RISSB
RAIL INDUSTRY SAFETY AND STANDARDS BOARD
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Measuring Safety Performance

Guideline

Notice to Users

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Document Control

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Contents

About this document

This guideline has been produced under licence to the Rail Safety and Standards Board (UK) (RSSB) to help rail transport operators identify the Safety Performance Indicators (SPIs) (also known as Key Performance Indicators) that are most appropriate to their operations and to ensure their continued effectiveness. It is based on research undertaken by the United Kingdom rail industry and established good practice detailed in HSG254[1] (Health and Safety Executive UK) and by the Organisation for Economic Cooperation and Development (OECD)[2].

It provides a good practice approach to:

- establishing an SPI program
- identifying SPIs
- evaluating SPIs
- using SPIs to support decisions
- reviewing SPIs

Who is this guideline for?

Rail organisations developing their first Safety Management System (SMS) will find this guideline helpful to determine their first set of SPIs. Organisations with a well-developed SMS may still find this document useful as they review and revise their SPIs.

Part 1 provides an overview and background to SPIs relevant to managers, supervisors and directors.

Part 2 gives detailed step-by-step guidance on how to develop and manage SPIs. This section is relevant to those leading an SPI program.

How to use this guideline

This guideline can be used to shape any review of the monitoring arrangements your organisation has in place. Research has been undertaken in the United Kingdom to establish good practice in developing and managing SPIs. This includes processes for establishing and maintaining an SPI program.

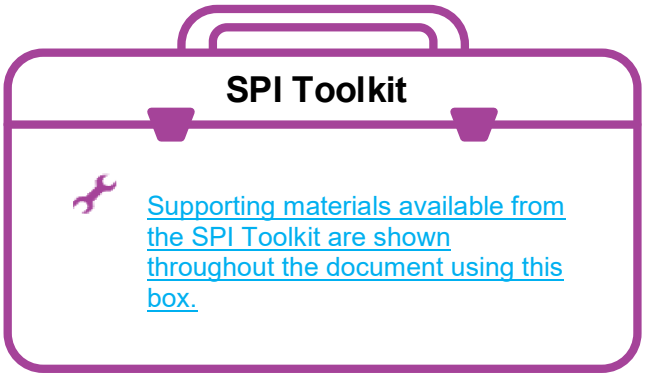
Specifying Indicators

This document does not set out to prescribe SPIs for an organisation to apply but it does suggest a process for selecting those that are appropriate for an organisation, based on an understanding of the risk and associated control arrangements.

The SPIs included in this document are examples and the list is not exhaustive. No two organisations are the same and therefore the most effective SPIs may differ from company to company.

The SPI toolkit

Further guidance and supporting resources can be downloaded from the SPI toolkit, which can be accessed from hyperlinks in the SPI Toolkit images:



Any associated queries can be emailed to rissb@rissb.com.au.

[1] **HSE.** *Developing process safety indicators: A step by step guide for chemical and major hazard industries*, 2006.
[2] **OECD.** *Guidance on developing safety performance indicators related to Chemical Accident Prevention, Preparedness and Response for Industry*, 2008.

Glossary

Activity indicator	A measurement of whether risk controls are in place to prevent undesired safety outcomes.
Causal chain	The sequence of events that led to an incident.
Criticality	The relative importance of a risk control (the extent to which its failure would increase the likelihood of an incident or loss)
Hazard	A source or a situation with a potential to harm someone (injury or illness) or damage property or the environment.
Immediate cause	The condition, event or behaviour that directly resulted in the incident.
Maturity	The capability of an organisation's safety management system to deliver effective risk control.
Normaliser	A common value used to standardise what is being measured to account for differences in exposure. For example, passenger incidents on route A may be greater than route B. When normalised (divided) by the number of passengers on each route, the figures may show that route A and route B have similar rates of incident occurrence.
Outcome indicator	A measurement of undesired events after they have occurred.
Outlier	A data point that appears separate or different from the pattern formed by the rest of the data.
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 an incident.
Residual risk	The level of risk remaining when the current control measures and their degrees of effectiveness are taken into account.
Risk control matrix	A matrix relating an organisation's risk control systems against their hazards or immediate causes of hazards.
Risk control system	A policy, procedure or process used to mitigate or manage safety
Risk profile	The distribution of risks that are present within a system.
Safety culture	The product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine commitment to, and the style and proficiency of, an organisation's health and safety management.
SMS	Safety Management System.
SPAD	Signal Passed At Danger.
SPI	Safety Performance Indicator.
Tolerance	A permitted variation in an SPI before action is taken.
Vulnerability	The extent to which a risk control is susceptible to deterioration short cuts, unreliability or uncertainty.

Part 1: Introduction to safety performance indicators

Background

On 23 March 2005 an explosion at BP's Texas City refinery resulted in 15 fatalities and more than 170 injuries. An independent review[3] recommended that BP improve its SPIs through considering proactive measures and monitoring its process (rather than personal) hazards. This encouraged the further development of SPIs and guidance across a range of safety critical industries.

Prior to the development of this guideline, within Britain's rail industry, SPI concepts had been explored by some organisations but no consistent practice had yet emerged. RSSB members therefore requested that research (project T852 The application of leading and lagging indicators to the rail industry (measuring safety performance)) was undertaken on the application of SPIs to the rail industry. The research was overseen by a steering group with representatives from train operating companies, the Office of Rail Regulation (ORR) and industry suppliers.

In Australia, rail industry members have been working together since 2007 to standardise ways of collecting and reporting safety data with a focus on using leading indicators to improve rail safety.

This guideline is an output of RSSB's research, which has been further reviewed by Australian rail safety professionals, and contextualised for our local industry.

Measuring safety performance

All rail transport operators use SPIs to monitor safety performance. SPIs are applied at a range of organisational levels and may have evolved informally, rather than through systematic analysis of what is required. They have also been developed in response to regulatory obligations under prevailing work health and safety legislation.

Rail Safety Law requires Rail Transport Operators to prepare an annual safety performance report, which must be submitted to the Rail Safety Regulator. This report provides information as specified in law, including a description and assessment of the safety performance of the operator's railway operation.

Traditionally, the rail industry has relied heavily on failure and incident data to monitor safety performance.

This creates a bias to introducing improvements or changes only after something has gone wrong. In addition, simply reporting the number of incidents does not readily support the full understanding of the underlying causes. Without this understanding there is a lack of ability to focus on the important SPIs. This often leads to a large, cumbersome and potentially ineffective suite of indicators, rather than a predictive tool that adds value to an organisation.

By managing hazards pro-actively it is possible to receive early warning of organisational weaknesses which could lead to an incident. This is particularly important for low frequency high consequence events where there is very little failure data. Proactive management requires confirmation that critical risk control systems are in place and working effectively. Example risk control systems include workforce competency, inspections, maintenance and audits.

An understanding of both the immediate and the underlying causes of incidents can help determine how likely they are to occur and identify preventative measures to reduce that likelihood.

[3] Baker, J, et al. The report of the BP US refineries independent safety review panel. 2007

Why do incidents occur?

People's actions can contribute to incidents either directly or indirectly. Direct acts usually occur at the last line of defence and so are routinely identified as being linked to incidents. However, it is now widely recognised that incidents are the result of a complex chain of latent contributory events or factors, and that some of these contributors are regularly present in normal working conditions.

Systems require multiple layers of defence to control hazards and human errors. This can be represented by the Swiss cheese model of incident causation (Figure 1). Some of the holes in the Swiss cheese are active failures of human or mechanical performance whereas others are latent conditions, such as:

- organisational factors (for example, poor safety culture)
- job factors (for example, poor system design)
- human factors (for example, competency).

When failures in the defences align, incidents can happen.

However, if steps are taken to reduce the gaps in the defences, the overall chance of incidents occurring will be reduced. Using SPIs to measure the effectiveness and presence of defences provides opportunities to reduce the gaps and improve safety performance.

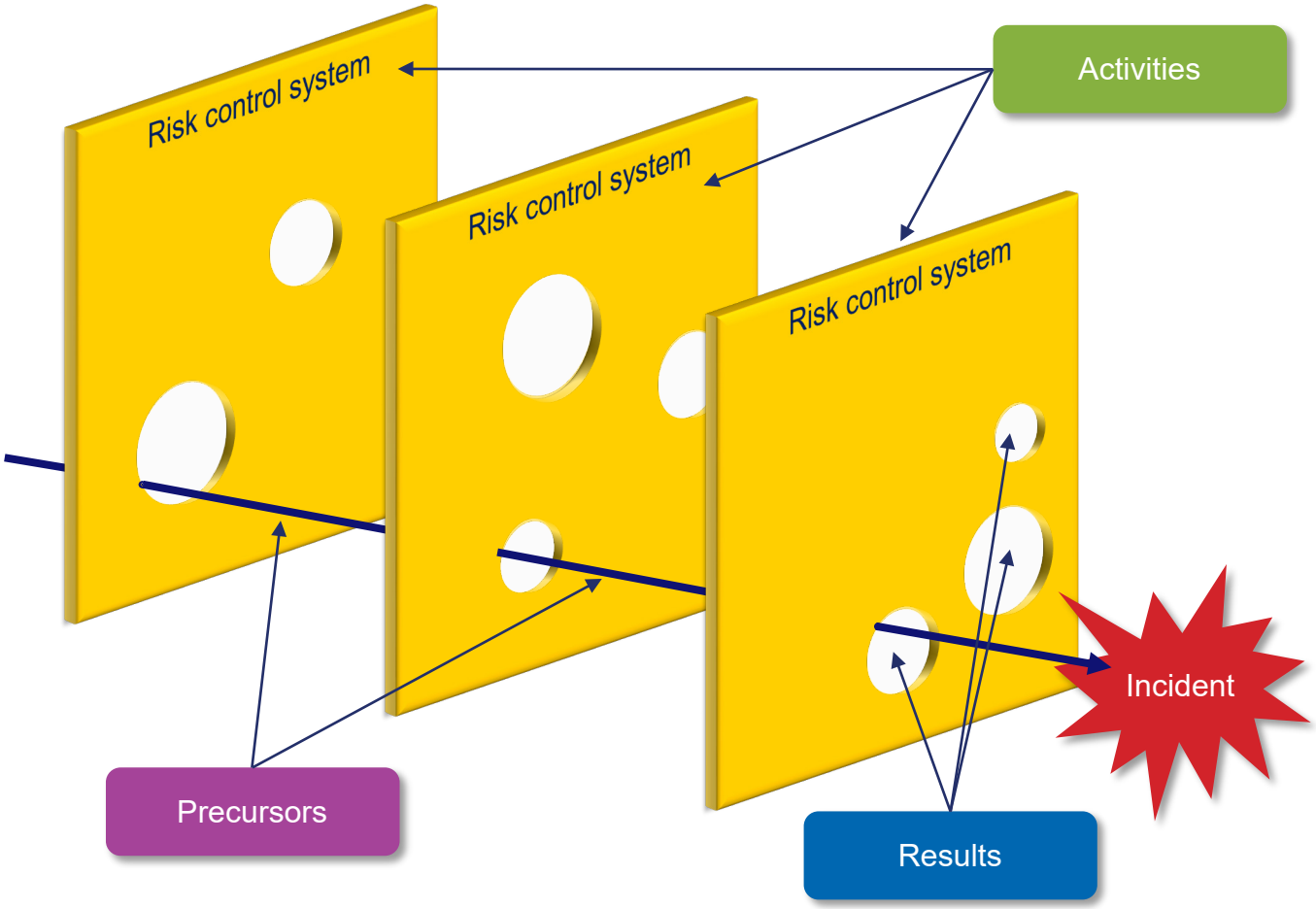


Figure 1 - Incident causation model[4]

[4] Adapted from Reason, J. Managing the Risks of Organizational Accidents, 1997

What are SPIs?

SPIs are measurements that reflect the effectiveness of the risk control arrangements within Safety Management Systems (SMS). As such they can be direct or indirect measures of risk or behaviours that promote a safe culture. They are used to determine whether or not any trends are appearing in performance relative to an organisation's safety objectives.

There are two key types of SPI:

- Activity indicators
- Outcome indicators

Activity indicators

An activity indicator is a measure of whether a risk control system is in place. Activity indicators allow weaknesses in the implementation of control measures to be identified. They direct actions to strengthen and improve processes before incidents occur. These are represented by the barriers or cheese slices in the Swiss cheese model shown in Figure 1 - Incident causation model.

Outcome indicators

An outcome indicator is a measurement of events after they have occurred. They give an indication of the effectiveness of the risk controls in place. Typically they fall into three categories (see Figure 2):

- **Incidents:** measures of the frequency and/or consequence of uncontrolled, unplanned, undesired events that have the potential to result in loss. Examples include, the number of train collisions or the total aggregated consequences from slips, trips and falls. These are represented by the final outcomes in Figure 1.
- **Precursors:** measures based on events which occur in the incident causal chain (usually because one or more safety barriers have been breached). These include system failures, sub-system failures, component failures, human error or operational conditions. Examples include the number of: Signals Passed At Danger (SPADs) or axle box failures. They are represented by barrier failures in Figure 1.
- **Results:** outcomes of an activity undertaken. Examples include inspection scores, audit findings, observed behaviours or the pass rate for assessments. These are represented by the number and size of the holes in Figure 1.

Leading or lagging?

Other documents may describe SPIs as leading or lagging. Leading refers to the opportunity provided by some SPIs to take corrective action before an incident occurs. Lagging refers to the delay after an unwanted event has occurred before the SPI triggers corrective action.

The distinction between the two is not clear cut but forms more of a continuum (as Figure 2 illustrates). For example, a leading indicator might be number of risk assessments carried out, where a lagging indicator would be Lost Time Incident Frequency Rates (LTIFR).

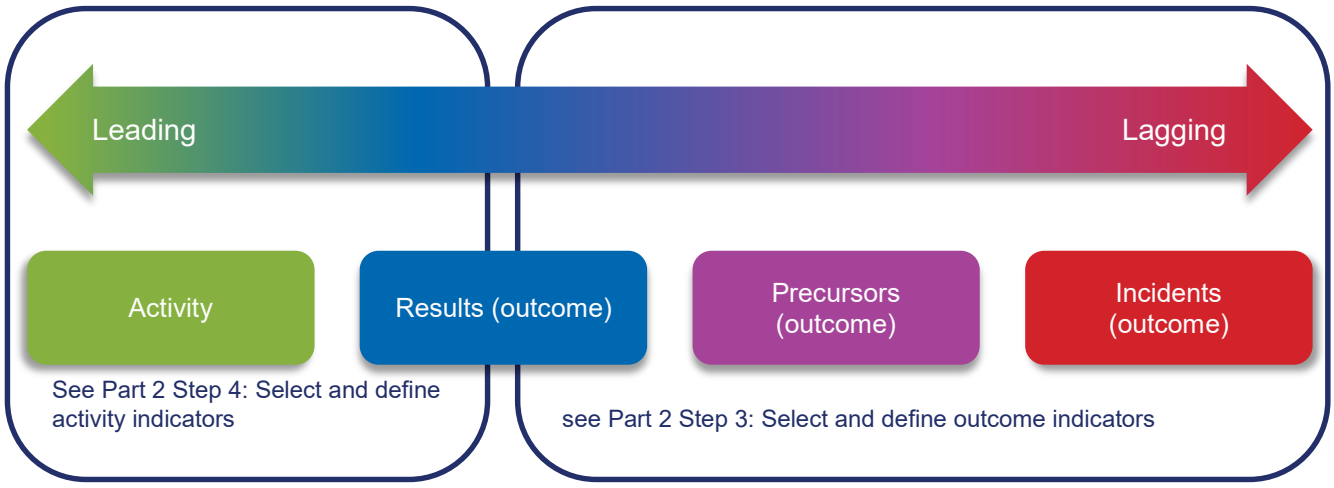


Figure 2 - SPI types

It is not important to clarify whether a particular SPI is considered leading or lagging; it can in fact be both. However, it is important to use a mixture of indicators that are appropriate to managing the organisation's risk. The mixture should include some leading indicators. Leading indicators give an organisation sufficient warning when there is a deviation from specified working and an opportunity to correct risk control weaknesses before harm occurs.

What to measure?

SPIs can measure different aspects of safety performance. This guideline considers four different focal areas:

- **Overall performance:** measuring general health of the organisation through consideration of the risk control systems that are employed widely. These include controls applied throughout the organisation such as safety planning, competence management and risk assessment.
- **Potential for low frequency high consequence events:** measuring the organisation's performance in preventing low frequency, high consequence events. Here, the emphasis is on the more leading SPIs (activity, result and precursor indicators) as there are few incidents that actually occur, but the potential still needs to be managed.
- **High residual risk:** measuring the organisation's performance in managing the dominant risks in the risk profile. Here incident indicators will be informative but activity indicators may help understand and manage the causes.
- **Targeted improvements:** measuring specific areas of interest where safety improvement is required or program implementation is considered necessary and may impact on the performance of the organisation.

Why use SPIs?

There are several benefits from using SPIs:

- Reducing risk, and ultimately incidents
- Providing dual assurance
- Improving safety culture
- Complementing other safety tools and processes
- Learning from others
- Enhancing efficiency

Reducing risk

SPIs can be used to facilitate the identification of weaknesses in an organisation's risk controls, either directly or by prompting further investigation. Resultant actions to improve safety performance will reduce safety risk, and potentially incidents associated with those risks.

Providing dual assurance

Activity and outcome indicators can be selected so that they work together, so that a comparison can be made between the effort put into managing safety and the resultant safety performance. Well paired SPIs should see a change in one reflected in the other. For example, improved driver training (activity) should lead to a reduced number of SPADs (outcome). Conversely, deterioration in the quality of driver training could lead to an increase in SPADs (unless remedial action is taken).

When activity and outcome indicators are used in parallel they provide confidence that the risk controls are operating effectively and a warning when safety performance deteriorates – a concept known as dual assurance[5]. This is a more robust method of determining the 'state of health' of an organisation's risk controls than using one type of SPI alone. The process described in Part 2 uses this principle to develop SPIs.

[5] **HSE.** *Developing process safety indicators: A step by step guide for chemical and major hazard industries,* 2006.

Improving safety culture

The SPI program described in this guideline proposes the involvement of workers at all levels of the business throughout the seven steps. The process therefore raises awareness of safety performance, improves worker's understanding of the organisation's risk profile, focuses attention on the organisation's vulnerabilities and encourages a more mature safety culture.

Implementing an effective SPI program reinforces an organisation's commitment to safety and continuous improvement. It can help develop a positive safety culture by enabling action to be taken earlier to improve safe working practices and to promote desired behaviour and attitudes.

SPIs that promote good behaviours and encourage safe working are preferable. Reviewing existing SPIs may identify and eliminate those that could have a negative effect on working safely, which could in turn lead to unintended consequences (for example, the use of competition resulting in unnecessary emphasis on winning – or not 'coming bottom').

SPIs that are perceived as being shared by everyone will reduce the need for adversarial management control and help embed the prevailing safety culture.

Complementing other SMS tools and processes

SPIs support other safety management initiatives and tools, as part of a continuous improvement process. This includes audits, direct observations, documentation reviews, root cause analyses, workshops and feedback. SPIs complement rather than replace other efforts to provide an overall picture of safety performance.

For example, audits can highlight when risk controls start to fail but they may fail to detect a sudden deterioration. Audit findings may be used to identify suitable SPIs, or provide an insight into why an SPI is showing a particular trend.

SPIs can provide evidence of the extent to which safety goals are being met or are on target to be met. This in turn can be used to help allocate resources.

Learning from others

Most organisations like to benchmark how they are performing in comparison to others. Aligned SPIs can allow comparisons to be made between companies or different sections of the same company (such as lines of route, stations or depots). This can help identify good practice as well as areas for improvement. However clearly understood definitions are required if the comparison is to be useful.

Organisations should ensure that SPI priorities which are not being benchmarked are not neglected in favour of SPIs which are.

The primary purpose of this guideline is to help organisations systematically identify SPIs that are relevant to their operation. If this process leads to different organisations using the same indicators, benchmarking will become possible. However, this is not explored in detail in this guideline document.

Enhancing efficiency

Through measuring safety performance, an organisation receives feedback on what it is doing, why, 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 business. Where safety is aligned with key business objectives, use of SPIs can provide further value to an organisation. This will provide efficiency savings from reduced down-time and associated costs.

SPI pitfalls

When using SPIs it is important to be aware of the potential pitfalls so they can be avoided.

Excessive workloads

Creating lots of SPIs can overburden the managers and other workers analysing and reporting results. It is better to agree what is feasible and prioritise the selection and use of SPIs on that basis. If SPIs are no longer useful or of low priority, consider discontinuing them in favour of those considered more useful.

Not considering the whole risk profile

Setting SPIs for just the highest priority risks may not give insights into those incidents that happen rarely but have severe consequences, or that vital safety improvement programs are being implemented effectively. A mixture of indicators that look at potential low frequency/high consequence events, high residual risks, general overall performance and targeted areas will help gain an insight to how the organisation is performing as a whole.

Lost in translation

When agreeing an SPI it is important to be clear what is being measured and how often. SPIs with clear definitions will aid the understanding of what the results mean, avoid mis-interpretation, and allow meaningful comparisons to be made over time.

Encouraging unwanted behaviour

Measuring SPIs can change behaviours and – in some cases – result in unwanted outcomes. For example, stringent targets for measuring reportable incidents may lead to under reporting, or, measuring the number of safety briefings may lead to a decrease in quality of the briefing. Phrasing SPIs positively can help avoid perverse behaviours. However, this is not always possible and further observations may be required to ensure that behaviour does not deteriorate.

SPIs can be used to identify weaknesses, which in turn provide opportunities for improvement. If these opportunities are regarded positively, it may prevent unwanted behaviours, such as under reporting.

Choosing metrics to suit the data

When choosing an SPI there is a danger of thinking about what is already measured rather than what could be measured. This could lead to measuring the easiest option rather than the most valuable. Both the benefits of an SPI and the effort in obtaining it need to be considered.

If the timescales to implement a new SPI are lengthy, an alternative interim SPI should be selected.

Overview of the SPI process

Part 2 of this guideline describes the seven-step process to developing, reviewing, implementing and responding to SPIs.

The process is designed to work for all SPI programs, from company-wide ones to those targeted at specific sites or issues.

The process considers an organisation's concerns based on its risk profile. It also provides focal areas and criteria to help filter the issues until the most critical and vulnerable ones are identified leading to an appropriate mix of SPIs (Figure 3).

Steps 1 to 4 describe the principal planning and workshop activities to set new SPIs and review current ones. Steps 5 to 7 describe the remaining implementation and review activities to complete the process (Figure 4).

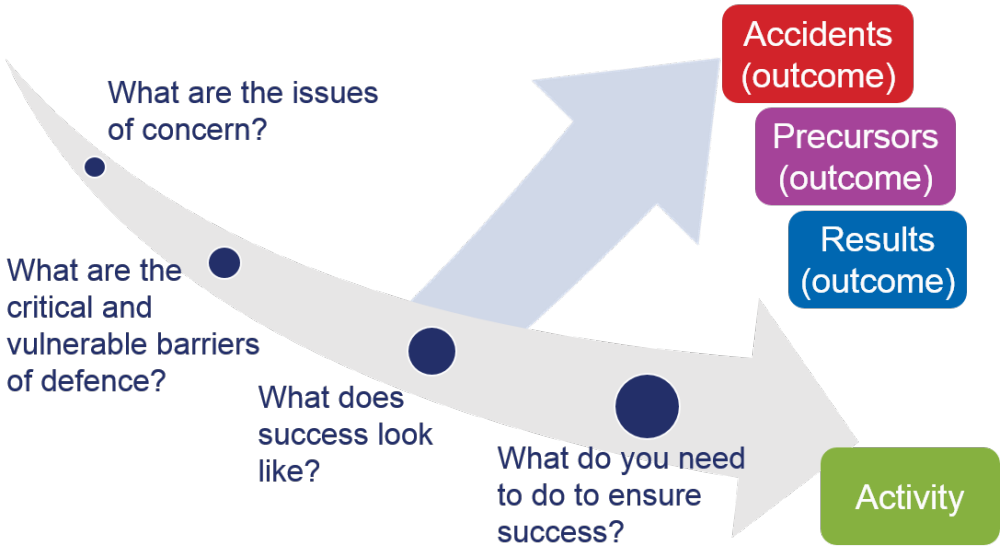


Figure 3 - Overview of setting and reviewing SPIs

Part 2: Seven steps to measure safety performance

This section of the guideline presents each of the seven key steps to measuring safety performance.

It is intended for those leading or facilitating an organisation's SPI program. It is relevant to establishing a new SPI program as well as reviewing existing practices.

Most rail organisations already measure some SPIs, though not necessarily as a part of a formal program. This section of the guideline adds detail to the principles of selecting a set of indicators appropriate to an organisation's risks. It also describes how to apply them. At the end of each step a requirements check list is provided as a guide for consideration before proceeding to the next step.

Figure 4 - SPI process

Step 1: Assign roles and responsibilities

Implementing a successful SPI program requires commitment from all relevant parts of an organisation and in particular senior management.

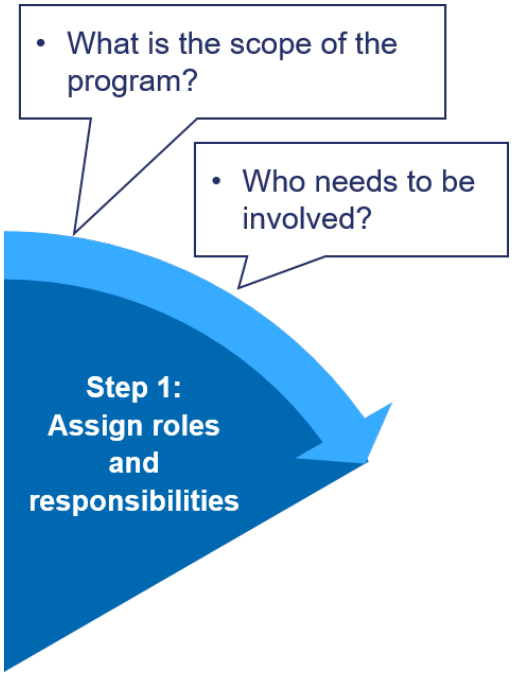


Figure 5 - Step 1 Assign roles and responsibilities

Involve senior management

As the recipients of assurance, senior management need to be involved in setting the scope and objectives of the program. Without this, there is a risk that the program will not address the senior management's concerns or needs. For company-wide programs this may include the executive board, whereas, for departmental programs this would include the head of department. If the head of safety is not the SPI champion or part of the implementation team, their support should also be sought.

It should be clarified that fewer SPIs does not necessarily mean less effective safety management. The important factor is the quality of each SPI, not the total number of SPIs. Senior management may provide guidance as to whether the SPI program should seek to replace, add to or reduce the existing suite. However, it is just as important to feed back to them why certain changes have been suggested and how this addresses the risk profile.

Visible senior management support and long-term commitment is essential to the success of the program. Senior management will need to demonstrate leadership and allocate appropriate resources for implementing, managing, monitoring and reviewing the program. They need to accept that the program may take some time (many months to years) before the benefits of a better understanding of safety performance are fully achieved.

Set intent

An outline intent should be established to direct the SPI program. This will confirm the overall scope of the program (such as whether it is company-wide, targeted as a station or depot, or at departmental level), the objectives, the key stakeholders, who should be involved, resources and budget. Clear roles and responsibilities are essential for successful delivery of the intent. Further refinement of the intent may be carried out in Step 2.

Appoint a champion

An SPI champion should be appointed to manage the process and deliver the intent. The choice of SPI champion will depend on the scope of the program. For a company-wide program the SPI champion may be the head of safety, whereas for a more targeted program such as driver management it might be a driver manager.

The champion should be a good facilitator who initiates, promotes, co-ordinates, communicates progress, taking responsibility for the overall implementation of the program. The champion needs to have sufficient authority, credibility and knowledge of the organisation to understand the impact of implementing changes. The champion is also responsible for maintaining support from the senior management, whilst administering their expectations and coaching them about what the indicators can, cannot and might show.

Establish an implementation team

The champion may need an implementation team. The size of the team will vary according to the size of the organisation and the scope of the program. It may be possible to use an existing cross company group to fulfil this role.

For company-wide programs it is beneficial to include representatives from each organisational

function who are able to make decisions and delegate actions in order to gather, analyse and act upon the chosen indicators as well as share the workload.

For smaller initiatives, the team may be scaled down but it is important to consult and gain support from each area of the organisation affected by the program.

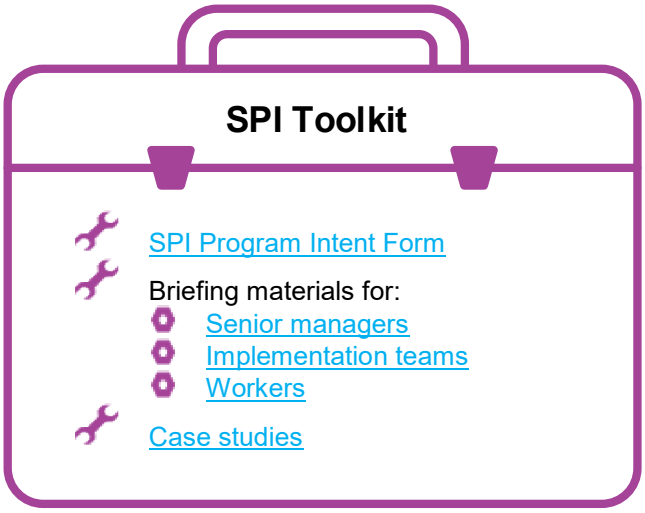
The team is responsible for:

- Clarifying and agreeing the scope and objectives of the program.
- Determining how best to involve workers.
- Developing a business case to secure resources for the program.

Include workers

The implementation team is unlikely to be able to identify, resolve and manage all issues effectively by itself. The team should consult workers with technical and/or practical expertise (typically via workshops) so that the SPIs are meaningful and practical, and proposed changes are smoothly integrated. It may also be necessary to liaise with contractors, suppliers and interfacing organisations, if they are affected.

Workers including (where appropriate) senior management will need to be briefed on the objectives of the program by the SPI team. This will allow them to prepare, contribute effectively and have confidence in the process and results.



Step 1 check list

- ❒ Senior management direction and commitment
- ❒ Outline intent
- ❒ SPI champion and implementation team
- ❒ Relevant parties briefed

Step 2: 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 (). Steps 2 to 4 that follow are designed to allow an organisation to identify, understand and focus on the areas of most concern and set SPIs accordingly.

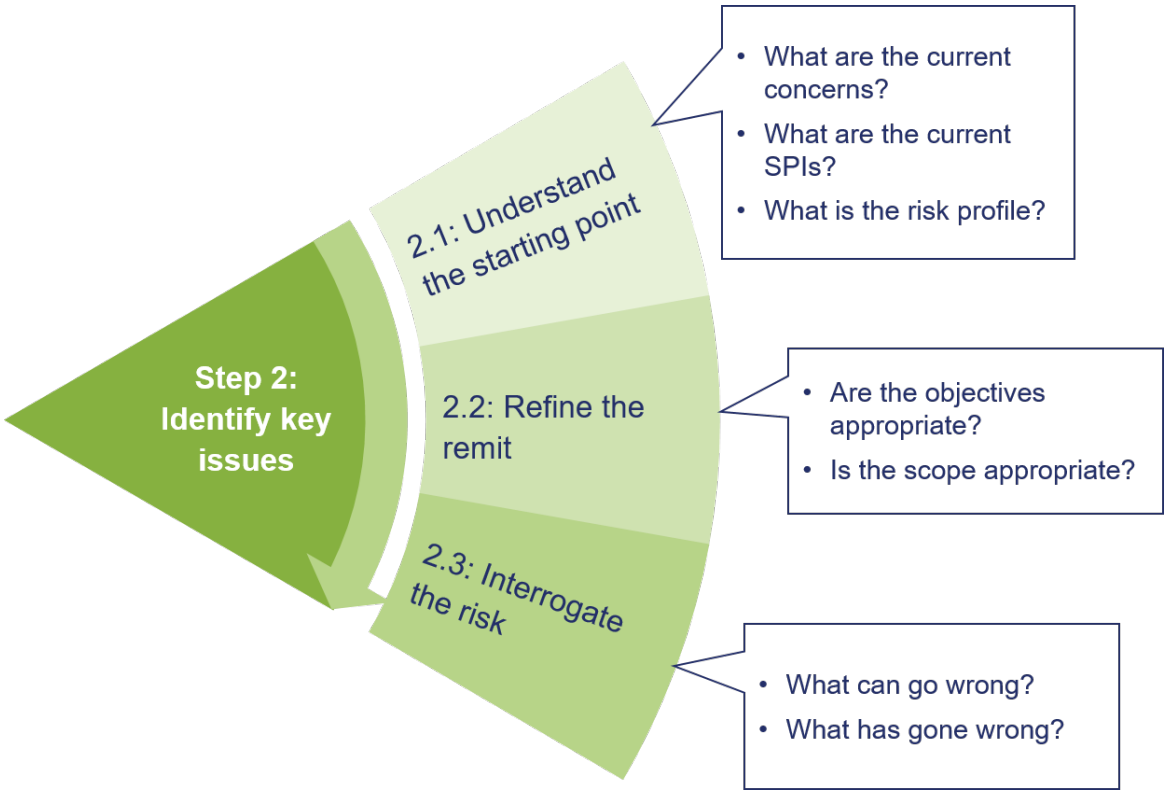


Figure 6 - Step 2 Identify key issues

Step 2.1: Understand the starting point

To ensure that the program intent is appropriate, it is important to understand the current position of the organisation. Reviewing the company's risk profile (in context of the intent scope) alongside any existing SPIs will identify previous areas of concern and whether there are any gaps or unnecessary SPIs. A good suite of SPIs would already consider the whole risk profile and address the areas of vulnerability through a mixture of activity and outcome indicators.

When reviewing the risk profile consider:

- What are the current concerns?
- Why are they concerns?
- Where are there gaps in the current suite of SPIs?

In the absence of an established risk profile, the following sources of information may prove useful:

- Changes to legislation, standards or rules
- Safety and business plans
- External interfaces
- Risk registers
- Audit and safety culture survey findings
- Benchmark and/or review industry information
- Incident/near miss investigation and ATSB reports
- Worker, customer and shareholder feedback.

Step 2.2: Refine the intent

The objectives and scope of the program need to be clear from the start. These should be agreed by the SPI team with input from senior management.

The intent should identify who the users of the SPIs will be and in what capacity the SPIs will be used. This will dictate the level of detail that the SPIs need to consider. For example, senior management will require an overview of the results whereas department heads and line managers may need more detailed information.

In addition, the objectives should outline, at the start of the program and at each review, how many indicators are desired. Experience from other industries has shown it is best to start with a small number and expand the program as experience is obtained. If every aspect of the SMS is measured, this could result in an unmanageable number of indicators. A more realistic approach is required focusing on critical and vulnerable areas. Selecting a few well targeted, informative indicators is likely to be more effective than attempting to address the whole risk profile. Limiting the number of SPIs will also help prevent indicator fatigue (that is a decline in benefits from the over use and direction of attention towards collecting data and monitoring SPIs rather than undertaking improvements and actions).

For larger programs, to help prioritise and target which aspects of performance to measure, Figure 7 shows four different focal areas. A few indicators identified within each focal area will draw the program nearer to addressing the whole risk profile effectively. The ideal number of SPIs within each focal area should be agreed at the outset, based on the greatest concerns and current gaps in the existing SPIs. The scope of the intent may require refinement after consideration of the risk profile and existing SPIs. This could include specifying the parties affected or deemed to be outside of the scope, including any organisational boundaries and their associated interfaces (such as with contractors, or rail transport operators). For larger programs, it may be appropriate to split the scope into more manageable work streams.

Step 2.3: Analyse the risk

Once the scope and objectives have been confirmed, it is essential to understand the nature of the risk (relevant to the scope) in order to help set and prioritise SPIs.

The key to interrogating and understanding the risk is to answer the following questions:

- What can go wrong?
- What has gone wrong?
- What hazards exist?

To help answer these questions, consider collecting and evaluating information from:

- Workers' knowledge and experience
- Recent reviews of key risks
- Risk registers
- SMS and other safety related performance data
- Incident/near miss investigation and ATSB reports
- Changes to the organisation or activities

Further considerations specific to the areas of focus are shown in Figure 8.

Overall performance	The performance of wide-ranging controls (such as risk assessment, or safety briefings) that provide insights to the overall health of the organisation without looking at specific operation areas separately.
Low frequency high consequence events	The risk control systems to prevent events with potentially severe consequences such as multiple fatalities (from, for example, train collisions). Because of their infrequent nature, there is potential for a deterioration in the effectiveness of their control measures to go unnoticed unless suitable precursor, result, or activity indicators are used.
High residual risk	The areas where risk is currently the greatest. It is usually the management of these areas where there is greatest potential for risk reduction. The hazards that fall in this category tend to have the most data but require more targeted use of indicators.
Targeted improvements	The specific areas of the organisation that have been identified as needing improvement or reinforcement or specific programs that need implementing. These might relate to recent changes (such as a reorganisation or letting a significant contract) or responding to audit/investigation findings (such as carrying out planned maintenance on time or errors in train control). SPIs for this focal point tend to have comparably short lives compared to those from other focal points.

Figure 7 - SPI focal areas

Overall performance	• What hazards does the organisation have to manage? • Where can improvements be made across the organisation? • What processes underpin the safety culture of the organisation?
Low frequency high consequence events	• What hazards have the potential for severe consequences? • Have there been any incidents that could have led to a high consequence event?
High residual risk	• What are the biggest risks? • What are the most frequent hazards that cause injury? • Where would additional understanding be beneficial?
Targeted improvements	• Where is improvement most needed? • What changes are being considered that could impact safety? • What is the safety objective of the initiative? • What is driving the improvement or change?

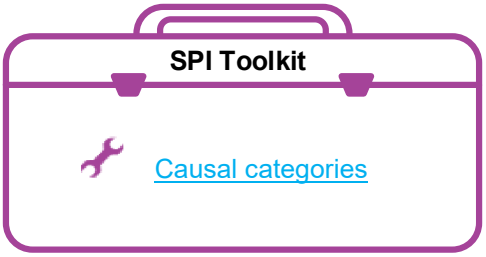
Figure 8 - Identifying hazards for each focal area

Once the above information has been used to add to or derive a list of key hazards, these should be analysed further to identify the principal immediate causes. These will then be used in Step 3 to identify the most critical and vulnerable risk controls. If the hazards and their causes are not fully understood it is unlikely that the SPIs chosen will be the most beneficial ones.

Immediate causes may include:

- Human errors
- Violations
- Equipment failures
- Environmental conditions
- Inadequate information/poor planning

An overview of why incidents occur is given in Part 1.



Step 2 check list

- ❒ Set of existing SPIs
- ❒ Risk profile
- ❒ Refined and agreed intent
- ❒ Hazard (and immediate cause) list

Step 3: Select and define outcome indicators

Step 3 presents a process for selecting incident and precursor outcome indicators. This is based on understanding what risk control systems an organisation has in place and the desired outcomes (Figure 10).

Incident and precursor indicators need to be selected first. After an incident or precursor indicator has been selected, consideration should be given to corresponding activity and result indicators (in Step 4). This may require steps 3 and 4 being repeated several times until all the hazards or issues within each focal area (identified in Step 2) have been considered (Figure 9).

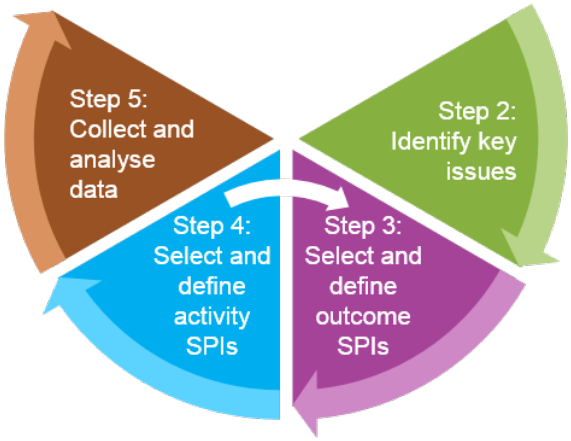


Figure 9 - Overview of process for setting indicators

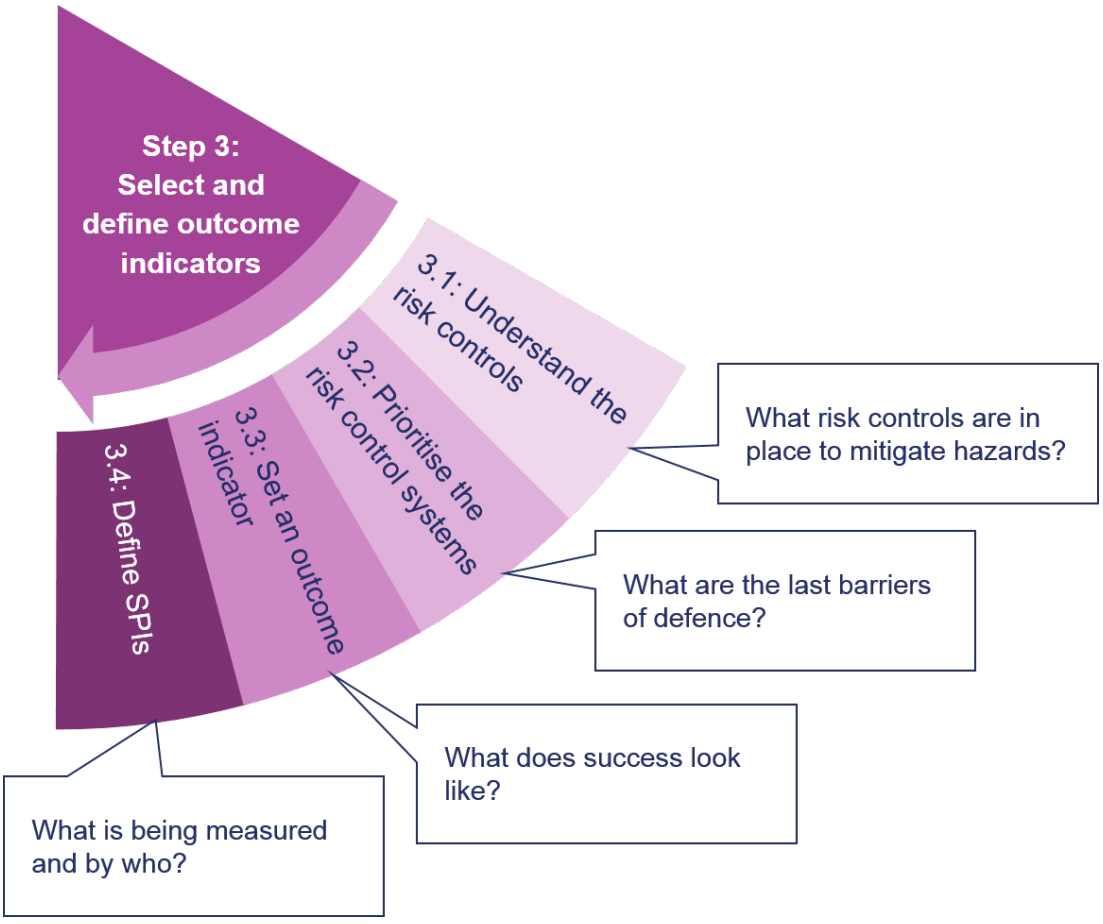


Figure 10 - Step 3 Set and review outcome indicators

Gain support from workers

One way to gain insight into the organisation's risks and controls is to hold workshops. The people invited to each workshop will depend on the scope of the program.

For example, a company-wide program would involve representatives from each function (and potentially each interface). Alternatively, a program considering a particular department would involve its members from all levels, from line management to front-line staff.

If the program scope is wide ranging, it may be necessary to hold a series of workshops, each focusing on a particular function or element of the organisation's operations.

Step 3.1: Understand the risk controls

It is important to understand which policies, procedures, systems and practices the organisation has in place in their Safety Management System to control or prevent each hazard identified (in Step 2 and in the operator's risk register) from occurring. These risk control systems are the defences that, when working effectively, prevent incidents or mitigate the severity of their outcomes. In some cases, one risk control system may mitigate against several hazards and their immediate causes, but with different degrees of influence. It is also highly likely that each hazard or cause is mitigated by several risk control systems.

To understand the relationship between risk controls and hazards and their immediate causes, it is useful to visualise them using a diagram. Figure 11 provides an example using sticky notes. To help order and structure risk controls put each one on a separate sticky note; discuss and order them with your SPI team. Alternative approaches that achieves similar results include fish bone diagrams, bow-tie models and fault tree analysis.

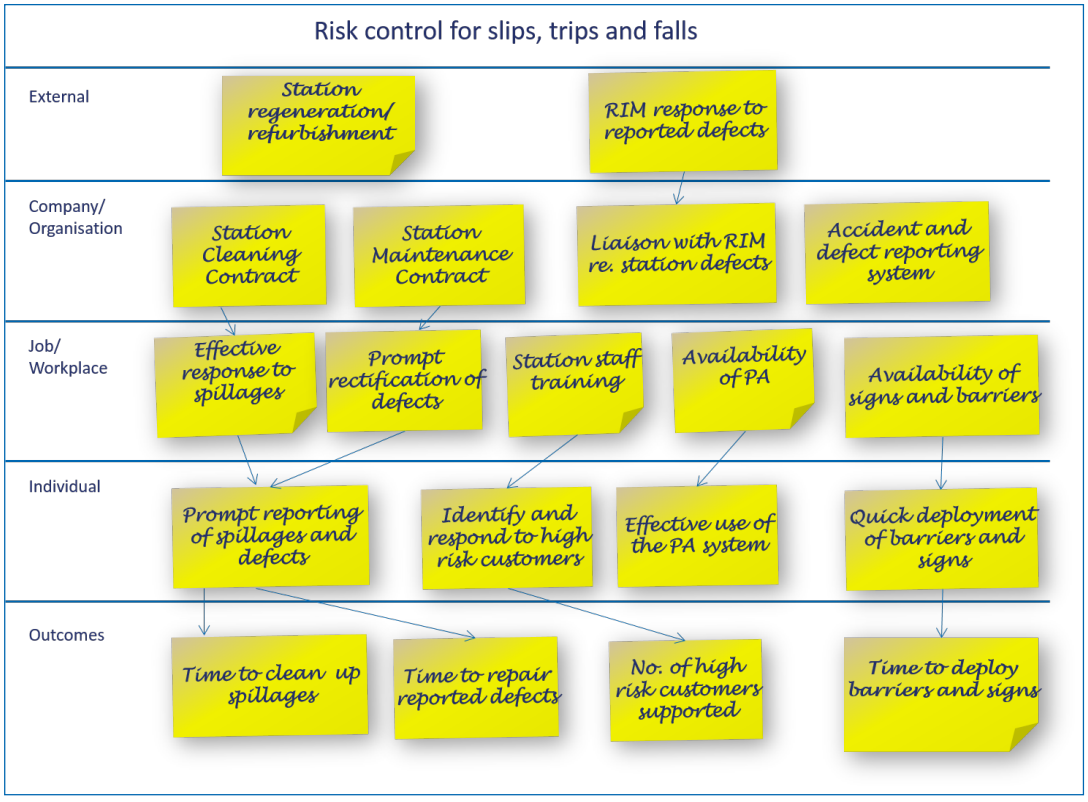


Figure 11 - Example risk control diagram using sticky notes

Step 3.2: Prioritise the risk control systems

It is likely that there will be multiple risk control systems in place, far too many for each to be individually measured. The SPIs selected should be those that are critical to the management of risk and that relate to the areas, which the organisation judges to be the most vulnerable. To identify these, consider the questions in Figure 12.

A rating matrix similar to the one shown in can help with the prioritisation process. The most critical and vulnerable risk controls being the priority.

The number of SPIs desired will determine how many risk control systems should be picked. For each risk control, generally, two or three individual SPIs would be selected.

Criticality: The relative importance of a risk control (the extent to which its failure would increase the likelihood of an incident or loss).

Vulnerability: The extent to which a risk control is susceptible to deterioration, short cuts, unreliability or uncertainty.

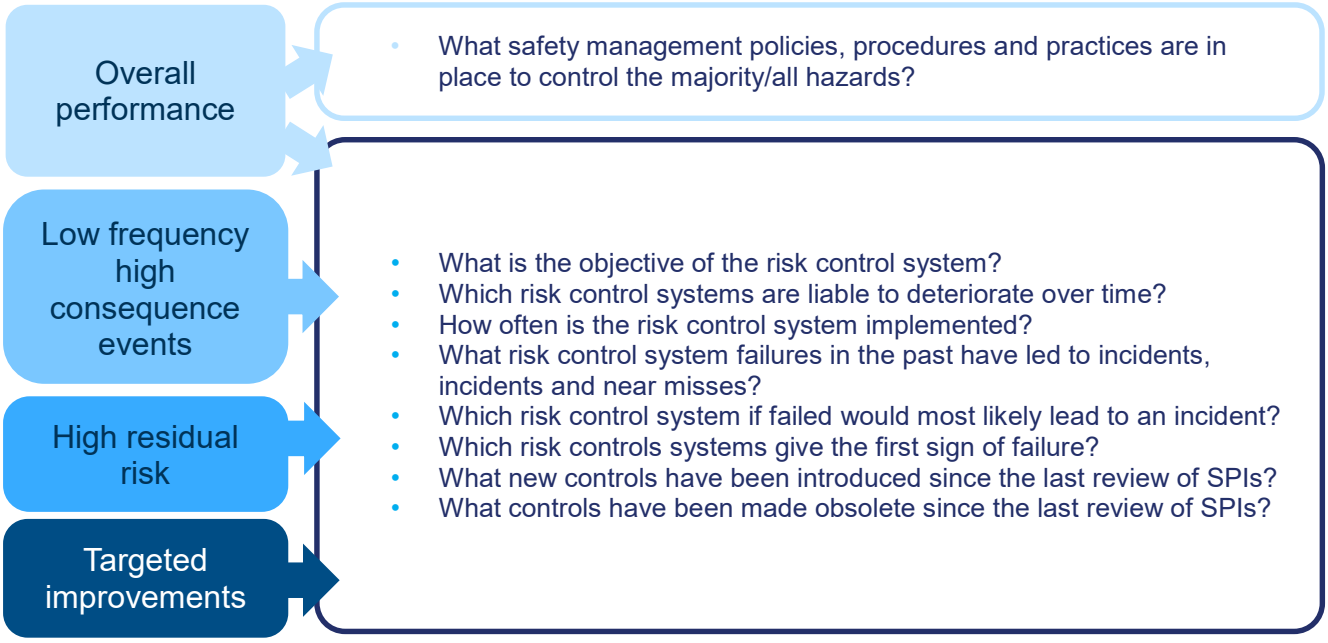


Figure 12 - Prioritising by vulnerability and criticality

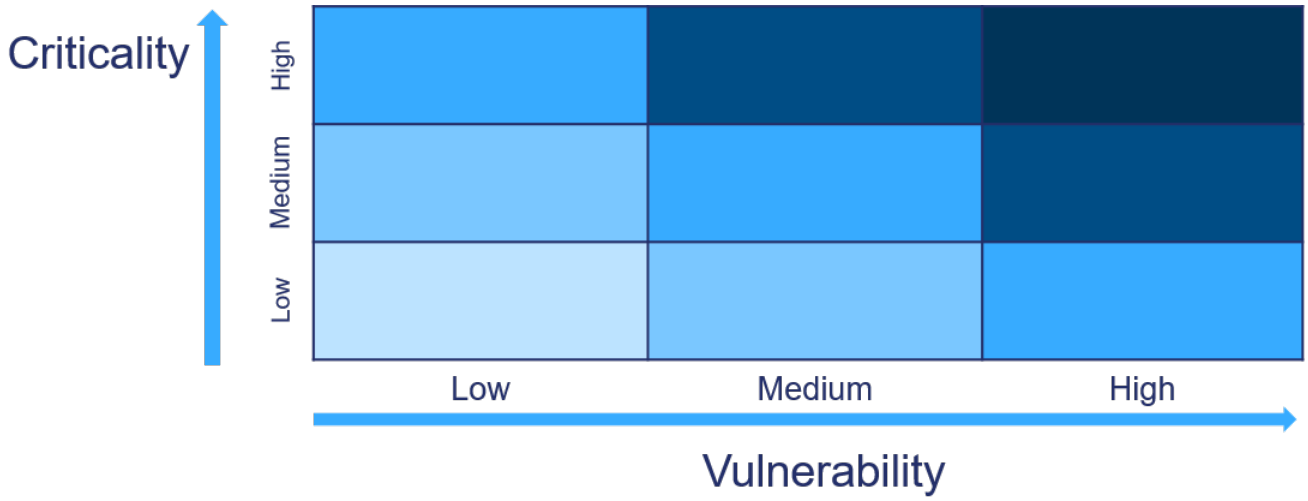


Figure 13 - Criticality and vulnerability matrix

SPI Toolkit

- Risk control visualisation guidance
- Risk control prioritisation guidance

Step 3.3: Set an outcome indicator

An outcome indicator is a measure of events that have occurred. To identify potential outcome SPIs, for a risk control system, first consider:

- What do you want to achieve?
- What does success look like?

By determining the desired outcomes, it should be possible to identify ways of measuring whether these objectives are being met. The closer the measure is to the first sign of failure in the risk control system, the greater the opportunity to correct the weakness and prevent incidents. Here, a failure could be:

- Not meeting the success criteria.
- Operating outside of desired parameters.
- Not achieving the required standard or performance.

An example risk control for preventing train collisions (an incident outcome) is driver competence. One sign of failure could be a SPAD (a precursor outcome). However, the measurement of non-ideal driver behaviour, such as over speeding and late braking, could give an earlier warning of deterioration in driver competence and therefore is a more proactive measure. These latter two measures are also precursor outcomes but provide an earlier opportunity for incident prevention.

Result outcomes measure the direct outputs of a particular activity, such as the results of a driver competence assessment. These could be the first sign of failure that a driver is not meeting the required standard. Result outcomes generally provide insights on one type of failure and the usefulness of the measure is affected by how often the activity is undertaken. Competency assessments taken bi-annually will report back on the company's obligation to instruct drivers to a particular standard, but this only reflects the status at the time of the assessment.

When selecting SPIs, thought should be given to what should be measured (in terms of incident causation) as well as what is currently being measured. New measurements may be more beneficial and potential changes can be assessed for cost effectiveness. Establishing a proven relationship between precursor and incident outcomes can help justify additional efforts in collecting and analysing data. This is because there will be confidence that an improvement in the precursor outcome should lead to an improvement in the incident outcome.

If there are any existing SPIs, it is worth considering:

- What outcome SPIs are currently set to monitor this control system?
- Do they provide meaningful insights into safety performance?
- Do they measure the first sign of failure?
- Are any additional outcome SPIs required?
- Could any existing outcome SPIs be combined?

The choice between selecting an incident, precursor or result outcome should be made based on the amount of data produced, the timeliness and strength of warning, and the desired breadth of coverage of failure modes. This may depend on the focal areas being considered.

Selecting outcome indicator types by focal area

High residual risk and **overall performance** generally will have sufficient data points to monitor using incident outcomes. However, if meaningful and measurable precursors can be identified these may provide earlier warnings of weaknesses in the risk control systems.

Low frequency high consequence events will benefit from measuring precursor outcomes. These are more targeted to the risk controls being considered and will produce more data for analysis than measuring the incidents alone.

Targeted improvements may not have a direct correlation with the occurrence of a particular hazard as the improvement may be focussed around a specific activity, such as contractor tendering or safety communications. Here setting a result outcome will demonstrate whether the goal is being achieved. This type of indicator may require refining after the completion of Step 4: Select and define activity indicators, which considers activity SPIs.

Creating a ‘decisions log’ to document why each indicator is being considered further or rejected provides a valuable ‘audit trail’ should the choice of indicators be challenged. This is particularly important, for example, if senior management approval is required for the release of additional resources.

Step 3.4: Define SPIs

It is important that any SPI selected is clearly defined so that it is consistently recorded, reported and understood across the organisation.

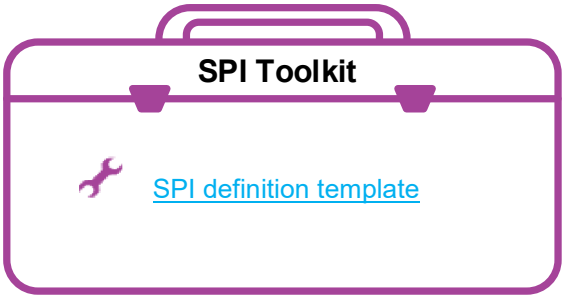
The definitions for each SPI will require input from all those involved in measuring, analysing, reporting, acting and reviewing, to ensure that the SPI is clearly understood.

Senior management should be leading from the front to align SPIs to business objectives, and be involved in setting the targets and agreeing the action plans.

The SPI definition should include:

- A description of what the SPI measures.
- The purpose of the SPI (that is, what it is intended to manage and who it is intended to inform).
- The units of measurement and any formula for its calculation, including any normaliser.
- Who is responsible for collecting, validating, analysing, reporting and acting on the SPI (these may be different people within different parts of the organisation).
- Where or how the data should be collected.
- The frequency of collecting, analysing and reporting the SPI.
- If appropriate, a target value, goal, tolerances and statistical tests that can be applied.
- Potential actions for when the SPI deviates from the accepted tolerances, including when the deviation should be reported to senior management.

When carrying out a review of existing SPIs it is worth checking that the definitions and responsive actions are still meaningful and relevant.



Step 3 check list

- ❒ Risk controls relevant to hazards/causes or completed risk control matrix.
- ❒ Completed definitions for each outcome SPI.
- ❒ Completed ‘decisions log’ for outcome SPIs.

Step 4: Select and define activity indicators

In this step activity SPIs are selected, evaluated and defined to address the key issues, with respect to outcome SPIs (selected in Step 3)..

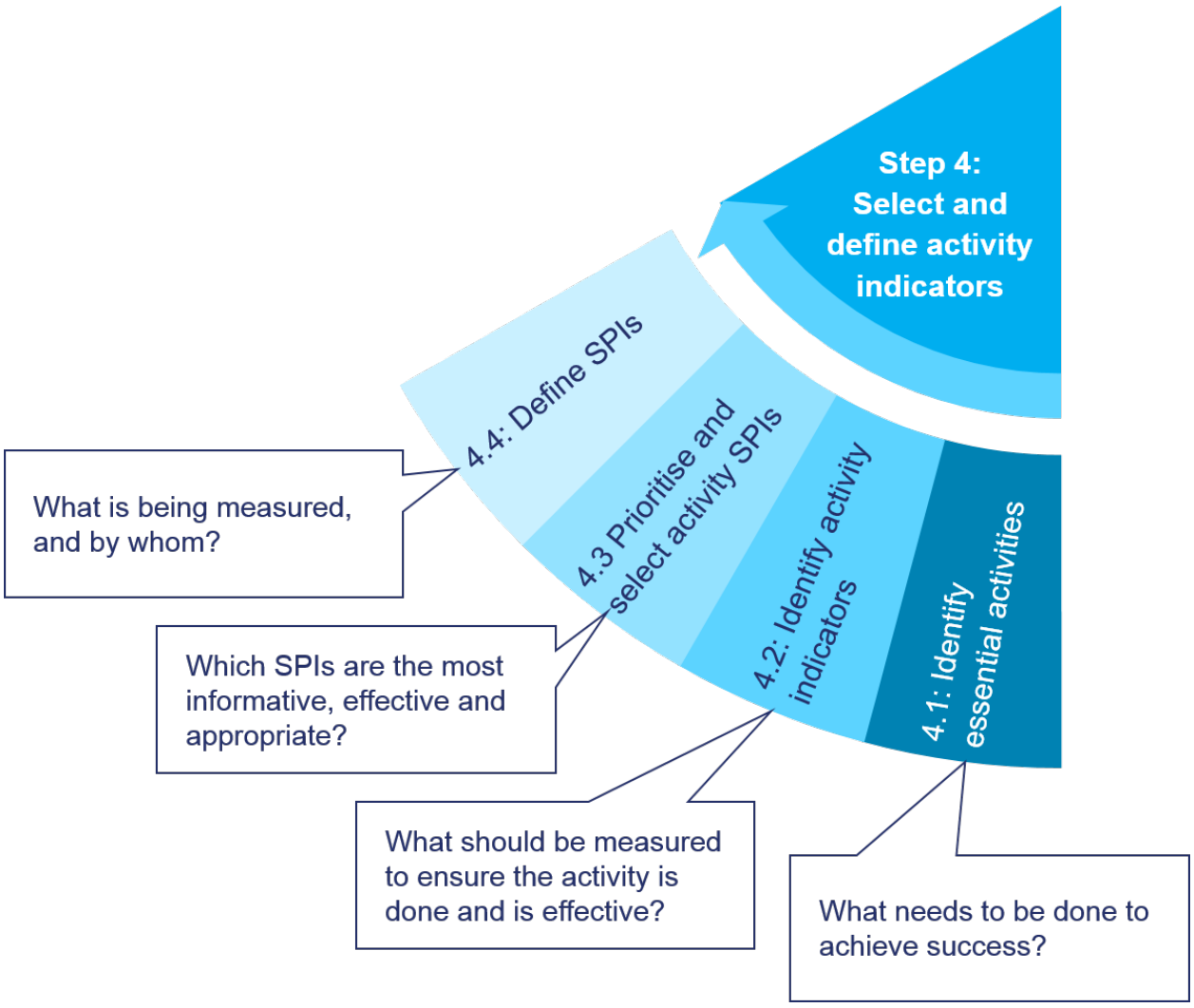


Figure 14 - Step 4: set and review activity indicators

Step 4.1: Identify essential activities

Activity SPIs are measurements of whether risk controls are in place and working effectively to prevent undesired safety outcomes. Therefore, to set an activity SPI it is first necessary to consider:

- What activities (inputs or processes) are the most important to delivering the objective of the risk control system?
- What are the activities that control the underlying causes of incidents?

Measuring activity SPIs provides assurance that the risk control systems are performing as intended and used to drive continuous improvement. The objective or success criteria for each risk control system should have been identified in Step 3.3: Set an outcome indicator. These can be used in conjunction with the underlying causes of incidents to determine the essential activities to implement the risk control systems. Activities, inputs and processes will fall into one or more of the following known incident causal categories:

- Competence and compliance
- Equipment
- Work and task planning
- Supervision and management
- Rules, procedures and methods of working
- Organisational structure and safety management
- Communications
- Safety performance monitoring, review and continuous improvement

It should be remembered that the scrutiny of the activities should be appropriate to the SPI users and scope of the program.

Each risk control system is likely to be made up of multiple activities, processes and procedures. For example, training and competence management could comprise training courses, supervision and mentoring, on-the-job assessments, and so on. Not all need to be measured to provide assurance that the risk control system is performing. Focussing on those considered important or essential will help to prioritise the selection of activity SPIs. Useful questions to consider include:

- Which activities are liable to deteriorate over time?
- How often is the activity carried out?
- Which activities (or lack of) have previously led to incidents?
- Which activity if not completed would most likely lead to an incident?
- Has there been a change with a high risk of impact?
- Which activities have been proven to have a direct impact on risk?

Example activity indicators

Competence and compliance: percentage of training plan delivered

Equipment: percentage of maintenance undertaken to schedule

Work and task planning: percentage of weekly resource plans reviewed

Supervision and management: percentage of planned station visits completed

Rules, procedures and methods of working: percentage of safe work method statements reviewed and updated

Organisational structure and safety management: progress of SMS review completed

Communications: time taken to sign for notices

Safety performance monitoring, review and continuous improvement: percentage of audits completed against plan

Step 4.2: Identify activity indicators

For each of the prioritised activities identified in step 4.1, consider what can be measured to increase confidence that the risk control system is performing as intended.

It is important to consider the maturity of an organisation when choosing what activity SPIs to measure. For example, an activity SPI could measure:

- The existence of an activity, input or process.
- The level of implementation or compliance with an activity input or process.
- The effectiveness of an activity, input or process (this is equivalent to a result (outcome) indicator).
- The use of an activity, input or process to identify areas of improvement.

Listed in order of organisational maturity, the first of these steps needs to be achieved before going on to measure the next. An organisation needs to recognise its own level of maturity and focus on the step where greatest value can be gained from monitoring.

The SPIs also need to be appropriate to the organisation's safety culture. For example, measuring the level of implementation could shift focus to completing the activity at the expense of a reduction in quality. This undesired behaviour could be curbed by pairing it with a result indicator. For example, measuring the number of safety briefings completed may result in content or method of delivery declining in quality. To manage this undesired behaviour one solution could also be to monitor attendee feedback comments or scores.

Step 4.3: Prioritise and select activity SPIs

It is likely that several potential activity SPIs will be identified. However, measuring all of them is likely to be impractical. It is more practical to measure one, well-chosen indicator (or two if paired with a result outcome indicator).

Before prioritisation can be done the potential SPIs need to be defined sufficiently (description, measure or formula, units of measurement, frequency) so they can be evaluated with a common understanding of what they mean.

To prioritise indicator selection it is worth considering the practicalities of the data availability. For example, are the indicators:

- Currently collected and reported
- Collected but not reported
- Available but not collected
- Not currently available

This will help to gain insights into the additional effort required to monitor the SPIs.

Selecting activity indicators by focal area

Overall performance activity SPIs will be general in nature addressing the overall risk profile.

SPIs associated specifically with **high residual risk** should be identified in addition to overall performance SPIs, and will be more targeted at the areas under consideration.

Similarly, activity SPIs for **low frequency high consequence events** will be more specific than overall performance SPIs and targeted towards the process being scrutinised.

Targeted improvements SPIs will be the most specific directed at a particular concern or program for change.

For example, risk assessment may be considered as an essential activity for mitigating the high residual risk associated with boarding and alighting incidents. However, this activity SPI may also be considered as part of the organisation's overall performance. Therefore, a more specific activity to boarding and alighting should be selected.

Analysis of data will help identify which measures are more specific and beneficial. For example, adherence to train dispatch plans or inspections of door steps and grab handles may be identified as a specific activity important to maintaining safe platform-train interfaces.

Further criteria for evaluating SPIs and identifying the best activity indicator are given in Figure 15. If the answers to the question list are predominantly 'Yes' the SPI is more favourable than an SPI for which the answers are predominantly 'No'.

Organisations may wish to apply different weightings to each criteria (for example apply greater emphasis on equipment design) to

distinguish further between the SPIs being considered.

Several related SPIs may be identified. Rather than choose one, consider whether combining the measures to form a composite SPI would be beneficial. For example, the two SPIs: the number of actions open relating to station improvements and the number of actions completed and closed out could be combined to form a single SPI measuring the ratio of open to closed actions.

As with outcome indicators, creating a 'decisions log' to document why each indicator is being considered further or rejected provides a valuable 'audit trail'. If there are several SPIs that appear promising, implementing a trial could help decide which SPI is the most useful before formally adopting it for wider use.

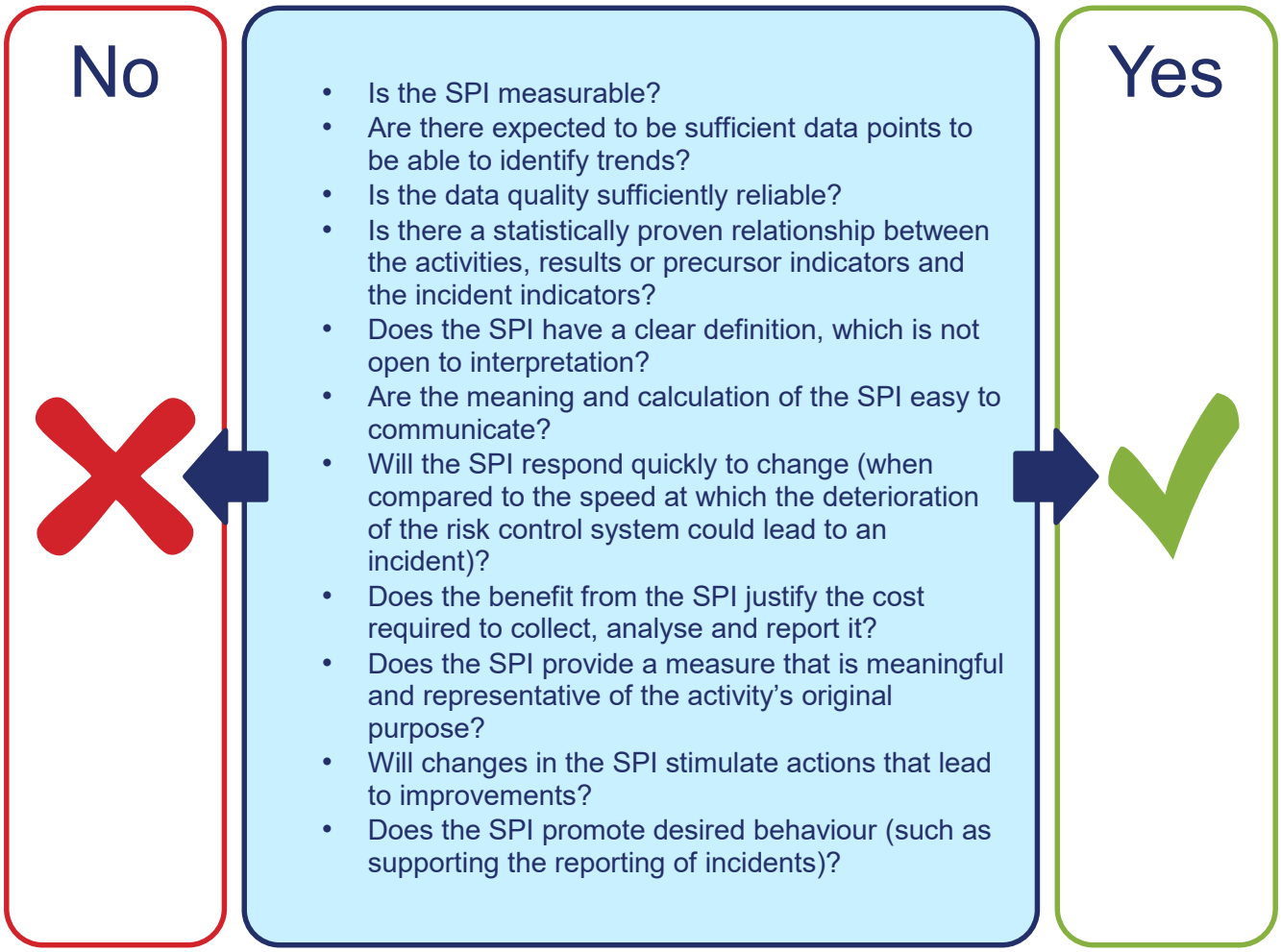


Figure 15 - Criteria for prioritising SPIs

Step 4.4: Define activity SPIs

Once the activity SPIs have been selected these need to be defined completely. A list of SPI attributes that need to be defined is given in Step 3.4 and a sample definition template form is provided in the SPI toolkit.

Step 4 check list

- ❒ Completed definitions for each activity SPI
- ❒ Completed 'decision log' for both outcome activity SPIs

Step 5: Collect and analyse data

Having selected and defined a set of SPIs the next stage is to implement the collection and analysis of SPI data.

Figure 16 - Step 5 Collect and analyse data

Step 5.1: Collect data

The first task in Step 5 is to brief and educate the staff involved in gathering the required SPI data and instigating the data collection.

The SPI definitions produced in Step 3 and Step 4 should include:

- Data sources
- How the data should be compiled
- Who will collect and compile the data
- The frequency at which the data will be collected, analysed and reported.

Depending on the nature and availability of the data this may take some time to set up and integrate into other business tasks. A pilot study may be required to demonstrate the benefits of a proposed SPI before it is used more widely.

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 each month.

When the data has been collected, it should be verified for completeness, accuracy and in accordance with the agreed SPI definition. Ideally, this should be done by someone who is independent from the data generation activity.

Step 5.2: Analyse data

Analysis and interpretation of the data should provide results that clearly show when action is required. Significant trends should be differentiated from random fluctuations where possible.

Techniques like the use of moving averages, cumulative scores, normalisation and comparison with tolerances can help identify trends from short-term fluctuations.

Where data points that do not fit with expectations are identified, these need to be investigated to identify the cause. Alongside the

analysis it may be worth keeping notes of key events that have triggered significant changes. For example, the start of a new training course program, or introduction of a new procedure. These could help when reviewing the SPI effectiveness in Step 7: Review.

Where large amounts of data are generated it might be appropriate to perform a statistical test to determine whether any variations are more than just random fluctuations.

SPI Toolkit

- Data analysis and presentation guidance
- Data types and collection

Step 5 check list

- ❒ Relevant staff trained and briefed
- ❒ Process for data collection and analysis agreed
- ❒ Verified SPI data

Step 6: Report and act on findings

Figure 17 - Step 6 Report and act on findings

The time taken from collecting data to reporting it should reflect the potential risk increase indicated in any warning produced by the SPIs. There is little benefit in reporting SPIs which reflect the status of the organisation six months previously, if the nature of the SPI requires action to be taken within a month. The reporting intervals may be reviewed and revised as part of a pilot study.

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.

Presentation of results

Typically reports could involve:

- A chart or graph to demonstrate how the SPI has performed over time, or to show the distribution of results or a comparison of one area of the organisation with another.
- A summary status, which could use graphics such as traffic light colours or direction of change arrows to show how performance has changed since the last report or the deviation from the target.
- A table of supporting information to show the reasons for any identified trends or outliers.

Figure 18 illustrates some graphical methods of displaying results.

If targets or objectives have been set, the results should be shown in comparison to allow senior management to see easily whether performance is within the set tolerances or whether action is required.

Related activity and outcome indicators should be reported alongside each other. This should make it clear how a change in activity results in a change in safety performance. It is also useful to report any actions underway to correct deviations or make improvements.

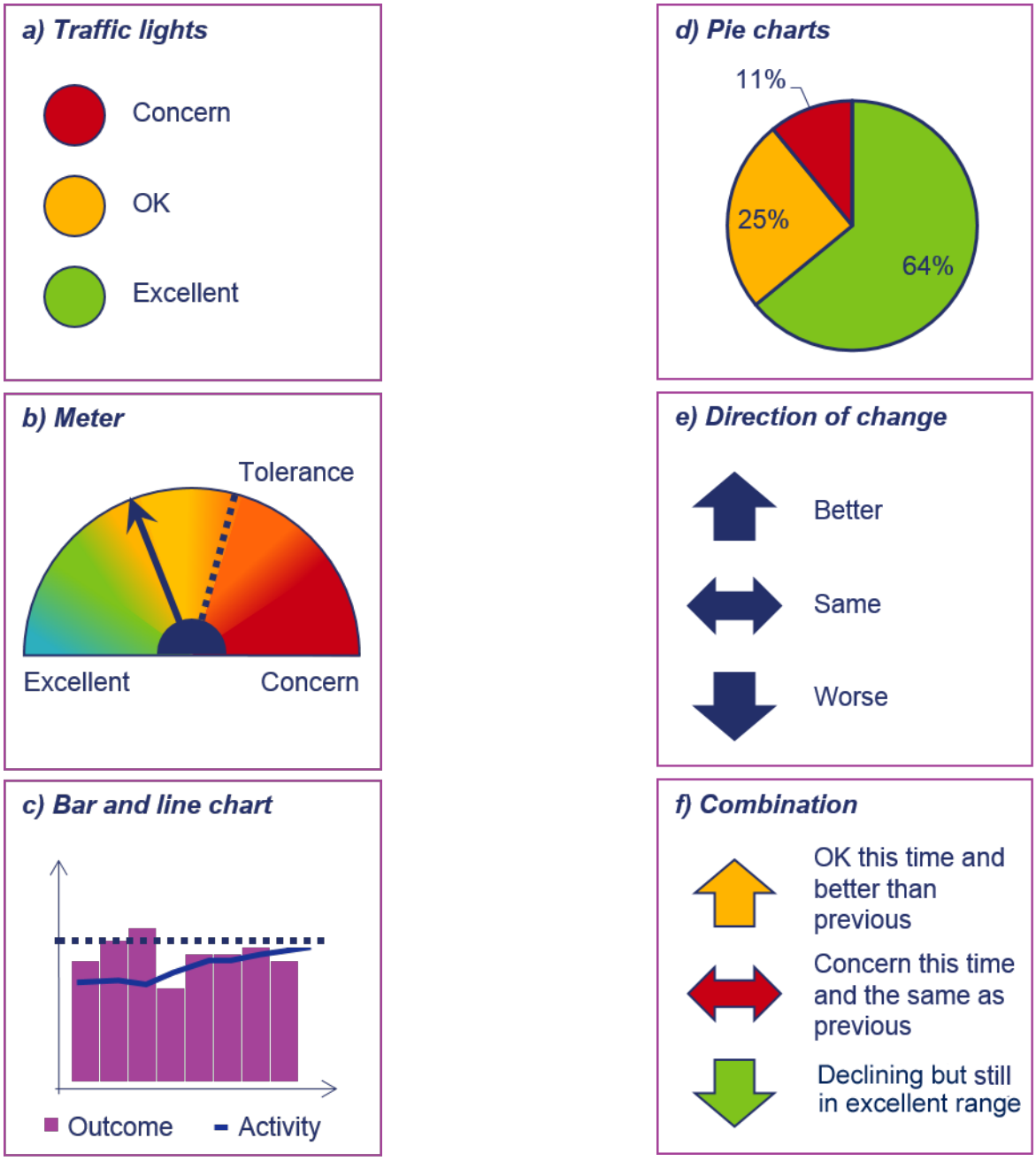


Figure 18 - Example methods of displaying results

Target readership

Senior management will need to see regular updates of the results. The data should be presented at a level suitable to the reader. Typically the number of SPIs reported will be greater lower down the organisation than at the top (see Figure 18).

Line managers may require detailed results specific to their activities whereas senior management may prefer aggregated summaries.

Senior managers may of course wish to investigate the components in more detail.

For example SPIs reported at stations A, B and C could be summarised to form one composite measure. This could be based on a weighted score derived from individual SPIs or by presenting the worst case. If station A stands out from B and C, senior management can examine the detailed SPIs to understand why.

Senior management should stipulate what detailed SPIs should be reported to them, if the values exceed agreed tolerances. The detailed

SPIs will support evidence for required changes or at least identify areas where further investigation is needed. Conversely, the owners of the SPIs need to inform senior management of concerns when the SPI data is showing unfavourable trends.

The results should be reported back to the workforce (including contractors), as well as the senior management. This may require a different report to reflect the different audience. As illustrated in ,Figure 19 workers may find emphasis on activities to be more relevant. Feedback to workers will reinforce the importance of worker participation in generating SPI data (such as reporting incidents or ensuring data quality) as well as providing safety performance feedback on what is going well and where changes are being introduced to make improvements.

Take action

Reporting of SPIs 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 6 check list

- ❒ Agreed report format
- ❒ Report generation process agreed
- ❒ Report circulation list

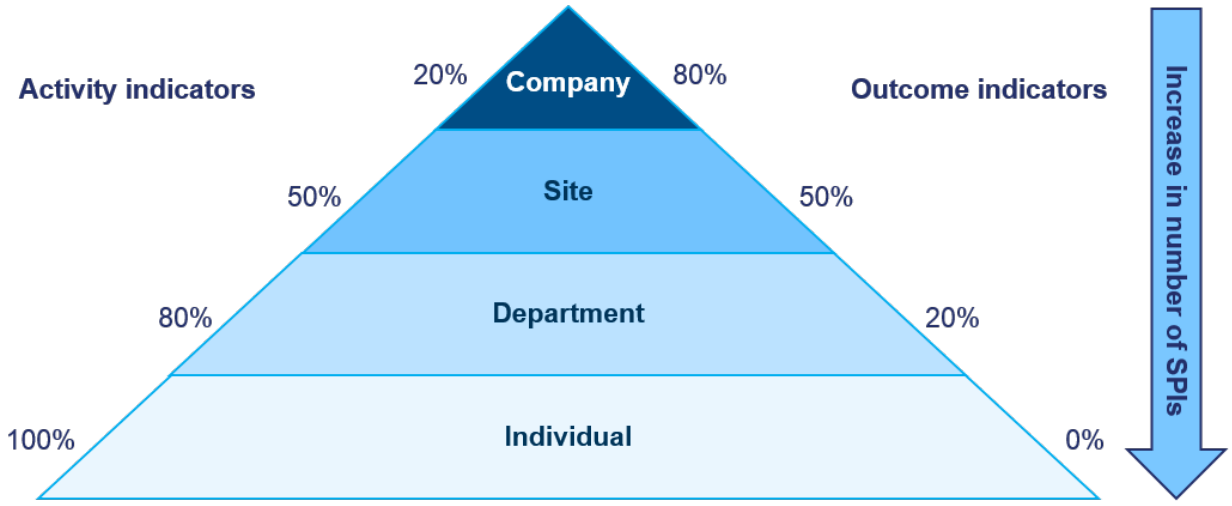


Figure 19 - The number of SPIs reported[6]

[6] Adapted and cited from Grabowski, M et al. *Accident Precursors and safety nets: leading indicators of tanker operations safety*, 2007, Maritime Policy and Management, Vol. 34 No. 5 pages 405-425.

Step 7: 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.

Figure 20 - Step 7 Review

A review should be carried out periodically (typically annually) or when an organisation makes substantial changes, in line with the organisation's SMS change management process. This may be following a reorganisation, the introduction of new technology, an increase in the number of incidents in a particular area, a major incident (possibly reported elsewhere), a SMS revision or change in legislation. The SPI review could be done in conjunction with an organisation's risk profile review, as typically this considers the organisation's concerns and risk control systems.

The review should consider:

- The scope and objectives of the program
- The effectiveness of the current SPIs
- Reprioritisation of the issues of concern

Repeating Steps 1 to 6 (Figure 4), reusing materials where appropriate, will identify where changes need to be made.

Program scope

The program scope and objectives should be reviewed to check that they are still relevant and that the scope is still sufficient to fulfil the objectives and address the whole risk profile.

Current SPI effectiveness

The current suite of SPIs should be reviewed to check that they are providing meaningful information. Reasons to discontinue or change SPIs to make them more meaningful include:

- Instances where SPIs are continually reporting the same value (such as zero or 100%). These are unlikely to be providing useful inputs to decision making.
- An SPI that measures something similar to another SPI and provides the same assurances is duplicating effort.
- If the target has been met for an SPI implemented to measure the introduction of a program or targeted improvement.

The criteria in Figure 15 may also prove useful to review whether or not an SPI should still be measured. After practical implementation some of the answers to the questions may have changed, and other SPIs may now be more favourable.

The relationships between activity and outcome indicators should be explored to verify that the right SPI combinations are being measured to provide dual assurance. An improvement in an activity indicator should lead to an improvement in a precursor or incident outcome indicator. If there is no agreement, it could be that:

- The activity indicators are measuring the wrong thing.
- The risk control systems being measured are ineffective.
- The controls being measured are already being completed to a high standard or are not the main influences on the hazard (so other activities should be the focus of attention).
- The indicators are too subjective and therefore deceptive (that is, if the person doing the measurement or assessment for an SPI perceives that there are no problems, few will appear).
- There is a time lag between improvements in activities and the outcomes.

The review should also consider whether other aspects of the SPI are still suitable, that is:

- Is the intention of the SPI still clear?
- Is the SPI being measured, analysed and reported at an appropriate frequency?
- Are the responsibilities clear and up to date?
- Are the targets or tolerances still appropriate?
- Are the actions associated with SPI deviations appropriate and up to date?

Reprioritisation of the issues of concern

The process of selecting SPIs includes consideration of the issues of concern. If, for example, targeted improvements have been achieved and sustained, the activities or outcomes may no longer be a priority. Then, the associated SPIs should be discontinued.

Similarly if, for example, a review of hazards, immediate or underlying causes, risk controls, audit findings, safety culture survey results or incident investigations, identifies new issues of concern, the development of new SPIs should be considered.

When reviewing the need to create new SPIs, it is worth considering what SPIs are currently being measured and whether these can be supplemented, adjusted or aggregated to address the newly identified needs.

SPIs that measure behaviour may lose effectiveness as people become aware of what is being measured. When adjusting SPIs, this should not be done to suit the data the organisation wants to provide or just to make the data appear more favourable.

The effects of change

When reviewing the SPIs, it is worth being aware of the benefits and disbenefits that SPI change can bring.

Disbenefits can include:

- Discontinuation of an indicator may stop recording data that could prove useful in the future.
- Frequent changes to the definition of SPIs can make comparisons over time difficult.

Benefits can include:

- SPIs reflect the current needs of the organisation and prevent indicator fatigue by creating new challenges.
- Keeping the number of SPIs manageable.
- Preventing the benefits of SPIs from being diluted by only focussing on the priority issues of concern.

Step 7 check list

- ❒ Review schedule
- ❒ Review findings
- ❒ Updated decision logs with proposed SPI changes

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