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## THE ROLE OF ACCIDENT INVESTIGATION AT A TIME OF IMPROVING RAILWAY SAFETY

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### SUMMARY

"How do you justify the 'overhead' of analysis of systems and process when accident rates are already low? Those people doing the analysis are not contributing to the 'bottom line' of efficient service delivery."

This was a challenge issued to the Rail Accident Investigation Branch's Chief Inspector when he attended a risk management forum earlier this year.

Starting with an analysis of whether accident rates really are low, we will see that the picture is a little more complex. However, even if rates are reducing, can we be confident that we have safety under control? Should we focus on accidents alone? 'Near-miss' incidents will have the same underlying causes as accidents. Therefore, the investigation of near-miss incidents can yield valuable safety learning.

Getting the basics right (such as undertaking competent risk assessments) is important, but so is a focus on 'softer' issues such as organisational safety culture. There is also safety learning to be obtained from the examination of why accidents did not occur or why their outcome was not more severe.

Accident investigators have a valuable role, alongside a committed railway industry, in continuing to drive down accident rates.

### INTRODUCTION

This paper inevitably focuses on experience gained by the Rail Accident Investigation Branch's (RAIB) experience in the United Kingdom. The author accepts that there is no 'world view' of current issues in railway safety, but believes that there are some common themes that would be recognised in many parts of the world.

The RAIB was established with the primary purpose of investigating major accidents. It was created in response to a recommendation made by Lord Cullen, who chaired the Public Inquiry into the Ladbroke Grove rail accident of 5 October 1999 in which 31 people lost their lives and many more were seriously injured in a collision between two trains. The context was thus multiple fatality accidents, and in the United Kingdom (UK), they continued to occur in the period before the RAIB became operational at Hatfield (17 October 2000, four fatalities), Great Heck (28 February 2001, ten fatalities), Potters Bar (10 May 2002, seven fatalities) and Ufton (6 November 2004, seven fatalities).

The RAIB finally became operational in 17 October 2005. Since that date, something remarkable has happened. There has not been a single multiple-fatality train accident on the UK main line railway network. This does not mean that there have not been major accidents; the high-speed derailment of a Pendolino train at Grayrigg in Cumbria in February 2007 resulted in a single fatality, but 30 passengers with serious injuries. Furthermore, as the RAIB has tramways in its scope, it will shortly be reporting on the derailment and overturning of a tram at Croydon on 9 November 2016, an accident that resulted in seven fatalities and 51 passenger being injured, 16 of them seriously.

### ACCIDENT RATES AND OCCURRENCES

So let us start with the central propositions of the paper, improving railway safety and (in the challenge), low accident rates. Have accident investigators done enough? Have the railway and tramway industries developed to the point where there is no longer a place for independent accident investigation?

Figure 1 illustrates the trend in fatal train accidents on Britain's main line railway network at the time this paper was written<sup>1</sup>. It strongly supports the notion of a declining trend in such accidents, and a notable ten-year rolling average of zero fatal train accidents. This should be rightly acknowledged as a remarkable achievement, particularly on a railway network which still largely depends on manual methods of train operation, with only limited pockets of automated driver supervision.

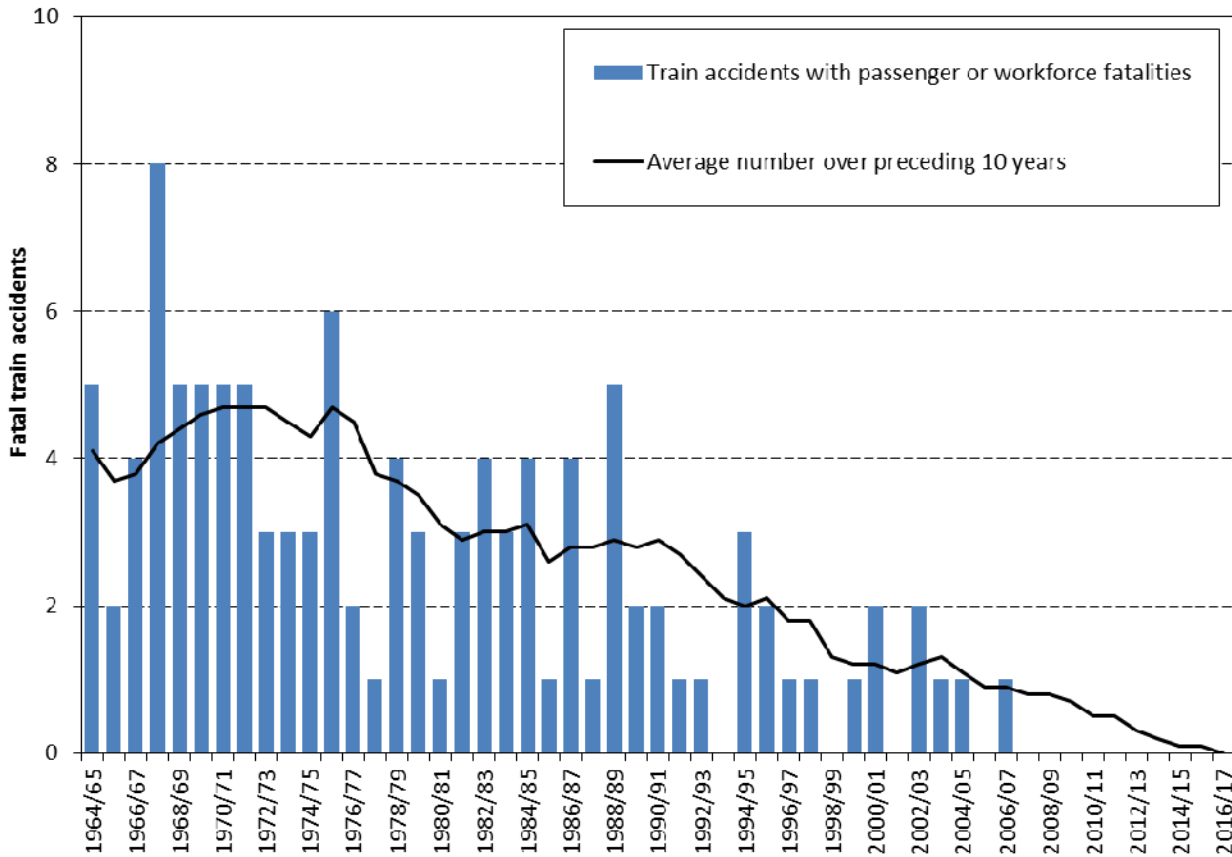


Figure 1: Number of fatal train accidents/year in the UK - 1964-2017 (Source - Rail Safety & Standards Board (RSSB))

However, table 1 shows a sample of some of the more recent multiple fatality accidents that have occurred on railways throughout the world, obtained through a quick internet search. It is by no means a complete list and the accidents selected are intended to show that they can occur in any country. The detail is unimportant; the list simply demonstrates that unfortunately our industry occasionally has the ability to generate multiple fatality accidents.

<sup>1</sup> In the UK, train accidents are defined as those directly arising from the operation of a train, such as collisions between trains and derailments. These are distinct from accidents associated with trains such as people being struck on level crossings, which are defined as movement accidents, and accounted for separately.



Date	Location	Brief details of accident	Fatalities <sup>2</sup>
29/06/09	Viareggio, Italy	Freight train derailment, explosion and fire	29
15/02/10	Halle, Belgium	Collision between two trains	19
23/05/10	Jiangxi, China	Derailed on landslide	19
22/02/12	Buenos Aires, Argentina	Train collision with buffer stops	51
17/11/12	Manfalut, Egypt	Collision between train and school bus on level crossing	50
06/07/13	Lac-Mégantic, Canada	Runaway freight train derailment, explosion and fire	42
12/07/13	Brétigny-sur-Orge, France	Train derailment on points	7
24/07/13	Santiago de Compostela, Spain	Train derailment	79
28/12/13	Kothacheruvu, India	Passenger train fire	26
12/05/15	Port Richmond, USA	Train derailment	8
09/02/16	Bad Aibling, Germany	Head-on collision between two trains on a single line	11
21/10/16	Eséka, Cameroon	Train derailment	79
25/11/16	Haf Khan, Iran	Collision between two trains	49

Table 1: Sample of multiple-fatality train accidents since 2009

So can we conclude that the UK has train accident risk firmly under control? Is it the case that the accidents referred to in table 1 could not have happened in the UK? Or is it simply a matter of good fortune that similar accidents have not occurred in the UK, or elsewhere for that matter?

Before exploring those ideas further, I would like to place the issue in the context of public attitudes to serious accidents.

### PUBLIC ATTITUDES TO MULTIPLE FATALITY ACCIDENTS

It is often said that the society in which we live is becoming more risk averse. One manifestation of this is the reaction to multiple fatality accidents, and, perhaps, an increasing unwillingness on the part of society to see them as accidents at all. On 14 June 2017, a terrible fire occurred in a high-rise apartment block in West London. The death toll was at least 80 people and around the same number of people were injured, some seriously. The circumstances under which those people died and others were injured were shocking.

The reaction to the fire has been swift and has demonstrated a desire on the part of those affected to make sure that their views and wishes are adequately considered. As a direct result of public pressure, the administrative and political leaders of the local government body responsible for the apartment block resigned, the chief executive of the building's management company also resigned and politicians have been roundly condemned for their actions and inactions. And all this before the Public Inquiry had even been set up. Furthermore, the local community has shown itself completely unwilling to accept the original terms of reference for the Inquiry being imposed upon them, and have made sure that all their areas of concern are to be addressed in one way or another. Meanwhile, a police investigation is ongoing at the time of writing this paper and the possibility of corporate manslaughter prosecutions has not been ruled out.

So what does this tell us about public attitudes to safety? It tells us that the public is not prepared to accept the occasional major accident as an inevitable feature of everyday life, and that when accidents do happen, those deemed to be responsible can expect to be asked some fairly searching questions and held to account, possibly very quickly. While this may be uncomfortable for those who are entrusted with the safety of the general public, it is difficult to argue that it is in any way unreasonable. Social media now plays a really important role in the public's response to disasters, allowing people to have immediate access to more information and greater awareness. It also becomes the medium for a collective response to events. There are interesting issues in their own right, but beyond the scope of this paper!

<sup>2</sup> In some cases these are approximate figures as there are conflicting accounts of the final outcome.

## INVESTIGATION OF INCIDENTS AND ACCIDENTS - SOME CASE STUDIES

Returning to our theme of serious railway accidents, the author believes that independent transport accident investigators can, and do, help those who are responsible for the safety of the travelling public stay out of jail (literally in some cases). They achieve this not by investigating accidents and incidents as such, but rather by making recommendations to prevent recurrence. In a climate where accident rates and/or accident risk are reducing, it would be very easy to think that the accident investigator's task is either complete, or can perhaps be modified to assume a light touch. That would be extremely unwise.

In order for any organisation to have the confidence that it has safety firmly under control, it is necessary not only to examine its safety record as manifested by accidents, but also the number and details of any incidents that had the potential to have serious safety outcomes. In particular, the key question that needs to be asked is "what was it that prevented the occurrence of a serious accident?"

The answer to the question (which can only be determined by thorough investigation) takes us down one of two different routes. We may find that a serious outcome was averted only by good fortune, or we may find that a critical safety defence (often the last line of defence) was effective in preventing a serious outcome. No matter: there is safety learning to be gained from either possibility.

I'd like to illustrate this by referring to case studies, based on incidents investigated by the RAIB recently. The first is an incident at Wootton Bassett Junction on the Great Western Main Line between London and Bristol.

On the evening of Saturday 7 March 2015, an excursion train hauled by a steam locomotive was 50 minutes into its return journey from Bristol to Southend when it approached Wootton Bassett Junction, which is the point at which the line from Bristol and the line from South Wales converge. At the time of the incident, trains were converging on the junction on both routes (see figure 2) and the signaller had given precedence to a scheduled passenger train from Swansea, which meant that the signal protecting the junction on the route from Bristol was showing a red (stop) aspect. The driver of the excursion train did not stop at the signal and proceeded onto the junction. Fortunately, the train from Swansea had passed through around one minute beforehand, and no accident occurred.

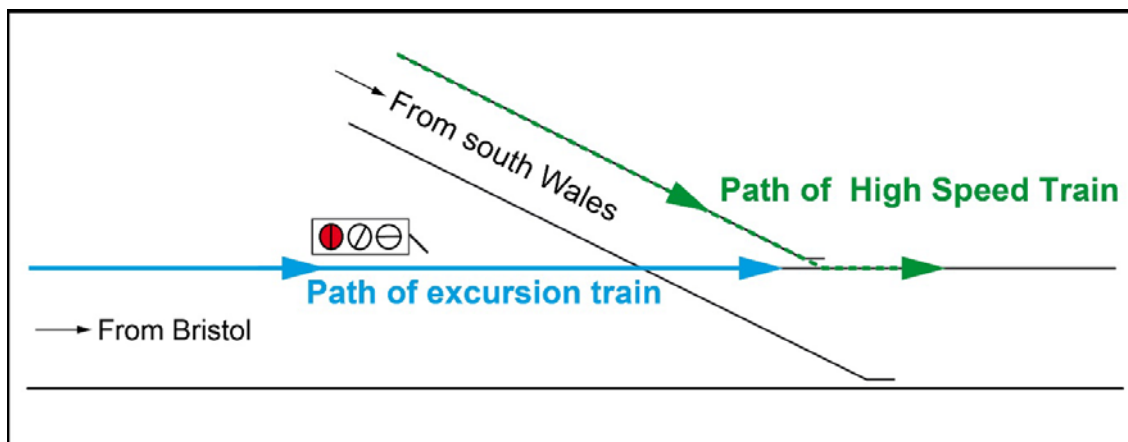


Figure 2: Track layout at Wootton Bassett Junction showing trains approaching on converging routes

There was the potential for a catastrophic outcome. The excursion train comprised 13 fully-loaded coaches of 'heritage' rolling stock; the train from Swansea was an Inter-City 125 train with eight coaches. In the worst case, the train from Swansea could have ploughed into the side of the excursion train at a speed of up to 70 mph (113 km/h), which would have had severe consequences for both trains and their occupants.

So was a potentially devastating accident avoided by railway defences, or good fortune? Clearly the latter. The only factor that averted the accident was timing. Had the excursion train been running 30 seconds earlier and the Swansea train 30 seconds later, they would have met on the junction.



So what of the railway defences that should have prevented the excursion train getting anywhere near the junction? Although it was hauled by a heritage steam locomotive, there is a requirement that such locomotives running on Britain's main line railway network be fitted with modern train protection equipment, which should have intervened to prevent the excursion train from reaching the junction, even if it had passed the signal at danger. This locomotive was fitted with the relevant equipment, so why did it not intervene? The reason is that the crew on the locomotive had isolated the system in order to by-pass an automatic brake application which had occurred at an earlier speed restriction. Although this was in contravention of the relevant rules the RAIB found that it had almost certainly become an accepted practice among some train crews on this locomotive.

The investigation also found that the driver of the excursion train did not reduce the train's speed on his approach to the red signal because he had not seen the preceding signal, which would have warned him that the next signal was at danger. He missed this preceding signal because he had become distracted by activity within the cab and possibly also because he was experiencing a higher workload than normal.

In respect of underlying causes, the investigation found that measures intended to prevent misuse of train protection systems had either not been adopted or had not been effectively implemented by the operator of the excursion train. In addition, the train protection system on the steam locomotive was installed in a way which meant that warnings from the system were not always audible to drivers (the working environment in a steam locomotive cab is rather noisy). It also concluded that the operator of the steam excursion had a weak safety culture and that this had affected the way its staff observed rules and instructions. I will have more to say about safety culture later.

The second case study relates to an incident at Shawford on the South Western Main Line between London and Southampton. Around lunch time on Friday 24 June 2016, two members of a track maintenance team had been asked to investigate a reported rail defect. In these circumstances, one of the two was responsible for the safety of the work, implementing well-established procedures to ensure that the person looking for the fault only went onto the track when there were no trains approaching. However, on this occasion, one of the team was on the track as a train approached at about 85 mph (137 km/h) - see figure 3. The driver of the train saw the worker in a place of danger and after realising that the track worker had not responded to the initial conventional warning of the two-tone horn, repeatedly used a single tone of the train's horn to alert the track worker of the danger he was in. He had just enough time to get out of the way.



Figure 3 - Train running at 85 mph (137 km/h) approaching track worker at Shawford

The investigation found that the track worker had become distracted while he was standing on a line on which trains were running. There had been a breakdown in safety discipline and vigilance between the two workers. The required safe system of work for going onto the railway had not been implemented, and the track worker who suffered the



near-miss had gone onto the railway without the permission of the person responsible for his safety. The investigation noted that it was probable that the track worker's alertness and decision making were affected by fatigue, because he had slept in his car all week to avoid making long journeys to and from home each day.

In contrast to the incident at Wootton Bassett Junction, an accident was averted on this occasion because a safety 'system', the last line of defence, did work. A train driver had the presence of mind to realise that the track worker was not responding to the conventional two-tone warning horn, and used continuous short blasts on the horn as a method of alerting the track worker to the danger. Was this a train driver just doing his job? Maybe, but the RAIB has investigated accidents where train drivers' use of the warning horn was either non-existent or ineffective, and it requires significant presence of mind to adapt to an unexpected and dangerous situation when you are approaching it at nearly 40 m/s.

There is no denying that the advance of technology has significantly reduced safety risk. For the most part, this technology is utterly dependable. However, railways in many parts of the world still depend on humans for their safe operation, and as we have seen at Wootton Bassett Junction, the technology that is provided to enhance safety can sometimes be circumvented – and often for understandable reasons. Even without human intervention, technology can sometimes fail, resulting in the need to fall back onto manual procedures which may not take account of variations in human performance. The RAIB investigated the derailment of a freight train at East Somerset Junction on 10 November 2008. The sequence of events started with the failure of the signalling system, which resulted in the need for the signaller to implement manual procedures to move a 4,000 tonne freight train from a quarry to the main line. The signaller made errors in the way that he set up the route for the freight train, as a result of which the train derailed on points which were not set correctly. The accident occurred in the early hours of the morning, and fatigue was likely to have been a factor.

As with all accidents, all three of these events were avoidable. All three demonstrated underlying weaknesses in safety regimes, but finding effective defences against them is challenging. Increasingly, there is a need to examine the role that can be played by organisational safety culture in continuing to achieve improvements in safety. This applies equally to technologically sophisticated systems where system failures can still place the focus on individuals to secure safety, and to those systems that are more inherently dependent on human action in the first place. The important point is that the investigation of the two near-miss incidents yielded exactly the same safety learning as would have been achieved if there had been a more serious outcome.

### **THE IMPORTANCE OF RISK ASSESSMENT**

I was pleased to see that this year's conference included risk assessment amongst its themes. I am old enough to remember when process industry risk assessment methodologies were introduced into railway operations for the first time in the late 1980s, and fortunate to have been involved in their application to the development of Britain's first (and so far, only) high speed line. It is gratifying that techniques such as Hazard and Operability studies, Fault Trees, Event Trees and Failure Modes and Effects Analysis are widely used within the industry, not just to analyse systems, but also the way that the system is operated.

However, I also have a concern that the very fact that such techniques have become well-established has led to their value being diminished. Let me explain. Once it has become a requirement for risk to be assessed, there is a danger that it becomes a chore, something that needs to be 'got out of the way', another hurdle to be crossed before a goal (such as regulatory approval, consent to operations, granting of a licence, etc.) is reached. In other words, the risk assessment is an end in itself. To approach risk assessment in that way is to fundamentally misunderstand its purpose.

Risk assessment is a means to an end, with that end being the deep understanding of the hazards arising from operations and the need to take steps to ensure the risk arising from those hazards is properly addressed and brought under control.

I think there is a need to reinvigorate the approach to risk assessment in some parts of our industry, perhaps focusing on two areas:

1. Conducting risk assessments with imagination. What are the hazards that really exist – are you drawing widely on the huge experience of your fellow transport operators at home and abroad? Are you approaching the identification of risk from both 'top-down' and 'bottom-up'? The railway industry in the UK has tended to be quite strong in assessing risk from the top down, i.e. asking what could cause collisions, derailments and other types of mishap. It is perhaps less widely practised to ask questions that start with the failure of a component, where that



component can be technological, engineering or human. Examining the effects of a driver or signaller having an 'off day' (particularly during degraded operations) can be quite enlightening! There is also the need to consider all possible outcomes, credible worst case as well as most likely.

2. Once complete, look at what the risk assessment is telling you. This particularly applies to the control measures you have identified. If the single control measure is 'driver training and competence', it immediately points to a vulnerability. If the associated hazard is a potentially high consequence event, then the vulnerability is one about which any operator should be extremely concerned. It may be that there is no other cost-effective way of managing the hazard, but the RAIB's experience suggests that aids to drivers and signallers do not always need to involve significant expenditure or the use of sophisticated technology. The human being is fallible and needs to be supported to do their job safely. No-one sets out to be unsafe, but occasionally every individual needs help and support to maintain optimum performance.

### ORGANISATIONAL SAFETY CULTURE

Strong risk management and the operational resilience that flows from it needs to be supported by a strong organisational safety culture (as referred to earlier in relation to the RAIB's findings from the Wootton Bassett Junction investigation). The author of this paper believes that the issue of organisational safety culture is of fundamental importance to securing the safety of railway operations. It is not a single entity, but rather a series of attributes which work effectively only when each of them are present.

It is not the purpose of this paper to conduct a review of organisational safety culture theory; those who are interested will find plenty of material available<sup>3</sup>. Rather, I would like to pick out one or two features that seem to be particularly relevant, and fit well with some of the key themes of this conference.

1. Managers need to be in-touch and informed. In the past, I have been asked, "how can I know about an underlying safety problem before it results in an accident?" Managers need to ask the people who know – those at the sharp end. Get out onto the ground and engage with those people who operate and maintain the system, understand its weaknesses, and perhaps have developed the by-passes and work arounds that can sometimes lead to incidents.
2. Secondly, it is necessary to develop a strong reporting culture. People who have been involved in incidents hold valuable intelligence about precursor events. If they do not report those events, then this is a critical loss of safety intelligence for the organisation.
3. This immediately begs a question, "how can an organisation encourage and facilitate a strong reporting culture?" In particular, if people have made mistakes, how confident will they feel that there is not to be an adverse outcome for them if they report it? The concept of a "just" culture helps here. If an organisation is able to engender the confidence in its workforce that the primary reason for wanting reports of incidents is safety learning, and that a deep understanding of why mistakes have been made is the guiding objective (rather than taking punitive action against the transgressor), then this may encourage better reporting. Completely open reporting is better, in my opinion, than confidential reporting, but both may have their place. If the only way that an organisation can find out about some safety incidents is through confidential reporting, this is clearly better than no reporting at all. We should also be clear that the concept of a just culture does not preclude action being taken to deal with immediate concerns. For example, if an individual reports an error that they made while suffering from fatigue, the organisation will need to consider the contributions made to that event by work content and workload, but also personal factors. It may be that an individual is suffering from fatigue partly because of domestic circumstances. A mature organisation will help the individual through that period (perhaps by finding alternative, less fatiguing work) and provide the necessary support to enable them to take up their normal duties again.

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<sup>3</sup> See for example:

Reason J (1997), Managing the risks of organisational accidents, Ashgate.

Westrum R (2004), A typology of organisational cultures, Quality and Safety in Healthcare, Vol. 13/2.

Parker D, Lawrie M and Hudson P (2006), A framework for understanding the development of organisational safety culture, Safety Science 44 (6) 441-562.



4. The last key element flows from the above – it is important that organisations do something with the information they have gathered. Sometimes, information-gathering can be seen as an end in itself. There are two consequences. The first is that no safety-learning has been achieved. The second is that because it will be seen as a pointless exercise, it will have a negative impact on reporting and risks alienating the workforce. From the perspective of management credibility, launching initiatives with a loud fanfare and then letting them fade away, is a major failing. It is vital that organisations reinforce reporting initiatives by taking appropriate actions and communicating what has been done to the team. Over time, this will enhance the credibility of the management team and provide a clear indication of its commitment to a strong safety culture.

### LOOKING AT WHAT WENT RIGHT

I wanted to end this paper on a positive note. The railway industry is staffed by dedicated people who have the safety of the public as their number one priority. Massive strides have been made in improving systems, harnessing technology, training and monitoring people, and learning from accidents and incidents. A declining accident rate is the manifestation of the effect of those initiatives.

As accident investigators we have a tendency to focus on what went wrong. However, the investigation of both incidents and accidents also affords us the opportunity to examine whether an adverse outcome (or more serious outcome) was actually averted by the system or actions of an individual. We need to look at processes as well as outcomes. I referred earlier in my paper to the incident involving a near-miss between a train and a track worker at Shawford, and the actions of the train driver in alerting the track worker to the danger he was in. There is good safety learning in this, but the question is how to draw the industry's attention to it. As accident investigators, we make recommendations, but recommendations tend to focus on changes that need to be made rather than highlighting on good practice.

The solution adopted by the RAIB was to include the issue as a learning point within its investigation report, referring to how the train's horn can be used by drivers to give an urgent warning can avert an accident if track workers on their line do not acknowledge the first horn warning. The hope is that the railway industry will use learning points in their periodic briefing to staff on safety matters, thus reinforcing the difference that certain actions and behaviours can make to the safety of all staff on the railway.

### CONCLUSION

So can we justify the analysis of systems and process when accident rates are already low? My answer, as you might expect, is an unequivocal 'yes'. I hope that this paper has highlighted the following points:

- While railway accident rates are low, serious accidents continue to occur periodically. The levels of societal tolerance for multiple-fatality accidents are low and the outcome for those whose actions are found to have contributed to them are likely to be severe.
- The continuing occurrence of near-miss incidents where only good fortune prevented an accident does not inspire confidence that railway safety is completely under control.
- Accident investigators have a role to play in developing their analysis of the causes of accidents and shedding light on some of the more subtle contributors to accidents – the underlying factors such as organisational attitudes and arrangements.
- We should also not neglect 'what went right' or, in some cases, how worse consequences were averted – there is no better way of making the point to those who are responsible for the safety of the public when rules, procedures, processes or design have been pivotal in saving lives.

It must never be forgotten that accident investigators make recommendations. They do not issue commands. It is for the industry to decide what action (if any) it wishes to take in response to those recommendations. Ultimately, we are all on the same side. High levels of safety, with a properly engaged workforce, is a benefit to a business rather than a cost. The battle for a completely safe railway has not yet been won, but industry and accident investigators, working in partnership, continue to strive towards that goal. The societies that we serve expect nothing less.