2019	15/06/2021	Assessments & frameworks			
EVALUATION RESEARCH GROUP: DECARB								

Project Reference Number	RSSB Database Source	Project Name	Project Start	Project Finish	Output Category (grouped for evaluation)	Implementation Data Output	RSSB Rated as Significant	Furthest Implantation Status
T1145	BPL	T1145 - Options for traction energy decarbonisation in rail	30/04/2018	27/09/2019	Policy recommendations & roadmaps	Options for traction energy decarbonisation in rail	Significant	Advanced
T1160	BPL	T1160 - Decarbonisation and air quality improvement - roadmaps for rail freight	11/09/2018	28/07/2021	Policy recommendations & roadmaps	Decarbonisation and air quality improvement of the freight rail industry	Significant	Advanced
T1195	BPL	T1195 - DECARB - Battery-powered trains - Route to enter into service	01/07/2019	28/07/2021	Policy recommendations & roadmaps	Battery powered trains: Route to enter into service	Significant	Initial
T1197	BPL	T1197 - DECARB - Carbon Measurements	01/07/2019	07/06/2021	Assessments & frameworks	DECARB: Carbon Measurements	Significant	Planning
COF-IPS-07	RMC-C	Hyd-Energy: Feasibility and Concept Design of Future Hydrail Enabled Railway Depots	26/02/2019	30/01/2020	Case studies & use cases	Hyd-Energy: Feasibility and Concept Design of Future Hydrail Enabled Railway Depots	Significant	Initial
COF-IPS-06	RMC-C	Digital Environment for Collaborative Intelligent De-carbonisation (DECIDe)	26/02/2019	31/07/2020	Case studies & use cases	Digital Environment for Collaborative Intelligent Decarbonisation (DECIDe)	Significant	Planning
COF-IPS-05	RMC-C	Green Valley Lines	26/02/2019	30/10/2020	Prototypes & product specs	Green Valley Lines	Significant	Initial
COF-IPS-03	RMC-C	Digital Displacement for Non-Passenger Rail	26/02/2019	30/04/2020	Case studies & use cases	Digital Displacement for Non-Passenger Rail	Significant	Planning
COF-IPS-02	RMC-C	Decarbonising High-Speed Hybrid Railway Vehicles through Optimal Power Control	25/02/2019	29/05/2020	Reports, presentations, guidance & standards	Decarbonising High-Speed Hybrid Railway Vehicles through Optimal Power Control	Significant	Planning
T1172	BPL	T1172 - Hydrogen Powered Trains- Route to Enter into Service	12/12/2018	23/07/2021	Policy recommendations & roadmaps	Hydrogen Powered Trains: Route to Enter into Service	Significant	Initial
T1200	BPL	T1200 - DECARB - Model improvements to T1145 Options for traction energy decarbonisation in rail	22/07/2019	13/08/2021	Toolkits & models			
T1199	BPL	T1199 - DECARB - Cost of different traction options to meet WebTAG requirements	22/07/2019	18/05/2021	Prototypes & product specs	Cost of different traction options to meet webTAG requirements		
T1198	BPL	T1198 - DECARB - Interim and long-term targets to achieve decarbonisation strategy	22/07/2019	27/10/2021	Policy recommendations & roadmaps			
COF-IPS-04	RMC-C	Dual fuel locomotives to decarbonise freight operations	26/02/2019	31/12/2020	Case studies & use cases			
OTH-PING-04	RMC-C	Assessing the carbon impacts of the RSSB research project portfolio	03/01/2019	17/05/2019	Assessments & frameworks	Assessing the carbon impacts of the RSSB research project portfolio		Not Monitored

EVALUATION RESEARCH GROUP: FREIGHT

Project Reference Number	RSSB Database Source	Project Name	Project Start	Project Finish	Output Category (grouped for evaluation)	Implementation Data Output	RSSB Rated as Significant	Furthest Implantation Status
T1119	BPL	T1119 - Investigating the effects of offset loading in containers on risk of derailment on twisted track	01/08/2016	10/08/2018	Reports, presentations, guidance & standards	Investigating the effects of offset loading in containers on risk of derailment on twisted track	Significant	Full
T1109	BPL	T1109 - Freight Suspension Analysis	01/04/2016	31/07/2018	Reports, presentations, guidance & standards	Freight suspension analysis	Significant	Initial
T1132	BPL	T1132 - Development of supplementary freight gauges	17/07/2017	27/01/2020	Prototypes & product specs	Development of supplementary freight gauges	Significant	Initial
T1112	BPL	T1112 - Quantify the distribution of unevenly loaded container wagons	01/08/2017	06/10/2017	Reports, presentations, guidance & standards	Quantify the distribution of unevenly loaded container wagons		Full
T1208	BPL	T1208 - Aerodynamics of freight trains	26/11/2019	11/06/2021	Reports, presentations, guidance & standards			
COF-UOH-36	RMC-C	Low Cost Improvements for Container Wagon Suspension	28/06/2017	05/06/2020	Process recommendations	Low Cost Improvements for Container Wagon Suspension		Further R&D

COF-UOH-47	RMC-C	Simulating Offset Loading of Bulk Wagons on Twisted Track	19/12/2018	16/08/2019	Reports, presentations, guidance & standards	Simulating Offset Loading of Bulk Wagons on Twisted Track		
COF-UOH-17	RMC-C	Track Twist / Offset Loading Derailments of Freight Wagons	22/03/2016	18/09/2017	Reports, presentations, guidance & standards	Track twist		Full

EVALUATION RESEARCH GROUP: PERFORM

Project Reference Number	RSSB Database Source	Project Name	Project Start	Project Finish	Output Category (grouped for evaluation)	Implementation Data Output	RSSB Rated as Significant	Furthest Implantation Status
T1135	BPL	T1135 - Development of an operational decision-making model for abnormal working	12/06/2017	18/03/2019	Toolkits & models	Development of an operational decision-making model for abnormal working	Significant	Advanced
T1154	BPL	T1154 - PERFORM - Enabling better planning and resource management during disruption	01/06/2018	22/02/2021	Process recommendations	PERFORM: Enabling better planning and resource management during disruption	Significant	Further R&D
COF-DSP-08	BPL	Frazer-Nash - REPAIR	23/07/2021	23/07/2021	Reports, presentations, guidance & standards	Rapid Evaluation and Planning Analysis Infrastructure for Railways (REPAIR)	Significant	Initial
IMP-T1135	BPL	IMP-T1135 - Implementation trial of G-FORCE decision support tool	19/09/2018	19/05/2021	Toolkits & models	G-FORCE Trial Report	Significant	Advanced
COF-DSP-03	BPL	Porterbrook	23/07/2021	23/07/2021	Prototypes & product specs	IntelliDwellTime	Significant	Initial
T1178	BPL	T1178 - PERFORM - Understanding what makes a good train regulation decision	01/06/2019	28/07/2021	Process recommendations	PERFORM: Understanding what makes a good train regulation decision with CP6 Metrics	Significant	Initial
COF-ICE-01	RMC-C	Development of an innovative framework for customer-centric rail passenger information applications - MMU	25/04/2016	23/12/2016	Assessments & frameworks	Innovative framework for customer-centric rail passenger information applications (MMU)	Significant	Planning
COF-ICE-02	RMC-C	Development of intelligent predictive models for crowding on trains using data-driven methodologies - Kent	25/04/2016	16/09/2016	Toolkits & models	Intelligent Predictive Models for Crowding on Trains using data-driven methodologies (Kent)	Significant	Further R&D
COF-ICE-03	RMC-C	Use of passenger loading data to influence behaviour, and provide an improved experience for passengers and operators alike - Southampton	25/04/2016	30/09/2016	Reports, presentations, guidance & standards	Passenger loading data to influence behaviour and provide an improved experience	Significant	Planning
COF-ICE-04	RMC-C	Integrating data sources to enhance the experience for passengers with special needs and/or disabilities through privacy aware mobile applications - Surrey	25/04/2016	16/09/2016	Prototypes & product specs	Integrating data sources to enhance the customer experience (Surrey)	Significant	Further R&D
COF-KTP-03	RMC-C	Innovative methods to measure and model 'real' rail capacity and to validate and improve capacity simulations and simulators	22/03/2016	31/08/2016	Toolkits & models	Innovative methods to measure and model "real" rail capacity and to validate and improve capacity simulations and simulators	Significant	Further R&D
COF-INP-06	RMC-C	Agent based modelling and visualisation of the causes and consequences of knock-on delays	09/03/2018	31/05/2019	Toolkits & models	Agent based modelling and visualisation of the causes and consequences of knock-on delays	Significant	Advanced
COF-INP-04	RMC-C	Providing data analysis insights into real to-the-second timing patterns of passenger rail services using Machine Learning techniques	17/01/2018	28/02/2019	Toolkits & models	Providing data analysis insights into real to-the-second timing patterns of passenger rail services using Machine Learning techniques	Significant	Initial
COF-INP-03	RMC-C	Predicting and mitigating small fluctuations in station dwell times	17/01/2018	31/05/2019	Toolkits & models	Predicting and Mitigating Small Fluctuations in Station Dwell Times	Significant	Initial
COF-G18	BPL	COF-G18 Automated Collection of Train Consist Information	16/07/2018	03/12/2018	Toolkits & models			
COF-DSP-09	BPL	COF-DSP-09 - Collateral Information Exchange (CollIE)	23/07/2021	30/11/2021	Reports, presentations, guidance & standards			
COF-G22	BPL	COF-G22 - RateSetter Development	25/09/2019	23/11/2021	Prototypes & product specs			

T1155	BPL	T1155 - PERFORM - Reviewing the risks and benefits of detonator usage	17/06/2018	14/08/2020	Process recommendations	PERFORM: Reviewing the risks and benefits of detonator use	Planning
T1167	BPL	T1167 - PERFORM - Evaluating the effectiveness of detonator and possession limit board protection	01/01/2019	30/08/2019	Reports, presentations, guidance & standards	PERFORM: Evaluating the effectiveness of detonator and possession limit board protection	Further R&D
IMP-T1154	BPL	IMP-T1154 - Implementation trial of the T1154 managing disruption toolkits	01/03/2019	09/11/2021	Toolkits & models		
COF-DSP-06	BPL	OpenSpace - A Real-Time Functional Digital Twin	23/07/2021	23/07/2021	Prototypes & product specs		
COF-DSP-05	BPL	RiskSolutions	23/07/2021	23/07/2021	Prototypes & product specs		
COF-DSP-02	BPL	Zipabout	23/07/2021	23/07/2021	Prototypes & product specs		
T1163	BPL	T1163 - Criteria for assigning differential speed categories	17/09/2018	23/02/2021	Assessments & frameworks		
T1212	BPL	T1212 - PERFORM - Understanding the barriers and enablers to applying rules and standards changes	19/02/2020	09/09/2021	Reports, presentations, guidance & standards		
T1175	BPL	T1175 - Enabling drivers to reliably stop trains in the correct position at stations	09/01/2019	13/01/2022	Reports, presentations, guidance & standards		
T1202	BPL	T1202 - Guidance for introducing and managing Selective Door Operation (SDO)	26/08/2019	08/12/2021	Reports, presentations, guidance & standards		
COF-AFR-01	RMC-C	Barriers and Opportunities for Automation of Rail Operations	06/07/2016	15/12/2017	Assessments & frameworks		
COF-CAN-03	RMC-C	Dynamic Responsive Signal Control for Railway Junctions	22/03/2016	28/06/2013	Toolkits & models	Dynamic Responsive Signal Control for Railway Junctions (UCL)	Not Monitored
COF-ECO-06	RMC-C	Economic drivers of railway demand and the potential role of telecommunications data	21/10/2019	22/12/2020	Toolkits & models		
COF-ATR-03	RMC-C	Creating Capacity by Minimising the Impact of Maintenance	22/03/2016	31/01/2013	Reports, presentations, guidance & standards		
COF-G17-01	RMC-C	GS0017 Updating the DEDOTS System for integration with C-DAS	03/02/2017	31/08/2018	Toolkits & models		
COF-UOH-31	RMC-C	Understanding Dwell Times	26/07/2016		Toolkits & models		
IMP-ESW-01	RMC-C	Inclusion of emergency special working requirements in the Rule Book	18/10/2017	22/11/2018	Policy recommendations & roadmaps		
IMP-T1154-01	RMC-C	PERFORM: Implementation trial of the T1154 managing disruption toolkits	19/03/2019	03/12/2021	Toolkits & models		
OTH-PING-02	RMC-C	Selective Door Operation (SDO) assessment tool evaluation and requirements capture	10/12/2018	31/03/2019	Prototypes & product specs		
OTH-PING-06	RMC-C	(cancelled) Investigating the impact of CP6 metrics on train regulation: scoping and requirements capture	25/02/2019	31/05/2019	Assessments & frameworks		
IMP-T1135-01	RMC-C	PERFORM: In service pilot of the T1135 operational decision making tool	21/08/2018	30/09/2020	Prototypes & product specs		
COF-INP-05	RMC-C	Anticipating and mitigating reactionary delays – a case study on the Northern line of Merseyrail	17/01/2018	31/05/2019	Case studies & use cases	Anticipating and mitigating reactionary delays – a case study on the Northern line of Merseyrail	
COF-INP-02	RMC-C	A feasibility study on developing an intelligence ensemble system for predicting and preventing train delays	17/01/2018	30/05/2019	Toolkits & models	A feasibility study on developing an intelligence ensemble system for predicting and preventing train delays	Planning
COF-G22-01	RMC-C	RateSetter+: platform-train interface flow optimisation and Merseyrail new fleet demonstration	16/02/2020	30/04/2021	Toolkits & models		
EVALUATION RESEARCH GROUP: STAFF HEALTH & WELLBEING							

Project Reference Number	RSSB Database Source	Project Name	Project Start	Project Finish	Output Category (grouped for evaluation)	Implementation Data Output	RSSB Rated as Significant	Furthest Implantation Status
T1124	BPL	T1124 - Understanding the conditions for successful mental health training for managers	30/04/2018	17/12/2019	Reports, presentations, guidance & standards	Understanding the conditions for successful mental health training for managers	Significant	Advanced
T1133	BPL	T1133 - Evaluating prevention and mitigations to manage cognitive underload for train drivers	21/03/2017	14/03/2019	Reports, presentations, guidance & standards	Identifying and evaluating techniques to mitigate cognitive underload for train drivers	Significant	Advanced
T1165	BPL	T1165 - Development of composite metrics for the monitoring and prioritisation of health & wellbeing conditions	01/03/2019	12/08/2021	Toolkits & models	Composite Metrics for Monitoring and Prioritisation of Health and Wellbeing Conditions	Significant	Planning
OTH-BMK-old	BPL	R&D · H&W Performance Benchmarking - old	02/04/2018	02/04/2018	Toolkits & models			
T1139	BPL	T1139 - Researching the impact of railway automation on health and wellbeing	18/07/2017	27/09/2019	Reports, presentations, guidance & standards	Impact of Rail Automation on Health and Wellbeing		Not Monitored
T1142	BPL	T1142 - Developing management and leadership skills for staff with operational line management duties	06/12/2017	27/03/2020	Reports, presentations, guidance & standards	Developing Management and Leadership skills for staff with operational line management duties		Planning
T1180	BPL	T1180 - Understanding the conditions for successful mental health training for managers longitudinal study	01/04/2019	19/02/2020	Case studies & use cases	Extension to Understanding the conditions for successful mental health training for managers		Not Monitored
T1213	BPL	T1213 - Understanding the health, safety and wellbeing risks and impacts of lone working to rail staff	01/02/2020	12/07/2021	Reports, presentations, guidance & standards			
T1239	BPL	T1239 - Industry Health & Wellbeing Performance Measurement System - Requirements Analysis	14/09/2020	28/07/2021	Prototypes & product specs	Industry Health & Wellbeing Performance Measurement System - Requirement Analysis		
T1130	BPL	T1130 - Fitness for duty decision aid	05/02/2018	13/09/2021	Toolkits & models			
T1173	BPL	T1173 - Identifying measures to prevent customer-on-staff work-related violence in the GB rail industry	27/09/2018	09/09/2021	Assessments & frameworks	Identifying measures to prevent customer-on-staff work-related violence in the UK rail industry		
IMP-FAT-01	RMC-C	Review and restructuring of fatigue management resources	27/07/2017	22/05/2018	Reports, presentations, guidance & standards			
IMP-FRM-01	RMC-C	Fatigue Risk Management Forum	17/06/2016	15/11/2016	Reports, presentations, guidance & standards			
T1193	BPL	T1193 - Understanding the functional requirements for train driver alertness and attention monitoring devices)	28/06/2019	18/06/2021	Prototypes & product specs			

EVALUATION RESEARCH GROUP: ENGINEERING INTERFACE OPTIMISATION

Project Reference Number	RSSB Database Source	Project Name	Project Start	Project Finish	Output Category (grouped for evaluation)	Implementation Data Output	RSSB Rated as Significant	Furthest Implantation Status
COF-UOH-09	RMC-C	Risks and Benefits of Economic Tyre Turning (WP1)	22/03/2016	19/07/2015	Reports, presentations, guidance & standards	Risks and Benefits of Economic Tyre Turning	Significant	Full
T1114	BPL	T1114 - Choosing metric or imperial units for driver display on ETCS L1 & L2 overlay areas	08/07/2016	06/09/2019	Prototypes & product specs	Choosing metric or imperial units for driver display on ETCS L1 & L2 overlay areas	Significant	Planning
T1120	BPL	T1120 - Providing safe electrical clearance at platforms to live electrical parts on rolling	25/08/2016	04/10/2019	Case studies & use cases	Feasibility of using non-conducting pantograph horns	Significant	Initial

		stock - Feasibility of using insulated pantograph horns						
COF-CAN-01	RMC-C	REPOINT	22/03/2016	30/06/2013	Prototypes & product specs	Radical new design of Redundantly Engineered POINTs which enable rapid fail-safe switching (REPOINT)	Significant	Initial
COF-KTP-01	RMC-C	Overhead electric line wear and fatigue model	22/03/2016	15/06/2015	Toolkits & models	Overhead electric line wear and fatigue model	Significant	Planning
COF-KTP-02	RMC-C	Self-powered track side sensors	22/03/2016	28/04/2017	Prototypes & product specs	Self-powered track-side sensors	Significant	Planning
COF-PTI-04	RMC-C	RateSetter: Improving passenger boarding rate and reducing risk at the PTI	06/01/2017	30/03/2018	Reports, presentations, guidance & standards	RateSetter: Improving passenger boarding rate and reducing risk at the PTI	Significant	Initial
COF-PTI-05	RMC-C	Using real-time data on train consist and loading to influence passenger positioning and boarding behaviour at the PTI	06/01/2017	30/04/2018	Reports, presentations, guidance & standards	Using Real-time Data to Influence Passenger Positioning and Behaviour at the PTI	Significant	Further R&D
COF-RAS-01	RMC-C	Feasibility study for robust automated servicing of passenger train fluids	22/03/2016	31/03/2017	Case studies & use cases	Feasibility study for Robust Automated Servicing of Passenger Train Fluids	Significant	Planning
COF-RAS-02	RMC-C	Cab front cleaning robot	22/03/2016	25/05/2017	Prototypes & product specs	Cab-front cleaning robot prototype	Significant	Further R&D
COF-UOH-20	RMC-C	Inerters in Rail	22/03/2016	27/07/2018	Case studies & use cases	Inerters in Rail	Significant	Further R&D
COF-UOH-43	RMC-C	Inerters 2: Optimised Suspension Design using Inerters for Stability and Curving in Primary Lateral Suspension	29/06/2018	14/06/2019	Prototypes & product specs	Inerters 2: Optimised Suspension Design using Inerters for Stability and Curving in Primary Lateral Suspension	Significant	Further R&D
COF-UOH-62	RMC-C	Using Wheel Impact Load Detector Data to Identify Defective Vehicles	05/05/2020	12/02/2021	Assessments & frameworks	Using Wheel Impact Load Detector Data to Identify Defective Vehicles	Significant	Planning
OTH-RES-01	RMC-C	Acceptance criteria and validation method to support electrical resonance compatibility assessment	05/02/2019	30/11/2019	Assessments & frameworks	Acceptance criteria and validation method to support electrical resonance compatibility assessment	Significant	Further R&D
IMP-PGG-01	RMC-C	Refinements to PG1 and PG2 gauges	20/07/2016	30/09/2017	Prototypes & product specs			
IMP-RCM-01	RMC-C	Cross Industry Remote Condition Monitoring Pilots	14/06/2016	28/06/2019	Toolkits & models			
IMP-VTM-01	RMC-C	VTISM development for novel vehicle formats	15/12/2017	30/04/2018	Reports, presentations, guidance & standards			
OTH-PING-01	RMC-C	Inductive power transfer technologies in rolling stock traction	29/11/2018	01/02/2019	Case studies & use cases			
T1110	BPL	T1110 - Automatic vehicle identification system benefits	18/05/2016	14/02/2017	Case studies & use cases	Assessment of benefits of Automatic Vehicle Identification		Not Monitored
T1113	BPL	T1113 - Number and frequency of transitions to and from ERTMS operation- Simulator trials	15/11/2016	20/02/2017	Assessments & frameworks			
T1116	BPL	T1116 - Developing guidance for the design and position of car stop markers	20/07/2016	15/11/2018	Reports, presentations, guidance & standards			
COF-UOH-65	BPL	COF-UOH-65 - Detecting vehicle anomalies by using machine learning methods on WILD data	23/07/2021	12/10/2021	Toolkits & models			
T1137	BPL	T1137 - Electrical and Data Control Compatibility Between Trains	01/08/2017	24/02/2020	Reports, presentations, guidance & standards	Electrical and Data Control Compatibility Between Trains		
T1150	BPL	T1150 - A feasibility study into the use of high voltage couplers on rolling stock	11/06/2018	24/02/2020	Case studies & use cases	Feasibility Study into the use of High Voltage Couplers on Rolling Stock		Further R&D
T1158	BPL	T1158 - Assessing the Case for Implementing a Long-Term Gauging Strategy	07/09/2018	18/06/2020	Case studies & use cases	Assessing the Case for Implementing a Long-Term Gauging Strategy		Not Monitored
T1161	BPL	T1161 - Improvements to pantograph collector strips and automatic dropping device	03/09/2018	17/05/2021	Prototypes & product specs	Improvements to pantograph collector strip maintenance and to the Automatic Dropping Device		Planning

OTH-PING-10	BPL	Managing ice on the conductor rail	23/07/2021	02/02/2022	Reports, presentations, guidance & standards
T1250	BPL	T1250 - Managing repeat pantograph raising onto overhead line at speed	14/09/2020	30/11/2022	Reports, presentations, guidance & standards
T1205	BPL	T1205 - Relationship between horn test measurements and perceived sound levels on the track	01/11/2019	04/01/2022	Reports, presentations, guidance & standards
T1196	BPL	T1196 - Development of a suite of Pantograph Gauges	20/08/2019	04/08/2021	Prototypes & product specs
COF-ARW-05	RMC-C	Lifetime extension of rail track via laser cladding technology	22/03/2016	30/08/2014	Prototypes & product specs
COF-ARW-06	RMC-C	XiSPAN Bridge Strengthening and Life Extension	22/03/2016	31/03/2014	Reports, presentations, guidance & standards
COF-ARW-07	RMC-C	Digital Displacement Rail Transmission with Flywheel Energy Storage	22/03/2016	31/03/2015	Reports, presentations, guidance & standards
COF-ARW-11	RMC-C	Synthetic Aperture Focusing Technique for the inspection of Railway Crossings	22/03/2016	31/03/2014	Process recommendations
COF-ARW-13	RMC-C	Energy efficient heating systems for snow melting and ice prevention of rail switch points	22/03/2016	30/11/2013	Case studies & use cases
COF-ARW-16	RMC-C	Introducing aerospace materials to rail	22/03/2016	21/03/2014	Reports, presentations, guidance & standards
COF-ARW-17	RMC-C	An integrated wayside condition monitoring system for axle bearings COMORAIL	22/03/2016	31/08/2013	Assessments & frameworks
COF-ATR-01	RMC-C	Improved Decision Making for Maintenance Using Data	22/03/2016	30/08/2013	Reports, presentations, guidance & standards
COF-ATR-04	RMC-C	Active Vibration Sensors	22/03/2016	31/01/2013	Case studies & use cases
COF-E13-01	RMC-C	Development of a bespoke Rail Trackbed Stiffness Tester and analysis tools for assessment, trackbed design and audit of renewals of ballasted and non-ballasted track systems	22/03/2016	31/03/2015	Assessments & frameworks
COF-ECO-02	RMC-C	Economic analysis and support for the 'Kneeling Train' concept	21/12/2018	05/10/2020	Case studies & use cases
COF-ECO-03	RMC-C	Economic analysis and support for 'Repoint'	21/12/2018		Case studies & use cases
COF-ECO-05	RMC-C	Valuation and Appraisal of Accessibility in Rail (VAAR)	05/06/2019	16/04/2020	Assessments & frameworks
COF-G14-01	RMC-C	GS0014 High Efficiency Auxiliary Drive	01/07/2016	31/12/2018	Prototypes & product specs
COF-G18-01	RMC-C	Automated collection of train consist information	29/05/2018	30/11/2018	Case studies & use cases
COF-G22-02	RMC-C	COVID-19 Ratesetter application	09/06/2020	31/07/2020	Toolkits & models
COF-GSC-01	RMC-C	Update of Manual on scour at bridges and other hydraulic structures (C551)	22/03/2016	13/11/2014	Process recommendations
COF-GSC-02	RMC-C	In-service third rail defect detection and measurement system	22/03/2016	01/10/2011	Assessments & frameworks
COF-HCT-02	RMC-C	Commonality And Standardisation of Processes for cost-Effective Rolling stock	22/03/2016	31/08/2013	Process recommendations
COF-INC-01	RMC-C	Virtual Lineside Signalling (VLS) System Cost	22/03/2016	25/03/2013	Assessments & frameworks
COF-INT-01	RMC-C	Inerter Prototype Development	27/03/2019	24/07/2020	Prototypes & product specs

COF-NMC-01	RMC-C	Whole life cost assessment of novel material railway drainage systems	22/03/2016	13/03/2019	Reports, presentations, guidance & standards		
COF-NMC-02	RMC-C	Rail-energy knowledge exchange on emerging materials (ALCHMy)	22/03/2016	22/03/2019	Reports, presentations, guidance & standards		
COF-NMC-03	RMC-C	Designing steel composites and microstructures to better resist degradation during wheel-rail contact	22/03/2016	29/06/2018	Prototypes & product specs	Designing steel composition and microstructure to better resist degradation during wheel-rail contact	Further R&D
COF-PTI-03	RMC-C	Feasibility study of a kneeling train	20/12/2016	30/03/2018	Case studies & use cases	Feasibility Study of a kneeling Train	Further R&D
COF-R14-01	RMC-C	Active Pantograph for Improved Current Collection	22/03/2016	28/02/2016	Prototypes & product specs	Active Pantograph for Improved Current Collection (Brecknell Willis)	Not Monitored
COF-RAS-03	RMC-C	Feasibility of the use of autonomous robotic systems for wheelset reworking	22/03/2016	31/03/2017	Prototypes & product specs	Feasibility of automated inspection of wheelsets (UoB)	Not Monitored
COF-RAS-04	RMC-C	Enhancing and automating non-destructive testing techniques for railway wheel-sets	22/03/2016	29/09/2017	Prototypes & product specs	Enhancing and automating non-destructive testing techniques for railway wheel-sets	Not Monitored
COF-SIN-01	RMC-C	Novel sensors for condition monitoring of earthworks	09/08/2016	30/09/2019	Prototypes & product specs		
COF-UOH-15	RMC-C	In service trials of Economic Tyre Turning	22/03/2016	08/03/2017	Case studies & use cases	Technical and economic feasibility of economic tyre turning / A positive technical and economic case for moving to wheel profiles with thinner flanges to extend wheelset life.	Not Monitored
COF-UOH-21	RMC-C	Response Based Track Maintenance	22/03/2016		Reports, presentations, guidance & standards		
COF-UOH-22	RMC-C	Revised P8 Wheel Profile	22/03/2016	29/09/2017	Assessments & frameworks		
COF-UOH-23	RMC-C	Flange Height and Thickness Limits	22/03/2016	26/01/2018	Prototypes & product specs	Flange Height and Thickness Limits	Not Monitored
COF-UOH-30	RMC-C	Wheelsets, Life Extension and Maintenance Optimisation	05/07/2016	27/05/2017	Reports, presentations, guidance & standards		
COF-UOH-37	RMC-C	Understanding and Predicting Squat Defects in Track	26/07/2017	20/09/2019	Reports, presentations, guidance & standards	Understanding and Predicting Squat Defects in Track	Planning
COF-UOH-39	RMC-C	Modelling the effect of plastic flow in rails	26/07/2017	26/09/2019	Toolkits & models	Modelling the effect of plastic flow in rails	Not Monitored
COF-UOH-52	RMC-C	Inerters 3: Inerters in rail vehicle suspensions – concept design, and extended simulation studies	15/05/2019	19/06/2020	Prototypes & product specs		
COF-UOH-56	RMC-C	Harmonising wheel flats limits	16/05/2019	25/12/2020	Reports, presentations, guidance & standards	Harmonising wheel flats limits	
COF-UOH-57	RMC-C	Squat Site Monitoring	16/05/2019		Case studies & use cases		
COF-WSM-01	RMC-C	Whole system modelling case study: Woking to Waterloo	17/01/2017	30/11/2019	Case studies & use cases	Whole system modelling case study: Woking to Waterloo	Not Monitored

EVALUATION RESEARCH GROUP: SAFETY INSIGHTS & ANALYSIS TOOLS

Project Reference Number	RSSB Database Source	Project Name	Project Start	Project Finish	Output Category (grouped for evaluation)	Implementation Data Output	RSSB Rated as Significant	Furthest Implantation Status
IMP-RAA	BPL	IMP-RAA - Implementation of the Red Aspect Approaches to Signals (RAATS) Tool	04/02/2019	04/11/2019	Toolkits & models	Transfer of the RAATS software to RSSB support and maintenance environment	Significant	Full
T1118	BPL	T1118 - Optimising the design and position of platform markings	20/07/2016	27/06/2018	Process recommendations	Platform markings	Significant	Full
T1128	BPL	T1128 - Research into human factors causes of signals passed at danger	01/04/2017	31/10/2018	Reports, presentations, guidance & standards	Research into human factors causes of signals passed at danger	Significant	Full

COF-UOH-07	RMC-C	Red Aspect Approaches to Signals	22/03/2016	31/03/2016	Toolkits & models	Tool to determine the number of red aspect approaches at a signal or group of signals (Red Aspect Approaches to Signals, RAATS)	Significant	Full
COF-UOH-19	RMC-C	Close Calls 2	22/03/2016	28/05/2016	Toolkits & models	Enhanced “close call” database for more effective safety management	Significant	Full
COF-UOH-24	RMC-C	Red Aspect Approaches to Signals 2	22/03/2016	29/06/2018	Case studies & use cases	Using Red Aspect Approaches to Improve Understanding of SPADs	Significant	Full
OTH-PING-05	RMC-C	Review current FWI injury categorisation	05/02/2019	31/05/2019	Assessments & frameworks	Review current FWI injury categorisation	Significant	Full
OTH-SRC	BPL	Understanding current practice for identifying and managing safety-related contacts from members of the public	01/07/2019	31/03/2021	Assessments & frameworks	Understanding current practice for identifying and managing safety-related contacts from members of the public	Significant	Planning
T1121	BPL	T1121 - Development of a Common Event Risk Scoring Method	01/02/2017	29/06/2018	Assessments & frameworks	Development of a Common Event Risk Scoring Method	Significant	Planning
T1136	BPL	T1136 - Development of a new Safety Risk Model (SRM) methodology	10/01/2018	11/05/2020	Assessments & frameworks	Development of a new Safety Risk Model (SRM) methodology	Significant	Further R&D
T1147	BPL	T1147 - The Health and Safety Effects of Crowding on Trains and in Stations	01/10/2018	23/01/2020	Assessments & frameworks	The Health and Safety Effects of Crowding on Trains and in Stations	Significant	Initial
T1166	BPL	T1166 - Minimising the impact of high and tight platforms on the overall PTI stepgap dimensions	08/10/2018	31/01/2020	Process recommendations	Minimising the impact of ‘high and tight’ platforms on the overall PTI step/gap dimensions.	Significant	Initial
T1168	BPL	T1168 - Evaluating Effective Trespass Mitigation Strategies	01/05/2019	17/07/2020	Process recommendations	Evaluating effective trespass mitigation strategies	Significant	Initial
T1182	BPL	T1182 - Industry trespass data collection requirements	01/03/2019	03/11/2020	Assessments & frameworks	Investigating Industry Trespass Data Collection Requirements	Significant	Planning
T1183	BPL	T1183 - Good practice guide to assess trespass risk	17/06/2019	16/07/2021	Reports, presentations, guidance & standards	Good practice guide to assessing trespass risk	Significant	Planning
COF-KTP-04	RMC-C	3D interactive immersive training techniques in the rail industry	22/03/2016	09/12/2016	Toolkits & models	3D interactive immersive training techniques in the rail industry	Significant	Initial
COF-G21-01	RMC-C	Train Emergency Stop System (TESS)	03/02/2019	20/10/2020	Prototypes & product specs	Train Emergency Stop System (TESS)	Significant	Initial
COF-PTI-02	RMC-C	Intelligent computer vision agents optimising PTI safety and train dwell times	20/12/2016	29/06/2018	Reports, presentations, guidance & standards	Intelligent computer vision agents optimising PTI safety and train dwell times	Significant	Initial
COF-UOH-18	RMC-C	OTMR - Train Driver Performance Indicators for Safety	22/03/2016	30/05/2017	Assessments & frameworks	OTMR - Train Driver Performance Indicators for Safety	Significant	Initial
T1151	BPL	T1151 - Making a step change in guards-on board operational staff route knowledge	16/07/2018	19/11/2019	Process recommendations			
T1238	BPL	T1238 - Transitioning driver and conductor training to remote delivery	08/07/2020	07/05/2021	Process recommendations			
COF-G21	BPL	COF-G21 Train Emergency Stop System (TESS)	01/03/2019	07/09/2020	Prototypes & product specs			
COF-ORR	BPL	COF-ORR Research into Attitudes to Railway Safety and Related Issues	25/06/2020	22/09/2020	Reports, presentations, guidance & standards	Research into Attitude to Railway Safety and Related Issues		Not Monitored
IMP-DRT	BPL	IMP-DRT - Driver Training 2017-2018	01/04/2017	31/05/2019	Reports, presentations, guidance & standards			
IMP-DTI-001	BPL	Driver Training Implementation 18-19	16/05/2018	26/04/2019	Reports, presentations, guidance & standards			
IMP-PTI-01	BPL	IMP-PTI review and restructuring of PTI resources	01/08/2018	15/05/2020	Reports, presentations, guidance & standards	Review and restructuring of PTI resources		Not Monitored
IMP-RAA-001	BPL	IMP-RAA-001 - RAATS Post-Implementation	01/11/2019	11/08/2021	Case studies & use cases			
IMP-T1078	BPL	IMP-T1078 - Implementation support for T1078 Developing a safety critical communications training programme	15/05/2018	02/09/2019	Reports, presentations, guidance & standards	Review of the uptake of the safety critical communications training programme		Not Monitored

IMP-T1151	BPL	IMP-T1151 - Publication of guidance for Guard and Train Manager Route Knowledge	02/12/2019	14/04/2020	Reports, presentations, guidance & standards		
OTH-PING	BPL	Evaluation of options for Novel Train Protection technologies	01/01/2019	10/06/2019	Prototypes & product specs		
COF-UOH-53	BPL	COF-UOH-53 - Using Machine Learning to Estimate Signal Approaches from Train Movement Data	23/07/2021	26/01/2022	Toolkits & models		
T1123	BPL	T1123 - Developing a framework for an Integrated Safety Risk Platform (ISRP)	23/03/2017	31/05/2018	Assessments & frameworks	Developing a Framework for an Integrated Safety Risk Platform	Planning
COF-UOH-61	BPL	COF-UOH-61 - Automating the categorisation of root cause data	23/07/2021	06/08/2021	Toolkits & models		
T1131	BPL	T1131 - Evaluating the potential for Virtual and Augmented Reality and gamification in rail industry safety critical training	15/03/2017	15/03/2019	Reports, presentations, guidance & standards	Evaluating the potential for Virtual and Augmented Reality and gamification in rail industry safety critical training	Planning
T1152	BPL	T1152 - Developing text analytics capability using Close Call data	01/09/2017	27/04/2020	Toolkits & models	Exploring the use of natural language processing and railway-specific ontologies to understand and classify Close Call reports	Full
T1169	BPL	T1169 - Review of the Uff-Cullen Recommendations related to train protection systems	04/12/2018	17/07/2020	Process recommendations	Review of the Uff-Cullen Recommendations related to train protection systems	Not Monitored
T1174	BPL	T1174 - Optimisation of TPWS Overspeed Sensor System	22/12/2018	19/04/2021	Prototypes & product specs		
OTH-PING-11	BPL	Mapping train horn warnings onto level crossing	23/07/2021	29/11/2021	Toolkits & models		
T1206	BPL	T1206 - Strategic review of cross-industry SPAD risk reduction activities	25/11/2019	04/03/2021	Reports, presentations, guidance & standards		
T1240	BPL	T1240 - Understanding barriers to implementing recommendations for trap and drag prevention	14/09/2020	01/02/2021	Process recommendations		
T1254	BPL	T1254 - Emergency GSM-R transmissions	29/10/2020	21/07/2021	Reports, presentations, guidance & standards		
T1143	BPL	T1143 - Devices to Guide Derailed Trains	30/04/2018	28/07/2021	Prototypes & product specs		
T1203	BPL	T1203 - Validation and review of driver test scores	11/11/2019	10/08/2020	Assessments & frameworks		
COF-CAN-04	RMC-C	SAFECAP	22/03/2016	31/03/2013	Toolkits & models	SAFECAP (UoNewcastle)	Not Monitored
COF-CAN-05	RMC-C	Challenging established rules for train control through a fault tolerance approach	22/03/2016	31/03/2013	Reports, presentations, guidance & standards	Challenging established rules for train control through a fault tolerance approach	Not Monitored
COF-ARW-02	RMC-C	Digital Imaging for Condition Asset Management (DIFCAM)	22/03/2016	31/01/2014	Case studies & use cases		
COF-DET-01	RMC-C	Testing the effectiveness of detonator protection and possession limit board lamps	02/10/2018		Case studies & use cases		
COF-G12-01	RMC-C	Social media in the aftermath of a major rail incident	22/03/2016	18/12/2015	Reports, presentations, guidance & standards		
OTH-SRC-01	RMC-C	Understanding current practice for identifying and managing safety-related contacts from members of the public	23/07/2019	12/02/2021	Process recommendations		
COF-GSC-03	RMC-C	Value of station staff with respect to security and passenger demand	22/03/2016	29/04/2013	Reports, presentations, guidance & standards		
COF-HSW-02	RMC-C	Managing the risks of slips, trips and falls for the ageing rail passenger population: 'Future proofing' risk models in rail	22/03/2016	06/06/2014	Toolkits & models	Managing the risks of slips, trips and falls for the ageing rail passenger population: 'Future proofing' risk models in rail (Loughborough)	Not Monitored
COF-HSW-03	RMC-C	A socio-technical system approach to risk analysis for integrated railway systems	22/03/2016	01/03/2014	Reports, presentations, guidance & standards	A socio-technical system approach to risk analysis for integrated railway systems (UoYork)	Not Monitored

OTH-PING-07	RMC-C	Understanding current practice for identifying and managing safety-related contacts from members of the public	15/07/2019		Process recommendations		
OTH-LTI-01	RMC-C	Survey and case study of the use of Lost Time Injury and Lost Time Injury Frequency rates	11/09/2018	23/11/2018	Case studies & use cases		
IMP-T1078-01	RMC-C	Implementation support for T1078 Developing a safety critical communications training programme	15/01/2018	30/08/2019	Case studies & use cases		
COF-UOH-34	RMC-C	TAVISON - Augmented bowtie for Station Safety	02/11/2016		Case studies & use cases		
COF-UOH-11	RMC-C	Close Call Data Analysis	22/03/2016	02/12/2014	Toolkits & models	Close Call Data Analysis	Full
COF-UOH-13	RMC-C	Risk Visualisation	22/03/2016	31/03/2016	Assessments & frameworks	Risk Visualisation	Not Monitored
COF-UOH-14	RMC-C	BDRA Lexicon for GB Rail	22/03/2016	31/05/2016	Prototypes & product specs	BDRA Lexicon for GB Rail	Planning
COF-UOH-16	RMC-C	BDRA System Architecture	22/03/2016	31/03/2016	Case studies & use cases	BDRA System Architecture	Planning
COF-UOH-28	RMC-C	BDRA Middleware	05/05/2016		Toolkits & models		
COF-UOH-29	RMC-C	TAVISON - Augmented bowtie for the assessment of SPAD risk	05/05/2016	21/12/2018	Toolkits & models		
COF-UOH-33	RMC-C	Integrating Close Calls and TRUST Data to identify accident precursors	13/09/2016		Case studies & use cases		
COF-UOH-38	RMC-C	Improving Understanding of Train Driver Human Error Rates	26/07/2017		Toolkits & models		
COF-UOH-41	RMC-C	Supporting the implementation of RAATS	09/01/2018	31/03/2020	Toolkits & models		
COF-UOH-42	RMC-C	Supporting T1152 - Developing text analytics capability using Close Call data	19/01/2018	24/05/2019	Reports, presentations, guidance & standards		
COF-UOH-44	RMC-C	Leeds to King's Cross Route Bowtie	29/06/2018	27/03/2020	Case studies & use cases		
COF-UOH-54	RMC-C	Identifying interesting Close Calls for qualitative reporting	16/05/2019		Case studies & use cases		
IMP-DRT-01	RMC-C	Driver Training	13/06/2016	29/06/2018	Reports, presentations, guidance & standards		
IMP-DTI-01	RMC-C	Driver Training Implementation	08/05/2018	31/03/2019	Reports, presentations, guidance & standards		
IMP-PRA-01	RMC-C	PTI Risk Assessment Tool Implementation	15/12/2016	31/03/2017	Toolkits & models		
IMP-RAA-01	RMC-C	Independent review of the RAATS tool Algorithms	09/04/2018	09/11/2018	Toolkits & models		
COF-UOH-08	RMC-C	Integrating Engineering and Safety Risk Models	22/03/2016	31/10/2014	Reports, presentations, guidance & standards	Integrating Engineering and Safety Risk Models	Not Monitored
IMP-RAA-04	RMC-C	RAATS Post Implementation	16/12/2019	24/09/2021	Toolkits & models		
IMP-SDO-01	RMC-C	Redevelopment of the Selective Door Operation (SDO) assessment tool	03/09/2018	30/06/2020	Toolkits & models		
IMP-T1151-01	RMC-C	Driver and Guard Route Knowledge promotion	23/01/2020	10/04/2020	Reports, presentations, guidance & standards		
IMP-T758-01	RMC-C	Update of the T758 Temporary Block Working Risk Model for COMPASS	23/05/2017	31/08/2017	Toolkits & models		
COF-ORR-01	RMC-C	Research into Attitudes to Railway Safety and Related Issues	28/04/2020	08/05/2020	Reports, presentations, guidance & standards		

COF-HSW-01	RMC-C	A Knowledge Elicitation approach to understanding railway SAFEty (KEEP SAFE)	22/03/2016	30/05/2014	Reports, presentations, guidance & standards	A Knowledge Elicitation approach to understanding railway SAFEty (KEEP SAFE) (CoventryU)	Not Monitored
COF-G13-01	RMC-C	Security Informed Safety Case	22/03/2016	31/08/2015	Reports, presentations, guidance & standards		
COF-ESC-01	RMC-C	Research to improve customer experience and safety when using escalators	08/12/2016	31/05/2021	Reports, presentations, guidance & standards	Research to improve customer experience and safety when using escalators	
OTH-PING-03	RMC-C	Evaluation of options for novel train protection technologies	11/12/2018	15/03/2019	Prototypes & product specs		
OTH-SMV-01	RMC-C	Detection of Red Aspect Approaches Using Machine Vision on Forward Facing Cameras	13/11/2019	19/10/2020	Toolkits & models		
OTH-SPAD-01	RMC-C	Human Factors SPAD Review: Proposed activities to support project implementation	14/06/2017	22/12/2017	Policy recommendations & roadmaps		

EVALUATION RESEARCH GROUP: OTHER

Project Reference Number	RSSB Database Source	Project Name	Project Start	Project Finish	Output Category (grouped for evaluation)	Implementation Data Output	RSSB Rated as Significant	Furthest Implantation Status
T1115	BPL	T1115 - Digital Rule Book	18/07/2016	06/12/2017	Process recommendations	Digital Rule Book	Significant	Full
T1111	BPL	T1111 - Building capacity for sustainable development	08/07/2016	26/05/2017	Policy recommendations & roadmaps	Recommendations to improve sustainability culture	Significant	Initial
T1117	BPL	T1117 - Guidance on making railways more accessible to everyone	30/04/2018	25/01/2019	Policy recommendations & roadmaps	Guidance on making railways more accessible to everyone	Significant	Initial
T1127	BPL	T1127 - Creating a social value measurement framework for rail	30/04/2018	31/10/2018	Assessments & frameworks	Common Social Impact Framework for Rail	Significant	Advanced
T1138	BPL	T1138 - Connected Train and Customer Communications - Development of Rail and Digital Industry Roadmap	01/08/2017	09/01/2019	Policy recommendations & roadmaps	Connected Train and Customer Communications: Development of Rail and Digital Industry Roadmap	Significant	Initial
T1140	BPL	T1140 - Defining the requirements of a seat comfort selection process	18/07/2017	24/06/2019	Process recommendations	Defining the requirements of a seat comfort selection process	Significant	Advanced
T1170	BPL	T1170 - Developing a Framework for a Sustainable Stations Accreditation Scheme (T1170)	15/11/2018	28/07/2021	Assessments & frameworks	Developing a Framework for Sustainable Stations Assessment	Significant	Planning
COF-AFR	BPL	COF-AFR Barriers to automation in rail	25/08/2016	18/09/2017	Reports, presentations, guidance & standards			
COF-RAS	BPL	RRUKA Robotics and Autonomous Systems for RSM	20/12/2016	31/03/2017	Toolkits & models			
COF-ECO-09	BPL	COF-ECO-09 - Revisiting the appraisal of new railway lines and stations	23/07/2021	01/02/2022	Process recommendations			
T1125	BPL	T1125 - Assessing how the rail industry can improve and influence the management of noise during line-side residential development processes	22/06/2017	21/09/2018	Process recommendations	Noise management for line-side developments		Initial
COF-MLD-01	BPL	Curating traveller identity	26/07/2021	26/07/2021	Assessments & frameworks	Curating traveller identity		
T1134	BPL	T1134 - Understanding key drivers that impact travel behaviour	02/01/2018	29/07/2019	Reports, presentations, guidance & standards	Understanding key drivers that impact travel behaviour		
T1164	BPL	T1164 - The Future of Refrigerants in Rail Vehicle HVAC Systems	31/08/2018	28/07/2021	Case studies & use cases	The future of air conditioning refrigerant systems for rail vehicles		Initial
T1204	BPL	T1204 - Economic benefits of having a connected rail corridor	30/08/2019	15/07/2021	Reports, presentations, guidance & standards			
COF-ARW-01	RMC-C	Formation Stiffness Measurement	22/03/2016	31/05/2014	Assessments & frameworks			

COF-ARW-08	RMC-C	Remote Condition Monitoring using Vibration Analysis for train door control systems	22/03/2016	31/05/2014	Case studies & use cases		
COF-ARW-09	RMC-C	ECO Train Interior: High efficiency, low cost	22/03/2016	30/11/2013	Case studies & use cases		
COF-ARW-10	RMC-C	Cable Carrying and Acoustically Damped Thermoplastic Sleepers (CAD_TPC)	22/03/2016	31/08/2014	Prototypes & product specs		
COF-ARW-14	RMC-C	Enhanced Customer (and Crew) Voice and Broadband Provision on Passenger Trains	22/03/2016	31/12/2013	Case studies & use cases		
COF-ARW-15	RMC-C	Choice Rail - Finding the best Rail Journeys	22/03/2016	31/03/2014	Toolkits & models		
COF-ARW-18	RMC-C	Railway Track Multipoint Wireless Rail Displacement and Temperature Monitoring System	22/03/2016	30/04/2014	Assessments & frameworks		
COF-ATR-02	RMC-C	Feasibility study for optimisation of possession authorisation requirements through the use of lean systems design and communications technologies	22/03/2016	31/01/2013	Case studies & use cases		
COF-CAN-02	RMC-C	OCCASION	22/03/2016	31/01/2013	Prototypes & product specs	OCCASION (UoSouthampton)	Not Monitored
COF-E12-02	RMC-C	Cost functions of mixed railway operations and their applications to optimization	22/03/2016	31/07/2017	Case studies & use cases		
COF-E13-02	RMC-C	Rail Companion - Concept to fully operational system	22/03/2016	24/03/2014	Prototypes & product specs		
COF-ECO-08	RMC-C	Covid CBA Framework for assessing mitigation	18/09/2020	31/03/2021	Assessments & frameworks		
COF-HCT-01	RMC-C	Economic incentives for innovation: A comparative study of the rail and aviation industries	22/03/2016	31/08/2013	Reports, presentations, guidance & standards		
COF-HCT-03	RMC-C	Design for control of railway vehicles and its business case impact	22/03/2016	28/06/2013	Prototypes & product specs		
COF-UOH-10	RMC-C	Wavestrapping Statistical Analysis in the Railway System	22/03/2016	07/02/2015	Toolkits & models	Wavestrapping Statistical Analysis in the Railway System	Not Monitored
IMP-SSF-01	RMC-C	Sustainable Stations Framework	05/01/2017		Assessments & frameworks		
IMP-T1117-01	RMC-C	Implementation of the Accessibility Maturity Assessment Tool	14/05/2019	31/10/2019	Toolkits & models	Implementation of the Accessibility Maturity Assessment Tool	
OTH-CON-01	RMC-C	Connected Train and Customer Communications: Development of Rail and Digital Industry Roadmap– Short-medium Term	23/06/2017	01/12/2017	Policy recommendations & roadmaps		
OTH-TCD-01	RMC-C	Scoping study for T1134: Understanding key drivers that impact travel choices	27/04/2017	05/06/2017	Case studies & use cases		
COF-ECO-04	RMC-C	Economic Versus Engineering Based Approaches for Track access charges	05/06/2019	14/02/2020	Reports, presentations, guidance & standards		

Table 16: Full list of RSSB R&D projects included in group analysis sample

Case Study – Selected Case Projects

The below Table lists the projects reviewed in depth as part of the case study analysis component of this evaluation. Case study analysis and findings can be found in Annex F.

	Research Group	Start Date	Output Type	Benefits Category
NOT SIGNIFICANT				
Case Study 1 - T1173 - Identifying measures to prevent customer-on-staff work-related violence in the GB rail industry	Health & Wellbeing	27/09/2018	Assessments & frameworks	Tangible Product
Case Study 2 - COF-G18-01 - Automated collection of train consist information	Interface Optimisation	29/05/2018	Case studies & use cases	Tangible Product
Case Study 3 - T1112 - Quantify the distribution of unevenly loaded container wagons	Freight	01/08/2017	Reports, presentations, guidance & standards	Non-Quantifiable
Case Study 4 - T1198 - DECARB - Interim and long-term targets to achieve decarbonisation strategy	Decarb	22/07/2019	Policy recommendations & roadmaps	Knowledge Product
SIGNIFICANT - NOT FULLY IMPLEMENTED				
Case Study 5 – COF-TAR-03 - Adhesion Riddle Feasibility Study on the use of Dry-ice for Rail Head Cleaning	Adhere	22/03/2016	Case studies & use cases	Knowledge Product
Case Study 6 – COF-DSP-03 – IntelliDwellTime Demonstrator Project	Perform	23/07/2021	Prototypes & product specs	Knowledge Product
SIGNIFICANT - FULLY IMPLEMENTED				
Case Study 7 – COF-UOH-07 - Red Aspect Approaches to Signals	Safety Insights	22/03/2016	Toolkits & models	Tangible Product
Case Study 8 – T1153 - Lineside Vegetation Management Review	Adhere	07/06/2018	Process recommendations	Knowledge Product
PRE-2016				

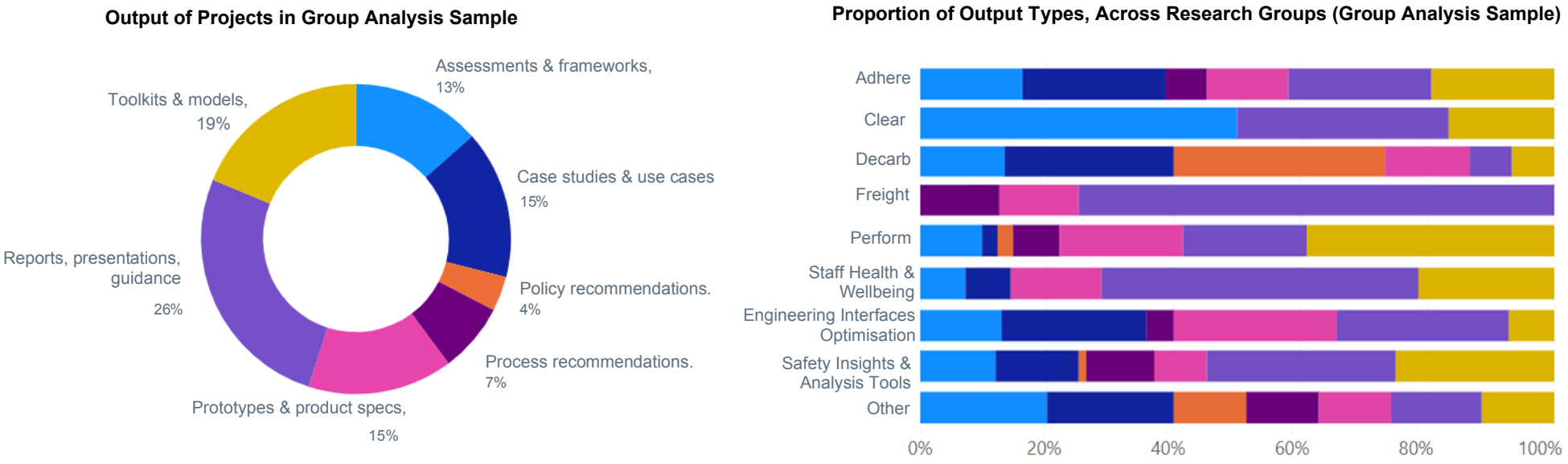
Case Study 9 – COF-UOH-09 Economic Tyre Turning	N/A	17/02/2014	N/A	Tangible Product
Case Study 10 – T1005 – Enhancement of the TCA Risk Advisor Tool to include on-track machines	N/A	22/01/2012	N/A	Tangible Product
Case Study 11 – T797 – Performance and installation criteria for sanding systems	N/A	24/04/2008	N/A	Tangible Product
Case Study 12 – T792 – Vehicle Track Interaction Strategic Model	N/A	16/04/2008	N/A	Tangible Product
Case Study 13 – T978 – Development of Passenger Standard Vehicle Gauges	N/A	02/02/2011	N/A	Tangible Product

Table 17: List of RSSB R&D projects included in case study sample.

Annex E: Group Analysis

As part of group analysis – projects were categorised into research groups where they were addressing a clear theme, research challenge, or had similar stakeholders or beneficiaries. There were nine overall research groups: Adhere, Clear, Decarb, Freight, Perform, Staff Health & Wellbeing, Engineering Interface Optimisation, Safety Insights & Analysis Tools and Other.

Across these research groups, projects' output was categorised to support understanding of the overall programme output and testing of the theory of change assumptions. Graph 8 below shows the breakdown of output for each research group:



Graph 8: Overview of Project Output produced across group analysis sample with breakdown of proportion of output types across research groups.

Stakeholder interviews were conducted with key beneficiaries and stakeholders for each group. Overall, 20 stakeholders were interviewed across suppliers, train operating companies and other industry groups. A minimum of two stakeholders for each research group were included. Evidence from stakeholder interviews was used to assess the presence, overall and at group level, of the theory of change causal pathways hypothesised for the RSSB R&D Programme.

The Table below shows the qualitative findings from the group analysis and is broken down into:

- Validation of research group addressing industry challenge and meeting market failure.
- Perceived quality of output (overview of output type produced per group shown in Graph 8 above).
- Evidence that insights shared to industry groups.
- Evidence of direct outcomes (better understandings, adoption, implementation).
- Examples cited of real-world impacts.
- High level impact on Safety, Sustainability, Optimisation.
- Other possible causes of change identified.

For each area, the following key has been used:

✓ Evidence for progress of output through theory of change.

❖ Evidence for partial progress output through theory change.

x No evidence of output through theory of change.

Research Group	Research Group Addressing Industry Challenge or Meeting Market Failure	Perceived Output Quality Stakeholders	Evidence that research insights shared to industry groups	Direct Outcomes (Better understanding / Adoption Implementation	Indirect Outcomes (Collaboration, Talent, Body of Knowledge)	Examples Cited of Real World Impacts	High Level Impact Safety / Sustainability / Optimisation	Other Causes of Change
Adhere – Projects aimed at achieving adhesion conditions, unaffected by the weather & climate.	✓ Cross industry focus ✓ Blue sky thinking, low TRL ✓ Industry & RSSB collaborating on research priorities – some challenge in getting projects accepted	✓ Good quality of output	✓ Insights shared through number of industry groups ❖ Challenges with wider dissemination – passing on of benefits ✓ Lessons learnt from 'failed' projects shared with industry	✓ Has led to better understanding of next steps of research ✓ Has improved understanding on products and standards – with adoption of products recognised by stakeholders ✓ Influence on decision making, through evidence used at board level ❖ Some challenge where lack of sponsorship route prevents influence of research. Challenge of adoption from TOCs (RSSB limited influence cited)	✓ Improved industry collaboration – citing ROSCO's talking to operators, suppliers, and infrastructure owners. ✓ Led to increase in body of knowledge	• Double rate variable sanders • Sanders's software model • Driver Behaviour	✓ Safety – directly quantifying safety benefits causing fundamental change	Innovate UK – later stage field trials Network Rail – Performance Innovation fund with adhere spin of projects / more implementation of projects UKKRIN EIM
Clear – Projects aimed at improving air quality.	✓ Cross industry focus ❖ Mixed feedback on collaboration with industry to prioritise research areas	❖ Mixed feedback on output – in some cases missing actionable next steps	✓ Insights shared through groups – Air quality steering group ✓ Improved understanding of next stages of research ❖ Challenges with wider dissemination	✓ Has led to new insights / better understanding of future research ✓ Improved understanding of Product, Standards, Policies; adoption of some standards and products cited by stakeholders ✓ Influence on decision makers through providing evidence base ❖ Challenges with adoption / implementation – funding & policy	✓ Improved industry collaboration ✓ Improved SME expertise ✓ Led to increase in body of knowledge	• Air quality mapping tool / framework • Improving accuracy of emissions reporting	✓ Sustainability – through increase in knowledge base, awareness & focus ✓ Safety – improving understanding & identification of problems	
Decarb – Projects aimed at reducing carbon levels in rail industry.	✓ Cross industry focus ✓ Meeting market failure ✓ Long term focus ✓ Industry, RSSB collaborate on research focus; appropriate push and pull from	✓ Positive beneficiary feedback: citing improvements to quality based on industry feedback	✓ Insights shared through Decarb Groups, into ICWG group; and further into networks members represent	✓ Has led to new insights / better understanding of future research ✓ Improved understanding of process, standards, products, policy; some adoption of products / policy – further change expected (too early to say) ✓ Influence on decision makers – providing evidence base for stakeholders to take to boards; enabling industry to make data backed decisions to invest	✓ Improved industry collaboration ✓ Led to increase in body of knowledge	• East West Rest Traction Power decision - directly influenced by understanding RSSB Brought (reporting, managing,	✓ Sustainability – bringing Decarbonisation to the agenda, understanding problem, shedding light on previously not well understood area	Policy (e.g., Jo Johnson 2018 rail challenge) Industry sector forms developed that outside of the Rail sector (e.g. Green construction)

	industry, government & RSSB					monitoring Carbon) • Hydrocarbon Trains - TOC are using evidence to present to board on investing		Network Rail R&D
Freight – Project aimed at supporting freight industry growth, and reducing freight traffic related risk	✓ Cross industry focus ✓ Industry collaborating with RSSB on research pipeline & focus ❖ Generally meeting market failure; some potential overlap with Network Rail	✓ High quality output; citing technical reports	✓ Insights shared through groups, & RSSB website & research catalogue ❖ Some challenges with wider dissemination – citing visibility, system sometimes being 'inwards looking'	✓ Has led to new insights / better understanding of future research ✓ Improved understanding of Product, Standards, Policies ✓ Indirect influence on Freight operating companies through RSSB evidence base ❖ Challenges with implementation from industry – citing funding & resource limits	✓ Improved industry collaboration ✓ Building industry talent	• Uneven load & track geometry • T1160 Freight loco decarbonisation	✓ Safety – perceived direct impact through RSSB owning safety strategy ✓ Sustainability – cultural move in part through RSSB evidence	Network Rail R&D
Perform – Projects aimed at achieving performance improvements to run more trains on type.	✓ Cross industry focus, addressing market failure ✓ Industry & RSSB collaborating on research priorities	✓ Good quality of output perceived by stakeholders ✓ Recognition of improvement of quality of products by stakeholder	✓ Insights shared through number of industry groups ❖ Challenges with wider dissemination of output identified	✓ Has led to new insights or better understanding of next steps of research, ✓ Has improved understanding of processes, standards and policies; with change in policies recognised by stakeholders	✓ Improved industry collaboration ✓ Led to increase in body of knowledge	• Driver training • Professional driving policies	✓ Optimisation – increased understanding of issues, and identification of opportunities to improve ✓ Safety - increased focus on risk an risk centric standards	DfT in good place to influence through contracting
Staff Health & Wellbeing – Projects aimed at improving staff head & wellbeing.	✓ Meeting market failure– providing value through economies of scale ✓ Positive perceived contribution from Industry on prioritisation of research focus areas	❖ Mixed feedback on quality – in some cases good quality & engaging, other cases lacking defined outcome or clear	✓ Output shared with immediate industry group ❖ Challenges with wider dissemination of output and insights across industry & organisations, wider groups in industry unaware of output or don't attend meetings	✓ Has led to new insights / better understanding of future research ✓ Has led to better understanding of standards & products – and adoption of new standards. ✓ Influences decision making indirectly through evidencing cases for change,. ❖ Challenge with implementation – making sense of output in practical way, resource limitations in interpreting and taking forwards.	✓ Improved industry collaboration ✓ Improved expertise in industry ✓ Led to increase in body of knowledge	• Colour vision standards in review • Drug & alcohol guidance • Assessing healthy behaviours	✓ Safety – Health less mature in the industry than safety, RSSB driving development of dashboards to be implemented	Transport For London (TfL) Research - focus is more on academic research / knowledge products.

		business / use case ❖ Not always clear on future focus or pipeline						
Engineering Interfaces Optimisation – Projects aimed at optimising engineering interfaces across the industry.	✓ Cross industry ✓ Market failure ✓ Long term future thinking ❖ Not always clear on alignment & direction – should be more focused on agreed problem statements ❖ Some projects such as implementation should sit elsewhere	✓ Outputs generally perceived positively by stakeholders; some raising future need of output with more road mapping / future steps	✓ Insights shared across industry groups in most cases; with well-established working group	✓ Has led to new insights / better understanding of future research ✓ Has led to better understanding of standards, process, policies & products. ✓ Some adoption across standards, process, policies; especially where projects validated in where work will be used. ✓ Influence on DFT / ORR in contract specifications ❖ Some challenges with implementation & feedback this should sit elsewhere	✓ Improved industry collaboration ✓ Improved industry talent – led to more experts in the felid ✓ Led to increase in body of knowledge; annual seminars cited	• Speed differential project (huge potential) • Standards project	✓ Sustainability – Improving understanding of challenges mainly within decarbonisation and air quality, as well as biodiversity management of water, circular economy. Influencing new contract specifications (DTF, ORR) ✓ Optimisation – Providing evidence and benchmarking	Sustainable Round Leadership Group Innovation funds Universities Network Rail UKKRIN
Safety Insights & Tools – Projects aimed at reducing risk and improving safety.	✓ Meeting market failure, cross industry ✓ Long term, low TRL ❖ Generally negative feedback on industry contribution to research focus.	✓ Generally positive feedback on output quality – always helpful & insightful.	✓ Insight shared – programme good at highlighting issues to industry, output used in briefings ❖ Challenges with wider visibility and understanding from industry on how to implement. In some cases due to lack of strong industry sponsorship.	✓ Providing industry direction in early research ✓ Better understanding of process, standards, policies ✓ Adoption of process, policies, products and standards ✓ Influence on decision makers indirectly – evidence for business case production, board briefings ❖ Ongoing challenges with adoption / implementation – handover, sponsorship, unionisation in industry	✓ Improved industry collaboration ✓ Led to increase in body of knowledge	• SPADS – insight tools • Underload toolkit • Workforce development plans	✓ Safety – risk understanding, SPAD knowledge & understanding, understanding issues & bigger picture, wealth of data	Rail safety events and accidents with high public visibility– causing general increase in industry focus on safety.

Other – Projects which did not comfortably align to one of the above research groupings.	✓ Cross industry focus ✓ Meeting market failure ✓ Addressing long term, low TRL research – 'horizon scanning' ✓ Positive feedback on Industry supporting direction of research – citing change of focus to end customer	✓ Positive feedback on quality of output – 'highest quality across industry'	✓ Insights shared to immediate groups via spark data base and presented through annual seminars ❖ Challenges with wider dissemination – RSSB could better articulate achievements	✓ Has led to new insights / better understanding of future research ✓ Better understanding of products, standards, process and some policies; with stakeholders citing adoption of products and standards ✓ Some evidence research influencing decision making through providing an evidence base to take to decision makers.	✓ Improved industry collaboration ✓ Improved industry talent ✓ Led to increase in body of knowledge	• RATS SPAD tool • Level crossings & understanding of risk • Variable rate sanders	✓ Safety – increasing focus, practical research to equip TOCs; improving understanding of risks ✓ Optimisation – projects improving track interaction, enabling wider changes	

Table 18: Qualitative findings from the group analysis sample.

Annex F: Case Study Analysis

A summary of case studies selected for this evaluation is included in Annex D. For more detail about the inclusion criteria, please refer to the methodology section (Section 2).

The following sources where use to gather evidence for the case studies:

- Interviews with key industry stakeholders. This was primarily the industry sponsor or beneficiary. However, if this individual was unavailable, an alternative stakeholder was used
- Interviews and feedback from RSSB project managers who were involved with the project
- Project documentation provided by RSSB
- Publicly available sources such as standards and industry strategies

Structure of Case Study Findings Write-Up

Each case study has been structured in the following way:

Project Overview

- RSSB research context – this provides context about the specific project and challenges the project is looking to solve.
- RSSB aim – this details the aims and requirements of the project.
- RSSB outcome – this details what the project produced.

Impact Analysis

- Project Logic map: Each project had a tailored logic map created, based on the generic programme theory of change which was used as the basis to understand, test and validate the casual link between outputs and impact.
- Assessment of performance against logic map: This section used the logic map to explore and assess the projects outputs, outcomes and impact. Through the interviews and documentation, evidence was gathered to validate the causal link.

  The following key was used to visualise progress along the logic map and assess the impact. By understanding the progress, an assessment could be made on the impact that the outputs have had.

Value for Money Analysis

- RSSB Project Benefits Data: This section used RSSB's project data, primarily from business cases and Post Project Reviews to understand the projected benefits and assumptions.
- Analysis of Assumptions: Assumptions and calculations were tested with SMEs from across industry to understand their accuracy and validity.
- Value for Money Assessment: The projects were given an assessment as to if they were likely to be value for money given the evidence provided.

Process Analysis

- This section used project documentation and stakeholder interviews to understand how the project had been delivered.
- This was reviewed against best practice and any specific areas of concern highlighted.

Overall summary

- An overall summary of the case study was provided which was fed into the main report where appropriate.

Case Study 1 - T1173 - Identifying measures to prevent customer-on-staff work-related violence in the GB rail industry

Project Overview

This project started in September 2018 and completed in May 2021.

RSSB Research Context: Work related violence (WRV) produces significant safety, business, and reputational costs for the GB rail industry. Railway companies currently invest in various WRV initiatives. However, the relative efficacy of these is unknown and, crucially, initiatives may not align with good practice identified in research.

RSSB Aims: This research aimed to identify promising interventions for the prevention and management of work-related violence in the rail industry. This included the exploration of different types of interventions:

- Organisational policies and procedures.
- Individual training and competence management.
- Environmental design adjustments.

RSSB Outcome: This project identified good practice in policies and interventions for preventing and managing work-related violence against frontline staff in the rail industry. Using insight gathered from British Transport Police (BTP) and Safety Management Intelligence System (SMIS) data, and examples of good practice from the literature, the research identified areas of improvement for preventing and managing work-related violence in rail and provides recommendations for improving company policies in this area.

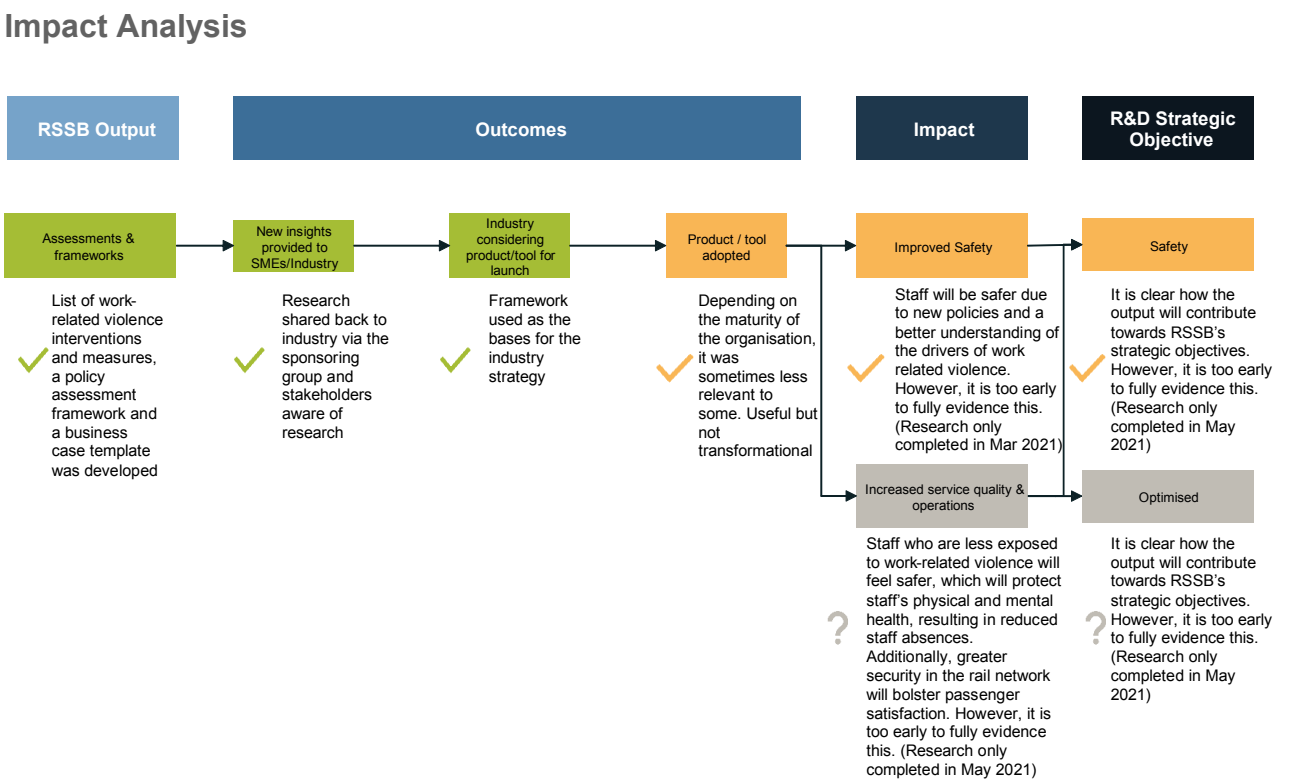


Figure 6: Case study 1 impact analysis.

Assessment of performance against logic map:

- **Purpose:** This piece of research was cross-industry focused and has a wide group of beneficiaries. WRV is an issue which affects multiple stakeholders. Therefore, this project is well suited to the R&D Programme.
- **Outputs:** A list of promising work-related violence interventions and measures was developed in light of best practice identified in literature. A policy assessment framework was developed which will facilitate organisations in designing and implementing an effective work-related violence policy, in line with good practice. The project also delivered a business case template which can help companies in the sector explore options for investing in training around the prevention and management of work-related violence.
- **Outcomes**:
    - Research shared back to industry via the sponsoring group and stakeholders aware of research. Stakeholders cited occasions when other Train Operating Companies (TOCs) referenced the outputs.
    - The project outputs were used as the basis for the industry strategy and used as a checklist for organisations to understand what they already had in place.
    - Depending on the maturity of the organisation, the research is more or less relevant. For example, the stakeholder who was interviewed already has comprehensive WRV policies so used it to sense check. It was seen to be useful but not transformational.
- **Impacts:** More comprehensive WRV policies and strategies will improve the safety of front-line staff. Similarly, there will be less work-related violence resulting in fewer staff absences. However, it is too early to fully evidence this as the research only competed in May 2021.

- **R&D Strategic Objective:** It is clear how the output will contribute towards RSSB's strategic objectives of safety. However, it is too early to fully evidence this as the research only competed in May 2021.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a 'Tangible Product' R&D project which is aimed at developing new products/services or improving existing ones. This means RSSB estimate a benefit cost ratio and look at unweighted and weighted benefits.

RSSB Cost of research:

- Research cost £97,272.
- Co-funding costs £13,500.
- Total £110,772.

RSSB Baseline data & assumptions:

- Safety Management Intelligence System (SMIS) data analysed in the context of this research showed that in 2018/19, around 4,000 days were lost because of staff being exposed to violence. Based on evidence from RSSB, the cost of one day of sickness absence is around £260.
- Therefore, the annual cost of work-related violence within the industry is estimated to be £1.04M (£260 x 4,000 days).

RSSB Improvement data & assumptions:

- Having effective measures in place is likely to lead to a reduction in work-related violence incidents.
- A study by RDG found that body-worn cameras resulted in a 26% reduction in assaults.
- Taking a lower estimate of a 20% reduction in work-related violence incidents would lead to a benefit of £208,000 per year (£1.04M x 0.2).

RSSB Weighting:

- It should be acknowledged that companies within the industry may already have incorporated some of the recommendations from this RDG research. Estimating that 50% of the available benefit is accounted for by existing work-related violence interventions, leaves a remaining benefit of £104,000 a year.
- If the recommendations from this research are implemented by 100% of the industry with the benefits being realised after 2 years, the total benefit that may achieved from this research is estimated to be £760,000 over 10 years.

RSSB Benefit Cost Ratio:

- 6.9 (£760,000 / £110,772).

Analysis of assumptions

Baseline: The stakeholder interviewed confirmed the SMIS is the most accurate data source for staff absences. Similarly, the cost of one day of sickness is similar to a band 4 or 5 job role (typically the individuals where most WRV occur).

Improvements: There was confirmation from an SME that the RDG study used as a basis for the improvement figure was well recognised and assumptions took a reasonable lower estimate.

Implementation: There is no mention of implementation cost associated with this project following the R&D investment. This is necessary to understand the full impact and return on investment of the project benefits. The stakeholder suggested this is not an accurate reflection, especially for smaller organisations as training material and time of employees could have a significant cost to the business which is not just an opportunity cost.

Weighting: There was confirmation that some of the benefits from the RDG study were likely to have been taken and 50% was a reasonable assumption. Realising the benefits after 2 years was deemed optimistic by the stakeholder as typically this type of change takes longer.

Value for Money Assessment: The analysis used for this calculation has been verified through key SME stakeholders. We are unable to complete the full value for money investment without implementation costs post R&D investment. That said, there is sufficient margin of error in the BCR that would allow for reasonable investment to still demonstrate value for money.

Process Analysis

Key project documentation is available for this project and a lessons learned exercise completed. Industry stakeholders were engaged throughout the process, both during idea generation and approving the final outputs.

Stakeholder feedback suggested outputs could have been tailored more to be more impactful.

Overall Summary

It is likely this project will have an impact in the industry but due to the research only completing in 2021, it is difficult to fully evidence this. This research provided insight for industry on the most effective interventions for work-related violence and provided tools for companies to make the case for interventions within their own organisation. Although it was considered successful, stakeholders saw it as useful rather than transformational, with more tailoring required to make it impactful.

Although no post R&D implementation costs were included in the business case, there is sufficient margin of error in the BCR that would allow for reasonable investment to still demonstrate value for money.

Case Study 2 - COF-G18-01 - Automated collection of train consist information

Project Overview

This project started in July 2018 and completed in November 2018.

RSSB Research Context: A consist is the group of vehicles that make up a train. There is currently no automated way of recording the consist of trains on the GB rail network. As a train enters a station, the location of carriages, their order and orientation are unknown and is therefore not easily communicated to the passenger / integrated in passenger communication systems.

Many systems and processes would be improved if accurate real-time information regarding consists was available. For example, the recording of the availability of on train facilities or the busyness of carriages only really makes sense if it can be attributed to a particular service; to do this requires an understanding of the train's consist.

RSSB Aims: The overall aim of this project was to assess the feasibility to automate the collection of train consists using new and existing CCTV cameras. Fixed CCTV cameras were mounted at strategic locations at Shoreditch High Street station and Gospel Oak station, enabling passenger trains to be recorded as they passed by. Image processing techniques and optical character recognition (OCR) were trialled to convert images into useable serial numbers.

RSSB Outcome: From a sample size of 126 serial numbers, a 100% success rate was yielded from images indoors (under constant lighting) and outdoors during daylight hours; whilst a 25% success rate was yielded from images outdoors during night-time. The research also identified other potential benefits, including the ability to detect passenger occupancy, carriage cleanliness and graffiti.

Impact Analysis

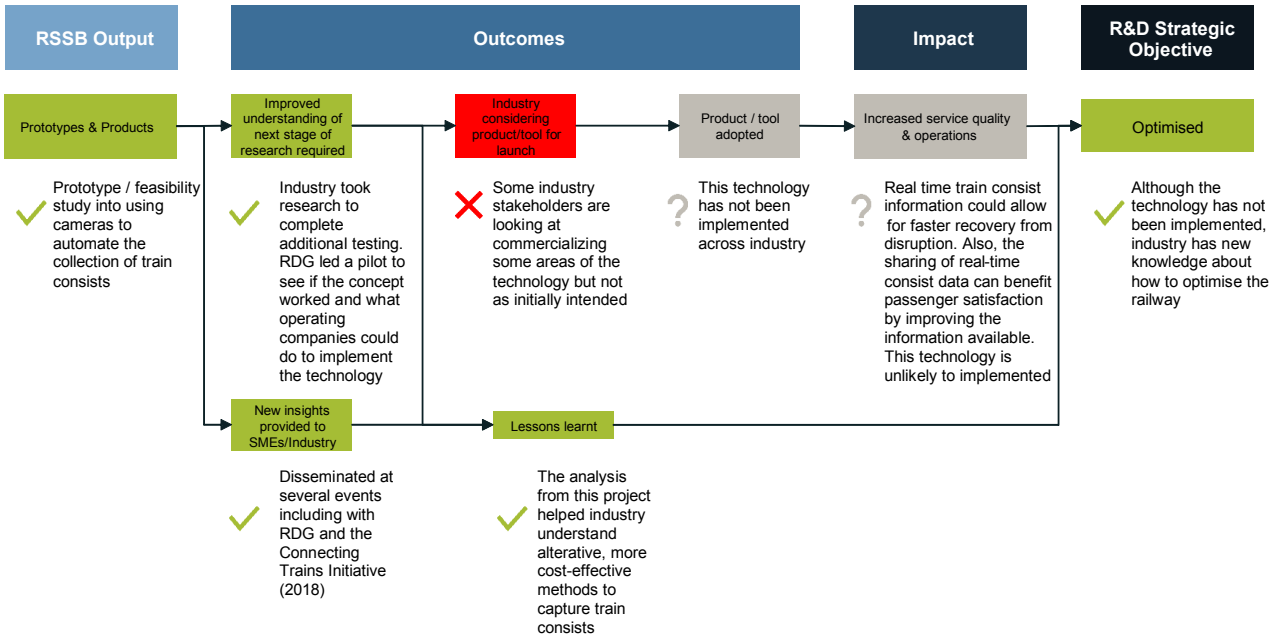


Figure 7: Case study 2 impact analysis.

Assessment of performance against logic map:

- **Purpose:** This piece of research was cross-industry focused and has a wide group of beneficiaries. As train consists is an industry interface between the station owners/operators, and train/freight operating companies, this project is suited to the overall purpose of the RSSB R&D Programme.
- **Outputs:** This project assessed the feasibility to automate the collection of train consists using new and existing CCTV cameras. It successfully achieved its outcome of testing the OCR technology.
- **Outcomes:**
  - This research was disseminated at several events including with the RDG and the Connecting Trains Initiative in 2018. The research also identified other potential benefits as well as areas of further development. This led the industry to complete additional testing. Specifically, the RDG led a pilot in Doncaster to see if the concept worked and what operating companies could do to implement the technology.
  - Following the further research, other solutions were considered ‘simpler’ and more cost effective and therefore progressed further. The initial research provided industry with the knowledge as to whether to progress the technology further. RDG confirmed they have chosen not to progress this technology further.
  - Parts of the technology are looking at being commercialised, but not using the initial use case or by the initial industry sponsor. At the time of this evaluation, this has not been implemented across industry and there hasn’t been a direct improvement in service quality or operations. It is not expected to make any significant further progress down this causal path.
  - However, the research has provided industry with knowledge and insight into this technology, if it is cost effective to implement and alternative solutions.

- **Impacts:** Real time train consist information could allow for faster recovery from disruption. Also, the sharing of real-time consist data can benefit passenger satisfaction by improving the information available. However, this technology is unlikely to implemented.
- **R&D Strategic Objective:** Although this technology is unlikely to be implemented, this research provided allowed industry to make informed decisions and select alternative solutions. This contributed towards the overall strategic objectives of creating an optimised railway.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a 'Tangible Products' R&D project which is aimed at developing new products/services or improving existing ones. This means RSSB estimate a benefit cost ratio and look at unweighted and weighted benefits.

RSSB Cost of research:
- Research cost £50,000.
- Co-funding cost £29,000.
- Total - £79,000.

RSSB Implementation costs:
- The cost of rolling out RFID trackers (641 sites) is £9,583,000.
- The cost of using new CCTV cameras (641 sites) is £4,487,000.
- There would be a saving of £5,096,000.

RSSB Weighting:
- Benefit weighting has been set at 90% to reflect the strong likelihood of take up by Rail Delivery Group and Arriva Rail London.
- This gives a saving of £4,586,400.

RSSB Benefit Cost Ratio:
- 1 (£4,586,400 / (£79,000 + £4,487,000)).

Analysis of assumptions

Baseline: The business case has not quantified the baseline position for this project.

Improvements: It is correct that using CCTV cameras over RFID trackers is more cost effective and there will be saving, however, this should be considered as an implementation cost. There is an assumption that RFID trackers must be purchased and there is no option of 'do nothing'.

Implementation: The numbers used for the cost of rolling out the RFID trackers and CCTV cameras are from Network Rail, thus considered accurate. The numbers also reflect the most stations with the highest volume of passenger traffic (DfT station category A-D data). This identified in the business case before project delivery.

Weighting: The weighting factor is reasonable as confirmed through stakeholder interviews. While the project was underway, industry was heavily engaged and articulated a strong appetite to implement the technology.

Benefit Cost Ratio: The BCR for this project is 1. Therefore, if fully successful, it would only cover the cost of development and there would be no additional value delivered. This BCR was only calculated in the Post Project Review.

Value for Money Assessment: Although the BCR was only calculated in the Post Project Review, the information to make this calculation (implementation costs) was already available in the case for research and grant application. This calculation should have been made to help inform whether to progress this project. Also, it is clear there was Industry 'pull' for this technology. However, that does not necessarily mean a project is value for money.

From the evidence provided, this project would not be considered value for money or good use of resources.

Process Analysis

In the case of this project, the entry management process was not effective, as implementation cost information was available in the case for research, which would have demonstrated the low BCR, indicating it was not a value for money project to progress.

Key project documentation is available for this project and industry stakeholders were engaged throughout the process, both during idea generation and approving the final outputs. However, the business case and PPR do not give an accurate reflection of the benefits. The baseline, benefits of technology or improvement are not included in the business case or PPR. Only a saving in implementation costs is identified.

The research produced the desired outputs, but ultimately was not adopted by industry. These lessons have been incorporated into the Programme and follow-on research pivoting from the initial technology. This demonstrates good exit management and incorporating lessons learnt.

Overall Summary

The initial research provided industry with the knowledge as to whether to progress the technology further and helped inform industry decisions. Although the original use case is unlikely to be realised, lessons have been fed back into the RSSB R&D Programme and parts of the technology are looking to be commercialised (for different use cases).

The assumptions used in the benefits case are not a true reflection of the benefits associated with this project. Additionally, the BCR only breaks even if fully successful. Therefore, this project would not be considered value for money or a good use of resources.

Case Study 3 - T1112 - Quantify the distribution of unevenly loaded container wagons

Project Overview

This project started in January 2017 and completed in July 2017.

RSSB Research Context: Following several high-profile freight train derailments (Reading West in 2012 and Camden Road in 2013) caused by a combination of unevenly loaded containers and track twist fault, the Chief Inspector of Railways of the ORR requested that several key companies in the Rail Industry work collectively to address concerns about freight train derailment relating to these areas.

As part of the response to this letter, the Cross Industry Freight Derailment Working Group (XIFDWG) was established to address these issues. This group was specifically set up and facilitated by RSSB. Several projects were identified such as: COF-UOH-17 Track Twist, Body Torsional Stiffness and Offset Loading of Derailment of Freight Wagons, T1112 Quantify the distribution of unevenly loaded container wagons and a separate project T1119 Simulating the effects of offset loading in containers on risk of derailment on twisted track.

COF-UOH-17 was focused on early understanding and knowledge and T1112 and T1119 represented two sides of the coin in understanding the risk of derailment due to uneven loading. T1119 looked to understand the effects of offset loading on propensity to derailment, this project T1112 looked to understand how containers are loaded in practice.

RSSB Aims: T1112 specifically looked to identify the extent and frequency that overloaded, and unbalanced containers are transported on the rail network within the Great Britain. Several key questions were asked to help provide a baseline for a sensitivity analysis for derailment.

RSSB Outcome: A summary knowledge report was produced as an output from this project as well as a data set of how containers are loaded.

Impact Analysis

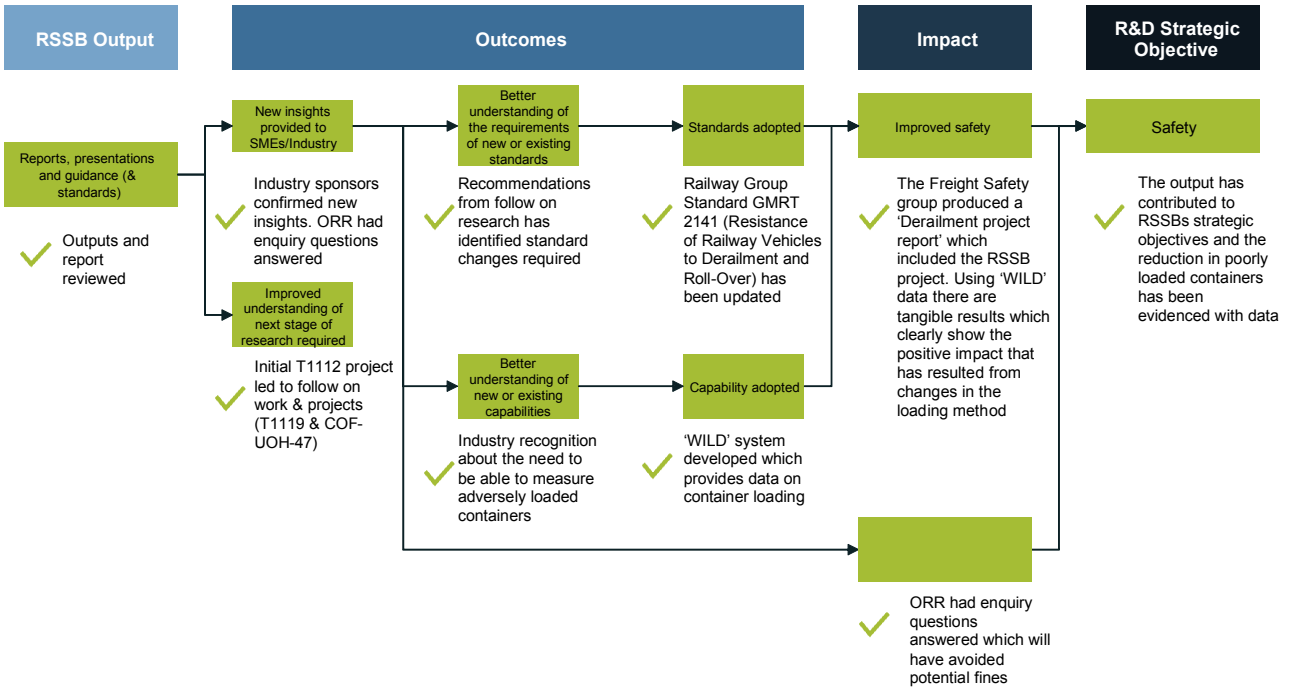


Figure 8: Case study 3 impact analysis.

Assessment of performance against logic map:

- **Purpose:** This piece of research was cross-industry focused and has a wide group of beneficiaries. As rail freight derailment is comprised of multiple factors and the ORR requested an improved understanding across industry, this project is suited to the purpose of the RSSB R&D Programme. Similarly, the data required for analysis was made up from several stakeholders and therefore needed central coordination.
- **Outputs:** A summary knowledge report was produced as an output from this project as well as a data set of how containers are loaded.
- **Outcomes**:
    - The report was shared with industry and the XIFDWG.
    - This project identified the next phase of research required which helped shape the future project COF-UOH-47.
    - The analysis of the follow-on project findings has provided new insight into the approval process of new wagon designs. As a result, Railway Group Standard GMRT 2141 (Resistance of Railway Vehicles to Derailment and Roll-Over) has been updated to include these recommendations.
    - The analysis also helped the industry recognise the need to be able to measure adversely loaded containers. This led to Network Rail developing the 'WILD' system which measures container loading.
- **Impacts:** The impact of these actions across the industry can be understood by reviewing NR's WILD trend data from the 'Derailment project report'. Across all freight types there is a clear reduction in risk, which can be linked to the actions taken by Freight Operating Companies and initial work by RSSB. Most striking is the significant drop in the most severe category of exceedance of loading limits.

Given that most severe exceedances were the most likely to derail, it is reasonable to conclude the actions taken by FOCs and rail freight customers have had a significant impact. Also, the XIFDWG has been able to respond to the ORR and answer all queries about the risk of freight derailments.

- **R&D Strategic Objective:** The output has contributed to RSSB's strategic objective of safety and the reduction in poorly loaded containers has been evidenced with data.

Value for Money Analysis

This specific project was categorised as 'Non-Quantifiable' in reporting of benefits. This means no calculations were made to calculate any benefits. As this was part of a larger project, some of the benefits analysis was included in the business case for T1119. This has not been reviewed for this analysis.

It was a relatively small piece of work with an overall budget of £10,000. Given the scope (safety related) and size of this project, this categorisation is reasonable. RSSB engaged extensively with haulage experts which secured the loading data for a very small cost. To measure this data would have been much more expensive. Multiple quotes were obtained suggesting RSSB ensured the prices were competitive.

This project was part of responding to an ORR enquiry. Had the industry not responded, it is possible the investment would have been mandated as legal compliance with the regulator may have been breached.

Value for Money Assessment: The relatively small cost of the project suggests it was value for money given the possibility of being non-compliant with ORR regulation and the direct impact it had on reducing risk. Quantifying this is not possible due to the influence of other projects and lack of information at the time of evaluation.

Process Analysis

Some key project documentation was available for this project, such as the research idea form, project specification and final report output. However, there was no 'post project review (PPR)' or specific business case available for this project. This was due to the project being considered a sub-project of one of the other projects, relatively small size of the project and governance processes which do not require authorisation of budget below a certain value. High-level benefits were found in the 'research idea form' but it is not entirely clear how the outputs from the project would achieve these benefits - a benefits map could have helped communicate this.

As mentioned previously this was a small project and part of a wider research challenge that together created value. However, it is not initially clear how these projects are linked and how follow-on projects are commissioned. There is no clear mechanism to identify these projects aside from free text comments in various benefits tracking and implementation spreadsheets. This has been a conscious decision from RSSB due to the resource and cost requirement of linking projects together. Not linking projects creates a risk that benefits could be double counted and/or overestimated if not linked.

During the idea generation phase, and initial investigations by RSSB/industry into the availability of data, it became clear that a lot of previous work had been done by a specific consultant. This was through extensive searching on the SPARK database and desktop research. Therefore, the scope was updated to reflect this and ensure the project provided industry with the necessary information it required and added new knowledge. This highlights a strength in RSSB's entry management process, to ensure projects do not duplicate existing research.

Overall Summary

Through key stakeholder interviews and reviewing standards and publicly available reports, it was clear this project has contributed to RSSB's overall strategic objective of creating a safer railway and has delivered impact. Across all freight types there is a clear reduction in risk, which can be linked to the actions taken by Freight Operating Companies and initial work by RSSB. Most striking was the significant drop in the most severe category of exceedance of load limits. Given that most severe exceedances were the most likely to derail, it is reasonable to conclude there has been a significant impact.

The process could be improved by linking projects and business cases. It was not clear when reviewing this project how it linked to other projects and stages of research.

This project was part of responding to an ORR enquiry. Had the industry not responded, it is possible the investment would have been mandated as legal compliance with the regulator may have been breached. The relatively small value of the project suggests it was value for money given the possibility of large fines across industry and direct impact it has on reducing risk. Quantifying this is not possible due to influence of other projects and being a safety-related project.

Case Study 4 - T1198 - DECARB - Interim and long-term targets to achieve decarbonisation strategy

Project Overview

This project started in July 2020 and completed in March 2021.

RSSB Research Context: In June 2019, the government set a statutory national target of net zero greenhouse gas emissions by 2050 as part of the UK's commitments to global efforts to limit climate warming to 1.5 degrees above pre-industrial levels.

In February 2018 the rail minister set a challenge to remove diesel-only trains from the network by 2040 and to develop a vision for decarbonisation. In response, the rail industry Decarbonisation Taskforce submitted its final report to the in July 2019. The Taskforce proposed a combination of electrification, hydrogen, and battery traction, as well as a whole life, whole system approach, as the most cost-effective way to deliver rail's contribution to the national target. The Traction Decarbonisation Network Strategy (TDNS), led by Network Rail's System Operator, built on the work of the Taskforce to produce a

map of the GB rail network. This set out where electrification, battery, and hydrogen trains may be best deployed to achieve these aims.

However, it was noted that the rail industry cannot rely on a single 2050 target. It was recognised that there is a need for advice and guidance on interim targets and decarbonisation pathways to inform the Department for Transport (DfT) and the industry more widely.

RSSB Aims: The aim of this project was to provide technical guidance and advice to DfT and the whole rail industry on the possible decarbonisation trajectories and interim target pathways for rail's contribution to the 2050 national net zero emissions target.

RSSB Outcome: This project identified four key issues in relation to the target-setting: types of targets, breakdown of targets, frequency of interim targets, and shape of absolute emissions reduction trajectory. Working with industry and through a review of existing literature, this project recommended a target-setting approach to decarbonisation. It also derived interim targets along with the roles for stakeholder groups for each target pathway.

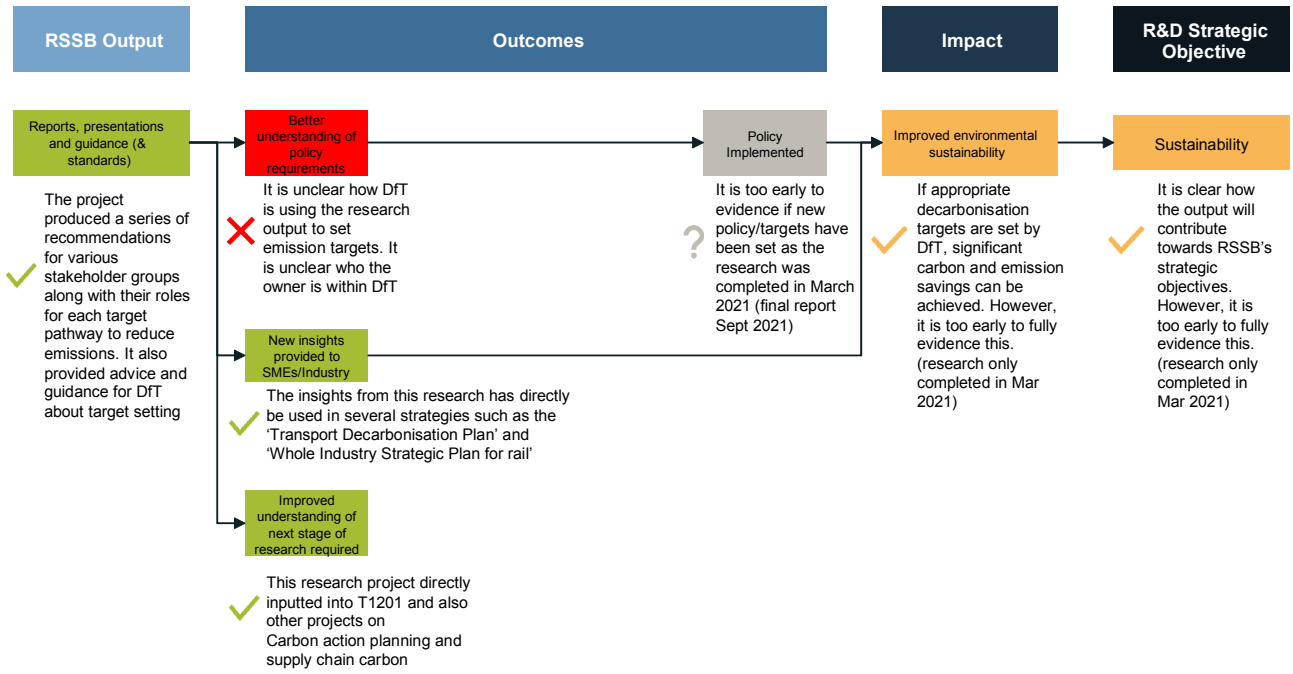


Figure 9: Case study 4 impact analysis

Impact Analysis

Assessment of performance against logic map:

- **Purpose:** This piece of research was cross-industry focused and has a wide group of beneficiaries. It provided guidance to the whole rail industry on the possible decarbonisation trajectories and interim target pathways for rail's contribution to the 2050 national net zero emissions target. Therefore, this project is suited to the purpose of the RSSB R&D Programme.

- **Outputs:** The project produced a series of recommendations for various stakeholder groups along with their roles for each target pathway to reduce emissions. It also provided advice and guidance for DfT about target setting.
- **Outcomes**:
    - It is unclear how DfT is using the research outputs to specifically set emission targets which was the aim of the project. There appears to be no clear owner within DfT of the guidance, despite DfT being the organisational owner. Suggested individuals to contact for more information have left the organisation and COVID-19 was suggested as a possible reason as to why this has become a lower priority. As the research was completed relatively recently (March 2021) it may be too early to observe any changes to policy or targets.
    - The project has provided insights to industry which has been directly included in several strategies such as the 'Transport Decarbonisation Plan' and 'Whole Industry Strategic Plan for rail'. It has also facilitated collaboration with over 100 stakeholders across the industry.
- **Impacts:** If appropriate decarbonisation targets are set by DfT, significant carbon and emission savings can be achieved. However, as the research was only completed in March 2021, targets have not yet been set and it is too early to evidence if the research is having its desired impact.
- **R&D Strategic Objective:** It is clear how the output aligns to RSSB's strategic objective of Sustainability. However, it is too early to fully evidence this as the research was only completed in March 2021.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a ''Knowledge Products'' for benefits monitoring meaning it delivered knowledge or facilitated industry decisions. This means the benefits reported by RSSB for the project was the 'size of opportunity'.

RSSB Cost of research:

- RSSB - £160,100.

RSSB Baseline data & assumptions:

- The baseline level of industry emissions in 2019 was 9,488,425 *tCO_2e.*
- Using DfT's WebTAG figure of £62 per tonne of CO2 gives a figure of £588M.

RSSB Improvement data & assumptions:

- Using pathway 3 for emission reductions, a 90% reduction could be achieved from the baseline.
- This would result in a reduction of £529M.

RSSB Size of Opportunity:

- £529,000,000 (over 25 years).

Analysis of assumptions

Baseline: The figures used for the calculation have been provided by DfT and align to the WebTag for calculating the cost of carbon.

Improvements: Pathway 3 has been used to calculate the benefits which is the more conservative estimate.

Value for Money Assessment: There are no implementation costs included so a BCR cannot be used to assess if this project is value for money. The size of opportunity is large enough to suggest it is likely to be value for money given the relatively small research cost. Techniques such as using a sensitivity analysis to calculate minimum improvement required to achieve a positive BCR or creating specific use cases/case studies within the size of opportunity, would help provide confidence that the investment is value for money.

Process Analysis

This project has key project documentation such as the research idea form, project specification, final report output business case and post project review.

A key part of this project was engagement with industry and DfT to ensure the outputs were as impactful as possible. This involved ensuring the requirements were collaboratively formed at the beginning of the project. Stakeholders interviewed confirmed these collaborative ways of working.

It is unclear who owned the research following completion suggesting that implementation was less effective for this project. Despite positive engagement throughout the project with DfT, it is now unclear how they are using the outputs to set targets.

Overall Summary

This project finished relatively recently so it is not possible to evidence if it is having an impact. However, there is clear evidence that the project is directly inputting into key industry strategies such as the Transport Decarbonisation Plan.

It has not been possible to contact the ‘customer’ of the project (DfT) to understand how they are using the outputs of the project to set industry targets – a key aim of the project. This could be due to various reasons such key stakeholders leaving the organisation and COVID-19 changing the priority. More focus could be required in the handover stage of the project to ensure industry/customer fully utilise the outputs.

Case Study 5 – COF-TAR-03 - Adhesion Riddle Feasibility Study on the use of Dry-ice for Rail Head Cleaning

Project Overview

This project started in 2016 and completed in 2017.

RSSB Research Context: Rail head adhesion, which refers to the 'slipperiness' of the rails due to surface contaminants such as leaves, rust, oil and grease, is a year-round, whole-system problem at the interface between train and track. The problem is complex because of the number of factors involved, some of which can be monitored and controlled and some of which cannot.

The lack of reliable and predictable braking results in significant train disruptions and cancellations and an increased number of safety related incidents. Low adhesion is the cause of substantial cost to the rail industry. The estimated direct costs (such as rail head treatment trains, manual rail cleaning) and indirect costs (such as driver reaction and morale; service disruptions and delays) make low adhesion an expensive challenge for the rail industry to tackle. One way to mitigate the problem of adhesion loss is to clean the rail head to remove moisture and contamination.

RSSB Aims: To assess the feasibility of using dry-ice blasting as a new approach to achieve rail head cleaning. As pellets of dry ice come into contact with a contaminant layer, they cool it causing the contaminant to crack and de-bond. Further bombardment, and the blast as the pellets turn into gas, acts to remove the contaminant.

RSSB Outcome: The project produced a feasibility study into using dry-ice blasting as a new approach to rail head cleaning. This increased the body of knowledge and outlined if it was feasible to use this technology to improve rail head adhesion. In this case, the technology was identified as a potential solution and the next steps required to progress and increase the TRL were outlined.

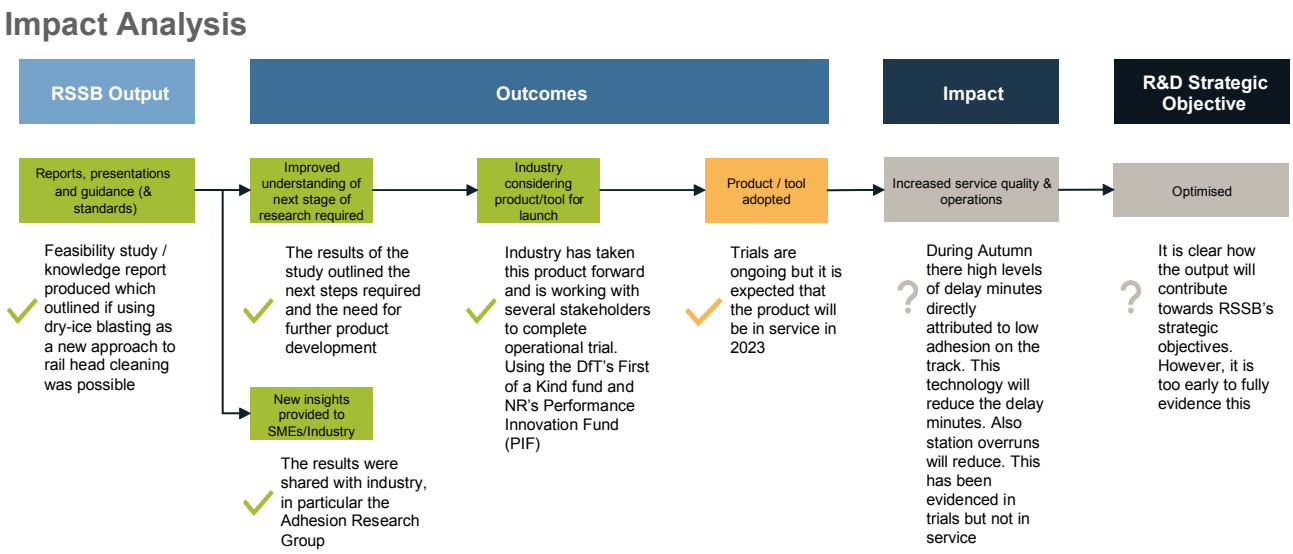


Figure 10: Case study 5 impact analysis

Assessment of performance against logic map:

- **Purpose:** Rail head adhesion is a cross industry issue as it is part of a key system interface. The project looked to address this issue and if successful would benefit the industry as a whole rather than an individual stakeholder. Therefore, this project was suited to the purpose of the research Programme.
- **Outputs:** The project produced a feasibility study into using dry-ice blasting as a new approach to rail head cleaning.
- **Outcomes**:
    - This project increased the body of knowledge and outlined if it was feasible to use this technology to improve rail head adhesion. In this case, the technology was identified as a potential solution and the next steps required to progress and increase the TRL were outlined.
    - This information was shared at the RSSB Adhesion Research Group and with industry more broadly through seminars and other related working groups.
    - Industry took ownership of this research and has since been driving it forward towards full implementation. RSSB has been facilitating this roll out and advising on other funding mechanisms to support operational trials such as the RSSB's Predictable & Optimised Braking competition, DfT's First of a Kind (FOAK) fund and NR's Performance Innovation Fund (PIF). It is expected that the product will enter service in 2023.
    - The trials have demonstrated that there is a measurable improvement in low adhesion, but the product still requires further development and trials e.g., fitting to operational trains.
- **Impacts:** From the initial trials, there was a clear benefit for reducing delay minutes which are attributed to low adhesion on the track. Further monitoring of this project would provide the evidence required to validate the causal path and quantify the impact. Following the stakeholder interviews, it is clear this project has had an impact as has been used in operational trials which demonstrated the ability to increase service quality through reduced delay minutes.

- **R&D Strategic Objective:** It is clear how the output will contribute towards RSSB's strategic objective of creating an optimised railway. However, it is too early to fully evidence this.

There is clear evidence that this project is likely to have an impact across the industry and will contribute towards the strategic objectives. However, it is too early to evidence the full extent of this.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a ''Knowledge Products'' for benefits monitoring meaning it delivered knowledge or facilitated industry decisions. This means the benefits reported by RSSB for the project was the 'size of opportunity'.

RSSB Cost of research:

- RSSB - £57,000.

RSSB Baseline data & assumptions:

- Adhesion-related issues cost the rail industry an estimated £63M per year.
- Of this, approximately £30M relates to railhead treatment and £5M to the cost of manual cleaning.

RSSB Improvement data & assumptions:

- If the technology is fully implemented, a conservative 10% efficiency could be achieved.
- Therefore, the size of this benefit could be £3.5M per year.

RSSB Size of Opportunity:

- £3,500,000 (per year).

Analysis of assumptions

Baseline: An Adhesion SME stakeholder confirmed the baseline cost to industry was an accurate reflection and proportion of manual cleaning.

Improvements: Reviewed with SMEs and a train performance manager from a TOC and confirmed these are accurate.

Value for Money Assessment: Having spoken to key stakeholders (TOCs), more comprehensive business cases have now been created. However, we have been unable to review these as they are commercially sensitive and specific to the individual organisation. Though there is not evidence to demonstrate value for money, based on the organisation progressing the technology further, it could be inferred the product is commercially viable and is proving value for money..

Process Analysis

Key project documentation was available for this project such as the research idea form, project specification, final report output and Post Project Review (PPR).

The stakeholder interviewed for this project suggested that funding, ownership and product development for the next stages of this specific research felt uncertain and slightly “hand to mouth”. RSSB stated that this research is part of the wider Adhesion working group’s roadmap and as such a full plan to implement a solution goes beyond a single project. Therefore, further roadmap and implementation steps are not within RSSB’s remit. More clarity may be required as to when RSSB involvement ends and when other organisations take ownership and drive implementation forward. However, having only spoken to one stakeholder, this is not conclusive.

Overall Summary

This project produced a feasibility study which was used to facilitate industry decisions on what technology to pursue for improving rail head adhesion. Industry stakeholders have used this initial piece of research to further develop this technology and are beginning to realise the benefits as more trials are complete. The product is expected to enter service in 2023.

The process and governance of this project was comprehensive, but stakeholders suggested no clear roadmap to full implementation. More clarity may be required as to when RSSB involvement ends and when other organisations take ownership and drive implementation forward. However, having only spoken to one stakeholder, this is not conclusive.

Case Study 6 – COF-DSP-03 – IntelliDwellTime Demonstrator Project

Project Overview

This project started in Jan 2020 and completed in July 2020.

RSSB Research Context: In 2017, RSSB launched the Data Sandbox initiative as a step on the way initiate data-driven solutions to enhance service reliability. This was a £500,000 call for research to identify novel data-driven solutions to better understand and improve service reliability, that is delays and cancellations.

In 2019 RSSB launched the Data Sandbox+ which built on the original 'Data Sandbox' initiative and data repository. It included new content and data from Network Rail, Rail Delivery Group, Connected Places Catapult, and a variety of TOCs, Met Office and others. Proposals were expected to deliver innovative data-driven solutions to better understand and improve service reliability, that is delays and cancellations.

This project is part of the Data Sandbox+ Initiative and looked to address station dwell times. An estimated 1 million delay minutes are incurred annually across the rail network during station stops (some 7% of total delay minutes).

RSSB Aims: The aim of this project was to create and develop an innovative data-driven software analytics demonstrator, IntelliDwellTime (IDT) to help both train operators and Network Rail (NR) better understand the variation in train dwell times at stations and therefore reduce operational delays.

This was delivered as a consortium. Porterbrook, in collaboration with Abellio ScotRail (ASR), Porterbrook's data science company partner, Elastacloud and the University of Southampton's GeoData Institute and Transportation Research Group worked collaboratively to deliver this project.

RSSB Outcome: The project created a tool generated from collecting data on the dwell times of a sample of trains during normal operation. This enabled users to analyse the data and test how different factors correlate with the length of the dwell time, such as station layout or precipitation and allowed the user to filter by parameters such as time of day or vehicle class. This led to a clearer understanding about dwell times and future benefits.

    - Changing priorities of industry due to reduced passenger numbers mean temporarily we are unlikely to see any progress. As priorities have shifted, it would not be a sensible use of resources to continue to develop the tool at this stage.
- **Impacts:** Reduced dwell times may reduce journey times leading to increased satisfaction and improved service reliability. Similarly, Network Rail may be able to identify areas where unnecessary dwell time allowances can be reduced. It is too early to evidence this.
- **R&D Strategic Objective:** It is clear how the output will contribute towards RSSB's strategic objectives of creating an optimised railway. However, it is too early to fully evidence this.

Impact Analysis

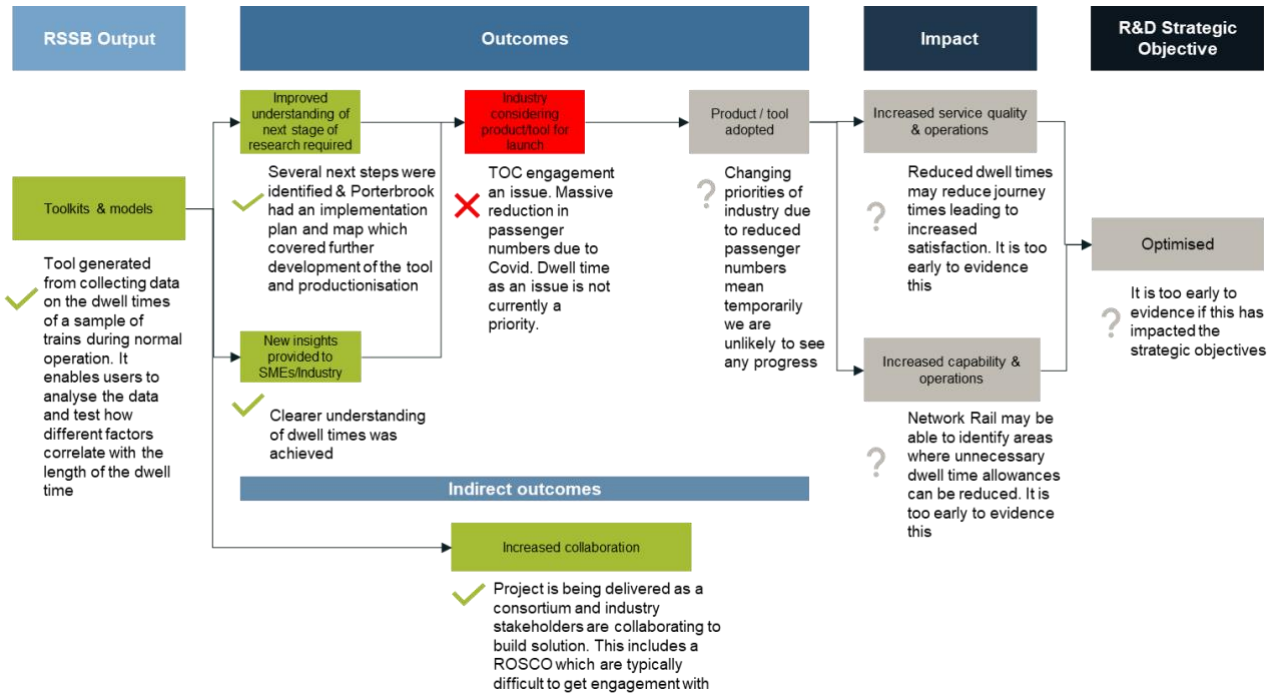


Figure 11: Case study 6 impact analysis.

Assessment of performance against logic map:

- **Purpose:** This project was part of a research challenge competition which encouraged users to create solutions to address key network performance challenges. The specific project looked at station dwell times - a challenge that is not well understood across the industry and one that affects multiple stakeholders. Therefore, this project was suited to the purpose of the research programme.
- **Outputs:** The output from the project was 'IntelliDwellTime (IDT)', a tool generated from collecting data on the dwell times of a sample of trains during normal operation. This enabled users to analyse the data and test how different factors correlate with the length of the dwell time, such as station layout or precipitation and allowed the user to filter by parameters such as time of day or vehicle class.
- **Outcomes**:
  - This project led to a clearer understanding about dwell times and future benefits.
  - Several next steps were identified & Porterbrook had an implementation plan and map which covered further development of the tool and productionisation
  - There is 3rd party ownership of the solution demonstrating interest from industry and pursuing progress with their own funds.
  - TOC engagement is now an issue. A massive reduction in passenger numbers due to Covid has meant TOCs are less receptive to developing the tool further with Porterbrook. Dwell time as an issue is not currently a priority.

The implementation of this project has been significantly impacted by COVID-19 and the associated reduced passenger numbers. This has led to dwell times at stations no longer being an industry priority while passenger numbers are reduced. Due to the interest from industry and IP ownership by a 3rd party, it is likely once passenger numbers increase and dwell times become a higher priority, an impact will be observed. Currently, it would not be a good use of resources to drive implementation forward.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a ‘‘Knowledge Products’’ for benefits monitoring meaning it delivered knowledge or facilitated industry decisions. This means the benefits reported by RSSB for the project was the ‘size of opportunity’.

RSSB Cost of research:

- RSSB - £81,900.
- Co-funding - £73,000.
- Total - £155,000.

RSSB Baseline data & assumptions:

- The number of delay minutes in 2018/2019 was 16.7M.

RSSB Improvement data & assumptions:

- Abellio ScotRail estimated that station dwell times are responsible for 7% of these delays, approximately 1 million delay minutes.
- Assuming a value of £50 per delay minute, this means these delays cost the industry approximately £50m per year (1 000 000 * £50 = £50 000 000).
- Over the course of a 5-year period after which the tool would need some fundamental update and modifications, this amounts to £250m (50m x 5).
- The degree to which this will be reduced due to the use of the tool is unclear but applying a fully developed version of this tool to optimise operations and thus delays due to unexpected dwell times would be reduced.

RSSB Size of Opportunity:

- £250,000,000 (over 5 years).

Analysis of assumptions

Baseline: The figures used for delay minutes was accurate and available from publicly available sources.

Improvements:

- Stakeholders involved in the project stated partnering with Abellio ScotRail meant estimates from station dwell times was based on real data making the calculations more accurate.
- A figure of £50 was used for delay minutes. Data from NR’s FMS-TRUST data would suggest a value of £88.10 is the average cost of a delay minute and give a more accurate estimate of the size of opportunity. The average is reflective of all regions (including regions with lower and higher delay minute impacts).

Value for Money Assessment: There are no implementation costs included so a BCR cannot be used to assess if this project is value for money. The size of opportunity is large enough to suggest it is likely to be value for money given the relatively small research cost. Techniques such as using a sensitivity analysis to calculate minimum improvement required to achieve a positive BCR or creating specific use cases/case studies within the size of opportunity, would help provide confidence that the investment is value for money.

Given the size of opportunity and subsequent commercial interest, it is likely this project was value for money.

Process Analysis

A call for ideas / research competition is a good way to source ideas from across industry and leads to increased collaboration as evidenced in this project.

Key project documentation was available for this project such as the research idea form, project specification, final report output and Post Project Review (PPR).

The stakeholder interviewed for this project suggested they were not fully aware of the implementation options and next steps. They were involved throughout the process but as ownership is now with Porterbrook, they may not be fully sighted on implementation plans. Added to this, the change in priority due to a fall in passenger numbers may have resulted in reduced communication and updates. RSSB have confirmed Porterbrook are still committed to the case but struggling with TOC engagement (as mentioned previously due to changing priorities).

Overall Summary

The implementation of this project has been significantly impacted by COVID-19 and the associated reduced passenger numbers. This has led to dwell times at stations no longer being an industry priority in the short-term. Due to the interest from industry and IP ownership by a 3rd party, it is likely once passenger numbers increase and dwell times become a higher priority, an impact will be observed.

Case Study 7 – COF-UOH-07 - Red Aspect Approaches to Signals

Project Overview

This project started in 2016 and completed in early 2017.

RSSB Research Context: A Signal Passed at Danger (SPAD) occurs when a train passes a stop aspect without authorisation and can lead to delays and potentially more serious incidents, such as train collisions or derailments. By its very definition a SPAD can only occur when a train approaches a red aspect signal.

Prior to this project, the industry knew how many SPADs occurred, but had no idea how many times signals were approached at red by a driver – this created a large gap in industry knowledge. On occasions when this information was required, time consuming and not particularly reliable workshops, with a small group of drivers, were held asking individuals how often they encountered red signals.

RSSB Aims: This project aimed to use available data to create an automated system to collect and categorise Red Aspect Approaches to Signal (RAATS) data to obtain previously unavailable insight into RAATS, and their relationship with SPADs.

RSSB Outcome: The project developed a web-based tool that provides intelligence on approaches to signals at danger. It allows users to determine how often a signal is approached at red. Results can be broken down by train type, day of the week or time of day and analysis can be carried out on signal groups. Users can interrogate and visualise data within the tool or export it to Excel.

The RAATS tool uses information feeds that Network Rail provides through its open data initiative. They contain the times that trains move between track sections and the times that signals change aspect. On a typical day around 3.7 million of these messages are generated. The tool processes them by applying complex algorithms to identify red aspect approaches from the raw data.

The tool was developed as part of the RSSB University of Huddersfield Strategic R&D Partnership. This is an important model as it allows better value for money using partnership rates rather than commercial rates and the ability to conduct follow on research more easily. Users can access it from the Rail Risk Portal section of the RSSB website.

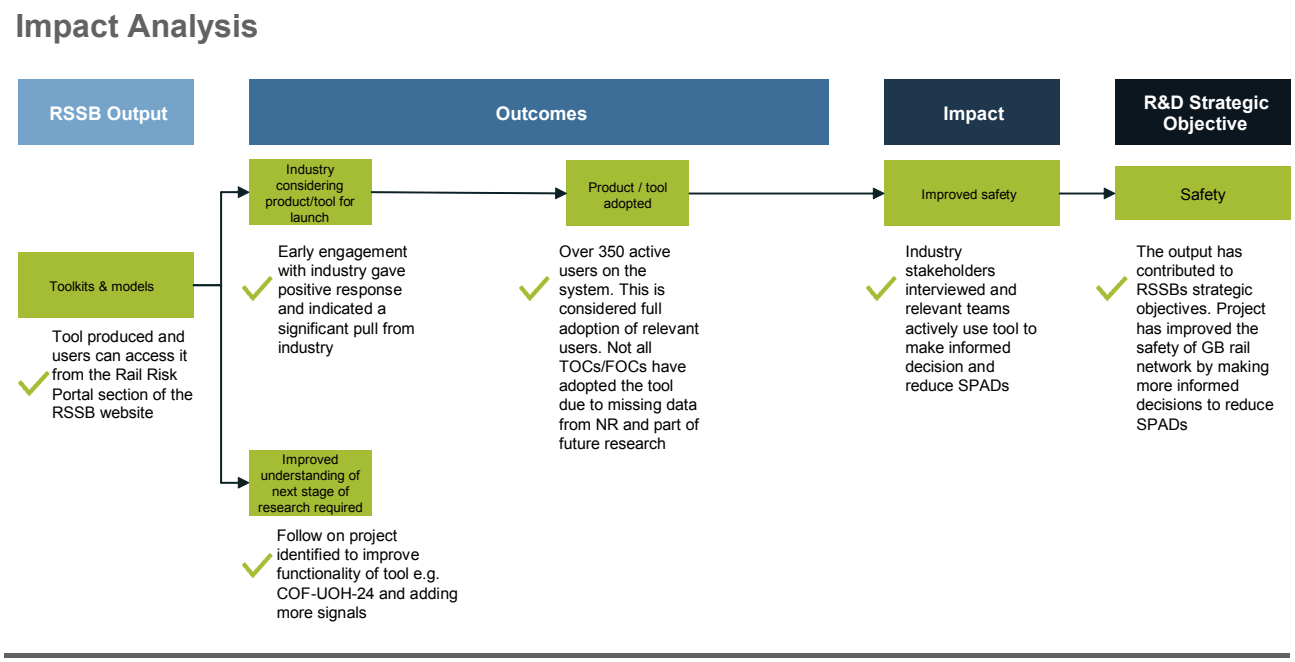


Figure 12: Case study 7 impact analysis.

Assessment of performance against logic map:

- **Purpose:** This piece of research has a wide group of beneficiaries and provided a platform for the industry to gain insight into SPADs using RAATS data. By creating this tool, multiple industry stakeholders could use the insights to make better informed safety decisions. Therefore, this project is well suited to the purpose of the RSSB R&D Programme.
- **Outputs:** The output of this project was a tool which can be accessed on the RSSB website and is free to users. Throughout the project, industry was involved which helped shape the requirements and ensure it would address the industry challenge and could be easily implemented.
- **Outcomes**:
  - Engagement with industry also identified follow on projects and development work for the tool (e.g., COF-UOH-24) which expanded the use case of the tool and improved functionality.
  - The tool is primarily designed to be used by train operators and Network Rail - there are over 350 registered users. Given there are approximately 25 TOCs and 12 FOCs in the GB rail network, it can be concluded that there has been widespread adoption across industry. Examples of the tools use are during SPAD investigations to put SPADs in context of the red approach rates at the signal and used to understand the change in red aspect rates for signals/ operators/ network during the reduced service levels as a result of Covid.
  - A RAATS user group has been established to share best practice to members and identify additional use cases & further development required.
  - An active member of the user group highlighted the importance of sharing best practice as some colleagues were less familiar with the tool than others.
- **Impacts:** The RAATS tool was highlighted by several stakeholders during interviews as a ‘real world’ example where their risk, modelling and analysis teams were using the output from RSSB to make more informed decisions and

improve safety. This includes using the tool to help upskill train drivers as well as in operational risk teams.
- **R&D Strategic Objective:** The causal link from the RAATS tool through to RSSB's strategic objective of improving safety is clear and can be evidenced. This project has directly improved safety on the rail network.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a 'Tangible Products' R&D project which is aimed at developing new products/services or improving existing ones. This means RSSB estimate a benefit cost ratio and look at unweighted and weighted benefits.

RSSB Cost of research:
- Research cost £67,263.
- Creation of online tool £135,000.
- Further enhancements £40,000.
- Total - £243,363.

RSSB Baseline data & assumptions:
- The total costs of SPADs on the GB network is estimated to be £250m per year.

RSSB Improvement data & assumptions:
- The use of this tool will empower stakeholders to make more informed decisions and reduce the occurrences of SPADs.
- A conservative estimate of 1% is likely (£2.5m). Over a 5-year period a benefit of £12.5m would be achieved.

RSSB Weighting:
- Industry coverage is likely to be 50% therefore £6.25m over 5 years would be achieved.

RSSB Implementation:
- Web tool support & maintenance £30,000 annually (assumed to be supported for 5 years - £150,000).

RSSB Benefit Cost Ratio:
- 15.9 (£6,250,000 / £393,363).

Analysis of assumptions

Baseline: It has not been possible to verify this baseline cost or source of this data.

Improvements: The figures used for the improvements have been reviewed by a SME from the RAATS user group who said this was a reasonable assumption.

Weighting: The assumption of 50% coverage is considered conservative by stakeholders as not all signals are available on the system.

Implementation: Implementation costs include ongoing support. As this review is retrospective, these costs have been confirmed.

Value for Money Assessment: Reasonable assumptions were made, and this project would be considered value for money.

Process Analysis

Key project documentation is available for this project and the analysis included in the business case is robust and comprehensive. The project lifecycle appears to have been followed and project delivered as intended.

The tool was developed as part of the RSSB University of Huddersfield Strategic R&D Partnership. Stakeholder feedback was very positive about this model as it allowed greater value for money (using partnership rates rather than commercial rates), the ability to conduct follow on research more easily and flexibility to shape requirements.

Overall Summary

This project has had a positive impact on industry and the causal link from the RAATS tool through to RSSB's strategic objective of improving safety is clear and can be evidenced. The RAATS tool was highlighted by several stakeholders during interviews as a 'real world' example where their risk, modelling and analysis teams were using the output from RSSB to make more informed decisions and improve safety.

Full coverage of signals on the network are not yet available on the RAATS tool. This means it is not useful to some train operators at this stage. However, this is due to a wider network issue rather than this specific project meeting its aims. Once the wider issue is addressed (separate research), the tool's impact will increase further.

Case Study 8 – T1153 - Lineside Vegetation Management Review

Project Overview

This project started in July 2018 and was completed in October 2018.

RSSB Research Context: In May 2018, the Department for Transport (DfT) commissioned a review into Network Rail's (NR) approach to vegetation management in England and Wales. The review was commissioned following media reporting of large-scale tree felling operations.

RSSB Aims: The review's aim was to consider NR's approach to vegetation management, including how effectively NR balances its statutory, operational and environmental responsibilities. The review had input from relevant environmental and industry experts including the Office of Rail and Road (ORR) and NR.

RSSB Outcome: The final deliverable for the project was a report which included the methodology, results and main conclusions/findings of all phases of the project, together with an executive summary and recommendations for further action.

Impact Analysis

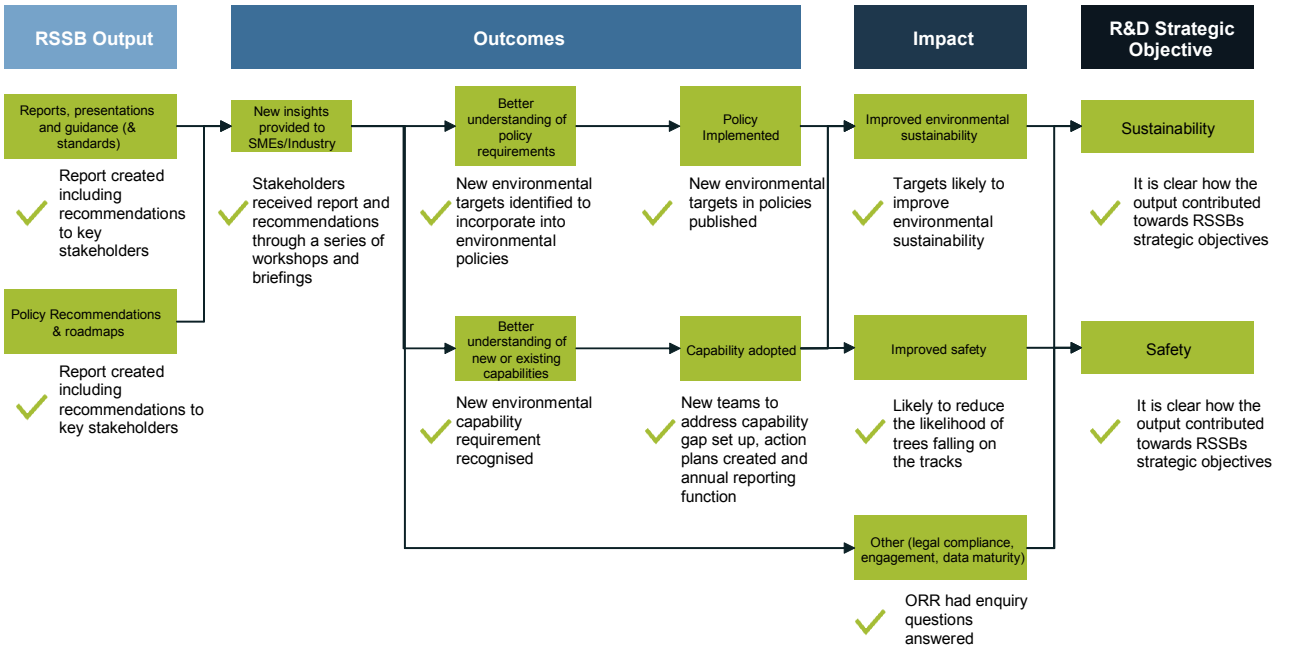


Figure 13: Case study 8 impact analysis.

Assessment of performance against logic map:

- **Purpose:** This piece of work was trigged by an event (a media article on tree felling on the railway) which led to DfT requesting a review of rail industry's approach to vegetation management. RSSB was well positioned to complete this work given their in-house expertise and industry-led structure. This allowed

cross-industry stakeholders to collaborate and understand the issue while also maintaining an independence.

- **Outputs:** The output of this project was a report with a series of recommendations for stakeholders within the industry.
- **Outcomes**:
  - The outputs were shared through several briefings and workshops where stakeholders accepted the recommendations.
  - Network Rail had several recommendations and came up with a plan of action to implement the recommendations. This included activities such as incorporating targets into their environmental strategy such as no net-loss by 2024 and net-gain by 2035. These exceed what had been recommended from the report and have now been published.
  - Network Rail also agreed to complete regular reporting on the 'state of the railway' with the first report due this year. A new bio-diversity action plan was also created.
  - Several teams have been created within Network Rail to address this issue and key environmental stakeholders are working together such as Environmental Agency, DEFRA, Natural England, DfT and Network Rail which hadn't happened before.
- **Impacts:** Key stakeholders of the project agree this report has driven action across the industry in a positive way and has been used as a springboard to accelerate progress. The targets likely to improve environmental sustainability and reduce the likelihood of trees falling onto the track.
- **R&D Strategic Objective:** There is clear evidence that this project has had an impact across the industry and contributed towards the strategic objectives of creating a more sustainable and safer railway.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a ''Knowledge Products'' for benefits monitoring meaning it delivered knowledge or facilitated industry decisions. This means the benefits reported by RSSB for the project was the 'size of opportunity'.

RSSB Cost of research:

- RSSB - £89,137.

RSSB Size of Opportunity:

- £100m per year.

Analysis of assumptions

Size of opportunity: This figure has been provided by Network Rail so is an accurate reflection of the cost of lineside vegetation.

Due to the project looking to understand the effective ways to manage lineside vegetation, the benefits were unknown and therefore it is appropriate for the project to be categorised by the size of opportunity

Value for Money Assessment: Considering the relationship to key industry strategies, the review supports the industry's 'Rail Sustainable Development Principles', specifically,

'Reducing our environmental impact' to minimise 'negative impacts on biodiversity' and implement 'opportunities for improvement'.

Given the size of opportunity, this is likely to be value for money.

Process Analysis

Stakeholders were very positive with the overall engagement and delivery of this project from RSSB. Throughout the process there was clear communication of progress as well as the opportunity to influence and input into the project.

The exit management process was well-coordinated with key stakeholders accepting the recommendations and implementing them in their organisations.

Overall Summary

This project has had a significant impact on influencing senior decision makers to update policies, guidance and drive change across the industry. These changes can clearly be evidenced as they have been published and are being tracked by industry.

Although the industry was aware of some of these challenges, this project acted as an evidence base and catalyst to kick-start the industry into action.

As Network Rail begins to report on this issue annually, it may be possible to further evidence the impact.

Case Study 9 – Pre-2016 COF-UOH-09 Economic Tyre Turning

Project Overview

This project started in 2015 and was completed in 2016.

RSSB Research Context: Research relating to wheel tread damage has historically focused on extending wheelset life through improved classification of damage and optimisation of maintenance practices. One area that was identified following discussions with fleet operators and maintainers during the RSSB research project T963 was the potential benefits of extending wheelset life through the adoption of an economic tyre turning (ETT) regime. ETT refers to the process of turning wheels to a profile that has the same tread shape but a thinner flange than the design case profile, allowing less material to be removed from the wheel diameter, and extending wheel life.

RSSB Aims: The work carried out for this project aimed to investigate potential benefits of ETT taking it through economic feasibility, wheel rail damage prediction modelling, trials with industry and practical guidance on implementing.

RSSB Outcome: This research produced a technical report and guidance which fulfilled the aims of the project as detailed above.

Impact Analysis

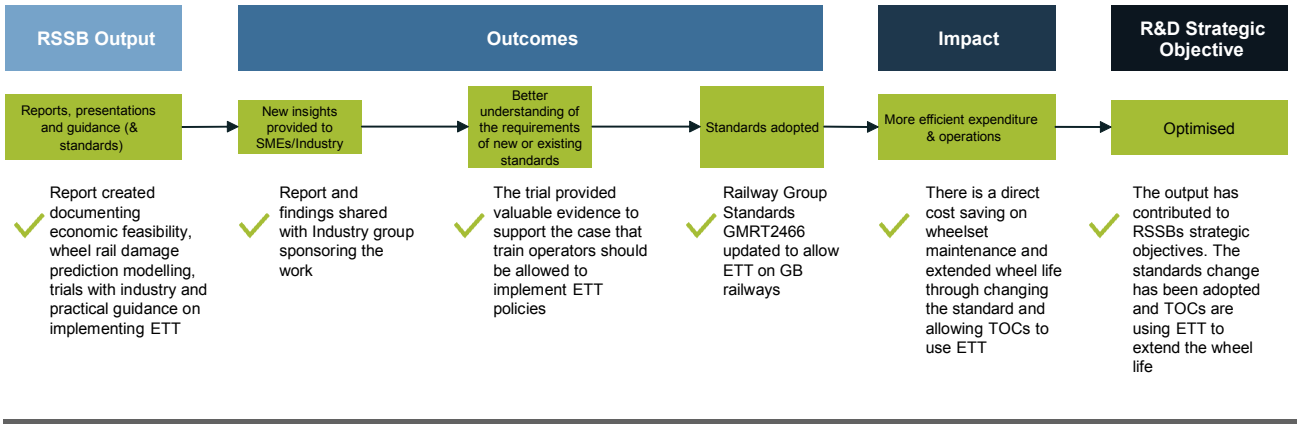


Figure 14: Case study 9 impact analysis.

Assessment of performance against logic map:

- **Purpose:** Wheel tread damage is a cross industry issue as it is part of a key system interface (train and track). The project looked to address this issue and if successful would benefit the industry as a whole rather than an individual stakeholder. Therefore, this project was suited to the purpose of the research programme.
- **Outputs:** The output of this project was a report documenting economic feasibility, wheel rail damage prediction modelling, trials with industry and practical guidance on implementing ETT.
- **Outcomes**:
  - The report was shared with industry and the sponsoring working group as well as within the RSSB's standards team.
  - The trial provided valuable evidence to support the case that train operators should be allowed to implement ETT policies.
  - This then led to the Railway Group Standards GMRT2466 being updated to allow ETT on GB railways.
- **Impacts:** There is a direct saving on wheelset maintenance and extended wheel life through the updating of the standard and allowing TOCs to use ETT. This has allowed more efficient expenditure and operations. This was evidenced during stakeholder interviews.
- **R&D Strategic Objective:** The output from the RSSB R&D Programme can be directly linked to the updated standard and subsequently more efficient expenditure and operations creating a more optimised railway.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a 'Tangible Products' R&D project which is aimed at developing new products/services or improving existing ones. This means RSSB estimate a benefit cost ratio and look at unweighted and weighted benefits.

RSSB Cost of research:

- Research cost £74,000.
- Co-funding cost £148,000.

- Total cost - £222,000.

RSSB Baseline data & assumptions:

- The estimated industry cost of maintenance for wheelset life is £108,000,000.

RSSB Improvement data & assumptions:

- An economic feasibility suggests that ETT could provide a potential savings of 0.8% to 5%.
- This gives a potential saving of £880,000- £5,100,000 annually.

RSSB Weighting:

- Once permitted by the standard, industry will be able to implement ETT with little extra cost.
- Assumed that 60% of industry would take up these findings linearly over the next ten years using a medium scenario.
- This equates to a total saving over 10 years of £9,000,000.

RSSB Benefit Cost Ratio:

- 40 (£9,000,000/£222,000).

Analysis of assumptions

Baseline: This figure has been derived from a previous academic study which used industry data to calculate the wheelset life costs.

Improvements: This figure has been derived through this research project and uses economic modelling techniques to calculate the costs. An estimate was given at the start of the project which was refined in the business case afterwards.

Weighting:

- The uptake and adoption have been modelled using input from industry stakeholders and forms part of the economic feasibility study.
- Having spoken to stakeholders, the assumption that industry will be able to implement ETT with little extra cost is optimistic. Although not directly related to this project, many have cited unforeseen implementation challenges such as training staff, creating new processes, and tooling. This could reduce the BCR.

Value for Money Assessment: The analysis used for these calculations have been verified through academic studies and sources reviews. Reasonable assumptions have been made and although the BCR may reduce due to unforeseen implementation costs, this project would be considered value for money.

Process Analysis

Key project documentation is available for this project and the analysis included in the business case is robust and comprehensive. The project lifecycle appears to have been followed, with the project delivered as intended.

Due to the age of the project and as key stakeholders involved have left respective organisations it is not possible to fully assess the process.

Overall Summary

The output from the RSSB R&D Programme can be directly linked to the updated standard and subsequently more efficient expenditure and operations creating a more optimised railway. The analysis used for business case has been verified, reasonable assumptions were made, and this project would be considered value for money.

Case Study 10 – Pre-2016 T1005 – Enhancement of the TCA Risk Advisor Tool to include on-track machines

Project Overview

This project started in October 2013 and completed in June 2014.

RSSB Research Context: This research focusses on managing the train detection performance of on-track machines (OTM), where fitted with track circuit assisters (TCA). OTMs are defined as rail-mounted plant able to operate independently on running lines outside engineering possessions.

Research has found that OTMs with specific characteristics, namely axle weight and number of axles, can be shown to operate track circuits reliably and do not need a TCA. It has also been shown that where a TCA is recommended, under certain circumstances, OTMs can be allowed to travel to and from a work site even with a failed TCA. Research has also developed a risk advisor tool to assess the risk associated with continued in service operation following TCA failure.

The current rule that cancellation of movement of OTMs when TCAs have failed can be costly and disruptive to the operation of the railway. Existing RSSB research showed that under certain conditions DMU stock can continue safe in-service operation with a single TCA failure.

RSSB Aims: This project seeks to supplement and extend the accrued knowledge to on-track machines, a significant proportion of which are fitted with a TCA. This would allow them to operate under specified circumstances if the TCA has failed. The work has been extended to assess whether new OTMs with specific characteristic need to be fitted with a TCA.

Implementation of the findings of the research is expected to provide an immediate commercial benefit to the operators of OTM and to relieve disruption to the railway network and track maintenance schedule.

The aim of this research is to transfer the benefits of continued operation following TCA failure from passenger fleets to on-track machines, based on the work previously

undertaken on RSSB Project T579. This is a potentially more severe test, in that these machines are usually only fitted with a single TCA.

RSSB Outcome: Data analysis provided several conclusions and recommendations. This was used to produce a OTM TCA risk advisor tool, user guidance and a technical report.

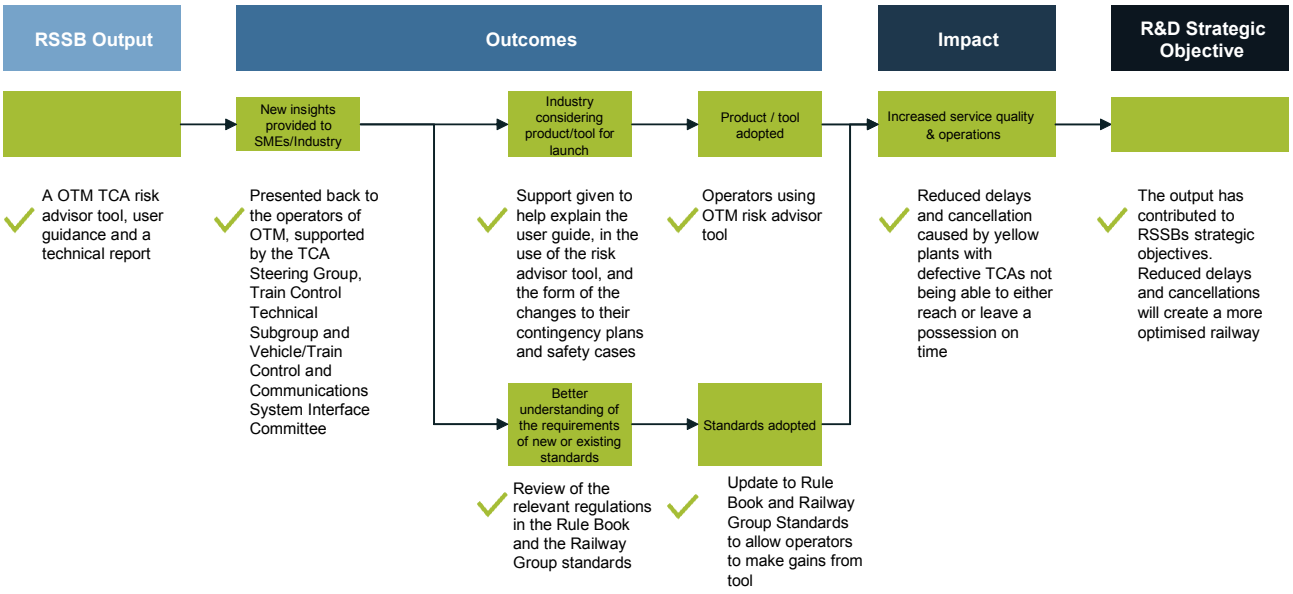


Figure 15: Case study 10 impact analysis.

Impact Analysis

Assessment of performance against logic map:

- **Purpose:** This piece of research was for a direct system interface (vehicle/train control) and cross-industry focused. Therefore, it is well suited to the overall purpose of the R&D Programme.
- **Outputs:** A OTM TCA risk advisor tool, user guidance and a technical report.
- **Outcomes**:
  - Presented back to the operators of OTM, supported by the TCA Steering Group, Train Control Technical Subgroup and Vehicle/Train Control and Communications System Interface Committee.
  - Although several OTM operators were actively involved in the research, support was given to explain the user guide, support using the risk advisor tool, and making changes to their contingency plans and safety cases – this helped them industry understand and adopt the tool.
  - A review of the relevant regulations in the Rule Book and the Railway Group standards (RIS-2777) was completed. Updates were then made to allow operators to make gains from tool.
- **Impacts:** Following the update to Rule Book and relevant Standards, immediate commercial benefit was provided to the operators of OTM and to relieve disruption to the railway network and track maintenance schedules that would otherwise have continued to arise from the failure of TCAs.

- **R&D Strategic Objective:** The output has contributed to RSSB's strategic objectives. Reduced delays and cancellations will create a more optimised railway.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a 'Tangible Products' R&D project which is aimed at developing new products/services or improving existing ones. This means RSSB estimate a benefit cost ratio and look at unweighted and weighted benefits.

RSSB Cost of research:

- Research cost £73,500.

RSSB Baseline data & assumptions:

- If an OTM loses a shift due to a failed TCA they can be penalised at up to twice the shift rate. This is an average rate of £10,000.
- There are approximately 80 OTMs used by operators and estimates suggest 20 have the potential for TCA-related problems.
- Of these, estimates were gathered from operators that half of their OTMs encountered a TCA failure each year (10).
- Therefore, the yearly cost is £100,000 (£10,000 x 10).

RSSB Improvement data & assumptions:

- A change in Rule Book and standards would allow OTMs to continue operating and remove the issue.
- Over a 20-year period, the benefit would be £2,000,000 (£100,000 x 20).

RSSB Implementation:

- Further research identified £87,700.
- Training costs £8,400.

RSSB Benefit Cost Ratio:

- 4.7 (£798,000 / (£73,500+£87,700+£8,400)).

Analysis of assumptions

Baseline: This figure has been derived using real data from OTM operators and therefore represents an accurate reflection of the baseline.

Improvements: A change in standard RIS-2777 and Rule Book would remove the disruption caused by a failure of a TCA.

Implementation:

- Consideration to both further research (for the standards change) and training to operators has been considered.
- Estimates from similar standard changes suggest an accurate figure.

Value for Money Assessment: The analysis used for these calculations have been reviewed and reasonable assumptions appear to have been made. Although it has not been possible to speak to OTM stakeholders to confirm the baseline, the business case uses real data from operators so is considered an accurate reflection. This project would be considered value for money.

Process Analysis

Key project documentation is available for this project and the analysis included in the business case is robust and comprehensive. The project lifecycle appears to have been followed and project delivered as intended.

Due to the age of the project and as key stakeholders involved have left respective organisations it is not possible to fully assess the process effectiveness.

Overall Summary

The output has contributed to RSSB's strategic objectives - reduced delays and cancellations will create a more optimised railway. Standards and the Rule Book were changed which led to a direct benefit for industry. The analysis used for business case has been verified, reasonable assumptions were made, and this project would be considered value for money.

Case Study 11 – Pre-2016 T797 – Performance and installation criteria for sanding systems

Project Overview

This project started in June 2012 and was completed in November 2015.

RSSB Research Context: The installation of sanding systems onto multiple units was covered by Railway Group Standard GM/RT2461 Sanding Equipment Fitted to Multiple Units and On-Track Machines. Since this standard was produced in 2001, the industry has gained significant operational knowledge through service experience and there have been a number of developments in modern sanding systems.

The relevance of the existing sanding parameters and their operation was therefore required to be reviewed to determine the performance of the sanding equipment under normal and emergency operation and the possible trade off from increased risk of loss of train detection.

RSSB Aims: This research project examined the relevance of the existing sanding requirements. It was divided into three work packages:

1. Review of legacy sanding work and international criteria.
2. Optimisation of the sand delivery to the wheel/rail interface.
3. Configuration of sanding systems on different arrangements of multiple units.

RSSB Outcome:

The project undertook testing and research to propose and support future changes to these requirements. The outcome of this research was fully described in three detailed research reports along with a summary report that bring together all the results.

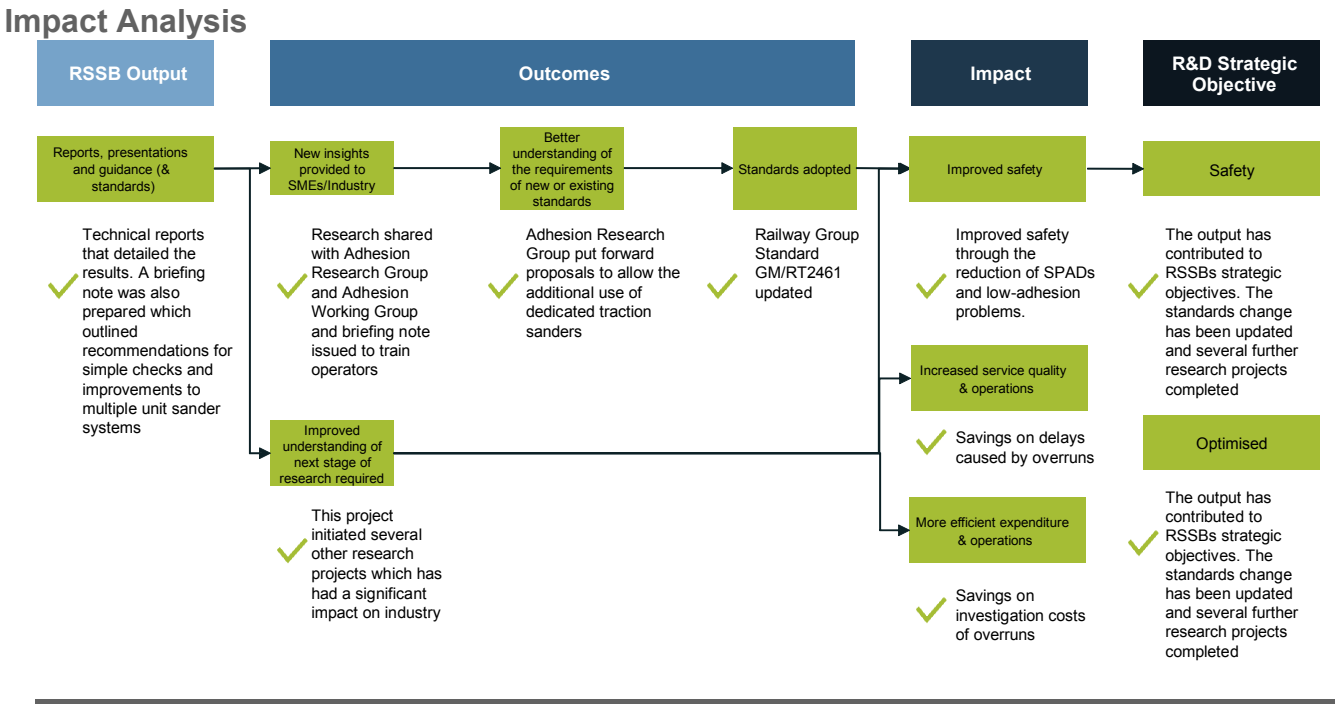


Figure 16: Case study 11 impact analysis.

Assessment of performance against logic map:

- **Purpose:** Adhesion is a cross industry issue as it is part of a key system interface. The project looked to address this issue and if successful would benefit the industry as a whole rather than an individual stakeholder. Therefore, this project was suited to the purpose of the research programme.
- **Outputs:** Technical reports that detailed the results were produced. A briefing note was also prepared which outlined recommendations for simple checks and improvements to multiple unit sander systems.
- **Outcomes**:
  - Research shared with Adhesion Research Group, Adhesion Working Group and briefing note issued to train operators.
  - Adhesion Research Group put forward proposals to allow the additional use of dedicated traction sanders and subsequently updated Railway Group Standard GM/RT2461.
  - This project initiated several other research projects which have had a significant impact on industry:
    - The findings directly informed *T1107 Trial of Sander Configurations and Sand laying rates* – this track testing initiative firmly concluded that Double Variable Rate Sanders (DVRS) can consistently provide improved low adhesion braking performance
    - This led to an in-service pilot of DVRS with West Midlands Trains. Through several RSSB research implementation activities, technical feasibility studies were undertaken on a range of fleets,

two WMT Class 323s were retrofitted with DVRS, safety assessment reports were undertaken and several Class 323s were fitted with data loggers. Class 323 DVRS driver familiarisation runs were also undertaken, confirming the results from T1107.
    - Informed by T1107 and implementation activities, a national business case on retrofitting DVRS was created by Rail Delivery Group. This has led to Porterbrook and Northern Trains successfully acquiring funding from the Performance Innovation Fund (PIF) to retrofit the entire Class 323 fleet with DVRS.
- **Impacts:** The initial project has resulted in a standard change which allowed train operators to make changes to the existing sanding parameters. This research has formed the basis of several other high-profile projects which has ultimately led to the application of funding for an entire fleet to be retrofitted with Double Variable Rate Sanders. This has significant impacts on improved safety, savings on delay minutes due to overruns and savings on overruns investigation costs. The use of DVRS should help remove the need for special autumn timetables and support operational performance improvements due to more consistent braking capabilities in all adhesion conditions.
- **R&D Strategic Objective:** The output from the RSSB R&D Programme can be directly linked to the updated standards and follow-on research which has created a more optimised and safer railway.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a 'Tangible Products' R&D project which is aimed at developing new products/services or improving existing ones. This means RSSB estimate a benefit cost ratio and look at unweighted and weighted benefits.

RSSB Cost of research:

- Research cost £215,791.

RSSB Improvement data & assumptions:

- Reduction in adhesion-related SPADs and collisions (applying relevant precursors to the FWI, a 5% improvement was recommended by stakeholders) - £45,121.
- Savings on investigation costs of overruns (in 2010 there was 177 adhesion related overruns/SPADs. A 20% reduction in these was deemed reasonable from stakeholders. Each overrun occurs a £7,500 investigation cost. Therefore 36 * £7,500 = £2,700,000 per year) - £2,700,000 (over 10 years).
- Savings on delays caused by overruns (average cost of overrun is 80 mins valued at £50 per min - £4,000 per incident. 20% reduction in overruns so 36 * £4000 = £144,000 per year) - £1,440,000 (over 10 years).
- Avoided cost of derogations (stakeholders estimated a conservative cost of £20,000 with 3 per year) - £300,000 (over 5 years).
- Total - £4,485,121.
- Adjusting for inflation, the projected benefits are £2,397,487.

RSSB Implementation:

- A notional cost has been assumed to account for the administrative costs of updating the guidance - £100,000.
- Cost of modifying sanders on all rolling stock - £2,000,000.
- Total - adjusting for inflation - £1,678,703.

RSSB Weighting:

- A sensitivity analysis was performed on the base case data to take into account optimisation bias, probability of occurrence and probability of success.

RSSB Benefit Cost Ratio:

- Most likely case – 1.3 (£2,397,487 / (£1,678,703 + £215,791).

Analysis of assumptions

Improvements: The business case uses robust assumptions and calculations for each of the improvement areas. These assumptions were verified with SMEs from across the industry and thought process clearly articulated in the document.

Implementation: Appropriate consideration was given to the implementation of the research. This was in terms of roll out of the sanders and administrative costs for updating the guidance. These types of costs are not often included in calculations but including them gives a much better reflection of the real costs.

Weighting: This project recognised the optimisation bias, probability of occurrence and probability of success improving the accuracy of the calculations.

Value for Money Assessment: The analysis used for this business case was comprehensive. This project would be considered value for money.

Process Analysis

Key project documentation is available for this project and the analysis included in the business case is robust and comprehensive. The project lifecycle appears to have been followed and project delivered as intended.

Overall Summary

The initial project has resulted in a standard change which allowed train operators to make changes to the existing sanding parameters. This research has formed the basis of several other high-profile projects which has ultimately led to the application of funding for an entire fleet to be retrofitted with Double Variable Rate Sanders. This has significant impacts on improved safety, savings on delay minutes due to overruns and savings on overruns investigation costs. The use of DVRS should help remove the need for special autumn timetables and support operational performance improvements due to more consistent braking capabilities in all adhesion conditions. The analysis used for this business case was comprehensive and assumptions reasonable. This project would be considered value for money.

Case Study 12 – Pre-2016 T792 – Vehicle Track Interaction Strategic Model

Project Overview

This project started in winter 2010 and completed in summer 2011.

RSSB Research Context: To deliver a sustainable railway, the costs for achieving this must be understood. If the costs are understood, the industry can optimise them. The Vehicle Track Interaction Strategic Model (VTISM) can help to deliver this. It is a software tool that enables the industry to plan and deliver changes to the vehicle/track interface (V/TI) more efficiently by adopting a system-wide approach, facilitated by interconnected models.

RSSB Aims: This research aimed to extend the modelling capability of the VTISM and improve the user interface. The objectives were delivered in two phases:

- Phase 1 aimed to address 'housekeeping' improvements, provide more accurate total track impact costs, improve the track maintenance and renewals model calculations, include costs of repair for vertical rail defects, and include track inspection costs for plain-line and S&C, providing a more complete set of maintenance costs.

- Phase 2 aimed to develop a Wheel Profile Damage Model (WPDM) to predict the rate of wear, conicity, and rolling contact fatigue (RCF) for wheelsets, develop and integrate a Wheelset Management Model (WMM) to predict wheelset costs in addition to track costs, and to provide strategic modelling of wheelset renewal and maintenance policies, and to implement usability improvements.

RSSB Outcome: This research was able to complete both phases as planned, extending the capability of the VTISM and improving the user interface. Extensive acceptance testing, verification, and validation was undertaken to confirm that the phases of this development of VTISM achieved the specified requirements and that the software was suitable for distribution.

Impact Analysis

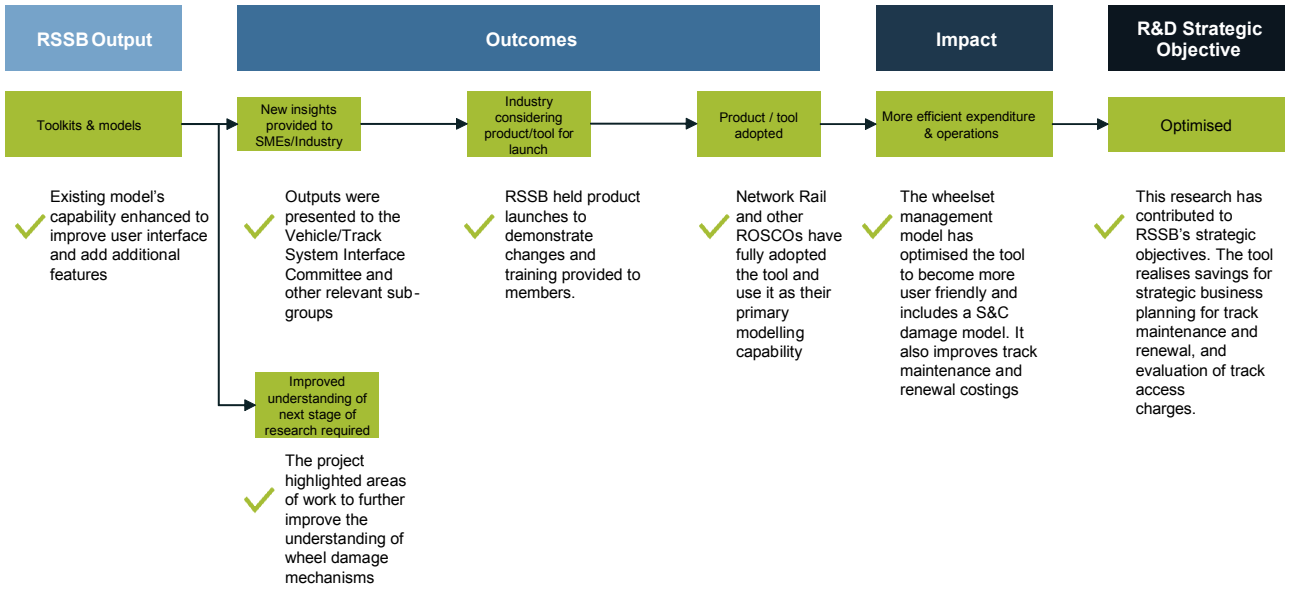


Figure 17: Case study 12 impact analysis.

Assessment of performance against logic map:

- **Purpose:** This piece of research was for a direct system interface (vehicle/track) and cross-industry focused. Therefore, it is well suited to the overall purpose of the RSSB R&D Programme.
- **Outputs:** Enhanced tool which extended the capability of the VTISM and improved the user interface.
- **Outcomes**:
  - Project was shared with V/T SIC, V/T SIC Technical Advisory Group, and relevant sub-groups.
  - RSSB held product launches to demonstrate changes and training provided to members.
  - Network Rail and wider industry (ROSCOs & Operators) have fully adopted the tool and use it as their primary modelling capabilities. This tool was already widely used by industry.
  - The project highlighted areas of work to further improve the understanding of wheel damage mechanisms.
- **Impacts:** Savings have been realised by using VTISM in the tender evaluation for the InterCity Express and Thameslink rolling stock projects, strategic business planning for track maintenance and renewal, and evaluation of track access charges. The wheelset management model has optimised the tool to become more user friendly and includes a S&C damage model. It also improves track maintenance and renewal costings.
- **R&D Strategic Objective:** This research has contributed to RSSB's strategic objective of creating a more optimised railway. The tool realises savings for strategic business planning for track maintenance and renewal, and evaluation of track access charges.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a 'Tangible Products' R&D project which is aimed at developing new products/services or improving existing ones. This means RSSB estimate a benefit cost ratio and look at unweighted and weighted benefits.

RSSB Cost of research:

- Research cost £473,398.

RSSB Improvement data & assumptions:

- Improved wheelset management model - £5,000,000.
- Improved user interface and accuracy of databases - £10,000,000.
- Inclusion of S&C vertical damage model - £10,000,000.
- Improved track maintenance and renewals costing - £3,325,000.
- Total - £28,325,000.
- Adjusting for inflation, the projected benefits are £17,284,178.

RSSB Implementation:

- Given that the stage 1 version of VTISM is already in use, the stage 2 version of VTISM will be managed as an 'enhanced product' launch and some training provided - £9,493.

RSSB Weighting:

- A sensitivity analysis was performed on the base case data to take into account optimisation bias, probability of occurrence and probability of success.

RSSB Benefit Cost Ratio:

- Best case - 36.5 (£17,284,178/£473,398).
- Most likely case – 25 (taking into account the weighting).

Analysis of assumptions

Improvements: The business case uses extremely robust assumptions and calculations for each of the improvement area. These assumptions were verified with SMEs from across the industry and thought process clearly articulated in the document.

Implementation: Appropriate consideration was given to the implementation of the research. For this case, the tool was already in use so ongoing maintenance costs were accounted for. The business case included costs for training users on the new features.

Weighting: This project recognised the optimisation bias, probability of occurrence and probability of success improving the accuracy of the calculations.

Value for money assessment: The analysis used for this business case was comprehensive and the most thorough seen in this evaluation. This project would be considered value for money.

Process Analysis

Key project documentation is available for this project and the analysis included in the business case is robust and comprehensive. The project lifecycle appears to have been followed and project delivered as intended.

Due to the age of the project and as key stakeholders involved have left respective organisations it is not possible to fully assess the process.

Overall Summary

There is clear evidence that this piece of research had an impact across the industry and contributed towards the strategic objectives of creating a more optimised railway. Savings have been realised by using VTISM in the tender evaluation for the InterCity Express and Thameslink rolling stock projects, strategic business planning for track maintenance and renewal, and evaluation of track access charges. The analysis used for this business case was extremely comprehensive and the most thorough seen in this evaluation. This project would be considered value for money.

Case Study 13 – Pre-2016 T978 – Development of Passenger Standard Vehicle Gauges

Project Overview

This project started in 2015 and completed in 2015.

RSSB Research Context: The need for a standard set of vehicle gauges is widely recognised in the rail industry. A significant benefit of a standardised gauge is that it will enable vehicles to be introduced to a new route with a minimum amount of gauging compatibility analysis as well as minimising the need for modification to the infrastructure.

It had been identified that suburban trains were most likely to be replaced by new rolling stock in the near future (as opposed to regional or intercity) and combined with the fact that suburban trains encounter a disproportionally greater number of platforms it follows that the development of a standardised suburban gauge would be of particular benefit to the industry.

RSSB Aims: This project aimed to produce a defined gauge for ‘suburban’ vehicles that can be written into the standard GE/RT8073 and EN15273 and could be used for specifying new rolling stock or for classifying vehicles in future cascades of rolling stock.

RSSB Outcome: This research was completed a technical review and analysis which documented and defined the derivation of two new vehicle gauges.

Impact Analysis

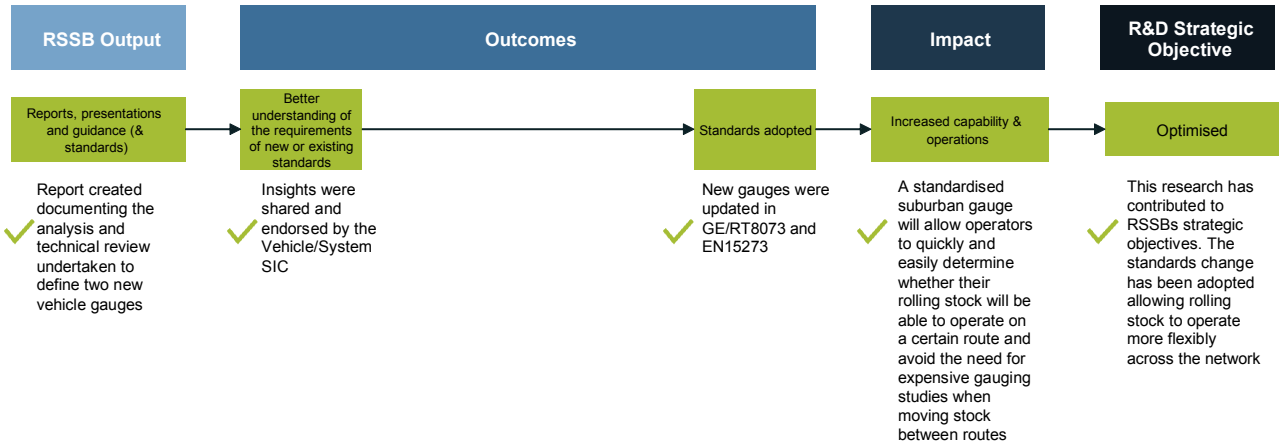


Figure 18: Case study 13 impact analysis.

Assessment of performance against logic map:

- **Purpose:** This piece of research was for a direct system interface (vehicle/system) and cross-industry focused. Therefore, it is well suited to the overall purpose of the RSSB R&D Programme.
- **Outputs:** A report created documenting the analysis and technical review undertaken to define two new vehicle gauges.
- **Outcomes**:
  - The insights were shared and endorsed by the Vehicle/System SIC resulting in a better understanding of the standards required.
  - These new gauges were then updated in GE/RT8073 and EN15273
- **Impacts:** There was increased capability and operations as a result of the standards change as allowed operators to quickly and easily determine whether their rolling stock will be able to operate on a certain route and avoid the need for expensive gauging studies when moving stock between routes
- **R&D Strategic Objective:** This research has contributed to RSSB's strategic objectives of creating a more optimised railway. The standards change has been adopted allowing rolling stock to operate more flexibly across the GB network.

Value for Money Analysis

RSSB Categorisation: This project has been classified as a 'Tangible Products' R&D project which is aimed at developing new products/services or improving existing ones. This means RSSB estimate a benefit cost ratio and look at unweighted and weighted benefits.

RSSB Cost of research:

- Research cost £58,823.

RSSB Baseline data & assumptions:

- The cost of completing a gauging study is £37,500.

RSSB Improvement data & assumptions:

- The standardisation of gauges will remove the need to complete a gauging study.

- On average one new rolling stock is introduced per year.
- Therefore, £37,500 will be saved per year.
- Over 30 years, £1,125,00 will be saved.

RSSB Weighting:

- Adjusting for inflation, the benefit is £436,834.

RSSB Benefit Cost Ratio:

- 7.4 (£436,834/£58,823)

Analysis of assumptions

Baseline: This figure has been derived from a previous gauging study giving an accurate figure for comparison.

Improvements:

- One rolling stock per year is based off previous data so an accurate figure. It doesn't account for existing stock being introduced to new lines so has not captured this additional benefit. However, this would only apply to existing rolling stock with the gauges.
- The timeframe of 30 years is reasonable as the gauge is unlikely to go out of date for at least the lifespan of current vehicles which can be at least 30 years.

Weighting: Applying a standard inflation calculator with suggests average interest rate of 3.5%, a discount benefit of £430,200 is obtained.

Value for money assessment: The analysis used for these calculations haven been verified through original data sources and stakeholders and reasonable assumptions made. This project would be considered value for money.

Process Analysis

Key project documentation is available for this project and the analysis included in the business case is robust and comprehensive. The project lifecycle appears to have been followed and the project delivered as intended.

Due to the age of the project and as key stakeholders involved have left respective organisations it is not possible to fully assess the process.

Overall Summary

There is clear evidence through changing of standards that this project has had an impact across the industry and contributed towards the strategic objectives of creating a more optimised railway. The analysis used for business case has been verified, reasonable assumptions were made, and this project would be considered value for money.