Rolling Stock

A guide to RSSB research

October 2012
Rolling stock

Photographs by:

Ant Davey, RSSB                           Cover, pages 2, 40, 97
Ant Davey, Shutterstock.com

LockStockBob, Shutterstock.com           Page 9

Matthew Gough, Shutterstock.com          Pages 4, 8

ND Johnston, Shutterstock.com            Page 6

RSSB                                      Pages 23, 81

Timothy Passmore, Shutterstock.com       Page 5

WH Chow, Shutterstock.com                Pages 7, 95

© RSSB Copyright 2012 Rail Safety and Standards Board.

This publication may be reproduced free of charge for research, private study, or for internal circulation within an organisation. This is subject to it being reproduced and referenced accurately and not being used in a misleading context. The material must be acknowledged as the copyright of Rail Safety and Standards Board and the title of the publication specified accordingly. For any other use of the material please apply to RSSB’s Head of Research and Development for permission. Any additional queries can be directed to enquirydesk@rssb.co.uk. This publication can be accessed via the RSSB website www.rssb.co.uk.

RSSB
Block 2 Angel Square, 1 Torrens Street, London EC1V 1NY
www.rssb.co.uk

Tel:    020 3142 5300
Fax:    020 3142 5663
Email: enquirydesk@rssb.co.uk
RSSB facilitates the resolution of difficult cross-industry issues and builds consensus.

RSSB delivers a unique mix of products and services to the industry – supplying knowledge, analysis, a substantial level of technical expertise and powerful information and risk management tools.

RSSB is a not-for-profit company owned by major industry stakeholders, working together to:

- Continuously improve the level of safety in the rail industry
- Drive out unnecessary costs
- Improve business performance.

The company is limited by guarantee and is governed by its members, a board and an advisory committee. It is independent of any single railway company and of their commercial interests.
Research and Development

A key part of the RSSB product range is the research and development (R&D) programme that it manages on behalf of the railway industry. The programme is funded by the Department for Transport (DfT) and aims to assist the industry and its stakeholders in achieving key objectives:

- **Improving performance in terms of health and safety, reliability, and punctuality.**
- **Increasing capacity and availability.**
- **Reducing cost.**
- **Integrating all of these to compete effectively with other transport modes (or complement them as appropriate) and deliver a sustainable future for the railway.**

The RSSB-managed rail industry research programme focuses on industry wide and strategic research that no individual company or sector of the industry can address on its own. The programme is also instrumental in supporting the development of a future vision that can be best delivered. In addition, RSSB manages the rail industry strategic research programme which has been specifically developed to support industry and its stakeholders in the delivery of ‘step changes’ in industry strategy in 10, 20, and 30 years’ time – as outlined in the Rail Technical Strategy.
This covers five major research topics, all concerned with reducing risk relating to the infrastructure, the rolling stock, their interaction with each other, and processes that keep the railway moving.

This booklet focuses on the rolling stock area of RSSB research and its aim is to:

- Inform you about research that has been done
- Show you where to find the results of the research
- Encourage you to find out more, including registering to receive the RSSB R&D e-newsletter

The R&D programme has generated substantial knowledge, information and resources – all specifically designed to support the rail industry’s day to day operations, at senior level and on the front line.

This booklet provides only a brief insight into the research projects – the best way to find out more about each project is to go to the Research and Development section of the RSSB website – www.rssb.co.uk – where you can find more details, including links to the research reports and outputs.

Key Contact:
Andrew Broadbent
Head of Engineering Research
Phone: +44 (0) 20 3142 5406
e-mail: andrew.broadbent@rssb.co.uk
Cross-Industry Groups

Cross-industry groups for this research include Rolling Stock Standards Committee, Vehicle/Vehicle System Interface Committee (V/V SIC) and its subgroups, the Diesel System Working Group, the Rail Industry Fire Forum, and the Cross-Industry Remote Condition Monitoring Strategy Group.

Rolling Stock Research

The rolling stock topic area is concerned with improving the performance of rail vehicles and, in the context of accidents, the protection and management of people. This includes human factors issues such as design of the man/machine interface for passengers as well as train crew. Research on environmental and performance issues is also included where relevant.

However, not all aspects of rolling stock are covered by this topic. Research on wheelsets and other issues driven by the wheel/rail interface is covered by the Vehicle/Track Interaction topic; research on electric current collection is dealt with in the Energy topic; and research on active train protection systems such as AWS is dealt with in the Control, Command & Signalling topic.

Area 1 – Research to further improve vehicle design to reduce injury in train accidents

Train accidents continue to occur, resulting in fatalities and serious injuries to passengers and traincrew. To reduce
injury this area of research considers the four principal mechanisms that cause injury: loss of survival space, intrusion, ejection, and fire.

Fire on trains remains a subject of some concern to the travelling public, although statistical analysis shows that it is a relatively rare phenomenon and that in comparison to other hazards in this topic the risk associated with fire is small.

A priority area for research is to better understand those properties of railway vehicles that are important for passenger survivability in a wide range of possible accident scenarios, despite the apparently diverse and chaotic vehicle dynamic interactions that take place in any individual accident. It is important to continue efforts to model train behaviour in accidents at significant collision speeds. This ability to model collisions accurately will allow an assessment of those vehicle characteristics that might allow future rolling stock to be even safer than it is today.

Further work may also need to consider how best to encourage appropriate passenger behaviour, both by means of general traveller information and ensuring effective communications in the immediate aftermath of accidents.

**Area 2 – Modelling whole life system costs to increase cost-effectiveness**

The focus of research in this area is to produce a whole life cost model (RS-WLCM) that has sufficient flexibility to analyse rail vehicles and their environment in order to compare various different features and determine the most appropriate configuration for a particular application. The capability of assessing the impact of rolling stock design on whole vehicle-track system, whole life costs will be enhanced through links with the Vehicle Track Interaction Strategic Model (VTISM), which is being developed in the Vehicle/Track Interaction topic.
Driven by V/V SIC the RS-WLCM will enable the industry to understand how different vehicle systems contribute to cost throughout the vehicle lifecycle, and importantly compare softer issues such as carbon dioxide emissions and the impact of vehicle mass on an equal footing. Further work is inevitable to translate the findings from modelling into industry change as well as enhance the model if deemed valuable.

**Area 3 – identify drivers to high vehicle mass and incentivise reductions**

Recent builds of rolling stock weigh significantly more than their predecessors. Higher vehicle mass increases traction energy costs and track damage costs; it also compromises rail sustainability. As a first stage in attempting to reverse this trend V/V SIC and Advisory Group for Rail Research and Innovation held a seminar in 2005 identifying several initiatives, which are being assisted by research in this area. Examples of this are the roles of standards in contingency, barriers to regenerative braking, track quality optimisation, standards for a dedicated high speed line, standards for community railways, real engineering limits on standards and a whole life cost model.

Other areas, which may be considered, are the use of new materials and novel methods of control in safety critical systems. For example, composite materials are not widely used in vehicle structures and may provide possible mass reduction, but their use needs to be commensurate with structural requirements. Mass reduction may also be possible from reducing the dependency on pneumatic and/or hard wired control systems, for example the use of digital control in place of copper wire and relays.

**Area 4 – Modelling to optimise seating/load capacity and speed**

Capacity is a complex subject and needs a system wide
approach involving operations, infrastructure controllers, signalling as well as implications of the rolling stock. There has been little work to date in this area and what work there is concentrates on specific niche areas, for instance, signal spacing for freight trains.

Though this area of research perhaps resides more aptly under Operations or Control, Command & Signalling, there is a contribution to the overall issue from the rolling stock aspect in areas such as train performance (acceleration and braking), passenger seating layout and, access and egress.

**Area 5 – Research to support emerging European legislation to understand risk, cost & performance implications**

The introduction of Euronorms under the umbrella requirements of the Technical Standards for Interoperability (TSI’s) and other emerging European legislation and directives may require Britain to relax its existing requirements for design or test methods. The impact of the potential changes need to be studied, for example in the areas of noise, physical agents and fire safety.

Legislation may also impose barriers to innovation in vehicle design and have implications on train design and these need to be studied. Conversely though, any requirement for GB railways to move away from common design principles in the rest of Europe will lead to increased costs so there is an additional need to see how such principles can be made to work in GB.

Emerging legislation may increase the need for the environmental impact to be considered in rolling stock design, operation and disposal. It is anticipated that research will be undertaken that will help the industry to accommodate such legislation. This may include novel toilet technologies and greater use of lighter and re-cyclable materials in vehicle construction.
# Rolling Stock Project Index

<table>
<thead>
<tr>
<th>Project</th>
<th>Project Title (Published)</th>
<th>Area 1</th>
<th>Area 2</th>
<th>Area 3</th>
<th>Area 4</th>
<th>Area 5</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>T009</td>
<td>Pooling of knowledge to promote rail safety (EU project: Trainsafe)</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>T035</td>
<td>Friction Stir Welding in rail vehicle manufacture (EU project: EUROSTIR)</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>T052</td>
<td>‘Snap wands’ and low location marking systems for emergency lighting on passenger vehicles</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>T052a</td>
<td>Improvements to safety signage on passenger trains</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>T052b</td>
<td>Hammers for breaking carriage windows prior to emergency egress</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>T052c</td>
<td>Signage and illumination of Emergency Door Release mechanisms in passenger vehicles</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>T052d</td>
<td>Communication technology and functionality in passenger vehicles</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>T052e</td>
<td>Windows and hatches for emergency egress from railway carriages</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>T066</td>
<td>Identification and quantification of injuries in railway vehicles during accidents</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>T066a</td>
<td>Development of a train evacuation risk model (‘Stay or Go’)</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>T117</td>
<td>Framework for evaluating control measures to improve accident survivability</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>T118</td>
<td>Whole train dynamic behaviour in collisions and improving crashworthiness</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>T119</td>
<td>Literature review of rail vehicle structural crashworthiness</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>T120</td>
<td>Review of measures to reduce risk from passenger train fuel tanks</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>T121</td>
<td>Communication for effective passenger behaviour immediately following an incident</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>31</td>
</tr>
<tr>
<td>Project</td>
<td>Project Title (Published)</td>
<td>Area 1</td>
<td>Area 2</td>
<td>Area 3</td>
<td>Area 4</td>
<td>Area 5</td>
<td>Page Number</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>T122</td>
<td>Human factors and injury information to be collected during accident investigations</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>T123</td>
<td>Ladbroke Grove Rail Inquiry Part 1 Recommendation 60: Rail passenger survey</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>33</td>
</tr>
<tr>
<td>T124</td>
<td>Review of tank wagon end protection</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35</td>
</tr>
<tr>
<td>T129</td>
<td>Design study for emergency exit on Mk III vehicle windows</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37</td>
</tr>
<tr>
<td>T177</td>
<td>Overhead line structure design to cater for collision</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38</td>
</tr>
<tr>
<td>T189</td>
<td>Optimal design and deployment of obstacle deflectors and lifeguards</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39</td>
</tr>
<tr>
<td>T190</td>
<td>Optimising driving cab design for driver protection in a collision</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>T201</td>
<td>Improving the design of seats and tables to minimise passenger injuries</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>42</td>
</tr>
<tr>
<td>T246</td>
<td>Development of common passenger safety signs</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>44</td>
</tr>
<tr>
<td>T305</td>
<td>Modelling collisions of rail vehicles with deformable objects</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>T310</td>
<td>Review of injury causation and human factors in vehicle accidents</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46</td>
</tr>
<tr>
<td>T314</td>
<td>Requirements for emergency lighting on passenger rail vehicles</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48</td>
</tr>
<tr>
<td>T358</td>
<td>Understanding the risk of on-board accidents</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>49</td>
</tr>
<tr>
<td>T399</td>
<td>Review of human factors risk in rail vehicle maintenance and inspection</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>T422</td>
<td>Completing the set of passenger train safety signage to improve legibility and comprehension</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>51</td>
</tr>
<tr>
<td>T424</td>
<td>Requirements for train windows on passenger rail vehicles</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>52</td>
</tr>
</tbody>
</table>
## Rolling Stock Project Index

<table>
<thead>
<tr>
<th>Project</th>
<th>Project Title (Published)</th>
<th>Area 1</th>
<th>Area 2</th>
<th>Area 3</th>
<th>Area 4</th>
<th>Area 5</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>T520</td>
<td>Benchmarking weld performance in aluminium joints (ALJOIN Plus)</td>
<td></td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td>53</td>
</tr>
<tr>
<td>T530</td>
<td>Review of train headlamps’ optical requirements</td>
<td></td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td>54</td>
</tr>
<tr>
<td>T600</td>
<td>Strategic European Rail Research Project - SafeInteriors Euronom</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td>56</td>
</tr>
<tr>
<td>T634</td>
<td>An analysis of potential fuel tank solutions</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>T676</td>
<td>Development of a rolling stock whole life cost model</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>T685</td>
<td>Investigating how the requirements for train brake systems affect vehicle mass</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td>61</td>
</tr>
<tr>
<td>T688</td>
<td>Technology transfer for reducing vehicle mass</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>62</td>
</tr>
<tr>
<td>T692</td>
<td>Water recycling technology for train toilets</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>63</td>
</tr>
<tr>
<td>T712</td>
<td>Research into trains with lower mass in Britain</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td>64</td>
</tr>
<tr>
<td>T782</td>
<td>Maximising rolling stock reliability</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>65</td>
</tr>
<tr>
<td>T814</td>
<td>Review of US requirements for passenger train emergency systems and their relevance to GB</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td>67</td>
</tr>
<tr>
<td>T835</td>
<td>Trends in GB rolling stock noise levels</td>
<td></td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td>69</td>
</tr>
<tr>
<td>T843</td>
<td>Assessment of TS 45545 fire testing regime for GB conditions</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70</td>
</tr>
<tr>
<td>T857</td>
<td>Detailed review of selected remote conditioning monitoring areas</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72</td>
</tr>
<tr>
<td>T878</td>
<td>Bodyside window containment tests for existing vehicle designs</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>T910</td>
<td>Review of railway vehicle interior crashworthiness research 1989-2009</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77</td>
</tr>
<tr>
<td>T958</td>
<td>Ensuring automatic coupler reliability during ice and snow</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>79</td>
</tr>
<tr>
<td>Project</td>
<td>Project Title (Projects in Progress)</td>
<td>Area 1</td>
<td>Area 2</td>
<td>Area 3</td>
<td>Area 4</td>
<td>Area 5</td>
<td>Page Number</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>T735</td>
<td>TrioTRAIN: Total Regulatory Acceptance for the Interoperable Network</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td>82</td>
</tr>
<tr>
<td>T860</td>
<td>Benefits of all-electric braking</td>
<td></td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td>84</td>
</tr>
<tr>
<td>T870</td>
<td>Fuel consumption metering for validation purposes</td>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>●</td>
<td>86</td>
</tr>
<tr>
<td>T986</td>
<td>Cross Interface Remote Condition Monitoring - Acoustic Bearing Monitoring Case Study</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>T1003</td>
<td>Standardisation of coupling arrangements</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td>89</td>
</tr>
<tr>
<td>T1010</td>
<td>Cross-industry remote condition monitoring programme phase 2</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>91</td>
</tr>
<tr>
<td>T1018</td>
<td>Assessment of rail vehicle seat fire testing</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>93</td>
</tr>
</tbody>
</table>
T009  Pooling of knowledge to promote rail safety  
(EU project: Trainsafe)

**Description**
This project supported the TRAINSAFE thematic network, consisting of 16 partners representing the rail industry across Europe aiming to share and co-ordinate safety information.

**Abstract**
The Advanced Rail Research Centre at Sheffield University (now ‘NewRail’ based at Newcastle University) established the ‘TRAINSAFE’ thematic network to encourage collaboration and the exchange of research information. This was specifically concerned with railway accidents, why they happen, and how injuries can be minimised. The network had 16 partners broadly representing the rail industry across Europe. It provided a mechanism for sharing and co-ordinating safety issues and facilitated the move towards a harmonised European approach to safety philosophies and commonality of issues concerning the safety of railway operations. The aim of this research was to provide support to this collaborative European project, which reviewed the current status of railway safety knowledge and assessed what future research was required. Duplicate effort has been minimised by establishing a pan-European way forward in four areas: standards, infrastructure, vehicles, and fire safety. TRAINSAFE has published its findings under the EURailSafe website (www.eurailsafe.net).

**Published**
July 2006

**Current Position**
TRAINSAFE provided a mechanism for sharing and co-ordinating safety issues and facilitated the move towards a common European approach to safety philosophies and issues. This pan-European approach covers four areas: standards, infrastructure, vehicles, and fire safety. Initial steps towards these objectives include workshops, documentation, and a website.

This has helped to establish a common ground for the newly expanded railway networks in the European Union.

This project was essentially for information purposes and there are no further implementation requirements.

The output from this has been used in a further collaborative European project in which RSSB is participated. Details of the project, T600 Strategic European Rail Research Project – SafInteriors can be found in this guide.
### Description
This pan-European project aims to promote the use of friction stir welding (FSW) within Europe. A specific initiative under this banner has been to compare FSW against conventional welding techniques to identify any benefits.

### Abstract
Eurostir® is a project funded by the European Commission that aims to accelerate the use of friction stir welding (FSW) in Europe. Unlike conventional welding techniques such as metal inert gas (MIG) (which is the predominant method used in rail vehicle manufacture), joints created using FSW have very little distortion and a good finish. Potentially they could also be stronger. A specific objective initiated under these collaborative arrangements has been co-funded by rolling stock owners and Rail Safety and Standards Board. TWI (formerly known as The Welding Institute) has conducted static and dynamic tests to compare FSW joints against MIG. A specific area of interest here was the ‘weld unzipping’ that has been seen in high-energy impacts such as at Ladbroke Grove. Tests conducted have been unable to recommend one overall process, but have led to conclusions on how to improve joint performance, and joint locations suitable for each process.

### Published
July 2007

### Current Position
RSSB became involved in the European ALJOIN project to investigate the joints in aluminium rail vehicles and ‘unzipping’ tendencies, in which some larger components have been tested.

Following on from this, research project **T520 Benchmarking weld performance in aluminium joints (ALJOIN Plus)** addressed the remaining issues from T035.

The FSW method is now used by suppliers of rolling stock to GB. An update of EN 15085-3 was published in 2009 and the information used by Hitachi on the class 395s.
### T052 ‘Snap wands’ and low location marking systems for emergency lighting on passenger vehicles

<table>
<thead>
<tr>
<th>Description</th>
<th>This project considers the use of low location marking systems and ‘snap wands’ as a means of providing lighting in an emergency. It addresses recommendation 75 in Lord Cullen’s first report on the Ladbroke Grove Rail Inquiry.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>In recommendation 75 of his first report on the Ladbroke Grove Rail Inquiry, Lord Cullen recommended consideration of ‘snap wands’ in passenger vehicles as a means of providing lighting in an emergency. The project addresses this recommendation and also the use of airline style floor lighting (known as low location marking systems (LLMSs)), which were also being considered by train operators. On behalf of RSSB, Interfleet Technology in conjunction with ICE Ergonomics Ltd. conducted the research drawing on extensive experience from the building and aviation industries. The work concludes that retrospective fitting of LLMSs cannot be justified on safety grounds alone, although there may be a case for new build particularly when other factors such as passenger perception are taken into account. It also found no overwhelming case to use or not-use ‘snap wands’. More holistic research into emergency lighting is being conducted in project T314.</td>
</tr>
<tr>
<td>Published</td>
<td>September 2005</td>
</tr>
<tr>
<td>Current Position</td>
<td>The research concludes there was no overwhelming case to either use or not use snap wands, although there may be a case for new build when passenger perceptions are taken into account. Each train operating company should consider the implementation of the devices according to their specific needs - and many have snap wands on their trains.</td>
</tr>
</tbody>
</table>
**T052a Improvements to safety signage on passenger trains**

**Description**
This project addresses the recommendations made by Lord Cullen in his first report on the Ladbroke Grove Rail Inquiry, pertaining to improvements in safety signage on passenger trains.

**Abstract**
In his first report on the Ladbroke Grove Rail Inquiry, Lord Cullen made a number of recommendations pertaining to improvements in safety signage. Recommendation 71 concerned the use of photoluminescent materials, recommendation 72 the use of pictograms in preference to text and recommendation 73, a common system of safety signage for passenger trains throughout Great Britain. This research conducted a best practice review of materials and requirements to develop a new range of fully tested pictograms to aid comprehension and recognition of passenger safety signs. Guidelines and procedures for the design of passenger safety signs were also developed. Working with ATOC, the project culminated in the development of an extranet to hold master copies of safety signs for use by train operators and owners.

**Published**
November 2007

**Current Position**
The primary output of this research project was ITL/GN0001 Graphics guidelines for safety signs and ITL/GN0002 Guidelines for symbol design and testing. These are available online at [www.rgsonline.co.uk](http://www.rgsonline.co.uk) and provide checklists for specific areas of vehicles, as well as check lists and guidance for the design process of emergency and safety information. The outputs have also been incorporated in GM/RT2130 *Vehicle Fire, Safety and Evacuation* and a method of implementing these measures is illustrated in the railway code of practice GM/RC2533 *Recommendations for Rail Vehicles Emergency and Safety Information’*

Additional deliverables including an initial set of common passenger signage is available to RSSB members on request.
### T052b Hammers for breaking carriage windows prior to emergency egress

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>This project addresses the recommendations made by Lord Cullen in his first report on the Ladbroke Grove Rail Inquiry, pertaining to the use of hammers as a means of breaking windows prior to emergency egress.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>In his first report on the Ladbroke Grove Rail Inquiry, Lord Cullen recommended investigations to improve the use of hammers as a means of breaking windows prior to emergency egress through them. Recommendation 80 concerns the enhanced provision of emergency hammers and recommendation 82 concerns the practicalities of integrating hammers into the passenger alarm. This research reviewed the type of hammers used in the UK and made comparisons with equipment used abroad and in other transport industries. The findings were used to identify best practice and develop a set of pictograms. The illumination of hammers and those windows designed for emergency egress was also considered, concluding that photoluminescent marking would provide the best solution. RSSB is reviewed the appropriateness of the use of windows for emergency egress under project T424.</td>
</tr>
<tr>
<td><strong>Published</strong></td>
<td>January 2005</td>
</tr>
<tr>
<td><strong>Current Position</strong></td>
<td>As well as responding to Recommendations 80 and 82, this research identified a number of recommendations for further work. When put into context with the follow-on research and other accidents in Britain, different priorities emerged. Owing to the number of passenger injuries from broken glass, and the danger to passengers when leaving the site of an accident, the follow-on research has revealed alternatives to the provision of hammers. Further research undertaken in this area includes project T424 Requirements for train windows on passenger-carrying rail vehicles, completed in January 2008, recommended that hammers are removed from passenger vehicles and led to the establishment of an industry containment strategy towards the installation of laminated glass.</td>
</tr>
</tbody>
</table>
### Description
This project addresses recommendation 78 made by Lord Cullen in his first report on the Ladbroke Grove Rail Inquiry, concerning signage and illumination of emergency door release mechanisms.

### Abstract
This project aims to encourage the correct use of emergency door release (EDR) mechanisms during a major incident by better use of signage and artificial illumination. It responds to recommendation 78 made by Lord Cullen in his first report on the Ladbroke Grove Rail Inquiry. This research examined a range of EDR mechanisms used in the UK and made comparisons with equipment used abroad and in other transport industries. The findings were used to develop a comprehensive set of pictograms that were then comprehension tested. The project determined that 55% of the pictograms developed reached acceptable levels of comprehension and that some additional text is necessary to provide adequate instruction. In addition, it was concluded that the photoluminescent marking of the EDR mechanism in addition to photoluminescent signage would provide the best solution for illumination.

### Published
September 2004

### Current Position
The research findings recommended changes to support successful deployment of emergency door releases (EDR). The research findings were incorporated into *GM/RT2130 - Vehicle Fire, Safety and Evacuation* and the complete set of requirements for signage and illumination of EDR mechanisms in passenger vehicles is available to RSSB members on request.
### T052d Communication technology and functionality in passenger vehicles

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>This project addresses the recommendations made by Lord Cullen in his first report on the Ladbroke Grove Rail Inquiry, pertaining to communication technology and functionality.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>In his first report on the Ladbroke Grove Rail Inquiry, Lord Cullen made a number of recommendations pertaining to communication technology and functionality. Recommendation 85 concerns communication between the passengers and signaller, recommendation 86 concerns roaming communications, and recommendation 87 concerns remote broadcasting. This research used a high level analysis of data obtained from train operators, Network Rail, and equipment suppliers to determine the likely safety benefits. The work recommends an additional function for GSM-R to allow emergency passenger communications not answered by the driver to be re-routed to the signaller. A roaming communication function is possible in the new GSM-R system as is remote broadcasting. However, a public address system capable of operation when vehicles are decoupled during an incident is considered impracticable. Before progressing the research’s recommendations it is important to first establish what needs to be communicated, how and when. These questions are addressed by project T121.</td>
</tr>
<tr>
<td><strong>Published</strong></td>
<td>September 2004</td>
</tr>
</tbody>
</table>
The findings addressed the feasibility and cost-effectiveness of three types of communication:
1) passenger to signaller communications
2) roaming communications
3) remote broadcasting

In response to the recommendations in T052d, research project T121 Communication for effective passenger behaviour immediately following an incident was conducted (published July 2009).

Within the Control, Command & Signalling topic area research has been carried out looking at communication technologies that are relevant to T052d findings:
- T351 A strategy to develop future railway communications systems
- T671 Communication and positioning systems in GB rail industry

Together with T121, these research projects established that there was already a good understanding of what needs to be communicated, to whom, and when; and that the findings were consistent and supportive of industry activities that are largely deemed best practice and already well established.
### T052e Windows and hatches for emergency egress from railway carriages

#### Description
This project addresses the recommendations made by Lord Cullen in his first report on the Ladbroke Grove Rail Inquiry, pertaining to windows as a means of emergency egress and consideration of escape hatches.

#### Abstract
In his first report on the Ladbroke Grove Rail Inquiry, Lord Cullen recommended research into windows as a means of emergency egress and consideration of the introduction of escape hatches. Recommendations 81 and 83 concern the feasibility of providing removable windows and escape hatches respectively in new and existing railway carriages. This research used a risk and benefit approach to develop conclusions and recommendations for both issues. The work included use of the Safety Risk Model developed by RSSB. In response to recommendation 81, the work concluded that removable windows, of the types used abroad, are not recommended for use in Great Britain and that further research is required to determine if ‘hammer less’ methods provide greater benefits than the existing break-glass window system (see project T424). In response to recommendation 83, the provision of escape hatches is not recommended in existing carriages, nor is it recommended in new carriages.

#### Published
September 2004

#### Current Position
The research assessed the feasibility of escape hatches in railway carriages and came to the conclusion that the use of hatches or removable windows was not recommended for GB trains - new or existing.

For improving access and evacuation in an incident, RSSB recommended further work on access markings as a means of facilitating emergency services.

Detailed research into emergency exits was followed up in **T129 Design study for emergency exit on Mk III vehicle windows** and **T424 Requirements for train windows on passenger rail vehicles**.

The issue of access markings has been surpassed by the research in T424 and more recently in **T814 Review of US requirements for passenger train emergency systems and their relevance to GB**.
**Description**

This project identified the nature of injuries suffered by passengers in railway vehicles during accidents. In doing so it provides a means by which the rail industry can consider whether there are any reasonably practicable changes that could be made to interior design and crashworthiness that would enhance passenger safety.

**Abstract**

This project identified the nature of injuries suffered by people in railway vehicles during accidents. In doing so it provides a means by which the rail industry can evaluate measures to improve interior design and crashworthiness, thus enhancing passenger safety. The work was carried out by consultants with many years’ experience of investigating railway accidents, supported by expert medical analysis from a recognised injury specialist. Evidence from railway accident records was used to develop a database of injuries to identify, categorise, and quantify injury levels. It assessed anthropomorphic testing devices (ATD - crash test dummies) that are used to measure injury levels in accident simulations and found that they could not assess all of the typical injuries found in railway vehicle accidents. The research recommended changes to currently accepted injury criteria and investigation of an improved ATD which led to the development of the Hybrid IIIRS.

**Published**

June 2007

**Current Position**

This project provided the data for a revision of ATOC code of practice AV/ST 9001, this has been superseded by the latest update to GM/RT2100 Requirements for Railway Vehicles Structures.

The research also developed a rail specific crash test dummy. The specifications for the Hybrid III RS Dummy (RSSB's ATD) are now available on the RSSB website.
**T066a Development of a train evacuation risk model (‘Stay or Go’)***

<table>
<thead>
<tr>
<th>Description</th>
<th>The research seeks to answer the question of whether it is safer to remain on the train after an incident or to evacuate.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Following an accident involving a passenger train there may be many largely uninjured passengers remaining in reasonably intact carriages. This research seeks to answer whether in such circumstances it is safer to remain on the train or to evacuate. This research developed a model to calculate and compare the risks of the two options: staying on a train following an accident, and evacuating promptly. The model divides the accident into two phases. The primary accident ends when all the rapid accident processes have finished and there is time to consider the question of whether or not to evacuate. The train is left in a particular ‘end state’. The primary accident is modelled using a qualitative event tree to classify these end states. Quantitative event trees, that look at the secondary accidents posing a threat to the passengers, then separately model the risks of the two options. The general conclusion is that in the overwhelming majority of cases it is safer for passengers to stay on the train as opposed to evacuating promptly.</td>
</tr>
<tr>
<td>Published</td>
<td>June 2004</td>
</tr>
<tr>
<td>Current Position</td>
<td>The outputs of this research have been used in a number of later research projects, including:</td>
</tr>
<tr>
<td></td>
<td>• T121 Communication for effective passenger behaviour immediately following an incident or accident</td>
</tr>
<tr>
<td></td>
<td>• T201 Improving the design of seats and tables to minimize passenger injuries</td>
</tr>
<tr>
<td></td>
<td>• T246 Development of common passenger safety signs</td>
</tr>
<tr>
<td></td>
<td>• T310 Review of injury causation and human factors in vehicle accidents</td>
</tr>
<tr>
<td></td>
<td>• T314 Requirements for emergency lighting on passenger rail vehicles</td>
</tr>
<tr>
<td></td>
<td>• T422 Completing the set of passenger train safety signage to improve legibility and comprehension</td>
</tr>
<tr>
<td></td>
<td>• T424 Requirements for train windows on passenger rail vehicles</td>
</tr>
</tbody>
</table>
### T117  Framework for evaluating control measures to improve accident survivability

<table>
<thead>
<tr>
<th>Description</th>
<th>This research investigated the feasibility of developing a quantitative framework within which control measures to improve accident survivability can be assessed and priorities determined.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Accident survivability has been raised as an important issue at recent public inquiries. This research investigated the feasibility of developing a numeric framework within which control measures to improve accident survivability can be assessed and priorities determined. The preliminary research defined key themes to be explored, identified typical accidents to analyse, and scoped further work necessary to realise the benefits. The work examined how the concept of design basis scenarios used in other industries could be employed to allow assessment of control measures in a single consistent framework. Though the research has been valuable in exploring the strategies used in other industries, RSSB feels that it parallels the existing Safety Risk Model that is now well established and used by the rail industry to determine and evaluate priorities. RSSB therefore has no plans to pursue this initiative further at the present time.</td>
</tr>
</tbody>
</table>

| Published   | The preliminary research examined how design basis scenarios, which are used in other industries, could be employed to assess control measures within a single and consistent framework. As this approach parallels the existing RSSB Safety Risk Model, which is well established and used by the rail industry, RSSB will not pursue this project until further notice, if appropriate. |
T118 Whole train dynamic behaviour in collisions and improving crashworthiness

Description
This research investigated improvements to passenger survivability, by establishing how crash energy could be better absorbed, by improving the ability of vehicles to remain upright and in-line during collisions.

Abstract
A significant number of fatalities have been directly attributed to a loss of survival space resulting from crushing of the passenger compartment or ejection from the vehicle through broken windows or tears in the body structure. On behalf of the Rolling Stock Research and Development Group, this research investigated improvements to passenger survivability. This was done by establishing how crash energy could be better absorbed, by improving the ability of vehicles to remain upright and in-line during collisions.

The research project was structured in two phases. The first involved a detailed review of work undertaken in structural crashworthiness and development activities across the industry. This showed that casualties are significantly reduced when vehicle stability is maintained following an accident. It also found a growing gap between the levels of crashworthiness that manufacturers can achieve and the lower levels required by the GB and European standards, despite there being a lack of understanding of whole train dynamics in collision scenarios.

The second phase sought to address this further, using computer simulation work and examination of conceptual design of solutions aimed at promoting whole train stability. Relevant inquiry recommendations were reviewed and commented on, and the benefit of bogie retention was evaluated. The findings from this research were assessed to determine how they can be used to inform the further development of GB and European crashworthiness design standards.

The second phase demonstrated that it is technically viable to design a train that will not derail following an end-on collision with a like train on a straight track, at a closing speed of 70km/h. In order to maintain stability under these crash conditions the research found that coupler collapse force and sufficient energy absorption, at leading and intermediate ends, were important. The research also concluded that it is better to retain bogies than release them if a train derails and rolls.
Abstract cont. This research has shown that no specific changes to the crashworthiness design standards mandated in BS EN15227:2008 or GM/RT2100 are needed. Additionally it has established that the impact forces generated by the proposed level crossing collision scenario in BS EN15227:2008 should not represent a derailment risk.

Published September 2009

Current Position The Rolling Stock Research and Development Group took account of the findings from this research, and considered that while the results of the research could be used to inform the further development of GB and European crashworthiness design standards, no specific changes to the crashworthiness design standards mandated in BS EN15227:2008 or GM/RT2100 Structural Requirements for Rail Vehicles are needed. In many respects, BS EN15227:2008 provides a good framework for developing future crashworthy trains. The standard allows for the introduction of additional design collision scenarios, based on a risk assessment of the railway system under consideration. It also provides guidance on what factors should be considered in the risk assessment.
T119 Literature review of rail vehicle structural crashworthiness

Description

A worldwide literature review has been performed to identify significant recent research work and best practice in the areas of railway vehicle structural integrity and crashworthiness.

Abstract

Significant crashworthiness research projects have been undertaken in recent years, particularly in Europe and the USA. These have been aimed at reducing casualties in rail vehicle accidents by improving structural crashworthiness of new trains. The aim of the literature review has been to gather as much information as possible from worldwide sources on the current status of rail vehicle crashworthiness. This is to enable a review and comparison of current British practice with the latest thinking and developments worldwide. This research has identified key approaches, findings and differences, and suggests means of understanding and evaluating these differences and their applicability to future developments.

Published March 2006

Current Position

The literature review has led to, a number of follow-up research projects. These in turn are informing domestic and European standards:

- T118 Whole train dynamic behaviour in collisions and improving crashworthiness
- T189 Optimal design and deployment of obstacle deflectors and lifeguards
- T305 Modelling collisions of rail vehicles with deformable objects
- T310 Review of injury causation and human factors in recent vehicle accidents
- T814 Review of US requirements for passenger train emergency systems and their relevance to GB

GM/RT2100 issue 5, Requirements for Railway Vehicles Structures: specifying the structural requirements for GB rail vehicles was published on 2 June 2012.
This research has quantified the risks associated with the carriage of diesel fuel on passenger trains, and identified viable risk mitigation measures using the ALARP principle.

Building on earlier work by the Health & Safety Executive, this research has quantified the risk associated with the carriage of diesel fuel on passenger trains and, using the ALARP principle, identified viable measures to reduce the risk. Casualties from fires in accidents are rare, but the Ladbroke Grove accident resulted in several fatalities and injuries caused by a diesel fuel fire. This work addresses the research aspect of recommendation 61 of the subsequent inquiry, and investigates possible safety improvements. The research considered twelve possible mitigation measures including: fuel additives, tank linings and honeycomb inserts, relocation, and refrigeration. A risk assessment and cost-benefit analysis was also carried out. None of the measures considered was found viable for retrofitting to existing rolling stock, but two measures were found viable for new designs of rolling stock. These are placing the tanks in less vulnerable locations and incorporating sacrificial panels in tanks.

The research has informed updates to two Railway Group Standards:
1. GM/RT2120 Requirements for the Control of Risks Arising from Fires on Railway Vehicles: to prevent tanks being located in vulnerable areas under the frame adjacent to bogies.
2. GM/RT2100 Structural Requirements for Railway Vehicles: to specify the design load cases for fuel tanks and to safeguard tanks from obstacle strikes.

GM/RT2120 has been updated to issue 2 (June 2004) and subsequently superseded (withdrawn August 2008) by GM/RT2130, issue 3 Vehicle Fire, Safety and Evacuation. The recommendation to avoid locating fuel tanks in vulnerable areas has been incorporated.
### T120  Review of measures to reduce risk from passenger train fuel tanks, *cont.*

**Current Position *cont.***

GM/RT2100 issue 2 was in force at the time of this research. It has since been updated and is currently at issue 5, which was published on 2 June 2012.

The research also identified the potential for additional work to assess the strength and deformation characteristics of current fuel tank designs. In particular it identified three potential developments:

- Burst panels and foam inserts for fuel tanks to verify efficacy
- Viability of honeycomb inserts in comparison to the viability of foam inserts and the performance of both measures
- Feasibility of fuel additives, including performance and cost.

The burst panel approach was considered the most feasible but following more detailed analysis in research project **T634 Turning potential fuel tank solutions into practice** (completed April 2009) it was concluded this did not present a viable option from a CBA perspective. In this light, industry decided that no further actioned need be taken.
This research conducted a holistic review of how staff should communicate with passengers following an accident or incident to promote survivability and reduce injury.

This research investigated human factors issues associated with passenger information and communication requirements on the railway network immediately following an accident or incident to promote survivability and reduce injury. The Cullen inquiry, following the Ladbroke Grove accident, made several recommendations regarding improvements to communications with passengers in the immediate aftermath of accidents. Although previous research has already looked at the technology that can be deployed to do this, it was also considered necessary to establish what behaviour needs to be encouraged. This research established how passengers behave in accidents and incidents, the optimal behaviour, and how the gap between the two should be addressed to improve behaviours in both normal and emergency situations on the rail network.

The research established that there was already a good industry understanding of what needs to be communicated to whom and when, and that the findings were both consistent and supportive of industry activities that are largely deemed best practice and already established in industry guidance such as ATOC guidance notes.

The initial investigations considered aviation, marine, public service vehicles, tunnels, and the built environment, as well as rail travel. Sources of information included published works, incident investigations, and confidential incident reports. The project established that there was already a good understanding of what needs to be communicated, to whom, and when; and that the findings were consistent and supportive of industry activities that are deemed best practice and already well established.

The rail industry concluded that there are no new emerging findings that are not already being addressed through other industry activities. Many of the issues that were confirmed by this work are now covered in existing ATOC documents such as ATOC Guidance Note ATOC/GN003 concerning staff training, and ATOC/GP004 concerning failure or non-availability of air conditioning.
### T122 Human factors and injury information to be collected during accident investigations

<table>
<thead>
<tr>
<th>Description</th>
<th>This research defined what information should be obtained from future accidents and how it should be managed, so that it can be used to inform future train design and egress strategies.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Accident investigation usually concentrates on the causes of accidents. However, we could also learn what features and events led to injuries as well as factors influencing egress. If captured and managed in a robust manner, this information could then be analysed, trends identified, and conclusions drawn to inform future train design and egress strategies. This research defined what information should be obtained from future accidents and how, as well as defining a strategy for the input, storage, and retrieval of the data. It responds to recommendation 66 made by Lord Cullen in his first report on the Ladbroke Grove Rail Inquiry. This research investigated what information exists from previous accidents and best practice in other related industries and other countries. A report has been published documenting this work and detailing the outputs specified above. The report has been shared with RAIB.</td>
</tr>
<tr>
<td>Published</td>
<td>March 2005</td>
</tr>
<tr>
<td>Current Position</td>
<td>Within Great Britain, very little historical information on passenger human factors and injury data from rail accidents exists in published form. In 2003/4, there was no consistent reporting process, nor structured approach to reporting and evaluating passenger human factors relating to egress from trains in GB rail accidents. Whilst RAIB reports now include analyses of the causes of injury, there is no obligation for the witness statements to be released to update the historical information which has limited the effectiveness of a single national database of all human factors and passenger injury information that is held by RSSB and was developed in the research project T310 Review of injury causation and human factors in vehicle accidents. The RAIB analyses includes injuries caused by primary impact, (during the initial cause of impact), for example a collision or derailment, and secondary impact (when a vehicle rolls over after a collision or derailment). Secondary impact injuries occur when occupants collide with the vehicle interior (fixtures, fittings, structure, etc) and/or other occupants.</td>
</tr>
</tbody>
</table>
This research surveyed rail passengers to establish their perception and awareness of risk, investigating their preferences for safety interventions. It responds to recommendation 60 in Lord Cullen’s first report on Ladbroke Grove.

Recommendation 60 of Ladbroke Grove Rail Inquiry Part 1 stated that ‘comprehensive market research in regard to safety related measures should be carried out in order to take account of the views of informed passengers’. In response, RSSB commissioned a survey of railway passengers. The aim of this research was to establish the perceptions of passengers, and their awareness of risk, and to investigate their preferences for safety interventions. Informed by preliminary interviews, questionnaires were developed, piloted, and finally distributed to approximately 900 people at 15 hub railway stations. A very good response rate (30%) was achieved for a survey of this nature. The results provide a valuable indicator of passenger perceptions of risk, especially when compared with quantitative assessments of actual risk. It suggests that the relationship between perceived and actual risk is not particularly strong. Reasons for this are discussed in more depth in the report.

The original research was carried out in response to the Ladbroke Grove Rail Inquiry Part 1, Recommendation 60. The results provided a valuable indicator of passenger perceptions of risk, especially when compared with quantitative assessments of actual risk.

The actual highest source of risk to people’s safety is trespass, not collisions as perceived by passengers in T123 research work. Further work into passenger perceptions is addressed in Operations research topic area under Public Behaviour: Area 3: Customer Needs and Perceptions. The overview for this topic states “Research in this area identifies customer needs, and evaluates customers’ experience and expectations of service provision.” The HSE has also carried out work about public perceptions of safety, which were published Q1/Q2 2002 and in the HSE review of ERTMS final report.
**T123  Ladbroke Grove Rail Inquiry Part 1 Recommendation 60: Rail passenger survey, *cont.***

**Current Position *cont.***

The subsequent RSSB research was published as *Public Attitudes to Safety on the Railways – General Public Research* by RSSB in June 2006 ([www.rssb.co.uk/sitecollectiondocuments/pdf/Public_attitudes_to_safety_on_the_railways.pdf](http://www.rssb.co.uk/sitecollectiondocuments/pdf/Public_attitudes_to_safety_on_the_railways.pdf)). The HSE research referred to was called *Public dialogue on train protection 2003* ([www.hse.gov.uk/research/rrpdf/rr055.pdf](http://www.hse.gov.uk/research/rrpdf/rr055.pdf)).
This research reviewed the provision of buffer override protection on tank wagons containing dangerous goods, in particular improvements to design requirements and justification of retrospective fitting to existing vehicles.

This research reviewed the provision of buffer override protection on tank wagons that carry dangerous goods. It looked particularly at improvements to design requirements and a potential justification of retrospective fitting to existing vehicles. The research addresses risks that could lead to catastrophic consequences and will inform RGSs. The research project has delivered a report, which has been issued. The research included a review of the current state of the British wagon fleet, applicable international regulations, buffer override incidents, and an assessment of the scope for design improvements. The research recommends more precise definition of the requirements for buffer override protection, to ensure that future designs are optimised as far as reasonably practicable. However retrospective fitting to existing vehicles is not justifiable on safety grounds.

February 2004

Recommendations from this research refer primarily to Railway Group Standards (RGS). It is proposed that the Standards should capture current industry best practice and include further refinements which this research work has shown to be beneficial. The need to permit retrofitting should no longer be one of the design criteria. Specific items for RGSs are:

- Concepts for buffer override protection should be maintained in the RGS.
- GM/RT2101 should redefine the requirements for future buffer override designs, as far as reasonably practical, to ensure optimal benefits.
T124  Review of tank wagon end protection, *cont.*

**Current Position cont.**

- RGS should contain a specification of guidelines for override protection dimensions and attributes of key design elements.
- Review the RGS periodically when the Tank Vehicle Working Group publishes its conclusions from the *Regulations concerning the international carriage of dangerous goods by rail (RID)* concerning the end protection of vehicles used for the carriage of toxic gases.

The requirements contained in *GM/RT2101 Requirements for the Design, Construction, Test & Use of the Tanks of Rail Tank Wagons Issue 1*, have been incorporated into *GM/RT2100 Issue 5 Requirements for Railway Vehicles Structures*. Industry has been notified that GM/RT2101 will be withdrawn in March 2011.
# T129  Design study for emergency exit on MK III vehicle windows

## Description
This research investigates how an escape hatch could be incorporated into the window of a typical vehicle, using a practical arrangement that minimises risk of inappropriate use.

## Abstract
This project follows on from research project T052 which considered Lord Cullen's recommendations pertaining to escape hatches and windows as a means of emergency egress. That project raised a number of issues which this one attempts to address, by investigating how an escape hatch could be incorporated into the window of a typical vehicle (MkIII), using a practical arrangement that minimises risk of inappropriate use. This research considered various methods of doing this and proposed an outline design for a sliding plug window. This solution appears to meet all the requirements; particularly ease of opening if a vehicle is on its side, and prevention of jamming in the event of vehicle distortion. Before taking this work further, the industry needs to be clear on what role windows need to perform; the safety role of containing passengers during accidents conflicts with their potential role as a means of evacuation after accidents. Research project T424 considers these issues.

## Published
September 2004

## Current Position
The research was continued in a wider context in project **T424 Requirements for train windows on passenger carrying rail vehicles**, launched in April 2004 and completed in January 2008. As a result, the industry concluded that there is no further justification for further development of emergency exits for MkIII vehicles or any other vehicles.
### T177 Overhead line structure design to cater for collision

| **Description** | Considerable damage and harm has been caused when derailed trains have collided with overhead line structures. This research investigates what can be done to the design of the structures to mitigate this. |
| **Abstract** | Considerable damage and harm has been caused when derailed trains have collided with overhead line structures in two recent accidents: Hatfield and Southall. In response to this, RSSB commissioned ARUP to determine the effects that different types of overhead line support structure have upon derailed vehicles, and to determine if there were practicable methods of designing these structures to reduce damage to such vehicles. ARUP used the technique of finite element analysis to create a simulation of the structure of a typical (Mark 3) coach body colliding with different types of overhead line support at various angles and with modifications to reduce sharp edges and to reduce the failure force of the mast. The work concludes that there are design methods for reducing the damage that line-side masts cause in an accident. However, the containing effect of the line-side masts may also be beneficial in some accident situations. |
| **Published** | September 2004 |
| **Current Position** | This research provided a useful understanding of the effects of a collision with an overhead line support structure and the complex dynamics that are involved. The research identified a need to determine whether additional measures are required in relation to either the vehicle or the design of overhead line support structures, and to take into account the risks and benefits. More specifically, existing overhead line structures are expensive to replace, so any further work should be targeted at those areas of greatest derailment risk, as highlighted in the RSSB Safety Risk Model. To date, further follow-on research has not been identified as a priority by the rail industry but RSSB did commission a report shortly after the Hatfield accident where the main findings centred on the use of reduced factors of safety for mast holding-down bolts making them more frangible on impact as well as a means of preventing loose weights at termination points from becoming detached. This is detailed in ORR’s final report on Hatfield ([www.rail-reg.gov.uk/upload/pdf/297.pdf](http://www.rail-reg.gov.uk/upload/pdf/297.pdf)) |
By investigating improvements to obstacle deflectors and lifeguards, this research aimed to determine what might be done to minimise the result of a collision with objects on the track, especially at level crossings.

With approximately 400 reported obstacle strikes every year and a small number (<1%) with potentially serious consequences that might lead to derailment and passenger fatalities, this project investigated what might be done to minimise the effects of an obstacle strike, by considering the design of obstacle deflectors and lifeguards.

On behalf of the Rolling Stock Research and Development Group, this research project examined past accident data, and performed a parametric modelling study of deflector and lifeguard designs to identify potential improvements to increase the ability of deflectors and lifeguards to prevent derailment. This work concluded that for obstacle deflectors there was little more meaningful research that could be done. Further work on a concept lifeguard design was supported by full size dynamic testing and established that there was potentially a reduction in the risk of derailment from use of the improved lifeguard design.

The research also assessed the mechanism leading to the derailment at Ufton Nervet and the likelihood of similar derailments. This was followed up by a cost benefit analysis to examine the practicability of retrofitting deflectors to the current HST fleet. A revised analysis has since been conducted using revised assumptions for continued service operation of HSTs and as a result the industry has recommended that there is insufficient justification for retro-fit on HSTs.

The results of this research were put forward as a response to Recommendation 9 of the Formal Inquiry into the train accident at Ufton Nervet in 2004. More recently, the development EN15227 and the updating of Railway Group Standard GM/RT 2100 have also addressed this recommendation. EN15227 has now been adopted, as a mandatory requirement by GM/RT2100 issue 4, Structural Requirements for Railway Vehicles: specifying the structural requirements for GB rail vehicles, which was published on 4 December 2010. The continued installation of lifeguards is also a recommendation from this project.
The project also assessed the mechanism leading to the derailment at Ufton Nervet and the likelihood of similar derailments. This was followed up by a cost-benefit analysis to examine the practicability of retro-fitting deflectors to the current HST fleet. As a result, the industry has agreed that there is insufficient justification for retro-fit on HSTs. The results of this project were put forward as a response to Recommendation 9 of the Formal Inquiry into the train accident at Ufton Nervet in 2004. In relation to the possibility of continued service operation, RSSB has updated the CBA for retro-fit of obstacle deflectors to HSTs. As a result of this further work, the industry has agreed that there is insufficient justification for retro-fit on HSTs.
This research investigated methods for improving protection of the driver during accidents in a number of different cab types, including mitigating the risk from debris ingress.

This research has investigated improved driver survivability in an accident, by identifying potential improvements to driving cab design for new vehicles and, where justified, modifications to vehicles already in service. This research developed an understanding of what happens to the driver in his cab during an accident, and undertook an evaluation of what protection could be provided to increase the probability of survival. The research has identified how drivers can be injured and has evaluated various protection systems, using computer simulations and full-scale mock-ups. Consultation with industry stakeholders has agreed the value of European standards, recommending the use of air bags and knee bolsters and RSSB is progressing this.

An extension to this project considered accidents where drivers died from asphyxiation owing to debris entering the cab space despite there being little structural damage. The work considered preventing debris ingress through the cab side access doors, improving the cab structural integrity if a train rolls over, and improving the windscreen attachment to the cab. It concluded that the implementation of the measures identified should be considered for new build only.

The initial research examined cab design requirements, driver response, feasibility, and viability. The project was then extended to include a review of debris ingress into drivers’ cabs following accidents.

Further to this research, industry asked RSSB to commission a cost-benefit analysis for two design mitigation measures. None of these measures were considered cost-effective if carried out retrospectively. These measures should apply to new build only.
**T201 Improving the design of seats and tables to minimise passenger injuries**

**Description**

This project looked at seats and tables and the use of seat belts to investigate how rail vehicle interior design may be improved to minimise injury in an accident.

**Abstract**

This research aimed to identify improvements to seat and table design to minimise injuries in an accident. The research led to the development of an anthropomorphic testing device (ATD - crash test dummy) specifically for the rail environment. The ATD was then used to evaluate the benefits of two-point lap belts (as used in commercial aviation) and three-point, lap and diagonal belts (as used in cars). Accident analysis, sled testing, and computer modelling concluded that neither type of seat belt should be used in rail vehicles. Two-point seat belts would usually increase passenger injuries in a crash, and while three-point seat belts could reduce injury to restrained passengers, they require the strengthening of seat backs which would increase injuries to unrestrained passengers. Seat belts also prevent passengers being thrown clear of structural damage. The investigation suggested that for every life that may have been saved by fitting seat belts eight lives may have been lost due to major structural collapse. Current crashworthy seats, that are designed to absorb energy in accidents, thus reducing injury to passengers, should be retained.

The crashworthy table design concept work studied accidents establishing that crashworthy table designs could provide benefits.

Analysis showed that while a significant proportion of injuries were caused by interaction between passengers and tables the proportion of severe injuries from tables was small.

A concept crashworthy table design with a self rotating leaf was developed and modelled. The principle of the concept is that the table leaves will self-rotate when a force is applied that is equivalent to the AV/ST9001 crash pulse used to assess vehicle interiors. The passenger would impact a broader surface, reducing the intrusion to the abdomen that would be encountered with a narrower table edge during an accident.
The modelling concluded that a rotating leaf table design with a rotating section of 150 mm was optimal in terms of predicted injury levels. These results will be shared with the EU Safeinteriors project and a cost-benefit analysis will be undertaken to establish the value of fitting a crashworthy table to a modern fleet during build.

The findings from the 2-point and 3-point seat belts study were used to inform the GB railway’s containment strategy. It confirmed that there was no benefit in fitting seat belts and that it is better to continue using crashworthy seats as are defined in standards.

A cost-benefit analysis (CBA) for crashworthy tables was completed to determine if the likely reduction in the severity of injuries from table impact outweighs the costs of introducing rotating crashworthy tables in future railway vehicles. The CBA supports the development of crashworthy tables and the next step would be to validate the modelling by using physical testing to ensure that the occupant kinematics and predicted injury levels are represented as they were ascertained from the project research.

RSSB has pursued the opportunity to conduct physical testing as part of the T600 Strategic European Rail Research Project - Safelnteriors.

Further work in this area was also carried out:

- **T310 Review of injury causation and human factors in recent vehicle accidents** (published October 2009)
- **T424 Requirements for train windows on passenger rail vehicles** (published June 2007)
### T246  Development of common passenger safety signs

**Description**  
This research produced a common set of passenger safety signs suitable for use on existing rail vehicles, made them available to the industry through a web-based catalogue, and developed a process for managing them.

**Abstract**  
This research produced a common set of passenger safety signs suitable for use on existing rail vehicles, and made them available to the industry through a web-based catalogue. The project also developed a process for submitting new signs and managing changes to the catalogue. This research implemented the ‘toolbox’ developed in an earlier project (T052a), which responded to recommendation 73 in Lord Cullen’s first report on the Ladbroke Grove Rail Inquiry. The research created a total of 99 safety signs and the processes for managing them. The information is made available to the industry on request from RSSB (enquirydesk@rssb.co.uk). The published report records the processes adopted to derive the catalogue.

**Published**  
September 2005

**Current Position**  
Research into common passenger safety signs began with project T052a, which developed the essential guidelines for the new symbols and signs. Project T246 developed the first set of new signs, and the remaining work was undertaken in project **T422 Completing passenger train safety signage to improve legibility and comprehension** (completed 2006). The guidelines and symbols, produced from the research, are available to RSSB members on request.
## T305 Modelling collisions of rail vehicles with deformable objects

<table>
<thead>
<tr>
<th>Description</th>
<th>This research provides an improved understanding of the consequences of collisions with deformable objects that behave very differently from the rigid objects used for design work.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Past research shows that over 30% of accidents involve collisions with obstructions, usually at level crossings. The collision is often with a relatively lightweight, deformable object that behaves very differently from the rigid objects used for design work. This research provides an improved understanding of the consequences of collisions with such objects, so that better protection can be designed. The research was conducted on behalf of RSSB as a PhD project. It employed computer-based models of collisions to compare impacts with a standard rigid wall or body, and impacts with a deformable object of the same mass. A good understanding has been obtained of the way trains and the objects deform but, as with all computer modelling, validation is required.</td>
</tr>
<tr>
<td>Published</td>
<td>March 2006</td>
</tr>
</tbody>
</table>
| Current Position | This research was considered in project **T118 Whole train dynamic behaviour in collisions and improving crashworthiness** and the traditional FEA process was used in project **T189 Optimal design and deployment of obstacle deflectors and lifeguards**.  
This research will also feed into further development of Euronorms for rail vehicle crashworthiness.  
The potential for more thorough validation of the modelling will be reviewed and may take into account:  
- The separation of internal components that could affect survival.  
- The role of obstacle deflectors and the wheel flange.  
- The momentary acceleration of the vehicle after impact. |
T310  Review of injury causation and human factors in vehicle accidents

Description
This research studied the causes of fatalities and injuries in major rail accidents, identified features of train design that contribute to them, and reviewed human factors information.

Abstract
This research studied the causes of fatalities and injuries in major rail accidents. It identified train design features that contribute to them, and studied how passengers react to and behave after a train accident (human factors). The study of post-accident information drew together injury data, human factors data, and vehicle investigations from HSE reports, post-accident vehicle investigations, witness statements from the British Transport Police, and witness interviews as data sources.

The research found that two main causes of a wide range of injuries were seats (injuries to head, neck, and legs) and tables (injuries to abdomen, chest, and head). Structural intrusion (deformation of vehicle structure encroaching on survival space) and ejections (being thrown from the vehicle wholly or partially) were also identified as two significant causes of fatalities. Human factors information also revealed that passengers’ first reaction after an accident was to leave the vehicle believing that the correct egress route was through a window and that train lighting would remain on. These results have led to specific research projects for the development of seat and table design (T201), emergency lighting requirements (T314), and supported the formation of an industry agreed escape strategy as part of a train evacuation risk model (T066a).

After the initial event of an accident there may be other risks to consider such as a fire developing or impact by an approaching train. For this reason it is important that occupants maintain a level of mobility to enable them to move to a position of relative safety unaided if necessary. The Mobility Index Severity Score was developed to allow analysis of how injuries may affect a person’s freedom of movement. It can be applied to highlight any deficiencies in furniture design and provide supporting information to amend standards.

Published  October 2009
The work in T310 was the first research anywhere in the world that analysed post-accident data with a combination of:

- Injury data
- Human factors data
- Vehicle investigations

The preliminary findings from this research are that there are two main causes of injuries which occur in the vehicle interior: collision with seats, and with tables and two significant causes of fatality: structural intrusion, and ejections.

An accident database has been developed from this research project and used in the T600 Strategic European Rail Research Project - SafelInteriors project. The database is also being used to support the safety intelligence aspects of the RSSB Safety Risk Model and to help validate information in the Safety Management Information System that is administered by RSSB on behalf of the industry.
**T314 Requirements for emergency lighting on passenger rail vehicles**

**Description**
This project has defined specifications for effective emergency lighting on rail vehicles, to encourage appropriate behaviour from passengers, and facilitate evacuation in the rare circumstances where it is required.

**Abstract**
Witnesses from recent accidents have highlighted many issues about the lack of effective emergency lighting. Lack of light prevents passengers from being able to see their surroundings so that they can react during an accident, it also inhibits orientation and deployment of first aid afterwards. This research investigated the fitting of emergency lighting in passenger carrying vehicles and determined how it should be specified. The work identifies locations that need to be illuminated, the levels of illumination required and the duration over which lighting should be available. The research confirms that technology is currently available that can deliver these levels and can survive the shock of an accident. It concludes that there are significant benefits that may well justify the fitting of emergency lighting to existing rolling stock. An industry code of practice has been developed to give guidance to train operators, owners, and builders on how to fit suitable emergency lighting. This code of practice has been validated and is being used to inform revisions to standards.

**Published**
December 2007

**Current Position**
The research recommended amending the current Railway Group Standard GM/RT 2176 Air Quality and Lighting Environment for Traincrew Inside Railway Vehicles, to address the issues concerning emergency lighting after a train incident.

However, GM/RT 2176 issue 1 (December 2005) was superseded by GM/RC 2531 issue 1 Recommendations for Rail Vehicle Interior Lighting (June 2008), which has new guidance for section 6 ‘Lighting Environment’.

Overall, the results of this research are useful information in the development of Technical Specifications for Interoperability and European standards.
### Description
The project provided further understanding of the causes of on-board accidents resulting from vehicle/track interaction, and assessed actions required to mitigate the risk.

### Abstract
A review of risk arising from the interaction between the wheel and rail identified three main groups of risk; derailment, collision (due to braking problems associated with low adhesion), and on-board accidents caused by train movement. Although collisions and derailments tend to be high-profile events receiving much investigation and attention, the risk associated with on-board accidents was found to be 4.16 fatalities and weighted injuries (FWI) per year, which is greater than the combined risk of the other two groups. These on-board accidents affect both passengers and staff and whilst there tend to be no fatalities, a significant number of minor injuries have been reported. The research reviewed these incidents and how they were reported to determine the major factors that contribute to the overall risk. It also made recommendations on how these risks are mitigated and on how both the Safety Risk Model and Safety Management Information System can be improved to capture better data surrounding these incidents.

### Published
January 2010

### Current Position
As a result of the research the RSSB Safety Risk Model has been updated twice, to provide enhanced information to industry on the extent of the risks.

The output from the work has been shared with the key stakeholder groups including at industry workshops and the guidance has been issued to them to use and implement as necessary.

The detailed work underpinning this research is available to duty-holders on request.
T399  Review of human factors risk in rail vehicle maintenance and inspection

**Description**
This research aimed to identify human factors related safety risks, risk reduction strategies, and options to minimise the cost associated with errors in rail vehicle maintenance and inspection.

**Abstract**
Rail vehicle maintenance has received less human factors (HF) input in comparison with other sectors (aviation) or other areas of rail safety. It was also believed that, although HF related issues are tackled informally, there is less evidence of a formal process for applying good practice.

The project focused on current good practice related to human factors in maintenance and inspection (M&I) from other industries and national/international railways. The human factors methods identified were tailored for use on rail vehicles and used to conduct two case studies which helped to validate current M&I practices and identify methods for reducing the impact of human error on the tasks.

This research provides a guidance tool to help apply the recommended systematic approach. The guidance package is available on the RSSB website.

**Published**
January 2008

**Current Position**
The toolkit has now been published on the website and is included in the Human Factors online library (www.rssbhumanfactorslibrary.co.uk). A follow on research project T774 Research into the effects of human factors in axle inspection is in progress in the Vehicle/Track Interaction topic area and will consider the human errors associated with the axle inspection process.
T422 Completing the set of passenger train safety signage to improve legibility and comprehension

Description
This research designed and tested a set of pictograms for use in safety signage on passenger trains. The symbols supplement those that were delivered by an earlier project.

Abstract
Previous RSSB research projects (T052 and T246) have considered train evacuation and signage issues. In T052, a large proportion of the safety signage used in passenger trains in Great Britain was optimised using internationally recognised best practice. The resulting signage is more legible and more easily understood, by a wider range of passengers, and in a wider range of conditions, than was the case for earlier types of signage. 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. This research produced the remaining signs that were necessary to complete the set. Twenty-two pictograms were identified through consultation with the industry and developed using the process defined and used previously in project T052. The new signs will be incorporated into ATOC’s extranet and used across the fleet.

Published
May 2006

Current Position
This work enabled the addition of the new safety symbols to the set of graphics and symbols developed in T052a Improvements to safety signage on passenger trains and T246 Development of common passenger safety signs. T129 Design study for emergency exit on Mk III vehicle windows also benefitted from this series of research projects. The guidelines and symbols developed in these research projects are available to RSSB members on request.
**Description**

This work has identified the performance requirements for windows, which have taken into account the conflict between the need for them to contain passengers during accidents, and their potential role as a means of evacuation after accidents.

**Abstract**

The safety role of windows in containing passengers during accidents conflicts with their potential role as a means of evacuation after accidents. This work investigated from first principles what safety functions are required from windows, and how this should influence 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 research established window performance requirements, matched with an evacuation strategy. The research established that windows should work to contain passengers, and that the need for passengers to break windows should not be part of an evacuation strategy.

**Published**

June 2007

**Current Position**

The findings recommend:

- The progressive replacement with stronger (laminated) windows for all passenger-carrying vehicles, except sleepers and light rail.
- The installation of laminated windows (only) for new build.
- The removal of hammers.

The requirements contained in *GM/RT2456 issue 2, Structural Requirements for Windows and Windscreens on Railway Vehicles* have been incorporated into *GM/RT2100 issue 5, Structural Requirements for Rail Vehicles* which was published on 4 December 2010. GM/RT2456 was withdrawn in March 2011.

This research developed a specification for windows that significantly altered contemporary thinking on escape solutions. The adopted specification is for laminated unbreakable windows to be fitted, instead of the existing toughened, breakable type. All stakeholder members, including fire and rescue services, were satisfied with the results. The research led to the establishment of an industry containment strategy that includes the phasing out of emergency hammers in passenger trains.
This research investigated the welded joints of a vehicle that was involved in the Ladbroke Grove rail accident to provide a benchmark for joints in this class of aluminium rail vehicle.

This research investigated the welded joints of the Class 165 diesel multiple unit that was involved in the Ladbroke Grove rail accident. Using knowledge from the European funded project ALJOIN, the research conducted mechanical tests, metallographic investigations, impact tests, and fracture mechanics tests to establish the characteristics of the welded joints and provide a benchmark for joints in this class of aluminium rail vehicle. The findings indicate the criticality of the tear resistance of the grade of aluminium and the weld design in improving crashworthy performance under dynamic crash loads. The research confirms the inherent weakness of partial penetration welds under dynamic crash loading and endorses the use of Al-Mg filler wire, now commonly used in rail vehicle construction. Recognising that even this would be insufficient to resist dynamic tear in a high speed collision, the research promotes weld over-matching (see project T035) as a means of dissipating energy in the structure so that welded joints cease to be a key determinant of vehicle structural integrity in the event of high-speed collisions.

February 2008

The design recommendations from this European project were incorporated into the latest issue of EN 15085-3 Railway applications - Welding of railway vehicles and components - Part 3: Design requirements that was published in November 2007.

These are now being used by rolling stock manufacturers introducing new rolling stock to Great Britain.
T530  Review of train headlamps’ optical requirements

Description  The optical performance of train headlamps was investigated, and their current acceptability determined. The findings were used to develop a specification for possible tests, to determine the optimum optical characteristics for headlamps.

Abstract  On behalf of the Rolling Stock R&D Stakeholder Group RSSB has completed this research project to investigate reports of glare from train headlamps.

The functional requirements for train headlamps are to provide visual warning to persons on the lineside and assist drivers reading certain lineside signs. In doing so, headlamps must not cause excessive glare to other train drivers. This project has reviewed historical and current developments in train headlamp optical requirements, and investigated day-time and night-time threshold brightness / visibility capabilities and glare limits. Consideration was also given to the existing requirements of Railway Group Standards and emerging Technical Specifications for Interoperability. A series of workshop sessions was held to determine the acceptability of existing train headlamps to drivers and trackside staff. The findings of these activities were used to develop a specification for laboratory and field tests, which can now be used by industry members to determine optimum headlamp characteristics.

This research has shown that a mis-match has developed between the optical properties of train headlamps (as currently specified in GM/RT2483 Issue 1) and their functional and performance requirements. Consequently, the adoption of the Performance Requirements Specification developed in this project is recommended. The alignment of the final version of prEN15153-1:2009 with the project recommendations will be monitored by the relevant CEN/TC 256 Working Group.

Published  February 2010
The research has shown that glare is still an issue, with 11 of 22 train companies consulted indicating that drivers see headlamp glare as a problem.

Headlamps are necessarily very bright, and achieving the balance between delivering sufficient brightness for visibility and controlling glare is difficult. This research has shown that a mis-match has developed between the optical properties of train headlamps (as currently specified in GM/RT2483 Issue 1 Visibility Requirements for Trains) and their functional and performance requirements. Consequently, the adoption of the Performance Requirements Specification developed in this project is recommended.

The proposal for a standard as per the recommendations was endorsed by the Rolling Stock R&D Stakeholder Group (RS R&D Gp). A vote to approve a revised version of the EN, which includes key elements of this research, closed September 2012. Currently, the outcome of this vote is pending. If positive a revision of the standard (GM/RT2483 Issue 1) will commence.

Standards around eye-sight testing for train drivers align with the DVLA requirements. RACOP GO/RC3651 Recommendations for Train Movement - Staff Suitability and Fitness Requirements provides guidance to railway employees for meeting the requirements of GO/RT3451 Train Movement - Staff Suitability and Fitness Requirements and includes a comprehensive appendix on laser eye surgery.
### Description
RSSB on behalf of the GB rail industry provided technical expertise and project managed some work packages in an EU 6th Framework programme project that set out to identify and define the requirements for a Euronorm on interior crashworthiness for passenger safety.

### Abstract
Interior crashworthiness is a key feature in determining passenger survivability in accidents. The requirements for mainline railways in Great Britain are specified in AV/ST 9001 Vehicle Interior Crashworthiness and Railway Group Standard GM/RT 2100 Structural Requirements for Railway Vehicles, issue 4. However domestic standards are being superseded by their European equivalents under the authority of the interoperability regulations and the Technical Specifications for Interoperability (TSI) to which they refer. The TSIs remain silent regarding interior crashworthiness for passenger safety although a subsidiary Euronorm is expected.

The EU 6th Framework SafelInteriors project consortium undertook work to identify and define the requirements for that Euronorm. RSSB was a consortium partner acting on behalf of the rail industry Rolling Stock Research and Development Group.

SafelInteriors aimed to identify and define the requirements on interior crashworthiness for passenger safety by providing the technical background for new feasible passive safety interior solutions and recommendations on occupant protection. This included new evaluation techniques, test methods, measuring devices, and design methodology.

The project had six work packages comprising one for management and dissemination and five technical work packages:

**Work package 2 - Framework for rail vehicle interior passive safety.** This was led by RSSB and has developed a framework for identifying rail vehicle interior passive safety measures.

**Work package 3 - Rail injury criteria, measuring and testing.** This researched biomechanical criteria to limit collision loading and acceleration on the human body to aid improvement of relevant vehicle features design.
Abstract cont.

Work package 4 - Functional specifications for interior equipment. This considered operational, commercial and sociological requirements and the influences that these have on vehicle interior configurations.

Work package 5 - Interior Design and Validation of identified configurations. This undertook physical dynamic testing of current vehicle interior components and developed baseline data to inform the virtual modelling and testing of vehicle interior configurations and components.

Work package 6 - Synthesis and recommendations for standards. This is the compilation of the main results and overall conclusions.

The project was completed in August 2010.

The project synthesis report makes proposals for the development of regulations to improve the passive safety of European rail vehicles. It identified some areas where further work would be beneficial.

RSSB has updated Railway Group Standard GM/RT 2100 Requirements for Vehicle Structures (Issue 4 published 4th December 2010). The specific requirements for interior crashworthiness and occupant protection are aligned with the project findings.

UNIFE and UIC are leading the Technical Recommendations Study Group for interior crashworthiness requirements for occupant safety. This process will involve assessment of the suitability of the results and proposals for standardisation. The outcome from this work will be a voluntary Technical Recommendation for rolling stock interiors passive safety. This is to help address the proposal for regulations to improve the passive safety of European rail vehicles. It is anticipated that this will eventually lead to a Euronorm on interior passive safety.

The group will consult with train operators within Europe.

Published

December 2010
In conclusion of the work completed by the research project consortium, proposals for development of regulations to improve the passive safety of European rail vehicles have been made. The Technical Recommendations Study Group led by UNIFE and UIC has started the process for developing the interior crashworthiness requirements for occupant safety using. The outcome from this work will be a voluntary Technical Recommendation for rolling stock interiors passive safety.

ATOC has updated its members advising what this research project was about, what was done, and what the key findings were noting many of which are for further work, and may already seem familiar to the GB railway.

RSSB has updated Railway Group Standard GM/RT2100 Requirements for Vehicle Structures (Issue 5 published 2 June 2012). The specific requirements for interior crashworthiness and occupant protection set out in Part 6 are aligned with the SafeInteriors project findings.
### T634  An analysis of potential fuel tank solutions

<table>
<thead>
<tr>
<th>Description</th>
<th>This research assessed and proposed solutions for burst panels and inserts for fuel tanks. It was developed in response to recommendations from research project T120 Review of measures to reduce risk from passenger train fuel tanks.</th>
</tr>
</thead>
</table>
| Abstract    | One of the major hazards of the Ladbroke Grove accident in 1999 was fire caused by spilled diesel fuel. One of the recommendations of the subsequent accident inquiry was to consider the redesign of fuel tanks in order to reduce the likelihood of the release of fuel under pressure.  

This research has assessed the most viable options from project T120, fitting and retro-fitting burst panels to fuel tanks on passenger trains. It has also provided a report on the assessment of risk from the use of burst panels.  

The research comprised a risk assessment and a cost-benefit analysis of the operational issues and safety benefits. This has provided the basis for an industry decision about whether further research is needed on the design of burst panels for fuel tanks in both existing and future build rolling stock. The costs have been found to significantly outweigh the safety and economic benefit that would be provided; the industry stakeholder group, the Rolling Stock Research and Development Group considered the results of the work and concluded that there is no justification to progress the project further. |
| Published   | April 2009                                                                                                                                  |
| Current Position | The research concluded, as a result of a cost benefit analysis, that none of the design solutions from project T120 Review of measures to reduce risk from passenger train fuel tanks would be viable for development.  

The rail industry has agreed no further work is required. |
**T676  Development of a rolling stock whole life cost model**

**Description** This project aimed to provide a decision support tool, the rolling stock whole life cost model, that describes all rail vehicle parameters and their impact in terms of cost. It was designed to assist with top-level design, and to support strategic decisions regarding new rolling stock and major refurbishments.

**Abstract** The Vehicle/Vehicle Systems Interface Committee (V/V SIC) identified the opportunity for the development of an industry standard rolling stock whole life cost model (RS-WLCM) that could be used by the GB rail industry. The RS-WLCM was intended to provide a decision support tool to assist with top-level design and strategic decisions regarding the whole life costs and associated risks regarding new rolling stock and major refurbishments.

The project was scheduled to be completed in two phases. The first involved the identification of the requirements and features leading to the development of a prototype model. The second phase was to convert the model and the algorithms into a suitable package, with enhanced functionality and improved user interfaces, and for the model to complement the Vehicle Track Interaction Strategic Model (VTISM) that is also under development.

The first phase development of the prototype model has been completed and it has been found to have some limitations. The V/V SIC has reviewed the prototype with the intent of progressing with the second phase development; it has decided, however, that there is insufficient justification to progress with improving it or initiating the second phase development at present. As a result, the model will be retained by RSSB in its current form.

**Published** July 2010

**Current Position** The model in its present form is only available to the rail industry via RSSB.

With the support of the Rail Research UK Association a number of feasibility studies are being commissioned that consider various aspects associated with an aspiration of a half cost train.
This research has studied the engineering of brake systems, the role standards play in determining the resultant mass of the system on the train, why they do so, and has identified where they may be challenged.

The role of standards upon the mass of a train’s brake system has been investigated with a review of Railway Group Standards, published and emerging Euronorms, Union Internationale des Chemins de Fer (UIC) leaflets, and Technical Specifications for Interoperability. None of the standards intrinsically affect train mass except that a full-duty friction brake is required where other brake systems, such as a dynamic brake, are used. It is believed that this requirement stems from unreliability of a dynamic brake and the need for the emergency brake to be highly dependable. Modern developments, particularly with permanent magnet traction motors, may challenge this requirement if the dependability can be quantified as being acceptable. This research has shown that there is some potential for mass reduction as a result of challenging standards and technology development.

The results from this project identified a number of possible options of consideration including:

- Performance optimisation development of electric dynamic brakes, under low adhesion conditions, in a similar manner to that of WSPER® for friction brakes.
- Continued support to the development of dynamic braking technology, particularly that of permanent magnet motors, and to quantify the reliability of dynamic brake and compare to current reliability of friction brakes.
- Trials of fibre reinforced ceramic discs.

The cost implications and cost benefits to the industry were not covered in this research. Whilst a cost benefit analysis of each option may assist in identifying which priorities are viable for follow-up, a number of these have been considered in research that has been completed, or is in development, including:

- T712 Research into trains with lower mass in Britain
- T860 Benefits of all-electric braking
**T688  Technology transfer for reducing vehicle mass**

**Description**
This research aimed to develop an understanding of the currently available technologies and how they could be implemented within the rail industry in order to reduce vehicle mass, and thus traction energy demand and track damage.

**Abstract**
Vehicle mass is a key influence on the sustainability of rail because of its impact on track damage and traction energy costs. Rail vehicles introduced into service over the last decade have tended to be heavier than their predecessors, at the same time carrying fewer passengers. Rail industry members agree that this trend needs to be reversed. This research reviewed currently available technologies and assessed the possibility of technology transfer to rail vehicles in order to reduce vehicle mass. State-of-the-art technology from both foreign rail administrations and non-rail industries was also examined. The research identified technologies that are transferable, and which activities would be required to transfer them, potential risks and impediments, an estimate of the investment involved, and the benefits that could be realised.

**Published**
February 2008

**Current Position**
Several projects are contributing to research into cost savings through reduced vehicle mass:

- **T676 Development of a rolling stock whole life cost model**
- **T712 Research into trains with lower mass in Britain**

This further research has established the financial value of weight in rolling stock and will help justify the case for determining a way to encourage technology-driven development that will lead to a significant reduction of damage to the track infrastructure that is caused by the weight of trains and reductions in the whole life energy demand for trains.
This research aimed to study and quantify the benefits to the rail industry and the environment of using environmentally friendly toilet systems that continuously clean and recycle water.

This research investigated the use of water recycling technology for train toilets to establish the benefits of using this environmentally friendly technology. Benefits identified included the possibility of reducing vehicle mass and water consumption. Another potential benefit from reduced water consumption that was identified was the potential for increasing the time between depot visits, which would help to reduce operating costs. The research also quantified the feasibility and associated costs of implementing water recycling technology. The results showed that, on applying this technology, the financial savings from water consumption would be low when compared to the operation and maintenance benefits. The approach taken was from the general perspective of optimising toilet provision on trains rather than facilitating development of an individual manufacturer’s product.

Published
February 2008

Current Position
This subject area is new to the GB rail industry. Whilst there are some benefits from implementation, appropriate standards are still lacking in this area and the technologies used elsewhere are untried in Britain.

Progressing the proposed next steps has not been considered a high priority for the industry but will be reviewed on a regular basis owing to the potential benefits associated with lower weight, lower water use and reduced energy consumption.
# T712 Research into trains with lower mass in Britain

## Description
Reduced infrastructure maintenance and energy saving costs may be achieved by reducing train mass. This strategic project evaluated the value (benefit) of mass reduction from a train in monetary terms, and will enable rolling stock Specifiers to use these values in the procurement of new rolling stock.

## Abstract
There is no consensus on a quantified value of the benefit of reducing vehicle mass. This creates great difficulties for those designing and specifying trains. This is because there is no yardstick for deciding where a manufacturer should invest in new technology, or what vehicle features to include in a specification.

On behalf of the Vehicle/Vehicle Systems Interface Committee, this strategic research has evaluated the value (benefit) of mass reduction. The potential impacts of lower mass on industry costs through reduction of the impact of the vehicle/train on the track and through energy costs were analysed. There are many factors that influence the wheel/rail interface. This project considered the effect of a series of weight reductions from existing reference vehicles. This determined if vehicle mass reduction could reduce infrastructure maintenance and energy consumption. The assessment used a set of reference scenarios agreed with the industry. The agreed values and resulting benefits will now enable appropriate strategic decisions to be made by the industry and regulatory bodies.

## Published
August 2010

## Current Position
The stakeholders have developed and proposed a wide range of scenarios comprising various routes and train classes, in order to develop a representative value of train mass reduction. This will enable industry to evaluate what the actual benefits of such reductions will be, in terms of track damage and energy consumption. The research was presented at the World Congress on Railway Research 2011.
### Description
This research examined how reliable passenger trains could conceivably be in the future, the barriers to achieving this, and how future reliability might be measured. It was a strategically focused project and will now help inform future transport policy.

### Abstract
To sustain increased demand in system capacity, reliability, and sustainability a greater level of confidence to complete the journey is required. This research therefore considered future rolling stock reliability to help inform future transport policy, to aid industry decisions about how reliable trains could be, and to determine ways of specifying and monitoring trains to deliver better reliability.

The research drew together four different perspectives on reliability: a GB rail industry review, an international rail industry review, outside industry comparison with the aviation and automotive industries, and a human factors survey. The project culminated in an industry event, with representation from organisations involved in all stages of a train's life.

The research identified three strategic areas for further consideration by the Technical Strategy Advisory Group (now the Technical Strategy Leadership Group), along with a number of deductions of a more tactical nature for consideration by the Vehicle/Vehicle System Interface Committee.

### Published
January 2009

### Current Position
Following a review of the research findings, industry has asked TSAG, ATOC, and the DfT to lead on the following issues:

1. Understand how rolling stock reliability interacts with overall system reliability, ie, what the passenger sees.

2. Establish an integrated approach to reliability which requires all players to work individually and collectively to facilitate improved reliability; and impress upon all levels of government and industry the importance of reliability as a key issue.
3. Create a stable feedback loop for reliability growth through:
   - A stable procurement cycle
   - Transparency and availability of data
   - An even pace of innovation that balances risk with the need to enhance the product offered to the public

Further research has been completed in T935 Making the case for a whole system strategic approach to reliability improvement and a follow on piece of research considering a case study on the Brighton Mainline is being developed for the Technical Strategy Leadership Group.
Description

An assessment of how and why GB standards are different to the US Federal Railroad Administration’s rule on passenger safety regarding emergency evacuation, rescue and communication systems. This research also took into consideration the European Technical Specifications for Interoperability (TSI) and UIC (International Union of Railways) documents.

Abstract

In January 2008, the US Federal Railroad Administration (FRA) issued a new rule for train emergency systems. This requires all passenger cars to be equipped with two communication systems that aid both crew and passengers during an emergency and escape. The rule also requires rescue access windows at all levels within the passenger seating area and that the roofs of all new passenger railcars must be equipped with emergency access locations.

On behalf of the Rolling Stock Research and Development Group, this research reviewed the FRA rule and supporting information, including European Technical Specifications for Interoperability and UIC (International Union of Railways) documents in order to understand what might be learned from this in a GB context. The research established how and why the current approaches to emergency provision in the design of passenger carriages in the US and GB differ, and provided a report summarising the findings. The Fire Service College, Moreton-in-Marsh, was also approached to reaffirm its position concerning the emergency access requirements for rail vehicles in GB and the equipment at its disposal.

The results of this research enabled the GB rail industry to review the existing industry evacuation and emergency rescue strategy in light of the FRA rule, and allowed the rail industry to confirm there was no justification to amend the GB position on containment or to revise the provisions in Railway Group Standards. More specifically the research identified how and why the US had arrived at their ruling and why it was particular to the US railway and not applicable to GB.
### T814 Review of US requirements for passenger train emergency systems and their relevance to GB cont.

<table>
<thead>
<tr>
<th>Published</th>
<th>September 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Position</strong></td>
<td>On behalf of the rail industry, RSSB will continue to share this and other related research with European partners, so that it can be considered when formulating any new TSIs and so that appropriate amendments to the existing TSIs can also be considered. This includes sharing the lessons learnt from emergency access trials in GB and relaying them to other countries. RSSB will also continue to work closely with the Fire and Rescue services.</td>
</tr>
</tbody>
</table>
This research tested the hypothesis that the noise performance of GB rolling stock fleets has improved over time, and is continuing to improve. The results will be considered as possible evidence to demonstrate compliance with the European Noise Directive.

The European Noise Directive places a requirement on the GB railway industry to participate in the production of Noise Action Plans to demonstrate evidence of active management of noise issues. It is envisaged that, at the strategic level, it will be possible to cite initiatives and regulatory compliance activity that is already under way, in support of these plans. It may also be possible to claim credit for improvements already complete.

Following a desk top exercise of analysis and generic traffic scenario modelling based upon existing data, there is now evidence to support the hypothesis that the noise performance of GB rolling stock fleets has improved over time, and is continuing to improve. It is now considered beneficial that the GB rail industry can demonstrate how current rolling stock fleets compare against current, recent past, and projected new rolling stock. The production of a 'noise trajectory' for the GB rolling stock fleet will now inform the debate on the need for, and cost-effectiveness of, further noise mitigation.

February 2009

The research reinforces the position of continuing to work towards noise mitigation, as required by the Noise Action Plans, and to comply with future potential updates to the noise TSI.

The results of the research are being used principally by DfT and ATOC, and also the Welsh Assembly, Scottish Executive and Defra.

The research has also been referenced in the Definition Consultation document, issued in late 2009 by Defra and is supporting T1008 Research into Noise Action Plan ‘Important Areas’ to provide a rail industry response to DEFRA.
T843  Assessment of TS 45545 fire testing regime for GB conditions

Description
This research project examined European standard TS 45545 relative to British and Railway Group Standard fire testing regimes and identified the implications and potential consequences of adopting the European rolling stock fire standard.

Abstract
It is intended that the CEN/TS 45545 is developed into EuroNorm 45545 and through the Technical Specifications for Interoperability (TSIs) adopted as the standard for railway vehicle fire safety throughout Europe. On behalf of the Rail Industry Fire Forum, a sub-group of the Vehicle/Vehicle System Interface Committee, this research identified the impact on the GB rail industry in changing from GB standards such as British Standard 6853 and Railway Group Standards GM/RT2130, but in particular with relation to BS 6853.

The research involved testing of key elements of train interiors against both the European and British testing regimes. For BS 6853 categories 1a, 1b, and 2, typical compliant materials or sub-assemblies were selected and re-tested according to TS 45545 part 2. This involved samples of floor, side wall and ceiling, and seating. In addition, materials believed to be permissible under TS 45545 which were presently excluded by GB standards, were included, if appropriate, in the test programme.

This research project produced an impact assessment for adopting TS 45545-2 material testing. This was based on changes in fire performance, implications for vehicle safety and the economic impact in terms of both material testing costs and manufacturing costs.

The research findings have enabled the GB rail industry to take an informed position in discussions on the proposed EN and make robust inputs to the process by feeding the results from the testing into the Joint Working Group of the CEN/CENELEC responsible for formulating the TS. It also helped the rail industry to identify changes that may be required to meet TS 45545, thereby allowing the industry to fully understand the implications and prepare for the introduction of the new standard. The EN is due to come into force from 2012 onwards.
Published  
September 2011

Current Position
The project demonstrated that the CEN/TS 45545-2 smoke density and flammability tests do not appear to differentiate between good and bad passenger seats in the same manner as BS 6853. Given the concerns highlighted in this research around passenger seat assessment, RSSB is delivering further research to assess alternative fire testing regimes. This research is T1018 Assessment of rail vehicle seat fire testing.

The research will enable the industry to respond from a position of knowledge to any proposal to adopt CEN/TS 45545-2 as a EuroNorm, and to understand potential consequences when the new standard comes into effect.
T857  Detailed review of selected remote condition monitoring areas

Description
A comprehensive review of a number of remote condition monitoring (RCM) areas to assist the industry with making more informed operational and development decisions for current and future RCM systems.

Abstract
Currently a range of track side and train-borne condition monitoring systems is used to measure various rolling stock and infrastructure component conditions. In the main, these systems inform on a ‘fault’ condition and provide a ‘go/no go’ indicator. They do not generally provide an indication that the component is deteriorating towards its fault condition. Identified faults invariably require immediate attention, with associated disruption to operations and/or maintenance schedules.

Condition monitoring forms part of the overall management and control of the in-service risk to the network from particular hazards, such as the failure of an axle journal bearing. These failures may also have a significant impact on service performance. Making the business case for changes to the equipment, the technology, the methods used, or other innovation is difficult, and often stifles the introduction of more appropriate and cost-effective ways of continuing to manage the risks and performance.

On behalf of the Cross-industry Remote Condition Monitoring Strategy Group, a sub-group of the Vehicle/Vehicle System Interface Committee, this research project reviewed selected current condition monitoring areas and quantified the safety and performance benefits, and associated costs. It also provides the industry with key information to construct secure business cases for improvements to or replacement of existing methods and systems and introduction of new technology and procedures.

This research assessed six areas of condition monitoring assuming that the appropriate RCM system, communication architecture, and enabling technologies, such as that for automatic vehicle identification, are in place.
The six areas were:
- Axle journal bearings
- Wheel impacts loads
- Pantograph integrity
- Overhead line integrity
- Vehicle ride monitoring
- DC third rail geometry and power

The first three are track side systems that monitor rolling stock components, the fourth and first part of the sixth are train-borne systems measuring an infrastructure component and the fifth and second part of the sixth are train-borne systems monitoring vehicle characteristics.

The results have shown there is a business case for exploiting RCM technology in the areas considered by this research. The work also aligns with the eight principles of RCM strategy and supports the vision of the DfT White Paper to improve the industry knowledge of the state of its assets.

Published
September 2012

Current Position
The Cross-industry Remote Condition Monitoring Strategy Group will take forward the following recommendations to progress the thinking, development and/or communication of:
1. The Cross-industry Remote Condition Monitoring Strategy Group along with the wider rail industry will review the outputs from this initial study to determine if the resulting business cases for the RCM system specified are strong enough to warrant further investigation of the use of those systems.
2. If further investigation of any specific RCM systems is deemed necessary, the business cases should be reviewed in more detail, focusing on the benefits that can be achieved through improved maintenance planning based on the outputs of the RCM system under consideration. The business case analysis for those specific RCM systems should be refined by:

   a. Applying failure mode, effects and criticality analysis to (FMECA) to identify the key functional failures and consequences for critical assets.

   b. Defining the routine asset management processes that could be rescheduled, reduced or eliminated if the identified condition data was available.

3. The necessary data requirements should drive the specification for RCM system development. These systems specifications should be functional and not overly prescriptive.

4. Suppliers of RCM equipment should be engaged early in the specification and development process to encourage innovation.

In addition, in order to support the above the Cross-industry Remote Condition Monitoring Strategy Group will consider:

5. Provision of frameworks for capturing cost and failure information against the identified failure modes to build industry-wide models of degradation.

This research has also been used by the Cross Industry RCM Strategy Group in support of T986 - Cross interface remote condition monitoring - acoustic bearing monitoring case study and will be further developed in the current T1010 - Cross-industry remote condition monitoring programme phase 2 research.
This research tested the ability of pre-privatisation designed windows, in particular hopper type windows, fitted with laminated glass, to provide containment.

Previous RSSB research work on the requirements for train windows was focussed on Mk III vehicles and forms the basis of the containment requirements for GM/RT 2100 Issue 4. This previous work did not consider the variety of mounting arrangements or the potential safety benefit of laminated glass to openable 'hopper' window designs. Hopper windows, as distinct from plain windows, may be more difficult to bring up to the new standard for containment using laminated glass owing to the lower support offered by the hopper glazing bar on the main window.

The research, on behalf of the Rolling Stock R&D Group, was conducted in three phases. The preliminary phase involved a series of containment tests on full size windows. Following this, a group of suitable representative windows were tested against the containment tests detailed in GM/RT2100 Issue 4. This was done to assess the effects of window mounting arrangements and the extent of any safety benefit from installing laminated glass in hopper style windows. A final phase of tests was then conducted, again with a group of representative windows, but with differing thicknesses of laminate interlayer.

The previous RSSB research project T424 Requirements for train windows on passenger rail vehicles provides evidence that using a toughened glass construction will not offer any containment. Windows of this type fail the impact test, the first of the three stage containment test requirements. The overarching conclusion from this research is that fitting laminated glass to existing vehicles will give a very considerable improvement in performance and offer a level of containment. In accordance with the agreed industry containment strategy, replacement laminated glazing should continue to be fitted to all vehicle types. The results from this research project have also supported minor corrections to GM/RT 2100 (Issue 4) about the containment test specifications and procedures.
The findings from this research and from T424 have been incorporated into GM/RT2100 Requirements for Rail Vehicle Structures, issue 5, published June 2012. Test procedures have been developed and trialled for containment testing.
The research work on railway vehicles interior crashworthiness, completed since 1989, is dispersed within the industry. This means that it is not easy to appreciate where there are good records or knowledge gaps, and the potential for repetition of effort is high.

Assembling all the related material in a single body of knowledge, accessible from RSSB, makes this available and easier to draw benefit from.

Extensive train crashworthiness research has been undertaken since the Clapham rail disaster in December 1988. The research gained further impetus in the wake of subsequent accidents. Many principles have been established from this work, which defines the current standards and design best practice for vehicle interior crashworthiness. With changes to organisations, many of the research reports and supporting data have become inaccessible and are at risk of being lost to the industry. The majority of the reports and supporting data is held by British Rail successor organisations.

On behalf of the Vehicle/Vehicle System Interface Committee, this research establishes a one-stop shop approach to capturing all the pertinent crashworthiness data in one place.

GB railway needs to ensure that a comprehensive, historic understanding is achieved of why and how the crashworthiness standards evolved. This will now help to ensure that future research can be precisely targeted, avoiding duplication of past work. It will also help to ensure that European projects can be robustly supported, and GB’s position warranted and understood.

The information held by particular successor organisations has been examined and reviewed by RSSB’s appointed technical expert. Précis’ of relevant interior crashworthiness research areas, and an easily searchable catalogue of the research projects, have been published. The deliverables now provide a ‘history’ that describes the information that has led to the current standards and design best practice for vehicle interior crashworthiness.
## T910 Review of railway vehicle interior crashworthiness research 1989-2009  
### Abstract

This benefits the industry by establishing the required links and providing a body of knowledge underpinning GB railway’s current standards and best practice. The information will be used by GB railway to precisely target future work in this area and help to avoid repetition of effort. All the related material is accessible from RSSB, thus making it easier to draw benefit from.

### Published

April 2012

### Current Position

This research has identified a significant body of work conducted into the improvement of interior crashworthiness, which will be useful in planning further work programmes or in formulating new standards. The review and output of this research will continue to contribute to the development of European standards in this area. In addition to the output and repository developed from this research project, V/V SIC is considering whether a large number of videos, photographs, informal test house reports, and other items, that were generated during the course of 20 years’ research in this area should also be reviewed and catalogued.
This research advises on the options available to the GB rail industry to minimise or eliminate winter-related coupler reliability issues, based on a review of good practice.

The GB rail industry recognises the importance of improving winter performance as a whole. During the winters of 2009-10 and 2010-11, adverse weather significantly affected the performance of GB rolling stock. In response, ATOC brought together the industry’s experiences of degraded performance.

Coupler reliability was highlighted as an area compromised by snow, ice and cold temperatures, causing a range of coupler-related problems.

On behalf of the Vehicle/Vehicle System Interface Committee (V/V SIC) and the train operating companies (TOC), this research produced a report that looks at current practice and possible solutions. Technical, financial and pragmatic appraisals were made for each solution; and the research identified techniques, strategies and technologies that could be applied to resolve the problems. The consequences of the range of operating regimes, vehicle types, and climatic conditions found across the country that affect the suitability of a particular solution are described. Recommended solutions are made for application to existing and for new-build rolling stock.

Wide and detailed consultation was undertaken with many relevant rail industry parties, including TOCs, coupler manufacturers, rolling stock companies (ROSCOS), weather experts, vehicle manufacturers and maintainers. The research used investigative analysis to further identify problems, and field research to establish good practice from GB and mainland Europe. A detailed review of the nature of adverse weather conditions and processes of reporting was conducted to establish pertinent weather characteristics and forecasting efficiency.

The research findings were presented to the Association of Train Operating Companies (ATOC) Engineering Forum and V/V SIC in July 2011 in order to affect winter preparedness from winter 2011/12.
**T958  Ensuring automatic coupler reliability during ice and snow**

**Abstract**

This included encouraging the utilisation of the Network Rail Seasons Management Team (also known as NRSMT) weather forecasting services. The research findings will now form part of a wider winter preparedness rail industry guidance note that RSSB is producing and also featured at the ATOC Seasonalisation Preparation Seminar 2011.

Industry implementation of good practice will help to improve winter performance of fleets across the GB rail network by reducing the likelihood of train cancellations and delays associated with coupler problems.

**Published**  
December 2011

**Current Position**

Following the presentation of the research findings to the ATOC Engineering Forum, output and recommendations from this research have been disseminated to its members in order to support winterisation preparedness ensuring that all TOCs are encouraged to utilise the NRSMT weather forecasting services. With a consistent approach established, it is possible for the industry to co-ordinate feedback to ensure that forecasting services are tailored to provide the most useful and relevant information. ATOC fully supports this approach and will lead progress in this area.

This research has been incorporated into a wider winter preparedness rail industry guidance note that RSSB is producing this was published in 2012.
T735  TrioTRAIN: Total Regulatory Acceptance for the Interoperable Network

Description
RSSB is a member of the EC Framework 7 project TrioTRAIN consortium looking at ways of reducing the costs and time taken to achieve trans-European rail vehicle certification. RSSB is acting as GB railways representative on the TrioTRAIN steering board.

Abstract
There are three separate TrioTRAIN projects. RSSB’s contribution to these is detailed in research projects T848 AeroTRAIN, T849 PantoTRAIN and T888 DynoTRAIN. Collectively, their aim is to propose innovative methodologies that will allow multi-system network and route approval in Europe to become a faster, cheaper and better process for all stakeholders involved.

The successful implementation of the TrioTRAIN project results will lead to:

1. A time reduction for relevant parts of the certification process from 2 years to 6 months.
2. An 80 % saving in effort for the acceptance of a new vehicle that has already been accepted in a previous country.
3. An estimated potential financial saving of € 20-50 Million per year for the European Community.

The TrioTRAIN projects propose to transfer rolling stock certification work away as much as possible from the current use of physical testing to simulation. Research will aim at developing innovative methods and processes for software-aided certification of vehicles and components capable of reducing the number of physical tests; the overall certification time; the associated costs and the influence of uncontrolled conditions.

On behalf of the Vehicle/Vehicle System Interface Committee, RSSB’s contribution includes shared responsibility for:

1. The ‘Programme of activities’, the ‘Plan for use and dissemination’ and identification of knowledge that could be the subject matter of protection.
2. The Board budget and the financial allocation of the European Commission’s contribution between the various activities.
### T735 TrioTRAIN: Total Regulatory Acceptance for the Interoperable Network  cont.

#### Abstract  cont.
3. Liaising with the TrioTRAIN Advisory Council to make sure that the project findings will at least maintain the level of the system safety, linked with the implementation of the proposed standards. In particular:

- reviewing the progress and outputs of the three TrioTRAIN projects and providing feedback.

- checking that the concepts developed by the three TrioTRAIN projects could be implemented easily into the assessment procedures.

#### Current Position
AeroTRAIN and PantoTRAIN were completed June 2012, and DynoTRAIN is due to complete in June 2013.

#### Published
In Progress
T860  Benefits of all-electric braking

Description  This research project will investigate the benefits of adopting an all-electric brake philosophy on Great Britain’s railway. The research will establish the constraints to be overcome to facilitate this approach, and propose solutions to replace other on-board air systems.

Abstract  Electric dynamic braking on mainline rolling stock has been used as an addition to the primary pneumatic air brakes fitted to vehicles. The electric brake has either been under independent control by the driver, or as part of a blended brake system more commonly found on fixed formation electric and diesel multiple units.

Dynamic brake operation is suspended while the Wheel Slide Protection (WSP) system is active, with only the pneumatic system used. Dynamic brake operation is also suspended during emergency braking, because there are concerns that it is not adequately reliable or fail-safe.

The consequence of this is that the vehicles are mandated to have a fail-safe pneumatic brake system capable of braking the trains from the maximum speed, under all conditions. The pneumatic brake system - compressors, reservoirs, pipe work, control valves, actuators, and brake application devices - contributes about 3% of the mass of the vehicles in a multiple unit formation.

On behalf of the Vehicle/Vehicle System Interface Committee, this research will examine current developments in electric traction braking as a means of reducing the requirement for, or even eliminating, the need for a pneumatic brake system. It will identify the potential benefits to the industry and estimate the likely savings for such electric braking systems.

As well as looking at the technical aspects of an all electric brake system, the research will also consider operational changes and assess the barriers that may affect making the transition. In addition, it will assess the impact on other rolling stock systems that require pneumatic air supply.
### Abstract

The research will support the industry in considering the adoption of all-electric braking on GB railways. It will provide evidence of the potential efficiencies and savings that electric brake systems can provide and how they can be introduced to GB railways.

### Published

In progress

### Current Position

The research deliverables are in the process of being approved for publication by the research steering group and is due to be published and completed in late 2012.
| **T870  Fuel consumption metering for validation purpose** |
|-----------------|-------------------------------------------------------------|
| **Description** | This research project will evaluate the use of a fuel flow meter to measure fuel consumption on DMUs and locomotives. This will enable operators to take informed decisions about design modifications and operational practices to improve fuel efficiency. |
| **Abstract**    | Currently the rail industry is unable to accurately measure and correlate fuel use by train type, route, load, or driving style for diesel multiple units. On behalf of the Diesel Systems Working Group, a sub-group of the Vehicle/Vehicle System Interface Committee, this research aims to establish a process by which fuel efficiency can be accurately measured. An approved automotive flow meter selected for this work has provided promising results during laboratory tests, as part of previous RSSB research into the use of bio-diesel fuel. This project will involve the installation of the fuel flow meter and a telematics facility to capture, record, and test the data, and to establish the reliability of the process. The research will provide industry with installation information, schematics, diagrams, CAD drawings, fitting instructions, technical approvals, operational guidance, and safety documentation. If successful, the rail industry will have a technology and process to accurately measure fuel efficiency that is proven in a railway environment. Train operators will be able to use the results as a template, with minimal additional work, in support of industry objectives to reduce energy consumption and carbon emissions. This should also help reduce train operating costs and contribute to improving the environmental image of the rail industry. |
| **Published**   | In Progress |
| **Current Position** | The settling tank installation and commencement of the three month trials is planned to start late 2012. |
Further use of cross-interface condition monitoring has been suggested as a method of improving the reliability of the railway system.

This project investigates the business case for further cross-interface condition monitoring, using acoustic axle bearing monitoring with automatic vehicle identification as an example.

One of the Rail Technical Strategy’s themes is ‘High Reliability, High Capacity’ which encompasses intelligent infrastructure and intelligent rolling stock with each able to monitor the other and prevent potential failure. There are a number of barriers that have inhibited the wider implementation of cross-interface remote condition monitoring (RCM), including:

- The cost of RCM equipment falls to one party, whilst the direct benefits might be gained by another.
- Data collected from infrastructure-based measuring equipment is not easily attributable to specific vehicles.
- The industry does not have an agreed data sharing architecture with associated interface standards for RCM.
- RCM is cheaper to specify at the design stage but there is no coherent set of guidelines or standards.

On behalf of the Vehicle/Vehicle System Interface Committee this research investigates these barriers, tests eight key principles of RCM developed by the cross-industry RCM group, and will produce a draft business case that will develop a cross-industry RCM strategy.

A case study looking at the use of acoustic axle bearing monitoring (AABM) with automatic vehicle identification (AVI) and the business case for the implementation of AABM with AVI will be assessed and used to inform the analysis.

The deliverables from this work will be a business case assessment for AABM with AVI and the specification for further work needed to develop a wider RCM strategy, including an RCM data sharing architecture, data sharing contractual frameworks and standards.
### T986 Cross-interface remote condition monitoring - acoustic bearing monitoring case study  *Cont.*

#### Abstract  
*Cont.*  
The Rail Value for Money study, 2011, examined the overall cost structure of the railway sector and identified options for improving value for money to passengers and the taxpayer, whilst continuing to expand capacity as necessary and drive up passenger satisfaction. Whole system thinking about reliability, supported by cross-interface RCM is seen as a key element in achieving this. This research also fulfils the aspirations to identify the future needs of the railway over a 30-year planning horizon that are bring reflected in an update to the Rail Technical Strategy.

#### Published  
In progress

#### Current Position  
The research deliverables are in the process of being approved for publication by the research steering group and will be published and completed in late 2012.
T1003 Standardisation of coupling arrangements

Description
This research will look at the benefits and high level technical consideration of standardising coupler arrangements on current GB passenger rolling stock and new trains. This is from a mechanical through to an fully electrical functionality.

Abstract
Passenger rolling stock is now almost universally fitted with automatic couplers however they cover a myriad of types, from the old buckeye and tightlocks, through BSI to Dellner and Schafenburgs. New electric stock has been good at standardising on mechanical aspects by adopting the Dellner as the preferred choice of coupler. There is however almost no standardisation in the electrical connections and virtually all modern stock will only operate in multiple with identical stock thus limiting operational flexibility.

On behalf of the Vehicle/Vehicle System Interface Committee this research will evaluate the benefit of standardising coupler arrangements on all passenger stock to provide at least universal mechanical coupling between trains. Both the practical and economic issues will be considered. The project will also evaluate the benefits and feasibility of providing a standard partial or fully electrical interface for a coupling head.

The project will aim to propose a high level solution and evaluate indicative costs and benefits of the interface if standardised couplers were to be applied across GB fleets. In doing so the research will also aim to provide comprehensive knowledge of relevant developments in coupler standardisation in other railways, Europe and globally; establish whether there is a long term industry business case for achieving standardisation at the mechanical, partial electrical or full electrical levels; define the interface requirements for those levels of standardisation and provide a toolkit to assist the industry in making decisions about where retrofitting is economically viable in order to bridge the gap and achieve compatibility at cascade.
## T1003 Standardisation of coupling arrangements  
*Cont.*

| **Abstract**  
*Cont.* | Through comprehensive stakeholder engagement, research and analysis this research will deliver reports and a toolkit that fully aligns with industry wishes and strategic view. This work will establish what if any action the GB rail industry could take to facilitate the realisation of these benefits alongside those activities underway in Europe. Thus, ensuring maximum engagement and ease to implement agreed next steps. Also, provided the case is made this research will deliver draft technical interface specifications and/or proposals to implement further study, design and/or development of relevant industry standards.  

There are potentially significant benefits available to the industry through standardisation of couplers. These arise from reducing the disruption caused in situations of rescue, and increasing operational flexibility. |
|**Published**  
In progress |
|**Current Position**  
This research is expected to commence in early 2013. |
This research is Phase 2 of the work done over the last year (T986) on producing a scope and business case scenarios (using Acoustic Axle Bearing Monitoring as an example). It aims to develop the enablers for sharing remote condition monitoring data across the industry, identified as part of Phase 1.

One of the Rail Technical Strategy’s themes is ‘High Reliability, High Capacity’ which encompasses Intelligent Infrastructure and Intelligent Rolling Stock with each able to monitor the other and prevent incipient failure. The following issues impede this vision:

- Often the cost of Remote Condition Monitoring (RCM) falls to one party whilst the direct benefits are gained by another.
- Data collected about vehicles is not easily attributable to specific vehicles.
- The industry does not have an agreed data sharing architecture with associated interface standards for RCM.
- RCM is cheaper to specify at the design stage of a project but there is no coherent set of guidelines or standards for project teams to follow.

On behalf of the Vehicle/Vehicle System Interface Committee and the Technical Strategy Leadership Group, the Cross-Industry Remote Condition Monitoring Strategy Group will progress the following areas of work in support of the eight RCM principles:

i. Architecture: The design of a cross-industry RCM data sharing architecture.

ii. Commercial: Business process mapping and the production of a contract framework for cross-industry data sharing.

iii. Standards: Encapsulating the knowledge by listing: the relevant existing standards; proposals for changes to existing standards; proposals for new standards as necessary.

iv. T857 Tool Extension: to include which organisation(s) is/are contributing to the costs, and which is/are gaining benefits.
## Abstract

The Rail Value for Money (VfM) study, led by Sir Roy McNulty (published in May 2011) examined the overall cost structure of all elements of the railway sector and identified options for improving value for money to passengers and the taxpayer while continuing to expand capacity as necessary and drive up passenger satisfaction. Cross-industry remote condition monitoring is a key element in achieving a “whole system” approach to Reliability. This research contributes to the industry’s Rail Technical Strategy, which identified several themes for change, such as “intelligent infrastructure, intelligent rolling stock each able to monitor the other and prevent incipient failure”.

## Published

In progress

## Current Position

This research is expected to commence in early 2013.
T1018 Assessment of rail vehicle seat fire testing

**Description**
This research will look at rail vehicle seat fire testing protocols as used in GB at present and the CEN/TS (now prEN) 45545-2 protocol, identify differences shortcomings and if required provide data for proposals to develop or change the European test.

**Abstract**
Data is required relating to the fire performance of modern train seats to support the development of national GB standards and inform the development of European standards. It is estimated that the current GB fleet alone is fitted with 750,000 passenger seats so even relatively modest changes will in time have a very significant effect.

Proposed European fire standards (EN45545-2) set out fire test requirements which have been shown to have inadequacies in terms of consistency and accuracy of results and at a level of safety such that the results risk diminishing the level of vehicle safety from that currently applied in GB. This was shown in the more general T843 research ‘Assessment of TS 45545 fire testing regime for GB conditions’ and has also emerged from the EU Transfeu programme. There is an opportunity to present proposals for suitable testing regimes that address these issues, for the benefit of not only GB but European railways generally.

The European Rail Agency (ERA) are keen to mandate a common European fire test regime including seats using EN 45545 when published. Unmodified, GB faces the risk that there will be a significant and adverse change in the levels of fire safety in GB rolling stock.

On behalf of the Rolling Stock Standards Committee, the aim of this research is to determine optimised testing arrangements for the fire performance of rail vehicle seats that is representative of the actual environment, provides a level of consistency of results and demonstrates a differentiation of performance across a range of seats tested. It is not intended to challenge the pass/fail criteria of the draft Euronorm, that being outside the scope of this research idea; the aim is to ensure a robust test protocol is incorporated in the final Euronorm.

**Published**
In progress

**Current Position**
This research is expected to commence in autumn 2012
Where can I find research?

All the research outputs that have been published since RSSB began its programme can be found at ‘Research Topics and Projects’:

www.rssb.co.uk/research/pages/researchanddevelopmenttool.aspx

If you know the reference number for the project – eg TXXX – you can use the Search field at the top of the projects list to find it. Alternatively enter a keyword in the Search field to find all the projects with that word in their title.

The previous pages contain listings of the published and current Rolling Stock projects – correct at the time of publication.

We hope this helps you find the information that is most relevant to you.

If you can’t find what you’re looking for, please contact us – enquirydesk@rssb.co.uk
Each Project has a research brief that provides a concise summary.

Research Brief

Review of US requirements for passenger train emergency systems and their relevance to GB
T814 - September 2009

Background

The Rolling Stock Research and Development Group (RSSB) identified apparent differences in emergency preparedness in the USA, stated in the Federal Railroad Administration Rule 49 CFR parts 223 and 238 Passenger Train Emergency Systems and the approach in GB, adopted following the analysis of incident by RSSB and their research concerning the required ‘containment’ properties of trains and glazing systems. The FRA rule, issued in January 2008, requires certain facilities for emergency responders, including structural soft spots in the roof or hatches and emergency access windows. It also requires emergency exit windows for passenger escape and access. These provisions are not required in the same manner for railways in GB.

Aims

This research project:
- Assessed the FRA ruling to see what could be learnt from a GB context
- Established why it is different to the GB ‘containment’ strategy
- Identified the relevant sections of the TSIs and UIC standards, and comment on the measures found in a GB context.

Findings

The results of this project enabled the GB rail industry to review the existing industry evacuation and emergency rescue strategy in light of the FRA rule, and allowed the rail industry to confirm there was no justification to amend the GB position on containment or to revise the provisions in Railway Group Standards.

The research also identifies the differences in the railways in the USA and GB (even in the types of vehicles (for example multi-level vehicles), their operating environments (including the remoteness of some US routes), the construction of vehicles (such as the use of polycarbonate windows retained by zip strips).
Where can I find research?

find it - learn it - share it

SPARK provides a way for the rail sector and others to work together and share knowledge more efficiently on-line, with the aim of reducing duplication, speeding up innovation, and maximising value.

Researchers, innovators, and decision makers across the rail community are able to upload and share information via SPARK so other users can find out what is known and who knows it, and this creates opportunities for networking and cooperation.

In partnership with UIC, RSSB is enhancing SPARK to create an even bigger on-line ‘knowledge sharing community’, drawing on the combined wisdom from railway administrations and centres of excellence from across the globe.

During this enhancement phase, access to SPARK will continue to be available to RSSB members, knowledge sharing partners and registered researchers in the Rail Research UK Association. From early 2013 new access levels will be available, including that of ‘reader’ which is open to all.

Register for access to SPARK at: http://spark.rssb.co.uk

If you have any feedback on SPARK, or experience any difficulties in registering, please contact the SPARK team. Also if you would like to know more or organise a SPARK demo for your organisation, please do not hesitate to contact us. You can reach us at: sparkerussb.co.uk
The RSSB R&D e-newsletter is an email bulletin that keeps the industry updated on the latest research projects to be started or published.

To view the most recent edition and to sign up for your own copy, visit:

www.rssb.co.uk/research/Pages/randde-newsletter.aspx

If you have enquiries about research contact the RSSB Enquiry Desk – enquirydesk@rssb.co.uk, tel 020 3142 5400