Evaluating impacts of completed rail research

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by C Read and V Ramdas (TRL), D Golightly, J Wilson and N Dadashi (University of Nottingham), R Palacin and M Robinson (NewRail, Newcastle University)

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Evaluating impacts of completed rail research

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(Chris Brown)

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Contents

Executive summary iii

1 Introduction 1
   1.1 Background 1
   1.2 Project objectives 1
   1.3 Industry timeline 2
   1.4 Report structure 2

2 Methodology 5
   2.1 Selection methodology 5
       2.1.1 Bottom-up approach 5
       2.1.2 Top-down approach 6
       2.1.3 Project sample structure 7
   2.2 Evaluation methodology 9
   2.3 Development of case studies 11

3 Selection of projects 12
   3.1 The project sample 12
   3.2 Analysis of projects 17

4 Evaluation of projects 21
   4.1 Utilisation and impact 21
   4.2 Top-down interviews 29
       4.2.1 Industry Developments 29
       4.2.2 The role of research 30
       4.2.3 Benefits of the top-down approach 33
   4.3 Enablers and barriers to success 34
   4.4 Key lessons learnt 35
   4.5 Case studies 37
       4.5.1 Analysis of case studies 37
   4.6 Summary of benefits 40

5 A mechanism for capturing future benefits 43
   5.1 Background 43
   5.2 Accessible and usable data 44
       5.2.1 Data repositories 44
       5.2.2 Improving data availability 44
       5.2.3 Data specific to the capture of benefits of future research 45
   5.3 Making it happen 47
       5.3.1 Additional Incentives 48
   5.4 Overall summary 49
   5.5 Dissemination plan 50

6 Conclusions 51
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Recommendations</td>
<td>53</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>55</td>
</tr>
<tr>
<td>Appendix A</td>
<td>Example interview questions</td>
</tr>
<tr>
<td>Appendix B</td>
<td>Case studies</td>
</tr>
<tr>
<td>Appendix C</td>
<td>A mapping of the lessons learnt from this project to the results of an internal RSSB project (part of Enabling Action 11)</td>
</tr>
</tbody>
</table>
Executive summary

The Rail Industry Research Strategy (RIRS), which was published in December 2007, established a set of strategic priorities for rail research to support the delivery of the rail industry’s long-term vision for the railway. In order to support the implementation of the RIRS a set of Enabling Actions aimed to tackle Strategic research, Collaboration and Delivery mechanisms were identified.

This research project (PPCA08092), Evaluating Impacts of Completed Rail Research, is Enabling Action 12 and sits within the area of delivery mechanisms. The project was sponsored by the DfT and carried out by TRL, University of Nottingham and NewRail at Newcastle University between September 2008 and April 2009. The objective of the project was to evaluate rail research carried out over the last 20 years in order to obtain an understanding of the impact of the research and to identify those characteristics of rail research that represent high value and enable strong uptake within the rail sector. The intention was to provide the rail sector with critical success factors, illustrated by specific case studies, required for future rail research to have the maximum impact on the sector, along with a better understanding of the barriers to success.

To achieve this, the project took a combined bottom–up and top-down approach to select a representative sample of 48 projects from rail research conducted over the last 20 years:

1. The bottom-up approach focused predominantly on information in the public domain, including libraries, databases and websites.
2. The top-down approach focused on interviewing key stakeholders in the rail sector for their views on research that had impacted on the industry and characteristics of rail research that lead to success or failure. The information was used to complement the wide-reaching and broad scope of the bottom-up approach.

Overall the review has shown that the data in the public domain from completed projects, and particularly those related to the pre-privatisation period, is insufficient for detailed analysis. Experience of people involved in the projects is critical to understanding the various project characteristics, the enablers and barriers to success and factors influencing the extent and timescale of utilisation of research outcomes.

Robust data on benefits estimated at the start of a project as well as any assessed benefits following completion of projects are not generally available. Even where solutions have been developed for clearly defined problems, the benefits are more by ‘implication’, e.g. increased efficiency, better use of resources, reduced risk of fatalities in future accidents etc. and not in terms of quantified or monetised values. However the overall view is that research has delivered and indeed has the potential to continue to deliver significant benefits over the costs expended.

Assessment of the utilisation and impact of the project outcomes has shown that for 38 of the 48 projects there is some evidence of utilisation of results within 5 years of project completion. However, this does not necessarily reflect the utilisation of rail research in general, as the projects selected were biased towards those that either had some utilisation or none at all. It mainly demonstrates the potential of research to contribute to changes and improvements in the industry.

The results were used to derive 10 key lessons to be applied to future projects by research practitioners:

1. Align with an appropriate strategy
2. Develop a business case that includes an estimation of expected benefits
3. Involve all the right stakeholders
4. Form a steering group
5. Agree scope and deliverables at inception
6. Appoint project champions
7. Agree communication strategy
8. Develop an implementation strategy
9. Plan for knowledge retention and transfer
10. Conduct reviews on post-project progress

The top-down interviews were particularly useful in identifying 10 of the selected projects for more detailed analysis and developing into case studies highlighting some of the key issues identified. The main drivers for research were core business issues (e.g. disruption to services), safety requirements (e.g. reducing risk of fatalities), policy requirements (e.g. HLOS), public opinion/concern (e.g. accidents), operational gains (e.g. staff performance and well being), customer focus (e.g. the need to understand human factors impact) and reduced costs (e.g. improving maintenance efficiency). A key issue highlighted by a number of the case studies is that ‘successful’ projects often address a problem that is clearly defined and is important to the rail industry in terms of issues such as impact on core business, improved performance, safety and cost savings.

Research is carried out to provide benefits. In principle, management, control structures and mechanisms are expected to be in place to identify, exploit and record these benefits. However, the examination of past projects has shown that this is an area that needs improvement. An improved process to track the benefits of future rail research has been proposed. The key elements of the proposed mechanism are a process for managing, evaluating, disseminating and applying research outcomes and benefits.

- Improve data quality, availability, accessibility and usability by setting up a databank of research.
- Develop a consistent data collection framework to ensure the appropriate data is collected (e.g. initial estimation of expected benefits and final assessment of benefits realised).
- Provide funding for project champions to drive not only the project itself but also to support the implementation process following project completion.
- Ensure stakeholder buy-in for the development and implementation of the proposed mechanism.
1 Introduction

1.1 Background
This Report has been prepared for the Rail Group, Department for Transport (DfT), and is the final output under Contract PPCA08092, Evaluating Impacts of Completed Rail Research. This work was undertaken by TRL with NewRail (Newcastle University) and the University of Nottingham.

The Rail Industry Research Strategy (RIRS), which was published in December 2007, established a set of strategic priorities for rail research to support the delivery of the rail industry’s long-term vision for the railway, as expressed in the Rail Technical Strategy (2007) and Rail White Paper (2007). The RIRS document is owned by the DfT and was produced for the following industry key stakeholders:
- Association of Train Operating Companies (ATOC)
- Department for Transport (DfT)
- Network Rail
- Rail Safety and Standards Board (RSSB)
- Rail Research UK (RRUK)
- Railway Industry Association (RIA)
- Rolling Stock Companies (RoSCos).

The RIRS also considered how rail-related research is managed, delivered and funded. To support the implementation of the strategy, a set of Enabling Actions defining the first year (2008/09) activities were developed. The Enabling Actions tackle three main areas:
- Strategic research – to encourage a step change in the delivery of strategic research, focused on meeting the long-term challenges of the railway as set out in the Rail Technical strategy.
- Collaboration – to ensure that best use is made of existing funding by leveraging in additional resources from the private sector, from Europe and from other non-rail public sector resources.
- Delivery mechanisms – to identify, promote and adopt best practice in the delivery of research.

1.2 Project objectives
This project, 'Evaluating Impacts of Completed Rail Research’ is Enabling Action 12 and sits within the area of delivery mechanisms. The main objectives of project were to:
- Review rail research carried out over the last 20 years
- Draw lessons from current and past research to inform future research
- Provide valuable feedback to those funding and undertaking future research projects
- Propose a mechanism to track the benefits of future research
- Improve the relevance and value of future research
1.3 Industry timeline

The rail industry in the UK has seen many changes over the past 20 years, mainly through privatisation during the mid 1990s. Figure 1.1 shows the timeline of a selection of rail industry organisations, in order to gauge an understanding of the organisational changes during this period. Figure 1.2 shows the timing of some significant events that have occurred during the past 20 years.

1.4 Report structure

This report presents the overall work from the project and highlights lessons learnt from past research, together with recommendations to support the capturing of benefits from future research.

The report contains the following sections:

- Section 2, Methodology: This section describes the methods used to identify and analyse the past rail research projects.
- Section 3, Selection of projects: This section describes the selected sample of 48 projects and the analysis against structured frameworks.
- Section 4, Evaluation of projects: This section details the evaluation of the projects and the stakeholder interviews. This includes an assessment of the utilisation and impact of each project; enablers and barriers to research; 10 key lessons learnt; development of 10 detailed case studies; and a summary of benefits identified.
- Section 5, A mechanism for capturing future benefits: This section describes a proposed mechanism to track benefits of future rail research. It also includes a dissemination plan applying the lessons learnt to capture benefits of the current project.
- Section 6, Conclusions: This section summarises the findings of this research project.
- Section 7, Recommendations: This section describes the specific recommendations made to implement short term improvements followed by the longer term implementation of the proposed mechanism for capturing future benefits.
- Appendices:
  - Appendix A, Example interview questions: Detail of the high-level questions used in the stakeholder interview process.
  - Appendix B, Case studies: Contains the 10 case studies developed as part of the evaluation of the projects.
Figure 1.1 Organisational timeline

Figure 1.2 Significant Rail Events timeline
2 Methodology

The methodology was based on selecting and analysing up to 50 projects through an examination of rail research carried out over the last 20 years to gain an understanding of the impact of the research on the rail industry, highlight enablers and barriers to project success, identify the lessons learnt to inform future projects and develop 10 of the projects into detailed case studies.

The methodology used to identify, select and evaluate a sample of projects is described in the following sections.

2.1 Selection methodology

A combination of bottom-up and top-down approaches was used to identify a representative sample of rail projects and the data required for in-depth analysis. A number of criteria, based on research characteristics and pragmatic constraints were adopted. This ensured a targeted approach to selecting projects for which relevant information could be obtained:

1. The project should be completed so that the outcome can be assessed. The exception to this criterion was if a project had some stages completed with an identifiable impact. We also included cases such as the Thameslink Programme which – despite being an ongoing project – started being planned in the early 1990s and was officially proposed in 1997 (originally planned to be completed in 2000), but only obtained approval in 2006, thereby making it a valuable project from which lessons could be learnt.

2. The project outcomes should – if possible – be assessable and should include enablers and barriers to ‘successful’ outcomes.

3. Project documentation should exist, e.g. project reports with supporting information such as a project specification.

4. Project contacts should be available, e.g. client or contractor. If this existed, project documentation was less important.

5. The selected projects should be distributed across a number of framework structures (see Section 2.1.3) and represent research across a broad subject base to prevent bias in certain areas.

2.1.1 Bottom-up approach

The bottom-up approach focused predominantly on information in the public domain, including libraries, databases and websites. A number of repositories were accessed, including projects data and reports held by government and regulatory bodies, research suppliers (including universities), rail organisations etc. The list of repositories searched and the number of items identified in each are shown in Table 2.1.
### Table 2.1 Project Repositories

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rail Safety and Standards Board (RSSB)</td>
<td>634</td>
</tr>
<tr>
<td>2</td>
<td>British Rail (BR) Research report index (RSSB)</td>
<td>526</td>
</tr>
<tr>
<td>3</td>
<td>Two Rail Human Factors conferences (University of Nottingham)</td>
<td>109</td>
</tr>
<tr>
<td>4</td>
<td>Rail Research UK (EPSRC funded network)</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>Strategic Rail Authority reports (DfT)</td>
<td>116</td>
</tr>
<tr>
<td>6</td>
<td>Advisory Group for Rail Research and Innovation (AGRRI) website (BR Research)</td>
<td>196</td>
</tr>
<tr>
<td>7</td>
<td>Office of Rail Regulation (ORR)</td>
<td>83</td>
</tr>
<tr>
<td>8</td>
<td>Human Factors review paper (University of Nottingham)</td>
<td>121</td>
</tr>
<tr>
<td>9</td>
<td>TRL Knowledge Base (Disciplines)</td>
<td>21,449</td>
</tr>
<tr>
<td>10</td>
<td>TRL Knowledge Base (Physical Sub-system)</td>
<td>11,619</td>
</tr>
<tr>
<td>11</td>
<td>Passenger Focus publications</td>
<td>68</td>
</tr>
<tr>
<td>12</td>
<td>Network Rail intranet</td>
<td>76</td>
</tr>
<tr>
<td>13</td>
<td>Centre For Rail Human Factors report database (University of Nottingham)</td>
<td>230</td>
</tr>
<tr>
<td>14</td>
<td>The Railways Archive website</td>
<td>1,933</td>
</tr>
</tbody>
</table>

**Total** 37,171

### 2.1.2 Top-down approach

The top-down approach was used to complement the wide-reaching and broad scope of the bottom-up approach. By directly asking key figures in the rail sector for their views on research that had impacted on the industry, the probability of finding suitable projects increased.

25 experts from a range of organisations related to the rail industry, listed in Table 2.2, were approached to capture their knowledge and opinions on the role of research in the rail sector and to identify potential research projects for analysis. The discussions also uncovered views based on personal experience on project success or failure.

The interviewees were selected to give a broad coverage of rail research funders, suppliers and users. The initial selection of interviewees was based on known key industry figures, and this was supplemented with other relevant stakeholders through recommendations at the early round of interviews. The interviewees were from Infrastructure organisations, Train Operating Companies (TOCs), Rolling Stock leasing Companies (RoSCos) and suppliers, strategy group such as the Railway Industry Association (RIA) and Universities (Rail Research UK). Researchers funded by the Engineering and Physical Sciences Research Council (EPSRC), and the European Union (EU) were also included. While there is a strong representation for engineering, the fields of human factors, economics, change management and marketing, and passenger research were also covered.
### Table 2.2 Types of organisations involved in the interview process

<table>
<thead>
<tr>
<th>Organisation Type</th>
<th>Typical roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government (e.g. DfT)</td>
<td>Director; Programme manager</td>
</tr>
<tr>
<td>Higher education (incl. RRUK members)</td>
<td>Head of Civil Engineering; Research Professor</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Senior Engineer, Senior Ergonomist; Head of business change</td>
</tr>
<tr>
<td>Systems integrators / Suppliers / RoSCos / Consultancies</td>
<td>Independent consultants; Director of Engineering</td>
</tr>
<tr>
<td>Advisory groups (e.g. RIA)</td>
<td>Technical Director</td>
</tr>
<tr>
<td>Passenger research</td>
<td>Head of Research</td>
</tr>
</tbody>
</table>

All the stakeholders approached were very willing to be involved in the study. Most of the interviews were conducted face-to-face, and the remainder were carried out using a questionnaire followed by a telephone discussion. The interviews proved the most effective route to capturing information, as this gave interviewees the opportunity to present documentations and reports to support their views.

The key high level questions listed in Appendix A were used to steer the interviews. The interviews lasted for approximately an hour, with some interviews extended to cover details of specific projects. In the case of specific project details, the interviews were a useful source for additional contacts linked to the projects.

Key points made in the interviews regarding the scope of the research in this project were:

- The term ‘research’ should be implied at the broadest level, i.e. not just fundamental research, but also applied research, development activities and in-house research within rail organisations;
- The scope of the work was not just engineering, but any aspect of rail related research, e.g. infrastructure, economics, human factors, safety, user requirements.

#### 2.1.3 Project sample structure

As part of the selection process for the project sample, it was important to ensure an even spread of the type of project being analysed to reduce the risk of bias within the analysis from a given type of project. This would also give the ability to rapidly sort through research according to various characteristics and to use those characteristics to drive the analyses.

Table 2.3 shows the 8 frameworks that were used to develop the project sample.
<table>
<thead>
<tr>
<th>Strategy Themes</th>
<th>Rail Technical</th>
<th>4Cs</th>
<th>Alternative Rail Framework</th>
<th>Disciplines</th>
<th>Rail Sub-system Framework</th>
<th>Physical Sub-system Framework</th>
<th>Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>By client</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research type</td>
<td>Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rail sub-systems</td>
<td>Rail sub-systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disciplines</td>
<td>Disciplines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train sub-systems</td>
<td>Train sub-systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Programme</td>
<td>Programme</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>Research</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table 2.3 Project Frameworks</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.2 Evaluation methodology

A number of characteristics were captured for each of the projects in the sample. These included:

- Project title
- Funding amount and by whom
- Project timescale
- Completed on time?
- Project steering group?
- Project summary
- Did another project directly lead to the project?
- What drove the creation of the project?
- Sponsor organisation
- Contractor organisation
- Type of research (fundamental, applied, experimental)
- Expected benefits estimated at the outset
- Output
- What changed as a result?
- Benefits realised
- Project impact
- Project barriers
- Project enablers
- Follow on work
- Did the project output feed into work that wasn’t a direct follow on of this project?

The capturing of these characteristics was aimed at assessing the following:

- The utilisation of the project results and time period that passed (timescale) before there was evidence of utilisation
- The impact of the project results
- Enablers to success experienced during the project
- Barriers to success experienced during the project
- Overall lessons learnt that can be applied to future projects

Table 2.4 and Table 2.5 show the utilisation and timescale metrics respectively.
Table 2.4 Project utilisation metric

<table>
<thead>
<tr>
<th>Utilisation of output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>Clear evidence of widespread use of results. Additional research might be needed but mainly only in complementary areas.</td>
</tr>
<tr>
<td>Medium</td>
<td>Some evidence of use of results. Follow up research may be necessary</td>
</tr>
<tr>
<td>Weak</td>
<td>Little or no known use of results has been identified. No follow up research has been identified.</td>
</tr>
</tbody>
</table>

Table 2.5 Project utilisation timescale metric

<table>
<thead>
<tr>
<th>Utilisation timescale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-term</td>
<td>Over 5 years until evidence of results utilisation</td>
</tr>
<tr>
<td>Medium-term</td>
<td>1-5 years until evidence of results utilisation</td>
</tr>
<tr>
<td>Short-term</td>
<td>Under 1 year until evidence of results utilisation</td>
</tr>
<tr>
<td>N/A</td>
<td>Not applicable (i.e. project results not utilised)</td>
</tr>
</tbody>
</table>

For comparison and uniformity, these metrics are consistent with the metrics used at European level by the European Railway Research Advisory Council (ERRAC).

An assessment of the project impact was carried out to understand whether and where the project results were having an impact in the rail industry. Table 2.6 shows eight impact areas, within which there are a number of metrics that were used to define whether a project had had an impact in this area. Section 4.1 describes the results of applying the utilisation and impact metrics to the project sample, along with associated information to complement the assessment.

The evaluation of project enablers and barriers was assessed using a combination of:

- Details captured from the project sample
- Views captured from top-down interviews
- Media reporting

Given the varied nature of the information captured on enablers and barriers, this information was then analysed in order for it to be organised into a list of generic enablers and barriers. Section 4.3 shows the results of the analysis of project enablers and barriers.
Table 2.6 Project impact metrics

<table>
<thead>
<tr>
<th>Commercial</th>
<th>Operational</th>
<th>Safety</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost reduction</td>
<td>Resulted in new procedures</td>
<td>Reduction in Fatalities/injuries</td>
<td>Reduction in emissions</td>
</tr>
<tr>
<td>Value of exploitable results</td>
<td>Updated existing procedures</td>
<td>Improving safety</td>
<td>Reduction in noise</td>
</tr>
<tr>
<td>No. of patents/licences</td>
<td>Supporting procedure development</td>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>Development plans</td>
<td>Efficiency improvements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Products</td>
<td>Procedural improvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Retention of knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social</th>
<th>Policy</th>
<th>Standards</th>
<th>Scientific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved accessibility</td>
<td>Resulted in new policies</td>
<td>Resulted in new standards</td>
<td>No. of publications</td>
</tr>
<tr>
<td>Increase in passengers and cargo</td>
<td>Updated existing policies</td>
<td>Updated existing standards</td>
<td>Further research</td>
</tr>
<tr>
<td>Other</td>
<td>Supporting policy development</td>
<td>Supporting standard development</td>
<td>Other</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.3 Development of case studies

Following the evaluation of the project sample, 10 projects were selected for a more detailed evaluation and to develop as case studies. The project sample was initially filtered for the projects that provided the most detailed information. This sub-set of projects was then analysed and case studies were developed to cover a number of subject areas and to highlight the key lessons learnt from past rail research. The case studies are discussed in Section 4.5.
3 Selection of projects

In total, approximately 37,000 references to rail research were identified in the bottom-up approach. Even taking into account possible overlap between some of these sources and the reports, this indicates a considerable volume of rail related research.

3.1 The project sample

Using a combination of the bottom-up and top down approaches described in Section 2.1 a sample of 48 projects was compiled. Table 3.1 shows the projects selected for analysis, the supplier and client organisations involved and the overall objective of the project.

<table>
<thead>
<tr>
<th>No.</th>
<th>Project Title</th>
<th>Supplier</th>
<th>Client</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Advanced Passenger Train (APT)</td>
<td>BR Research</td>
<td>BR Research</td>
<td>To develop a high speed tilting train to maximise speeds on curved sections of the UK rail network.</td>
</tr>
<tr>
<td>2</td>
<td>British Rail’s Tribometer train</td>
<td>BR Research</td>
<td>BR Research</td>
<td>The British Rail tribometer train was a full-scale unit specially developed to accumulate a large amount of adhesion data from which an improved understanding of the natural variation of adhesion could be developed.</td>
</tr>
<tr>
<td>3</td>
<td>Investigation into the King’s Cross Underground Fire</td>
<td>Desmond Fennell OBE QC</td>
<td>DfT</td>
<td>The fire in King’s Cross Underground station on 18 November 1987 resulted in 31 fatalities. The inquiry investigated how the fire occurred and how the risk of such an incident occurring again could be mitigated.</td>
</tr>
<tr>
<td>4</td>
<td>Preparation of Springboard software for rolling noise generation</td>
<td>European Rail Research Institute (ERRI)</td>
<td>European Rail Research Institute (ERRI)</td>
<td>Separate models for individual parts of the process of rolling noise generation had already been developed. This project aimed to package these separate programs together so that they exchanged data in standardised formats and command files.</td>
</tr>
<tr>
<td>5</td>
<td>European overnight stock (aka Nightstar)</td>
<td>GEC Alstom</td>
<td>European Night Services</td>
<td>To develop an overnight sleeper service from various parts of the United Kingdom to continental Europe, via the Channel Tunnel.</td>
</tr>
<tr>
<td>6</td>
<td>Transient ground movements caused by High Speed Trains over soft soil</td>
<td>University of Nottingham</td>
<td>Engineering and Physical Sciences Research Council (EPSRC)</td>
<td>To study the potential problem of large transient deflections, caused by the passage of high-speed trains, of a railway track bed on thin embankments located on soft subgrades.</td>
</tr>
<tr>
<td>7</td>
<td>Integrated Study of Rolling Contact Fatigue (ICON)</td>
<td>Industry-academia consortium</td>
<td>European Commission</td>
<td>To increase knowledge of rolling contact fatigue damage and wear mechanisms and to create improved and validated models.</td>
</tr>
<tr>
<td>No.</td>
<td>Project Title</td>
<td>Supplier</td>
<td>Client</td>
<td>Objective</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>8</td>
<td>The Southall Rail Accident Inquiry</td>
<td>Professor John Uff QC FREng</td>
<td>HSE</td>
<td>The Southall rail crash occurred on 19 September 1997, on the Great Western Main Line at Southall, West London. Seven people were killed and 139 were injured. The inquiry was set up by the Health &amp; Safety Executive to establish the causes of the accident and to make recommendations designed to prevent similar accidents occurring in the future.</td>
</tr>
<tr>
<td>9</td>
<td>Train crashworthiness for Europe railway vehicle design and occupant protection (SAFETRAIN)</td>
<td>Industry-academia consortium</td>
<td>European Commission</td>
<td>To improve railway cars passive safety by developing technology to manage the collision energy and designing specific impact structures to crush in a controlled and progressive way.</td>
</tr>
<tr>
<td>10</td>
<td>Railway trackbed engineering</td>
<td>University of Nottingham</td>
<td>Scott Wilson</td>
<td>To develop a method for predicting the effect of train traffic on track deterioration to assist in maintenance and renewals planning and whole life costing for infrastructure.</td>
</tr>
<tr>
<td>11</td>
<td>Development of risk-based examination intervals for Network Rail Bridges</td>
<td>TRL</td>
<td>RSSB</td>
<td>To examine the possibility of varying the frequency of detailed inspections for particular bridge structure types and develop a methodology that allows the engineer to alter the interval between Detailed Inspections for certain groups of structures.</td>
</tr>
<tr>
<td>12</td>
<td>Non Passenger Survey</td>
<td>MVA Limited</td>
<td>SRA</td>
<td>To understand the views of &quot;non-rail&quot; passengers to complement the findings of SRA’s National Passenger Survey and the parallel consultation work with rail industry.</td>
</tr>
<tr>
<td>13</td>
<td>UNification of accounts and marginal costs for Transport Efficiency (UNITE)</td>
<td>University of Leeds</td>
<td>European Commission</td>
<td>To support policy makers in setting charges for the use of transport infrastructure by providing appropriate empirical evidence and methodologies to allocate costs.</td>
</tr>
<tr>
<td>14</td>
<td>Improving railway infrastructure productivity by sustainable two-material rail development (INFRA-STAR)</td>
<td>Industry-academia consortium</td>
<td>European Commission</td>
<td>To develop a railhead with an additional surface layer (the INFRA-STAR two-material rail) which prevents rolling contact fatigue and reduces noise emissions in narrow radius curved rail.</td>
</tr>
<tr>
<td>15</td>
<td>Rail and Road Emission Model</td>
<td>AEA Technology</td>
<td>SRA</td>
<td>To review and update emission factors for rail vehicles and construct a model to allow rail emissions to be compared to displaced road emissions, so that the net impact of a rail development scheme can be estimated.</td>
</tr>
<tr>
<td>16</td>
<td>Analysing Impact of changes in On-Rail Competition</td>
<td>Institute for Transport Studies</td>
<td>SRA</td>
<td>To develop a computerised model to analyse the impact of changes in on-rail competition between Train Operating Companies.</td>
</tr>
<tr>
<td>17</td>
<td>Passive safety of tramway for Europe (SAFETRAM)</td>
<td>Industry-academia consortium</td>
<td>European Commission</td>
<td>To develop cost-effective structural safety improvements for trams and light rail vehicles and produce modular bodyshell designs.</td>
</tr>
<tr>
<td>No.</td>
<td>Project Title</td>
<td>Supplier</td>
<td>Client</td>
<td>Objective</td>
</tr>
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</tr>
<tr>
<td>18</td>
<td>Crashworthiness of joints in aluminium rail vehicles (ALJOIN)</td>
<td>Industry-academia consortium</td>
<td>European Commission</td>
<td>To investigate joining techniques (MIG or FSW welding, adhesive bonding) of double skinned aluminium extrusions and their performance in collision situations in an effort to eliminate the phenomenon of fast brittle fracture (weld unzipping) of such joints in rail vehicles.</td>
</tr>
<tr>
<td>19</td>
<td>Assessment of workload for signallers</td>
<td>University of Nottingham</td>
<td>Network Rail</td>
<td>To develop a set of contrasting tools to assess the work load of signallers from their tasks, systems and settings, and to assess their subjective impressions of the demands on them and the effort they put in.</td>
</tr>
<tr>
<td>20</td>
<td>Why good staff (sometimes) work unsafely?: factors that contribute to unsafe behaviour in track workers</td>
<td>University of Nottingham</td>
<td>Serco</td>
<td>To examine the behaviours and attitudes contributing to poor safety during trackside maintenance. The specific focus was on the perceptions of Serco Rail staff about the factors influencing an individual’s behaviour and the organisational safety culture in which the behaviour takes place.</td>
</tr>
<tr>
<td>21</td>
<td>Route Analysis and Dynamics Assessment Research (RADAR)</td>
<td>AEA Technology</td>
<td>SRA</td>
<td>To investigate why train service performance showed a marked deterioration between 1999 and 2002.</td>
</tr>
<tr>
<td>22</td>
<td>Safety implications of weather, climate and climate change</td>
<td>AEA Technology</td>
<td>RSSB</td>
<td>To identify the implications of future weather and climate change related increase in the susceptibility to hazards on the railway.</td>
</tr>
<tr>
<td>23</td>
<td>Railway Interoperable Manufacture and Modular Safety (TRAINSAFE)</td>
<td>Industry-academia consortium</td>
<td>European Commission</td>
<td>To promote and enhance the safety of the rail system through a collaborative project bringing together rail operators, suppliers to the rail industry, and academia.</td>
</tr>
<tr>
<td>24</td>
<td>Requirements for train windows on passenger rail vehicles</td>
<td>DeltaRail</td>
<td>RSSB</td>
<td>To investigate the role of windows as emergency egress routes as well as potential containment of passengers in the case of an accident.</td>
</tr>
<tr>
<td>25</td>
<td>Radical Possession Strategies</td>
<td>L.E.K consulting</td>
<td>SRA</td>
<td>To provide a high level assessment of the potential efficiency benefits from adopting radical possessions strategies. This assessment would support development of the emerging engineering strategy for the industry.</td>
</tr>
<tr>
<td>26</td>
<td>Road rail vehicle warning system</td>
<td>Network Rail</td>
<td>Network Rail</td>
<td>To develop a warning system for road/rail vehicles to prevent bridge strikes and similar occurrences.</td>
</tr>
<tr>
<td>27</td>
<td>Fears and experiences of assault and abuse on the railway</td>
<td>Risk Solutions</td>
<td>RSSB</td>
<td>To investigate the fears and experiences of railway staff and customers in relation to assault and abuse on the railway and identify measures to improve personal security, risk analysis, best practice and partnerships.</td>
</tr>
<tr>
<td>No.</td>
<td>Project Title</td>
<td>Supplier</td>
<td>Client</td>
<td>Objective</td>
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<td>-------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>28</td>
<td>Comparison of Hatfield and alternative UK rails using models to assess the effect of residual stress on crack growth</td>
<td>University of Newcastle</td>
<td>Health &amp; Safety Executive (HSE)</td>
<td>To model the effect of residual stress on crack growth.</td>
</tr>
<tr>
<td>29</td>
<td>Predicting the life of various grades of steel railway track</td>
<td>University of Birmingham, University of Newcastle</td>
<td>EPSRC</td>
<td>To improve fundamental understanding of the metallurgical and mechanical changes in rail steels during the initial stages of service loading. This would involve producing an accurate mechanics model for the wear-fatigue interaction in rails during service, and an accurate model for predicting rail life for different steel grades and in-service conditions.</td>
</tr>
<tr>
<td>30</td>
<td>Geogrid reinforcement of railway ballast</td>
<td>University of Nottingham</td>
<td>Royal Society</td>
<td>To develop a better understanding of the mechanisms of the strengthening properties of polymer grid reinforcement of railway ballast.</td>
</tr>
<tr>
<td>31</td>
<td>Railway noise – curve squeal noise, roughness growth, friction and wear</td>
<td>University of Southampton, Manchester Metropolitan University</td>
<td>RRUK</td>
<td>To develop a validated model of curve squeal noise generation, accounting for vehicle curving behaviour, friction characteristics and excitation due to unstable forces between the wheel and rail.</td>
</tr>
<tr>
<td>32</td>
<td>Development of a universal level crossing risk tool</td>
<td>Arthur D. Little</td>
<td>RSSB</td>
<td>To develop a risk tool to encompass all level crossings and locate the tool in a web browser environment in line with Network Rail Information Management Strategy.</td>
</tr>
<tr>
<td>33</td>
<td>Railway Ergonomics Questionnaire (REQUEST)</td>
<td>University of Nottingham</td>
<td>Network Rail</td>
<td>To survey attitudes and opinions of railway signallers and those in associated roles on a range of human factors such as job satisfaction, the workplace, culture and stress.</td>
</tr>
<tr>
<td>34</td>
<td>Post Hatfield investigation of rolling contact fatigue</td>
<td>University of Newcastle, Health &amp; Safety Laboratory, University of Sheffield</td>
<td>ORR, HSE</td>
<td>To develop greater understanding of the conditions which give rise to rolling contact fatigue in rail steels.</td>
</tr>
<tr>
<td>35</td>
<td>3rd Rail de-icing</td>
<td>ARUP, University of Birmingham, Manchester Metropolitan University, University, University of Liverpool</td>
<td>Network Rail</td>
<td>To produce analytical results, validated through experimentation, to reinforce the current understanding of the conductor rail/shoe contact in normal and severe weather conditions. Also, to develop recommendations for system improvements based on quantitative analysis and provide scientifically based guidance for operational decisions during winter months.</td>
</tr>
<tr>
<td>36</td>
<td>Evaluating Policy Fares Regulation Options</td>
<td>University of Leeds</td>
<td>SRA</td>
<td>To assess the impact of changes to fares regulation and ticketing (qualitatively and quantitatively).</td>
</tr>
<tr>
<td>No.</td>
<td>Project Title</td>
<td>Supplier</td>
<td>Client</td>
<td>Objective</td>
</tr>
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</tr>
<tr>
<td>37</td>
<td>Development and evaluation of improvements to the TPWS to mitigate reset and continue risk</td>
<td>RSSB</td>
<td>RSSB</td>
<td>To identify, develop, and evaluate a redesign of train borne TPWS equipment to prevent unauthorised resetting of the brakes following an Overspeed Sensor System (OSS) or Train Stop System (TSS) brake application.</td>
</tr>
<tr>
<td>38</td>
<td>Completing the set of passenger train safety signage to improve legibility and comprehension</td>
<td>Davis Associates</td>
<td>RSSB</td>
<td>To design and test a set of pictograms for use in safety signage on passenger trains. The symbols supplement those that were delivered by an earlier project.</td>
</tr>
<tr>
<td>39</td>
<td>Network Modelling Framework (NMF)</td>
<td>Steer Davies Gleave, DeltaRail</td>
<td>DfT</td>
<td>To develop a Network Modelling Framework (NMF) as a strategic modelling tool to support DfT, ORR and Transport Scotland (the Client Group) in testing schemes or options as part of defining the High Level Output Specification (HLOS and SHLOS).</td>
</tr>
<tr>
<td>40</td>
<td>Reducing uncertainty in structure gauging</td>
<td>Atkins</td>
<td>RSSB</td>
<td>To reduce the uncertainty of the factors influencing structure gauging, including track position variation, measurement accuracy and the effects of crosswinds on vehicles. This would enable better use of the loading gauge.</td>
</tr>
<tr>
<td>41</td>
<td>Railways and the Environment: Towards a strategy for 2005 and beyond</td>
<td>Institute for European Environmental Policy (IEEP), Independent Rail Consultancy Group (IRCG), Open University</td>
<td>SRA</td>
<td>To provide railways with effective environmental policy, covering climate change and greenhouse gas emissions, other pollutant emissions, noise, use of materials, waste arising, contaminated land, land management, amenity and biodiversity.</td>
</tr>
<tr>
<td>42</td>
<td>Benchmarking weld performance in aluminium joints (ALJOIN Plus)</td>
<td>Industry-academia consortium</td>
<td>RSSB</td>
<td>To provide the necessary information to create a bench mark for joints in aluminium rail vehicles against which improvements in joint design can be measured.</td>
</tr>
<tr>
<td>43</td>
<td>An assessment of Railtrack’s methods for managing broken and defective rails</td>
<td>TCCI</td>
<td>ORR</td>
<td>To determine whether Railtrack’s management of the rail network was consistent with its licence obligations, and whether these activities were reducing the safety risks arising from broken rails to the lowest reasonably practicable level.</td>
</tr>
<tr>
<td>44</td>
<td>InnoTrack</td>
<td>Industry-academia consortium</td>
<td>European Commission</td>
<td>To develop cost effective high performance track infrastructure, aiming at providing innovative solutions towards significant reduction of both investments and maintenance of infrastructure costs and optimising life cycle costs.</td>
</tr>
<tr>
<td>45</td>
<td>Concept Validation Hybrid Trains</td>
<td>Birmingham University</td>
<td>DfT</td>
<td>To create a computer based model that can be used to demonstrate the technical feasibility of a hybrid concept for a typical HST type train, identify the likely cost and benefits, and allow proposed designs for hybrid trains to be evaluated.</td>
</tr>
</tbody>
</table>
### 3.2 Analysis of projects

The searches for projects looked at research mainly over the past 20 years. While past research appears to have influenced more recent research, there is insufficient information in the published reports to easily establish direct links. Published reports generally cover the technical aspects and the outcomes of the research but not the information necessary to enable the evaluation of project metrics, including aspects such as initial objectives, whether or not they were met, lessons learnt etc. There is inherent difficulty in obtaining information about projects 'pre-privatisation'- due to the difficulty in identifying and contacting people involved in older projects resulting from time effects as well as the changes in the industry. Also, the advances of IT over the past 10 years has meant that the electronic storage, and hence availability, of project files and reports is more prevalent over the last decade. In general, an understanding of issues related to the projects such as background, objectives, the drivers, stakeholders, political/organisational impacts, outcomes etc has been gained mainly through discussions with people with some level of involvement in the projects. Overall this has biased the project sample to the last 12 years. Figure 3.1 shows the distribution of the timings of the selected projects over the past 20 years.

As part of the selection process for the project sample, it was important to ensure an even spread of the type of project being analysed to reduce risk of bias within the analysis from a given type of project (see Section 2.1.3).

Figure 3.2 shows the distribution of projects across each of the frameworks. There is a good representation of the different organisations, with some frameworks showing a strong engineering contingent, which is inevitable given the subject of rail, but not detrimental to the analysis of rail research.
### Project Sample Timeline

<table>
<thead>
<tr>
<th>Start Year</th>
<th>End Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>1988</td>
<td>Investigation into the King's Cross Underground Fire</td>
</tr>
<tr>
<td>1990</td>
<td>1990</td>
<td>Preparation of Springboard software for rolling noise generation</td>
</tr>
<tr>
<td>1992</td>
<td>1997</td>
<td>European overnight stock (aka Nightstar)</td>
</tr>
<tr>
<td>1997</td>
<td>1999</td>
<td>Transient ground movements caused by HST over soft soil</td>
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</tr>
<tr>
<td>1997</td>
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<td>The Southall Rail Accident Inquiry</td>
</tr>
<tr>
<td>1997</td>
<td>2001</td>
<td>Train crashworthiness for Europe railway vehicle design and occupant protection (SAFETRAIN)</td>
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<td>1999</td>
<td>2001</td>
<td>Railway trackbed engineering</td>
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<td>2000</td>
<td>Development of risk-based examination intervals for Network Rail Bridges</td>
</tr>
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<td>2000</td>
<td>2000</td>
<td>Non Passenger Survey</td>
</tr>
<tr>
<td>2000</td>
<td>2002</td>
<td>UNIfication of accounts and marginal costs for Transport Efficiency (UNITE)</td>
</tr>
<tr>
<td>2000</td>
<td>2003</td>
<td>Improving railway infrastructure productivity by sustainable two-material rail development (INFRA-STAR)</td>
</tr>
<tr>
<td>2001</td>
<td>2001</td>
<td>Rail and road Emission Model</td>
</tr>
<tr>
<td>2001</td>
<td>2003</td>
<td>Analysing Impact of changes in On-Rail Competition</td>
</tr>
<tr>
<td>2001</td>
<td>2004</td>
<td>Passive safety of tramway for europe (SAFETRAM)</td>
</tr>
<tr>
<td>2001</td>
<td>2005</td>
<td>Crashworthiness of joints in aluminium rail vehicles (ALJOIN)</td>
</tr>
<tr>
<td>2001</td>
<td>2006</td>
<td>Assessment of workload for signallers</td>
</tr>
<tr>
<td>2002</td>
<td>2002</td>
<td>Why good staff (sometimes) work unsafely?: factors that contribute to unsafe behaviour in trackworkers</td>
</tr>
<tr>
<td>2002</td>
<td>2002</td>
<td>Route Analysis and Dynamics Assessment Research (RADAR)</td>
</tr>
<tr>
<td>2002</td>
<td>2003</td>
<td>Safety implications of weather, climate and climate change</td>
</tr>
<tr>
<td>2002</td>
<td>2004</td>
<td>Railway Interoperable Manufacture and Modular Safety (TRAINSAFE)</td>
</tr>
<tr>
<td>2002</td>
<td>2007</td>
<td>Requirements for train windows on passenger rail vehicles</td>
</tr>
<tr>
<td>2003</td>
<td>2003</td>
<td>Radical Possession Strategies</td>
</tr>
<tr>
<td>2003</td>
<td>2003</td>
<td>Road rail vehicle warning system</td>
</tr>
<tr>
<td>2003</td>
<td>2004</td>
<td>Fears and experiences of assault and abuse on the railway</td>
</tr>
<tr>
<td>2003</td>
<td>2006</td>
<td>Comparison of the Hatfield and alternative UK rails using models to assess the effect of residual stress on crack growth</td>
</tr>
<tr>
<td>2003</td>
<td>2006</td>
<td>Predicting the Life of Various Grades of Steel Railway Track</td>
</tr>
<tr>
<td>2003</td>
<td>2006</td>
<td>Geogrid Reinforcement of Railway Ballast</td>
</tr>
<tr>
<td>2003</td>
<td>2006</td>
<td>Railway Noise – Curve Squeal Noise, Roughness Growth, Friction and Wear</td>
</tr>
<tr>
<td>2003</td>
<td>2006</td>
<td>Development of a universal level crossing risk tool</td>
</tr>
<tr>
<td>2004</td>
<td>2004</td>
<td>Railway Ergonomics Questionnaire (REQUEST)</td>
</tr>
<tr>
<td>2004</td>
<td>2004</td>
<td>Post Hatfield investigation of rolling contact fatigue</td>
</tr>
<tr>
<td>2004</td>
<td>2005</td>
<td>3rd Rail de-icing</td>
</tr>
<tr>
<td>2004</td>
<td>2005</td>
<td>Evaluating Policy Fares Regulation Options</td>
</tr>
<tr>
<td>2004</td>
<td>2005</td>
<td>3rd Rail de-icing</td>
</tr>
<tr>
<td>2004</td>
<td>2006</td>
<td>Development and evaluation of improvements to the TPWS to mitigate reset and continue risk</td>
</tr>
<tr>
<td>2004</td>
<td>2007</td>
<td>Completing the set of passenger train safety signage to improve legibility and comprehension</td>
</tr>
<tr>
<td>2004</td>
<td>2007</td>
<td>Network Modelling Framework (NMF)</td>
</tr>
<tr>
<td>2004</td>
<td>2007</td>
<td>Reducing uncertainty in structure gauging</td>
</tr>
<tr>
<td>2005</td>
<td>2005</td>
<td>Railways and the Environment: Towards a Strategy For 2005 and Beyond</td>
</tr>
<tr>
<td>2005</td>
<td>2006</td>
<td>Benchmarking weld performance in aluminium joints (ALJOIN Plus)</td>
</tr>
<tr>
<td>2006</td>
<td>2006</td>
<td>An assessment of Railtrack’s methods for managing broken and defective rails</td>
</tr>
<tr>
<td>2006</td>
<td>2006</td>
<td>InnoTrack</td>
</tr>
<tr>
<td>2007</td>
<td>2008</td>
<td>Concept Validation Hybrid Trains</td>
</tr>
<tr>
<td>2007</td>
<td>2008</td>
<td>On-train energy metering</td>
</tr>
<tr>
<td>2007</td>
<td>2008</td>
<td>Defining the values for Network Rail</td>
</tr>
<tr>
<td>2007</td>
<td>2015</td>
<td>Thameslink programme</td>
</tr>
</tbody>
</table>
Figure 3.2 Distribution of projects (totalling 48) within frameworks
4 Evaluation of projects

Using the utilisation and impact metrics defined in Section 2.2, the sample of projects was analysed to understand the contribution of the project outcomes to the rail industry, how soon this occurred, and the areas affected.

4.1 Utilisation and impact

The 48 selected projects were examined using the utilisation and timescale metrics described in Table 2.4 and Table 2.5. Figure 4.1 shows the summary results of the utilisation analysis. The ‘Utilisation of output’ proportions demonstrate that the selection methodology was successful in identifying a range of projects in terms of project successes. 81% of the project sample showed evidence of utilisation of results within 5 years of project completion. However, this does not necessarily reflect the utilisation of rail research in general, and should not be used in this way due to potential biases in the identification and selection of projects. It mainly demonstrates the potential of research to contribute to changes and improvements in the industry.

![Utilisation of output](image1)

![Utilisation timescale](image2)

Figure 4.1 Utilisation and timescale of project outputs

Table 4.1 contains the utilisation results for the sample of projects, together with more detail describing the utilisation. Where the utilisation of output metric is strong or medium, in general the timescale is either short-term or medium-term and only a few projects have a long-term timescale.

Table 4.1 Project utilisation and timescale analysis

<table>
<thead>
<tr>
<th>No.</th>
<th>Project Title</th>
<th>Utilisation timescale</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Advanced Passenger Train (APT)</td>
<td>Long-term</td>
<td>Technically there was a weak utilisation initially, and the prototype developed was removed from service. However, the technology was sold on and contributed significantly to modern day tilting trains.</td>
</tr>
<tr>
<td>No.</td>
<td>Project Title</td>
<td>Utilisation timescale</td>
<td>Detail</td>
</tr>
<tr>
<td>-----</td>
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</tr>
<tr>
<td>2</td>
<td>British Rail’s Tribometer train</td>
<td>Medium-term</td>
<td>The train operated between 1972 and 1996. Specific phenomena examined include the effect of rain, adhesion in tunnels, the effect of leaves on the railhead, problems resulting from faulty flange lubricators, effects of curved track and adhesion variations with speed. Train design today still utilises this research because there is nothing more recent.</td>
</tr>
<tr>
<td>4</td>
<td>Preparation of Springboard software for rolling noise generation</td>
<td>Long-term</td>
<td>The software as delivered by the project was in use in applied rolling noise research by BR Research for a few years before TWINS became available.</td>
</tr>
<tr>
<td>8</td>
<td>The Southall Rail Accident Inquiry</td>
<td>Short-term</td>
<td>The report of the Southall rail accident inquiry, chaired by Professor John Uff, was published in February 2000. It included 93 recommendations aimed at improving rail safety. 3 months later the HSE published an action plan to implement the recommendations. Over the next 2 years, the HSE carried out progress reviews on the action plan and by February 2000 action on most of the recommendations (84) was regarded as complete.</td>
</tr>
<tr>
<td>9</td>
<td>Train crashworthiness for Europe railway vehicle design and occupant protection (SAFETRAIN)</td>
<td>Medium-term</td>
<td>The research serves as basis for the Euro Norm production within the Work Group 2 of the CEN regarding the crashworthiness requirements for rail car bodies Classes I to 111.</td>
</tr>
<tr>
<td>11</td>
<td>Development of risk-based examination intervals for Network Rail Bridges</td>
<td>Medium-term</td>
<td>Research was carried out for RSSB and the results have been taken up by Network Rail. Although work is following on to implement the methodology, and change in internal client has led to a different view on implementation, which has hindered the process.</td>
</tr>
<tr>
<td>17</td>
<td>Passive safety of tramway for Europe (SAFETRAM)</td>
<td>Medium-term</td>
<td>The results from Safetram will form the basis of CEN European Standard 12663 Part II for tramcar categories IV and V. This will help greatly towards harmonising tram operators' requirements for passive safety, and it is believed it will also contribute decisively to eliminating obstacles in the functioning of the single market for rail-based mass transit vehicles.</td>
</tr>
<tr>
<td>18</td>
<td>Crashworthiness of joints in aluminium rail vehicles (ALJOIN)</td>
<td>Short-term</td>
<td>As a result of this work welding guidelines have been introduced in standards namely: EN 15085 Railway applications – welding of rail vehicles and components, Part 3, Annex H &amp; EN 15227 Crashworthiness of rail vehicle bodies.</td>
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<tr>
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<tr>
<td>19</td>
<td>Assessment of workload for signallers</td>
<td>Short-term</td>
<td>Full implemented within Network Rail ergonomics team.</td>
</tr>
<tr>
<td>24</td>
<td>Requirements for train windows on passenger rail vehicles</td>
<td>Medium-term</td>
<td>Project results have led to a change in the type of windows used in UK vehicles.</td>
</tr>
<tr>
<td>28</td>
<td>Comparison of the Hatfield and alternative UK rails using models to assess the effect of residual stress on crack growth</td>
<td>Medium-term</td>
<td>The project has supported Network Rail and others in their understanding of rolling contact fatigue and the role of rail metallurgy in the failure of rail steel.</td>
</tr>
<tr>
<td>30</td>
<td>Geogrid Reinforcement of Railway Ballast</td>
<td>Medium-term</td>
<td>Currently being rolled out to Network Rail based on trials.</td>
</tr>
<tr>
<td>32</td>
<td>Development of a universal level crossing risk tool</td>
<td>Short-term</td>
<td>The ALCRM is now being used by Network Rail across its network as an important tool in their safety decision making process. For the first time it is allowing direct comparison of risk at the full range of crossing types, helping to optimise the targeting of expenditure to reduce the level of risk.</td>
</tr>
<tr>
<td>34</td>
<td>Post Hatfield investigation of rolling contact fatigue</td>
<td>Medium-term</td>
<td>The work supported increased understanding of the behaviour of rail steel post Hatfield. The work has been disseminated to Network Rail, and the RSSB Vehicle-Track system interface committee through dedicated meetings, discussions and presentations.</td>
</tr>
<tr>
<td>38</td>
<td>Completing the set of passenger train safety signage to improve legibility and comprehension</td>
<td>Medium-term</td>
<td>The new forms of signage have been accepted by ATOC (and are available to train operators via the ATOC extranet), so that passengers will now see consistency across the fleet.</td>
</tr>
<tr>
<td>39</td>
<td>Network Modelling Framework (NMF)</td>
<td>Medium-term</td>
<td>Used by Network Rail, ORR, DfT. Further work is in progress to develop modules.</td>
</tr>
<tr>
<td>42</td>
<td>Benchmarking weld performance in aluminium joints (ALJOIN Plus)</td>
<td>Short-term</td>
<td>Identified the causes of the weld unzipping failure mechanism of aluminium welded joints found in the rail vehicles involved in the Ladbroke Grove accident, and provided the recommendations for eliminating this type of failure by improved joint design. The results provided RSSB the necessary information to enable them to make recommendations for improved manufacturing procedures in aluminium rail vehicles to enhance passenger safety.</td>
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<tr>
<td>44</td>
<td>InnoTrack</td>
<td>Medium-term</td>
<td>Indications of strong utilisation of output and timescale are already shown although project concludes in 2010.</td>
</tr>
<tr>
<td>46</td>
<td>On-train energy metering</td>
<td>Short-term</td>
<td>Provided a greater understanding of the technical aspects to metering a train and differences in energy consumption. Energy saving software has been introduced across the Pendolino fleet.</td>
</tr>
<tr>
<td>47</td>
<td>Defining the values for Network Rail</td>
<td>Short-term</td>
<td>Project was adopted rapidly within Network Rail.</td>
</tr>
<tr>
<td>48</td>
<td>Thameslink programme</td>
<td>Short-term</td>
<td>Very strong utilisation, the research has led into development of stations and to understand the infrastructure demands.</td>
</tr>
</tbody>
</table>

**Utilisation of output: Medium**

<table>
<thead>
<tr>
<th>No.</th>
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</tr>
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<tbody>
<tr>
<td>3</td>
<td>Investigation into the King's Cross Underground Fire</td>
<td>Medium-term</td>
<td>In 1991 a report found only eight of the 26 safety recommendations made after the inquiry had been implemented fully.</td>
</tr>
<tr>
<td>7</td>
<td>Integrated Study of Rolling Contact Fatigue (ICON)</td>
<td>Medium-term</td>
<td>Data library for fatigue performance of rail steels, demonstration of the effect of various contaminants (sand, ballast, lubricants) on rail wear and fatigue. Data has supported many following investigations of rail wear and fatigue, contributing to rail maintenance understanding.</td>
</tr>
<tr>
<td>10</td>
<td>Railway trackbed engineering</td>
<td>Short-term</td>
<td>Utilised quickly. Only moderate impact for organisation as training associate moved on to another company.</td>
</tr>
<tr>
<td>13</td>
<td>UNIfication of accounts and marginal costs for Transport Efficiency (UNITE)</td>
<td>Short-term</td>
<td>Many of the results adopted explicitly by the Directorate-General for Energy and Transport (DG TREN) in its Handbook on social costs.</td>
</tr>
<tr>
<td>14</td>
<td>Improving railway infrastructure productivity by sustainable two-material rail development (INFRA-STAR)</td>
<td>Medium-term</td>
<td>The recommended coatings were not taken up due to cost issues. However, the development of rail coatings has been continued by DUROC following the results of the project and has led to new particle impregnated rails that are being field-tested in Holland.</td>
</tr>
<tr>
<td>15</td>
<td>Rail and road Emission Model</td>
<td>Long-term</td>
<td>Following on from this work, further development of the rail emission model has been carried out and incorporated within the Network Framework Model. Currently further research is being carried out to develop robust energy algorithms for the passenger railway part of the environment module.</td>
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<tr>
<td>16</td>
<td>Analysing Impact of changes in On-Rail Competition</td>
<td>Medium-term</td>
<td>The software enabled a deeper understanding of on-rail competition. Applying the model on the case study of Transpennine services between Leeds and Huddersfield, an example reduction in service capacity to 175 seats combined with a 30% increase in full fare leads to 14.2% reduction in demand but revenue remains largely unaffected.</td>
</tr>
<tr>
<td>20</td>
<td>Why good staff (sometimes) work unsafely?: factors that contribute to unsafe behaviour in track workers</td>
<td>Short-term</td>
<td>The results were adopted relatively rapidly. This was aided by having a dissemination plan closely linked to the project. Medium utilisation because the results were implemented, but phase 2 not completed due to change in personnel. 20 Controllers of Site Safety (C OSS) were trained on new safety briefing practices.</td>
</tr>
<tr>
<td>21</td>
<td>Route Analysis and Dynamics Assessment Research (RADAR)</td>
<td>Short-term</td>
<td>The report was shared with the industry and other franchise bidders. It helped to prioritise delay issues and prompt debate about causes. It led onto RADAR 2 and fed into the rail performance National Task Force.</td>
</tr>
<tr>
<td>22</td>
<td>Safety implications of weather, climate and climate change</td>
<td>Medium-term</td>
<td>A series of risk scenarios were identified associated with various weather factors. The increased occurrence of extreme weather events appears to present the primary threat to the system. Recommendations for actions to support a response to these issues have been developed, focusing on identified priorities. As a result of a follow on project, Network Rail uses the output as part of their strategic planning for managing infrastructure in coastal regions.</td>
</tr>
<tr>
<td>23</td>
<td>Railway Interoperable Manufacture and Modular Safety (TRAINSsafe)</td>
<td>Medium-term</td>
<td>Output highlighted areas in need of further work (passive safety). As a consequence projects such projects as SafeInteriors and SafeCab are being carried out. It also raised awareness of passive safety issues.</td>
</tr>
<tr>
<td>25</td>
<td>Radical Possession Strategies</td>
<td>Long-term</td>
<td>The results were used to develop new revenue loss compensation methodologies by ORR and allowed Network Rail to adapt their strategies through new quantifications.</td>
</tr>
<tr>
<td>27</td>
<td>Fears and experiences of assault and abuse on the railway</td>
<td>Medium-term</td>
<td>Lead to further research work, and altered perceptions and understanding of risks to station staff, and the general perception of risk by passengers on the railways (perception vs. reality).</td>
</tr>
<tr>
<td>31</td>
<td>Railway Noise – Curve Squeal Noise, Roughness Growth, Friction and Wear</td>
<td>Long-term</td>
<td>The research led into development of steady state curving analysis programs.</td>
</tr>
<tr>
<td>33</td>
<td>Railway Ergonomics</td>
<td>Short-term</td>
<td>Utilisation within Network Rail across certain roles e.g. signallers. Immediate and ongoing.</td>
</tr>
<tr>
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<tr>
<td>36</td>
<td>Evaluating Policy Fares Regulation Options</td>
<td>N/A</td>
<td>Results may benefit policy and standards in longer term.</td>
</tr>
<tr>
<td>43</td>
<td>An assessment of Railtrack’s methods for managing broken and defective rails</td>
<td>Medium-term</td>
<td>Subsumed into post Hatfield work.</td>
</tr>
<tr>
<td>45</td>
<td>Concept Validation Hybrid Trains</td>
<td>Short-term</td>
<td>The project successfully validated the concept of a hybrid HST, although further research work was required to validate the concept for commuter trains.</td>
</tr>
<tr>
<td>5</td>
<td>European overnight stock (aka Nightstar)</td>
<td>N/A</td>
<td>The 139 carriage stock order began construction in 1992 and continued slowly until the whole project was put on hold in 1997, then formally abandoned in 1999.</td>
</tr>
<tr>
<td>6</td>
<td>Transient ground movements caused by HST over soft soil</td>
<td>N/A</td>
<td>No utilisation of results yet, but may benefit commercial partners in longer term.</td>
</tr>
<tr>
<td>12</td>
<td>Non Passenger Survey</td>
<td>N/A</td>
<td>No evidence of the utilisation of results.</td>
</tr>
<tr>
<td>26</td>
<td>Road rail vehicle warning system</td>
<td>N/A</td>
<td>Despite a fully working prototype being developed, the system was not adopted.</td>
</tr>
<tr>
<td>29</td>
<td>Predicting the Life of Various Grades of Steel Railway Track</td>
<td>N/A</td>
<td>No utilisation of results yet, but may benefit commercial partners in longer term.</td>
</tr>
<tr>
<td>35</td>
<td>3rd Rail de-icing</td>
<td>N/A</td>
<td>The initial phase did not produce anything that could be successfully implemented. The recommendation was for follow on work. Therefore, although technically failing to identify improved techniques, further research was required to investigate other methods for de-icing.</td>
</tr>
<tr>
<td>37</td>
<td>Development and evaluation of improvements to the TPWS to mitigate reset and</td>
<td>N/A</td>
<td>The recommended (via prototype) changes to the TPWS have not been implemented. It was believed that an alternative of driver training should be explored and that a stronger business case be developed. Follow on work is in progress on the business case.</td>
</tr>
<tr>
<td>40</td>
<td>Reducing uncertainty in structure gauging</td>
<td>Medium-term</td>
<td>The analysis carried out in the project provides for a more sophisticated tool for analysing complex gauging issues in a more refined way. It is intended to be included in the Railway Group Standards (RGS) catalogue. Whilst showing clear benefits, this</td>
</tr>
</tbody>
</table>
needs to be taken forward with some caution as there are still some areas that need to be further investigated.

<table>
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<tr>
<th>No.</th>
<th>Project Title</th>
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<th>Detail</th>
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<tbody>
<tr>
<td>41</td>
<td>Railways and the Environment: Towards a Strategy For 2005 and Beyond</td>
<td>N/A</td>
<td>Results may benefit policy and standards in longer term.</td>
</tr>
</tbody>
</table>

Figure 4.2 shows the distribution of project impacts using the impact metrics shown in Table 2.6. There is a similar level of impact between Commercial, Operational, Safety and Standards; between 35% and 40% of the project sample had an impact in these areas. The highest level of impact was scientific (50% of projects) and the lowest impact was in the Environmental and Social areas. Table 4.2 shows the impact distribution for each project; 79% of projects impact between 2 to 4 areas; this shows that the research is having an impact and ultimately providing a benefit in these areas.
<table>
<thead>
<tr>
<th>No.</th>
<th>Project Title</th>
<th>Commercial</th>
<th>Operational</th>
<th>Safety</th>
<th>Environmental</th>
<th>Social</th>
<th>Policy</th>
<th>Standards</th>
<th>Scientific</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>The Advanced Passenger Train (APT)</td>
<td>X</td>
<td>X</td>
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<td>2</td>
<td>British Rail's Tribometer train</td>
<td>X</td>
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<td>Investigation into the King's Cross Underground Fire</td>
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<tr>
<td>4</td>
<td>Preparation of Springboard software for rolling noise generation</td>
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<td>X</td>
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<td>5</td>
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<td>6</td>
<td>Transient ground movements caused by HST over soft soil</td>
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<td>7</td>
<td>Integrated Study of Rolling Contact Fatigue (ICON)</td>
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<td>8</td>
<td>The Southall Rail Accident Inquiry</td>
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<td>10</td>
<td>Railway trackbed engineering</td>
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<td>15</td>
<td>Rail and road Emission Model</td>
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<td>Passive safety of tramway for Europe (SAFETRAM)</td>
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<td>Crashworthiness of joints in aluminium rail vehicles (ALJOIN)</td>
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<td>Route Analysis and Dynamics Assessment Research (RADAR)</td>
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<td>Railway Interoperable Manufacture and Modular Safety (TRAINSAFE)</td>
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<td>Radical Possession Strategies</td>
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<td>26</td>
<td>Road rail vehicle warning system</td>
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<td>Geogrid Reinforcement of Railway Ballast</td>
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<td>31</td>
<td>Railway Noise – Curve Squeal Noise, Roughness Growth, Friction and Wear</td>
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<td>33</td>
<td>Railway Ergonomics Questionnaire (REQUEST)</td>
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<td>35</td>
<td>3rd Rail de-icing</td>
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<td>36</td>
<td>Evaluating Policing Fares Regulations</td>
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<td>37</td>
<td>Development and evaluation of improvements to the TPWS to mitigate reset and continue risk</td>
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<td>38</td>
<td>Completing the set of passenger train safety signage to improve legibility and comprehension</td>
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<td>39</td>
<td>Network Modelling Framework (NMF)</td>
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<td>40</td>
<td>Reducing uncertainty in structure gauging</td>
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<td>41</td>
<td>Railways and the Environment: Towards a Strategy For 2005 and Beyond</td>
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<td>42</td>
<td>Benchmarking weld performance in aluminium joints (ALJOIN Plus)</td>
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<td>43</td>
<td>An assessment of Railtrack's methods for managing broken and defective rails</td>
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<td>44</td>
<td>InnoTrack</td>
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<td>45</td>
<td>Concept Validation Hybrid Trains</td>
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<td>46</td>
<td>On-train energy metering</td>
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<td>47</td>
<td>Defining the values for Network Rail</td>
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<td>48</td>
<td>Thameslink programme</td>
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4.2 Top-down interviews

The top-down interviews were initially planned to acquire expert opinion on the role research plays within the rail sector, what constitutes successful research, and on barriers, enablers, and successful dissemination mechanisms for research. The results have been grouped into two main subjects:

- Industry developments
- The role of research

The barriers and enablers identified during the interviews are combined in Section 4.3 with those extracted in the analysis of the project sample.

4.2.1 Industry Developments

Examples of developments (or events) in the rail industry, where research played a significant role, that were highlighted in the interviews included:

- The Hatfield rail crash and related developments in the area of Rolling Contact Fatigue (RCF): 5 references
- Tilting trains (from APT through to Pendolino): 5 references
- Bogie developments, and wheel profiles: 5 references
- Demand forecasting and financial changes: 5 references
- Signalling developments (solid state interlocking, Integrated Electronic Control Centres, Automatic Route Setting, European Rail Traffic Management System): 4 references
- Organisational changes (privatisation, franchising etc.): 4 references
- Remote condition monitoring and the ‘Uninterrupted Journey’: 4 references
- Crashworthiness: 4 references
- Developments in passenger experience (e.g. smoother ride, withdrawal of slam door rolling stock, passenger behaviour): 4 references
- Traction / power control: 4 references
- Ballast / track-bed developments: 4 references
- Channel Tunnel Rail Link: 3 references
- High-speed trains (HST): 3 references
- Advances in ticketing e.g. smart ticketing: 3 references
- Aerodynamics (e.g. cross wind effects on trains): 3 references
- Energy efficiency (e.g. light-emitting diode (LED) lighting leading to reduced power consumption): 3 references
- Interoperability Directive and EU generally: 2 references
- Wheel-rail adhesion (i.e. ‘leaves on the line’): 2 references
- Mobile telephony and communications: 2 references
- Introduction of human factors based developments such as the Cullen Report for the Ladbroke Grove accident inquiry: 1 reference

A significant number of these developments are covered in the project sample, which highlights the important role played by the stakeholder interviews in identifying projects for analysis.
4.2.2 The role of research

Understanding the types of research that exist, and the role it plays, is critical to understanding the requirements and constraints of different types of research, and therefore making judgements on success and value of the research.

A number of the developments listed above have been highlighted as developments where research played a significant role. This role appears to come in three forms:

1. Development (or event) drives the need for research. For example, the Hatfield rail crash and the issue of RCF in the early 2000s, the economic effects of privatisation and increasing focus on improving service to the customer (e.g. passenger surveys to understand the implication of fare changes).

2. Research drives developments in the rail sector. For example, tilting trains and signalling developments are examples where the research primarily opened up opportunities and capabilities for the rail sector. While research may drive developments, it most often requires commercial and operational focus, or a clear understanding of the issue that can be addressed, in order for it to have value as a viable proposition.

3. Developments outside of the rail sector influence the rail sector. For example, the introduction of mobile technology, advances in Non-Destructive Testing (NDT), new techniques for modelling aerodynamics have all opened up new areas for rail-related research.

In combination, and over the long term, these roles exhibit a close, and often, circular relationship; Research drives developments, which change operational / economic / performance factors to the degree that they then drive more fundamental research. For example, technical developments which have lead to the introduction of the HST have in turn led to the need for more research into the effect of HSTs when travelling over soft-soil.

Research also varies in terms of the stage at which it is introduced within a product or development lifecycle. This can be structured by ‘Technology Readiness Levels’ (TRL), a framework quoted directly by some interviewees. This is a nine-stage process going from TRL 1, highly conceptual research, through TRL 4, 5 and 6, which cover small to large scale product development and testing, up to TRL 9, operational implementation.1

Different levels have their own challenges, risks, and roles. For example, university participants interviewed tended to view their role as being between TRLs 1 and 6, but mainly in the area of fundamental research (i.e. TRL 1 to 3), although they did provide development work when necessary (i.e. TRL 4 to 6).

The use of this framework highlighted a number of issues:

- Funding varies within the TRLs. Generally, organisations like RRUK is funded by the EPSRC to carry out fundamental or ‘precompetitive’ research (i.e. TRL 1 and 2), the EU provides support for more applied research projects (i.e. 3 and 4) and commercially-funded projects, partnerships and consultancies tend to cater for TRLs 5 and 6.

- The outcomes of later stages of TRLs can prompt more fundamental research (TRL 1), which reflects the way that developments can drive research. For example, findings on some of the EU-funded projects on RCF have raised more fundamental research questions that have been taken on by RRUK.

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• Industry tends to have limited involvement at the earlier TRLs. With the end of British Rail laboratories, capacity to support industrial conceptual development has been greatly reduced. There is a general perception that this can be overcome with the use of research bodies who can engage in comparatively small-scale, high-risk (to return on investment) projects that could not be funded under commercial pressures. However, it is also felt that this causes a divide that makes it difficult to get conceptual research from the ‘laboratory environment’ into development and beyond. There has always been an issue in seeing immediate ‘returns’ on research investment, as knowledge may lie dormant, or end up being developed outside of the UK (e.g. tilting trains) in order to become commercially viable. The break-up of the rail sector has further exacerbated the problem.

• To go from start to finish along this process can take longer than 5 years. This provides significant challenges for commercial organisations as this is often beyond their strategic horizon (e.g. a control period). Initiatives such as the 2030 railway and the role of strategic bodies such as the Railway Industry Association (RIA) are critical to overcoming this issue.

• It was acknowledged that some research sits outside of the TRLs. The TRLs lend themselves well to ‘product’ research and development. In addition, there are research ‘capability’ developments, which cover knowledge and techniques that should be considered across the development process. Examples of this include Human Factors or Aerodynamics. It is also not clear yet how marketing or economic research fit into the TRLs, so while useful, it requires validation for rail research generally.

Figure 4.3 shows a simplified version of the progression from fundamental research to implementation (with equivalent TRLs). Also included on this diagram are the typical barriers encountered described by participants, when moving from the fundamental (or at least, conceptual) research stage through to a development phase and then implementation. These barriers are discussed in the Section 4.3. However, the key points to make are:

• Different types of research and innovation come from different sectors. Fundamental research is predominantly from the higher education (HE) sector, with relatively little being supported by industry due to, amongst other things, perceived risk and cost. As a result, this form of work is more likely to be funded by research bodies such as EPSRC.

• Often certain conditions need to be in place, such as a reduction in the cost of technology, before the outcomes of fundamental research can be applied. Issues also arise in applying the fundamental knowledge due to factors such as applicability to rail and knowledge being lost due to a lag between the initial research and the opportunity to develop it.

• Development at later stages of research and development takes more of a collaborative funding model, possibly through the EU or direct academic / industry partnerships, (e.g. KTPs are cited as a useful means to foster this transfer).

• The final stage of implementation is mostly conducted in-house. It is here that the issues of change management are most likely to lie.

It is also possible to use this diagram to describe the different types of flows from research into implementation and further research. Figure 4.4 shows three models that represent the different paths research may take. For example, research may move from fundamental innovation, through to development and then implementation (Model 1). While this may appear the most logical path, feedback from participants highlight that it is not the only one and may not even be the most common. If we take a broad view that development work is equivalent to direct ‘problem solving’ research, then much of the
research in the rail sector begins at this point. Fundamental work is therefore a subsequent examination of the underlying principles (Model 2) which may in turn lead to its own innovations. The response to RCF in the wake of Hatfield is an example of this, with fundamental work arising from initial solutions to the problem. Finally, as noted above, there are a number of innovations that occur outside of the rail sector, that are then adopted within rail (Model 3). This may in turn lead to more fundamental research (leading back to Model 2). There are likely to be further models (e.g. implementation issues leading to fundamental human factors work) and the variety of models demonstrates that it is inappropriate to take a homogeneous approach to supporting rail research.

Figure 4.3 Simplified model of transition between research and implementation, including key barriers between stages

Figure 4.4 Models of the progression of research and innovation
An important issue that was highlighted was the difference between competitive and pre-competitive research. Private organisations (e.g. systems integrators, rail vehicle builders, equipment manufacturers) tend to have research and development budgets and will carry out their own research, or fund directly the research (based on confidentiality agreements with key research providers) on subjects that they expect will give them a competitive advantage. Therefore, they are unlikely to take up results of research that does not provide a market advantage over a competitor by doing so. A typical example is the development of design solutions to reduce the weight of body shells.

A number of respondents also commented on the increasing relevance of the EU and the need for developments within the UK to reflect the move towards interoperability across the EU. At the same time, the UK also needs to ensure that its needs are met within emerging EU standards.

There is a critical role in understanding research beyond the rail sector. For example, developments in power electronics outside of the rail sector have been cited as a major driver of subsequent changes to traction control within the rail sector. Therefore, the remit of anyone charged with monitoring developments relevant to the rail sector would be well served to look at the broader transport sector and beyond to understand the opportunities for innovation.

4.2.3 Benefits of the top-down approach

There were a number of benefits to using the top-down approach:

1. The interviews proved to be an excellent source of research projects and case-studies. While broad searches of existing repositories was suitable for generating a large volume of ‘hits’, and highlighting the main areas of research, it was not possible to easily identify projects with sufficient background information or accessible contacts, to allow further analysis. The top-down interviews in fact turned out to be the major source of projects and case studies. The interviewees were able to suggest projects (both successful and unsuccessful) that illustrated the issues discussed, and were often happy to suggest specific individuals for follow up discussions.

2. The experience across multiple projects and seniority of the interviewees provided additional value. They were able to highlight a number of factors concerning the execution and use of research, cite direct examples of the use (or under-use) of research, and give views on the characteristics of success.

3. There was also a level of consistency in the responses – for example, most of the developments in the rail sector were referenced by more than one participant, and many by four and five respondents. In terms of enablers (discussed in the next section) topics emerged repeatedly such as the role of strategy, ownership and the role of a sponsor and research being as much about people as innovation. At the same time, top-down interviews allowed the respondents to give points that were specific to their perspective, that might not otherwise have been captured by a bottom-up approach (e.g. perceptions on issues related to research within a competitive environment, and with implementing innovation within large organisations).

4. The interviews also identified important contextual factors that surround research, particularly with respect to their pre-cursors, and gave a historical context. So, while a number of projects emphasised the exploration of RCF issues post-Hatfield, interviewees were also able to discuss the role of pre-Hatfield RCF work.

5. The relatively large number of interviews enabled better understanding of a range of perspectives – so it was possible to see the view of those involved in
fundamental research, in development, in utilisation (e.g. in Network Rail or RoSCos) and then in terms of financial implications or impact on passenger satisfaction.

6. Finally, the interviews helped to capture the role of research not directly identifiable as ‘rail projects’. The main example of this is the role of research that is actually conducted outside of the rail sector (e.g. in power electronics, but also in other areas such as in the development of new software from the aviation sector to support aerodynamic modelling)

4.3 Enablers and barriers to success

The enablers and barriers identified from the sample of projects and the stakeholder interviews were examined to form key generic factors. Table 4.3 and Table 4.4 show the frequency distributions of the enablers and barriers identified. These should be read more as a list of potential barriers and enablers rather than giving too much weight to the different frequencies with which they were identified.

It was clear that a number of the factors identified could be an enabler and/or a barrier, depending on issues specific to particular projects. For example, having a ‘focused project scope’ was highlighted as both an enabler (e.g. by setting clear goals) and barrier (e.g. by preventing flexibility).

**Table 4.3 Frequency distribution of identified enablers**

<table>
<thead>
<tr>
<th>Enabler</th>
<th>Frequency</th>
<th>Total frequency</th>
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<tbody>
<tr>
<td>Involving the right stakeholders</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Promotion of project results</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Industry awareness and demand</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>An overall long-term strategy</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Support from client organisation</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Focused scope</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Cost benefit evidence</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Early consultation with stakeholders to develop project specification</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Prior existence of working relationship between organisations</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Accident safety driver</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Formation of a steering group</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Understanding balance of fundamental research and applied research</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Close geographical location of organisations</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dissemination of industry contacts across the project team</td>
<td>1</td>
<td>1</td>
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<tr>
<td>The use of full-scale experimentation</td>
<td>1</td>
<td>1</td>
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<tr>
<td>High public profile</td>
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<td>1</td>
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<tr>
<td>Linked with similar project</td>
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<td>1</td>
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<tr>
<td>Political influence</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Prioritising recommendations</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Regular independent review on progress</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Support from supplier organisation</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Utilising and adapting commercially available products</td>
<td>1</td>
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</tbody>
</table>
### Table 4.4 Frequency distribution of identified barriers

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Frequency</th>
<th>Project sample</th>
<th>Interviews</th>
<th>Total frequency</th>
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</thead>
<tbody>
<tr>
<td>Lack of strategy</td>
<td></td>
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<tr>
<td>Personnel changes</td>
<td>1</td>
<td>5</td>
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<td>6</td>
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<tr>
<td>Stakeholder concern over imposing changes</td>
<td>2</td>
<td>3</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Budget limitations</td>
<td>3</td>
<td>2</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Inadequate business case</td>
<td>4</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Not involving the right stakeholders</td>
<td>3</td>
<td>1</td>
<td></td>
<td>4</td>
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<tr>
<td>Poor communication across project team</td>
<td>1</td>
<td>2</td>
<td></td>
<td>3</td>
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<tr>
<td>Lack of regular independent review on progress</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
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<tr>
<td>Multiple suppliers</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Implementing results in industry</td>
<td>0</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Lack of equipment / expertise</td>
<td>0</td>
<td>2</td>
<td></td>
<td>2</td>
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<tr>
<td>Lack of quality in available data</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
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<tr>
<td>Lack of detailed requirements at project inception</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
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<tr>
<td>Lack of agreed scope at inception</td>
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<td>1</td>
<td></td>
<td>2</td>
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<tr>
<td>Cost benefit evidence</td>
<td>1</td>
<td>0</td>
<td></td>
<td>1</td>
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<tr>
<td>Intellectual Property Rights issues</td>
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<td>Lack of support from industry</td>
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<tr>
<td>Developments in the airline industry</td>
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<tr>
<td>Lack of railway access</td>
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<tr>
<td>Organisational changes</td>
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<tr>
<td>Rushing product launches due to internal / external pressures</td>
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<td>0</td>
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<tr>
<td>Focused scope</td>
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<tr>
<td>Time constraints</td>
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<tr>
<td>Contractual delays</td>
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<tr>
<td>Lack of support from client organisation</td>
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<td></td>
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<tr>
<td>Lack of impartiality and objectivity</td>
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<td>1</td>
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<tr>
<td>Lack of consideration to alternative solutions</td>
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<td>0</td>
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<td>1</td>
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<tr>
<td>Multiple stakeholders</td>
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### 4.4 Key lessons learnt

10 key lessons learnt from the evaluation of research projects and the enablers and barriers are listed below. Not all the lessons will apply to all research projects, because of the differences in research types. They represent actions that could mitigate the common barriers and make best use of the common enablers:

**Lesson 1 - Align with an appropriate strategy**

The objective of the research needs to be aligned with an appropriate short or long-term strategy for the rail industry. There may be a need for fundamental research in certain aspects of rail which could take a number of years. Without a clear strategy, the risk is that the industry may lose interest and drive while waiting for results of the long-term research. On the other hand, industry may also require quick interim solutions to specific problems.

**Lesson 2 - Develop a business case that includes an estimation of expected benefits**

A robust business case to justify the project is fundamental to ensuring take-up of the results in the longer term. In addition, the business case should be refined at different stages of the project as further knowledge is obtained. This could reduce the risk of project results being 'shelved'. The business case does not always have to be financial in nature; it may be more appropriate in many cases to predict an impact on some area of business or operational activity.

**Lesson 3 - Involve all the right stakeholders**

Involving all the relevant stakeholders can improve buy-in and the acceptance of projects results. Early stage involvement will help to define the research question
to meet stakeholder needs. This could consider all stakeholders who may have direct (or indirect) interest in the research and its outcomes, e.g. implementers of the results, or members of public that the results may have an effect on. In particular this should be done at the start of a project and not as a 'box ticking' exercise at the end of a project.

**Lesson 4 - Form a steering group**

A Project Steering Group made up of a select group of experts participating in the project discussions has provided benefits in a number of projects. They can form a useful source of knowledge and guidance, steer the project appropriately and also provide a form of acceptance from their respective organisations.

**Lesson 5 - Agree scope and deliverables at inception**

A clear definition of the scope (and whether this can change dependent on interim findings) and deliverables at the start of the project can help to prevent project results not meeting client expectations. Allowing for scope change due to findings during a project is also important, as long as the resource implications are understood and accepted.

**Lesson 6 - Appoint project champions**

Champions to support the project during its life, promote the results across the organisation / industry, and take post-completion responsibility for promoting implementation can influence project success and help to realise the benefits. The promotion of research project results is often a key factor in the benefits being realised.

**Lesson 7 - Agree communication strategy**

Agreeing the communication channels at the start of a project will ensure that stakeholders are kept informed of project progress and any issues that could affect the project outcomes. Setting a regular frequency of communication will help to ensure interest and 'drive' in the project are not lost. This is particularly important for projects of long duration.

**Lesson 8 - Develop an implementation strategy**

An implementation strategy with a post-project champion taking responsibility can contribute to better use of the research outcomes and securing the benefits. Research projects can often result in a number of recommendations and prioritising the recommendations can help to focus the implementation process; a good example of this is the Southall rail crash inquiry, which allocated time periods for compliance to all of the report’s recommendations.

**Lesson 9 - Plan for knowledge retention and transfer**

To prevent loss of knowledge when either personnel or organisational changes occur, the knowledge obtained through research should firstly be retained and disseminated throughout an organisation at the end of a project. The knowledge should then be consolidated centrally to minimise the impact of changes across the organisation.

**Lesson 10 - Conduct reviews on post-project progress**

This will help prevent a common issue that results of research often go unused for one reason or another, whether it is due to the need for further research or other business demands.

In support of Enabling Action 11 of the Rail industry research strategy implementation plan, RSSB has conducted an internal project to identify the features that combine to influence the implementation of research. The project identified six key “project
conditions” that lead to successful research implementation and six key “project attributes” that must be managed to increase the likelihood of successful research. Appendix C demonstrates how these conditions and attributes map to the 10 key lessons derived from this project. The lessons learnt are based on an analysis of a wide range of projects covering a 20 year time span while the RSSB project focussed on selected internal projects carried out since 2003. However, as Appendix C shows, there is significant agreement in the outcomes from the 2 studies with each project condition / attribute mapping on to at least one of the lessons learnt from this project.

4.5 Case studies

The following projects were developed into detailed case studies:

1. Case study 1: Network Modelling Framework (NMF)
2. Case study 2: Crashworthiness of Joints in Aluminium Rail Vehicles (ALJOIN)
3. Case study 3: Geogrid Reinforcement of Railway Ballast
4. Case study 4: Requirements for train windows on passenger rail vehicles
5. Case study 5: Development of a universal level crossing risk tool
6. Case study 6: The Advanced Passenger Train (APT)
7. Case study 7: Development of risk based examination intervals for Network Rail bridges
8. Case study 8: Assessment of workload for signallers
9. Case study 9: Route Analysis and Dynamics Assessment Research (RADAR)
10. Case study 10: Analysing Impact of Changes in On-Rail Competition

The case studies are included in Appendix B.

4.5.1 Analysis of case studies

The case studies were selected to highlight some of the key issues identified from the analysis of the selected projects. Figure 4.6 shows the distribution of the case study projects within the frameworks described in Section 2.1.3. This illustrates the even spread of the 10 case studies across all frameworks.

Some of the main ‘drivers’ of research are:

- Core business issues (e.g. disruption to services)
- Safety requirements (e.g. reducing risk of fatalities)
- Policy requirements (e.g. HLOS)
- Media interest (e.g. accidents)
- Customer focus (e.g. the need to understand human factors impact)
- Reduced costs (e.g. improving maintenance efficiency)

A key issue highlighted by a number of the case studies is that ‘successful’ projects often address a problem that is clearly defined and is important to the rail industry in terms of issues such as impact on core business, improved performance, safety and cost savings. For example:

- Stakeholders support for the project ALJOIN was driven by the issue facing the industry, that aluminium rail vehicles make up a considerable proportion of the rail fleet and poor performance of joints in these vehicles could have a significant impact on safety and crashworthiness.
Tensar International were looking to increase the use of geogrids (part of their core business) on the rail network and Network Rail to reduce the annual cost of tamping (~€60m) and disruption to users. This lead to research into geogrid reinforcement of railway ballast.

The case studies also highlight some of the following key lessons learnt, as described in Section 4.4:

1. Case study 1: Network Modelling Framework (NMF)
   - Lesson 5 - Agree scope and deliverables at inception
   - Lesson 7 - Agree communication strategy
   - Lesson 3 - Involve all the right stakeholders
   - Lesson 4 - Form a steering group

2. Case study 2: Crashworthiness of Joints in Aluminium Rail Vehicles (ALJOIN)
   - Lesson 3 - Involve all the right stakeholders
   - Lesson 6 - Appoint project champions

3. Case study 3: Geogrid Reinforcement of Railway Ballast
   - Lesson 1 - Align with an appropriate strategy
   - Lesson 3 - Involve all the right stakeholders

4. Case study 4: Requirements for train windows on passenger rail vehicles
   - Lesson 7 - Agree communication strategy
   - Lesson 3 - Involve all the right stakeholders

5. Case study 5: Development of a universal level crossing risk tool
   - Lesson 5 - Agree scope and deliverables at inception
   - Lesson 7 - Agree communication strategy

6. Case study 6: The Advanced Passenger Train (APT)
   - Lesson 2 - Develop a business case that includes an estimation of expected benefits
   - Lesson 3 - Involve all the right stakeholders
   - Lesson 8 - Develop an implementation strategy

7. Case study 7: Development of risk based examination intervals for Network Rail bridges
   - Lesson 2 - Develop a business case that includes an estimation of expected benefits
   - Lesson 8 - Develop an implementation strategy

8. Case study 8: Assessment of workload for signallers
   - Lesson 3 - Involve all the right stakeholders
   - Lesson 5 - Agree scope and deliverables at inception

9. Case study 9: Route Analysis and Dynamics Assessment Research (RADAR)
   - Lesson 4 - Form a steering group

10. Case study 10: Analysing Impact of Changes in On-Rail Competition
    - Lesson 5 - Agree scope and deliverables at inception
In terms of the impact of the case study projects, shown in Figure 4.5, 50% have a commercial impact while 40% had an impact on operations, safety, standards and scientific. As with the overall project sample, there was little or no impact in terms of Environmental, Social or Policy.

![Figure 4.5 Distribution of impact of case study projects](image-url)
4.6 Summary of benefits

The top-down and bottom-up approaches showed the difficulty in obtaining robust data on estimated project benefits at the start of a project as well as any assessed benefits following completion of projects. Even where solutions have been developed for clearly defined problems, the benefits may be in terms of increased efficiency, better use of...
resources, reduced risk of fatalities in future accidents etc. that are difficult to quantify in monetary terms.

The benefits of the analysed projects and rail research in general are summarised below:

- Although the economic benefits have not been fully assessed, the benefits have been seen to exceed the cost of research and implementation, often by a significant margin. For example:
  - The research on the aluminium joints in rail vehicles showed that the cost of the research to improve the safety performance of rail vehicles was less than the statistical value of 1 fatality. There were 31 fatalities in the Ladbroke Grove accident.
  - The total spent on research into Rolling Contact Fatigue (2000 – 2002) following the Hatfield accident is estimated to be about £3M. While there are no figures available on the direct benefits of the research, it has had a significant impact on the way maintenance is carried out on the network and is expected to lead to new standards.
  - The use of geogrids on the network has increased intervals between successive tamping operations significantly. It has been acknowledged that geogrids are inexpensive, easy to install and give significant benefit to track quality. Currently geogrids are installed in more than 10% of track renewed each year.

- Human factors research has had significant impacts on ways of working, identified ways to mitigate risks to users and workers on the network and contributed to safety standards.

- Research has helped to provide solutions to new requirements resulting from changes in the way the network operates. For example, ‘leaves on the line’ is not a new problem. However, the lighter diesel and electric trains in use are more susceptible to the problem of ‘leaves on the line’ and the increasing emphasis on minimising delays on the network has resulted in new research into wheel-rail adhesion properties.

- Based on the projects reviewed and case studies selected, 79% of the research projects impacted between 2 to 4 areas (see Section 4.1). These impacts are ultimately the benefits realised by these research projects.

- Research is generally considered beneficial and of significance if the outcome fulfils the objectives set. When the outcome does not fulfil the objectives set, lessons can be learned about the research subject, the suitability of the approach, or the practical and strategic research planning issues. A good example of this is the research on tilting trains, where despite failing to produce a production train, valuable technological lessons were learnt; As a result, the research was beneficial to the later development of tilting trains.

An important observation from this project is the gap in data on the monetary benefits of research. It is usually possible to identify the areas where there is an impact and a qualitative assessment of the impact but little information is available to express the benefits in terms of reductions in ‘money spent’. If these benefits are to be understood, there is a clear need to have rigorous cost benefit analyses as part of the follow up to research projects. A robust business case is increasingly a requirement to obtain funding.

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2 A stakeholder’s guide to participating in the RSSB-managed rail industry research and development programme’, RSSB (2007) provides guidance on producing a robust business case
5 A mechanism for capturing future benefits

Research is carried out to provide benefits. In principle, management, control structures and mechanisms are expected to be in place to identify, exploit and record these benefits. However, the examination of past projects has shown that this is an area that needs improvement. The aim of this Section is to propose a new or improved process to track the benefits of future rail research. A number of actions may be required to facilitate and ensure that the process actually works (e.g. capturing and storing the right sort of data is fundamental to the successful tracking of the benefits of research).

5.1 Background

In examining the requirements for an improved mechanism to capture benefits of future research, we have taken account of two particular aspects:

- Lessons learnt from carrying out this project that are particularly relevant to ensuring that benefits of future research can be tracked:
  - It is generally expected that the basis of research proposals or plans will have been subjected to some form of business approval process, and details on project time-scales, costs, benefits and perceived risks should be available for each project. The reality is that for completed research projects this information is in most cases not available.
  - Also, for most projects there is no formal record of post project evaluation covering issues such as, whether the initial objectives were met, changes to the planned programme and reasons, lessons learnt, actual benefits achieved etc. So assessment of completed research projects to establish whether initial objectives, predicted benefits etc were met is difficult.
  - The availability and accessibility of formal project outputs needs to be improved.
  - The research knowledge and lessons learnt while carrying out projects invariably reside with personnel involved in the projects. In most cases this knowledge is lost when people move away from the projects or becomes fragmented due to changes in responsibility or personnel in the project team.
  - Communications within organisations and between stakeholders need to improve; poor communication can result in duplication of work and poor realisation of the potential research benefits.
  - Two critical gaps that need to be bridged are:
    - Between early research and development, due to
      - loss of knowledge
      - change in personnel
      - research being forgotten between time research is done, and time business conditions are right
      - lack of expertise in interpreting and developing ideas)
    - Between development and full, successful, implementation, due to
      - lack of training
      - lack of previous stakeholder (end-user) involvement
      - lack of support
      - tendency to “just follow the process” rather than integrate technology into general working practice
• The need to align any new process with the state of research activity in the rail industry, both current and planned:
  o There have been major changes as well as increase in the extent of rail research activity in recent years. A number of investments and major projects are underway or are being planned to meet defined short-term and medium-term targets.
  o The Rail Technical Strategy provides a framework for addressing the longer-term issues and is intended to be a live document. The 30-year route mapping exercise (steered by TSAG to meet the 30-year vision for rail), being carried out by RSSB can be expected to influence rail research over the next few years.
  o The concept of ‘journeys’ rather than travel by a particular mode is gaining in importance. This may influence research activities with the need to consider the interaction and links between different modes.

5.2 Accessible and usable data

5.2.1 Data repositories
There are a large number of repositories (Table 2.1) that include research outputs (e.g. reports, papers and publications) covering a wide range of rail research over a long period of time. However the accessibility, availability and usability span a wide range:

• The repositories hold reports providing different levels of detail, from brief abstracts to full reports.
• The focus tends to be mainly on reporting on the research itself (e.g. methodology, results and outcomes, recommendations, further work required etc).
• It is often difficult to link individual reports to specific projects or to a series of projects (e.g. programme) and therefore the particular outcome or changes.

The advances in IT, data storage facilities and search engines is improving the availability of and accessibility to information (in the public domain) and there is ongoing work to improve this situation. For example the recent RSSB publication, ‘An overview of existing websites containing information and publications relevant to GB rail research programmes, December 2008’, provides a brief overview of websites containing research information that is of interest to the GB rail industry including the availability of the research and datasets they refer to. Information is based on a desktop review using a standard web browser to identify information readily available over the internet. The aim is to provide some form of access to the wide variety of rail industry research for the benefit of industry as a whole.

5.2.2 Improving data availability
There would be benefit in ‘consolidating’ knowledge related to previous and current research. We propose that a knowledge base, ‘databank of rail research’ is setup whereby reports from rail research are collated, classified, assessed and made available and accessible to all research funders, researchers and users. Key stakeholders will need to agree on who is responsible for the databank (person / organisation) and their duties. Our view is that the databank should be publicly managed (e.g. by the RSSB on behalf of the rail industry stakeholders\(^3\)). The aim is to gather, promote and transfer knowledge related to previous and existing research.

\(^3\) The databank could be managed by RRUK or its successor, or by RSSB as part of their Knowledge Management in support of Enabling Action 7 of the Rail industry research strategy implementation plan. The
- A "databank of rail research" would ensure continuity of data availability beyond the lifetime of the funding of particular projects and regardless of the circumstances of the individuals involved in the project after a period of time (career mobility, change of responsibilities etc).

- Contents of the databank (e.g. what goes in, the format, keeping data up to date) will need to be clearly specified.

- It would require support and buy-in at senior organisational levels and from the key stakeholders as well as the dedication of sufficient staff resources to manage of the databank and keep it up to date.

- A centralised repository will improve coordination of knowledge development and transfer by improving the links between different streams of research activities, reducing risk of duplication and also enabling better alignment of research activities with the overall programme of research.

- The databank needs to be reviewed at regular intervals (e.g. every 2 years) to make sure it is effective and offers 'value for money'.

### 5.2.3 Data specific to the capture of benefits of future research

The data that can support the capture of research benefits\(^4\) needs to be identified and collected in the correct format from each project and stored in the databank. It is important to assess project value (to establish business case and post-project evaluation) at a number of levels:

- Within the customer organisation
- For the rail sector generally
- For the economy (UK PLC)
- To consider role of EU – for better future integration, and to ensure UK is a contributor to EU standards and legislation that supersede Railway Group Standards where appropriate.

The process requires 'champions' to facilitate different stages of the project and its implementation. The champion’s role should continue beyond the completion of the project until the benefits are realised, or consensus is reached on the validity of the results. Stages of the process where the role of the champion would add value are:

- During the lifetime of the project – the project champion can usually be someone from within the organisation(s) expecting to benefit from the research and have the responsibility to facilitate buy-in from stakeholders consultation and within the organisation and benefits capture as the research outcomes become available; support hand-over issues to appropriate personnel on project completion.

\(^4\) This is related to work being carried out by RSSB in support of Enabling Action 11 of the Rail industry research strategy implementation plan – Estimation of benefits at proposal stage. The aim is 'to ensure that best practice in defining the potential benefits of rail research projects is communicated and used widely by sponsors and managers of research'. RSSB has published an industry best practice guide and the approach is already being applied to RSSB-funded and managed research. Other stakeholders are encouraged to adopt a similar approach, or at least the key principles, as soon as practically possible, if they have not already done so. A review is to be carried out to ascertain whether, and how, systematic approaches to defining the benefits of research at the specification stage have been adopted across industry stakeholders, and the type and detail of benefits being proposed or demonstrated.
• Post project completion – the post-project champion would usually be the customer for the research and has the responsibility to ensure efficient handover and manage the implementation process.

• Across the rail industry – research facilitator for the whole rail industry to support efficiency (e.g. prevent duplication, knowledge transfer etc).

A framework describing the data to be recorded at different stages in the life of the project and following completion (to enable capture of benefits) is described below:

1. At pre-project approval stage
   i. Project title
   ii. Clear statement of the purpose of the project and what is needed
   iii. Where does it fit within current research frameworks, e.g. 4Cs target, Rail Technical strategy themes
   iv. Business case to support the project

2. At the start of the project
   i. Project title, sponsor, contractor, estimated cost and duration
   ii. Project champion
   iii. Stakeholder involvement, e.g. Project Steering Group, Workshops
      • Participants and Organisations
   iv. Definition of the research problem
      • What is the problem that is being addressed?
      • Project drivers
   v. Lessons learnt from previous similar projects
   vi. Expected outputs, (Reports, Model, Standards etc)
   vii. Implementation plan (what, how, duration, training etc)
   viii. Estimated costs and benefits in qualitative or quantitative terms
   ix. Project timing (start and end dates)

3. At the end of the project and/or at intermediate stages (e.g. if the project is carried out in phases), record any changes to information provided at the start of the project:
   i. Project title, sponsor, contractor, estimated cost and duration
   ii. Project champion
   iii. Stakeholder involvement, e.g. Project Steering Group, Workshops
      • Organisations
      • Personnel
   iv. Definition of the research problem
      • What was the problem that is being addressed?
      • Project drivers
   v. What are the expected outputs, (Reports, Model, Standards etc)
   vi. Implementation plan (what, how, duration, training etc)
   vii. Actual costs and benefits (re-assessed based on actual project information) in qualitative or quantitative terms
4. Additional information on project completion
   i. Project summary and recommendations
   ii. Barriers and enablers encountered during the project
       • Organisational
       • Political
       • Others (e.g. technical)
   iii. Lessons learnt (e.g. overcoming the barriers and/or making best use of
        the enablers
   iv. Follow-on work (e.g. further work or new research)

5. Post project completion (Start about 3 to 6 months after completion, review
   periodically and archive ‘n’ years after completion of the project. The post-project
   evaluation period and the level of detail will vary with the size / importance /
   relevance (short-term, longer-term) of the project)
   i. Post-project champion
   ii. Progress of implementation plan
       • On target
       • Not on target / reasons
       • Abandoned / reasons
   iii. Dissemination activities
       • Internal to organisations (sponsor / contractor), for example a
         seminar to present results;
       • External – conferences, publications
   iv. Project evaluation (against defined metrics or assessment criteria), for
       example:
       • Utilisation metric/assessment criteria
       • Time-scale metric/assessment criteria
       • Impact metrics/assessment criteria
       • Quantified benefits/assessment criteria
       • Knowledge metric/assessment criteria

6. Final report & Archive

5.3 Making it happen
Setting up processes is often the easy part. Actions and / or incentives need to be put in
place to ensure that the ‘process’ works and is not overlooked as just another ‘task’:
   • Get buy-in from stakeholders - The structure / framework and the ownership /
     management of the process needs to be agreed with key stakeholders (DfT,
     RSSB, ORR, Network Rail, RIA, ATOC, TSAG, RRUK, EPSRC and ERRAC). The
     levels of confidentiality requirements and issues such as IPR will vary between
     organisation and between projects.
   • Providing data (e.g. project reports, benefits evaluation framework) in the
     appropriate format should be a mandatory part of the new projects and treated
     as a project deliverable. This means that projects should have the funding needed
     to cover the efforts required.
• The creation of ‘project champion’ and ‘post project champion’ roles to support the benefits capture process are different. The project champion may be a member of the project team with assigned responsibility to deliver the data required in the proforma in the course of the project. The post project champion (usually the customer) will "outlive" the duration of the actual research project and will be responsible for ensuring the longer-term data requirements, implementation and / or establishing the next link in the progression of the research work towards fulfilment of its potential. An option to consider would be for the same person to be post-project champion for a portfolio of projects and will be:

  o The owner of the whole of the process
  o Responsible for gathering, managing and providing the data to the databank
  o Responsible for maintaining contact details of project personnel
  o Responsible for the assessment of the projects
    ▪ Successes and failures
    ▪ Quantification of benefits

• If the ‘project champion’ and ‘post project champion’ are different people, a process would need to be defined for the handover of responsibilities between project champions. The post project champion would need to be involved throughout the project (e.g. in a steering group) in order that they are fully informed to take the project results forward.

• The creation of ‘facilitator’ roles to coordinate the benefits capture process and ensure this is done:

  o A facilitator within each stakeholder organisation. This may not need to be a full-time role, but would require time for regular reviews of projects and meetings with other stakeholder facilitators to review the data framework (see below).
  
  o An industry wide facilitator, appointed and paid for by the rail stakeholders, with responsibility to improve research efficiency, knowledge transfer and communication could add value to the overall research scene. This is an option to that could be investigated to determine the scope of the role and the possible costs and benefits.

• Formally review the data framework periodically (e.g. annually or every 2 years) to make sure that it continues to be fit for purpose and value for money. This responsibility would lie with the industry and organisation Facilitators.

• Use the data collected to carry out in-organisation reviews of completed research

  o Agree metrics within organisation or with stakeholders as appropriate
  o Five year (maximum) intervals
  o Make the results of the review available to stakeholders – funders, researchers and other users

5.3.1 Additional Incentives

It will require focussed effort to get the mechanism in place and working. Possible incentives to encourage funders, researchers and implementers to adopt a consistent mechanism include:

• Provide funding for champions – during project and post project making it part of their regular work.
• Use some of the realised benefits to provide additional funding for research; this can be as a fixed amount or a percentage of benefits. This will require buy-in from the appropriate stakeholders.

• Reduce the risk of the appropriate data not being provided to the databank by:
  o Tying in the need to complete the framework with project deliverables and agree the frequency with which it needs to be updated during the life of the project as part of project contractual requirements (and hence cover the funding needed).
  o Provide researchers with access to the information from past projects.

• Support research fellowships within the industry environment and encourage knowledge transfer from generation to application. For example, where PhD students, registered within a rail experienced university group, are embedded within a rail industry organisation, there is good evidence that their research is not only applied more readily but that it is better guided to be application relevant through constant reality checking. Indeed the cost benefits of such systems have been shown to come from: the value of the knowledge generated; the application of that knowledge whilst it is being generated; contribution of those students to other on-going projects, broadening their experience and providing temporary headcount increases for the industry partner; and the extended two-way implied interview and assessment process which cuts recruitment costs and risks markedly.

5.4 Overall summary

The key elements of the proposed mechanism are processes for managing / evaluating / disseminating / using research outcomes and benefits:

1. Tools to support the process:
   a. A databank that gathers together rail research and guides potential funders and researchers to the relevant sources.
   b. A framework to ensure that the right data is collected at the right time, before the start of the project, during the project and after completion of the project.
   c. Procedures to ensure lessons from similar previous projects are sought out at the start of the project; lessons learnt in the course of the project are appropriately documented for future use.

2. Involving the stakeholders – They are the ‘process owners’ as well as being some of the major stakeholders in rail research, e.g. DfT, Office of Rail Regulation (ORR), RSSB, Network Rail, the Engineering and Physical Sciences Research Council (EPSRC), The European Rail Research Advisory Council (ERRAC), Technical Strategy Advisory Group (TSAG) and the Advisory Group for Rail Research and Innovation (AGRRI).

3. Implementation plan – As well as having a process, actions and incentives to make the process happen include:
   a. Getting stakeholder buy-in
   b. Appointment of Project Champion(s)
   c. Appointment of Facilitator(s)
   d. Periodic review of the framework
   e. Periodic assessment of completed projects and disseminating results
5.5 Dissemination plan

Applying the lessons learnt in carrying out this project, an initial draft dissemination plan to communicate the project outcomes has been developed. The main objectives are to develop, refine and agree a mechanism with stakeholders for the capture of benefits of future research and also make the project outcomes available to the wider research community. The main actions proposed (to take place within 6 months of project completion) are:

1. Appoint Post-project Champion (from customer organisation, in this case DfT) to support the dissemination actions.

2. Prepare a summary (about 4 or 5 pages) of the project outcomes including:
   - The main findings
   - Recommendations for follow-on work
   - Mechanism to track benefits of rail research
   - Completed data framework to support benefits evaluation (see Section 5.2.3)

3. Get stakeholder buy-in for the mechanism and agree approach:
   - Confirm stakeholder organisations and representatives with project champion. Potential organisations who could be included are the DfT, RSSB, ORR, Network Rail, ATOC, EPSRC, ERRAC as well as the strategic groups such as TSB and TSAG driving research.
   - Organise stakeholder consultation (e.g. workshop) to agree on the mechanism that would be used for capturing benefits of all future research projects.
     - Prepare presentation materials for the workshop (summary report, Power point presentation, workshop objectives)
     - At the workshop, agree on mechanism, method to pilot the mechanism on new projects and timescale for review of progress
     - Produce report on workshop outcomes

4. Make project outcomes available, accessible and usable:
   - Circulate final report to stakeholders (top-down interviewees)
   - Present outcomes within the client organisation (e.g. DfT Research Management Co-ordination Group)
   - Publish report on the TRL website

5. Explore other opportunities to inform practitioners:
   - Publish article(s) in appropriate journal(s)
   - Present papers at conferences
6 Conclusions

A sample of 48 rail research projects was compiled for detailed analysis; this contained projects that had experienced wide utilisation of results, together with projects that for various reasons did not succeed in being utilised. Overall the review has shown that the data in the public domain from completed projects is insufficient for detailed analysis. Experience of people involved in the projects is critical to understanding the various project characteristics.

Of the 48 projects analysed, results from a significant proportion had been utilised within a 5 year timescale. 10 key lessons derived from past completed projects that would improve future research are:

1. Align with an appropriate strategy
2. Develop a business case that includes an estimation of expected benefits
3. Involve all the right stakeholders
4. Form a steering group
5. Agree scope and deliverables at inception
6. Appoint project champions
7. Agree communication strategy
8. Develop an implementation strategy
9. Plan for knowledge retention and transfer
10. Conduct reviews on post-project progress

The main barrier encountered while carrying out this project was, in spite of the large amount of project related material in various data repositories, the difficulty in obtaining detailed information on projects (i.e. more than a report abstract), and particularly for older projects pre-1990. The accessibility, availability and usability of the available data spans a wide range and in general it is difficult to link individual reports to specific projects or to a series of projects (e.g. programme) and therefore to particular outcomes. Knowledge essentially resides with people and a considerable body of knowledge from past research has been lost. To protect and benefit from knowledge generated by future research there is a need to consolidate knowledge in a ‘databank of rail research’ that is available and accessible to all research funders, managers, researchers and users.

Robust data on estimated project benefits at the start of a project as well as any assessed benefits following completion of projects are not generally available. Even where solutions have been developed for clearly defined problems, the benefits are more by ‘implication’, e.g. increased efficiency, better use of resources, reduced risk of fatalities in future accidents etc. and not in terms of monetised values. However the overall view is that research has delivered and has the potential to deliver significant benefits over the costs expended.

A consistent mechanism, accepted by the key stakeholders in the research community, is essential to enable the tracking of the benefits from future research and also to make effective use of lessons learnt from completed projects to inform future work.
7 Recommendations

Key recommendations from the study are targeted at improving the data available and enabling tracking of the benefits of future research:

1. Improve data quality, accessibility and availability and usability
   a. Specify a standardised data framework to be completed for each project; a structure to form the basis of discussion with stakeholders has been proposed.
   b. Develop a ‘databank of rail research’ consolidating data from across the industry. This could be managed by RSSB as part of their Knowledge Management, or by RRUK or its successor.

2. All projects should be required to provide a robust business case describing costs and estimated benefits (quantitative and/or qualitative) and a post project evaluation that will quantify the realised benefits.

3. Elect project champions with responsibility to drive projects during their lives as well as after completion to drive the utilisation of the project results and disseminate knowledge.
   a. Develop a hand-over process to define the transfer of responsibilities from a project champion to a post project champion (if different).

4. Agree a common mechanism for tracking future benefits among the key stakeholders in the rail research community

5. Investigate the need for an overall industry facilitator to oversee the operation of the mechanism; determine the scope of the role and the possible costs and benefits.

6. Carry out annual reviews of the mechanism process and its implementation. This will not only serve as a review of how well the mechanism is meeting its objective, but also to compile and disseminate the lessons learnt from research.

7. Carry out reviews of the impacts and benefits of research using the databank of research project information.
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Appendix A  Example interview questions

The intention is that the interviews will be semi-structured, and be based around the following key questions.

1. Give examples of major development in the rail sector over the last 20 years?
2. Has there been any contribution of research – either directly or indirectly – to these developments? If so, what has that contribution been?
3. Can you give other examples of specific research (good and bad), either recent or current?
4. For any of the above, where can we source specific documentation and/or access project details?
5. What leads to success or failure in research?
6. How best can the adoption of research be supported?
7. Is there anybody else we could be speaking to?

It is likely that these questions will be enough to drive a 60 minute session. However, there are a number of specific questions that will be drawn on, depending on role and experience of the interviewee. These include:

As a user of research

General Questions

1. What are the major innovations that have taken place in the last 5, last 20 years, that you have been involved with? (targeted to given SME)?
2. Did the changes drive research, or did they use existing research? Examples?
3. How has research contributed to these developments?
4. In what ways can research lead to successful outcomes (money saved, safety, standards etc.)
5. Was some research easier to use, or apply?
6. What are the characteristics of useful, valuable, implementable research?
7. What gaps were there in knowledge which have yet to be filled?
8. In general what would make you, a user of research, implement recommendations from research projects?
9. What barriers / enablers might you come across in trying to implement recommendations and/or introduce changes?

Project specific questions

1. What was it about that project that was useful?
2. What were the drivers for the project?
3. Did the project recommend any changes?
4. If so, were the recommendations implemented?
5. Were the benefits assessed? Did they meet anticipated levels?
6. If the recommendations were implemented, why? and vice versa.
As a contributor to research

General Questions

1. Can you recall any projects that you have been involved in that have resulted in,
   a. a follow up project, or
   b. Industry take-up?
2. What types of project have you been involved with as a contributor?
3. What ways can research lead to successful outcomes (money saved, safety, standards etc.)?
4. Are there any barriers to successfully assessing the output of research, or getting it used effectively?
5. Are there any enablers to successfully assessing the output of research, or getting it used effectively?
6. What makes a project a success?
7. What makes a project a failure?

Project specific questions

1. Have you ever followed up a research project after completion to ascertain its industry take up?
2. Have you commissioned the work, or been involved with the research?
3. How did you judge the project’s success afterwards?
4. What formal or informal criteria did you use?

Unsuccessful (either as contributor or user)

1. Give examples of projects that have not worked, or have not been useful afterwards?
2. Why were the projects not successful? What could have been done differently?

Approaches to dissemination and utilisation

1. How are you aware of and how do you access existing knowledge?
2. What tools, processes, approaches could be used to increase the value of projects – both in terms of doing the project, and in terms of accessing the outcomes later?
Appendix B  Case studies

B.1 Case study 1: Network Modelling Framework (NMF)

<table>
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<tr>
<th>Project title</th>
<th>Network Modelling Framework (NMF)</th>
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<td>Area(s) of research</td>
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Client | Contractor(s)
---|------------------
DfT | Steer Davies Gleave and AEA Technology/Delta Rail

Key project drivers
The drivers were the 2004 Rail White Paper and Railways Act 2005, which set out requirements for the Secretary of State for Transport (for England and Wales) and Scottish Ministers (for Scotland) to present to ORR a specification of the high level outputs (HLOS) they want the railway to provide, and a statement of funds available (SoFA). ORR must then determine the outputs that Network Rail must deliver to achieve the HLOS, the cost of delivering them in the most efficient way, and the implications for the charges payable by train operators to Network Rail for using the railway network.

Key project precursors
Contributing modules developed by stakeholders that fed into the NMF.

Project objectives
The NMF is a strategic modelling tool designed to support the Client Group (DfT, ORR, Transport Scotland (TS)) and Network Rail in assessing schemes and options against requirements to meet High Level Output Specification (HLOS and SHLOS). It was developed to provide the evidence base for linking decisions about expenditure on the railway to the outcomes that the expenditure can deliver.

The aim was to develop a single model rather than having each organisation developing separate models, thereby enabling a common approach to appraisal across the organisations.

Summary of work
Following the 2004 Rail White Paper and the Railways Act 2005, the HLOS requirements set out what the Secretary of State had to deliver and publish by July 2007.

In June 2005 DfT began scoping the requirements for a model with the stakeholders. An Invitation To Tender (ITT) was produced for a Scoping Study, which was carried out by Steer Davies Gleave and DeltaRail.

DfT organised a seminar on the conclusions of the Scoping Study and then followed it by an ITT to further develop the NMF specification; this could have been in the form of developing the Scoping Study proposals or proposing an alternative approach. Steer Davies Gleave and DeltaRail were chosen to carry on the development of a prototype following their Scoping Study proposals. Assessing which proposal would have the smallest risk to delivery influenced the selection of the contractor.

A further seminar was held in March 2006 to present the prototype version, which had limited functionality.
The NMF modules were developed and incrementally added to form interim versions, which culminated in the version which was used to analyse HLOS Options for publication in July 2007. The NMF incorporated modules developed by other organisations, for example:

- The Infrastructure Cost Model (ICM) developed by Network Rail to estimate the costs of operating, maintaining, renewing and enhancing the network and inform their business planning process is now a component of NMF. The ICM can be both by Network Rail (to estimate their budget requirements) and by ORR to review the Network Rail submissions, particularly if there is a mismatch of outputs and funds.

- The development of the NMF drove a parallel project by RSSB to enable the RSSB’s Safety Model to be included as a component safety module in the NMF.

**Outputs**
The two main outputs from the project were:
- the NMF itself, which was installed at the DfT, ORR, Transport Scotland and Network Rail, and
- supporting documentation for the component modules within the NMF. The supporting documentation included a User Guide, an overview document and background documentation for the modules of the NMF that were developed as part of the project (the externally developed modules were not documented).

The outputs from the NMF include:
- Forecasts of infrastructure and TOC costs
- Passenger demand and revenues
- Train performance (PPM)
- Safety metrics

**Impact measurement**
The project was a success from the point of view of the HLOS process working smoothly. The model is still a work in progress as DfT has a significant programme of work to improve it for HLOS2.

- **Commercial**
  - The outputs from the NMF formed the basis of DfT HLOS and TS HLOS submissions. The NMF has enabled DfT to attain improved Value for Money (VfM) from improved economic evaluation of scheme options. *(For example, estimates of the cost the work to develop NMF (including work prior to and after this project) are about totalled £2. Compared to the estimated budget for Network Rail of about £30bn over 5 years, the outputs from NMF would only need to contribute an efficiency saving of 0.03% in the first year alone for it to be cost beneficial).*
  - The NMF is influencing the replacement of ATOC’s Passenger demand model (MOIRA), since the NMF utilises MOIRA as one of its component modules.
  - Steer Davies Gleave is carrying out a project for Network Rail looking at developing a model for new rail lines, which is using inputs from the NMF.
  - TRL is developing an improved emissions model to support the evaluation of environmental costs of rail.

- **Social**
  - The DfT has presented the work from this project to other organisations (e.g. RRUK) and at conferences (e.g. Presentation to Annual Energy Modelling Conference of the UK Energy Research Centre).
• **Environment**
  - The NMF influences scheme options through reporting of CO₂ emissions. This module of the NMF was a follow on project and was completed in August 2007. Further work is currently being carried out to develop an enhanced emissions model that can be fully integrated into the NMF.

• **Policy**
  - The NMF supported the work to meet High Level Output Specification (HLOS) requirements from the Railways Act 2005.

**Enablers**
- Having a strong driver for the project. In this project it was the government requirement for meeting HLOS requirements.
- Starting early consultation with stakeholders and potential contractors to develop specification.
- After proposals from the initial Scoping Study produced by the contractor, a further consultation and ITT process was carried out for producing a working prototype of the NMF. This enabled other contractors to suggest alternative approaches that could improve on the initial proof of concept idea. This additional stage helped confirm ideas of the direction of the NMF development.
- Having stakeholders such as ORR as part of the HLOS development process meant not only that they could influence it but also they meant we were never surprised by anything in the HLOS process.
- Meeting stakeholder requirements. For example, for the ORR, it was an arguably essential (though in the event unused) insurance policy in that through the model ORR had the capability to exercise their duties if there had been of a shortfall of funds for either DfT or TS.
- The subsequent audit of the NMF by an independent contractor (ARUP) gave confidence to the stakeholders that the NMF was performing as expected.

**Barriers**
- Having multiple contractors that do not communicate well. The client experienced difficulties during the early stages of the project, when it became evident that the two contractors were not communicating effectively. This resulted in the client enforcing fortnightly progress meetings to encourage a closer working relationship.
- Not detailing the requirement of good software documentation. The background documentation left out significant detail of the methodology behind the NMF, sometimes due to expected lack of understanding from the anticipated audience of the documentation. This was picked up in the audit by ARUP.

**Lessons learnt**
- Consulting stakeholders prior to the production of any project specification and having the key stakeholders as part of the development process worked well in this project. It ensured that proposals put forward by any bidding contractors were designed to meet the needs of all stakeholders.
- The stakeholder consultation was continued throughout the project with Steering Group meetings with the client, stakeholders and contractors. This gave them the opportunity to influence the development and work towards a solution that would meet the needs of all the intended users of the system.
- Agreeing the communication channels and frequency of communication at the start of the project can mitigate the risks of poor outcome due to poor communication between contractors.
- When carrying out research that develops new software, it is important to capture all the knowledge behind the software. In order to prevent it becoming a “black box” which isn’t understood by the client and uses, it is important to specify the requirement of detailed documentation from the developer(s). This should include all
assumptions, formulae, algorithms etc. Essentially, this documentation should have the potential of aiding a rebuild of the software from scratch.

References

B.2 Case study 2: Crashworthiness of Joints in Aluminium Rail Vehicles (ALJOIN)

<table>
<thead>
<tr>
<th>Project title</th>
<th>Crashworthiness of Joints in Aluminium Rail Vehicles (ALJOIN)</th>
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<td>When (start and end)</td>
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<td>Area(s) of research</td>
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| Client | European Commission |
| Contractor(s) | European Consortium made up of Denmark (DanStiraps), Italy (D’Appolonia SpA), Switzerland (ALCAN Fabrication Europe) and the UK (Newcastle University-NewRail, Bombardier Transportation and TWI). |

Key project drivers
The key project drivers were the identified requirements to address the research needs and safety concerns over the performance of aluminium welds in rail vehicles. Recommendation 57 in the Rt Hon Lord Cullen PC Inquiry Report in the aftermath of the Ladbroke Grove accident stated:

- In the case of new vehicles constructed of aluminium, consideration should be given to:
  - a) the use of alternatives to fusion welding;
  - b) the use of improved grades of aluminium which are less susceptible to fusion weld weakening; and
  - c) the further development of analytical techniques.

Key project precursors
No link to earlier research was identified.

Project objectives
Observation of the rail carriages following the Ladbroke Grove accident, in which 31 people lost their lives, showed that some of the longitudinal seam welds had fractured for some metres beyond the zone of severe damage. The panels themselves were generally intact without significant distortion. Safety concerns over the performance of aluminium welds in rail vehicles raised in the Rt Hon Lord Cullen PC Inquiry Report were the main driver for this project. The aim of the project was to provide sufficient knowledge to design cost effective aluminium rail vehicle bodies that will not fail by catastrophic joint failure even under extreme loading.

Summary of work
The first phase of the research phase consisted of a thorough investigation of existing joint designs and joining techniques and this revealed shortcomings in existing joint designs:

- Partial penetration welds that acted as crack initiators facilitated the process of dynamic tear of welds under impact loading.
- Al-Si filler wire (allowed by current manufacturing standards) produced welds with lower strength, ductility and fracture toughness compared to Al-Mg filler wires.
The next stage of the work concentrated on understanding the fundamental properties of aluminium weldments and an investigation of the performance of alternative joining techniques such as adhesive bonding, bolted joints, laser welding and friction stir welding. Adhesive bonding was shown at an early stage to be unsuitable for rail vehicle construction. Improved understanding of joint properties was used to develop analytical failure models and validated with component tests. The models showed close agreement between experiment and prediction and the modelling procedure was used to examine solutions for improved joint performance.

The final stage of the project concentrated on modelling to simulate rail vehicle impact with and without the improved joints. Furthermore an experimental methodology was developed to assess the dynamic loading performance of joints and “rank” the impact performance of various joint designs.

**Outputs**
The key project findings were:
- The stress levels at the weld region should be brought close to those of the parent plate, through thickening of the aluminium plate at the weld region. The precise amount of thickening would depend on alloy grade and welding procedure.
- Friction stir welding (FSW) and MIG welding with Al-Mg filler wire are the best performing joining methods in terms of crashworthiness (as long as the above recommendation is implemented).
- Aluminium alloys other than the 6005 alloy in the T6 temper do not provide any appreciable improvement in joint strength.

**Impact measurement**
- **Safety**
  - The results have improved the crashworthiness of aluminium rail vehicles and as such, can contribute to a reduction in fatalities and injuries in potential future accidents involving this type of vehicle. According to DfT’s Highways Economics Note No. 1, the value of preventing a statistical fatality is £1.428m (2005 prices); There were 31 fatalities in the Ladbroke Grove accident. Therefore, the cost of this research (£1.37m) is less than the statistical value of 1 fatality.

- **Standards**
  - The output from ALJOIN has directly contributed to 2 European Standards, EN 15085 "Railway applications - Welding of railway vehicles and components" and EN 15227, “Crashworthiness of Rail Vehicle Bodies”.

- **Scientific**
  - The study has improved the fundamental understanding of the issues related to aluminium structures for rolling stock. 2 Journal papers, 2 specialised publications and 9 conference papers have been produced. A dedicated International Conference on Aluminium Crashworthiness held at the National Railway Museum in York on 07 September 2005.
**Enablers**
- The widely publicised accident and investigation report following the accident ensured the commitment of stakeholders to address the identified safety-critical issues.
- The expertise provided by the consortium led to a successful outcome.
- The dissemination of the results beyond the lifetime of the funding, due to the interest generated, created longer-term use of the results.

**Barriers**
- No significant barriers were identified during the project.

**Lessons learnt**
- Industry recognition of a problem affecting the core of their business and their commitment to find a solution can drive the success of the project. In this case the safety concerns were particularly critical as most modern rail vehicles are aluminium built.
- A coordinated response to a research need identified as a consequence of a tragic event led to the understanding of fundamental issues related to Aluminium joining technologies and their crashworthiness. This emphasized that a strong need for research is beneficial to success.
- The quality of the work also contributed to the success of the project as has the dissemination of its result beyond the lifetime of the funding. This is an important lesson that shows that results from research cannot be self promoting and appropriate post-project dissemination is critical to maximise the benefits.

**References**

ALJOIN final technical report (2005)


There were 7 papers resulting from this project at the International Conference on Aluminium Crashworthiness, 7-8 September 2005, York, UK.
B.3 Case study 3: Geogrid Reinforcement of Railway Ballast

<table>
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<th>Project title</th>
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**Client**
Royal Society and Tensar International

**Contractor(s)**
Nottingham Transport Engineering Centre (NTEC), University of Nottingham (Nottingham Centre for Pavement Engineering at the time)

**Key project drivers**
About £30m is spent annually on tamping and any reduction in the frequency of tamping will deliver benefits in terms of reduced maintenance cost and disruption in users and improved ride quality. The key project drivers were:
- For Tensar International, the potential to enlarge product market take up by improving understanding of the effect of one of their products in a rail context.
- For Network Rail, potential benefit of reduced frequency of tamping
- In a wider context, knowledge transfer between road and rail infrastructures.

**Key project precursors**
High stiffness polymer geo-grids to reinforce rail ballast have been used since the early 80s. In early 1990, BR Research investigated the use of Tensar geo-grid and results showed the impacts on settlement and rate of deterioration could result in reduced maintenance requirement. However the basic mechanics of the reinforcement were not well understood. This 2006 study aimed to improve understanding of the fundamental mechanisms and further optimise the design of the geo-grids for use on the rail track bed.

**Project objectives**
Track settlement develops differentially resulting in deterioration of ride quality and it is caused mainly by the development of plastic strains in the ballast under repeated loading. This results in the need for tamping operations that are a major maintenance cost and source of disruption to users. The objective of this project was to investigate the use of the Tensar polypropylene geogrids to reinforce track ballast and control settlement and thereby increase the periods between maintenance.

**Summary of work**
This project took the concept of polymer grid reinforcement of railway ballast, already in use in UK railways, and sought to place it on a scientific footing. This was achieved by practical testing, both at element scale and in a purpose built full-scale railway test facility, in particular by measuring railway track settlement with different designs of reinforcing grid.
Prototype grids were manufactured by Tensar International to a range of specifications (strength, aperture size) and ‘composite element tests’ were carried out, consisting of an element of ballast beneath and around a sleeper section. In parallel, discrete element modelling of grid reinforced ballast was also conducted.

In both cases, the data pointed firmly at an aperture size of 60-70mm. A particular grid specification was chosen and then trialled, first in the railway test facility and then on a site on the West Coast Main Line. This showed clear benefit in both cases in terms of reduced trackbed deformation. The project generated a design approach based on the knowledge obtained from tests using a simplified analysis package.

**Outputs**
- A final report was produced along with software for modelling ballast settlement with grids, and a test rig.
- Guidelines were produced for the implementation of grids (change in size of grid aperture), which were trialled and are now used within Network Rail.
- Six publications were produced along with presentations at conferences to disseminate the results.

**Impact measurement**
- **Commercial**
  - Although there are no figures available, it has been accepted that the financial savings from reduced maintenance far exceed the initial works cost. Network Rail has granted product acceptance certification and the Tensar geo-grid is used extensively by Network Rail (approximately 30-40 miles of track per year) to extend maintenance life. [http://www.buildingtalk.com/news/tns/tns160.html](http://www.buildingtalk.com/news/tns/tns160.html)

- **Standards**
  - No standard exists as yet, but there was a change in Network Rail practice from using 35mm mesh to 65mm mesh.

- **Scientific**
  - Six publications were produced plus conference presentations. Talks were delivered on the work in the USA at the University of Minnesota and to Itasca staff at their office in Minneapolis.
  - The test rig developed is available for use in other projects and has resulted in a follow-on PhD.
  - As a result of this successful project, subsequent work for NTEC was funded by Tensar.

- **Operational**
  - Savings in performance were found at Cottlemoor test site where maintenance needed was reduced to a fraction of the previous requirement of several interventions a year.
  - Created improved track bed conditions and a better understanding of when and how to implement grid reinforcement.

**Enablers**
- Involving Network Rail and experts from rail consultants in the Project Steering Group was a key aid in the project success.
- Having a tandem EPSRC (rail-related) project (Micro Mechanics of Railway Ballast Degradation) aided the project by providing additional research and helping to fund test facilities.
• Having good quality students on a university project.

**Barriers**
• No significant barriers were identified.

**Lessons learnt**
• Involving stakeholders in research that improves their performance is clearly an advantage in having the results approved and the output taken forward.
• The tandem EPSRC project has highlighted the advantage of maximising test facilities to solve more than one research issue. Results from one project can then often feed into other projects creating cost savings.
• Although often difficult to guarantee, making sure that the right staff are involved in the project is essential, matching the right skills with the right job.

**References**


B.4 Case study 4: Requirements for train windows on passenger rail vehicles

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**Client**
RSSB

**Contractor(s)**
DeltaRail

**Key project drivers**
The key project drivers were the identified requirements to address the research needs and safety concerns over the role of emergency train windows. Recommendation 81 in the Rt Hon Lord Cullen PC Inquiry Report in the aftermath of the Ladbroke Grove accident (5 October 1999) stated:

“There should be research into the feasibility of, and risks associated with, removable windows, the adequacy of windows as a means of emergency egress, the number of dedicated windows which are necessary and the provision as to the maximum distance between each passenger and a bodyside door or emergency exit”.

The subsequent accident at Ufton Nervet (06 November 2004) reinvigorated the urgent need to address this issue.

**Key project precursors**
A number RSSB funded research projects:
- Review of injury causation and human factors in recent rail vehicle accidents;
- Identification and quantification of injuries in rail vehicles during accidents;
- Development of a train evacuation risk model;
- Windows and hatches for emergency egress from railway carriages;

**Project objectives**
The aim of the project was to improve glazing integrity as a means of preventing ejection of passengers in case of accident. The work sought to resolve the dichotomy of containment versus escape as well as developing and validating escape strategies and standards. The project was carried out in 6 phases:
- Accident data review
- Containment/escape requirements
- Glass specification
- Validation testing
- Window performance specification
- Strategy for containment and escape

**Summary of work**
The safety role of windows in containing passengers during accidents conflicts with their potential role as a means of escape after accidents. This project investigated from first principles what safety functions are required from windows, and how this influences
contemporary train design. Drawing from a review of past accident data to quantify the conflicting requirements for containment and escape, and investigating the requirements and experience of the rescue services, the project established performance requirements for windows and developed a compliant prototype window for potential use on existing vehicles. The research found that one fifth of fatalities in recent accidents arose from involuntary ejection through bodyside windows. It found that escape windows that permit the glass to be broken by hammer do not provide effective containment and therefore represent a greater risk to passengers. The work recommended the progressive adoption of stronger ( laminated) windows at all positions in passenger carrying vehicles, the removal of hammers and the appropriate revision of labels and emergency instructions. A changed passenger egress strategy reflecting these findings was also recommended.

**Outputs**
The project produced the following recommendations:

- The following escape strategy should be adopted for all passenger-carrying vehicles (excluding sleepers and light rail) operating on Network Rail managed infrastructure:
  - Passengers should be encouraged to remain where they are and await rescue by the emergency services unless there is a real and immediate threat to their safety.
  - If it is not possible to do this because of a threat, then passengers should move to a position of safety further along the train and await rescue by the emergency services.
  - If it is not possible to do this, passengers should evacuate the train via the external bodyside doors, or an open vehicle (gangway) end. Passengers should not attempt to exit trains through windows.

- All future new vehicles should have laminated glass (or equivalent) only. To this end, the test suite developed during this project should be considered for adoption into the Railway Group Standard GM/RT2456 when it is next reviewed.

- Windows on existing vehicles should be considered for progressive replacement with laminated glass particularly at refurbishment.

- Hammers should be removed and signage amended accordingly such that the primary egress route, in the event of an evacuation being required, is recognised as being via the doors and gangways instead of breakable windows.

- Following consideration by the passenger operators, a common strategy should be adopted and the travelling public should be made aware of it. This should include information as to the actions to take following an accident or incident.

**Impact measurement**

- **Safety**
  - The project has contributed to improved safety and survival rates of passengers in the event of an accident by successfully containing them within the vehicles with laminated windows.
  - An example of this radical improvement is given by the performance of the vehicle involved in the Grayrigg accident (23 February 2007). This vehicle was fitted with laminated windows rather that toughened glass. The accident investigation report praised the performance of the windows and their role in providing safety to the occupants. Section 37 of the summary conclusions states “...the crashworthiness performance of the class 390 Pendolino avoided, almost completely, a number of hazards. These include multiple ejections through windows [...] all of which have been known to cause fatal and serious injuries in the recent past.”
  - Putting a value/cost on lives is extremely complex and rather delicate issue. According to DfT’s Highways Economics Note No. 1, the statistical value of preventing a fatality is £1.428m (2005 prices); The cost of this research (~400k) is less than the value attributed to one fatality. Although comparisons are difficult, an accident such as Grayrigg involving a different
type of vehicle may have resulted in a higher number of casualties (The only fatality in the Grayrigg accident resulted from of a heart attack).

- **Standards**
  - The output from the project has contributed to the review of the Railway Group Standard GM/RT2456.

- **Scientific**
  - A number of key RSSB reports have been produced on the topic, T424, T310, T52e. These results have been presented and disseminated at a number of conferences and specialist publications. T424 held two workshops on window containment.

**Enablers**
- The two accidents at Ladbroke Grove and Ufton Nervet with fatalities due to ejection through the windows and the resulting investigation reports were strong drivers behind the project.
- Involving the right stakeholders from the beginning successfully addressed a safety related issue and ensured their commitment. Workshops served to engage a wider audience.
- Senior RSSB management took a keen personal interest in the project and the combination of their technical expertise and understanding of the political sensitivities proved to be a great enabler.
- The credibility of the experts involved in the work as well as the support from industry helped to achieve the objectives of the research.
- Good communications planning and considerable time spent on stakeholder engagement.
- Advice from stakeholders on publishing the results to reach a wider audience on a sensitive topic was key to managing the intense media and industry interest.
- Although not an enabler per se, the outstanding performance, in the Grayrigg accident, of a vehicle fitted with the type of windows recommended by the different reports provided reassurance to industry and elsewhere about the suitability of the solution. The accident acted almost as a validation of the research.

**Barriers**
- Multiple politically sensitive stakeholders to the project
- A degree of opposition from survivor groups caused obstruction to the work but sharing the results of the research and explaining how the conclusions were reached addressed these concerns.
- Intense media interest

**Lessons learnt**
- In dealing with sensitive topics with impacts on the safety of passengers and attracting intense media interest, a clear communication and management strategy was critical and instrumental in delivering and disseminating the results appropriately.
- The strong commitment and support of all relevant stakeholders (including the client, RSSB) as well as their technical capability and reputation were key contributors to the success of the project.

**References**

Rail Accident Investigation Branch-RAIB (2008), Rail Accident Report: Derailment at Grayrigg.


B.5 Case study 5: Development of a universal level crossing risk tool

<table>
<thead>
<tr>
<th>Project title</th>
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**Client**
RSSB and Network Rail

**Contractor(s)**
AD Little and Strategic Thought

**Key project drivers**
Level crossings are the main source of train accident risk on the rail network and reducing risks at level crossing is a high priority to the rail sector. As such, a number of research projects have been carried out to address different aspects of safety at level crossings.

Network Rail had a need for a single central systemised model to predict risks at all types of crossing on its network.

During the project, the accident at Ufton Nervet (November 2004) automatic half barrier crossing in Berkshire renewed the focus on the crossing environment as a source of risk to passengers and staff on board the train. This led to the commissioning of an extended model for train derailment in order to determine the impact of collision consequences on risk.

**Key project precursors**
Work done from 1995 onwards by BR, Railtrack, Safety and Standards Directorate (S&SD) and Railway Safety on risk modelling at level crossings leading to the development of the precursor Automatic Level Crossing Risk Model.

**Project objectives**
To develop a single central systemised risk tool to encompass all level crossings and locate the tool in a web browser environment in line with Network Rail Information Management strategy.

**Summary of work**
AD Little and Strategic Thought for RSSB and Network Rail carried out this project. It extended the application and functionality of an existing risk model for automatic level crossings to all level crossings. The new model, the All Level Crossings Risk Model (ALCRM), improves Network Rail’s ability to manage the risk to crossing users, passengers and rail staff by targeting those crossings with the highest risk for remedial measures.

Complex algorithms created by AD Little were transferred by Strategic Thought to a web-browser software environment. A key feature of the project was to ensure that in the transfer the model’s integrity was not corrupted. This required close co-operation...
between the two suppliers, under the management of Network Rail Information Management.

The Model allows local Network Rail level crossing practitioners to enter data for their crossings and establish the risk for their crossings.

**Outputs**
- A single central systemised web-based risk tool, ALCRM, to predict risks at all types of level crossings and available for use by practitioners responsible for the management of level crossings. The ALCRM is now being used by Network Rail across its network as an important tool in their safety decision making process. For the first time it is allowing direct comparison of risk at the full range of crossing types and helping to optimise the targeting of expenditure to reduce the level of risk.

**Impact measurement**
- **Operational**
  - The ALCRM is now being used by Network Rail across its network as an important tool in their safety decision-making process. It is available to practitioners through the Network Rail Information Management network.
  - A key aspect of the implementation of the model is to ensure that all users are properly trained. Network Rail designed and delivered training courses for use of the model for their various level crossing practitioners.
  - Network Rail chairs a monthly review panel, attended by RSSB, to identify and develop improvements and enhancements to the model. A batch of changes (cost c £100k) funded by Network rail is in the final stages of development.

- **Safety**
  - Although probably too early to say as the risk reduction measures identified (e.g. crossing closures, upgrades, changes to existing crossings or management processes) will be phased in over several years, especially at appropriate time when crossing equipment is due to be replaced (life cycle is ~25 years).

**Enablers**
- The two parties RSSB and Network Rail worked very well together to manage the two interrelated contractors, and managed the complex challenges associated with this project. So even though delays were introduced, the work is an excellent example of knowledge transfer from research to practice. Network Rail managed the IT specialist, while RSSB managed and facilitated the transfer from AD Little work to the IT supplier and Network Rail.

**Barriers**
- IPR issues were significant and had to be managed. The handover of RSSB’s work to Network Rail and the management of multiple suppliers managed was challenging.
- The project had to wait for Network Rail to get into contractual relationship with the IT supplier (due to the limits of RSSB’s remit) before the algorithms could be transferred to the IT specialist to develop into a usable tool.
Lessons learnt

- Careful planning is required when the project involves multiple suppliers with complex and independent structures.
- Consideration of IPR issues, particularly in software development projects.
- Consideration of contractual requirements prior to starting a project.

References
RSSB, Development of a universal level crossing risk tool. 
http://www.rssb.co.uk/Proj_popup.asp?TNumber=028&Parent=877&Ord
B.6 Case study 6: The Advanced Passenger Train (APT)

<table>
<thead>
<tr>
<th>Project title</th>
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<tr>
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**Client**
British Rail

**Contractor(s)**
British Rail

**Key project drivers**
There was a growing desire in the 1960s and 1970s to build high-speed rail networks. In order to facilitate high-speed trains, steeper banking of the rails on curves would be required, which caused a problem for slower trains using the same lines. Japan and France avoided this problem by building new rail networks that minimised curves to enable high speed. This was not an option for British Rail due to reasons such as land availability in built up areas. Tilting train technology was seen as a potential solution.

**Key project precursors**
There were previous experimental developments of tilting train technology in other countries, but these used different techniques and did not feed directly into this project.

**Project objectives**
The objective of the Advanced Passenger Train project was to introduce tilting trains through a three-phase project:

- Phase 1 - Development of an experimental APT (APT-E)
- Phase 2 - Introduction of three prototype trains (APT-P) into revenue service on the Glasgow/London route.
- Phase 3 - Introduction of the Squadron fleet (APT-S).

**Summary of work**
The APT was an experimental tilting High Speed Train developed by British Rail during the 1970s and early 1980s.

In 1972 the APT-E was constructed and consisted of two power cars and two carriages, which contained instrumentation. Having successfully produced the proof of concept model, work on the prototype APT-P started in 1974. In 1981 the train was launched, but had to be quickly withdrawn from service after just 3 days to due technical problems with the brakes and tilting system, and also due to passengers complaining of motion sickness. This highly publicised failure damaged the project so hard that, despite being reintroduced into service in the summer of 1984, the project did not progress to Phase 3 and the production APT-S units was never started.
Outputs
- The project developed one APT-E followed by three APT-P units. As part of the development work, fundamental knowledge and design aspects of the APTs were transferred into other rail developments and research.

Impact measurement
- **Commercial**
  - The technology did not get buy-in in the UK – from industry as there was no robust business case and from passengers as it produced motion sickness. However, the technology was taken up in other countries (e.g. Sweden and Italy where the lessons learnt from the UK experience incentivised them to design the trains to compensate for the motion sickness).
  - The project influenced modern day tilting trains through the sale of tilting technology to Fiat Ferroviaria for use in its Pendolino trains.
  - Aspects of the APT-P influenced the design of the InterCity 225 designed for the East Coast Main Line electrification.
  - The initial research into vehicle dynamics enabled freight trains to be sped up, such that hundreds of miles of relief track could be removed.

- **Social**
  - The project helped to influence the achievement of increased capacity through the long-term development of high speed trains.

Enablers
- The large political influence was the driving force behind the creation of the project, which helped feed the budgets required. However, this was ultimately a barrier when the poor press from the APT-P launch resulted in the diminished political drive and removal of funding.

Barriers
- The project suffered from not considering passengers as the most important stakeholder in the project.
- The launch of the APT-P was rushed due to pressure from within British Rail and from government. This meant that existing technical problems were not solved prior to launch.

Lessons learnt
- The key lesson from this project is to not rush implementation of developments prior to full acceptance testing. In this case, the high profile nature of the project meant that the poorly publicised launch caused the ultimate demise of the project.
- Apart from the technical issues that were a factor in the poor publicity, it was apparent that not enough work had been carried out in terms of testing views of passengers. The lesson to take from this is that it is important to fully understanding the needs of stakeholders in projects. Had the motion sickness issues been identified prior to the launch, the poor publicity that was received could have been avoided and ultimately the project may not have failed.
- Other countries realised the benefits, but BR were prevented by immediate setbacks.

References
B.7 Case study 7: Development of risk based examination intervals for Network Rail bridges

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**Client**
RSSB

**Contractor(s)**
TRL

**Key project drivers**
The potential benefits (e.g. reduced frequency of inspections) to Network Rail from optimising the bridge inspections processes by matching resources to where they are most needed.

**Key project precursors**
None

**Project objectives**
The current inspection regime for Network Rail bridges comprises an Annual Inspection and a six-yearly Detailed Inspection. The six yearly interval applies to all bridge structures, yet the appearance and rate of development of defects is different for different structure types. Whilst it would appear more logical to develop an inspection regime to suit the particular requirements of individual structures, the cost of doing this would be prohibitive.

This project aimed to examine the possibility of using a risk based approach to varying the frequency of detailed inspections for particular bridge structure types.

**Summary of work**
The project established the principles upon which risk-based examination intervals could be determined on the basis of bridge type, and developed a risk-based method of determining the interval between detailed examinations taking account of:

- The defects commonly associated with that type of structure and the rate at which a structure deteriorates to an unacceptable condition.
- The level of detection provided by the examination regime (i.e. the ability to identify defects in good time to deal with them before the structure reaches an unacceptable condition).

The rate at which a defect progresses determines the length of time between the defect being initiated and subsequently attaining an unacceptable state. The slower the rate, the greater the scope for extending the interval between examinations.
The more amenable a structure is to examination, the earlier the defect is likely to be picked up by the examination regime (i.e. the higher the level of detection provided by the examinations) and the greater the scope for extending the interval between examinations.

The project considered the range of possible interactions between deterioration rates, and the detection levels provided by detailed and visual examinations. From this, it was possible to develop a simple risk-based method for determining the interval between detailed examinations.

**Outputs**
- A simple risk-based method for determining the examination interval for bridges.

**Impact measurement**
- **Commercial**
  - Adoption of a risk-based method for determining the examination interval for bridges would lead to a more efficient use of resources and should also result in a more even distribution of risk across Network Rail’s bridge stock. Network Rail acknowledged value of the research by taking ownership and funding further work towards implementation.

- **Operational**
  - Implementation of the new approach to bridge examination will make the procedure of bridge stock inspection more efficient.

- **Policy**
  - The project underpins the follow-on work, currently being carried out by Network Rail, which is looking towards developing the recommended methodology into a new bridge inspection policy.

- **Standards**
  - In the process of altering the policy for bridge examination, standards are expected to change.

**Enablers**
- Identifying the clear efficiency benefit from implementing the recommended inspection methodology enabled Network Rail to see the value in taking the work forward into implementation.

**Barriers**
- During the follow on work to implement the methodology, changes in personnel within Network Rail brought different ideas to the work; in particular there was some debate regarding the number and type of technical documents required in order to implement risk-based examinations. This has resulted in delays to implementation.

**Lessons learnt**
- This project shows the value of demonstrating the benefits of new/revised processes. Although the final report did not describe a full cost benefit analysis, it highlighted the annual expenditure on the examination of Network Rail’s bridge stock and the benefits in terms of increased efficiencies and value for money that would be achieved from the recommendations.
- Change in personnel during the life of a project can lead to additional challenges, with new ideas (good or bad) and different objectives. The change process needs to be managed to ensure benefits are not lost. The current status and future direction of the project should be agreed between the contractor and both the old and new project sponsor personnel prior to proceeding further with a project.
References
B.8 Case study 8: Assessment of workload for signallers

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<th>Project title</th>
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**Client**
Network Rail

**Contractor(s)**
Centre for Rail Human Factors, University of Nottingham

**Key project drivers**
Issues were raised by signallers, supervisors, Local Operations Managers (LOM). There was also a requirement to understand design parameters (e.g. area covered) when designing / re-design signal panels.

**Key project precursors**
No specific precursor.

**Project objectives**
Mental workload of signallers was recognised to have a pervasive influence upon signaller performance and wellbeing. However, workload is a difficult multi-factorial notion to measure and evaluate and no tools to do so had been built specifically for a rail setting. This long-term research programme has seen the development of a set of contrasting tools to assess the loading on signallers from their tasks, systems and settings, and to assess their subjective impressions of the demands on them and the effort they put in.

**Summary of work**
The overall aim of the work was to produce a validated toolset for assessing signaller workload. This involved evaluation of similar techniques (such as NASA TLX) from other domains, and fieldwork and observation to understand the nature of workload in rail signalling. From this initial work, the tool set was developed. Tools developed include a self report Integrated Workload Scale, an Operational Demand Checklist, an Activity Analysis and Timeline Analysis Tool, and a Decision Probe Tool. These were taken from research prototypes and are now in regular active use as a toolkit used by Network Rail to evaluate the person-task-equipment fit in signal boxes and control centres.

**Outputs**
- Final report
- Toolset (ODEC, IWS, AAT, Principles, workload probe, ASWAT (See Lowe & Pickup, 2008))
- PhD
- Publications
Impact measurement

- **Safety**
  - It is expected that better management of signaller work load will reduce the risk of accidents. It is however to quantify as there are a number of contributing factors, in addition to signaller workload.
  - There is anecdotal evidence of reduced signaller absenteeism and reduced signaller stress, e.g. there were many requests to assess workload at Wimbledon before the assessment. However there have no requests since and workload appears to have reduced due to recommendations based on review.

- **Scientific**
  - The project has provided a Toolset for further research and is being used in RRUKB2, Future Situation Awareness and impact of automation work, as well as ongoing fundamental work to assess cognitive factors that contribute to workload.
  - The project has added to the skill base in Network Rail – the doctoral student is now a research fellow working as consultant for Network Rail.

- **Operational**
  - Network Rail ergonomics team (10 people) have been trained in all aspects and 5 consultancies have been trained in using a variety of aspects.
  - Approximately 45 signal boxes have been assessed and actual changes as a result of workload assessment have been made in 20 boxes.
  - There is anecdotal evidence of time and efficiency savings due to more effective staffing resulting in better routing of trains, i.e. better service due to reduced workload.

![Integrated Workload Scale (IWS)](image)

Example of Integrated Workload Scale (IWS) used to demonstrate differing impact of workload on automation – as used in Sharples et al (paper accepted to appear at HCI International Conference, San Diage, 2009)

**Enablers**
- Good contact and access by having support within the organisation.
- Having a focus – a set of problems to address.
- Many problems to address meant many opportunities to refine method.
- People could see value of work because it was problem focussed.
- Having a simple and tangible vision, in the form of a toolset, helped get early buy in.

**Barriers**
- Getting staff buy-in to the aims of the work.
- Railtrack converted to NR, so period of change.
- Unions.
- Availability of stakeholder (customer, SMEs) to help support the project – their workload tends to be more variable than the workload of researchers.
Lessons learnt

- Having a focused scope with well defined problems that were being addressed.
- Better range of SMEs to draw on is required. Having only two meant that views were too specific and provided a narrow range of experience.
- Validation is not always easy.

References


L Pickup, J R Wilson, S C Sharples, B J Norris, T Clarke, and M S Young (2005), Fundamental examination of mental workload in the rail industry. Theoretical Issues in Ergonomics Science, 6 (6), 463-482.

Case study 9: Route Analysis and Dynamics Assessment Research (RADAR)

When (start and end) 2002 - 2003
Area(s) of research Economics, Marketing
Type of research Fundamental research
Cost range £250k
Project number 21

Key project drivers
The significant deterioration in Train Service performance between 1999 and 2002 needed to be understood before improvements could be expected. Accidents such as Southall (19th September 1997), Ladbroke Grove (5 October 1999), Hatfield (17 October 2000) and Potters Bar (10 May 2002) have had a significant influence on Train Service Delivery and the effects of Hatfield have been particularly acute.

Key project precursors
It initiated as a direct result of discussion within the G6 group (a group setup and run by the SRA, which included Network Rail, ATOC, the ORR, the HSE and the freight operators) on 13 May 2002.

Project objectives
The primary objective within the study was to identify and quantify the major factors which, interacting as part of a complex system, determine overall train service performance. In particular the aim was to understand, in the context of two route corridors, what is causing the gap between current performance levels and those achieved prior to the Hatfield accident, recognizing that at that time Railtrack were forecasting further improvements. The main aim has been to ensure that the analysis addresses the issues that are perceived to be driving delays and established the facts.

Summary of work
This project investigated why train service performance showed such a marked deterioration between 1999 and 2002. RADAR combined analysis of train running data from several sources with extensive industry consultation and assessment of the less tangible issues, and some specific theoretical modelling work, to ensure that the considerable breadth of knowledge available in the industry has informed, guided and contributed to the final outcome.

The study compared data from May 99-April 00 with May 01-April 02 (i.e. pre and post Hatfield). Over that period, there was a step-change drop in passenger train service performance (measured using the 'Public Performance Measure'). Between the two years, PPM fell by 12.5% on long distance services (excluding Gatwick Express) and 8.1% on London and South East Services.
The major factors which caused performance deterioration have been listed as (figures in brackets estimate the extent of their contribution to the problem):

- Temporary speed restrictions (69% on ECML, 0% on SCN)
- Professional (or defensive) driving when approaching station stops or non-green signals (10% on ECML, 50% on SCN)
- Delays on trains newly fitted with Train Protection and Warning Systems
- (1% on ECML, 13% on SCN)
- More, and longer lasting, incidents (13% on ECML, 16% on SCN)
- Changing to a less robust timetable (0% on ECML, 12% on SCN)
- Longer stopping times due to more passengers (0% on ECML, 5% on SCN)

The project concluded that the reduction in performance could not be attributed to:

- Network congestion
- More major incidents
- Tighter programming of rolling stock and train crew
- Deterioration in rolling stock reliability
- More possessions or possession overruns (i.e. track maintenance)
- Changes to operating rules and protocols
- Failure to manage inter-train-operator delays

In 2003 a follow up research was conducted to investigate the factors in more detail and quantify the major ones with the MERIT (a system which enables managers to understand the performance of their timetable, by simulating train operations and interactions over a network) simulation systems.

**Outputs**

- The project concluded that in some regions, the introduction of defensive driving accounted for a significant proportion of the increase in delays. It also found defensive driving to be a significant contributor to the increase in delays on South West routes; Stopping times were consistently longer in 2002/3 during both peak and off-peak periods than they were in 1999/2000. This suggested that the increase was due to a more cautious driving style. A separate analysis showed that drivers were braking later for station stops than they had been before, and that drivers were driving more slowly under cautionary aspects. Taken together, these findings may be evidence of a change to a more appropriate rather than an overly cautious style of driving.
- The report was shared with the industry and other franchise bidders. It helped to prioritise delay issues and prompt debate about causes. It led onto RADAR 2 and fed into the rail performance National Task Force.

**Impact measurement**

- **Scientific**
  - Further research was conducted after the publication of the final report in 2002 to investigate the effect of other factors in more detail.
  - The results of the research were used in later work (Risk Aversion in the UK Rail Industry) by Arthur D. Little for the DfT, which looked at the existence and extent of risk aversion in the UK rail industry.

**Enablers**

- Although the results were controversial, the sharing of the results with the industry helped to promote the issue of declining performance and was a factor in driving further research.
Barriers

- The controversial nature of the findings resulted in the results not being accepted across the rail industry.

Lessons learnt

- Projects that could publish potentially controversial results should be managed in a way that encourages agreement of the findings across the industry. An example of this would be to create a steering group of all stakeholders and to agree the approach from the start. Obtaining this buy-in, and disseminating the results to the steering group prior to publication, could improve the acceptance and take up of the results.

References


R Phillips, S Draper, M Lee (2003), Project RADAR: Supplementary report.
B.10 Case study 10: Analysing Impact of Changes in On-Rail Competition

<table>
<thead>
<tr>
<th>Project title</th>
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Client       Contractor(s)
SRA           Institute for Transport Studies

Key project drivers
The degree of competition faced by franchised passenger rail services is moderated by the Rail Regulator. The Rail Regulator was requested to apply further relaxations of the restrictions on competition in the next stage of the moderation of competition process. The SRA wanted to develop a model to enable deeper understanding of on-rail competition.

Key project precursors
No specific pre-cursor

Project objectives
The aim of the project is to develop a model to analyse the impact of changes in on-rail competition:
- Improve understanding of the optimal level of on-rail competition when measuring against the SRA’s planning criteria.
- Determine on individual flows, whether increased competition leads to passenger benefit and whether competition is sustainable in the long run.

Summary of work
A computerised simulation model that can be used in a variety of situations to assess the impact of a change in the level of on-rail competition between Train Operating Companies was developed. The work was carried out in 4 phases:
1. Technical specification
2. Programming
3. Applying case studies
4. Provide the final version of the software

Outputs
- Final report
- Software for modelling On-Rail competition
- Guidelines and user notes
- Validation results
- Publications
Impact measurement
• **Commercial**
  - Applying the model on the case study of Transpennine services between Leeds and Huddersfield provided interesting findings. For example, a reduction in service capacity to 175 seats combined with a 30% increase in full fare leads to 14.2% reduction in demand but revenue remains largely unaffected.

• **Scientific**
  - Publications and conference presentations.

Enablers
• Iterative design, validating and improving the model within a reasonable amount of time will increase the chance of success.

Barriers
• No significant barriers were identified.

Lessons learnt
• A lesson here appears to be the iterative design methodology, which encouraged the acceptance of the model. This seemingly shows that incorporating acceptance stages during a process like this, helps to ensure that the final product delivers what was expected at the and is therefore more likely to be used.

References


G Whelan, D Johnson, C Nash (2003), Updating PRAISE to Assess the Implications of overcrowding.
Appendix C  A mapping of the lessons learnt from this project to the results of an internal RSSB project (part of Enabling Action 11)

<table>
<thead>
<tr>
<th>Evaluating Impacts of Completed Rail Research (Enabling Action 12) - Lessons learnt</th>
<th>1</th>
<th>2</th>
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<th>4</th>
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<th>7</th>
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<tr>
<td>1. The right expertise to specify and steer the project is applied</td>
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<td>2. There is clear industry buy-in and demand</td>
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<td>3. There is potential to add significant value via research exists</td>
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<td>4. Clear industry champions and enablers can be identified</td>
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<td>5. There is a compelling case for action</td>
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<td>6. The research links to an existing industry or organisational momentum for change</td>
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Key: Signifies that the project condition / attribute is related to the lesson learnt
Evaluating impacts of completed rail research

The Rail Industry Research Strategy (RIRS), which was published in December 2007, established a set of strategic priorities for rail research to support the delivery of the rail industry’s long-term vision for the railway. In order to support the implementation of the RIRS a set of Enabling Actions aimed to tackle Strategic research, Collaboration and Delivery mechanisms were identified. This research project, Evaluating Impacts of Completed Rail Research, is Enabling Action 12 and sits within the area of delivery mechanisms. The project was sponsored by the DfT and carried out by TRL, University of Nottingham and NewRail at Newcastle University between September 2008 and April 2009. The objective of the project was to evaluate rail research carried out over the last 20 years in order to obtain an understanding of the impact of the research and to identify those characteristics of rail research that represent high value and enable strong uptake within the rail sector. To achieve this, the project took a combined bottom–up (predominantly information in the public domain, including libraries, databases and websites) and top-down (interviewing key stakeholders in the rail sector) approach to select a representative sample of 48 projects from rail research conducted over the last 20 years. This report provides the rail sector with critical success factors, illustrated by specific case studies, required for future rail research to have the maximum impact on the sector, along with a better understanding of the barriers to success.

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