Transport Research Laboratory

The Second Rail Industry Research Strategy - Appendices

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The Second Rail Industry Research Strategy

Appendices

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V1	22 Nov	Work in progress draft	NH	BC
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V3	7 Dec	Second Draft	NH	VR
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The Second Rail Industry Research Strategy

Appendices

Contents

Acronyms and Abbreviations

4Cs – Customer, Cost, Capacity and Carbon

AGRRI – Advisory Group on Rail Research and Innovation

ATO – Automatic Train Operation

ATOC – The Association of Train Operating Companies

BR – British Rail

CP5 – Control Period 5

DfT – Department for Transport

EPSRC – Engineering and Physical Sciences Research Council

ESRC – Economic and Social Research Council

ERA – European Railway Agency

ERRAC – European Rail Research Advisory Council

HLOS – High-Level Output Specification

HSE – Health and Safety Executive

IPR – Intellectual Property Rights

LUL – London Underground Limited

MoU – Memorandum of Understanding

ORR – Office of Rail Regulation

RCF – Rolling Contact Fatigue

RD&D – Research Development & Demonstration

RIA – The Rail Industry Association

RIRS1 – The first Rail Industry Research Strategy

RIRS2 – The second Rail Industry Research Strategy

RISRP – The Rail Industry Strategic Research Programme

RRUK – Rail Research UK

RRUK-A – Rail Research UK Association

RTS – Rail Technical Strategy

SIC – System Interface Committee

SRP – The Sustainable Rail Programme

TPWS – Train Protection and Warning System

TSAG – Technical Strategy Advisory Group

TSB – Technology Strategy Board

UIC – The International Union of Railways

UNIFE – The Association of the European Rail Industry

Appendix A – The Rail Technical Strategy, the First Rail Industry Research Strategy and the Rail Industry Strategic Research Programme.

A1 The Rail Technical Strategy

Supporting National Policy
The Rail Technical Strategy (Department for Transport, 2007) supports national policy for the development of the railway over a 30-year planning horizon. The Rail Technical Strategy (RTS) brings together a long term vision of the railway as a system and how technology can contribute to meeting the key challenges it faces. When published in 2007, the RTS gave as its stated purposes:

- To establish and document an industry view of the technical changes that need to be made to the railway
- To create a 'road map' showing how change can be achieved

The following delivery mechanisms were identified:

- Creation of appropriate incentives
- Appropriate standards and guidance for the specification of asset renewal
- Harmonisation of objectives for major projects
- Definition of key priorities for long-term research
- Helping to shape Britain's response to European initiatives
- Application overall of a whole life, whole system cost approach

The Role of TSAG
Ownership of development and delivery of the RTS sits with the owners and operators of the railway. To assist them, the Technical Strategy Advisory Group (TSAG), a cross-industry expert body made up of senior executive staff, is charged with developing and championing implementation of the strategy, supporting communication, managing strategic research, identifying opportunities, barriers and actions.

Since the RTS was published, TSAG has led the industry activity programme to take forward the strategy, by developing vision in each key technology area, commissioning research and technology watches and building understanding around implementation issues and their solutions. Critically, TSAG is investing energy in creating an environment within the rail industry in which technical innovation is embraced and building supplier confidence in the business case for innovation.

Review of the RTS
As part of preparing the way for the second edition of the Rail Technical Strategy in 2012, TSAG has developed a Consultation Document in order to capture views from across the rail industry (TSAG, 2010). This Consultation Document describes emerging thinking on how technology can help provide solutions to the key strategic problems facing the railway.

To assist the consultation process, TSAG has identified five 'game changers' which need to be taken forward now so that decision makers in organisations can collectively identify and draw on the appropriate benefits and take technology decisions in a 30-year time frame. The five game changers are:

- Enabling innovation
- Establish next generation traffic management
- Optimise energy strategy
- Build in whole system reliability
- Provide smarter data and communications

Details of the five game changers are provided in Box A1.

Box A1 – Game Changer Research

Enable innovation, not re-invention
Systems leadership is key to innovation. Industry needs an incentive and a process to embrace the potential for improvement, without awkward technical, structural or cultural obstacles.

Establish next generation traffic management
Centralisation of rail traffic control into a single system or 'guiding mind' to optimise the network's capacity and increase customer satisfaction, reliability and safety. This will require the bringing together of commercially available systems and integrating them. Increases in rail's delivery potential will be reflected in revenue increases, income which might currently be out of reach through capacity constraints, while reducing operations costs through better management of the network, better utilisation and lower energy consumption.

Optimise energy strategy
We must make savings on the railway's annual £500m traction energy bill through better exploitation of new and existing technology. Train regenerative braking is already in use on the network. This and other ideas need to be deployed further to make greater inroads into the collective traction energy bill.

Build in whole system reliability
A business case for a whole system strategic approach to reliability is needed. This would help reduce the £600m annual cost of delays and a host of other related business performance costs in agreeing delay claims. Technology can help deliver better asset management, via deployments such as remote condition monitoring and systems for sharing performance data.

Provide smarter data and communications
We promote a strategy for rail mobile communications which relies on commercially available, off-the-shelf systems to provide enhanced information in line with the needs of both front-line railway operations and customers.

A2 Rail Industry Research Strategy

Following on from the RTS, the industry developed the first Rail Industry Research Strategy (RIRS1), which was published in December 2007 (Department for Transport, 2007), followed by an implementation plan in May 2008 (Department for Transport, 2008). The implementation plan identified a series of Enabling Actions to be carried out during 2008 and 2009 to enhance the effectiveness of rail research in the UK.

RIRS1 set out a future direction for rail research and put forward mechanisms for the delivery of this agenda to complement arrangements that existed at that time. The strategy emphasised the importance of carrying out more strategic research to meet the long-term targets for the railway. The following four Areas of Focus were identified:

- More strategic research
- Securing more support from users
- Promoting greater collaboration
- Defining the benefits

For each of these Areas of Focus, a series of Enabling Actions were defined which were intended to be undertaken in 2008 and 2009. Details of the Enabling Actions are provided in Appendix B, along with a brief update on the progress made in implementation, as of July 2010.

A3 Rail Industry Strategic Research Programme

A significant consequence of RIRS1 was the launch of the rail industry strategic research programme (RISRP). The programme was launched in September 2008 (TSAG, 2008), and aims to support the rail industry, its customers, suppliers and other stakeholders in enabling the step changes needed to deliver the industry strategy in 30 years' time, as outlined in the Rail Technical Strategy (RTS). The Department for Transport (DfT) has expressed its intention to grant £15 million over 5 years to RSSB, to manage the RISRP on behalf of the rail industry. The Technical Strategy Advisory Group (TSAG) has been established as the client-group for the Strategic Research Programme.

The RISRP concentrates on defined but broad-ranging subjects where a need for improvement has been identified, and a promising technical solution outlined but not the exact solution. Projects that would be suitable for funding under RISRP are likely to:

- Have the potential to influence the delivery of more than one of the RTS themes
- Affect several elements of the railway (e.g. rolling stock, track, signalling) and therefore have significant interface issues to be addressed
- Require cross-industry collaboration to address these interface issues and develop a whole-system solution
- Address major and complex issues requiring significant levels of resource and time to develop potential solutions

As part of RISRP, TSAG commissioned a technology 'route-mapping' programme which produced an industry vision based around the Rail Technical Strategy, revealing knowledge gaps and suggesting how the Rail Industry Strategic Research Programme can address them. This programme provides a cornerstone from which to build the RISRP research priorities. Further information about the technology route mapping project is provided in Appendix E.

More details about the RISRP can be found at www.futurerailway.org.

A4 References

Department for Transport (2007). Rail Technical Strategy. Available on-line at: http://www.dft.gov.uk/about/strategy/whitepapers/whitepapercm7176/railwhitepapertechnicalstrategy/pdfrailtechrtssummary.pdf

Department for Transport (2007). The Rail Industry Research Strategy. Available on-line at http://www.dft.gov.uk/pgr/rail/researchtech/research/railresearch.pdf

Department for Transport (2008) The Rail Industry Research Strategy Implementation Plan. Available on-line at:http://www.dft.gov.uk/pgr/rail/researchtech/research/implementationplan

TSAG (2008). The Rail Industry Strategic Research Programme. Available on-line at http://www.futurerailway.org/StrategicResearch/Pages/Home.aspx

TSAG (2010) Shaping the 30-year Rail Technical Strategy. Available on-line at: http://www.futurerailway.org/Pages/Consultation.aspx

Appendix B – Enabling Actions from RIRS1

Table B1 – Status of Enabling Actions from RIRS1 as of July 2010

Area of Focus	Enabling Actions	Owner	Status
More Strategic Research	1 – Client Group for Strategic Research	TSAG	• Established
	2 – Strategic Research Framework	TSAG	• Established • Further work may be needed
	3 – Strategic Research Programme	DfT	• Programme launched October 2008
	4 – Development of Route Maps	TSAG	• Route maps developed and reports published[B1, B2]
Securing More Support from Users	5 – Co-Funding Mechanisms	RSSB	• One mechanism launched in June 2009. More still to be done with TSB, see also EA8
	6 – Technology Development Activities	RIA	• Report by RIA on Enabling Technology Development[B3] • TSAG report on Enabling Innovation[B4]
	7 – Knowledge Management	RSSB	• First short-term objective complete • Further work in hand
Promoting Greater Collaboration	8 – Collaborative working with Research Councils and other Research Funders	RSSB	• MOU with EPSRC signed and first Call issued • Initial discussions with TSB
	9 – Engaging Effectively in European Research	AGRRI	• Short-term objective complete. NR successful in 3rd Call • Slow progress on bi-lateral collaborations
	10 – Technology transfer from other industries and countries	RSSB	• RSSB thinking presented to AGRRI • More still to be done
Defining the Benefits	11 – Estimation of Benefits at Proposal Stage	RSSB	• Complete[B5]
	12 – Evaluating Impact of Completed Research	DfT	• Evaluation complete, and report published[B6]

Web Links for Table B1

B1 -
http://www.rssb.co.uk/sitecollectiondocuments/pdf/reports/research/T793_rpt_final.pdf

B2 - http://www.rssb.co.uk/pdf/reports/research/RMS110038826.pdf

B3 -
http://www.futurerailway.org/getinvolved/News%20and%20Publications/IMechE%2028-04-09%20-%20%20Francis%20How%20RIA%20-%20Technology%20Development%20(final)%20(2).pdf

B4 –
http://www.rssb.co.uk/sitecollectiondocuments/pdf/reports/research/T934_rpt_final.pdf

B5 -
http://www.rssb.co.uk/pdf/reports/research/short_guide_to_estimation_of_benefits_issue_1.pdf

B6 –
http://www.trl.co.uk/online_store/reports_publications/trl_reports/cat_traffic_and_transport_planning/report_evaluating_impacts_of_completed_rail_research.htm

Appendix C – The Process of Developing RIRS2

The process adopted for developing RIRS2 was similar to that adopted in developing RIRS1. Representatives from across the rail industry with an in-depth knowledge and interest in research, technology development and innovation participated in a series of facilitated workshops to discuss key issues. The rail industry organisations represented at the workshops were:

- The Rail Industry Association (RIA)
- Network Rail
- The Association of Train Operating Companies (ATOC)
- Rolling Stock Companies
- London Underground
- Passenger Focus
- Rail Research UK (RRUK)
- RSSB
- Office of Rail Regulation (ORR)
- Department for Transport (DfT)

Those attending the workshops (the RIRS2 Steering Group) are listed in Box C1. The workshops were facilitated by TRL (Transport Research Laboratory) under contract to DfT.

The specific issues that were addressed at the workshops were:

- Purpose and Assumptions of the Strategy
- Areas of Focus
- Enabling Actions
- Governance and Monitoring Arrangements for the Strategy

Implementation of the strategy was recognised as a key success factor; this implied a high-level of buy-in and commitment from the rail industry. Accordingly, towards the end of the review process, a seminar took place involving a wider level of participation from across the rail industry to discuss the draft strategy. The industry representatives at the seminar endorsed the broad thrust of the revised strategy and strongly supported the importance that was attached to the issue of leadership. The feedback and comments from this Consultative Seminar have been incorporated into RIRS2.

Box C1 – The RIRS2 Steering Group

- Francis How, The Rail Industry Association
- Louise Shaw, The Association of Train Operating Companies
- John Amoore, Network Rail
- Paul Richards, Network Rail
- Chris Moss, Eversholt Rail (Rolling Stock Companies)
- Iain Flynn, London Underground Limited
- Ian Wright, Passenger Focus
- Roger Goodall, Loughborough University (Rail Research UK)
- Guy Woodroffe, RSSB
- Marius Sultan, Office of Rail Regulation
- Simon Heptonstall, Office of Rail Regulation
- Chris Brown, Department for Transport

Appendix D – Overview of Rail Research in the UK

Organisations involved in rail research are identified below. More information about the role of key UK organisations is provided in Box D1.

D1 Funders of Rail Research

- Network Rail
- Train Operating Companies
- Freight Operating Companies
- Rail Industry Suppliers
- Transport for London/London Underground
- RSSB
- Department for Transport
- Technology Strategy Board
- UK Research Councils
- Passenger Focus
- European Commission

D2 Organisations that Undertake Rail Research

- Universities
- Engineering Companies
- Research & Technology Organisations
- RSSB
- Technology Consultancy Companies

D3 Advisory and Interface Organisations

- Office of Rail Regulation (ORR)
- Technical Strategy Advisory Group (TSAG)
- Rail Research UK Association (RRUK-A)
- System Interface Committees (SICs)
- Advisory Group on Railway Research and Innovation (AGRRI)
- European Rail Research Advisory Council (ERRAC)

D4 International Rail Research Organisations

- The Association of the European Rail Industry (UNIFE)
- The International Union of Railways (UIC)
- World Congress on Railway Research
- International Railway Research Board
- European Railway Agency (ERA)

D5 Type of Research and example projects

A wide range of research projects are undertaken covering the full research landscape from tactical research through strategic research to longer-term research funded by the Research Council. Some example projects under each of these headings are listed in Box D2.

Box D1 – Role of UK Organisations in Rail Research

Department for Transport
- Develops and sets the future strategic agenda for the railways.
- Funds the RSSB managed industry R&D programme.
- Sponsors its own research to support railway policy.
- Member of the European Rail Research Advisory Committee (ERRAC).

Transport for London/London Underground
- Undertakes research on sustainable transport and the operation of underground railway.
- Member of the RSSB Advisory Committee.

Office of Rail Regulation
- Ensures safety research is undertaken.
- National Safety Authority seat in all ERA working groups.

RSSB
- Manages industry programme of R&D on behalf of its members.
- Manages individual research projects.
- Member, facilitator and coordinator of TSAG.
- Participates in World Congress of Rail Research and the International Rail Research Board.

Technical Strategy Advisory Group
- A cross-industry expert group facilitated by RSSB, drawn from the organisations directly responsible for funding, specifying, and operating the railway.
- Client body for the Rail Industry Strategic Research Programme.

Network Rail
- Runs own research programme to manage its own business risks.
- Member of the RSSB Advisory Committee.
- Member of ERRAC (on behalf of European Infrastructure Managers).
- Participates in World Congress of Rail Research and the International Rail Research Board.

Association of Train Operating Companies
- Sponsors RSSB managed R&D.
- Member of the RSSB Advisory Committee.
- Participates in UIC Research Platform.

Rail Industry Association
- Facilitates EU cooperation on R&D through UNIFE links.
- Member of RSSB Advisory Committee.
- Associate Member of UNIFE.

Passenger Focus
- Passenger Focus undertake evidence-based research to find out what matters to rail passengers.
- Member of the RSSB Advisory Committee.

Advisory Group on Rail Research and Innovation (AGRRI)
- An informal think tank and industry-wide stakeholder group.
- It is composed of senior members from all parts of the rail industry.
- AGRRI documents are based upon individual inputs from AGRRI members.

Rail Research UK (RRUK) and Rail Research UK Association (RRUK-A)
- RRUK was a consortium of UK Universities that specialised in Railway Research.
- It received core funding from EPSRC until 2010. It undertook additional research council, industry supported and EU funded research.
- Rail Research UK Association (RRUK-A) is a partnership between Britain's rail industry and UK universities; it was set up in 2010 to be a bridge between industry and universities
- It is open to all UK universities and is funded by RSSB.
- It provides a forum for targeted knowledge exchange between universities and the industry, including the organisation of focused workshops and seminars, as well as wider networking opportunities; it does not have funding for research.

Box D1 (Cont'd)

Technology Strategy Board

- Stimulates technology-enabled innovation in the areas which offer the greatest scope for boosting UK growth and productivity.
- Establishes Knowledge Transfer Networks in key areas of technology and business applications, including transport, to stimulate innovation.
- Investing in Technology and Innovation Centre to bridge the gap between universities and businesses, and helping to commercialise the outputs of Britain's world-class research base.
- Providing a Helpline to assist UK researchers in becoming involved in EC Research Framework programmes.

Research Councils (EPSRC and ESRC)

- Nurturing the highest quality research to provide the UK with a competitive advantage. The Research Councils fund basic, strategic and applied research which is undertaken by universities and research institutes.
- DfT and RSSB have formed a partnership with EPSRC to jointly fund academic research related to the performance and sustainability of the railway system.

Box D2- Examples of Rail Research Projects

Tactical/Responsive (i.e. short-term problem solving)

- Benchmarking for level crossing renewals
- New approaches to adhesion management
- Overcoming gauge constraints cost-effectively
- Technology to deliver advisory speeds to drivers

Strategic research

- Station design and crowd control
- Mega city suburban by segregation
- Traffic and disruption management
- Whole life carbon footprint of the rail industry
- Railway functional architecture
- Improved hubs
- Adapting to extreme climate
- Whole system reliability – evidence gathering

Research funded by Research Councils

- Modelling the dynamic behaviour of vehicle/track interaction
- Pile stabilisation of large landslides
- Modelling track stability under a range of complex loading scenarios
- Effect of train vibration on the performance of laptop users
- Numerical methods in wave-domain for railway applications
- Vibration in railway bridges and tunnels
- Dynamic/aerodynamic interaction
- Quantifying the effects of climate change on the rail network

Appendix E – The Technology Route Mapping Project

E1 Background

TSAG commissioned a major technology route-mapping study for the industry, undertaken between August 2008 and April 2009. The aim was to develop a cross-industry collective view of rail technology in Great Britain, seeking to answer questions such as:

- Where are we now?
- Where do we want to get to?
- How can we get there?
- Why do we need to act?
- What should we do?
- How should we do it?
- By when?

TSAG made a working assumption that there will be a significant gap between what the 4Cs might need to be in 30 years time and the improvements that current/planned industry activity will deliver. Accordingly, significant further improvement would require a large step change in the levels of performance. In order to 'size the gap' it was considered necessary to enumerate what the values of the 4Cs might need to be in 2038. Therefore, for the purposes of the route-mapping work, and to ensure that route-mapping participants were challenged to be radical, TSAG adopted the following metrics for the 4Cs:

- Customer – reduction in dissatisfaction by 90%
- Cost – halving the cost of running the railway
- Capacity – doubling the capacity where required
- Carbon – reducing carbon in line with Government policy (50% by 2050 at the time)

These metrics present significant challenges to the rail industry and indicate what it might aspire to over a 30 year period.

On the basis that simply doing more of what is already done will not deliver sufficient improvement in the areas of customer focus, cost, capacity, and carbon, the route-mapping process sought to identify technological initiatives and innovation which would contribute to closing this gap.

E2 Route Mapping Workshops

The Rail Technical Strategy (RTS) identifies eight long term themes for change (see Section 5). Each RTS theme was the subject of one of a series of route-mapping workshops. 150 senior rail industry professionals, academics and representatives from other sectors participated in the workshops. Steps in delivery of the programme included:

- Identifying trends and drivers
- Setting down current industry activity and plans
- Identifying future technical possibilities and insertion points
- Estimating possible contribution to the 4C challenges
- Validating and calibrating the outputs

The outputs were then tested against the four scenarios from the Sustainable Rail Programme (RSSB, 2007).

In the first of three sessions during the day, delegates were asked to review and add to a list of proposed applications described in the pre-read material. Once completed, delegates were asked to vote for those applications that they considered to be of greatest importance in the context of the 4C metrics. For the purposes of this programme of work, each of the 4C metrics was considered to be of equal importance. However, the data from this session still exists and could be analysed using other weighting factors for the 4Cs; for example, giving much greater importance to cost factors.

The eight highest scoring applications from the above process were then considered further in the second session. In this second session, delegates formed small groups in which they considered themselves sufficiently expert to contribute to discussion about the eight highest scoring applications. They were asked to develop their thinking on the scope of the application, describe the contributory technology elements, the resource requirements and the knowledge gaps that had to be addressed in order for the application to become a reality.

The groups were then asked to indicate the maturity of the application over time through the allocation of Technology Readiness Levels[1]. Where possible, they were also asked to identify any technology insertion points (time-bound opportunities for the technology to be deployed), and any key risks or enablers associated with development and deployment of the application. Finally, the groups were asked to suggest estimates of the contribution that each of the eight applications might make towards the achievement of the 4Cs challenges.

E3 Priority Applications

The following 15 applications emerged as those having the highest priority:

- Traffic Management
- Disruption Management
- Mega-City Suburban
- Service Quality
- Station Design & Crowd Management
- Yield Management
- Improved Hubs
- Freight Oriented Railway
- Regional Metro
- ATO & Driverless Trains
- Optimisation of Assets
- Integrated Transport & Ticketing
- High Capacity Trains
- Standards for Carbon
- Modular Trains and Infrastructure

The contribution that the full range of technologies could make to meeting the 4Cs targets has been shown in Section 3. Further details of the route mapping project are available in the project report (RSSB, 2009).

E4 References

RSSB (2007) Sustainable Rail Programme. Available on-line at http://www.rssb.co.uk/np/SRP/Pages/default.aspx

RSSB (2009). Technology route-mapping to support the planning for Rail's 30 year vision. Available on-line at: http://www.rssb.co.uk/SiteCollectionDocuments/pdf/reports/research/T793_rpt_final.pdf

[1] Technology Readiness Level is a measure used by Governments and major companies to assess the maturity of evolving technologies. Technologies are assessed on a nine-point scale with 1 representing a technology for which basic research is still being undertaken, whilst 9 means the technology is ready for commercial application.

Appendix F – The Effectiveness of Rail Research

F1 Outputs and Outcomes from Research

In order to better understand the benefits of rail research, DfT commissioned a research study to review the outputs and outcomes from a selection of GB rail research projects (TRL, 2009). A sample of 48 projects undertaken over the last 20 years was selected for analysis. The results of this study showed that for the projects included in the study:

- 81% of projects – utilisation of outputs was either strong or medium[2]
- 71% of projects – implementation of outputs was either in the short-term (<1 year) or medium–term (1-5 years)

The report of the study emphasises that the above data is not intended to be a definitive statement of the utilisation of GB rail research projects as there may have been biases in the projects selected for analysis. Rather, the results were used to derive the following 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

Good practice guidance was then developed outlining the processes which will best ensure the utilisation of outputs.

The results from the DfT study are broadly similar to those from a study undertaken by the European Rail Research Advisory Council (ERRAC) of projects funded under European Union Framework programmes (ERRAC, 2010). In the ERRAC study, of the 138 projects that had been funded under the Framework programmes, 39 were selected for evaluation. Nineteen of the projects (i.e. just less than 50%) were found to have strong or medium market uptake.

F2 Cost-Benefits of Research Projects

The benefit provided by R&D is a combination of saving cost and adding value. Research and development:

- Produces direct cost savings
- Saves costs via improved performance, safety, and reliability
- Identifies ways of making the railway more attractive and viable

The three case studies described in Box F1 were compiled by RSSB (RSSB, 2006) and illustrate how R&D reduces costs and delivers additional benefits. A theme running through these three very different examples is improvement in the quality of strategic decisions made by industry and government in their management of the railway.

[2] "Strong" is defined as clear evidence of widespread use of results, and "medium" as some evidence of use of results. These metrics are consistent with the metrics used at the European level by the European Research Advisory Council (ERRAC).

- Case Study 1 illustrates the benefits of better decisions that result from including direct cost savings
- Case Study 2 illustrates a range of performance, safety and cost benefits
- Case Study 3 illustrates how better information helps with identifying and assessing options

Box F1 – Case Studies Compiled by RSSB Illustrating the Cost Benefits of Research

Case study 1: Train driver licensing system
Following the Ladbroke Grove accident, the Cullen report recommended that there should be a licensing system for train drivers; meanwhile, a European initiative was proposing a driver certification system. RSSB invested £155k in research that examined the options for a driver licensing system, and considered the costs and the practicality of producing a scheme consistent with the proposed European approach. The research established that following the direction implied by European thinking would have cost £40m initially, plus a recurring annual cost of £20m. These costings were then used by DfT and HSE to make the case for creating a simpler system for application in Great Britain. The value of the work is seen in the overwhelming cost-effectiveness of investing £155k to avoid spending in excess of £40m.

Case study 2: Rolling contact fatigue (RCF)
RCF came to prominence in the Hatfield accident of 2000. Whilst the safety risk associated with RCF is relatively low, it is kept low by costly maintenance activities. In the aftermath of Hatfield, annual expenditure on RCF-related track maintenance and renewals was around £200m, whilst the cost of delay minutes attributed to RCF reached £12.5m. RSSB invested £1.8m over three years on a suite of R&D projects addressing RCF. As a result, the causes, propagation, and likely locations of RCF are much better understood. This has given the industry the confidence to step back from treating rail RCF as an emergency, so that the necessary track work can be tied in efficiently with other planned work. Delays attributed to RCF have reduced 10-fold, so the research has contributed to an effective cost saving in the region of £10m per year in performance terms. Even if only 10% of this is fully attributable to the research, it has still paid for itself in two years; and this is without including the direct savings related to the cost of track work, and reductions in RCF-related safety risk.

Case study 3: TPWS reset and continue
Safety risk due to Signals Passed at Danger has been reduced due to the implementation of the Train Protection and Warning System (TPWS) and other measures, including research on human factors. However, the effectiveness of TPWS is reduced by the occurrence of 'reset and continue' events, in which the driver mistakenly believes that TPWS should not have been activated and that it is safe to continue. RSSB has invested £370k in developing and evaluating possible changes to TPWS addressing this issue. The R&D shows that changes could be made, costing around £6.5m and reducing safety risk by about one fatality in 14 years. Whilst this level of cost would be commensurate with the cost/benefit ratio for TPWS as a whole, it is higher than for some safety-related investment opportunities. The research has therefore given the industry good quality information on the choice of options available and the costs and benefits of each.

F3 References

ERRAC (2010) How to embed market uptake in research projects. Available on-line at http://www.errac.org/IMG/pdf/errac_wp06_how_to_embed_market_uptake_in_research.pdf

RSSB (2006). Prospectus for the Research and Development Programme. Available on-line at: http://www.rssb.co.uk/SiteCollectionDocuments/pdf/r_and_d_prospectus.pdf

TRL (2009). Evaluating impacts of completed rail research. Available on-line at http://www.trl.co.uk/online_store/reports_publications/trl_reports/cat_traffic_and_transport_planning/report_evaluating_impacts_of_completed_rail_research.htm

Appendix G – Railway R&D – in support of Sustainable Transport

AGRRI[3] discussion paper, March 2010

Mobility is a vital part of the functioning of modern society and one of the strategic challenges of global warming is maintaining mobility in a sustainable way. The railway has the potential to provide a significant low carbon means of transport into the future, with its ability to use energy from a variety of sustainable sources, and with an extensive existing network where the carbon associated with construction is already embedded.

However, this potential will not be delivered without considerable effort applied in the wider context of achieving a step change in the key areas identified in the Railway Technical Strategy and known as the 4Cs:

- Carbon: achieving the required low carbon system
- Cost: significantly reducing the unit costs
- Customers: provision of a service attractive to future customers
- Capacity: increase in system capacity to meet treble the current usage

Some progress in this direction is already being achieved by application of modern technology and new processes. Further progress over the next 5-10 years can be expected by application of current technology, eg via future builds of high speed intercity trains and Network Rail's high-performance maintenance trains. Further gains over the following 10 - 15 years can be expected if investment is available for incremental development of the most beneficial of modern technology.

However, if the railway is to meet the strategic challenges of 15 years and beyond, more will almost certainly be required than we currently know how to deliver, particularly with likely constraints on investment. As in any technology-based industry, longer term progress depends upon coherent and successful application of effective R&D[4], in order to establish new ideas, and to de-risk their implementation.

Experience of past research shows that successful projects almost always have three key characteristics: they meet a clear strategic need, have an identified route to implementation and have a clear 'champion'.

The strategic need is already clear, ie to facilitate the required step changes in performance against the 4Cs. TSAG is identifying and investigating potential solutions which are aligned with these strategic requirements.

As a result, several types of R&D can be identified, where the funding and control of the work are likely to be different in each case, eg

- Commercial development by suppliers against a defined requirement, where the main challenges are clarity and coherence of purpose, rather than funding

- System-wide development which requires concurrent and collaborative action by several stakeholders (frequently, although not always, major client organisations

[3] AGRRI is an informal think tank composed of people from various parts of the industry, including LUL, Government, and Academia, who are concerned with railway research. AGRRI documents are based upon individual inputs from AGRRI members, but do not necessarily represent any official view.

[4] 'R&D' covers anything from development of core knowledge and blue skies thinking, through to concept demonstration, but not commercialisation. It extends up to Technology Readiness Levels 6 or 7 (see Appendix E for an explanation of Technology Readiness Levels).

in the industry), and which is likely to require 'pump-priming' funding to initiate progress

- Sound system-wide core knowledge, which is needed to underpin both of the above, to validate future decision making and to avoid potentially serious errors; such research may involve international collaboration

Examples of the significant contribution that railway research has already made include:

- Enabling a 25% speed increase on existing infrastructure
- Enabling significant cost reductions through electronic signalling systems

Establishing the route to implementation is rarely easy, whatever the organisational structure. Usually it involves a range of inter-departmental or inter-company interfaces, with a need to allow due time to consider the whole implementation plan, to secure the agreement of all parties involved, and to undertake the required work on project definition and evaluation in a systematic and structured manner.

More fundamentally, commitment to specific R&D activities is dependent upon high level acceptance of the strategic need for an R&D programme in the first place, with positive and visionary leadership drawn from across the rail industry. This is necessary in order to sustain momentum and direction and also to overcome potential barriers to innovation, such as imbalances between local and system benefits.

We recommend that a senior level cross-industry group, comprising representatives acceptable to all stakeholder groups, should be established with a remit to agree and promote programmes of collaborative action to facilitate the existence, development, and implementation of the R&D programme. We acknowledge that TSAG, as currently constituted, is making good progress in this area; but we consider that significantly more momentum is needed to address the challenges.

A programme of this scale and significance will require a major financial commitment and some funding may be provided from existing sources:

- Commercial organisations, making their own business decisions
- Existing programmes fund some fundamental research
- EU framework programmes fund strategic research on specified topics

However, there remains a range of strategic system-wide initiatives for which there is no current business or investment imperative, that require funding to support a soundly based, successful and economically affordable future for the rail industry.

There is no generic 'benchmark' to determine the optimal level of R&D funding for an individual industry sector: informed judgement as well as analysis is required to establish an appropriate R&D budget for the rail industry. Mobile telecommunications networks appear to provide one comparator, since networks are 'shared systems' and invest heavily in R&D to increase capacity. However, the telecommunications industry has a much faster invention to application cycle time than the rail sector, so an equivalent research spend would be an unrealistic target. Similarly the EU Lisbon Strategy target of 3% of turnover is also inappropriate, given the system aspects of the rail industry.

Reviews undertaken by RSSB have confirmed that cross-industry railway R&D projects can yield major cost reductions and productivity improvements (see Appendix F). But we recognise that individual business cases cannot simply be scaled up to strategic programme level.

Accordingly, our proposal is based on an informed judgement of the likely contribution of a strategic rail R&D programme for the attainment of the 4Cs objectives set by TSAG, benchmarked against the turnover of the rail industry as a measure of economic activity. Put simply, 2% of the annual equivalent benefit resulting from attainment of the 4Cs objectives approximates to c£25M pa, whilst 0.25% of rail industry turnover equates to c£20M pa.

Whilst it is possible to devise other targets for R&D funding, we consider that an overall budget of broadly £25M per annum is likely to be necessary and appropriate to fund the programme of research activities required to support a successful, sustainable and affordable rail industry.

Appendix H – Management Areas of Focus: Key Issues

The Enabling Actions and associated specific objectives were developed through a series of individual working groups involving the rail industry participants with facilitation by TRL. The output of the working groups are summarised in Section 5. Below is an outline of the key issues that were explored at the working groups.

H1 Strategic Direction

- **Leadership and Ownership** - Fragmented industry leads to a consensus-seeking approach. There is facilitation rather than leadership and lots of piece-meal activity. This can lead to non-adventurous research and not doing the "big things". In addition, implementation of research still needs to be improved. Going forward, the emphasis has to be on leadership of change. What is required is to put in place for rail the leadership role that would normally exist in a large corporation (w.r.t. research). Industry does not have ownership of research strategy. It is essential to get ownership of the research strategy at a higher level so that those who will gain from the outputs of the research have fully committed to implement it. Researchers are then empowered to deliver the research. Accordingly stakeholder engagement is critical. This will help bring a greater clarity of roles and greater value to the industry.

- **Making the Case for Rail Research** – this is an important part of "strategic direction"; it includes commitment to clear responsibilities. Demonstrating how benefits have resulted from investment in research will also help make the case for research and feedback best practice to the next generation of research. As a result of the route mapping exercise, the rail industry knows what to do ("shopping list") but not how much to spend to meet the 4Cs targets. What is lacking is a forward-looking portfolio of projects with coherent financial case/plan which includes development, demonstration and commercial implementation as well as research.

H2 Knowledge

- **Networking and Connecting People –** Knowledge management is fundamentally about "networking" and "connecting". But these activities are rarely part of people's day-jobs or job descriptions – so done on an informal/volunteering basis. Networking and connecting people can help overcome silo thinking within the industry. RSSB is intending to establish a "R&D clearing house" to assist with this issue.

- **Corporate Memory –** Like other mature industries, the changes in industry structure is leading to a loss of "corporate memory". This is particularly important in the context of the rail industry given the high proportion of ageing assets. BR-trained people knew the whole industry – and knew who knew what, and where to go for information. People within the rail industry now become specialised very quickly.

- **Commercial Models for Accessing Information –** Increasingly there is a need to pay for information, even for "legacy" information. But fully commercial models for knowledge management rarely work on their own either for supplier or user.

- **Knowledge Management Systems –** Knowledge Management systems need to be built step-by-step; it cannot be done in one go. Network Rail is developing its

own approaches to "on-line knowledge" and RSSB is working with them under the banner of a "Rail research clearing house". This needs to be built on and opened up to other industry stakeholders. The intention is to go beyond a "corporate library" towards building an on-line community.

- **Collaborative working** – This should go beyond research and should include other collaborative arrangements such as knowledge-sharing and secondments.

- **Learning from Other Sectors –** The rail industry is too hard on itself. Lots of "horror stories" on technology from other sectors unsuccessfully applied, e.g. Pacers. But success stories are usually over-looked, e.g. "fly-by-wire" and semi-conductor power control. Product approval processes can be a disincentive for innovation – particularly for technologies from other sectors. In addition we need to learn from other industry examples about what the best options are for a realistic knowledge/technology network for the rail industry.

- **Developing University Research –** The RRUK Rail Research Cluster is small and needs to be developed with the industry engaging with universities and other knowledge-based organisations.

- **European Research –** An holistic approach is lacking and the rail industry does not come together to deliver a UK view; fortunately, both Network Rail's and ATOC's links into European research are strong. Nonetheless, the GB rail industry is not making the most of European research opportunities and the potential for greater collaboration. This may require a greater alignment/connectivity between UK research and other EU research.

- **Partnerships for Innovation and Commercial Development** – More commercial partnerships are needed between UK companies and non-UK companies to develop and exploit innovative thinking originated in the UK.

H3 Route to Market

- **Capacity for Innovation** - there is not a strong culture of innovation within the rail industry. The need to meet short-term targets is paramount; this can act against the long term interests of the rail industry. Also, procurement specifications and standards can be too prescriptive, and so inhibit innovation. The industry needs to be able to operate outside its normal comfort zone. Accessing industry data is often necessary to support innovative developments, but can be difficult to obtain.

- **Risk Management** - processes for sharing risks of technology development are not available or are not encouraged. There is poor access, and low awareness of, facilities for testing and trialling. Acceptance processes are insufficiently flexible. The lack of intermediary organisations who can help the rail industry implement the outputs of research increases implementation risks.

Appendix I – Encouraging the Implementation of Research

Paper to EPSRC/RSSB/DfT Strategic Partnership Steering Group
by Francis How (Technical Director, Rail Industry Association)

Introduction

The problem of getting from research into technology development and application has been the subject of discussion in various places in the rail industry, including RSSB, RRUK Association and the rail Technical Strategy Advisory Group (TSAG). It is often described as the "valley of death", and is associated with moving through Technology Readiness Levels[5] 4 to 6.

The impact of this problem is potentially very significant for the industry, in terms of lost opportunities for application as well as the cost of undertaking research that has little or no take-up. However, there is also a downside to undue emphasis on research implementation in that it can make the justification for investment in "blue skies" research more difficult, since the outcomes are more uncertain.

This is particularly relevant to work that might be commissioned by the EPSRC/RSSB/DfT Strategic Partnership, where we are endeavouring to promote university-based research in topic areas where outcomes that lead to practical applications are by no means guaranteed. The AGRRI paper on *Railway R&D – in support of Sustainable Transport* (see Appendix G) captures the key ingredients for success:

- "*Experience of past research shows that successful projects almost always have three key characteristics: they meet a clear strategic need, have an identified route to implementation, and have a clear champion.*"

Key observations from other work conducted so far

The key good practices relevant to encouraging the implementation of research are listed in Table I1. These are drawn from the references listed below; particular use has been made of the work associated with the Highways Agency.

What do we do about all this?

The question naturally arises as to what this Steering Group should do about this, if anything. The actions fall into two parts:

- What, if anything, do we need to do specifically in relation to the work we have already commissioned, and might be considering commissioning?

- What is our involvement in addressing the issues on a "whole industry" basis, bearing in mind that other parties with significantly more resources can (and perhaps should) contribute towards meeting the challenges?

[5] See Appendix E for an explanation of Technology Readiness Levels.

References

H Viner. Examples of successful implementation of research in road infrastructure (personal communication)

ERRAC (2010) How to embed market uptake in research projects. Available on-line at http://www.errac.org/IMG/pdf/errac_wp06_how_to_embed_market_uptake_in_research.pdf

TRL (2009). Evaluating impacts of completed rail research. Available on-line at http://www.trl.co.uk/online_store/reports_publications/trl_reports/cat_traffic_and_transport_planning/report_evaluating_impacts_of_completed_rail_research.htm

RSSB (2009). Defining and Identifying ways of improving research implementability Available on-line at http://www.rssb.co.uk/sitecollectiondocuments/pdf/reports/research/ResearchImplementability.pdf

Table I1 – Lessons from Good Practice

No.	Good practice	Comments / additional information
1	**Research objectives** Ensure there is a clearly defined scope and set of objectives at the beginning of the research.	Specific objectives seem to lead to strong market uptake, vague aims often lead to weak market uptake. Get agreement amongst the stakeholders, including those actually doing the research, as to what the objectives are, and how success will be measured. Build on the results of previous projects. Often a series of research projects is required before success is achieved (see item 2 below – "Long term focus").
2	**Long term focus** Build a sustained, long-term focus on a small number of key research themes.	Within the Highways Agency, investment has been maintained in specific areas over an extended period (≥20 years) and includes the full spectrum of activities from blue skies research (generating new knowledge or ideas), targeted research (generating solutions to specific problems) and consultancy (delivering implementation). The Highways Agency approach contrasts with a more "pepper pot" approach to lots of small, unrelated research endeavours which, although covering many areas of interest, risks producing insufficient output for commercial adoption. Long term research programmes do not consistently happen within the rail industry, with multiple overlapping and separately managed research projects being in evidence. But, for instance, the work by Southampton University on track research is a long-term programme that seems to exhibit the characteristics associated with success.
3	**Stakeholder engagement** Include key stakeholders in the research project. Have an identifiable "champion" for the research to strengthen the customer pull. Make sure there is an agreed plan for hand-over to key stakeholders at the end of the research project.	Many projects appear to involve some stakeholders but fail to involve the key stakeholders who will implement the results of the research. Make sure you understand who those key stakeholders really are. Consider a key stakeholder steering group. Use existing industry groups where possible. Successful stakeholder engagement creates "customer pull", but timing the research with other industry activities and strategies can be critical in securing this "pull". Research needs to be aimed where possible at major investment decisions or other key intervention points, such as the development of major international standards.

No.	Good practice	Comments / additional information
4	**Collaboration** Maximise the extent of industry involvement in research so as to increase the interest in, and likely take-up of, research ideas.	By "industry" we mean both suppliers and major client organisations such as Network Rail. Within the highways domain, industry has steered the research, so it is focussed on recognised problems, contributes through joint funding or "in-kind" (eg. through pilot trials), and gains benefit via access to the research results in advance of them being made public. There are some significant barriers to widespread adoption of this approach within the GB rail industry, where nervousness about IPR and mutual distrust between suppliers and major clients, coupled with concerns about falling foul of procurement legislation, makes collaboration difficult.
5	**Business Case for R&D** Prepare a business case at the start in order to help clarify and define who the beneficiaries and likely adopters/users of the research are likely to be.	The discipline of trying to write a business case early provides valuable focus across a range of issues. The standard business case for research project approval in the Highways Agency includes: - Objectives, benefits, likely methodology, milestones - Key outputs; how to measure whether outputs are fit for purpose - How will the knowledge gained be implemented? - Why make the investment – why now; why at all? - Risks to time and cost; dependencies with other projects Some projects will never make sense commercially, because - the economic case does not add up although there are other clear benefits (eg safety benefits) that are not readily expressed in financial terms, or - the outcomes of the research are potentially large but are also uncertain, for instance because the research may demonstrate that a proposed technology solution cannot be made to work).
6	**Implementation pathways** Implementation pathways must to be identified as early as possible (if possible, in the Business Case), e.g. - introduction of new or revised Standards or procedures - specification of contracts for procurement	Ongoing review of the suitability and effectiveness of those implementation routes needs to happen throughout the research work, modifying both the research itself and the plans for take-up as necessary, so as to maximise the likelihood of implementation. Use existing implementation channels where possible (Standards, supply chains etc). Conduct reviews on post-research progress, to see whether the implementation pathways were followed and were ultimately successful. Learn from the lessons.

No.	Good practice	Comments / additional information
7	**Maintaining momentum during R&D** Make sure that visible progress with, and interest in, the research is sustained throughout the programme, to avoid the risk of the work being abandoned by stakeholders or being prematurely closed down through lack of resources.	Momentum is often lost before research is at a stage where it can be implemented. The reasons for this happening include changes of priorities or personnel, poor timing of the research, failure to sustain focus and effort until all the issues are resolved. The Highways Agency has found that continuity of personnel is an important factor in maintaining momentum, both within the client organisation and in the on-going partnership between the client and the research provider. The detailed, expert knowledge necessary to devise and implement innovative solutions is often vested in a fairly small number of individuals within the client and research providers' organisations. Continuity of interest and funding maintains their employment and develops expertise.
8	**Commercial adoption of R&D output** Encourage commercial interest in taking forward the outputs of the research.	Research will be taken up by industry if it is commercially attractive for it to do so, i.e. because it improves profitability, increases the chances of winning future contracts, etc. Many applications will require a high degree of confidence in any new technology or processes before it can be taken up. In an industry with a small number of major/key client organisations, confidence that those clients will purchase the commercialised outputs of the research is also vital. Take-up can in some circumstances be forced by some form of regulation, change to Standards, or other contractual imperative. However, where this is being contemplated it is important to ask why such mechanisms are considered necessary, and why commercial attractiveness alone does not work.
9	**Knowledge Management and Communications** Make knowledge emanating from the research as widely and freely available as possible. Agree and implement a communications strategy for the research, focussed on raising and maintaining awareness of the work throughout all phases of the research, from planning through to implementation.	The availability/usability of information on completed research work and the mechanisms for recording benefits are both significant issues that can help or hinder the take-up of research. The Highways Agency has tried to capture research outcomes in a "research compendium" website. This has proved difficult and as a consequence the site has recently been revamped in the new "knowledge compendium" which should deliver a significant improvement in the usability of information. Making all knowledge generated freely available as it emerges, and encouraging active ongoing communication between personnel in the client, research and industry organisations, can help to minimise the loss of knowledge and the impact of any loss that does occur.