



Report on improvements in the safety of passengers and staff involved in train accidents

RSSB
Block 2, Angel Square
1 Torrens Street
London EC1V 1NY
020 3142 5400

The report may be downloaded from the RSSB website: www.rssb.co.uk.

© Rail Safety and Standards Board 2009

Contents

Executive summary		2
1	Trends in train accident risk	4
2	Rolling stock and derailment	7
	2.1.1 Lifeguards and obstacle deflectors	7
	2.1.2 Vehicle crashworthiness	7
	2.1.3 Bogie retention	8
	2.1.4 Coupler strength	8
3	Passengers and staff on board trains	9
	3.1.1 Seat belts	9
	3.1.2 Passenger and crew containment	9
	3.1.3 Drivers' cabs	10
4	How the rail industry learns from experience	12
Appendix 1.	Rail accidents involving passenger fatalities since 1997 and summary of themes arising	15
Appendix 2.	Rail industry research	16
Appendix 3.	Inquiry recommendations addressed	17
Appendix 4.	Bibliography	21
Appendix 5.	Definitions	22
Appendix 6.	Glossary	24

Executive summary

Executive summary

Over the last 10 years, the rail industry has seen extensive changes, including institutional reorganisation, significant growth and further investment.

Sustained improvements in safety performance and risk have resulted from many of these changes, together with the efforts of railway managers and staff to continuously improve. Some improvements derive from the learning that is taken from operational experience and accidents, including the Ladbroke Grove accident of October 1999.

This report:

1. Summarises the overall reduction in risk to passengers and staff from train accidents. Since 2001, the fatality risk to passengers from train accidents has decreased from 2.45 per ten billion passenger kilometres to 0.45 per ten billion passenger kilometres. For staff, the fatality risk per one billion train kilometres has decreased from 5.21 to 1.14.¹
2. Summarises the current position on vehicle crashworthiness, which supports current standards in this area and shows how the last remaining relevant recommendations from recent accidents have been addressed.
3. Summarises the industry position on passenger containment, which favours the use of all laminated glass in future rolling stock and the progressive upgrading of existing long-life rolling stock (which was adopted in 2007).
4. Shows how industry processes enable it to learn from its experience and integrate learning into future standards, designs and strategies.
5. Lists the train accidents that have led to passenger fatalities since 1997 and the issues that have been addressed as part of the industry learning process.

The hazardous events that led to the accidents referred to in this report include infrastructure failure (points, track), signals passed at danger (SPADs) and road vehicle incursion. Many steps have been taken to reduce the risks from each of these event types and the likelihood of their reoccurrence, including:

- The application of better technology, such as the Train Protection and Warning System (TPWS).
- The withdrawal of Mark I coaching stock from the main line network.
- Smarter appreciation of operational safety issues, including a broader understanding of the human factors that relate to driver and signaller behaviour in relation to SPADs.
- Non-rail stakeholders playing their part to protect the impact their activities have on the railway at relevant interfaces, such as the Highways Agency putting in flank protection on road bridges.

¹ These figures are derived from the RSSB Safety Risk Model, which is compiled using pan-industry data, collected through the Safety Management Information System over the last 11 years. Normalisers for these figures have been chosen to best reflect the exposure to risk for each person type.

- A broader execution of a risk-based approach to safety, such as Network Rail's management of level crossings.

These issues are all extensively documented elsewhere. The combined effect of all the actions to manage the risks is to reduce the *frequency* of accidents. The work summarised in Chapters 2 and 3 of this report is focussed on reducing the *consequences* of accidents.

This work includes a review of lifeguards and deflectors, which may provide protection against obstacles on the line, the structural and interior crashworthiness research, passenger and traincrew containment issues, and evacuation and escape strategies. Sources that have been used in compiling this report include the Safety Risk Model (SRM), accident inquiry recommendations, RSSB's database of injuries, risk analyses, industry stakeholder engagement (including the work and outputs from many cross-industry groups that RSSB facilitates) and the outputs from extensive research and development (R&D) activity led by RSSB on behalf of its stakeholders.

In all cases, the work undertaken by RSSB has been overseen by the appropriate specialist stakeholder group from within the industry. Where standards have either been changed or introduced, this has been effected through the recognised industry process, which involves full consultation and ultimately decisions by the relevant cross-industry Standards Committee. Where recommendations from accident inquiries were for research involving rolling stock, the findings of the research and the published research briefings were reviewed and endorsed by the Rolling Stock R&D Stakeholder Group. The findings relating to passenger containment and egress from trains were endorsed by a specially constituted steering group, presented to the Board of the Association of Train Operating Companies (ATOC), and then publicly communicated by RSSB in July 2007.

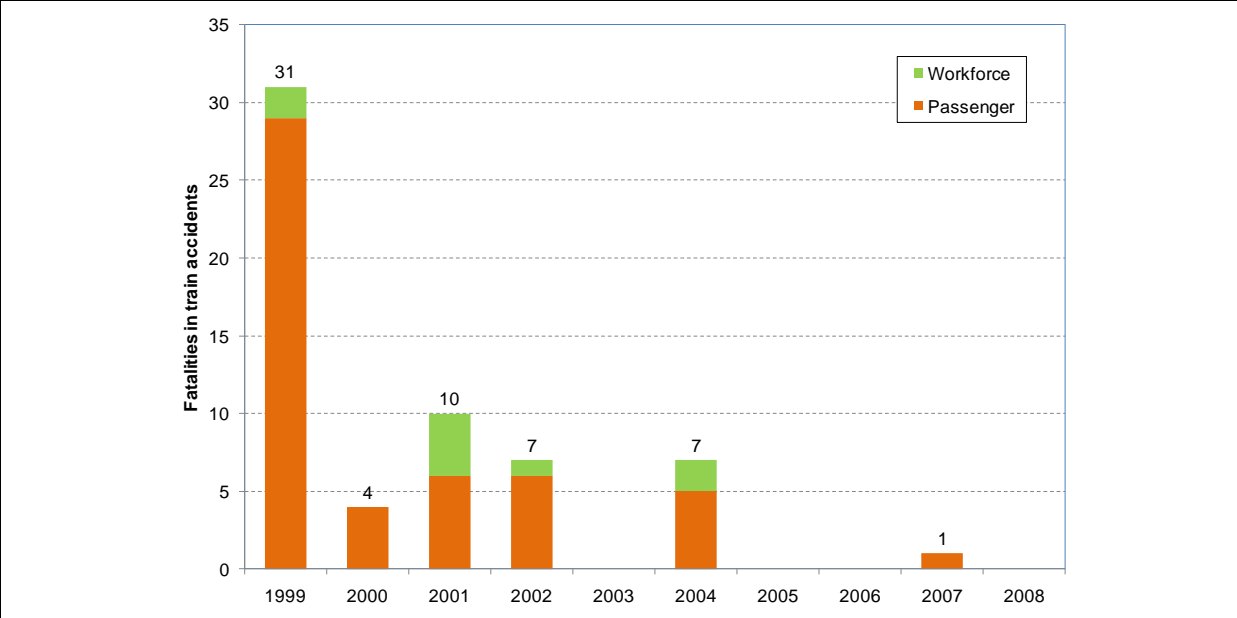
Please note: a list of Definitions and a Glossary of terms are provided at the back of this document.

Trends in train accident risk

1 Trends in train accident risk

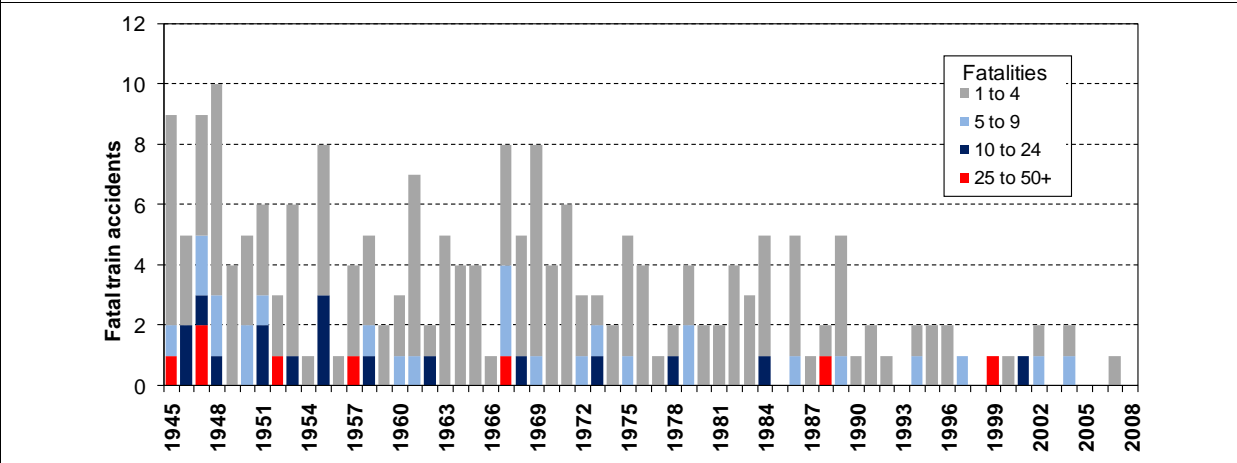
Over the last ten years, 51 passengers and nine members of staff have lost their lives in train accidents.

Chart 1. Passenger and workforce fatalities in train accidents



Train accidents involving loss of life are rare events. Indeed, as the chart below shows, their frequency has fallen significantly over the last 50 years.

Chart 2. Train accidents leading to passenger and workforce fatalities²



Despite this positive downward trend, the rail industry continues to analyse the various factors that can affect the extent of injuries or fatalities when these rare events do happen.

RSSB monitors the impact of the various precursors to train accident risk through the Precursor Indicator Model (PIM).³ The PIM provides an indicator of underlying risk by

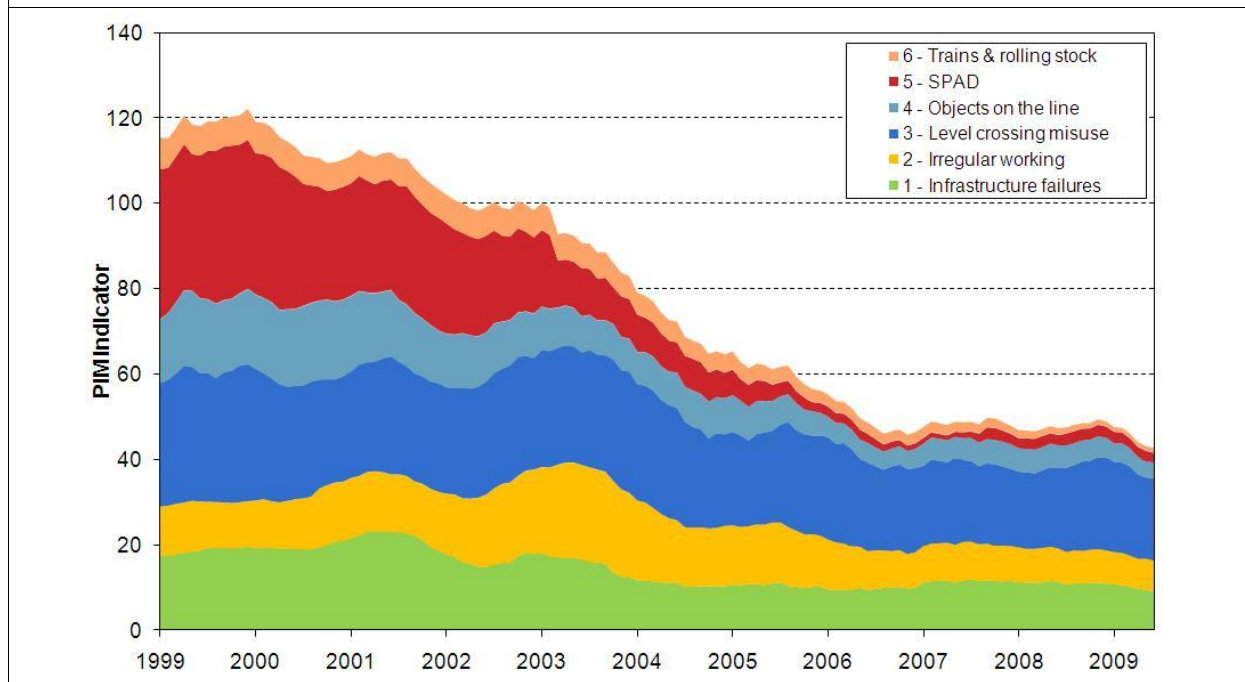
² See RSSB, *Annual Safety Performance Report 2008* (RSSB, 2009), p. 129.

³ See RSSB, *Annual Safety Performance Report 2008* (RSSB, 2009), pp. 139–142 for more information on the PIM.

Trends in train accident risk

tracking changes in the occurrence of accident precursors. The current output from the model is shown in Chart 3.

Chart 3. Trends in train accident risk per the Precursor Indicator Model



The PIM indicator has decreased significantly over the past 10 years. The most dramatic reduction has been in the risk from SPADs. Ten years ago, SPADs contributed the largest element of the PIM indicator value; the most significant contributor to risk now arises from level crossing misuse.⁴

The outcome of the work the industry has undertaken in the last decade, both to avoid accidents happening and to mitigate the effects when they do occur, is an overall significant reduction of the risk to passengers and staff. This is illustrated by the table below, which shows the changes since July 2001 in the modelled frequency of accidents involving different fatality levels (as estimated by successive versions of the SRM).

Table 1. Return periods of train-related incidents leading to multiple fatalities

Number of fatalities (passengers, staff and members of the public)	Time between incidents (years)				
	SRMv2 (Jul-01)	SRMv3 (Feb-03)	SRMv4 (Jan-05)	SRMv5 (Aug-06)	SRMv6 (May-09)
>=5 fatalities	1.4	2.4	3.8	5.3	5.4
>=10 fatalities	3.1	5.6	7.9	9.1	15.3
>=25 fatalities	[not included]	[not included]	[not included]	48.5	50.2

Another way of looking at the risk is to show how the modelled fatality risk has changed for passengers and members of the workforce with each version of the SRM published since 2001 (see Table 2, below).

⁴ Note that the PIM includes the risk to road vehicle occupants who are involved in collisions with trains (for example, at level crossings).

Trends in train accident risk

Table 2. Fatality risk from train accidents since July 2001

SRM version (release date) ⁵	Normalised fatality risk ⁶				
	SRMv2 (Jul-01)	SRMv3 (Feb-03)	SRMv4 (Jan-05)	SRMv5 (Aug-06)	SRMv6 (May-09)
Passenger risk per 10 billion passenger kms	2.45	1.58	0.97	0.72	0.45
Workforce risk per billion train kms	5.21	2.88	1.70	1.52	1.14

For both passengers and staff, the fatality risk has decreased by around 80% in the last eight years.

This remainder of this report focuses on activities addressing the mitigation of effects.

⁵ The release date is later than the cut-off date for the data used in each version of the SRM.

⁶ Normalisers have been chosen to best reflect the exposure to risk for each person type.

2 Rolling stock and derailment

2.1.1 Lifeguards and obstacle deflectors

Lifeguards have been fitted to locomotives and multiple units since the mid-1830s. Obstacle deflectors were introduced by British Rail after the Polmont collision of 1984.⁷ Both serve to help mitigate the effects of obstacles on the track (such as cars, animals or railway assets) and reduce the likelihood of post-collision derailment. Obstacle deflectors are not currently required for high axle-load power cars and locomotives. The inquiry into the Ufton Nervet accident of 2004, however, recommended that retro-fitting to High Speed Train (HST) power cars be considered.

A number of developments subsequently occurred in both Group and European Standards. In addition, a significant research project (T189: *Optimal design and deployment of obstacle deflectors and lifeguards*) looked at potential changes and whether there would be a case for the retro-fitting of obstacle deflectors to HST power cars.

The conclusion from the research and the developed industry position is that both obstacle deflectors and lifeguards should continue to be fitted on the leading ends of new rolling stock. These requirements are included in Railway Group Standard (RGS) GM/RT2100 (*Structural requirements for railway vehicles*), Issue 3 of which sets out the requirements to meet the post-Polmont position. GM/RT2100 Issue 4, which is currently undergoing industry consultation and is scheduled for publication in Spring 2010, retains existing lifeguard requirements and will extend the application of obstacle deflectors to all leading vehicles irrespective of leading axle load by mandating the requirements set out in Euronorm EN15227 (*Railway applications – crashworthiness requirements for railway vehicle bodies*). The Euronorm requirements match the current high-speed technical specification for interoperability (TSI) requirements.

The evaluation of the case for retro-fitting obstacle deflectors to HST power cars found that there is a very high cost to potential safety benefit ratio (ranging from 24:1 to 166:1); it was concluded that such action is not reasonably practicable.

2.1.2 Vehicle crashworthiness

Research examined the importance of effective collision energy management and the benefit of maximising the distribution of collision energy through a train. **It concluded that the contents of EN15227-2008⁸ embody the best available framework for developing and designing future vehicle bodies.**

⁷ This incident occurred when an 85mph push-pull train (lightweight driving vehicle leading) collided with a cow and derailed. Thirteen people were killed and 17 were injured. See Department of Transport, *Report on the Derailment that occurred on 30th July 1984 near Polmont in the Scottish Region British Railways* (HMSO, 1985).

⁸ The objective of the 'passive safety requirements' described in EN15227 is 'to reduce the consequences of collision accidents'. The measures considered 'provide the last means of protection when all possibilities of preventing an accident have failed. It provides a framework for determining the crash conditions that railway vehicle bodies should be designed to withstand based on the most common accidents and associated risks'. See BS/EN15227, *Railway applications – crashworthiness requirements for railway vehicle bodies* (British Standards Institute, 2008), p. 5.

Rolling stock and derailment

2.1.3 Bogie retention

The research considered whether any changes should be made to the design of vehicles to increase or reduce the likelihood of bogies becoming detached during accidents. Following the work undertaken for research project T118 (*Whole train dynamic behaviour in collisions and improving crashworthiness*), and the incremental improvement in designs in recent years, **it is concluded that, to manage the risk most effectively, no changes to the current bogie attachment strength requirements should be proposed.** It should be noted that at Grayrigg⁹, where the rolling stock was designed to the current standard, there was very limited bogie detachment compared to earlier accidents. In the earlier accidents where significant numbers of bogies were completely detached, they contributed to structural damage and levels of injury.

2.1.4 Coupler strength

When two trains impact end on, the coupler force and stiffness characteristics have an important role in how the collision energy is distributed. The management of the collision energy has a significant effect on the outcome of the accident. Whilst a high axial coupler force can be useful as an energy absorption mechanism in low-speed collisions, at high speeds the coupler can generate sufficient yawing and pitching moments to result in derailment. Designers of passenger rolling stock have to consider the conflicting requirements of protecting vehicles in low-speed accidents and preventing derailment at higher speeds. **The findings of the research suggested that a revision to Guidance Note GM/GN2690 (*Guidance on traction and rolling stock – mechanical coupling systems*) could be considered, in order to improve the stability of trains during collisions.** The Guidance Note will soon be obsolete, so these findings are being carried forward to new Guidance Notes GM/GN2686 (*Guidance on bodyshell, bogie and suspension elements*) and GM/GN2689 (*Guidance for mechanical and electrical coupling of rail vehicles*), both of which are undergoing industry consultation and are scheduled for publication in Spring 2010.

Recommendations

Recommendations relevant to vehicle crashworthiness, obstacle deflectors and lifeguards were closed out in September 2009 through the publication of the research briefs¹⁰ for the following R&D projects:

- T118 – *Whole train dynamic behaviour in collisions and improving crashworthiness*
- T189 – *Optimal design and deployment of obstacle deflectors and lifeguards*

⁹ On 23 February 2007, a passenger train derailed at Grayrigg in Cumbria. The immediate cause was deemed to be a set of points which were in an unsafe condition. One passenger was killed, 28 people received major injuries and 59 received minor injuries.

¹⁰ A research brief is a summary of the completed work.

3 Passengers and staff on board trains

In order to maximise survival rates and reduce injuries, research and analysis looked at the means by which people are contained/restrained within vehicles during accidents and the means by which they leave vehicles after accidents. Several significant pieces of work were undertaken to explore injury causation, the potential for using seat belts (both lap belts and three-point belts), the potential for changing the type of windows used in passenger vehicles and the general approach to escape/egress.

Research project T424 (*Requirements for train windows in passenger rail vehicles*):

- Undertook extensive analysis of injuries in a number of accidents.
- Developed an innovative crash test dummy to test different types of seat belt.
- Explored the containment properties of toughened and laminated glass used in passenger trains.
- Undertook risk analysis to demonstrate the changes in risk that would apply in different accident and escape scenarios.

Through an industry stakeholder group and ATOC Engineering Council, a proposed set of actions for the industry was developed, which was presented to the ATOC Board in 2007. Following the presentation, RSSB publicised the proposed approach widely. The main themes developed are outlined in the following sections.

3.1.1 Seat belts

Seat belts have the potential to restrain people during accidents, but they can also cause damage to the wearer through their impact on different parts of the body under similar circumstances. More importantly, the analysis of injuries and damage to vehicles showed that, if people were restrained in their seats during an accident, the loss of 'survival space' arising from damage and intrusion to the bodysides of passenger vehicles would be likely to lead to more injuries and fatalities than if people are not so restrained. The seat reinforcement required for fitment would also increase injury potential for occupants who, for whatever reason, were un-belted¹¹(that is, they would have something harder to strike against). **Accordingly, the use of seat belts in passenger trains was ruled out and the passenger and crew containment strategy was established.**

3.1.2 Passenger and crew containment

Analysis of train accidents that have occurred in the last 10 years showed that 20% of fatalities occurred through people being ejected through breakable windows (usually when a carriage has turned onto its side). If windows are strong or tough enough, they can prevent people from being ejected from trains *during* an accident. However, if breakable, windows can be used to escape from trains *after* accidents. The analysis showed that, if the breakable windows are replaced with essentially unbreakable windows (using laminated glass), then more people would be expected to survive accidents on those rare occasions when such events occur.

¹¹ For example, those passengers not using a belt at all (including standing passengers and those going to or returning from toilets or catering vehicles).

Passengers and staff

One consequence of having all laminated windows is that passengers would no longer be able to use windows for escape after an accident without the intervention of the emergency services. Further exploration of the accidents database, and consideration of an extensive review of emergencies on trains overseas (including fires), found no examples where a life has been lost, or would have been lost, because of an inability to get out through the window. The research shows that either there is no imminent requirement to leave the train under the circumstances, or alternatively, there are better (and safer) egress routes through the bodyside doors and gangway ends. Indeed, a number of significant injuries have been sustained by people escaping from derailed trains through windows. Furthermore, most serious train fires arise from external sources; even after impact, laminated glass is generally retained in position and helps prevent fire from entering railway vehicles. These concepts were discussed with the rescue services, all of which provided much useful additional information.

Risk analysis showed that it is important that the industry has a clear and consistent approach to escape as passengers seeking to break unbreakable windows would put themselves and others at risk; it was duly recommended that all hammers provided for breaking windows be removed, even on those vehicles with breakable windows. **Accordingly, the analysis supported an industry approach that passengers should be contained in a rail vehicle in the event of an accident, particularly when they overturn, and should not be encouraged to escape through windows at all.**

The conclusions that were reached in this work, presented to the ATOC Board and the Office of Rail Regulation (ORR), were:

- All bodyside windows in passenger and traincrew areas on new vehicles should be fitted with laminated glass and have a high degree of containment; consideration should also be given to the frame and mountings.
- Windows on existing vehicles should be considered for progressive replacement with laminated glass, but should always be replaced when broken, subject to cost-benefit analysis on refurbishment.
- To facilitate the incremental fitment of laminated glass, train operating companies (TOCs) should remove hammers and alter signage such that the primary egress route, in the event of an evacuation being required, is recognised as being via the doors and gangways instead of breakable windows.
- In order to realise the full safety benefits of laminated windows, a consistent transition strategy should be developed and implemented across all TOCs.

All passenger trains built since 1993 have mostly laminated windows, but the research confirmed that the best approach was to dispense with *all* designated escape windows. The containment work in T424 (*Requirements for train windows on passenger rail vehicles*) has been developed into a series of measures for vehicle bodyside windows, including a comprehensive suite of test requirements. These are incorporated in GM/RT2100 Issue 4, which is currently undergoing industry consultation and is scheduled for publication in Spring 2010. The introduction of a common approach to escape is being coordinated by ATOC.

3.1.3 Drivers' cabs

The structural integrity of driving cabs and the way their doors open has been considered in project T190 (*Optimising driving cab design for driver protection in a collision*). A specific

supplementary report on debris ingress (included as part of this work in order to analyse and learn from the accidents at Ufton Nervet and Great Heck) confirmed that doors on drivers' cabs should have their hinges at the front; the standards for the integrity of drivers' cabs have now been established in GM/RT2161 (*Requirements for driving cabs of railway vehicles*). The findings are being carried forward to the new Guidance Note GM/GN2686 (*Guidance on bodyshell, bogie and suspension elements*), which is currently undergoing industry consultation and is scheduled for publication in Spring 2010.

4 How the rail industry learns from experience

The rail industry's primary safety objective is to avoid accidents in the first place. However, there is always some residual risk associated with the transportation of people and goods. Accordingly, the industry also seeks to minimise the impact of any events on passengers and staff. One of the main contributors to the improvement of safety is the learning that flows from operational experience, near misses and accidents.

In fact, the industry – or whichever regulatory body oversees it – has been learning lessons from accidents and incidents since its inception. Early incidents like the death of William Huskisson MP at the opening of the Liverpool & Manchester Railway in 1830, for example, led to the first Railway Regulation Act (1840), which required all injurious accidents to be reported to the Board of Trade. Within 50 years, block signalling, interlocking and continuous braking on passenger trains had been made mandatory. The twentieth century saw further advances, ranging from continuous welded rails and multi-aspect signalling, through to automatic train protection systems. These advances will continue as the industry builds on its achievements and adopts new technologies and practices.

RSSB builds consensus and facilitates the resolution of difficult cross-industry issues. It provides analysis, knowledge, a substantial level of technical expertise, along with powerful information and risk management tools, and delivers to the industry across a whole range of subject areas.

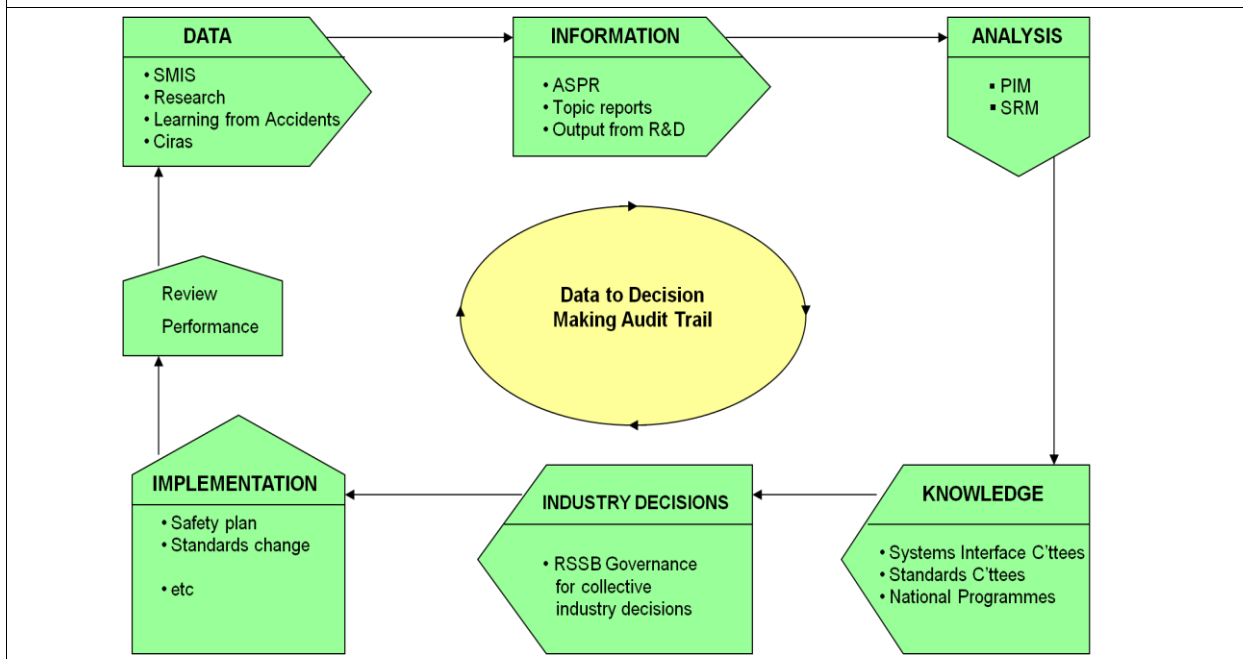
These services help the industry to:

- Where reasonably practicable, continuously improve the level of safety in the rail industry.¹²
- Drive out unnecessary cost.
- Improve business performance.

RSSB generally works on the 'plan, do, review' learning principle outlined in the HSE document *Successful health and safety management* ('HSG65'), which fits into elements of rail industry safety management systems. This is referred to as the 'industry data to decision making audit trail' (see Figure 1).

¹² This issue is considered in some detail in the RSSB publication *Taking safe decisions*, which sets out the rail industry consensus for how to make such decisions.

Figure 1. Industry Data to Decision Making audit trail



Learning continuum

All accidents and incidents which occur on the mainline railway are input into the industry's Safety Management Information System (SMIS), which was introduced in 1998.

These events are then coded, categorised and validated by analysts for many purposes, the results being fed into the industry's cycle of safety planning and performance reporting, which supports both duty holder and joint industry safety improvements. Key outputs include RSB's *Annual Safety Performance Report (ASPR)*, the industry Safety Risk Model (SRM) and a Precursor Indicator Model (PIM). Railway companies use this data and intelligence, together with their own experience and understanding of risks, to compile their own safety plans. RSB collates these plans, together with company initiatives and projections of the safety benefits they will achieve, in the railway *Strategic Safety Plan (SSP)*.

Learning from investigations

The principal investigation of any safety event is conducted by the party immediately responsible for the activity. To facilitate this, railway companies have their own arrangements for carrying out internal formal and local investigations, as defined in Railway Group Standard GO/GN3119 (*Accident and incident investigation*). This includes the possibility of undertaking independently chaired investigations when appropriate. The outputs are managed by the companies concerned, with actions being picked up by their own tracking systems. The results of duty holder-led formal investigations are also summarised in SMIS to give others the chance to learn from the information.

The more significant accidents (involving loss of life or potentially significant consequences) are investigated by the safety regulator (ORR) and the independent Rail Accident Investigation Branch (RAIB). RAIB was established in 2005, following which RSB ceased its accident investigation role (2006).

Learning from experience

RAIB was set up following a recommendation made by Lord Cullen's inquiry into the accident at Ladbroke Grove (a subsequent European Directive on rail accident investigation also required Member States to create such bodies).

If an accident involves a derailment or collision which results in, or could result in, the death of at least one person, serious injury to five or more people or extensive damage to rolling stock, the infrastructure or the environment, then RAIB will lead an investigation, draw conclusions and make recommendations.¹³

RAIB investigates incidents on UK railway infrastructure without apportioning blame or liability. It is independent of the rail industry and the Office of Rail Regulation (ORR), with the Chief Inspector of Rail Accidents reporting directly to the Secretary of State for Transport. RAIB's recommendations are addressed to the ORR, which must then ensure that they are considered and that, where appropriate, action is taken. More information on RAIB may be found via its website: www.raib.gov.uk.

¹³ RAIB may also investigate other incidents that have implications for railway safety, including those which, under slightly different circumstances, may have resulted in an accident.

Appendix 1. Rail accidents involving passenger fatalities since 1997 and summary of themes arising

This table lists all train accidents that have led to passenger fatalities since 1997. The accident inquiries led to many and varied findings and recommendations which are not pertinent to this report have been followed up elsewhere. However, the issues listed in the fifth column of the table were highlighted in more than one accident and prompted some of the research listed in the final column. The learning from these accidents, and the research that followed, contributed to the development of the overall industry approach to these issues.

Date	Incident location	Incident type	Passenger/workforce fatalities	Issues raised relevant to this report	R&D project ('T' number)
1997	Southall	Passenger train SPAD and collision with freight train	7	Passenger containment, vehicle crashworthiness.	T424
1999	Ladbroke Grove	Passenger train SPAD and collision with passenger train	31	Vehicle crashworthiness, bogie retention, passenger containment, drivers' cabs.	T118, T189, T190, T424
2000	Hatfield	Passenger train derailment	4	Bogie retention, coupler strength, vehicle crashworthiness.	T118, T177
2001	Great Heck	Passenger train collision with road vehicle, derailment and subsequent collision with freight train	10	Vehicle crashworthiness, bogie retention, drivers' cabs, lifeguards and obstacle deflectors.	T118, T120, T189, T190
2002	Potters Bar	Passenger train derailment	6	Passenger containment, bogie retention.	T424
2004	Ufton Nervet	Passenger train collision with road vehicle on level crossing and subsequent derailment	6	Passenger containment, bogie retention, coupler strength, drivers' cabs, lifeguards and obstacle deflectors.	T118, T189, T424
2007	Grayrigg	Passenger train derailment	1	Passenger containment.	T118, T310

Appendix 2. Rail industry research

The following research projects have supported rail industry learning relevant to the themes discussed in this report.

- T118 – *Whole train dynamic behaviour in collisions and improving crashworthiness*
- T120 – *Review of measures to reduce risk from passenger train fuel tanks*
- T177 – *Overhead line structure design to cater for collision*
- T189 – *Optimal design and deployment of obstacle deflectors and lifeguards*
- T190 – *Optimising driving cab design for driver protection in a collision*
- T310 – *Review of injury causation and human factors in recent vehicle accidents*
- T424 – *Requirements for train windows in passenger rail vehicles*

Appendix 3. Inquiry recommendations addressed

The following table lists those inquiry recommendations that have been addressed through the work summarised in Chapter 2 of this report.

The recommendations below have been closed out with the publication of research reports T118 and T189. Note that these recommendations are the last remaining recommendations in the area of crashworthiness. Although the industry continues to learn from experience and emerging knowledge, at the time of publication of this report, RSSB has no further plans to research in this area.

2	Ladbroke Grove (Cullen, part 1)	Close-out statement
54	<p>The current standard for crashworthiness in respect of new vehicles should be reviewed in the light of the crash at Ladbroke Grove with respect to the objectives referred to in Recommendation 53.</p> <p>(Recommendation 53: The enhancement of the cabs on HSTs to improve driver protection along with energy absorption and compatibility with other vehicles, and the enhancement of measures for the retention of bogies on the coaches of HSTs, should be considered, subject to an assessment of feasibility, costs and benefits, with a view to possible retro-fitting.)</p>	<p>September 2009, RSSB</p> <p><u>Crashworthiness</u></p> <p>Project T118 looked at whole train dynamic behaviour in collisions and improving crashworthiness, phase 2 of which included specific work to consider bogie retention in crashes. This confirmed that bogie retention is highly desirable but, to manage risk most effectively, no changes to the current bogie attachment strength requirements should be made.</p> <p>Since the construction of the existing HST fleet (c.1974-82), a move to the present body/bogie loading requirements was affected. This is reflected in the current Railway Group Standard (GM/RT2100 Issue 3, dated 2000).</p> <p>Recent GB incidents with newer rolling stock suggest these levels to be broadly satisfactory.</p> <p><u>Drivers' cabs</u></p> <p>Project T190 investigated methods for 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. The work considered preventing debris ingress through the cab side access doors, improving the cab structural integrity and improving the windscreen attachment to the cab. It concluded that the implementation of the measures identified should be considered for new build only.</p> <p><u>General situation</u></p> <p>It should be noted that train design has evolved considerably since the Ladbroke Grove accident and that train manufacturers have since improved on the issues raised by Recommendation 54. Indeed, since 2000, all new rolling stock has been built to the crashworthiness standards set out in GM/RT2100 Issue 3.</p> <p>Following extensive European research, Euronorm EN15227 was published and sets out scenario-based requirements for structural crashworthiness. It includes specific requirements for:</p> <ul style="list-style-type: none"> • Collision scenarios and collision speeds. • The preservation of survival space for train crew in the cab. • The preservation of passenger survival space in

Appendices

		<p>saloons and vestibules.</p> <ul style="list-style-type: none"> • Fitment of obstacle deflectors to all leading vehicles. • Validation using dynamic testing and numerical methods. <p>This has now been adopted as a mandatory requirement by GM/RT2100, issue 4 of which includes standards for cab interiors, doors and windscreens that have also been updated in light of the T190 project research findings.</p> <p>GM/RT2100 therefore now addresses this recommendation. It is currently out for consultation and is due for publication in June 2010.</p> <p>RECOMMENDATION CLOSED</p>
56	<p>The current standard for crashworthiness should be reviewed, in the light of the crash at Ladbroke Grove, in order to ensure that there are adequate measures for safeguarding survival space.</p>	<p>September 2009, RSSB</p> <p>This was originally planned to be covered by research project T118, but more recent work on developing EN 15227 and the update to GM/RT2100 now address this recommendation.</p> <p>EN15227 includes specific requirements for:</p> <ul style="list-style-type: none"> • Collision scenarios and collision speeds. • The preservation of survival space for train crew in the cab. • The preservation of passenger survival space in saloons and vestibules. • Fitment of obstacle deflectors to all leading vehicles. • Validation using dynamic testing and numerical methods. <p>It has now been adopted as a mandatory requirement by GM/RT2100 (which is out for consultation and is due for publication in June 2010).</p> <p>RECOMMENDATION CLOSED</p>
58	<p>The revision of the Group Standard for crashworthiness should be pursued with particular reference to:</p> <p>(i) the design requirements for more realistic scenarios;</p> <p>(ii) high speed accidents; and</p> <p>(iii) dynamic verification testing.</p>	<p>September 2009, RSSB</p> <p>This was originally planned to be covered by research project T118, but more recent work on developing EN 15227 and the update to GM/RT2100 now address this recommendation.</p> <p>EN15227 includes specific requirements for:</p> <ul style="list-style-type: none"> • Collision scenarios and collision speeds. • The preservation of survival space for train crew in the cab. • The preservation of passenger survival space in saloons and vestibules. • Fitment of obstacle deflectors to all leading vehicles. • Validation using dynamic testing and numerical methods. <p>These collision scenarios and requirements were developed through the EU funded SAFETRAIN project that analysed a number of collisions and incidents that occurred throughout Europe.</p> <p>EN15227 has now been adopted as a mandatory requirement by GM/RT 2100 (which is due for publication in June 2010).</p> <p>RECOMMENDATION CLOSED</p>

Appendices

6.	Ufton Nervet	
9	<p>The exemption for axleloads greater than 17 tonnes from the general requirement in Railway Group Standard GM/RT2100 to fit obstacle deflectors to new-build leading vehicles should be reviewed, taking into account the mechanism of derailment of the leading power car at Ufton.</p> <p>Objective: To reduce the likelihood of derailment after striking an obstruction.</p>	<p>This was originally planned to be covered by research project T189, the findings of which are as follows:</p> <p><u>Obstacle deflectors</u></p> <ul style="list-style-type: none"> • The application of EN 15227 within GM/RT2100 addresses the Ufton Nervet recommendation that obstacle deflectors should be fitted to all leading vehicles with a leading axle load of less than 170 kN by requiring all leading end vehicles to be fitted irrespective of axle load. • Design loads specified in Group Standard GM/RT2100 appear adequate for removing most large obstacles. These will however be replaced by the design load requirements of EN15227 which are essentially equivalent. • Adoption of EN 15227 supersedes the recommendation that a cost-benefit analysis should be undertaken to determine the benefit of fitting deflectors to third rail DC stock. • The parametric study of obstacle deflectors indicated that, apart from positioning deflectors as far forward on the vehicle as possible, there is little to be gained by changing deflector geometry. On this basis, no further development or testing is proposed for obstacle deflectors. • A cost-benefit analysis, including sensitivity analyses, for retro-fitting deflectors to HSTs gave cost/benefit ratios ranging from 24:1 to 166:1. As a result the industry has agreed that there is insufficient justification for retro-fit on HSTs. <p><u>Lifeguards</u></p> <ul style="list-style-type: none"> • The continued installation of lifeguards is recommended. <p>EN15227 has now been adopted as a mandatory requirement by GM/RT 2100 (which is due for publication in June 2010).</p> <p>RECOMMENDATION CLOSED</p>
12	<p>The requirements in Railway Group Standard GM/RT2456 and ATOC Standard AV/ST9001 relating to the provision of laminated windows should be extended to cover vehicles undergoing major internal refurbishment. The RSSB research work on the provision of windows for emergency egress should be accelerated so that implementation of the requirements on vehicles undergoing major refurbishment is not delayed by lack of information on the optimum disposition of toughened and laminated windows.</p> <p>Objective: To reduce the risk of passengers or staff being ejected or partially ejected from vehicles or being injured by broken window glass or debris entering vehicles.</p>	<p>September 2009, RSSB</p> <p>RSSB split this recommendation into two activities. Its first action plan (12.1) stipulated that the progress of research project T424: Requirements for train windows on passenger rail vehicles should be examined to determine whether the research findings can be released sooner than programmed, as it had direct relevance to this recommendation. Action 12.1 was closed out after the publication of a summary of the extensive research work on seat belts and windows (T424) in July 2007. Action 12.2 involved the ensuring of uniform practice via a standards change and is detailed below)</p> <p>1) T424 concluded that the following strategy should be adopted for all passenger-carrying vehicles (excluding sleepers and light rail) operating on Network Rail managed infrastructure:</p> <p>i) Passengers should be encouraged to remain where they are and await rescue by the emergency services unless there is a real and immediate threat to their safety.</p> <p>ii) If it is not possible to do this because of a threat, then</p>

Appendices

		<p>passengers should move to a position of safety further along the train and await rescue by the emergency services.</p> <p>iii) If it is not possible to do this, passengers should evacuate the train via the external bodyside doors, or an open vehicle (gangway) end.</p> <p>Passengers should not attempt to exit trains through windows.</p> <p>2. All future new vehicles should have laminated glass (or equivalent) only.</p> <p>To this end, the test suite developed during this project should be considered for adoption into the Railway Group Standard GM/RT2456 when it is next reviewed.</p> <p>3. Windows on existing vehicles should be considered for progressive replacement with laminated glass particularly at refurbishment.</p> <p>4. Hammers should be removed and signage amended accordingly such that the primary egress route, in the event of an evacuation being required, is recognised as being via the doors and gangways instead of breakable windows.</p> <p>5. Following consideration by the passenger operators, a common strategy should be adopted and the travelling public should be made aware of it. This should include information as to the actions to take following an accident or incident.</p> <p>Furthermore, a guidance note was issued to First Group (which operates HSTs) and subsequently to ATOC regarding refurbishing Mark III coaching stock.</p> <p>The relevant rolling stock elements of these recommendations are included in GM/RT2100 Issue 4, which is currently undergoing industry consultation and is scheduled for publication in Spring 2010 and GM/RT2130. The introduction of a common approach to escape is being coordinated by ATOC.</p> <p>RECOMMENDATION CLOSED</p>
--	--	---

Appendix 4. Bibliography

British Standards

BS/EN15227, *Railway applications – crashworthiness requirements for railway vehicle bodies* (British Standards Institute, 2008)

Railway Group Standards and Guidance Notes

GM/RT 2100, *Structural requirements for railway assets*

GM/RT 2161, *Requirements for driving cabs of railway vehicles*

GM/RT 2456, *Structural requirements for windscreens and windows on rail vehicles*

GM/GN 2686, *Guidance on bodyshell, bogie and suspension elements*

GM/GN 2689, *Guidance on mechanical and electrical coupling of rail vehicles*

GM/GN 2690, *Guidance on traction and rolling stock – mechanical coupling systems*

Other documents

Department of Transport, *Report on the Derailment that occurred on 30th July 1984 near Polmont in the Scottish Region British Railways* (HMSO, 1985)

HSE, *Successful health and safety management* (HSE, 2008)

RSSB, *Annual Safety Performance Report 2008* (RSSB, 2009)

RSSB, *Risk Profile Bulletin version 6, June 2009* (RSSB, 2009)

RSSB, *Taking safe decisions – how Britain's railways take decisions that affect safety* (RSSB, 2008)

RSSB (on behalf of its members), *The railway strategic safety plan 2009–14* (RSSB, 2009)

Appendices

Appendix 5. Definitions

Term	Definition
Annual Safety Performance Report	An RSSB document which presents the GB railway industry's safety trends for a calendar year. It reviews performance levels across a number of topic areas and considers how safety issues are being addressed.
Block signalling	This refers to the division of railway lines into sections, known as blocks. In normal running circumstances, only one train is allowed into each block at a time. This minimises the risk from collision and is one of the basic principles of all railway signalling systems.
CIRAS	CIRAS stands for 'Confidential Incident Reporting and Analysis System'. It is an alternative way for anyone working on or around the railway to report safety concerns that they feel unable to report through company safety channels. It is an independent and confidential way to report safety concerns without fear of recrimination.
Continuous braking	Where the brakes are applied throughout the train when a brake application is initiated from any part of that train, or automatically should the integrity of the brake pipe be interrupted from any cause such as a train becoming divided.
Euronorm	A European standard, as adopted by various European standards bodies.
Fatalities and weighted injuries (FWI)	An overall measure of safety harm, taking account of injury and fatalities in the following way: One FWI = one fatality = 10 major injuries = 200 RIDDOR-reportable minor injuries or class 1 shock/traumas = 1,000 non RIDDOR-reportable minor injuries or class 2 shock/traumas.
Interlocking	A general term applied to the setting and releasing of signals and points to prevent unsafe conditions arising; also the equipment which performs this function.
Lifeguard	This is a metal bracket fitted in front of each of the leading wheels of a train in order to deflect small objects from the wheels to reduce the risk from derailment.
Mark III	This refers to a design of carriage, first introduced by British Rail as part of the prototype HST in 1972. They are superior in strength and crashworthiness to their predecessors and are still used by those TOCs which operate HSTs and loco-hauled sets today.
Multi-aspect signalling	A signalling system using coloured lights in place of the traditional semaphore arms, and incorporating track circuit block and route setting capability.
Network Rail managed infrastructure (NRMI)	This falls within the boundaries of Network Rail's operational railway and includes the permanent way, land within the lineside fence, and plant used for signalling or exclusively for supplying electricity for operational purposes to the railway. It does not include stations, depots, yards or sidings that are owned by, or leased to, other parties. However, it does include the permanent way at stations and plant within these locations.
Precursor	A system failure, sub-system failure, component failure, human error or operational condition which could, individually or in combination with other precursors, result in the occurrence of a hazardous event.

Term	Definition
Precursor Indicator Model (PIM)	An RSSB-devised model that measures the underlying risk from train accidents by tracking changes in the occurrence of accident precursors.
Safety Management Information System (SMIS)	A national database used by railway undertakings and infrastructure managers to record any safety-related events that occur on the mainline railway. SMIS data is accessible to all of the companies who use the system, so that it may be used to analyse risk, predict trends and focus action on any areas of safety concern.
Safety Risk Model (SRM)	A quantitative representation of the safety risk that can result from the operation and maintenance of the GB rail network. It comprises 125 individual models, each representing a type of hazardous event (defined as an event or incident that has the potential to result in injuries or fatalities).
Signal passed at danger (SPAD)	<p>An incident when any part of a train has passed a stop signal at danger (ie, a 'red') without authority or where an in-cab signalled movement authority has been exceeded without authority.</p> <p>A category A SPAD is a SPAD that occurs when the stop aspect (ie, a 'red'), end of in-cab signalled movement authority or indication (and any associated preceding cautionary indications) was displayed correctly, in sufficient time for the train to be stopped safely at the signal or end of in-cab movement authority.</p>
Strategic Safety Plan	<p>This is a joint statement by the companies responsible for Britain's mainline rail network setting out an agreed industry approach to managing safety.</p> <p>The 2009-2014 plan was developed by bringing together commitments made by industry companies in their own individual safety plans, thus creating a linkage with the duty holder planning process.</p>
Train operating company	A company responsible for the operation and maintenance of trains, but not the maintenance of infrastructure.
Train Protection and Warning System (TPWS)	A safety system that automatically applies the brakes on a train which either passes a signal at danger, or exceeds a given speed when approaching a signal at danger, a permissible speed reduction or the buffer stops in a terminal platform.

Appendices

Appendix 6. Glossary

Acronym	Expansion
ASPR	Annual Safety Performance Report
ATOC	Association of Train Operating Companies
CIRAS	Confidential Incident Reporting and Analysis System
FWI	fatalities and weighted injuries
HST	High Speed Train
NRMI	Network Rail managed infrastructure
ORR	Office of Rail Regulation
PIM	Precursor Indicator Model
R&D	Research and Development
RAIB	Rail Accident Investigation Branch
RGS	Railway Group Standard
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (1995)
RPB	Risk Profile Bulletin
RSSB	Rail Safety and Standards Board
SMIS	Safety Management Information System
SPAD	signal passed at danger
SRM	Safety Risk Model
SSP	Strategic Safety Plan
TOC	train operating company
TPWS	train protection and warning system
TSI	technical specification for interoperability