

Measuring Safety Performance – Do you know how well implemented and effective your risk controls are?

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SUMMARY

This paper provides an introduction to the guidance document Measuring Safety Performance [1], including the principles behind safety performance indicators (SPIs), the potential benefits they can provide and the pitfalls to avoid. It also gives an overview of the seven-step process that the guidance sets out for implementing a successful SPI programme. The process reinforces the idea of measuring SPIs across an organisation's risk profile, using a mixture of proactive and reactive indicators, whilst prioritising them in order to keep their numbers at a manageable level. Reactive (or outcome) indicators typically look at events, such as accidents, where risk controls have already failed. Proactive (or 'activity'), indicators focus on the ensuring that risk controls are in place and are effective. Greater assurance on the outputs, or performance, to be obtained is achieved by understanding what activities are being carried out and how well they are being done.

The paper also gives examples of where the guidance has been trialled and the benefits observed so far. Although the scope of the research mainly considered the application of SPIs within passenger train operating companies, it is believed that the findings apply to all areas of the rail industry, and not just in Great Britain (GB).

INTRODUCTION

It seemed that BP had come a long way since Texas City [2]. That accident – a huge refinery explosion that claimed 15 lives in March 2005 – had been a wake-up call for the company, the oil industry and others. One of the main lessons that came out of the resulting Baker Panel review [3] was that 'the passing of time without an accident is not necessarily an indication that all is well and may contribute to a dangerous and growing sense of complacency'. When we stop appreciating how our safety systems are meant to work, these systems – and their controls – can decline, lessons can be forgotten, and deviations from safe operating procedures can become the norm.

On the evening of 20 April 2010, senior staff at BP gathered at the Deepwater Horizon rig to be told it was 'the best performing rig' the company had in its fleet; in fact, there hadn't been a single 'lost-time incident' in seven years of drilling there. Yet a backlog of maintenance, coupled with the complexity of the operation, a disconnect between management and the front line and a failure of the industry to think beyond company silos (inter alia) was about to explode – literally – on BP, the oil industry and the way it was regulated.

At 21:45, hydrocarbons escaped from a well onto the rig, engulfing the platform in a ball of flames, killing 11 people and injuring 17 more. The fire burned for 36 hours until the rig sank. Hydrocarbons continued to flow from the reservoir through the wellbore and blowout preventer for 87 days, causing a significant oil spill which was as disastrous for the local economy as the local ecology. The following month, US President Barack Obama announced the creation of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling: an independent, non-partisan entity, directed to provide a thorough analysis and impartial judgment. The Commission reported in January 2011 [4]. Its findings, along with preliminary

findings from the US Chemical Safety and Hazard Investigation Board [2], suggested that the lessons from Texas City had not been learnt by all.

Meanwhile, the rail industry in GB was keen to learn from the Baker Panel review and explore through research the application of more proactive SPIs, which help prevent accidents from occurring. SPIs have been used for decades to inform organisations of how well they have been operating. However, often the SPIs being measured have been the same for some time, and the reason for their adoption forgotten. The GB rail industry is no different and has traditionally relied on the use of reactive SPIs, that is, learning and making changes only after accidents have occurred.

RSSB therefore undertook research into SPIs, with specific reference to their application in GB's rail industry. This led to the production of the guidance document Measuring Safety Performance in late 2011, which incorporates the good practice learnt from the railways and other industries. This paper provides a summary of the guidance and its application.

WHAT ARE SPIS?

If a doctor said your health would suffer unless you lost weight, how would you know if you were on track to losing those kilograms? Would you keep weighing yourself in hope that eventually the weight would disappear, or would you consciously monitor what you ate and how much exercise you took?

So how do you tell if you are managing safety well? Some would say 'count how many accidents you've had'. Take train collisions for example. But what if you hadn't had any? Are you perfectly safe? Or is there is an accident just waiting around the corner (Figure 1)? If you had seen a train collision, how confident are you that it (or similar) would not happen again?

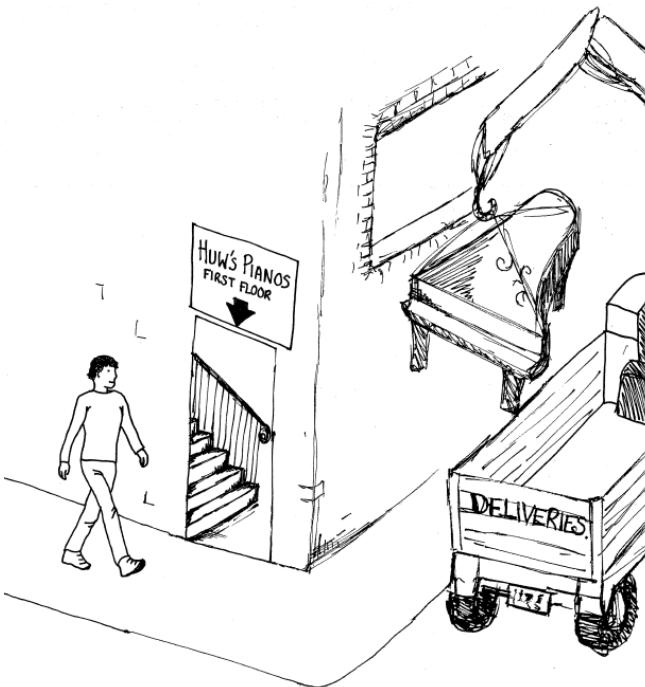


Figure 1 An accident just round the corner

Some SPIs can help us to look round the corner, by providing knowledge (and assurance) on the safety performance of our organisations. They are measurements that reflect the effectiveness of the risk control arrangements within safety management systems. They measure whether risk controls are being implemented, and how well they prevent accidents from occurring. As such, they can be direct or indirect measures of risk or behaviours, and be used to work out if there are any trends in performance relative to our safety objectives.

SPIs can measure what has happened and also provide information on what could be about to happen through two key types of indicator: activities and outcomes.

Activity indicators are measures of whether a risk control system is in place. They can direct action to strengthen and improve risk controls before accidents occur. In terms of Reason's [5] well known Swiss cheese accident causation model (Figure 2), these represent putting the barriers or slices of cheese in place. Going back to the personal health example, this could be a measure of how much exercise you carried out each day. In the context of the railway, this could be whether train driver in-cab observations or drugs and alcohol tests are carried out to plan.

Outcome indicators are measures of events after they have occurred. They measure the effectiveness of the risk controls in place. They can be used to measure:

- **Accidents** – events that result in injuries or damage, the final outcome in Figure 2. In terms of personal health, this could be death from heart disease, or in context of the railway the number of collisions or derailments.
- **Precursors** – an unwanted event in the accident causal chain, the partial trajectories in Figure 2. In terms of personal health this could be the degree of obesity, or in the context of the railway the number of signals passed at danger or occurrences of over-speeding.
- **Results** – the direct outcomes from activities, representing the number or size of holes in the barriers in Figure 2. In managing personal health, it could be the number of calories burned each day while exercising, or in the context of the railway the number of issues identified during driver in-cab observations or drugs and alcohol tests failed.

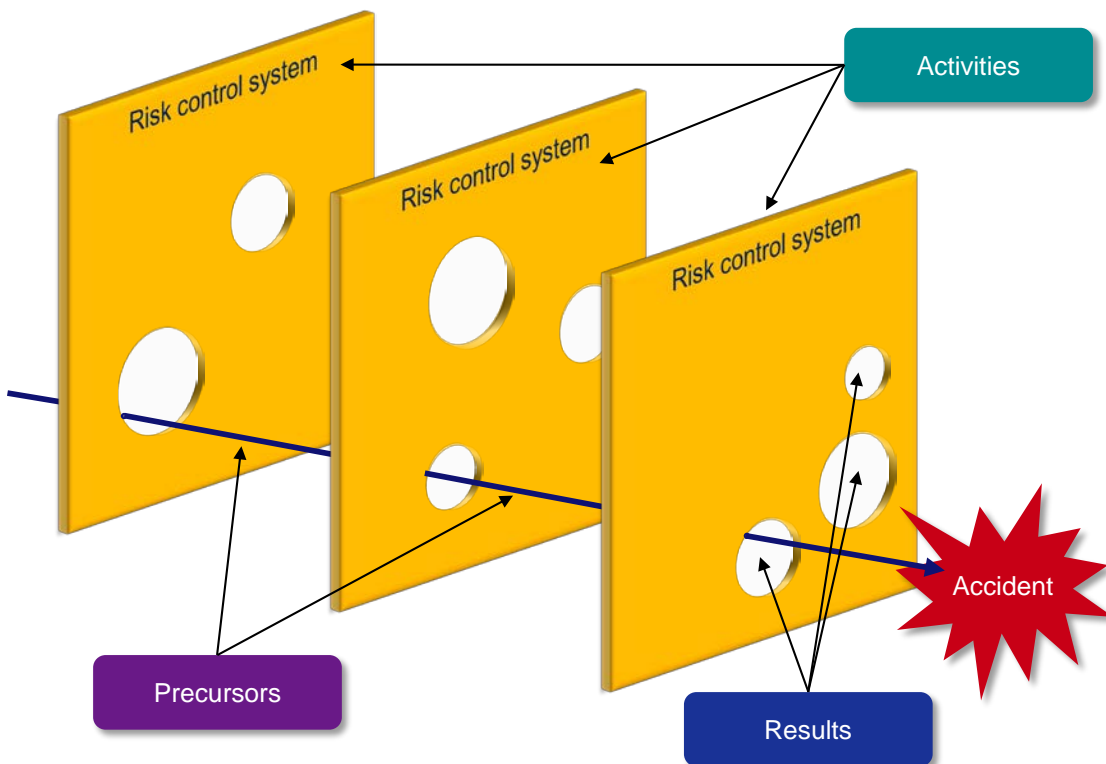


Figure 2 Swiss cheese accident causation model (adapted from [5])

The Baker Panel review and others refer to leading and lagging indicators. Leading refers to the opportunity provided by the SPI to take corrective action before an accident occurs. Lagging refers to the delay after an event has occurred before action is taken. As such the distinction between leading and lagging is not clear cut and forms more of a continuum (Figure 3). Whether or not an indicator is leading or lagging is not really that important. What is important is to use a mix of indicators that are appropriate to managing an organisation's risk.

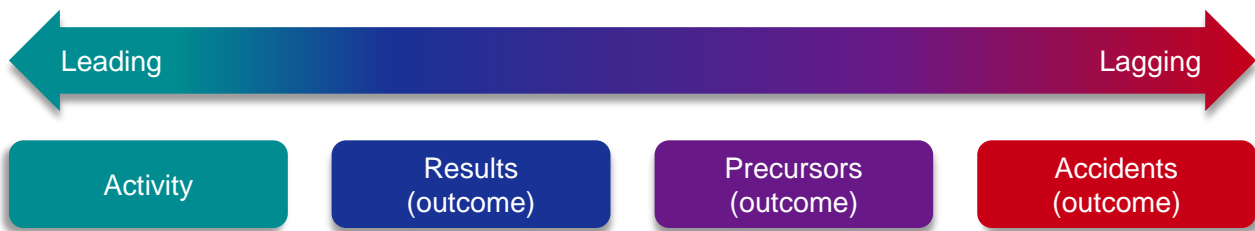


Figure 3 SPI continuum

WHY DO WE NEED SPIS?

SPIs provide knowledge and assurance on how well risk controls are being implemented and how effective they are at preventing accidents. But they can do more...

For example, they can be used to identify weaknesses in the system, highlighting areas where action needs to be taken to reduce risk, perhaps through the strengthening of existing risk controls or the introduction of new ones.

An SPI programme, like the one presented in Part 2 of Measuring Safety Performance, involves employees at all levels of the business through reviewing, updating, collecting, reporting and taking action in response to SPIs. This raises the awareness of safety performance, improves employees' understanding of the organisation's risk profile, focuses attention on the organisation's vulnerabilities and encourages a more mature safety culture. It also reinforces an organisation's commitment to safety and continuous improvement. SPIs that are perceived as being shared by everyone will reduce the need for adversarial management control and help embed the prevailing safety culture.

SPIs complement other safety management initiatives and tools as part of a continuous improvement process such as audits and risk assessments. For example, audits can highlight when risk controls start to fail but they may fail to detect a sudden deterioration, unlike SPIs. In turn SPIs, can be used to identify areas where an audit may be required, providing insight into why an SPI is showing a particular trend.

SPIs can allow comparisons to be made between companies or different sections of the same company. This can help identify good practice as well as areas for improvement.

Through measuring safety performance, an organisation gets feedback on what it is doing, why it is doing it and whether it is working. This allows the organisation to understand where improvements can be made and is a key element of delivering a successful and efficient business.

HOW NOT TO USE SPIS

SPIs should be there primarily to help organisations, not hinder them. Measuring everything is not practical, especially in a complex environment like the rail industry. SPIs should not be created for the sake of fulfilling a 'need' for SPIs. They should be targeted and prioritised to provide insight where insight is required – a good way of doing this is to focus on critical components of safety management that have potential vulnerabilities. Don't be afraid of discontinuing an SPI if it is no longer useful; use the resource on another SPI that will provide value.

SPIs should not just measure the risks that are obvious – the high residual risks like slips, trips and falls. These will not provide insights into those accidents that happen rarely but have severe consequences. The risk from these low-frequency, multi-fatality events can be greater, it's just through safety management that their residual risk is lower. It is useful to ensure that the programme comprises a mixture of indicators that captures the whole risk profile. This can be done by considering SPIs for high residual risks and multi-fatality events, as well as SPIs for overall safety performance and targeted areas of improvement.

SPIs provide little value if they are not clearly defined. They can be open to interpretation and any proceeding action may be misdirected. With clear definitions, the results will be more meaningful and allow true comparisons to be made over time.

Measuring SPIs can change behaviours; sometimes for the good, but also sometimes for the bad. Applying stringent targets, for example, to accident reporting may lead to under reporting, or in the case of the number of safety briefings lead to a decline in their quality. Careful wording of the SPI – its name and definition – can help avoid this although subsequent checks may be required so that the original intent of the SPI is being achieved.

Don't use a SPIs just because the data already exists. This can lead to measuring the easiest option rather than the most valuable. A balance should be struck between the effort to obtain new information and the benefit that it will provide.

WHAT SHOULD YOUR ORGANISATION BE DOING?

Now that the SPI basics have been introduced, do you feel confident that your organisation has the right SPIs and is making the most of them? Maybe it's time to take another look.

Part 2 of Measuring Safety Performance describes seven steps to implement an SPI programme (Figure 4). The process covers a plan-do-act-review cycle. Most rail organisations already measure some SPIs. This process is not about starting from scratch but attempting to understand why certain SPIs are already measured, and whether they are still appropriate.



Figure 4 Seven Steps to a SPI Programme

Step one: assign roles and responsibilities

The first step is to complete an outline remit for the programme and identify who needs to be involved. An SPI champion should be appointed to manage the overall process and deliver the remit. The SPI champion may need the support of an 'implementation team', depending on the scope of the programme. Key to the success of the programme is to obtain input and support from the senior team and other employees. Visible senior management support and long term commitment is essential to the success of the programme. Senior management will need to demonstrate leadership and allocate appropriate resources for implementing, managing, monitoring and reviewing the programme. The implementation team should consult employees with technical and/or practical expertise to help identify, resolve and manage issues. Involvement of staff at all levels helps strengthen an organisation's safety culture through promoting learning and visible ownership of issues.

Step two: identify key issues

Before setting SPIs, it is necessary to identify the key issues and how they are controlled. This includes developing an understanding of any current SPIs and the risk profile (both controlled risk and residual risk). Based on this information, it may be necessary to refine the remit scope and objectives. An understanding of the ideal number of SPIs will help guide the areas to be looked at initially. It's not possible to measure everything, but consideration of a few SPIs that represent overall performance, multi-fatality events, areas of high-residual risk and targeted improvements will give a good perspective. Once the remit has been refined the risk profile relevant to the scope should be interrogated to understand 'What can go wrong?', 'What has gone wrong?' and 'What hazards exist?'

Step three: select and define outcome indicators

Outcome and activity indicators are defined in pairs. That is, outcome indicators for a particular topic are set first and then the associated activities (step four) are considered before moving on to the next topic. This may require several iterations of steps three and four to fulfil the scope of the remit. To identify the outcome indicators, it is first necessary to identify the risk controls in place to prevent the hazard. Here the development of a risk control matrix may help – that is a map of what risk controls help mitigate which hazards events.

Having identified the risk controls, they need to be ranked in terms of what are considered the most critical and vulnerable. 'Criticality' concerns the degree to which something has to be done right each and every time, to ensure that an accident does not occur. 'Vulnerability' concerns the potential for a control to not be implemented or for the control to lack quality. Once the key controls have been identified it is a case of identifying what it is you want to achieve from each control (that is, defining success and attributing an outcome indicator to measure it). This could be a measure of occurrence of an accident or its precursor. Once an outcome indicator has been selected, it's important to define it so it is clearly understood what it is, what it is for and who is responsible for it.

Step four: select and define activity indicators

Once an outcome indicator has been identified and success is understood, the next step considers what needs to be done to achieve that success. Focusing on the essential activities will help prioritise where activity indicators will have the most benefit. Care should be taken to ensure that the measure attributed to the activity suits the culture of the organisation. That is, if the concern is that the activity does not always take place, then the measure should focus on 'how well is the control implemented?', such as the number of tests carried out versus the number of tests planned. Whereas, if the concern is that perhaps sometimes corners are cut or the activity is not done to the required standard, the measure should look at the quality or the effectiveness of the activity, that is the direct result of the activity, such as the number of tests passed. There may be multiple suggestions for activity indicators that could be measured. The guidance includes some criteria based on SPI characteristics [6] that can help prioritise the choice of indicator. In the event that there are several credible SPIs, it may be worth piloting a few so that use of the less informative ones

can be discontinued at a later date. As with outcome indicators once the activity indicators have been selected it is important to define them.

Step five: collect and analyse data

Having selected and defined a set of SPIs, step five considers the collection and analysis of SPI data. The frequency of data collection, analysis and reporting needs to take into account the potential for degradation of the risk control during the collection interval (providing the opportunity to react promptly to any change in the SPI) and the need for sufficient data points to show a meaningful trend. Some indicators will be more reactive and variable over time than others. The more reactive ones might be reported weekly, whilst others, which are less reactive, might be reported less frequently. The urgency with which data is collected and reported should reflect the potential risk increase indicated in warnings produced by the SPIs.

Step six: report and act on findings

The results of the analysis need to be clearly presented so that decisions can be made and ideas for change supported. When compiling the results it is important first to identify the message to be conveyed and for whom it is intended. Embarking on an SPI programme only has merit if action is taken to make improvements. If corrective action plans do not already exist, deviations in SPIs should be used to prompt discussion on what changes should be made to strengthen the risk controls affected.

Step seven: review

Reviews of the SPIs should be carried out to ensure that the SPIs selected are providing value to the business by representing the issues of most concern or where vulnerable controls exist. A review should be carried out periodically (typically annually) or when an organisation makes substantial changes. The review should consider: the initial scope and objectives of the programme; the effectiveness of the current SPIs and reprioritisation of the issues of concern.

HERE'S ONE WE MADE EARLIER

As part of the research to develop Measuring Safety Performance, RSSB carried out some trials with volunteer train operating companies (TOCs). One TOC completed a trial within its fleet directorate. This TOC represents a regional operator that is responsible for carrying out a significant amount of maintenance of its fleet in-house at its central depot. At the kick-off meeting, it was agreed that the objective of the trial was, in general, to reduce fleet-related incidents and defects, and to cut down accidents and incidents in depots. During the discussions at the meeting, it was recognised that safety-related defects caused by human errors and violations (rather than component failures) were an area of vulnerability which might lead to catastrophic events like train collisions or derailments. The agreed scope was therefore the management processes and maintenance activities at the central depot contributing to catastrophic and personal risk.

The number of SPIs was not predefined. Instead it was considered more appropriate to consider the number of fleet components to analyse. At the end of the first workshop held to identify the key issues, three components were selected for SPI review and development: brakes, component detachment and wheelsets. One outcome indicator was selected for each. These were agreed to be:

- Brakes: the number of poor brake performance reports
- Component detachment: the number of loose components reported
- Wheelsets: the number of wheelset problems in service reported

The workshops progressed by developing risk control matrices and mapping immediate causes to risk controls for the three key areas in turn. The team decided on a rating scale to indicate the strength of the mapping; zero meaning no relationship, through to three, indicating a very strong relationship. Table 1 gives the risk control matrix that was developed for wheelsets. The risk controls considered reflected varying strengths of influence on mitigating the different immediate causes. 'In process checks' were considered to have no influence on any of the immediate causes identified. Whereas, 'final oil drive analysis', 'providing a

suitable workplace for carrying out maintenance' and 'vehicle maintenance instructions (VMIs)/procedures' were identified to have the highest total scores (each scoring 24) and were initially considered to be the most important. However, the weakness in taking this approach was that it led to identifying controls without recognition of the differing impact on each immediate cause. Therefore, a control that is critical, but that only maps to one precursor, might be overlooked. This was overcome by further workshop review, including voting for the risk controls of most concern.

Risk controls	Immediate causes									
	Component wear	Defective component	Incorrectly maintained system/component	Component quality	Weather induced repercussions	Component damage	Off depot repairs	Post external overhaul inspections	Incorrect component	Total
Staff competence										
Training	3	3	3	1	1	3	1	1	1	17
Health and welfare	1	1	1	1	1	1	1	1	1	9
Staffing levels	2	2	2	1	1	2	0	3	2	15
Competence assessment programme	3	3	3	1	1	3	1	1	1	17
Inspection										
In process checks	0	0	0	0	0	0	0	0	0	0
Post work reviews	3	3	3	1	1	2	0	3	2	18
Final drive oil analysis	3	3	3	3	3	3	0	3	3	24
Conformance to parity and tolerance specifications	3	3	3	1	3	3	0	3	0	19
Ultrasonic axle testing	3	3	3	3	3	3	0	0	0	18
Under frame cleaning	3	3	3	1	1	3	0	0	3	17
External auditing	0	0	1	1	0	1	0	0	1	4
Maintenance										
Tooling	3	3	3	0	1	2	0	2	0	14
Suitability of the workplace (including storage)	3	3	3	3	3	3	0	3	3	24
Contractors	3	3	3	1	0	3	0	0	1	14
Component suppliers	0	0	0	3	0	0	0	0	2	5
Process										
VMI/vehicle operating instructions/procedural standards	3	3	3	1	3	3	2	3	3	24
Defect reporting	3	3	1	1	3	3	2	0	0	16
Availability of information/documentation	3	3	3	1	3	3	3	3	3	25

Table 1 Example wheelset risk control matrix

Following the completion of each risk control matrix, the workshop agreed the most important risk controls in managing each key area. These were derived taking into account the strength of each risk control in terms of the number of precursors it mapped to, concerns regarding the potential vulnerability of the control and the scope for better management of the control. This led to the selection of the following risk controls for SPI development:

- Brakes: staffing levels and availability of documentation.
- Component attachment: competence assessment programme, component identification/quality, and availability of documentation.
- Wheelsets: final drive oil analysis (highlighted in Table 1).

The selected SPIs were defined and a person allocated to be responsible for collection and reporting back to the depot manager. The implementation team continued to meet periodically and review the data collected. During these meetings, other opportunities for improvements to work process were identified and implemented. One of these improvements included a new reporting system that allowed all staff to be involved.

One year later, some of the SPIs were found to have proved their worth. For example, wheel oil analyses were consistently being taken and the results returned quickly. It was decided to discontinue these indicators. The TOC is now considering whether the other SPIs are still suitable or whether they need to be refined or new issues addressed.

Having completed the trial, the TOC recognised some benefits of following the process, including:

- Greater understanding of the hazards, immediate causes and risk controls that their work encountered and mitigated; reinforcing the importance of doing things right the first time.
- Improved working relations between the staff involved and the development of a more open culture.
- Improved efficiencies in processes, like the oil analysis testing, and ways to reduce the likelihood of errors during maintenance.
- Greater confidence that critical working practices are being undertaken in a timely manner and are effective.

CONCLUSION

Using a mixture of activity and outcome, or leading and lagging, indicators can help prevent accidents, especially those low-frequency, high consequence events where currently a large number of organisations only learn after the event. BP has learnt the hard way. Now other organisations, including those in the rail industry, have the opportunity to learn from these mistakes and become more proactive in measuring safety performance. Of course, measuring SPIs is only one aspect: without responding and taking action, measuring has little value.

The guidance Measuring Safety Performance captures the good practice identified during research into the application of SPIs within the GB rail industry. This aims to help rail organisations strengthen and bolster their SPI programmes to improve their safety performance. Although the guidance was developed through working with TOC, it is believed that the principles apply to all areas of the rail industry in GB and beyond.

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APPENDIX 1:

APPROVAL TO PUBLISH PAPER



I/WeJay Heavisides.....
of Company (if applicable)RSSB.....
hereby give permission to the International Railway Safety Conference 2012 (IRSC 2012) to publish the
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Insert TitleMeasuring Safety Performance – Do you know how well implemented and effective your risk
controls are?.....

To be presented at the IRSC 2012 conference to be held at the St Pancras Renaissance Hotel, London,
England on 8 - 12 October 2012.

In the following media (tick as appropriate):

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