Investigators' Handbook

Part 4 – Causation

Part 4 – Accident causation

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Causation theory

Contents

This section is intended to provide an overview of some of the theories relating to identifying the causes of accidents and incidents.

Domino theory

HW Heinrich's 'Domino theory' of the 1920s has, perhaps, been the most influential theory of accident causation and states that an accident leading to injury or damage is the result of a five stage sequence.

Each of the five stages – represented by dominoes (see Figure 1 below) – represents a linked cause; remove any one of them and the sequence cannot run its course and, therefore, injury or damage will not occur.

In Heinrich's original accident causation model an injury at work was invariably the result of an accident which is the consequence of an unsafe act or condition generated by the fault of some person. The faults of a person are in turn described as the result of genetic and social factors. If these are represented by 5 dominoes standing on end the 'inevitable' causal chain can be demonstrated. Modern approaches now tend to favour multi-causality rather then the narrow causal path of Heinrich's 'Domino theory'.

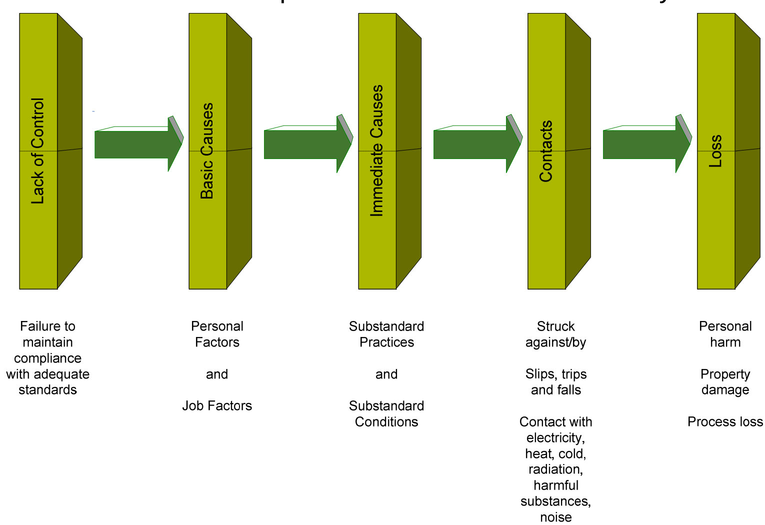

Figure 1 – Domino theory

Heinrich's model was updated in the 1930s by an American, Frank Bird, who replaced the term 'unsafe acts and conditions' with 'substandard acts and conditions'. 'Faults of person' was altered to 'job factors and personal factors' and the initiating domino (genetic and social) was given the label 'management system failures'. Bird also added the attribute of chance to the result by adding categories of damage and near miss accidents at the end.

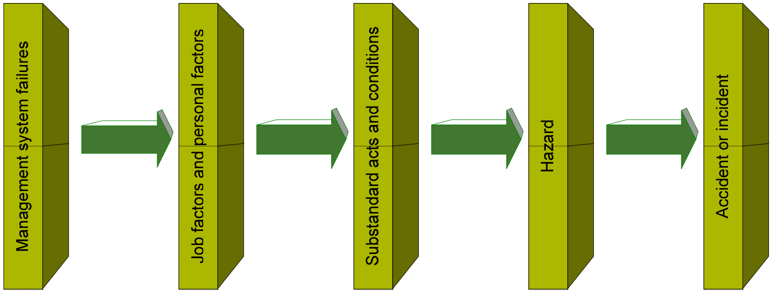

Figure 2 – Revised Domino theory

Over time, the type of cause represented by each domino has been revised with the following being considered by some to be more appropriate:

1	Work situation	lack of supervision, work pressures, etc.
2	Fault of person	stubbornness, recklessness, personal problems, etc.
3	Unsafe Act or Condition	short cuts, unguarded tools/machinery, process error, etc.
4	Accident	events such as falls, pinch points, etc. that result in injuries or damage
5	Injury	any level of injury from first-aid to catastrophic

Over time the model has been further developed. Initially the worker was seen as the prime source of accidents and incidents, with prevention concentrated on removing the third domino through a combination of disciplinary and protective measures.

The emphasis then switched to the second domino, and the preventive action centred more on training and work design.

More recently, safety practitioners have focussed on the first domino, as it was considered senior management held the ultimate responsibility for safety matters, and in the importance of designing systems and processes which are safe at the outset.

HSG245

In its guidance publication HSG245 *Investigating accidents and incidents*, the HSE uses the 'Domino theory' in a slightly different way to explain the 'Domino effect', i.e. the chain of failures and errors that lead almost inevitably to an accident or incident.

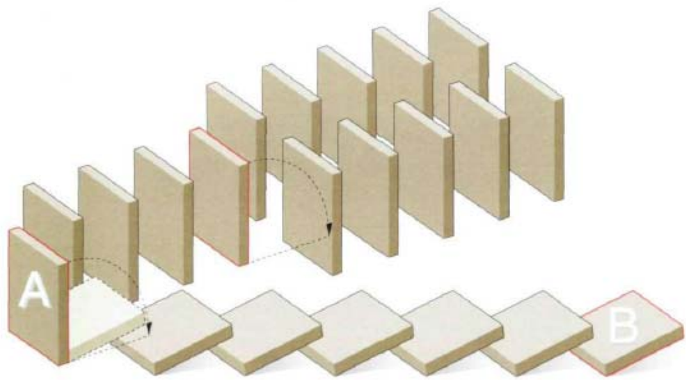

Figure 3 – HSE's Domino theory diagram from HSG245

In the HSE's diagram (see Figure 3 above) each domino represents a failing or error which can combine with other failings and errors to cause an accident or incident.

Addressing the immediate cause (B) will only prevent this sequence but addressing all causes, especially root causes (A) can prevent a whole series of adverse events.

The HSE classifies causes:

Immediate causes	The agent of injury or ill health (the blade, the substance, the dust etc.)
Underlying causes	Unsafe acts and unsafe conditions (the guard removed, the ventilation switched off etc.)
Root causes	The failure from which all other failings grow, often remote in time and space from the adverse event (e.g. failure to identify training needs and assess competence, low priority given to risk assessment etc.)

To prevent accidents and incidents, effective risk control measures need to be provided which address the immediate, underlying and root causes.

Adequate investigation of the accident or incident should identify these causes.

The 'Swiss Cheese' model

The trend for leading organisations to integrate health and safety into mainstream management sparked a search for new accident causation models which recognised that organisational and workplace factors are at the root of most unsafe acts.

One such model was put forward by Professor James Reason in 2000 (although he himself did not attribute this title to his model).

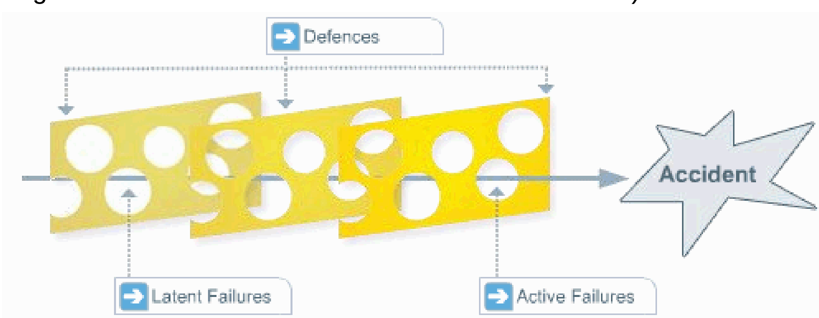

Figure 4 – Reason's 'Swiss Cheese' model

In the model, accidents and incidents tend to be the result of a complex chain of contributory events. These have come together to create an accident or incident. A slice of Swiss cheese represents each layer of defence (i.e. control measures) with areas of weakness (i.e. failures or errors/unsafe acts) shown as holes in the cheese slices.

The system as a whole produces failures when all of the holes in each of the slices momentarily align so that a hazard passes through all of the defences, leading to a failure – with potentially serious consequences.

Defences	Defences are layers of protection that make a safe system. They are either 'hard' defences which include things like alarms, interlocking, system design and protective equipment or they can be 'soft' defences which include rules, procedures, permits to work, supervision and training.
Latent failures	Latent failures include poor design, gaps in supervision, unworkable procedures, shortfalls in training, under-manning, less than adequate tools and equipment. These arise from strategic and other top level management decisions and organisation processes such as budgeting, planning, resource allocation and auditing. They combine with local circumstances and active failures to penetrate the organisation's defensive layers and cause an accident or incident.
Active failures	Active failures are unsafe acts by people at the 'sharp-end'.

In Reason's model, organisational factors include:

a) resource allocation;

b) health and safety goals;

c) delegation of responsibility and authority;

d) workplace design;

e) procurement of equipment, etc.

These are communicated throughout the organisation as workplace factors, such as policies and procedures, work schedules, instructions, training, and so on.

These factors affect the frontline worker and (in accident scenarios) may influence them to cut corners, for instance, to meet an urgent deadline, or to assume that a key maintenance action can be left for someone else to carry out.

The 'Swiss Cheese' model has proven to be highly popular, with wide dissemination and use across various industrial domains such as aviation, patient safety, rail and marine.

Task, Material, Environment, Workers, and Management

A simple model identifies causes of any accident grouped into five categories – **Task, Material, Environment, Workers, and Management**. Possible causes in each category should be investigated.

Each category is examined more closely below but bear in mind that the questions to be asked – as part of any investigation –are examples only and will not be a complete list of what may need to be asked.

Category	What is explored	To be asked as part of an investigation
Task	The actual work procedure being used at the time of the accident/incident	• Was a safe work procedure used? • Had conditions changed to make the normal procedure unsafe? • Were the appropriate tools and materials available? • Were they used? • Were safety devices working properly? • Was lockout used when necessary?

Category	What is explored	To be asked as part of an investigation
Material	Possible causes resulting from the equipment and materials used	• Was there an equipment failure? • What caused it to fail? • Was the machinery poorly designed? • Were hazardous substances involved? • Were they clearly identified? • Was a less hazardous alternative substance possible and available? • Was the raw material substandard in some way? • Should personal protective equipment (PPE) have been used? • Was the PPE used?
Environment	The physical environment and especially sudden changes to that environment. The situation at the time of the accident/incident is what is important, not what the "usual" conditions were.	• What were the weather conditions? • Was poor housekeeping a problem? • Was it too hot or too cold? • Was noise a problem? • Was there adequate light? • Were toxic or hazardous gases, dusts, or fumes present?

Category	What is explored	To be asked as part of an investigation
Worker	The personal characteristics, including the physical and mental condition, of the individuals directly involved	• Were workers experienced in the work being done? • Had they been adequately trained? • Can they physically do the work? • What was the status of their health? • Were they tired? • Were they under stress (work or personal)? **Note**: Some factors will remain essentially constant while others may vary from day to day

Category	What is explored	To be asked as part of an investigation
Management	The role of supervisors and higher management, since 'Management' holds the legal responsibility for the safety of the workplace	**Note**: Answers to any of the preceding types of questions logically lead to further questions. • Were safety rules communicated to and understood by all employees? • Were written procedures available? • Were they being enforced? • Was there adequate supervision? • Were workers trained to do the work? • Had hazards been previously identified? • Had procedures been developed to overcome them? • Were unsafe conditions corrected? • Was regular maintenance of equipment carried out? • Were regular safety inspections carried out?

This model provides a guide for uncovering all possible causes and reduces the likelihood of looking at facts in isolation.

Some of the example questions could be placed in different categories, but the categories are not important, so long as each pertinent question is asked.

Obviously, there is considerable overlap between categories and this reflects the real life situations.

'Why? Because' analysis

The 'Why? Because' Analysis (WBA) is a technique, for causally analysing the behaviour of complex technical and socio-technical systems.

Its primary application is in the analysis of accidents, mainly within transportation systems (i.e. air, rail and marine). It may also be used for safety requirements analysis during system development.

WBA is based on a rigorous notion of causal factors – whether one event or state is a causal factor in the occurrence of another is determined by applying the 'Counterfactual Test'.

The 'Counterfactual Test' is done in the form of a question, i.e. "If the cause had not been, could the effect ever have happened?". If the answer is 'yes', then the cause is a "Necessary Causal Factor" (NCF) for the effect.

During analysis, a '*Why? Because' Graph* (WB-Graph or WBG) is built, showing the causal connections between all events and states of the behaviour being analysed. The completed WB-Graph is the main output of WBA.

The WBG provides a rigorous causal explanation of the behaviour being analysed. However, mistakes may be made in constructing the WBG, as with any human activity.

To detect such mistakes, WBA provides a 'formal proof' method which allows a check to be made as to whether the WBG is correct and relatively complete.

WBA is the only accident analysis method with such a formal consistency/completeness check.

The WBA should not be confused with the 'Why? Because' technique for determining the underlying causes that is explained in the Identifying the causes section of this Part 4 of the handbook.

HFACS

The Human Factors Accident Categorisation System – HFACS – was originally developed for use in aviation (by Shappell and Wiegmann, 1990). They needed a human error tool that was theoretically based, and which provided a general framework of human error around which they could base new investigative methods and restructure existing accident databases. None of the multitude of existing tools could meet their requirements, hence the development of HFACS.

HFACS is based upon the work of Professor James Reason (see above), where he describes a model – known as the ‘Swiss Cheese’ model – of accidents as the result of relations between:

a) real time unsafe acts by front line operators (such as signallers, power plant operatives, aircraft maintainers, pilots etc.); and

b) historical latent conditions (which may lie dormant for many years until a set of certain circumstances bring them into play).

Models such as this are sometimes referred to as ‘sharp-end, blunt-end’, where the ‘sharp-end’ refers to active failures and the ‘blunt-end’ the many layers of system factors that affect the individual carrying out a task.

According to Reason’s model it is necessary to analyse all levels of a system in order to fully understand the reasons for an accident occurring. It is no longer appropriate to simply focus on what the operator did to cause an accident, which is consistent with the general move from a blame culture to a just culture.

Reason identified four levels of a system which it is necessary for an investigator to explore when looking to comprehensively identify accident causation:

Unsafe acts	At the operator level (so in rail, examples are signallers and train drivers). This is the level at which most focus is typically placed in an investigation, and where most causal factors are uncovered.
Preconditions for unsafe acts	These are factors which contributed to or influenced the occurrence of the unsafe act. An example is excessive mental workload (e.g. which may have led to a signaller forgetting a vital piece of information or forgetting to undertake an act). Such factors are sometimes referred to as Performance Shaping Factors (PSFs) or Performance Influencing Factors (PIFs).

Supervisory factors	In many cases, it is possible to trace instances of existing preconditions for unsafe acts back to unsafe supervision. For example, a supervisor's task may be to produce work schedules. A poorly prepared schedule of work for staff may lead to fatigue (physical and mental) of the operator. Other examples of supervisory factors include a lack of correction of unsafe work practices, or not leading by example with safety critical communications.
Organisation	The organisation can impact at all of the previously described levels. For example, a lack of finances in an organisation may lead to a decrease in training, and the need to lower staffing levels. However, the need to continue to produce safe and effective work at the same levels as previously is unlikely to diminish and, as a result, supervisors may need to start to evaluate what tasks staff may be able to 'cut corners' on in order to continue to complete jobs on time. The effect of this on front-line staff will be to establish a culture of short-cuts in work, and eventually this may result in an accident or incident occurring.

Identifying the causes

Contents

This section is intended to provide an overview of:

a) the Why? Because technique that should be used to identify the underlying causes of the event;

b) attributing the underlying causes identified to the 10 Incident Factors;

c) using the immediate causes shown in the SPAD Data Collection form RT3119B (Railway Undertakings).

Immediate cause

The immediate cause should be the action, behaviour or condition that directly led to the event.

It should also relate to the event that is being investigated, as identified in the remit.

Do not simply state what is being investigated or what the accident/incident was.

For example, when investigating a Category A SPAD, ***do not*** record the immediate cause as "The driver failed to stop at the signal".

More than one immediate cause?

In most cases, there is likely to be only one immediate cause but it is possible for there to be more than one, e.g. an unsafe act and an unsafe condition which both immediately preceded the event.

Category A SPADs

In the case of a Category A SPAD, the immediate cause should be the most appropriate the immediate causes listed at Part 13 of the SPAD Data Collection form RT3119B (Railway Undertakings).

Underlying causes

These must include those issues/factors that the investigation team considers were:

Causal	when it is most likely that because of this the event occurred
Contributory	When 'causal' does not apply but the issue/factor increased the likelihood of the event.

The split between causal and contributory will, to some extent, rely on subjective judgement. Anything that is not considered to be a 'causal' or 'contributory' issue/factor must be included under 'Other safety related issues' (see below)

The underlying causes should be the action, behaviour or condition that led to or preceded the immediate cause(s) and will therefore include:

a) unsafe acts (an action or behaviour) and/or unsafe condition that was necessary for the event to occur;

b) the failures, including organisational failures (i.e. associated with the overall management systems or organisational arrangements), from which all other failings initiate – these may often be remote (in time and space).

For the purposes of this Handbook, **underlying causes** refers to what are also referred to elsewhere as **root causes**.

Identification of these underlying causes will emerge from reviewing the evidence and/or interviewing witnesses, and using the Why? Because technique to understand why each occurred.

Following accidents and incidents, processes and procedures may be reviewed and revised, and training and assessment material updated, but it is easy to miss the obvious that changes to a process, procedure, training, etc. may not address.

When an individual commits an unsafe act, there's a need to understand exactly why the individual did so. Was there a reason – an influencing factor – for the unsafe act?

Influencing factors may include, for example, peer pressure, corner cutting or getting the job done quickly in order to get home early (i.e. 'job and finish'). There will undoubtedly be others, but it is important to understand as much as possible what led to the unsafe act occurring.

There is a limit to the extent that engineering and system controls can be developed to control potential risks, and beyond this limit such controls are likely to be expensive and overly complex. These controls can, however, become ineffective or overcome by poorly motivated and/or unsafe decisions, especially when the reliability of such controls is an issue.

Other safety related issues

It is important to bear in mind that the investigation may, in using the Why? Because technique (see the As with the immediate and underlying causes, an 'Other safety related issue' will need to be:

a) supported by relevant discussion in the 'Factors discussed' section of the report, and

b) cross-referenced to the relevant paragraphs containing such discussion.

Why? Because technique sub-section below), identify a safety related issue which, whilst not a 'causal' or 'contributory' issue/factor in the event, needs to be addressed and for which it may be appropriate to make a recommendation or local action to address it.

However, it will need to be identified within the investigation report – as 'Other safety related issues' – and a recommendation and/or local action made to address it.

Such issue may be considered to be one which, if addressed, would not prevent a recurrence but which may mitigate the consequences or reduce the likelihood of recurrence. This may include, for example, issues related to the post-incident management of the event such as:

a) evidence preservation or collection;

b) 'for cause' testing of the staff involved;

c) recovery operations.

Such issue should still be in the context of the event itself, rather than any other – and, possibly, separate – issue that happened to be identified during the course of the investigation.

As with the immediate and underlying causes, an 'Other safety related issue' will need to be:

c) supported by relevant discussion in the 'Factors discussed' section of the report, and

d) cross-referenced to the relevant paragraphs containing such discussion.

Why? Because technique

This is a simplified version of the technique that is explained in the Causation theory section of this Part 4 of the handbook.

This simplified technique encourages investigators to ask "Why?" the immediate cause occurred and to then keep asking "Why?" until satisfied that there's no "Because" and all the underlying causes have been identified.

Using this simplified technique is a useful tool for identifying both the human failures and unsafe conditions. But remember it is not just about the individual's failures or the unsafe condition – it is about understanding what led the individual to make a mistake or what led to the existence of the unsafe condition.

The following are examples of how this simplified 'Why? Because' technique can be used:

A driver passed a signal at danger because he failed to locate the signal

Why?

Because

The signal was partially obscured by vegetation

Why?

Because

The planned vegetation clearance programme has not been applied in area

Why?

Because

The maintenance team whose responsibility it was did not have sufficient people to carry out the work safely

Why?

Because

Two members of the team were off on long term sick and inadequate provision had been made to cover their jobs

Why?

Because

There was no process to assess the implications of inadequate resources which would have highlighted that certain safety critical activities would not be able to be carried out

Why?

Because

There was inadequate contingency budget available to make alternative arrangements to ensure either the jobs could be covered or that the activities could have been contracted out

Figure 5 – 'Why? Because' model example 1

A train has run through a set of points because the train was routed incorrectly by the signaller

Why?

Because

The signaller forgot to change the direction of the points following the passage of the previous train

Why?

Because

The signaller was not using the route cards to check the routes he was manually setting

Why?

Because

The signaller did not see the point in using the route cards and had never done so before

Why?

Because

The importance of using the route cards had never been explained to the signaller and his manager had never reinforced their use always turning a blind eye to their lack of use in the past

Figure 6 – 'Why? Because' model example 2

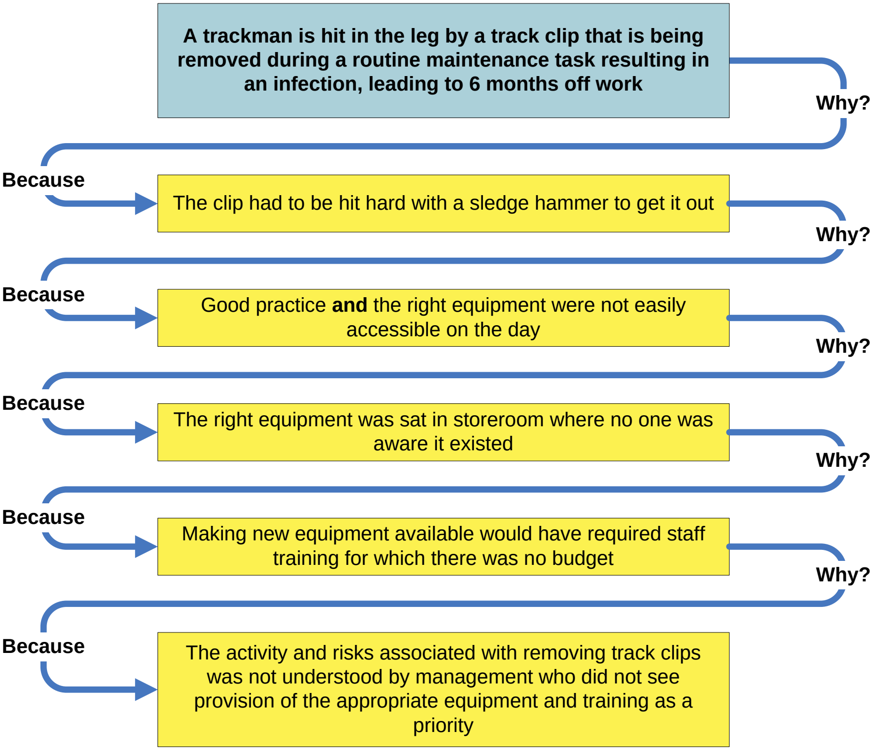

Figure 7 – 'Why? Because' model example 3

Multiple cause options

The above examples identify only one chain or series of answers to the questions asked. Very often, a "Why?" will lead to a number of possible answers – or underlying causes.

In such circumstances, the 'Why? Because' technique should be used for each of the possible answers.

The following is an example of how this could apply:

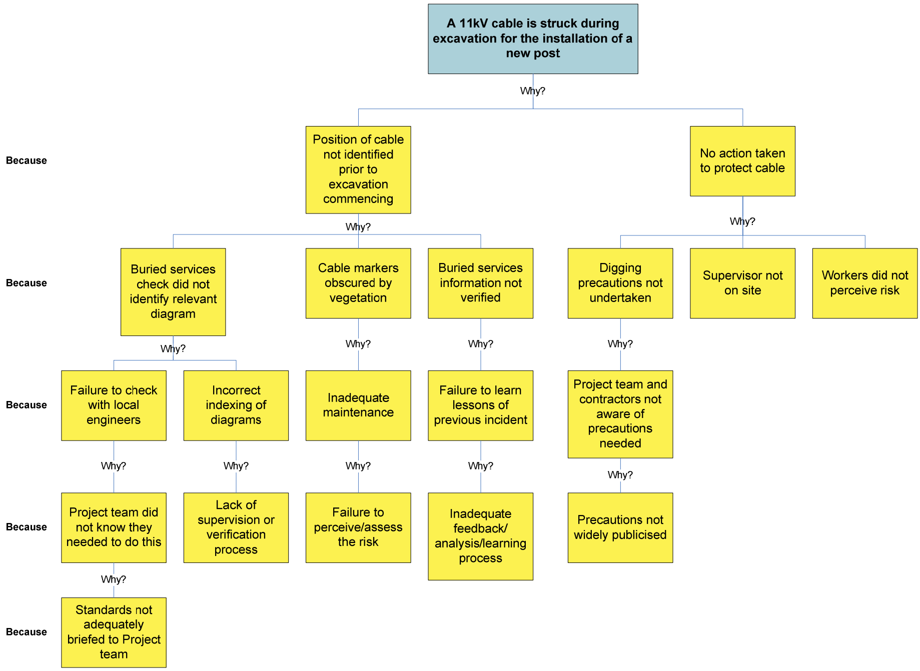

Figure 8 – Multiple answers in 'Why? Because' technique

Attributing the underlying causes to the 10 Incident Factors

Having identified the underlying causes of the event, there is a need to identify within the investigation report:

a) which of the 10 Incident Factors applies to each of the underlying causes, and

b) who made the error relative to the applicable Incident Factor.

The investigation report templates include an 'Incident factors causal analysis' table which must be completed by the lead investigator when drafting/revising the report.

The information recorded in this table will be used to update the SMIS record.

For each underlying cause identified, the lead investigation will need to complete the 'Incident factors causal analysis' as follows:

Column No.1 Add the underlying cause number – from Section A of the report – against the applicable incident factor(s).

Column No.3 Identify who made the error relative to the applicable incident factor(s) shown in **Column 2**, i.e. driver, signaller, PICOP, ES, etc. Where more than one person is identified against a particular underlying cause and incident factor, enter all persons identified.

(**Do not** show the person's name).

See the 10 Incident Factors section of this Part 4 of the handbook for more details on the 10 Incident Factors.

Introduction to 'Human Factors'

Contents

This section is intended to provide an overview of human factors as part of the investigation.

Further, more detailed information on human factors as part of the investigation can be found in the Accident Investigation Learning Programme.

What is 'human factors'?

Human factors is about understanding the strengths and weaknesses of people and making sure that systems are designed and operated to match an individual's mental and physical capability to what is being expected of them.

Human factors refer to the:

a) environmental factors;

b) organisational factors;

c) job factors; and

d) human and individual characteristics

which influence behaviour at work in a way which can affect health and safety.

A simple way to view **Human factors** is to think about these aspects.

Who is doing it?	• Competence • Attitude • Capability
What are people being asked to do and where?	• Task • Environment • Equipment
Where are they working?	• Leadership • Resources • Culture

Ergonomists and human factors specialists are concerned with:

a) how and why people make mistakes;

b) how people interact with equipment, tools, procedures and processes;

c) individual issues, e.g. fatigue, stress and personal difficulties;

d) designing to fit the work to the worker;

e) maintaining worker health and well-being.

Ergonomists and human factors specialists are not concerned with **Human resources**. While there are some overlaps, particularly in the area of selection and training, **Human resources** are more focussed on managing and coordinating the processes for recruiting, training and managing staff. **Human factors** is more concerned with how we do these to optimise behaviour.

The HSE refers to Human Factors as the "environmental, organisational and job factors, and human and individual characteristics which influence behaviour at work in a way which can affect health and safety".

The following diagram in the HSE's publication "Reducing error and influencing behaviour" (HSG48) provides a simple way to view human factors and the job, the individual and the organisation factors and how they impact on people's health and safety-related behaviour.

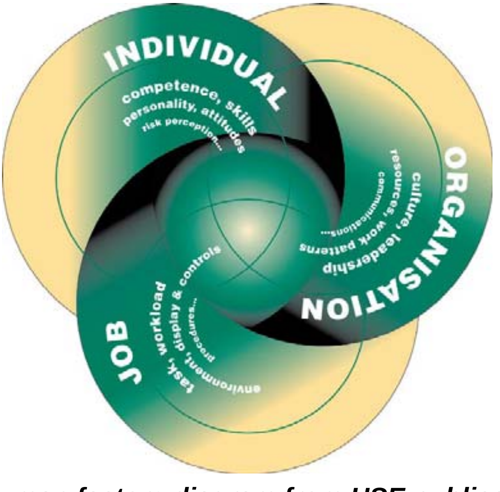

Figure 9 – Human factors diagram from HSE publication HSG48

'Human factors' or ergonomics?

Ergonomics and human factors are sometimes thought of as different disciplines but are they? The following provides an explanation of the two.

Human factors is a term used mainly in the United States. In Europe and the rest of the world, the term **Ergonomics** is more prevalent.

In the UK, **Ergonomics** is a term that has become associated with just the physical aspects of how people interact with tools and equipment in a system. While this is important, **Ergonomics** does have the same broad focus as **Human factors**.

Within Network Rail the term **Ergonomics** is used to describe the discipline of optimising human performance in the workplace. It is therefore concerned with identifying and managing **Human factors**.

Therefore, **Human factors** and **ergonomics** are synonymous – there is no difference between the two terms. They represent a discipline which is concerned with making sure people's needs and capabilities are matched to the jobs they undertake and the systems in which they operate, so that they perform effectively, reliably and safely and in a way that is natural to them.

Without using the interchangeable disciplines of **Human factors** and **Ergonomics**, we would be unable to manage people's behaviour or optimise their performance.

Why is 'human factors' important?

It is not always easy to sell the importance of human factors and it is easy to criticise something that is not fully appreciated. Common criticisms are:

"Human factors costs too much."	While a contribution to take account of human factors will incur a cost, this will be outweighed by the savings made from getting it right the first time. There are also financial and less tangible benefits from having people who can perform effectively at work without making mistakes. Specifically addressing human factors can reduce the costs associated with retrofitting, training, maintenance, incidents and injuries.
"Ergonomics is all common sense."	Some of it is common sense, but this is often in short supply without a structured framework that encourages people to identify what it is people are required to do at work and what they have the capability to do.
"People can adapt so why be worried?"	Sometimes consideration of human factors has been omitted because of the belief that people can adapt very well to the systems and equipment they have to operate with. Human beings can be their own worst enemy because of this adaptability. So, people can manage with, or work around, the poor designs of equipment, poor instructions, poor environments and jobs that they have been given, to keep the company working effectively and safely. But such adaptability can come at a cost to workers' safe performance, health and satisfaction.
"People will always make mistakes."	Our inherent strengths and weaknesses mean we will make mistakes – but the potential for making mistakes can be minimised. Errors are often made inevitable by the planning, organisation, equipment, job and procedures, design and training programmes that have been undertaken. An ergonomics approach will help predict misuse and identify ways of managing it.

Ergonomists and Human factors specialists have expertise in:

a) some of the approaches and tools that can be used to identify what it is people are required to do at work and what they have the capability to do (for example, task analysis and human reliability assessments);

b) human performance limits and behaviour.

Why are human factors important to investigations?

People are fallible. They are brilliant, flexible and adaptable, but they are fallible – and they can and do make mistakes. Understanding why a person did not act or behave in the way that was expected is what the investigation needs to try to understand and determine.

There is evidence to suggest that human error is implicated in 80–90% of all accidents and incidents.

Given the range of human involvement in work systems, this is not surprising. However, such a statistic is not that useful to understanding why an accident or incident happened.

Errors should be regarded as a consequence (rather than a cause).

The term 'human error' implies that all unsafe acts can be the same, but errors take different forms – with different psychological origins and occurring in different parts of the system.

Rather than being a **cause** of an event they should be regarded as a **consequence**.

Direct and indirect failures

The contribution of error to an event is often differentiated depending on whether it is the result of a **direct** or **indirect failure**.

Direct (or active) failures	These usually have an immediate consequence and tend to be made by frontline people such as signallers, drivers, track workers and controllers, e.g. a driver passing a signal at danger without authority is an **active** failure, as is a signaller setting a route incorrectly. Usually an active failure is the immediate cause of the event.
Indirect (or latent) failures	However, there are usually a number of factors that are found to be at least partially responsible and these are referred to as **indirect** or **latent** failures. Latent failures: a) are associated with activities distant, both in terms of time and space, from the frontline operations, such as the managerial and organisational activities. These include, for example, ineffective supervision, shortfalls in training, poor design and poorly written procedures. b) may exist within the organisation many years before they contribute to an event. c) include poor design, gaps in supervision, unworkable procedures, shortfalls in training, under-manning, less than adequate tools and equipment. These arise from strategic and other top level management decisions and organisation processes such as budgeting, planning, resource allocation and auditing and they combine with local circumstances and active failures to penetrate the organisation's defensive layers and cause an event.

"Rather than being the main instigators of an accident, operators tend to be the inheritors of system defects…their part is that of adding the final garnish to a lethal brew whose ingredients have already been long in the cooking."

James Reason – Professor Emeritus at the University of Manchester.

Defences

Accidents tend to be the result of a complex chain of contributory events that have come together to create an accident.

Defences are layers of protection that make a system safe. They are either:

a) “hard” defences which include things such as alarms, interlocking, system design, and protective equipment; or

b) “soft” defences which include rules, procedures, permits to work, supervision and training.

The ‘Swiss Cheese’ model (see Figure 1 below) represents each layer of defence as a slice of Swiss cheese with areas of weakness in a defence shown as holes in the cheese.

The system as a whole produces failures when all of the holes in each of the slices momentarily align, permitting (in Reason's words) "*a trajectory of accident opportunity*", so that a hazard passes through all of the holes in all of the defences, leading to the accident.

It is as important to identify the active and latent failures – the holes in the defences – in order to provide the full story about how or why an accident actually occurred. Reason's ‘Swiss Cheese’ model shows how active and latent failures come together to create an accident.

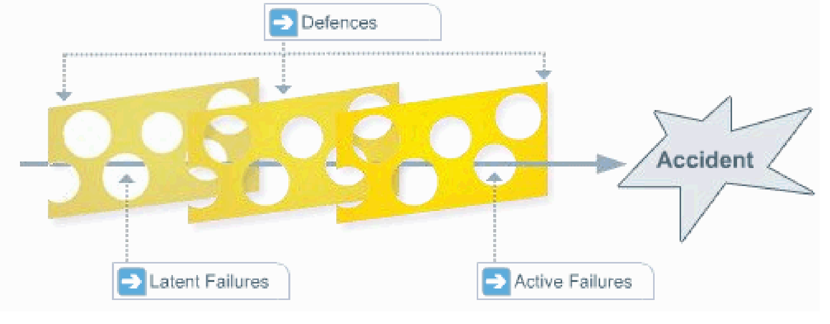

Figure 10 – Reason’s ‘Swiss Cheese’ Model

The 10 Incident Factors

See the Identifying the causes section of this Part 4 of the handbook for more details of the 10 Incident Factors.

Human error classification

Contents

This section is intended to provide an overview of:

d) the difference between errors and violations and how they can occur;

e) how the brain processes information and the way we make decisions about the world around us;

f) the underlying weakness of humans in relation to attention, memory recall and perception.

Further, more detailed information on human factors as part of the investigation can be found on the Accident Investigation Learning Programme.

The difference between errors and violations

An investigation is about making sure that all the human failures that contributed to an event are identified and being able to distinguish between errors and violations.

Human error	*A **human error** is an action or decision which was not intended and which led to an undesirable outcome.* Different errors occur depending on types of performance.
Violation	*A **violation** is a deliberate deviation from rules, procedures, instructions or regulations.* This is where a person knowingly takes shortcuts, circumvents or does not apply the safety rules. Violations are usually motivated by the desire to carry on with the job. They are rarely wilful acts of sabotage or vandalism.

Table 1 – Difference between error and violation

Generic Error Model for Rail

The Generic Error Modelling System (GEMS) is the most common method for categorising different human errors. It is based on the belief that different errors occur depending on three types of performance.

GEMS has been developed further for use within Network Rail as the Generic Error Model for Rail (GEMR) and this is explained and used in Figure 11 below.

In GEMR, errors and violations are classified according to:

- the intention of the act;
- the cognitive process of the act;
- and the influencing factor(s) of the act, as shown in Figure 11.

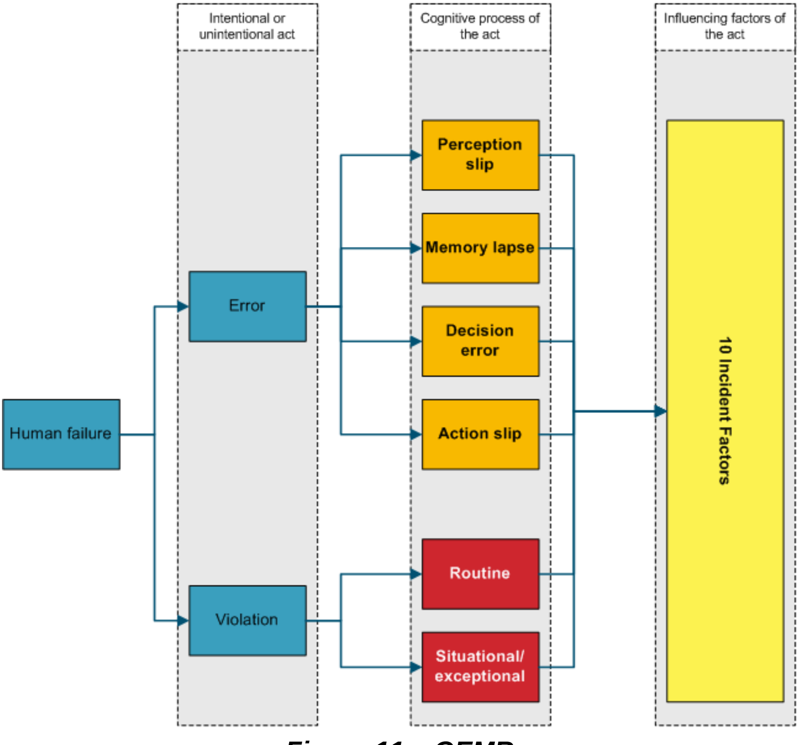

Figure 11 – GEMR

The main advantage of using this model is that it will help to understand why an event has occurred, and what can be done to prevent it happening again.

Errors

Different errors occur depending on types of performance. Examples of these error types are provided in Table 4 below:

Perception slip	Perception slips are errors in visual detection and searching, and listening errors. So these error types are to do with if a person mis-saw or mis-heard, or failed to see or hear something.
Memory lapse	Memory lapses are errors concerned with failure of short or long-term memory. So these error types are to do with if the person forgot or mis-recalled information, or forgot to do something.
Decision error	Decision errors are errors in acts of judgement, decisions or strategies. They typically rely on knowledge and information being correctly recalled but wrongly applied. So these types of error are to do with errors in making decisions or deciding on what to do in situations.
Action slip	Action slips are when actions or speech are not performed as planned (i.e. unintentionally). Such errors or speech are the execution of correctly formed decisions. So these types of error are to do with a person doing or saying something they did not intend, or being inadvertently incorrect or unclear.

Table 2 – Error types

Violations

These may occur for a range of reasons, so it is important to categorise them.

Routine	This is when breaking the rule or not following the procedure has become the normal way of working. It is almost invisible until there is an accident (or sometimes as the result of an audit). Routine violations are promoted by a relatively indifferent environment, i.e. one that rarely punishes violations or rewards compliance: "We do it like this all the time and nobody even notices."
Situational/ exceptional	This is when people break the rules because of particular pressures or circumstances arising from a specific job. An example of a situational violation concerns railway shunters; the Rule Book prohibits shunters from remaining between wagons when wagons are being connected. Only when the wagons are stopped can the shunter get down between them to make the necessary coupling. On some occasions, however, the shackle for connecting the wagons is too short to be coupled when the buffers are fully extended. The job can only therefore be done when the buffers are momentarily compressed as the wagons first come into contact with each other. Thus the only way to join these particular wagons is by remaining between them during the connection and watching your head. The result is obvious. Other examples of violations are provided in Table 4 below.

Table 3 – Types of violation

The following provides examples of the different types of errors and violations:

A driver reads the wrong signal from a gantry and passes the signal that applies to the train at danger as a result.	**Perception slip**
A signaller is distracted during arrangements for a possession and fails to use a reminder appliance as required.	**Memory lapse**
A train is inadvertently routed into a possession. The signaller had not switched ARS 'off' and was using reminders to make sure the trains were not routed towards the possession.	**Situational/ exceptional violation**
A driver did not check the aspect of a signal; it had always been green in the past so the driver's mindset was that it would be green and, hence, he decided not to check the signal's aspect.	**Decision error**
A lookout uses the vigilance switches on his lookout warning system (LOWS) equipment to identify a train coming towards the worksite, rather than the train announcing switches (due to their similarity of design).	**Action slip**
Short-circuiting straps are always laid out prior to isolation being granted, as the team likes to save time where possible.	**Routine violation**

Table 4 – Examples of errors and violations

Actions to prevent **violations** occurring will depend on the type of violation but areas to consider are:

- work resources (planning, equipment, time, people);
- supervision;
- management;
- careful selection to ensure that the appropriate individuals are being chosen for the job.

Processing information and decision-making

Human beings are unreliable – our eyes are not like cameras, so we have to filter information to make sense of it and we can be forgetful.

By looking at how the brain processes information, we can understand why people make mistakes.

To err is human. Everyone, regardless of knowledge, experience or training, will at times make mistakes.

The way we behave, the decisions we make and the things we do are a result of the way we process information around us. By understanding the limitations of these processes we can begin to understand how errors can occur.

Recognise-Act cycle

This is a simple model that describes the way we process information (see Figure 12 below).

Detect	Receive sensory input from the external world (e.g. through our ears and eyes).
Recognise	Use and interpret this information to make decisions about what we want to do next.
Act	Carry out the actions we want to take.

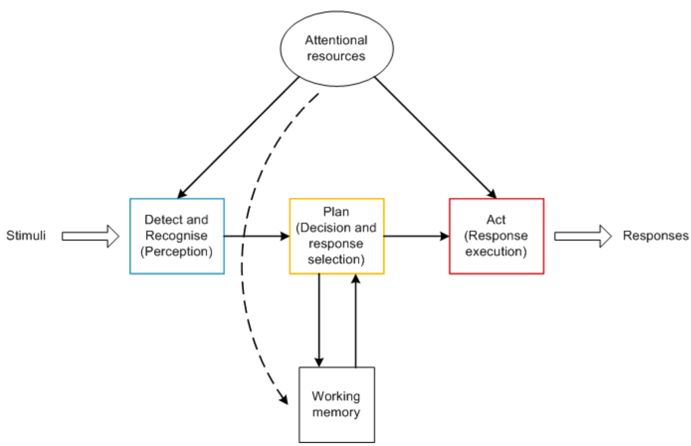

Figure 12 – Recognise-Act model

The tables below examine the Recognise-Act cycle from the point of view of a track worker (a lookout) and a signaller.

Detect	Plan	Act
The lookout remains vigilant and alert looking out for the approach of trains.	The lookout determines that a train is approaching and that he needs to provide a warning to the workgroup.	The lookout provides a warning to the workgroup.
The signaller remains vigilant and alert monitoring information about the state of the traffic and the infrastructure through signalling displays and other information sources. The signaller will detect that a train has arrived into their area of control and recognises its destination.	The signaller assesses whether this train requires a route to be set and if so which is the optimal route given the traffic situation, or whether to continue monitoring its progress.	The signaller executes the plan and sets the route or continues to monitor.

Table 5 – Recognise-Act model examples

Mental processes

The mental processes that influence how we deal with information are:

a) Perception;

b) Attention;

c) Memory;

d) Situational awareness.

Understanding these mental processes can help to explain why errors occur and how influencing factors can create the potential for error.

It is also useful to understand the limitations of some of these mental processes as each has the potential to interrupt and disrupt the information processing in different ways, resulting in different types of errors.

In addition, each can be influenced by factors such as stress, individual differences, fatigue and trauma.

Perception

This involves the process by which we turn visual (and other sensory) information into something meaningful, as an internal model of the external world.

Perception enables us to create an internal **mental model** or representation of the external world. It has both **physiological** and **psychological** components.

Physiological	In these terms, lighting is a key requirement for effective vision as people do not see well in the dark. However, whilst light will enhance visibility, it will not necessarily guarantee **conspicuity**. Many influences on **conspicuity** are physical and relate to factors such as *contrast, brightness, shape, texture and placement*. Other aspects of **conspicuity** are related to people's experiences, expectations and emotions, which will make some things much more conspicuous than others at certain times. It is a fairly common experience to notice things much more when they have direct relevance to something of current importance to the observer, e.g. a person buys a new red Daewoo car and suddenly Daewoo cars seem to be very much in evidence despite the fact they were not noticed at all before the purchase.

Psychological	In these terms, perception is not a passive process of simply absorbing and decoding incoming sensory information. If it were, people would have a very poor understanding of the environment as visual information, for example, would simply be a constantly changing, confusing mosaic of light and colour. Instead, the human brain takes the sensory input that bombards us all and actively creates from that the coherent world that is perceived and makes sense to us. The role of prior **experience** and **expectation** in the visual perception process has an extremely strong influence on what people 'see'. Faced with new, incomplete or ambiguous information, people tend to use their own way of looking at the world to process and interpret what they see. This can be a major factor in why people make performance errors.

People's strong propensity to make sense from visual stimuli can be illustrated by 'visual illusions', all of which can be explained through perceptual processes.

Attention

Attention is a key mental process. Our ability to manage all the information that bombards us is limited, so we cannot deal with all of it at the same time. So we need the following mechanisms to enable us to select what will be consciously perceived and then used to make decisions.

The following are the ‘Attention’ mechanisms that help us make decisions:

Selective	This refers to the process by which we attend to those things that are relevant or important to us.
Focussed	This refers to the intensity of attentional focus. It varies depending on how many things we are trying to focus on. For example, the narrower the width of our focus (e.g. when concentrating on a new or difficult task), the stronger our attention will be. Whilst this can be very useful, in that our full attention can be focussed on an immediate problem or piece of information, it does have the potential disadvantage that sometimes other important things may be missed which can lead to error.
Divided	This refers to our ability to ‘switch’ our attention. For example, a driver approaching a station will be required to divide his attention between looking ahead outside the train and looking down at the speed indicator. However, while it is possible to do two things at once, dividing our attention between two separate activities increases the potential for error as we may become pre-occupied with one of the activities, leaving the other activity unchecked. We are also prone to becoming distracted by more “attention-grabbing” features in our environment, such as alarms, a loud bang, telephone calls, colleagues and environmental stressors (e.g. heat, light and noise), or by something which suddenly appears in our field of vision.

Automated pilot

The ability to automate behaviour brings a number of distinct advantages for performance, especially for multi-tasking, but there are also disadvantages.

Advantages	**Disadvantages**
• Quick • Useful in multiple task situations (the automated process rarely interferes with concurrent tasks) • Helps skilled operators to cope with unplanned situations	• Open to error These errors occur because when in auto-pilot, you form a hypothesis about what is going to happen which is difficult to over-ride in the light of better, more abundant information.

The following are examples of 'automated' errors:

Example 1	The point at which drivers first sight the signal, they see what they expect to see and fail at this and later stages to perceive what is actually there.
Example 2	A driver approaching a red signal may **anticipate** a signal clearing on the basis of past experience and fail to prepare to stop appropriately.
Example 3	A driver may look at the signal but actually believe the aspect is showing something to the contrary: a model-induced illusion also known as **false hypothesis** or **confirmation bias.**
Example 4	Signallers may anticipate that certain train running codes indicate a particular route for a train because they always go that way. They can then be caught out when that train's head code is for a train that should be routed elsewhere.

Memory

We rely on our memory to do most things – from remembering who we are to recognising the words we read and the sounds we hear.

Memory consists of working (also known as short-term) memory and long-term (or stored) memory.

Working memory	This enables information to be retained for a short period of time. In order to hold information in working memory you must direct attention to the process. The reason for this is that the capacity of working memory is limited. Research shows that the maximum number of unrelated items that can be maintained in working memory, when full attention is devoted to rehearsal is roughly **7**. Once this limit is exceeded, one or more items are likely to be lost through the process of interference. Information held in working memory is likely to be replaced with the arrival of new information (e.g. a conductor talking to a driver may cause the driver to forget the aspect of the previous signal).
Long-term memory	This contains information that has been transferred from the working memory by applying meaning to the information, and relating it to information already stored. Rules and procedures are examples of stored memory. Other examples include route knowledge and local knowledge. As well as storing the meaning we apply to the things we are able to do, long-term memory also includes our knowledge about specific events (e.g. a particular incident). It is important to note that the information stored will not remain static – it will be influenced by our need to make sense of our experience and our expectations of what should have happened. Recollection of such events is, therefore, influenced by our expectations of the world. This tendency for us to remember what should have been, rather than what was, is a particular issue for accident investigators.

Situational awareness

The mental processes that work together to help a person build up a picture of what is going on in order to make a decision about what to do can be described as **situational awareness**. The most common model or explanation of **situational awareness** is that it comprises three levels:

Perception	The perception of elements or cues in the environment (which for a signaller might be a change in status of an alarm on the display).
Comprehension	The comprehension of what these elements mean (e.g. what perturbation is occurring on the track).
Prediction	Projection, or prediction of the status of the elements and the system in the future (e.g. what will happen if no action is taken or if certain signals are reset). Consequently, the better an operator's situation awareness the better his performance: he can better anticipate what will happen and what risks will emerge.

As well as the factors relating to the mental processes previously described, there are others relating to the individual that can affect situational awareness. These are factors that are a function of individuals and their environment:

Individual experience, expertise and training	Greater experience can lead to greater expertise at recognising cues from the system about its status and what is happening. Those with more experience tend to "see" the underlying pattern of events and consequently less time is needed to obtain situational awareness. Training operators in system-related knowledge and different system states can compensate for inexperience and provide operators with the information they need to recognise important cues and patterns in events that improve situational awareness.
Individual memory capacity	The greater an **individual's memory capacity**, the more experiences they can call upon to help them recognise cues and events in the system.

Mental Models	Operator's **mental models** guide them to look for particular cues and information to help them build up a picture of what is going on. However, the problems described above in the 'Attention' section can influence how successful this process is: if we know what we are looking for, there is a danger that we will see what we **expect** to see, and we could be wrong. Knowing what to look for is the key, but questioning what we see is critical. Simply making assumptions about something that is happening can be dangerous.
Workload	**Workload** affects an operator's ability to attend to and interpret necessary cues and thus it can directly affect situational awareness. In high workload conditions operators might work so intensely that they have limited spare capacity or attention to focus on other information. On the other hand in low workload conditions operators may reduce their vigilance to the point that they attend to cues ineffectively or fail to seek out information that they need for situational awareness.
Automaticity	Operators can compensate for the effects of high workload by using **automated pilot** when completing tasks they often perform. As described above, the problem with **automated pilot** is that the operator is performing the task with little conscious effort so there is a chance that they could miss new, changed or unexpected cues/information and find it difficult to modify their picture of what is going on.
Equipment	**Situational awareness** is obtained from a number of different sources (the displays, alarms and alerts we see and hear and the information we obtain from colleagues or interrogating information sources, for example). Displays that present information in a confusing manner require operators to expend more effort interpreting the data than well-designed displays.

10 Incident Factors

Contents

This section is intended to provide an overview of the 10 Incident Factors used within Network Rail's Accident Investigation Learning Programme.

Consideration of the 10 Incident Factors should be undertaken as part of the investigation's general objectives (see the remit).

The 10 Incident Factors are listed below:

Communications
Practices and processes
Information
Equipment
Knowledge, skills and experience
Supervision and Management
Work Environment
Teamwork
Personal
Workload

An explanation of each is provided on the following pages.

Note that the 10 Incident Factors shown above and in the following pages supersede those previously included in the 'Investigating the Human Factors' E-learning programme on the E-Business Suite (On Line Manager) and the disk copy provided by Senior Investigators to DCPs and investigators.

See the Appendix B of the 'Preparing for the investigation' section of Part 2A of the handbook for details of 'Investigator Prompts', i.e. questions based on the 10 Incident Factors that may need to be asked when reviewing the evidence or interviewing witnesses at an investigation.

The 10 Incident Factors

These are explained below.

Incident Factor	This Incident Factor is concerned with
Communications	Communications is concerned with how we relay information to each other in the context of safety critical information. Typically this includes people not communicating information at all or not reaching a clear understanding when they are communicating. It includes: • failure to apply communications protocols to reach a clear understanding; • misinterpretation of communications; • inappropriate volume of communications; • appropriateness of the communication method; • appropriateness of the information communicated (i.e. inaccurate, or missing information); • inadequate handovers.
Practices and processes	This refers to the rules, standards, processes and methods of working which guide and structure how certain activities are undertaken in the railway industry. It includes the operational rules in the Rule Book and also technical standards which dictate how activities should be undertaken. It also includes the safe systems of work that are set up to protect people in safety critical and other railway environments. It is concerned with finding out primarily why the work practice or process followed has not been in accordance with the accepted or authorised way of working and consideration should be given to: • Availability, i.e. Was the practice/process: » not available? » not in existence?

Incident Factor	This Incident Factor is concerned with
Practices and processes – continued	• Applicability, i.e. Was the practice/process: » difficult to follow? » impractical/not appropriate? » not comprehensive? » inaccurate? • Planning work processes, i.e.: » Were they based on inaccurate information? » Were they based on inappropriate job knowledge? » Were they lacking geographical knowledge? » Did they identify inappropriate resource allocation? • Delivery, i.e. Did the practice/process include: » poor task assignment? » inadequate resources? » inadequate opportunity for rest breaks? If it is possible that the reason a work practice has been carried out incorrectly was because of workload (e.g. excessive workload, time pressures, etc.) then see 'Workload' below.

Incident Factor	This Incident Factor is concerned with
Information	Information is used to support an activity. Railway examples include: • the information track workers receive about the hazards on the track and their safe system of work; • train running information; • timetable simplifiers; • late notices; • special train notices; • weekly/periodic operating notices; • pre-job information; • electrification/isolation diagrams and signage. It also includes information about changes to technical and operational standards. Consideration needs to be given to: • Information content, i.e. Was it: » inaccurate? » not available? » out of date? » not comprehensive? » not relevant? » contradictory? • Information presentation, i.e. Was it: » over complex? » inappropriately structured? » lacking clarity? » appropriate in format? • Insufficient dissemination of information, i.e.: » unaware of briefing responsibilities; » no process for undertaking staff briefings; » time constraints.

Incident Factor	This Incident Factor is concerned with
Equipment	This refers to any equipment that is used to undertake or support an activity and can be a factor if it is not being used as intended; if it is faulty; if its design is not compatible with its use; or if the layout is not in the order in which it is used. Different types of event involve different types of equipment: SPAD related incident: The equipment includes both the train and the signals/signalling layout. The SPAD Hazard Checklist provides a structured set of questions to determine the extent to which the signal and the signalling layout was a factor in the incident. Track related incident: The equipment includes both the equipment being used by the work group and the infrastructure that they are repairing or maintaining. In addition it can include the PPE supplied to workers. Signaller related incident: The equipment includes, for example, the signalling displays, signalling levers and alarms. Consideration needs to be given to: • Design, i.e.: » Was equipment not compatible for its intended use? » Were important displays/information clearly visible and did they provide information at the right time? » Were there inadequate alarm arrangements? » Was there no correction of known flaws? » Were there arrangements for ensuring competence in its use? » Were its positioning and layout suitable? • Use/operation, i.e.: » Was it deliberately misused? » Were there inadequate arrangements for ensuring competence in using it *(see supervision and management)*? » Was the right equipment not available? » Was the equipment unreliable?

<table>
<tr><th>Incident Factor</th><th>This Incident Factor is concerned with</th></tr>
<tr><td>Equipment – continued</td><td>Maintenance, i.e.:
» inadequate maintenance;
» inappropriate maintenance specification;
» were faults incorrectly reported?
Storage of equipment and material, i.e.:
» poor housekeeping;
» appropriateness of security of storage arrangements;
» appropriateness of storage arrangements.</td></tr>
<tr><td>Knowledge, skills and experience</td><td>Knowledge, skills and experience can be a factor in an event if the individual(s) involved did not have the appropriate knowledge to perform safely, or if they were not familiar with the circumstances in which they found themselves.
When evaluating whether it is a factor, the investigation should extend beyond checking certification and when the last training or assessment took place.
Consideration needs to be given to:
Training, i.e. Was it:
» relevant?
» comprehensive (i.e. did the training cover both the knowledge and the skills needed to perform the activity, and were there sufficient opportunities for practice)?
» accurate?
Assessment, i.e.:
» Was it sufficiently frequent?
» Was it adequate (i.e. did it include assessment of both knowledge and application)?
» The appropriateness of support and follow-up arrangements.</td></tr>
</table>

Incident Factor	This Incident Factor is concerned with
Knowledge, skills and experience – continued	• Experience, i.e.: » Was it relevant (i.e. did the operator's work experiences match the task being performed at the time of the event)? » Was the operator inexperienced?
Supervision and Management	Supervisors and managers can be an underlying reason for an event occurring because of the decisions they make about resources, budgets, work allocation and planning. They can also have a more direct impact through the example they set and the monitoring and assessment processes they have responsibilities for, and which are aimed at detecting and managing errors or the potential for errors. This incident factor covers a wide range of supervision and management activities, from directly supervising worksites to the way in which people are managed. It includes how we manage our contractors, too. When establishing whether or not this was a factor, consider both the actions/omissions of the supervisor/manager and the reasons for this; for example, whether they have conflicting activities, or are not aware of their responsibilities, or are not trained in how to perform them. Consideration needs to be given to: • Monitoring and correction, i.e.: » failure to correct errors/inappropriate behaviour; » failure to undertake safety checks; » inadequate feedback systems; » inadequate escalation processes; » failure to correct known problems; » failure to initiate corrective action.

Incident Factor	This Incident Factor is concerned with
Supervision and Management – continued	• Resource management, i.e.: » Was there inappropriate cost cutting? » Was there an inadequate budget? » Were there inadequate resources (people and/or equipment)? » Was there inappropriate resource allocation? • People management, i.e.: » not accessible to staff; » inappropriate performance management processes; » inadequate mentoring arrangements; » inappropriate behaviours and attitudes (of supervisor/manager); » failure to provide job related/professional guidance/support. • Inadequate supervisory/management skills, i.e.: » overworked supervisor manager; » inadequately trained supervisor/manager; » perceived lack of authority.

Incident Factor	This Incident Factor is concerned with
Work Environment	The working environment contains environmental stressors such as lighting levels, noise, temperature and vibrations. These can lead to feelings of discomfort or act as distractions, impacting on an individual's performance. Consideration needs to be given to: • Weather conditions; • Noise – this often results in needing more effort to perform tasks; perceived mental workload increases and tolerance reduces; • Lighting – more specifically over lighting or glare, from VDUs, for example, can cause distractions and visual fatigue as well as physical discomfort. • Temperature – temperatures lower than 0ºC or higher than 32ºC can lead to reductions in manual and mental performance. This can be an important consideration in events involving track workers who may have been outside for long periods of time in extremes of temperature and weather; • Vibrations; • Space – for example, the layout of the environment is important; work areas and operating positions should be laid out so they allow for free movement, safe access and exit routes, as well as unhindered visual and verbal communication.

Incident Factor	This Incident Factor is concerned with
Teamwork	This is concerned with how we work together and coordinate to achieve safe performance. There are certain factors that will influence the likelihood of team errors, including the number of people in the team, team structure, team stability and team leadership. Consideration needs to be given to: • inappropriate number of people in the team; • lack of team's "shared" understanding; • failure to notice or respond to another's errors; • inappropriately influencing the actions or decisions of others; • inadequate team co-operation; • inappropriate level of team trust (i.e. too much/too little); • ineffective delegation of team duties and responsibilities; • appropriateness of communications between different levels/parts of the organisation.

Incident Factor	This Incident Factor is concerned with
Personal	This incident factor refers to a collection of influences arising from the individual themselves. These influences are concerned with fatigue, physical and mental well-being and attitudes. Consideration needs to be given to: • Work related fatigue, i.e.: » poor shift and roster design; » excessive working hours; » inadequate rest breaks during work; » excessive travelling time to and from work. • Home-life related fatigue; • Physical well being, i.e.: » influenced by drugs or alcohol; » ill-health; » influenced by medication; » failure to comply with medical standards. • State of attention, i.e.: » pre-occupation/distraction; » complacency; » mind-set; » expectation; » confused; » stress. • Work-related attitudes, i.e.: » low morale; » confidence; » propensity for risk taking; » over accommodating. A tool for assessing the fatigue and risk associated with hours of work – the Fatigue and Risk Index – is available. See the 'Useful tools' sub-section in Part 8 of the handbook for more information.

<table>
<tr><th>Incident Factor</th><th>This Incident Factor is concerned with</th></tr>
<tr><td>Workload</td><td>Workload is about understanding the demand created by particular activities. Demand is created by a combination of a number of factors:
<table>
<tr><td>The task</td><td>The nature of the task and the number and combinations of tasks they have to complete.</td></tr>
<tr><td>The context</td><td>How and where they have to complete them and the urgency or accuracy necessary to ensure safety and organisational performance targets are met.</td></tr>
<tr><td>The individual</td><td>Their skill, experience and perception of their work.</td></tr>
</table>

If the workload is in excess of acceptable limits it will be stressful, fatiguing, de-motivating for the individual which will make their performance slower and less accurate. It will also affect an individual's ability to maintain awareness of what is going on around them (situational awareness).
Reducing workload is not always the solution as this too can affect performance. Reduced workload or workload involving simple, repetitive tasks over extended periods, can increase boredom and increase the difficulty for an individual to maintain vigilance.</td></tr>
</table>

Incident Factor	This Incident Factor is concerned with
Workload – continued	There is a need to consider: • conflicting activities that require excessive demands on attention (i.e. trying to monitor two physically separate parts of a signalling panel); • time pressure; • productivity pressure; • emergency/non-routine circumstances; • poor job design; • inappropriate resource allocation; • additional activities over and above the norm. Network Rail's Ergonomics National Specialist Team has a number of tools for measuring workload. If you believe it is a factor in an incident then you should contact the team for advice and a more detailed workload assessment.

See the Appendix B of the 'Preparing for the investigation' section of Part 2A of this handbook for details of 'Investigator Prompts', i.e. questions based on the 10 Incident Factors that may need to be asked when reviewing the evidence or interviewing witnesses at an investigation.