Good Practice Guide on Cognitive and Individual Risk Factors
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Synopsis:

The aim of this document is to raise awareness of the cognitive and individual factors that can influence the potential for driver error, the distinction between different categories of errors and violations, and to offer good practice guidance on the proactive management and mitigation of the human risks.
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1. Introduction

1.1 Purpose and scope
This document has been published by the Rail Safety and Standards Board. It replaces Appendix K ‘Behaviour Identification Checklist’ and Appendix N ‘Behavioural and Human Factors Guidance – Practical Guidance for Drivers and Managers’ contained within GO/RC3551 ‘Approved Code of Practice – Train Driving’ which has now been withdrawn.
Although a stand-alone document, this Good Practice Guide is one of a suite of new publications that have been produced to replace GO/RC3551.

The intention of RSSB is to raise awareness of the cognitive and individual factors that can influence the potential for driver error, the distinction between different categories of error and violation, and to offer good practice guidance on managing and mitigating the risks (eg prior to an incident).

Information includes:

a) The human information processing system and its inherent limitations (eg perception, memory, attention, decision making, action)
b) Cognitive and individual factors that can increase the likelihood of driver error (eg expectation, habituation, distraction, automation, workload, fatigue, stress)
c) The distinction between different error types and violations
d) Risk mitigation techniques for drivers – situation awareness and risk triggered commentary.

The information in this guide is primarily based upon the role of train driver. However, as the document pulls together both generic human factors information (eg cognitive limitations, proactive identification of individual risk factors), as well as guidance specific to drivers, it will be of interest to a broad audience, including:

- Driver managers
- Train drivers
- Assessors
- Trainers
- Instructors
- Managers of other safety critical workers (eg signallers, trackworkers)
- Accident and incident investigators
- Occupational health professionals
- Those with responsibility for establishing and maintaining safety management arrangements.

The aim of the document is to encourage a shift away from a ‘reactive’ style of (driver) management (eg post incident), to a more proactive approach based on the recognition that errors are inevitable, and normal, and that all potential consequences need to be managed.

A proactive approach to error management can benefit organisations in a number of ways:

a) Feed into and support the driver monitoring process by (i) increasing awareness and identification of human risks, and (ii) ensuring remedial action plans, developed to address performance issues are based on an accurate identification of the underlying causes(s) [1]
b) Adopting a non-punishing approach to error management and communicating a formal understanding that errors will occur encourages an organisational ‘learning culture’ that has the support and buy-in of its employees
c) Improve human performance
d) Reduce risks
e) Reduce frequency of human error
f) Reduce consequences of human error
g) Increase individual and organisational efficiency.
2. Introduction and background

2.1 Human factors defined
Human factors is an applied scientific discipline which draws on knowledge from engineering, psychology, ergonomics and physiology. In its broadest sense, human factors refers to influences on performance associated with people’s interactions with their physical and social environments [2].

The Health and Safety Executive (HSE) define 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’.

This definition can be represented as three overlapping spheres that represent the interaction between the individual, the organisation and the job itself (see Figure 1).

![Figure 1 HSE model of human factors](image)

Each sphere includes a range of factors that can influence performance. In train driving terms, this includes consideration of:

- Cognitive and individual factors – eg driver alertness, attention, perception, situational awareness, personal issues;
- Organisational factors – eg company culture, training, procedures, resources, teamwork;
- Job-specific factors – eg signalling, train controls and instruments, communications.

As illustrated by figure 1, it is important to recognise that the factors that influence performance within each sphere can operate either independently and/or in interaction with factors in other spheres.

A popular framework that helps us understand and apply human factors is the SHELL model (see Figure 2).
Figure 2: SHELL Model

SHELL is an acronym for software, hardware, environment and liveware. Figure 2 illustrates the five components and their relationship to each other. There are two Liveware elements, one to represent the central human operator (Liveware Central) and one to represent the interactions between people in a work context (Liveware Peripheral). In more detail, the five components are:

**Software** includes policies, procedures, rules, standards, checklists and information. Such factors can influence behaviour in a variety of ways. For example, inadequate or inappropriate documentation can lead to increased response times, create confusion or cause unnecessary distraction. Additionally, the clarity of rules and their perceived usability will affect whether they are followed properly.

**Hardware** includes the design and layout of equipment and tools and incorporates issues of usability both physically and mentally. For example, the design of controls can influence human performance as this will impact on an operator’s handling and interpretation of equipment.

**Environment** includes the physical conditions in which work is carried out. Factors such as lighting levels, temperature and noise can all influence behaviour by acting as a distraction or, for example, discouraging effective communication and teamwork.

**Liveware Peripheral** considers human interactions. There are a number of factors which may affect human performance which result from working with other people, such as the effectiveness of team work, communication and employee-supervisor interactions. Interaction with other people also includes organisational factors such as supervision and the work environment which can affect how employees interact and work with each other.

**Liveware Central** includes factors related to human performance concerned with individuals’ physiology, psychology and perception. Issues such as attention, workload, experience, knowledge, training and stress will affect performance because they influence how an individual perceives a situation, makes decisions and how much capacity they have to perform efficiently and safely.

### 2.2 System safety

The primary focus of this guide is on the cognitive (eg ‘Liveware Central’) and individual factors that can impair driver performance.

In human factor terms, driver (performance) errors directly due to ‘liveware central’, are often referred to as active failures (eg driving through a red light, perhaps due to distraction, workload or stress). The more indirect influences on performance error (eg ‘software’ – management factors; ‘hardware’ – poor system design; ‘environment’ – temperature; ‘liveware peripheral’ – communications) are often referred to as latent failures (or, more commonly, ‘accidents waiting to happen’) and are recognised as contributory factors to performance error.

Sometimes an active failure (perhaps the result of a rule violation – see section 5.5) is the root cause of a performance error, but often latent conditions are found to be at least partially responsible for the active failure that occurs.
To understand more about these (latent) contributory factors, and how they can come together to cause an accident, Professor James Reason, developed the now widely-known ‘Swiss cheese’ model of accident causation (see figure 3).

The model illustrates the fact that organisations have multiple layers of defence against hazards and errors (eg train protection warnings, training programmes, safety management processes, etc). It is only when failures in these defences line up with each other (eg poorly designed shift patterns, coupled with poor employee awareness of fatigue risks and other safety management failings, etc.) that an accident or incident results.

![Figure 3 - Swiss cheese model of accident causation](image)

Figure 3  ‘Swiss cheese’ model of accident causation

It is now widely recognised that accidents are the result of a complex chain of contributory events or factors, and that some of these contributors are permanently present in normal working conditions (see Appendix A for a summary of the individual, job-specific and organisational human factors that can contribute to errors and violations). This moves away from the notion of the operator (eg driver) being ‘at fault’, towards a genuine appreciation of the range of issues which may be detrimental to good driving performance.

In any safety critical environment, the human operator (eg driver) can be viewed as the last line of defence against failures at different system/organisational levels. Skilled and motivated operators of equipment can be very effective last-line defences under surprisingly adverse conditions as they search to prevent a bad situation getting worse. However, it is primarily the ways in which an operator perceives, interprets and reacts to the prevailing conditions that forms the basis of our understanding into the causes of (and potential solutions to) human performance errors.

For example, it is estimated that about 85% of signals passed at danger (SPADs) are attributable to human causal factors (see Appendix B ‘Human Causes of SPADs’). This is not surprising given that the task of train driving (and operation of the railway) relies heavily on humans interacting with equipment, and each other. Whilst safety systems such as AWS (Automatic Warning System), TPWS (Train Protection and Warning System) and DRA (Driver’s Reminder Appliance) have all been introduced to automatically control the train (generally by making an emergency brake application if the driver does not provide a response), the driving task is still essentially a human one. It is difficult, therefore, for any human to complete the driving task, day in day out, without ever making an error.

SPADs, station overruns, excessive speeding and roll backs are all examples of events that can lead up to significant operational hazards on the railway (eg derailments, collisions). Accident investigations (eg Clapham Junction, Ladbroke Grove) repeatedly emphasise the contribution of human factors in precursory events and the influence of these on driver performance (eg fatigue,
distraction, poorly designed equipment, management failings, training gaps). For this reason, it is therefore essential that railway undertakings build on lessons learned and establish systems to identify, manage and mitigate the human risks. This should be done at the individual, job and organisational levels (see figure 1) to:

a) Close any defensive gaps in the system (see Figure 3), and,
b) To prevent an over-reliance on the primary control (eg driver) who, at times, will be prone to error.

**Good practice example - SPAD Human Factors Hazard Checklist [3]**

This is a checklist which is designed to ensure all possible human factors causes of SPADs are considered (including infrastructure and underlying operational issues). It provides a way of prioritising which features of a signal location are generating the greatest SPAD risk and identifies possible risk reduction/mitigation measures for each hazard. It helps investigators identify the contributory human factors problems associated with a SPAD incident and encourages them to consider the wider human factor issues associated, such as poor infrastructure and management failures, rather than simply focusing on driver issues such as competency, shift patterns, fatigue, etc.

### 2.3 How to apply the information in this guide

The intention of the RSSB in producing this Good Practice Guide is to encourage the industry to move away from the notion of the front line operator being *at fault*, to an appreciation of the various human factors that can influence performance at work.

The aim is that, by increasing awareness of the cognitive and individual limiting factors, that this knowledge will be used *proactively* by industry and integrated into everyday operations (at all levels) to identify, manage and mitigate the risks from human error. This means that, by having a better appreciation of what is ‘going on out there’, specific problems can be targeted as they emerge (eg training gaps, poorly designed equipment).

We know from preliminary research on driver management good practice, for example, that SPAD levels are lower for drivers whose managers spend more time on the following:

a) Continuous assessments
b) Ongoing (planned and unplanned) monitoring and observation (eg by manager/colleague, in cab, at stations, other vantage points, reassessments, simulations, etc)
c) Using train recording data
d) Supporting drivers (eg regular face-to-face discussions on driver performance and safety issues (separate from the company’s safety briefing process))
e) Following up on the causes of train delays
f) Post incident report support and monitoring.

Where there is an indication of an underlying competency issue this may lead to the triggering of the ‘Specially Monitored Driver’ (SMD) process, which should include provision for managing sub-standard driver performance. Guidance is available from the Office of Rail Regulation (ORR) to assist railway undertakings maintain and develop competence, and manage sub-standard performance, as part of their Competence Management arrangements [1].

Managers should also be aware that there will be times in a driver’s working life when personal issues or other behavioural factors may affect their concentration and ability to perform tasks which, if not addressed, may ultimately pose a threat to safety. The need for additional monitoring and support may therefore result from:

a) Direct approach by driver
b) Evidence of harassment from others
c) Absence due to stress or exceptional circumstances

d) A driver experiencing a traumatic rail incident

e) Manager's own observations which indicates safe performance is being compromised

f) Awareness of drivers returning to work following personal issues (e.g. following a major incident, bereavement, divorce, house move, etc) [see Appendix C 'Recognising behavioural change'].

Where there is evidence of an underlying personal and/or behavioural issue, a driver's immediate fitness to continue duty should be assessed by a suitably qualified person (see Appendix C for a checklist of behaviours that may indicate an underlying personal and/or behavioural issue). If a driver is not considered fit to continue duty, an appropriate course of action should be agreed, which may include:

a) Exceptional domestic, or other type of leave

b) Sending them home for remainder of shift

c) Referral to Occupational Health Service

d) Transfer to alternative duties for a temporary period.

The success of any performance monitoring system is dependent upon correct identification of the underlying cause(s) and initiating appropriate remedial action. This should have the buy-in and support of the individual concerned, who should be an active participant in developing a programme to address any performance issue(s).

Railway undertakings are encouraged to formally communicate their commitment to and rationale for proactive error management and the driver monitoring process. This should be done in a supportive, blame-free environment and should include mechanisms for the confidential reporting of issues that may indicate an increased risk of (driver) error (e.g. outside of the SMD process).
3. The human operator – the last line of defence

You may have heard the phrase, ‘to err is human’. Implicit in this statement is the fact that everyone, regardless of knowledge, experience or training, will, at times, be prone to error [4].

In order to understand why errors occur the following sections give a basic overview of how the human brain processes information.

3.1 Human information processing

‘Information processing’ is the term used by Psychologists to refer to the way in which humans:

- a) Receive sensory input from the external world (eg through our eyes and ears)
- b) Use this information to make decisions about what we have learnt
- c) Decide upon the actions we want to take.

Figure 4 illustrates a typical model of human information processing. It is based on the assumption of a series of mental (cognitive) operations that occur between information being received by the senses, decisions being taken and responses selected and executed.

For our purposes, the key components of interest are:

- Perception
- Attention
- Memory
- Decision making
- Action.

Such models are used to explore:

- Different types of error in more detail, eg whether due to a perceptual or memory failure, or as a consequence of having successfully interpreted the information but having failed to take the appropriate action, and;

- The influence of individual factors (eg stress, individual differences, fatigue and trauma) on human performance.

The key components of human information processing are described in more detail overleaf.
3.2 Perception

Perception involves the conversion of sensory information into meaningful structures which enables us to create an internal mental model or representation of the external world.

Visual and auditory information is stored briefly in either the visual or auditory sensory memory. An important point to note is that information stored in sensory memory will be quickly lost. In fact, information stored in the visual sensory memory lasts between 0.5 and 1 second; information stored in auditory sensory memory lasts between 2 and 8 seconds.

The importance of sensory memories is that they enable us to retain information for a brief period of time until we have sufficient spare processing capacity to deal with new inputs.

The interesting point about human perception is that the mental models we create are not only dependent on both the quality and quantity of the information, but also on our experience and expectations of the world. What this means is that, having developed a mental model of the world, we tend to seek information which will confirm our ‘view’, at the expense of other contradictory inputs. This can lead to errors in visual and auditory detection, identification and interpretation.

Visually, for example, driving tasks include searching for new information that we may not be expecting to appear, such as people or animals on the line, and for anticipated information, such as aspects of signals. Drivers also need to communicate with signallers, on-board train crew, passengers and other rail functional groups. Such communication can be face-to-face or remote via radio or telephone. In all of these areas there is the potential for error.

There are both physiological as well as psychological components in the way that we perceive information.

In physiological terms, lighting is a key requirement for effective visual discrimination as people do not see well in the dark. However, whilst light will enhance visibility, it is not the only important factor. Other influences on visibility are physical and relate to factors such as contrast, brightness, shape, texture and placement.
Other important physiological attributes of perception include:

a) Visual acuity – the ability to focus and see clear, sharp images, allowing people to see very fine or small detail, a characteristic of vision which declines with age

b) Colour vision deficiency – whereby only a limited number of colours can be identified, the most common form of colour vision deficiency being an inability to distinguish between red and green

c) Blindspot – refers to a spot on the retina that contains no photoreceptors; visual information that falls on this spot will not be processed into images.

All of the above three physiological features of perception can be detected by standard eye tests.

As stated above, in psychological 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 would 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, based on people’s experiences, expectations and emotions.

It is for this reason that some things in our environment will be much more visible than others at certain times. For example, 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 hatchback car and suddenly red hatchbacks seem to be very much in evidence despite the fact they were not noticed at all before the purchase).

The role of prior experience and expectation in the visual perception process cannot be overstated as it has an extremely strong influence on what people ‘see’. In the face of new, incomplete or ambiguous information, people tend to use their own way of looking at the world to process and interpret what they see in a way that makes sense in a given context. This can be a major factor in why people make performance errors (see Part 5).

Humans also have a natural tendency to make what they will from visual stimuli as illustrated by numerous visual illusions (see Figures 5-7), all of which can be explained through perceptual processes.

Common features of perceptual processing include:

- Individuals filling in missing information (see Figure 5):

![Figure 5](image)

**Figure 5** One whole or individual components?
• What the person regards as borders to distinguish figure (the meaningful element) from background (see Figure 6):

![Figure 6 A vase or two faces?](image)

• The way things are conceptually grouped together to form a ‘gestalt’ (whole figure) (see Figure 7). This will include consideration of: proximity (how close things are to each other); similarity (how similar they are to each other); common fate (whether or not they appear to be connected/interdependent); continuation (whether elements seem to create a single continuous form); closure (‘filling in’ of apparently incomplete objects):

![Figure 7 Which is the longer?](image)

• How people adjust to changes in image size, shape and colour, etc. on the retina to perceive movement, distance, shadow, viewpoint.

• The ability to select, focus, and divide attention when a person is faced with various stimuli competing for attention (particularly if related to the same sense, such as sight). At some stage, one stimulus will become more powerful than another in attracting attention. When this happens, processing of the less attended information will not be fully effective.

### 3.3 Attention

The key point to note here is that our ability to attend to all of the information that bombards our senses is that it is limited by the channel capacity of attentional processing. The fact that our attention is limited means that we are unable to devote conscious thought or ‘attend’ to all of the stimuli that impinge upon us. For this reason, the human brain is capable of filtering information at an early stage of processing to enable us to select the stimuli that will be consciously perceived and used as the basis for thought and decision making.
a) **Selective attention.** This refers to the process by which sensory inputs are selected to ensure that the information we want to process in detail is relevant to the task. Information we select and are receptive to will relate to the context and other intellectual and emotional influences. Personal values and interests will play a major role, as well as physical characteristics, such as size, brightness, movement, etc.

It would be unfortunate, however, if this process were so rigid that information not directly related to the task was always lost (eg failing to hear our name called whilst concentrating on an activity). In fact, people are rather good at detecting information of relevance to them, such as their name. This is due to the fact that, even if not consciously aware of it, information can still be processed and tested for importance. For example, apart from our name, some stimuli, such as loud noises and flashing red lights are particularly ‘attention-grabbing’. It is for this reason that they are important in the design of warning systems. However, the fact that we can be so easily distracted by stimuli in our environment does mean that we are vulnerable to error (see Part 4).

b) **Focussed attention.** This refers to the width and intensity of attentional focus. For example, the narrower the width of our focus (eg when concentrating on a new or difficult task), the stronger our attention will be. Whilst this can be very adaptive in that the full capacity of our attention can be focussed on an immediate problem or piece of information, it does have the potential disadvantage that sometimes relevant stimuli may be missed.

c) **Divided attention.** This refers to our ability to be able to ‘switch’ conscious thought between different sources of information. 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. This ability to divert attention for the core task activity (eg driving), to a secondary task (eg speed indicator) enables performance to be continually checked and monitored using a process known as closed loop feedback (see Figure 8).

![Figure 8 Closed loop feedback](image)

It must be re-emphasised, however, that the detection and interpretation of sensory inputs will be greatly influenced by what we are expecting to receive. Decisions that have already been made, or information stored in short or long term memory may influence recognition of input in the sensory store. Moreover, when we become so consumed or preoccupied with the core task, the strength of our attention will be reduced and the ability to use other sources of information to monitor performance can go unchecked and lead to error.

The amount of attention available will also vary according to the level of:

a) Physiological arousal, or general alertness (see Part 4). For example, attention can be affected by extended periods of high mental workload, leading to fatigue, by low arousal, due to the monotonous nature of a task, and also by environmental factors, such as cab temperature and noise levels.

b) Level of skill acquisition (see ‘automaticity’ overleaf).
3.3.1 Automaticity

On many tasks (e.g., driving a car), practice leads to a reduction in the amount of processing capacity required by the individual and may eventually lead to the execution of the task becoming automatic.

Automatic processing is defined as being fast, attention-free, unconscious and unavoidable. By definition, automaticity is the opposite of controlled processing, which is slow, attention-demanding, under conscious control and adaptable. For this reason, automaticity is associated with highly skilled performance.

For example, the initially demanding task of changing gear in a car will eventually be performed by a skilled driver with little or no conscious awareness. Skilled drivers can easily drive a car and maintain a conversation at the same time. All that is required is that the driver monitors their performance. Continuous conscious control is no longer required.

Automaticity is explained by the fact that practice and experience increase the knowledge base and lead to rapid retrieval of past solutions from memory. Experts perform by implicit anticipation (e.g., ‘open-loop’ behaviour), rather than by feedback. Novice performance, on the other hand, is characterised by a lack of knowledge. Automaticity is therefore associated with a situation of low uncertainty and high predictability.

The ability to automate behaviour brings a number of distinct advantages for performance. Expertise is commonly associated with efficiency, and is consequently seen as a positive indicator of performance. Automaticity is also useful in multi-task situations, as the automatic process hardly interferes with concurrent tasks. This also means that skilled operators are more able to cope with unplanned situations. It has also been cited as a prerequisite for situation awareness (see Part 6).

Unfortunately, our ability to ‘automate’ skilled behaviour is also open to error. This is due to strong, inflexible expectations that influence selective attention and the fact that automatic processes are unconscious and unavoidable. Performance decrements are especially apparent in such situations if the task has been learned by repetition, rather than understanding, as the operator cannot adapt to new circumstances. Moreover, if the demands of a task change (e.g., driving becomes difficult) then full
controlled attention would be necessary (eg operator is forced to resort to a feedback/novice strategy) to ensure flexibility in response (and hence any secondary activity, eg conversation, would have to stop).

The irony is that expert performance needs to be monitored in a controlled fashion if errors are to be detected and corrected, but that controlled processing does not by definition equate with expert performance. Only if the task is consistent and there are no problems, should automatic processing guarantee error-free performance.

### Good practice examples – facilitating learning

a) Rehearsal: organisations should encourage a culture in which drivers review information critical to performance on a regular basis, ie reading training manuals daily, regular Rule Book review. This should be reinforced by training/assessment/simulation exercises and material.

b) Question and answer sessions with supervisory staff on an informal but regular basis.

c) Transference of critical information to ‘crib cards’ by the driver to allow regular review during periods of inactivity and to facilitate the learning process.

d) Noting main points of safety briefings for own personal use.

e) Introduction of manager or trainer surgery hours to answer questions which arise after training has been completed.

f) Introduction of ‘study weeks’ with a specific focus of attention each week, i.e. a different section of the Rule Book each week, followed by a review period or question and answer session.

g) Increased practical applications, wherever possible, of theory learnt during training.

h) Option for driver to request assistance during a shunt move not attempted previously, where the driver feels insufficiently conversant with the move.

i) Learning by observation (modelling), eg learning what takes place simply by having the learner observe the appropriate response.

### 3.4 Memory

The memory system consists of working (or short term) memory and long term (or stored) memory. Both types of memory are crucial for train driving tasks.

#### 3.4.1 Working memory

*Working memory* enables information to be retained for a short period of time. For example, drivers use working memory when repeating information to signallers and recalling the aspect of the previous signal.

In order to hold information in *working memory* a driver must direct attention to the process. If not attended to, information in working memory will be lost in 10 to 20 seconds. Such attention is achieved through the process of *rehearsing* the information to be retained. For example, a driver may continuously repeat the aspect of the previous signal to hold this information in working memory. The problem is that, even if the information is rehearsed, there will be a decay in working memory over time, which will become more pronounced as the amount of information held in working memory increases.

The reason for this is that the capacity of working memory is *limited*. We know from research that the maximum number of unrelated items that can be maintained in working memory, when full attention is devoted to rehearsal is roughly *seven*. This has important implications for the design of systems to be operated by humans.

Once this limit of about seven is exceeded, one or more items are likely to be lost or transposed through the process of *interference*. This causes information held in working memory to become replaced with the arrival of new information (eg a conductor talking to a driver may cause the driver to forget the aspect of the previous signal because they cannot rehearse the information whilst holding a
conversation), or confused by that which was previously stored (eg ‘cat’ may be recalled instead of ‘mat’).

It is for this reason that driver aids, such as the Drivers Reminder Appliance (DRA), are used to prompt the driver to check a signal has cleared, rather than rely on the driver’s memory to store the information. For example, when a driver performs the act of switching on the DRA they can be said to be dividing their attention. It may be that by performing this action the driver reaches an overload in their working memory which would mean that the retrieval of the information (ie why they are switching it on) may be misplaced. Also, if at full working memory capacity, it is very possible that the driver will occasionally forget to complete the task (switching the DRA on) due to a simple distraction (eg some external event, or someone attempting to communicate with them).

### Good Practice examples – facilitating retention

<table>
<thead>
<tr>
<th>Good practice examples – facilitating retention</th>
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<tbody>
<tr>
<td>a) The number of items retained in working memory can be expanded by the <em>clustering</em> or ‘chunking’ of related material (eg remembering a familiar telephone code such as 020 7 as 0207).</td>
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<tr>
<td>b) <em>Chunking</em> unrelated items into groups of three and four, eg 055 2781, will assist the maintenance of items.</td>
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<tr>
<td>c) The impact of <em>interference</em>, and hence forgetting, may be reduced by increasing the time between the arrival of inputs to be held in working memory and by reducing the similarity between items.</td>
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<tr>
<td>d) <em>Rehearsal</em>: research shows that the more the information to be committed to memory is read and reviewed, the more likely it is to be retained.</td>
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<tr>
<td>e) <em>Regular reviews</em> of those aspects of training which are not put into practice on a regular basis.</td>
</tr>
<tr>
<td>f) Memory techniques (known as <em>mnemonics</em>) can be used to improve the retention of information (eg remember a list by using an easily remembered word, phrase or rhyme whose first letters are associated with the list items).</td>
</tr>
<tr>
<td>g) <em>Demonstrations</em> by a minder driver or driver instructor can ‘bring to life’ or operationalise those areas with which the driver has difficulties.</td>
</tr>
<tr>
<td>h) <em>One-to-one sessions</em> with experienced drivers provide the opportunity to explore suggestions for remembering particular signal sequences and routes.</td>
</tr>
<tr>
<td>i) Review and modify current simulation, training and assessment exercises to integrate above strategies and lessons learned.</td>
</tr>
<tr>
<td>j) Ensure delivery and content of training material matches the cognitive capabilities and needs of the target audience.</td>
</tr>
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#### 3.4.2 Long term (stored) memory

Information from working memory is transferred to *long term memory* by applying *meaning* to the information, and relating it to information already stored. For example, new temporary working instructions or procedures could be related to existing memorised procedures, and the differences between the two memorised.

The information in stored memory (ie existing procedures) is recalled with comparison and in relation to new knowledge (ie temporary procedures). So, to recall temporary working procedures, reference would be made to the stored usual procedures.

In such cases, there is the potential for error, in that the stored usual working procedures may interfere with the recall of the temporary procedures. For example, it may be difficult to distinguish between the stored and temporary procedures, especially when a driver is under additional pressures, such as time.

Examples of the use of stored memory are procedures, rules and route 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, for example, a particular incident. The important point
to note here is that the information stored will not remain static, but will be influenced by our need to make sense of our experience and our expectations of what should have happened. Recollection of such events are, 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.

3.5 Decision making
Once information has been perceived, a decision must be made about what should be done with it. It may be used to initiate an immediate response, or be entered into part of the memory system (see above). For example, on hearing a warning sound, an operator may switch off the system, in which case the decision will involve the selection of a response. Alternatively, the operator may decide to hold the information in working memory whilst a search is made for the problem that triggered the alarm.

Decision making involves the close interplay between working memory and long term memory, in that in order to make a decision, judgement, or form a strategy, a driver has to call on information or knowledge (eg the weight of the train, the locomotive’s braking characteristics, track gradient, aspects of previous signals, etc). Drivers have to judge or project distances and speeds (to signals, platforms, and of their train), make decisions (such as when to brake, what speed to proceed at) and form strategies (such as how far ahead of a signal they need to brake given their train configuration).

The ability to initiate a correct and timely response will be influenced by many factors. These include:

- a) Skill level of the driver
- b) Task complexity
- c) Quality of information
- d) Quantity of information
- e) Previous experience, knowledge and training
- f) Competing information
- g) Workload
- h) Fatigue levels
- i) Stress levels
- j) Time pressures.

**Good practice examples – managing decision making**

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>a)</td>
<td>Drivers should be aware that it is of paramount importance to make the correct, rather than the fastest response.</td>
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<tr>
<td>b)</td>
<td>Rehearse moving through the routines of the day, most importantly, re-check signal aspect and perform system checks before moving away.</td>
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<tr>
<td>c)</td>
<td>Develop and practice a mental checklist of considerations before moving out of a station, away from a signal, etc.</td>
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<tr>
<td>d)</td>
<td>Drivers and colleagues should be aware/develop a habit of checking anxiety levels (eg are there signs of nervousness, anxiety, worry, agitation, or irritability? Is there more sweating than usual, more restlessness or emotion? Do they feel that their heart is racing?). If anxiety levels are high, action should be taken to reduce it by moving through the routines of the day in a calm and considered manner.</td>
</tr>
<tr>
<td>e)</td>
<td>Try to consider all options available before taking action. For example, if drivers are about to make a shunt move which they are not confident about, pause, and consider potential options (eg contact manager/signaller).</td>
</tr>
<tr>
<td>f)</td>
<td>Drivers should think about the logic behind the actions being carried out, eg braking procedures, whilst carrying out these procedures. They should question their own actions for appropriateness and effectiveness.</td>
</tr>
<tr>
<td>g)</td>
<td>Drivers should refer back to training material and feedback on performance from colleagues, on a regular basis to inform decisions.</td>
</tr>
<tr>
<td>h)</td>
<td>Use the STAR principle - ‘Stop, Think, Act, Review’ (used in the nuclear industry) to manage decision making.</td>
</tr>
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</table>
3.6 Action

In order to initiate a response, a decision must be translated into a specific sequence of conscious actions, words, or both, unless the behaviour has become automatised. Such actions, or speech, are the execution of previously formed (and correct) decisions.

Drivers have to physically interact with in-cab equipment, and must routinely select objects in the external environment in order to perform actions. However, when performing these actions there is the potential for error if there is a failure at the attentional level. For example, a driver may make an action slip if the wrong control is selected due to two controls being placed in close proximity to each other.

In a situation where there is pressure to make a rapid response, several factors must be borne in mind, since there will frequently be a trade-off between the need for speed and accuracy:

a) In certain situations, where any delay can have catastrophic consequences, there will be pressure to make a response before sufficient information has been processed
b) Conditions that increase arousal levels will lead to faster, but less accurate responding
c) Since auditory stimuli are more likely to attract attention, than visual stimuli, they are more likely to be responded to in error
d) If we expect a stimulus and prepare the appropriate response, we will respond more rapidly if the expected stimulus occurs; however, if an unexpected stimulus occurs, we will be more likely, under pressure, to make the wrong prepared response
e) As age increases between 20 and 60 years responding tends to become slower, but more accurate.
4. Concentration and attention – limiting factors

Using the task of train driving as the primary example, this section summarises the main cognitive and individual factors that can impair attention and concentration and increase the potential for error.

4.1 Visibility, perceptual and vigilance factors

Research has suggested a number of influences that will affect whether a driver’s attention is focused at the right time. These can be categorised as visibility, perceptual and vigilance factors (see figures 9-14 below):

![Figure 9](image9.png) Visibility factors: station furniture can obscure signals

![Figure 10](image10.png) Visibility factors – ‘bleaching’ on emerging from a tunnel can temporarily impair vision

![Figure 11](image11.png) Visibility factors: curved approach can limit sighting time

![Figure 12](image12.png) Perception factors: curved approach can give wrong signal illusion
4.2 Mental workload/operational demand

This refers to both the amount of work and the nature of the tasks. Since our ability to process information is limited (see Part 3), this will have obvious implications for the level of performance we are able to achieve.

The relationship between workload and performance can be conceived in the form of an inverted ‘U’ curve (see Figure 15).

Human performance at low levels of workload is not particularly good. Work under-load is where a job is routine, repetitive and under-stimulating. Under load also induces boredom, which may create lack of motivation and a loss of skills and can lead to errors with individuals being less alert and more prone to distraction.

Thus, at low levels of workload (underload) errors typically take the form of missed information due to individuals not taking in information from the environment around us.

As the demands of the task, or the workload is increased, the standard of our performance increases until an optimum level of workload and performance is achieved. Any increase in workload after this point will lead to a degradation in performance (eg too many tasks to complete in the available time, tasks are too similar and easily confused, conflict between the type of tasks required). At extremely high levels of workload (overload), important information may be missed due to the narrowing or focusing of attention on to only one aspect of the task.
When a driver pulls into a busy station with a number of signals and points in unusual track conditions, workload increases and attention can become more focused on the core task information available to the driver, such as the signal aspect in front of them. This means the driver may be less able to detect changes in the situation around them.

The human information processing model (see Part 3) can help us to determine the source of overload. It may be that the task is too difficult, for example, the amount of information to be perceived in order for a decision to be made is beyond the attentional capacity of the human. Alternatively, there may be too many responses to be made within the time available.

Assessing driver workload

The RSSB have developed a simple method of carrying out an initial assessment of driver workload [5]. It can be used to identify significant issues and the need for a more in-depth workload analysis. It is based on a set of primary and secondary principles (see below). Primary principles are essential for safety and performance; secondary principles are desirable; if it is apparent (either through observation or suggestion by those working on a particular train or route) that these are not achievable, then further investigation would be warranted. In all cases, it is recommended that judgements are arrived at through joint discussion between a driver Subject Matter Expert and personnel with some human factors knowledge. Further information is available from the RSSB website (www.rssb.co.uk).

Primary principles:

a) Drivers are able to maintain sufficient attention to monitor for incoming information and for changes to the expected environment. They are not bored and able to remain fully alert at all times.
b) Drivers are physically able to see and reach all equipment that assists in monitoring, controlling and receiving feedback.
c) Drivers receive information (visual and verbal) clearly, sufficiently, and in good time to assist decision making (eg to brake, stop, accelerate) for safe and effective driving.
d) Conditions should allow incidents/problems to be dealt with effectively. This suggests minimal distractions and work demands that do not impact on both safety and performance.
e) Drivers are able to communicate with all staff with whom they have to exchange information.

Secondary principles:

a) Drivers have hours of work and shifts that allow for sufficient rest between and during shifts, to minimise fatigue and maximise attentiveness and effectiveness.
b) Personnel whose operations directly impact on driver’s work will perform as expected of the driver’s Rule Book.
c) Conditions of work support worker well-being.
d) Equipment that impacts on a driver's role is reliable and performs to assist the driver’s task.
e) Drivers have sufficient training, updates and/or supervision to manage the nature of the work experienced in a specific cab environment.
f) The supervisor or immediate manager works in a style that supports and facilitates driver function.
g) The systems or information provided at an organisational level facilitates driver’s function.
4.3 Expectation and mental autopilot

The nature of, and familiarity with a task can influence the intensity and direction of attentional focus. For example, drivers build up knowledge and experience of the route and the handling of the train. They store (ie create mental models of) past perceptual events such as where signals are positioned. Through knowing where the exact locations of the signals are that they must respond to, drivers search for signals in the places where they are expected to be. Together with the monotonous, predictable work environment, these factors encourage drivers to drive on mental autopilot, with certain routine, highly practised behaviours becoming automatic (see section 3.3.1).

This mental automatic control operates without conscious attention to changes in the environment, and requires no effort. Mental workload is reduced and levels of physical arousal decrease. However, although this allows drivers to drive to their upper limits by being able to anticipate certain events or circumstances, levels of alertness have been reduced, along with their ability to detect error. This can be further compounded by a reduction in alertness that naturally occurs mid-afternoon and can have an obvious impact on safety. These ‘mid-afternoon’ or early morning dips can be more pronounced when work of a monotonous or repetitive nature is being conducted and drivers move into mental autopilot.

Two different types of error may result from an over-reliance on previous stored memories, or mental models:

a) A driver approaching a red signal may anticipate a signal clearing on the basis of past experience and fail to prepare to stop appropriately. This is known as a slip-type error (see Part 5). Anticipation error, for example, occurs because mental models are difficult to override. By using mental models and driving in autopilot, attention levels are limited. Changes in the environment, for example a signal change, require active attention. Drivers are known to get stuck in mental autopilot and cannot shift mental gears from automatic, unconscious processing to active attention.

b) Alternatively, 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. For example, signallers can come to anticipate that certain train running codes indicate a particular route for a train because that's the way they always go. They can then be caught out when that train’s head code is for a train that is supposed to be routed elsewhere.

Research suggests that model-induced illusion errors occur because drivers form hypotheses on the basis of early and unreliable information that interferes with the later interpretation of better, more abundant data. Thus, it is feasible that at 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.
4.4 Habituation

Train drivers are repeatedly presented with the same information day in day out, which can lead to an over-familiarity with the information around them. This can result in a decrease in sensitivity to attend and respond to repeated information (e.g., a stimulus is either ignored or responded to in error by force of habit). This is known as ‘habituation’. A good example of this is habituation to the AWS system which provides a ‘bell’ sound at clear signals and a ‘horn’ sound at restrictive signals. The provision of auditory warnings for all signals, however, is likely to actually lower the relative effectiveness of the warning system. As drivers become so used to hearing the sound of the AWS alarm, for example, quite often it is cancelled without realising or registering its meaning.

**AWS design – a problem of association**

The Automatic Warning System (AWS) installed on all passenger trains in the UK is an example of a system that was not designed with limitations of human attention in mind. It is a device fitted in the train cab, based on the mechanical system of signalling that used to signal either STOP or PROCEED. It sounds a bell when a clear (green) signal is passed and a horn when caution or danger is signalled. The AWS is a useful safety system in that if the horn is not acknowledged by the press of a button, then the train begins to stop automatically. However, times have changed since it was designed. In today’s commuter traffic, many signals will be at the ‘caution’ aspect, and given the frequency of signals (spaced 1km apart), most drivers will face two signals per minute. Since people ‘automate’ highly repetitive behaviour, drivers can lose focus on the reasons for carrying out this repetitive task, and act in reflex whenever the buzzer sounds. The end result is that drivers often hear the horn and press the button reflexively without thinking about train speed and location. *(Source: Davies (2000)).*

4.5 Distraction/preoccupation

While it is possible to do two things at once, dividing our attention between two separate activities does increase the potential for error as we are prone to become pre-occupied or distracted with one of the activities, leaving the other activity un-checked (see Part 3.3).

Driving a train involves many tasks that have to be performed at the same time, such as checking signs, target speeds and warning devices, all of which cause attention to be focused away from checking the signal. Research into the dynamics of visual attention suggests there is a possibility that, with everything a driver has to look at, sooner or later a signal will not be attended to.

Our attention to a task can be impaired by our natural response to react to more ‘attention grabbing’ external features in our environment, such as alarms, a loud bang, telephone calls, colleagues, other work-related equipment, environmental stressors (e.g., heat, light and noise), or by something which suddenly appears in our field of vision.

Safety incidents, including SPADs, occur when a distraction of some kind is more attention-grabbing than the core task information (e.g., signal, line side, speed, distance) at a time when it is safety-critical that the driver attends to the core task. An example would be a driver becoming distracted by a passenger walking across a footbridge and being oblivious to a changing signal aspect.
In-cab warning systems, such as AWS, help attract a driver’s attention back to the core task of driving, although, as highlighted above, repeated presentation of the same stimulus can cause lead to habituation and the automatic triggering of a response (e.g. slip-type error).

As mentioned above, the simplicity of the task can also lead to distractions. Lowered mental activity, due to low job demands, causes attention to be directed elsewhere or to internal thoughts. This is a possible reason for the start away SPAD. The driver responds in an automatic fashion to the ‘ding, ding’ from the guard. As it is an automatic response to start, the driver is not fully attentive and may either be distracted or simply not notice the red signal.

**Social distraction**

Social influences are considered in relation to having more than one person in the cab. Two people can be a distraction in that some drivers may feel a perceived lack of control over what that other person might do. Some feel it is an invasion of their personal space or feel the presence of another contributes to their workload. On the positive side, a second person may add variety to an otherwise monotonous activity, can provide support, and may cause the driver to drive more safely if they feel they are being evaluated or because they want to prove their ability as a safe driver.

Preoccupation is another form of distraction and can be caused by issues specific to the individual such as problems at home, financial difficulties or work problems. When attention is directed to internal thoughts, for reasons such as dissatisfaction with work, work-related events, and/or domestic concerns, all of which cause intrusive thoughts, more attention resources than normal can be allocated to them. An individual may not just be preoccupied with negative issues. Events that an individual is looking forward to, such as the birth of a child or an imminent holiday, can be just as distracting.

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**Good practice examples – maintaining vigilance whilst driving**

a) Drivers should develop their ‘situational awareness’ to help them plan ahead and anticipate what is coming up (see section 6.1).

b) Drivers should talk themselves through aspects - saying out loud ‘two yellows, one yellow’ etc to bring themselves back from autopilot to conscious control and take appropriate action (see section 6.2).

c) Drivers should talk themselves through their driving technique. They should imagine that they are instructing someone, providing that this does not distract them away from their core-driving task.

d) Drivers should be conscious of prevailing weather conditions and run through the route ahead in their mind to anticipate any performance issues.
Good practice examples – raising vigilance

a) Drivers should be encouraged to consciously monitor the route and outside environment to actively anticipate what is coming up, rather than rely on mental models (see section 6.1).

b) When drivers have heavy passenger loading at a station, or when stopped at a signal at a station, where they have sufficient time, they should be encouraged to leave the cab and walk around. If using this strategy, drivers must not be distracted from their core-driving task.

c) Opening the window when it’s getting stuffy can help, but drivers should be aware that at higher speeds the noise from an open window may present further distraction. This strategy should be used sparingly to raise vigilance levels.

d) Managers should work with their drivers to identify strategies to raise awareness of features of the environment which have become overly familiar. For example, a useful approach might be to get drivers to say out loud the colour of signals that are normally green but very occasionally display a yellow aspect, as each signal is passed. They may feel quite odd doing this at first, but it is a simple strategy to raise their awareness of something which they have fixed expectations of (see section 6.2).

e) Explore ‘cab exercises’ to encourage and maintain periodic active attention to the core task, in other words, to promote arousal. For example, these might involve you explaining out aloud why you have just started to brake, why you have sounded the horn.

f) Managers should review defensive driving techniques with drivers.

Working environment

The working environment contains environmental stressors such as lighting levels, noise, temperature and vibrations. These can lead to feelings of discomfort and act as distractions which will impair an individual’s performance. Lighting, or more specifically over-lighting or glare (eg from visual display units) can cause distraction and visual fatigue, as well as physical discomfort for some types of glare.

Noise makes performing tasks more effortful; perceived mental workload increases and tolerance reduces. Temperatures lower than 0ºc or higher than 32ºc have produced reductions in manual and mental performance.

The design and layout of the working environment is also essential for optimum safety performance. Work areas and operating positions should be arranged so they allow for free movement, safe access and egress, unhindered visual sight lines and reaching distances to primary equipment, etc and support verbal communications.

Good practice examples for drivers – managing distraction

1) Eliminate the source – keep mobile phones switched off; stabilise any loose items (food, bags, folders, etc);

2) Tell the Driver Standards Manager (DSM) about any ongoing sources of distraction;

3) If you find yourself distracted by a thought or an event:

   i) Tell yourself to focus on driving

   ii) To help ‘clear your head’, talk aloud, commentate on what you are seeing, thinking and anticipating as this can help you re-focus

   iii) Tell yourself to ‘park the thought’ until the end of the journey

   iv) Decide to tell someone later on – having a plan is important.
4.6 Fatigue
Fatigue refers to feelings of extreme tiredness and being unable to perform work effectively. It has both physical and mental effects, but from a safety critical perspective, mental fatigue is by far the most dangerous.

The reason for this is that it leads to a gradual slowing of normal cognitive functions, such as memory, alertness, decision making and concentration. Coupled with a general deterioration in mood and motivation, the risk of being involved in an incident and/or making an error when fatigued increases significantly.

Fatigue can be caused by:

a) The amount and type of work being undertaken (see ‘mental workload’)
b) The individual’s lifestyle and any personal factors (eg new baby, moving house, bereavement, etc), which can affect the quality of an individual’s rest and sleep

c) Shift patterns – certain features of shift work can lead to a build up of fatigue and an increased risk of having an incident (eg SPAD). These include:

- Successive night shifts (ie more than 2/3 unless it is permanent nights)
- Early starts (ie before 0730hrs)
- Long commuting times (ie over one hour)
- Shifts that extend beyond 12 hours and inadequate breaks (ie no break for four hours).

Shift work and lifestyle issues

Shift work creates problems when the body’s natural clock is disrupted and work or sleep patterns conflict with the known peaks and troughs in alertness [6,7] Humans are designed to wake at dawn and to fall asleep during the evening when it gets dark.

Shift work inevitably results in reduced sleep duration and sleep disturbances which can have an impact upon safety. Firstly, as fatigue increases, the individual is more likely to drop off and therefore compromise safety. Secondly, as stated above, high levels of fatigue are likely to result in impaired performance, decision-making and judgement. In addition, lapses of attention where the driver fails to recognise a signal for what it is, or fails to respond to it appropriately, are more likely to occur in fatigued individuals. Shift work can also inhibit social and family life, which in turn can lead to a build up of stress (see below) and lowered attention levels.

Good practice examples – fatigue management

The Office of Rail Regulation (ORR) has published guidance on ‘Managing fatigue in safety critical work’. This relates to regulation 25 of the ‘Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) [8] and sets out a series of stages that controllers of safety critical work should follow to manage fatigue risks.

Further information on worker and company fatigue management is available from the RSSB website (www.rssb.co.uk) and the Office of Rail Regulation (www.rail-reg.gov.uk).

Good practice example – Fatigue Risk Index

The Fatigue Risk Index (FRI) [9] is a simple tool, developed by the HSE, to provide an assessment of short-term, daily fatigue and cumulative fatigue risks associated with shift work. The FRI is based on five main factors known to have an impact on fatigue:

a) Shift start time
b) Shift duration
c) Length of the interval between finishing one shift turn and starting the next
d) Breaks
e) Number of consecutive shifts.

It enables calculation of the build up of cumulative levels of fatigue over a number of shifts.

Further information is available from the HSE website (www.hse.gov.uk).
4.7 Stress

‘Stress’ means different things to different people, but whilst most people agree that a certain amount of stress can be beneficial to motivation and performance, there is also a general acceptance that stress at work is usually considered to be a ‘bad thing’.

Modern theories of stress essentially argue that people will only experience stress if they perceive the demands on them to outweigh the resources they have to cope. This means that when two people are in very similar work situations, one might experience stress, whilst the other will not. The reasons for the different experiences are not determined by the actual situation as such, but by the individuals’ perception of that situation (ie the demands being made on them) and their perception of their ability to meet those demands (ie their skills, experience, time, support, intellectual/emotional capacity, other commitments, etc).

Although modern stress theories state that there are no absolute stressors, there is wide recognition of certain well-established potential stressors in the work and home environments. These include:

- Physical stressors (eg noise, vibration, crowding, inadequate light/ventilation, heat, etc)
- Accident/incident history
- Some shift patterns
- Workload (overload and underload)
- Time pressures
- Company culture
- Poor team working
- Monotony
- Excess complexity
- Job insecurity; lack of career progression; feeling undervalued
- Lack of control
- Harassment
- Poor relationships with colleagues/supervisors/senior management, etc
- The conflict between safety and customer service
- Personal circumstances, eg family/financial problems or life events such as marriage, divorce, house moving, birth, bereavement, etc.

Good practice example – team working

The RSSB has produced ‘Teamworking in the railway industry: The Journey Guide’ [10]. It is the result of a 15 month study into the definition of best practice in teamworking for the railway industry. It is designed to accompany the RSSB Guidance Note on Teamworking for all railway organisations. It provides straightforward support on how to diagnose and improve teamworking with railway organisations. The document is released with a CD-ROM containing supporting tools in the form of Adobe pdf and Microsoft Excel files.

Further information can be found on the RSSB website (www.rssb.co.uk).

Good practice example – RSSB safety culture assessment

The RSSB have developed a web-based Safety Culture assessment tool [11] for Train Operators which can be used to explore workforce attitudes and behaviours and safety leadership and commitment. The toolkit can be assessed by logging on to http://rssb.info-exchange.com/
Given that a driver is in isolation for the greater part of the time, this will allow them to dwell on issues, compounding the problem.

The usual effect of stress will be to increase the arousal level or general activation of an individual. The level of arousal will influence the scanning pattern and hence the perception of information by an individual. For instance, a driver during a quiet period of the route, when his arousal level may be low, will not scan the instruments as frequently as he will during the approach to a station when his arousal level will be at a significantly higher level. Under conditions of high stress and arousal, the sampling rate may be increased, but the pattern of sampling will be reduced to a narrower range of stimuli as a consequence of attention being restricted to the primary task (eg ‘narrowing of attention’). This can lead to the undesirable situation of important information required in an emergency being missed by an operator because his stress response to the situation caused his attention to be restricted to the primary source of the problem.

Various physiological, psychological and behavioural symptoms of stress have been identified. These include: headaches, proneness to colds, changes to eating/sleeping/ smoking/drinking habits, and some deterioration in the quality of people’s performance and work relationships. Signs of stress can include changes in behaviour from the norm (see Appendix C). For example, an individual who is normally talkative and outward going may become withdrawn and quiet. In the longer term, continued stress can have quite severe effects on the cardiovascular, respiratory, gastrointestinal and immune systems as well as being related to depression, absenteeism and burnout.

Unfortunately, the existence of stress is rarely noticed prior to performance problems, which, in safety critical industries, is sometimes too late. Many people regard personal stressors/domestic circumstances as very private and tend to be reluctant to discuss such problems at work, especially

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Good practice examples – reducing stress

Practical interventions that might reduce experiences of stress include:

a) Elements of job redesign to provide a physically more comfortable environment, more work control, less pressured demands etc
b) Increasing of resources (especially skill training, time management, etc)
c) Stress management courses that include relaxation techniques and attitude change programmes to help people reframe problems as challenges.

However, whilst attention to physical factors can help reduce sources of stress in the workplace, the organisation has little control over personal/domestic circumstances. Often, the best that can be offered in situations where the main sources of stress comes from outside the workplace is access to Occupational Health and/or a counselling/information service and, where possible, some flexibility.

Individuals may find some of the following suggestions useful for reducing stress levels:

a) Carry out deep breathing exercises and relaxation exercises provided at least once a day and more if feeling stressed
b) Keep a stress diary, either simply for personal review, or if the driver feels comfortable with discussion of its content; it may be of benefit to review the diary regularly with their manager
c) Rate their stress level am and pm and make a note in their diary
d) If they are feeling stressed make a note in their diary of what is causing the stress
e) Look at trends
f) Avoid those things that make him/her stressed
g) Discuss any issues with family, trusted close friends or trusted colleagues
h) Take regular exercise.

Various physiological, psychological and behavioural symptoms of stress have been identified. These include: headaches, proneness to colds, changes to eating/sleeping/ smoking/drinking habits, and some deterioration in the quality of people’s performance and work relationships. Signs of stress can include changes in behaviour from the norm (see Appendix C). For example, an individual who is normally talkative and outward going may become withdrawn and quiet. In the longer term, continued stress can have quite severe effects on the cardiovascular, respiratory, gastrointestinal and immune systems as well as being related to depression, absenteeism and burnout.

Unfortunately, the existence of stress is rarely noticed prior to performance problems, which, in safety critical industries, is sometimes too late. Many people regard personal stressors/domestic circumstances as very private and tend to be reluctant to discuss such problems at work, especially
with line managers. In addition to the sensitive nature of some personal problems, people often feel unwilling to be seen as unable to cope, which further decreases the likelihood of reporting personal problems.

Some organisations operate monitoring systems and many offer internal or external employee assistance programmes that are available, confidentially, to employees. However, for various reasons, the utilisation of such programmes is not always very high. It is therefore important to promote an organisational culture in which individuals feel able to discuss personal issues in a confidential and supportive environment.

4.8 Traumatic events
Inevitably, the nature of the work means that a driver may be involved in, or witness a fatality or other safety of the line incident. There are huge variances between how well an individual will cope with trauma and in how this response might be exhibited. It is important to remember that not everyone who experiences a particular traumatic event is traumatised and the perception of what is traumatic will depend on the individual. For some, a traumatic event may result in:

- a) Lack of confidence
- b) Stress
- c) Anxiety
- d) Depression
- e) Aggression
- f) Apprehensiveness
- g) Withdrawal
- h) A change in character
- i) Problems concentrating.

Good practice example – managing trauma
A study carried out by the RSSB ‘Minimising the impact of suicides on railway staff’ [12] uses case studies to explore the issues and different approaches to trauma management. Good practice examples and recommendations are also offered.

Some individuals also experience flash backs to the incident, problems sleeping and distressing dreams. Others will react in the opposite way and avoid talking about the problem or issues that are causing them concern. They may also avoid situations that remind them of the incident. This avoidance is usually a coping strategy but needs to be managed carefully, as in the longer term it can be detrimental to the individual, by not allowing them to recover properly, and ultimately the ability to drive safely.

Good practice example – driver confidence
A driver’s confidence in their own ability to deal with situations, particularly unexpected ones, is prompted by having a sound knowledge base on which to draw any positive experiences. Some drivers may need more time to get to grips with, or be more focused on, aspects of basic training such as rules, regulations and route learning. Some of the good practice examples suggested in this guide (eg to facilitate learning, retention and manage decision making) will involve management as well as driver action.

4.9 Individual factors
There are many differences between people that have the potential to affect performance, which means that some individuals will be more or less susceptible to error than others:

- a) Concentration ability - Research undertaken in the late 1990’s indicates that the ability to concentrate varies greatly between drivers, affecting their ability to divide their attention
between tasks. For drivers, the ability to concentrate, attend to information and remain vigilant is critical for safe performance, particularly in familiar surroundings where well-practiced sequences of actions minimise the need for effortful attention. As seen in Part 3, however, we know that this ability can be further compounded by the inherent limitations of human information processing.

b) **Personality of the driver** - Research has shown that extroverted, more emotionally unstable people are more accident-prone. For example, a major study of the five key personality dimensions [13] (extraversion, neuroticism, conscientiousness, agreeableness and openness) revealed that:

- Individuals low in agreeableness and low in conscientiousness are more liable to be involved in an accident
- In occupational settings, neuroticism and low agreeableness were generalisable and valid predictors of accident risk, and
- Extraversion, low conscientiousness and low agreeableness were generalisable and valid predictors of (non-occupational) traffic accidents.

A comprehensive review of 40 studies and associated literature also found a relationship between risky driving and another personality dimensions referred to as sensation seeking [14].

With specific reference to train drivers, research indicates that those drivers who rate themselves on a personality questionnaire as more extroverted, outgoing, socially confident and spontaneous are more likely to be rated ‘at risk’ or ‘specially monitored’.

For these reasons, it is important to ensure the right people are selected for the job. One way of achieving this is through the use of psychometric tests which provide a consistent, systematic and objective way of collecting assessment information that allows comparisons to be made.

Psychometric testing is just one way, amongst a number of assessment methods which, in combination, can help to make sensible decisions about who is, or who is not, suitable for a certain role.

There are two main types of tests:

- The first looks at how well a person can perform a task (eg particular skills and typical performance), such as knowledge or verbal reasoning tests;
- The second assesses how a person will typically go about performing a task (eg motivation and interests), such as personality tests.

All good tests will be backed up by thorough research. This means that every test must be supported with information that gives someone using it the confidence that the test is measuring what it claims to measure (ie that they are valid and reliable predictors of performance).

**Use of psychometric tests in train driver management**

There is no requirement to use tests in driver management, but a number of companies are doing so. Tests can be used to provide an insight into how drivers are performing or might perform. This has a number of benefits for both the driver and the company. For example, if you have a concern that a driver’s performance no longer meets the required standard you could use a test to help you check if this is the case. This could also benefit drivers by providing early warning about whether they need help before their performance becomes a problem. Also, a test maybe able to suggest ways to help drivers overcome problems they are experiencing.

The purpose of testing in driver management is to give you:

a) A good understanding of the reasons why a train driver acted in a particular way
b) Confidence that train drivers are able to do their job properly
c) Ideas for how to help drivers perform better.
Before using tests for these purposes

Using tests in these circumstances raises some sensitive issues. People who have not fully appreciated what they can and cannot do have misused tests in the past. So, the first thing to remember is that only competent individuals can:

a) Decide which tests to use
b) Administer the chosen tests
c) Check their reliability and validity
d) Interpret the test results.

Another thing to keep in mind is that psychometric testing must be used in combination with other methods of assessment. Like selection, decisions cannot be based just on the results of tests. Instead tests should be used to assess certain aspects of a train driver’s behaviour and used along with information from other assessment methods to give a more complete picture of a train driver’s performance.

Situations in which testing could be used

There are four situations where testing, including comparing results with previous outcomes, may be able to give you useful information to help with driver management issues. These are:

a) Training and development, including progression and promotion
b) Post trauma counselling
c) Pre-incident counselling
d) Post incident investigation.

The table below summarises how you can use tests to help you make decisions regarding progression and promotion.

<table>
<thead>
<tr>
<th>When you may want to use a test</th>
<th>Why you may want to test</th>
<th>How you might use tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Following initial recruitment.</td>
<td>To help guide initial driver training.</td>
<td>• Immediately after recruitment you can use selection test results to help identify areas where the recruit may need greater help or attention during driver training.</td>
</tr>
<tr>
<td>When you have to make progression, promotion and development decisions.</td>
<td>To find out the suitability of your drivers for future roles.</td>
<td>• First, you need to identify future job demands which differ from current demands. • Then, you should identify tests which match those future demands. • Remember not to use the same tests used in recruitment since these may not be relevant and the applicants have already passed them.</td>
</tr>
</tbody>
</table>

Table 1 Using psychometric tests to make decisions on progression and promotion

The table on the next page describes how you can use tests to help you manage an incident, both to help investigate the causes and to help identify driver welfare issues.
### What other assessment methods support testing?

<table>
<thead>
<tr>
<th>When you may want to use a test</th>
<th>Why you may want to test</th>
<th>How you might use tests</th>
</tr>
</thead>
</table>
| **Following an incident.**      | To help establish explanations of behaviours. | - Psychometric tests should not be first port of call.  
- Observation, interviews and assessment on simulators should be used first to establish likely causes of driver’s actions.  
- Where these possible explanations can be investigated using tests, identify suitable tests to understand better why a driver behaved in a particular way.  
- The purpose of testing will be to support or challenge the possible explanations identified earlier in the process.  
- These tests will often not be the ones used for recruitment since they do not cover all the abilities required. For example, you may want to test for a suspected memory problem using a specific test.  
- Remember that re-testing post incident is itself a stressful event which may result in a driver performing less well than they would in normal circumstances. |
| **If you have reasons to believe a driver's performance may be introducing risk.** | To find out if they are unlikely to be able to continue doing their job properly. | - If you suspect that a driver’s performance has deteriorated but you are unsure why.  
- You will need to assess them to find out if this is really the case.  
- Consider using the following sequence of assessment methods to help you do this:  
  - Interview the driver.  
  - Observation.  
  - Simulation.  
- Re-test, using the selection tests – you can compare these results with the original ones to see what, if any, changes there are in performance.  
- Based on these outcomes you may wish to use other psychometric tests to look at particular areas of concern, such as described above. |
| **Following an event which may affect a driver's health and welfare.** | To establish if a driver’s mental well being has been affected. | - You may want to find out how an event has affected a driver. This has two purposes.  
  - Do they need extra support to handle the effects of the event?  
  - Do you need to change their duties because their performance has been affected?  
- Remember that traumatic events can occur outside work.  
- The tests used for recruitment would be relevant here since trauma can result in measurable reductions in test performance.  
- However, other tests might also be useful for assessing changes in a driver’s personality (eg levels of anxiety) or behaviour.  
- Some of these might include specialist assessments of how the human body reacts to stress and pressure (eg a higher pulse rate can indicate increased levels of stress).  
- This requires the use of qualified, competent assessors.  
- Again, tests may not be first port of call – other methods of assessments may be better for identifying probable explanations and causes for sub-standard performance. |
Psychometric testing should never be used as the only way to help you make driver management decisions, and nor should it be the first thing you do. Observation, interviews and assessment on simulators should always be used first to help establish probable explanations of behaviours and actions. These methods are often better at taking all the performance factors into account, and appear to the driver to be more realistic and relevant and are therefore less threatening and more acceptable to them.

Only once this has been done, and preliminary conclusions reached on probable explanations for behaviours, should you think about using suitable psychometric tests to help support, or challenge, your findings.

When using other methods of assessment always remember to:

a) Explain to the driver carefully the reasons why you are using these methods, what it entails and what will be done with the information collected.

b) The people who use the results need to be trained to understand and apply what the results of the assessments can tell you.

c) It is vital to share assessment results and follow up actions with drivers.

d) The results should only be available to those individuals competent to interpret them properly.

e) To help make sure that assessment information is not misused, people who are not qualified assessment users should never see the unprocessed assessment scores.

Good practice example – driver selection

Further information is available from the RSSB Human Factors team on selection criteria and definitions used by industry as part of the driver selection and recruitment process to assess the cognitive abilities and personality attributes relevant to the role of driver.
5. Understanding the difference between human error and violations

5.1 Error classification

In terms of finding out more about why errors occur, it is useful to understand how they can be defined and classified. This helps us to understand why incidents occur and what we can do to manage and mitigate the risks from human error [4].

Human errors are defined as *unintended actions or outcomes* and are a fundamental part of everyday life. They differ from true accidents by being due to individual behaviour without the influence of an unforeseeable event. Errors result in performance detriment as indicated by failure to achieve intended performance goals.

Error is very wide ranging and there are a number of approaches to categorising different human errors. These include whether the error was the result of problems with:

a) Task planning (eg failure to reach a destination on time due to not checking the route beforehand)

b) Task execution (eg making a right hand turn instead of a left hand turn when the correct turn was known)

c) Through ‘omission’ of an important part of the task (eg failing to depress the clutch before trying to change gear), or

d) Through ‘commission’ or failing to perform an act correctly, perhaps by inserting extra steps in the process or wrongly carrying out a step (eg pressing on the brake pedal at the same time as the accelerator when intending to drive off).

Errors of omission and commission are often relevant to maintenance tasks.

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Human error should be regarded as a consequence rather than the cause and part of the Human Factor specialist’s job is to investigate the causes underlying the errors people make.

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The most common categorisation within a human factors framework is the Generic Error Modelling System (GEMS) (see Figure 16). This is based on the belief that different errors occur depending on three types of performance. The three types of performance are:

a) **Skill-based performance** where we routinely perform highly practised activities with little conscious effort (eg driving a car or train, setting a route on an NX panel)

b) **Rule based performance** where we have more mental involvement and apply previously learned rules to tasks we have usually been trained for (eg planning a route in a signal box before setting it, talking a driver past a signal at danger, applying protection arrangements)

c) **Knowledge based performance** where we have even more mental involvement, often involving a new and unfamiliar situation and where the person has little or no previous experience to draw upon (eg dealing with a major signalling failure).
Figure 16 Classification of human errors and violations

The model also includes a separate category for violations. This is due to the fact that, unlike errors, which are unintentional, sometimes people break a rule deliberately. This means that rule-breaking is not really an error, but a violation.

Overwhelmingly, people do not break rules maliciously, but for entirely rational reasons. In general, violations result from the conflict between an organisation that is attempting to control the behaviour of the workforce, and the individual who is attempting to carry out their task as easily as possible.

The UK railway industry classifies violations into five main categories (see section 5.5 for more detail):

- a) Routine violations
- b) Situational violations
- c) Exceptional violations
- d) Personally optimising violations
- e) Sabotage.

5.2 Errors in skilled-based performance

Skill-based errors are commonly associated with routine tasks that have become almost automatic but can suffer from inattention. They tend to occur when a task is so familiar that the operator does not have to concentrate on what they are doing so allows concentration to slip and a performance error results (eg when using spell checker the programme may suggest a change to an inappropriate word but, if the operator is not concentrating they may automatically click on ‘change all’ resulting in document errors).

Slips and lapses are errors that tend to occur in skill based performance. The nature of skill based performance means that because we are so practised and experienced at a task we can carry it out automatically. This means, however, that we are vulnerable to errors if our attention is diverted even momentarily resulting in either the wrong action being performed or omitting to carry out a step in the process.
There are several types of slips and lapse type error:

**Slips** tend to occur at the initiation or execution stage of an action, for example, where a person had the correct intention to perform a particular activity but then does the wrong thing (i.e., switching the wrong switch). These can either be:

a) *Familiarity slips* where something we frequently do ‘takes-over’ a similar but less familiar action. For example, we might dial a frequently used telephone number when intending to dial a similar one.

b) *Similarity slips* where the intended action is similar to other actions we do a lot, so that we perform the right action on the wrong object. For example, a signaler might normalise the wrong points switch on a panel because it is close to other switches that look the same.

c) *Association slips* where the brain makes a faulty connection between two ideas, often when one is an external stimulus that typically provokes a certain action. An example is a driver reacting to one alarm as if another was going off.

**Lapses** are where a person again had the correct intention to perform a particular activity but then forget to carry it out or even forget what they had intended to do. An example is forgetting why we entered a particular room. Another is the driver who forgets to use their AWS ‘sunflower’ display to remind them that they have overridden a warning to slow down. Yet another is the signaler who is distracted during arrangements for a possession and fails to use a reminder appliance as required.

<table>
<thead>
<tr>
<th>Good practice example – slips and lapses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slip and lapse type errors are best mitigated by such things as:</td>
</tr>
<tr>
<td>a) Reminders and alarms to remind the person to perform a particular action at the right time</td>
</tr>
<tr>
<td>b) Fatigue friendly work patterns so that the person’s attention is not reduced by fatigue</td>
</tr>
<tr>
<td>c) Workplace design so, for example, switches are not designed or positioned in such a way that the wrong one can be easily and inadvertently operated.</td>
</tr>
</tbody>
</table>

5.3 **Errors in rule-based performance**

These are mistakes we make in applying known rules. Mistakes are made where a person does the wrong thing believing it to be right. They are associated with situations in which we have to apply some conscious effort to decide upon a course of action. For example:

a) *Misapplying a good rule* – that is, applying the rule in a situation where it is not appropriate. This is often a rule that is frequently used and seems to fit the situation well enough

b) *Applying a bad rule* – so that in certain situations the job gets done, but with unwanted consequences

c) *Failing to apply a good rule* – that is, ignoring a rule that is applicable and valid in a certain situation.
5.4 Errors in knowledge-based performance

Knowledge-based performance is especially prone to mistakes. They arise from a lack of knowledge, uncertainty, lack of concentration, or a misapplication of knowledge, particularly in novel situations. Examples include:

a) Availability bias – choosing a course of action because it is the one that comes most readily to mind

b) Confirmation bias – fixation on a particular course of action

c) Overconfidence bias – actively pursuing supporting evidence or ignoring contradictory evidence.

Each of these biases can lead us into making faulty conclusions about a situation, and so drawing up and executing a faulty plan to accomplish the task.

Good practice example – preventing mistakes

Lack of knowledge and skills can lead to rule and knowledge based mistakes. In order to establish whether it was an influencing factor, consider when the last training or assessment took place. Training effectiveness is influenced by how well the training needs were identified in the first place (to ensure trainees are provided with the relevant skills and knowledge) and how well it is delivered (taking account of different learning styles and training media available). Consideration could be given to:

a) Whether initial training was provided and whether it was adequate and/or relevant to the situation that led to the incident

b) Whether the last assessment was simply a test of the individual’s knowledge or their ability to do the task

c) How often the skill has been practiced since training

d) Whether the specific task/location/equipment was involved in the incident covered in the training or was it a new situation for the individual

e) The quality of training delivery.

Both rule and knowledge based mistakes are associated with situations in which the operator has to apply some conscious effort to decide on a course of action. Rule-based contexts involve set procedures, often with clear guidelines of what to do in given situations. Rule-based mistakes arise due to correct application of a bad rule or misapplication/non-application of a good rule (deliberate misapplication or non-application of a good rule is a violation rather than an error). A classic example of a rule-based error relates to driving. A good rule, under most circumstances, is that of turning the steering wheel in the direction you want to go. However, in icy, skidding conditions, the wheel has to be turned in the opposite direction to correct for environmental influences.

Knowledge-based contexts involve the need to use stored knowledge of the context situation in novel ways to find a solution to a given problem. Knowledge-based mistakes often occur in unfamiliar, unexpected circumstances when the conditions for good decision making are, typically, flawed. It could be argued that the steering wheel example given above would represent a knowledge-based error for many people, who do not have any ‘if x, then y’ rules to follow for skidding situations.

Appendix D provides examples of different types of error.
Good practice examples – how can you reduce error?

Error management should be tailored to suit specific contexts in particular organisations. The challenge for organisations is to create environments in which people can make their mistakes without dire consequences. This means using the most cost-effective combination of the following approaches to error management:

a) **Training** – ensure people are rehearsed in their skills and knowledge so that they are less likely to make mistakes and are better able to recover from them. Training programmes/refresher courses should increase awareness of human factors that have the potential to increase the risk of error in different situations (eg distraction, habituation, workload, stress, fatigue, automatic responding, etc). More training on skills, rules and knowledge is of little benefit to those who commit deliberate violations. Violations are better dealt with by showing people the consequences of their actions.

b) **Design** – ensure equipment, including alarms and alerts, are intuitive to operators (eg matches their mental model). It should be designed such that people cannot make certain sorts of mistakes, or enable users to review decisions before enacting them (eg a dialogue box that asks ‘are you sure you want to delete selected file?’). Equipment layout (eg in cab) should also support the user (eg within easy reach of normal seated position).

c) **Staffing** – ensure the right people are selected for the right jobs. This will ensure that people are recruited who can be trained in the skills and responsibilities to the level that will be required of them.

d) **Organisational culture** – this is developed by an organisation through its visible leadership, management and teamwork so that people work in a supportive, blame-free environment. This should include mechanisms for staff to discuss/raise issues/ concerns in a confidential manner. This encourages a responsible approach to managing the detection and correction of mistakes, reducing their consequences and preventing their re-occurrence.

e) **Conditions** – increasing awareness of the need to identify and mitigate the risks of gaps in organisational ‘defences’ (see section 2.2) and the error consequences of human factors such as stress, fatigue, workload, motivation and morale etc.
Good practice example – over-confidence

Over-confidence in drivers has been identified as a significant risk factor, particularly during first two years in any safety critical job (Halcrow workshop, 2006) due to the thin dividing line between boredom/complacency and over confidence.

It is important for management to understand and recognise over confidence and other precursor behaviours. Key signs of over-confidence include:

a) Changes in behaviour (eg rule non-compliance, turning up late), attitude or appearance
b) Risk taking
c) Inability to accept constructive criticism.

 Causes include:

a) Boredom (eg due to familiarity with task; over-skilled for job)
b) Repetitive nature of safety systems (eg AWS cancellations)
c) Peer pressure
d) Making assumptions based on poor information/anecdotes/developing bad habits
e) Personality type.

What can be done to reduce the risk of error from over-confidence? The suggestions below are starting points for possible avenues for discussion rather than definitive solutions.

a) Introduce variety in tasks to combat boredom
b) Discuss defensive driving techniques and link to human factors that can impair performance
c) Control distraction risk – highlight strategies to keep drivers vigilant, eg risk triggered commentary driving can help promote the hazards and methods of dealing with the risks (see Part 6)
d) Highlight techniques to improve driver’s short term memory
e) Reduce the risk during irregular working
f) Get drivers to recognise they have not seen/experienced everything before (eg altered methods of working, seasonal changes)
g) Consider the traits of the over-confident person such that they can be better detected at the selection stage
h) use downloads from train data recorders to highlight good driver behaviours and behavioural traits
i) Use the Specially Monitored Driver process to determine and address the over-confident person
j) Review training processes to identify behavioural patterns that signify over-confidence;
k) More emphasis during training in getting individuals to understand and take responsibility for avoiding over-confidence and complacency
l) Simulation training and table top exercises to test abnormal degraded working conditions
m) Gathering of more detailed information for analysis to enable value judgements to be made, eg wrong routing and driver performance monitoring
n) Continue to build on industry good practice.
5.5 Violations

An important aspect of performance errors in the Human Factors context is that a clear distinction is made between ‘errors’ and ‘violations’. Errors involve performance detriments (e.g., intended goals have not been achieved), but result from *unintentionally inappropriate* actions for a given situation. Violations represent deliberate deviations from rules, procedures, instructions or regulations which exist for safe and efficient operation and equipment maintenance. The key point is that to be a violation, the act must be *deliberate*, such as where a person knowingly takes shortcuts, circumvents or just doesn’t apply safety rules.

Violations do not always result in performance error, but they do serve as signals that all is not well and merit further investigation. Violations may occur for a range of reasons. For example, poorly designed systems/procedures; time pressures; conflicting objectives; acceptance of rule breaking; poor safety culture; personal reasons, etc.

While violations are deliberate rather than unintentional deviations from safe practice, most violations are motivated by a desire to carry on with the job and/or complete a task in less time. Very rarely are they wilful acts of sabotage or vandalism.

The distinction between an error and a violation is often difficult to establish. Careful consideration should be given to the available task information and expert opinion from Subject Matter Experts (SMEs), such as train drivers and operations specialists, when deciding if a task could be subject to a violation (see Figure 17 for an example of how one railway undertaking assesses culpability).

![Culpability Model Flow Chart](image)

**Figure 17** Example culpability model flow chart
Violations are divided into five categories:

a) **Routine** – this is when breaking the rule or not following the procedure has become the normal way of working. This can be due to a belief that the rule/procedure is too restrictive, that it no longer applies or because it simply hasn’t been enforced.

b) **Situational** - this is when breaking the rule is due to pressures from the job such as being under time pressure, insufficient staff for the workload, the right equipment not being available or even extreme weather conditions.

c) **Exceptional** – sometimes also known as ‘optimising violations’. These involve violating for the thrill of it. Speeding in your car for the joy of speed or to indulge aggressive instincts is an example of an exceptional violation.

d) **Personally optimising** – this is when an individual decides to violate in order to benefit personally from a work situation, when it is considered ‘worth it’ or in an individual’s best interests. An example would be when an individual wants to finish ahead of time and do more rewarding work, or to be able to go home earlier.

e) **Sabotage** – very rare. Sabotage violations will usually occur as a consequence of conflict (real or perceived) between the individual or group and an organisation.

It is essential that railway undertakings reinforce that there is little tolerance for deliberate violations. This is due to the fact that violations weaken safety defences, to the point where there is less chance of trapping significant events that could culminate in an accident/incident. Figure 17 illustrates one railway undertaking’s approach to evaluating culpability.

### Good practice example – preventing violations

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

- Work resources (planning, equipment, time, and people)
- Supervision
- Management
- Selection, to ensure that the appropriate individuals are being chosen for job.

Procedures and rules (including job aids) are designed to create safe systems and methods of work and guide people’s behaviour. However, poor procedures can be a reason why people do not follow the recommended actions. We are less likely to follow a procedure if it is difficult to understand, does not reflect actual practice, is too onerous in terms of time and effort, is incomplete, inaccurate, contains too many cross references or is simply confusing.

Consider:

a) Was the procedure difficult of awkward to comply with?
b) Was the need for the rule/procedure understood and accepted?
c) Was there a conflict between the rule violated and another rule?
d) Was this rule violation common?
e) Had individuals received the appropriate training/briefing/instruction in the rule/procedure?
f) Were individual’s being appropriately supervised? (Individuals are more likely to comply with a process if they are being monitored and supervised).
5.6 Cognitive classification of human error and violation

The flow chart in Figure 18 provides an alternative means of proactively classifying the potential for error and violations according to different cognitive domains (e.g., perception, memory, decision-making, action). This can also be used reactively to explore the underlying cause of an incident or accident.

Table 3 provides a high level summary of the different cognitive failures that could lead to error and an explanation of the underlying psychological causes. The classifications and examples provided are derived from a re-analysis of Formal Inquiry reports carried out by the RSSB Human Factors team.
Figure 18   Flow chart to identify source of driver error/violation
Table 3  Summary of cognitive error failures, violations and psychological causes

<table>
<thead>
<tr>
<th>Domain</th>
<th>Error mode</th>
<th>Psychological cause</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Violation</td>
<td>Routine</td>
<td>Could the driver behave in opposition to the rule, procedure or instruction, but in a way that has become a normal or automatic way of behaving within the person’s peer or work group?</td>
<td>Overriding of TPWS which is normal for the group.</td>
</tr>
<tr>
<td></td>
<td>Situational</td>
<td>Could the driver violate as a result of factors dictated by the employees’ immediate workspace or environment?</td>
<td>Violation due to factors such as weather and time pressure.</td>
</tr>
<tr>
<td></td>
<td>Exceptional</td>
<td>Could the driver commit a rare violation that would occur only in exceptional circumstances?</td>
<td>Violation of rules/procedures due to an emergency situation where the driver deems such violation necessary.</td>
</tr>
<tr>
<td></td>
<td>Optimising</td>
<td>Could the driver violate due to a motive to optimise a work situation?</td>
<td>A bored driver violates procedures on stopping the train by experimenting with the braking system of the locomotive in order to test its limits.</td>
</tr>
<tr>
<td>2. Perception</td>
<td>Mis-hear/</td>
<td>Expectation</td>
<td>Driver mis-sees a red aspect as he expects to see a green aspect.</td>
</tr>
<tr>
<td></td>
<td>Mis-see/</td>
<td></td>
<td>Confusion</td>
</tr>
<tr>
<td></td>
<td>No detection</td>
<td></td>
<td>Discrimination failure</td>
</tr>
<tr>
<td></td>
<td>(auditory)/</td>
<td></td>
<td>Tunnel vision</td>
</tr>
<tr>
<td></td>
<td>No detection</td>
<td></td>
<td>Overload</td>
</tr>
<tr>
<td></td>
<td>(visual)</td>
<td></td>
<td>Vigilance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Distraction/preoccupation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SLIP</td>
</tr>
<tr>
<td>3. Memory</td>
<td>Forget action/Forget information/Misrecall information/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Confusion</td>
<td>Driver confuses train numbers and driver numbers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overload</td>
<td>Driver cannot remember all of the instructions he received from a signaller.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Insufficient learning</td>
<td>A previously learned procedure interferes with the recall of a new procedure.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distraction/preoccupation</td>
<td>Driver is distracted by a member of the train staff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LAPSE</td>
<td>Other memory lapses not covered by the above.</td>
<td></td>
</tr>
<tr>
<td>4. Decision</td>
<td>Misprojection (eg could the driver misproject or misjudge spatial-temporal information such as braking times/distances?)/Poor decision or strategy/Late decision or strategy/No decision or strategy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misinterpretation</td>
<td>Driver failed to understand information for a signaller on how to proceed at a faulty signal.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Failure to consider side or long-term effects</td>
<td>Driver failed to consider the long-term effects of not reporting a partially obscured temporary speed board.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mind set</td>
<td>Driver believed a signal did not apply to him.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge problem</td>
<td>Driver had not received sufficient training to correctly use the IVRS radio system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decision overload</td>
<td>Driver fails to make a decision due to work overload.</td>
<td></td>
</tr>
<tr>
<td>5. Action</td>
<td>Selection error/Unclear information/Incorrect information/Non-performed action</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variability</td>
<td>A driver's communications are unclear and his intonation does not indicate the seriousness of the situation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Confusion</td>
<td>Driver selects the switch to open the track-side rather than platform-side doors.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intrusion</td>
<td>Driver performs two tasks, and a step from one task intrudes into another.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distraction/preoccupation</td>
<td>Driver is distracted by track-side events.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other slip</td>
<td>Other action slips not covered by the above.</td>
<td></td>
</tr>
</tbody>
</table>
6. Risk mitigation techniques

Professional driving involves a combination of personal attitudes, behaviours and train driving techniques which minimises the risk of driver error and enables the driver to mitigate the effects of system and equipment failures and the errors of others. It includes defensive driving and the control of risks caused by behaviour and other factors arising within and outside the work environment. Professional driving involves meeting, and often exceeding, minimum competence requirements and seeking opportunities for further improvement in safety performance.

This section considers two key approaches that can be used to mitigate the risk of driver error.

6.1 Situational awareness

A number of SPAD investigations by railway undertakings have reported that drivers are ‘losing concentration’ and are not attending to information, and that this is believed to have led to a number of SPAD incidents. In addition, problems have been reported to increase station overruns and station ‘fail-to-calls’.

Developing ways to improve driver attention and awareness is therefore an important element of tackling this type of problem. Understanding how drivers see, comprehend and predict what is happening around them is core to helping ensure that drivers are able to decide on the best course of action.

The concept of situation awareness has therefore been used by an RSSB research project to understand how drivers acquire route knowledge and identify what information is used whilst driving. Aircraft pilots and Formula 1 drivers, where excellent reliability and control are essential, are trained and practiced in improving their situation awareness to improve performance. Therefore understanding how we acquire and use information from signalling, cab warnings, and other sources is the first step to help tackle problems where drivers lose attention.

Evidence indicates that those who have a high level of awareness of what is going on around them can better anticipate what will happen and what risks will emerge. Being able to anticipate what is about to happen improves risk perception and is a key part of professional driving and feeling in control. Having a high level of situation awareness can be trained and can turn a good driver into an excellent driver.

Anticipating what is about to happen and making decisions requires considerable effort. It is not enough to use our expectations about what might happen; we need to look harder, question what we are seeing, consider all reasons for what is happening and combine our observations to decide what to do. These elements are covered in the three levels of situation awareness (see figure 21).

![Figure 19  3 level model of situation awareness](Uncontrolled When Printed)
Level 1 – perception
Perception is when we look, see and even ‘feel’ things around us. We have all disagreed with someone over ‘what happened’. In sport one may genuinely believe that ‘the ball was over the line’, though the opponent may not. Having good quality unambiguous information is key to having good situation awareness. Making the most of this information is crucial – knowing where to look for a signal increases the time we have to correctly see its aspect. However, there is a trap here; 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 key, but questioning what we see is critical. Simply making assumptions about something that is happening can be dangerous.

Actively looking for signals and other cues helps, waiting to ‘see’ them can mean that we see them too late. Looking is an active process and requires a target; sometimes we know this target exists (a signal), at other times we don’t (eg trackworkers or vandals). Actively searching for targets is the basis for a good strategy. A wide indiscriminate ‘focus’ means that only part of the available information will be used.

The challenge is to think about how to improve on search strategies, for example:

a) What to look for (see below on what makes a good visual cue)
b) How to keep searching on a plain track
c) Where to look
d) Tracking across the scene in steps, noting emerging features (bridges, signals, trains, etc).

Work that RSSB commissioned on visual strategies identified that drivers use a variety of different approaches (see Figure 22).

Figure 20 Driver’s visual search strategies

Below are some quotations taken from drivers’ actual comments:

- **Visual strategies - Looking for anything out of the ordinary**
  ‘Looking for anything untoward really’
  ‘Anything that moves or shouldn’t be there’

- **Non-visual strategies - Using sound to identify location on the route**
  ‘Use sound of track’
‘Over bridges, can’t miss them and get swooshing noise when you go through them’. This research highlighted that:

a) Drivers look at gantry signals earlier and for longer than other types of signals  
b) Drivers glance more frequently at gantries with four or more signals  
c) Drivers look at the signal more often and for longer in the urban environment  
d) Drivers look at signals more often and for longer at low speeds compared to high speeds, independent of the type of signal  
e) Drivers combine visual and auditory information to maintain situation awareness  
f) Drivers look at the landscape longer when approaching a green aspect  
g) Drivers spend longer looking at single yellow signals than double yellow or green.

Scanning the cab and track environment helps keep a driver ‘in-the-loop’, especially during long plain stretches where it is easier for our thoughts to wander. As discussed in Part 4, when workload is low we tend to cut down on the amount of effort we put into scanning for new information, which can reduce our ability to detect changes. When something does change and we are not actively interrogating the visual field, the change can take longer to recognise and lead to us to thinking ‘where did that come from?’.

Being prepared for the unexpected is important and when something that could not be anticipated does happen, eg seeing trackworkers, it is important to continually monitor what can be seen in peripheral vision. This often occurs automatically, though it can be practiced and learnt. Keeping tabs on the most important information (eg a single yellow) whilst searching and selecting new targets is a skill worth perfecting.

<table>
<thead>
<tr>
<th>Good practice example – situation awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation awareness can be tested by asking:</td>
</tr>
</tbody>
</table>
| a) Can you re-run in your mind a journey that you have recently made?  
| b) How detailed is it?  
| c) Are there any key gaps?  
| d) How often do you forget a previous signal aspect? |

According to RSSB research, all surveyed drivers reported that they ‘occasionally’ forget a previous signal’s aspect.

**Level 2 - think**

This level involves understanding the significance of what is being seen and heard. It involves combining the various things that we perceive and know into an understanding of what is going on. An Automatic Warning System (AWS) horn could be assumed to mean ‘caution’ or ‘more restrictive speed’, however evidence indicates that drivers acknowledge the warning without understanding its exact meaning. In this example a driver may:

a) Know from his/her memory of a route that the AWS horn is for a speed restriction  
b) Look at the signal to see the aspect.

We are trying to ‘weigh up’ what we are seeing actually means. Often this is done without realising, though when doubt creeps in, drivers become more aware that they are trying to work out what is going on.

One of the traps that drivers fall into is to decide what something means too early, or choose to ignore something that is contradictory to avoid uncertainty. Dealing with contradictory information means working in uncertain situations which can lead to anxiety and tension. It is all too tempting to come to a conclusion and disregard information as ‘wrong or false’. There is a danger of interpreting what we
see in keeping with what we want to see – we make assumptions to help get us out of tricky situations. Handling warnings and updates that we do not believe are true, is a trap.

To give an example, a brake intervention that is not understood leads the driver into the role of diagnosis – answering the question ‘what’s happened’. If the intervention was from TPWS following a SPAD, the driver has to recognise, from up to 18 other possibilities, a key visual warning that TPWS has intervened. More often than not, a driver does not believe that they have passed a signal at danger and so they are not actively looking for the indication. If they do see that TPWS has intervened, they may distrust the indication – ‘I have not had a SPAD’. In this situation a driver is ‘out-of-the-loop,’ something’s happened and he/she cannot work out what. To bring the situation under control, he/she may switch off the desk ‘to clear the system’ and continue forwards to the conflict point.

The lesson to be learnt is that dismissing information is risky, as is making assumptions about what is going on. As uncomfortable as it is, we need to stay in the state of flux and doubt until we can understand exactly what has happened. In the case of the TPWS example this should involve contacting the signaller.

We therefore need to constantly check what we are doing, for the more information we consider, the better our ability to correctly anticipate what is going to happen.

If we are not looking for the warning, we could acknowledge the AWS without even being aware that we have done so which can easily lead to a SPAD.

In working out what something means we lay the foundation for anticipating what will happen next, level 3.

**Level 3 - anticipate**

At level 3 we start by already seeing and correctly understanding the situation around us. Anticipating what is going to happen is the highest level of situation awareness. There may be many things that we can see and understand. Being able to accurately predict what might or will happen enables us to make good decisions about what to actually do. Often our understanding of what is going on provides us with a number of different options. We naturally evaluate these options before coming to a decision. Different driving styles are associated with different decisions, though all could have a successful outcome.

From level 2, we learnt that making assumptions can lead us into traps. When it comes to anticipating what is about to happen, a good tip is to constantly question our beliefs. If we don't, something that we predict or anticipate will happen turns into something we expect to happen. Expecting that ‘something’ will happen leads us to assume that it will happen, we are often surprised when it doesn’t. For example, a driver nearing an ‘approach release signal’ may expect the signal to clear to green as ‘that is how they work’. The driver will then be waiting for it to clear, if it does the driver is fine, if not the train may SPAD if the driver does not realise it has not cleared. Ideally a driver will approach the signal and anticipate that it will not clear. Think the worst.

### 6.1.2 Factors that can affect situation awareness

**a) Distraction and wandering attention**

As discussed in section 4.5, distraction occurs when we divert our attention away from what we should be focussing on. This leaves us open to missing important cues from our environment. When an emergency test call is received over the radio it is a distraction to the task of driving, though a real emergency call is definitely not a distraction. Distractions are often mistaken to be relatively short-term. Children throwing stones at the train may take our attention away initially, though the impact of this can last for a long time after, and also can come into our minds sometime after the event (this links also to stress).

When workload is low, we can find our minds wandering – we feel that we have ‘spare’ capacity to think about other things. In such cases a change in our environment may appear to be sudden. In
terms of situation awareness, focussing on the journey ahead and thinking through what is coming up is preferable to thinking about the weekend.

b) Stress

Being stressed can create major problems for situation awareness as it reduces our ability to perceive, think and predict (see section 4.7). An event that happens on your journey is distracting and can be stressful – eg abuse from a passenger. You may find yourself repeating the event in your mind and thinking about different outcomes, doing this chips away at our ability to concentrate on driving. Acknowledging to oneself that ‘it happened and I am going to focus on my driving and deal with it later’ is one option, talking about the route and your driving is another. However if a driver believes he/she has become too wound up, they should stop and report to the signaller.

c) Life events

Being at work can be an escape for difficulties at home, though leaving thoughts at home can be hard. Personal issues don’t have to be outwardly stressful to affect situation awareness. It is important therefore that drivers tell their managers of any problems going on at home so that these can be managed accordingly.

d) Fatigue

Fatigue is a major problem for situation awareness (see section 4.6). Feeling tired reduces the amount of effort we can give to ensuring that we are ‘situationally aware’. As fatigue levels increases, so does the likelihood that a person will fall asleep. In addition, high levels of fatigue are likely to result in less effective performance, lapses in attention, decision-making and judgement.

It is therefore important to be aware of those times when drivers might be more at risk from the consequences of fatigue, for example:

a) When they are stressed
b) Imminent life events such as the birth of a baby
c) Two hours into shift
d) After 10 hours into a shift
e) When they have early starts
f) When they have a run of successive earlies or successive nights
g) Before drivers are about to take leave
h) When drivers return from leave
i) During the post-lunch dip
j) When suffering from accumulated sleep deficit.

Research carried out on the effects of shift work on safety and performance indicates that drivers are most at risk during the periods of time outlined above. A reduction in the amount of sleep which they have, in addition to disturbances to normal sleep patterns, can impact upon safety in a number of ways.

e) Knowledge of the route

The knowledge a driver has of knowing where they are along a route is critical to having good situation awareness. The use of visual cues helps to target what to look for. As we know, actively searching for targets is important.

Research on driver route knowledge has highlighted the following features of a good visual cue:

a) It should be easily available in all contexts (eg dark, light, fog, etc) - if not, then several cues associated with a key decision point will be required
b) It should be distinctive from other cues
c) It should be easily distinguishable from nearby objects
d) It should be there year on year

  e) It should be located near a key choice/decision point along the route.

---

Good practice example – situation awareness

A lack of attention as a resource inhibits situation awareness. Drivers can increase the amount of ‘cognitive resource’ that they have to allocate to driving via training and practice.

Memory skills can be improved by rehearsal and repeating relevant risk-based information (see Part 3).

Workload levels can affect situation awareness. Be conscious that:

  a) Too little is a problem – eg boredom and mind wandering
  b) Too much is a problem – eg a driver cannot manage demands or they have an inaccurate impression of what is going on (see Part 4).

---

Good practice example – raising situation awareness

How aware are you?

You must be aware that you are aware.

Are you Looking, Thinking and Anticipating?

Before a journey:

  - Are you well rested?
  - Is this a familiar route? Think through the route and stops.
  - Is this an unplanned journey? Think through the route and stops.
  - If you are driving to work, can you scan the environment in a similar way to that you use when in the cab?

During a journey:

  - Do you feel in control?
  - Can you tell what is going on?
  - Don’t assume anything, anticipate what is happening and question what you are doing.
  - Do you question and check what you see and think?
  - Unknown brake application? – think TPWS.
  - Consider all changes to instruments, new signs etc.

Additional ways to improve situation awareness include:

  a) In the cab: use commentary driving with instructors/assessors (if acceptable).
  b) Instructors to look out for lapses of attention and late actions.
  c) Practice infrequently driven routes (eg diversionary routes) using a video of the route, simulator, etc.
6.1.3 Tactics to help drivers ‘stay in the loop’

(i) **In a briefing**
There are a number of ways to help develop situation awareness. One approach is to play a film of a particular route to a driver, stopping the footage occasionally and then directing a series of questions to the driver. It would be preferable to integrate findings from route risk assessments. Questions that could be asked include:

   a) What are the up-and-coming risks?
   b) What is around the corner?
   c) What cues would you be using at this point?
   d) How risky do you think the signal you are approaching is?

(ii) **In training/assessment**
On a simulator there is greater flexibility as the driver is actually driving. Here it would be important to remove all information from the driver – blank screen and possibly cover cab indicators (speedometer and AWS sunflower). Additional questions could be:

   a) What colour was the last signal?
   b) What do you anticipate is coming up?
   c) What was your last AWS indication (bell/horn)?
   d) What was your last AWS warning for (e.g. speed restriction)?
   e) Where is your next signal?
   f) What is your next station stop?
   g) When should you be slowing down?
   h) What is your speed?
   i) How close are you to the permitted speed?

There are many different and yet correct driving styles. It would not be possible or appropriate to prescribe a set of ‘right’ answers. Some drivers may struggle to answer questions whilst they are highly aware of what is going on. An assessor should be looking for evidence that the driver is looking, understanding and anticipating.

6.1.4 Assessing situation awareness
There are a number of ways drivers’ route situation awareness can be measured. For example, the following is an extract on situation awareness training from a project on Train Driver Route Knowledge:

   a) The assessment could be applied on an in-service/route knowledge train when the driver is driving, or as he watches someone else drive. If the driver was driving as well as answering the probing question fewer questions could be asked at one time;

   b) Probes could also be used within a route simulator, in which the images can be frozen and several queries can be administered. Queries may include probes such as ‘how long would it take to get to the station’ or ‘where is the next signal’. Also the simulator could be manipulated to include different weather conditions, to assess the driver’s ability to gain and maintain route situation awareness in specific weather conditions;

   c) Videos of specific routes could be shown to the drivers and frozen at specific points and questions could be administered. However this may result in issues regarding the drivers feeling ‘out of the loop’ as they have no control over the presentation, therefore a true measure of situation awareness may by unobtainable;

   d) Drivers could also be shown a video/DVD and when it is paused asked to draw on paper where they are on the route, this may provide interesting results, highlighting cues that drivers use to distinguish that part of the route from others.
6.2 Risk Triggered Commentary (RTC)

In Part 3.1 of this guide characteristics of working (or short term) memory were described. These include:

a) Limited capacity of roughly seven items
b) Information can only be retained for between 10 – 20 seconds.

For train drivers and other safety critical staff, however, it is essential that information relating to safety operations (e.g. control of the train) is not lost in working memory. One suggested approach to help retain (and remember) critical information in working memory is an advanced driving technique known as Risk Triggered Commentary (RTC).

A one month trial of RTC driving was carried out by Arriva Trains Wales (ATW) with a cross section of drivers in October 2005. The aim of the trial was to explore the benefits and any issues arising in relation to the use of RTC to help reduce operational incidents/SPADs. As a result of the trial, Arriva Trains Wales recommend RTC where there is a need to remember: (i) key information relating to the safe control of a train, and (ii) to make a specific action(s). The technique has been designed to be flexible and to help drivers increase their awareness of risk, improve concentration levels and manage potential distractions.

It should be emphasised that RTC is not mandatory, rather it is just one technique that drivers may choose to use to aid their situational awareness. Moreover, the technique should not be confused with Commentary Driving which may be used when a driver is accompanied and in specific situations of increased risk (e.g. for assessment purposes, defective on board equipment, etc).

6.2.1 Applying the use of Risk Triggered Commentary

Using a process of continuous verbal rehearsal and repetition (e.g. speaking to yourself, quietly muttering or silently repeating), the aim of RTC driving is to help a driver stay ‘in the loop’ and focussed to ensure that operational risks are identified, managed and that the appropriate action is taken.

The process of ‘speaking out’ is especially effective as it is a combination of external and internal memory aids, involving the internal retrieval of the memory and the external feedback of the voice. The fact that ‘speaking out’ involves two levels of recall should therefore increase the likelihood of successful recall.

In using the process it is important that drivers use a technique that is effective for them (e.g. ‘speaking out’ or muttering under the breath or mentally running through the message). However, speaking out is the more effective method as it provides the external feedback of the voice, which assists a driver in remembering the action(s) they have to take.

To help to retain information, the application of RTC driving should, ideally, be continuous from when the commentary on identifying the risk is started, until the action that must be taken is actually performed. This is because information may not be retained if the message is not repeated beyond a time of between 10 to 20 seconds.

Research also indicates that when train drivers verbally rehearse a signal aspect, the meaning of the aspect must also be rehearsed in order to create a more durable memory, for example, a driver would state ‘caution, next signal red’. Whichever system is used, it is important that the meaning of the message is stated so that any actions that are required are fixed in working memory.
For example, when starting from a station which was approached after passing a single yellow aspect and the next signal is not in view a driver could state ‘DRA reset, caution - last signal yellow, stop at the next signal’. The message should be repeated, using the preferred technique, until the appropriate action, according to the operating conditions, has been made. This will involve planning ahead, and may involve shutting off power, coasting or applying the brake.

### Good practice examples - benefits of risk-triggered commentary

- a) An effective memory recall tool as it retains relevant information in the working memory
- b) Some RTC, even if limited, aids the processing of relevant information in the memory for recall at a later point
- c) It means that no retrieval is required from long term memory
- d) ‘Speaking out’ is effective as it combines external and internal memory aids (eg internal retrieval of the memory and external feedback of the voice) increasing the likelihood of success
- e) RTC aids the prevention of mistakes caused by automatic actions
- f) Is a method to check that actions taken are appropriate for the risk situation
- g) Helps to keep the mind focussed on driving – controlling risk from distractions on the railway/removing human factor/personal issues from the mind
- h) Can help overcome fatigue by increasing cab and trackside awareness
- i) Acts as an aid to avoid operational safety incidents.

### Risk situations where the technique could be applied include:

- a) Starting from stations on a yellow signal;
- b) Where the signalling or speed profile change is more restrictive;
- c) When certain degraded conditions apply;
- d) When running on single yellows;
- e) Having reset the DRA following a cautionary aspect and the signal ahead cannot be seen.

A limitation of RTC, however, is that continuous commentary may not always be achievable as other important tasks will need to be carried out, such as respond to information from safety systems/radio messages etc. The technique therefore requires important actions to be prioritised when interruptions occur so that the most appropriate action may be taken. Moreover, due to the limitations of working memory in applying verbal rehearsal (eg RTC may occupy working memory capacity,) there is also a risk that a driver may be unable to attend to other incoming information (eg safety systems in the driving cab (AWS resetting) and radio messages (emergency broadcasts)). There is also a possibility that the driver’s visual tasks will be affected (checking AWS indicator).

Guidance is therefore required not only on how to apply RTC driving, but also on prioritisation in relation to other tasks that the driver has to carry out, which means that verbal rehearsal will at some stage have to be interrupted. For example, when interruptions occur (by other actions a driver may need to take), the RTC process may have to be stopped. When the interruption has been dealt with, a driver can return to repeating the message (providing it has not been overtaken by events).
Despite the fact that verbal rehearsal will be interrupted, however, there are still advantages to limited verbal rehearsal, as research has shown that retention levels drop dramatically when verbal rehearsal is not applied.

The Arriva Trains Wales trial identified phrases that worked well for the drivers involved. Examples are listed below.

These are for guidance purposes only, as each individual should develop their own phases that are suitable to them.

```
a) ‘danger, stop at next signal’, repeated until sighting danger signal, then, ‘signal red, red signal’
b) ‘red ahead’, ‘red ahead’, ‘red ahead’ until brake applied or signal cleared
c) ‘yellow received, next signal at XX location is ON’
```
APPENDIX A Characteristics that could affect human performance

The list below gives a summary of human factors which can contribute to errors or violations.

<table>
<thead>
<tr>
<th>Personal factors/ individual</th>
<th>Characteristic that an individual brings to a work situation that affect the person’s performance</th>
</tr>
</thead>
</table>
| Physical fitness            | • Ill health/ incapacitation  
                               | • Temporary disability  
                               | • Influence of medication/drugs/alcohol |
| Psychological fitness       | • Psychometric suitability (personality, traits etc)  
                               | • State of mind  
                               | • Psychological illness/condition |
| Age/experience              | • Age of person in years  
                               | • Total time in current role/previous related roles |
| Previous incident history    | • Involvement in previous incidents and accidents |
| Competency                   | • Insufficient  
                               | • Knowledge  
                               | • Experience  
                               | • Skill |
| Attention and processing    | • Preoccupation  
                               | • Distraction  
                               | • Micro-sleep/lapse of concentration  
                               | • Disorientation  
                               | • Unfamiliarity |
| Influence of confirmation bias | Interpreting evidence to fit existing hypothesis |
| Expectancy                   | Interpreting visual environment in line with what is expected |
| Reliance on inappropriate cues | Wrongly associating two unrelated events leading to incorrect assumptions |
| Fatigue                      | • Effects of time on task  
                               | • Effects of shift work pattern (successive nights/earlies) |
### Job/ situational factors

<table>
<thead>
<tr>
<th>Factors associated with the task and the environment they are being performed in</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assessment</strong></td>
</tr>
</tbody>
</table>
| **Equipment** | • Not available  
• Poorly designed  
• Not fit for purpose (e.g., design, maintenance) |
| **Environmental conditions** | • Weather effects  
• Sun/lighting (phantom/shadow effects)  
• Temperature |
| **Task factors/workload** | • Overload  
• Underload  
• Insufficient time  
• Excessive workload |
| **Briefing and information** | • Information not given  
• Wrong information given  
• Information not understood |
| **Training** | • Not given/not sufficient  
• Not appropriate |
| **Communication** | • Failure to follow protocol  
• Equipment failure  
• Miscommunication (wrong information, ambiguous, misinterpretation) |
| **Procedures/documentation/written instructions** | • Not available  
• Not clear  
• Inaccurate/incomplete  
• Too much information  
• Too little information |
| **Supervision** | • Lack of supervision  
• Inadequate supervisory knowledge, skills, experience  
• Failure to monitor  
• Inappropriate supervisory style  
• Lack of clear responsibilities of supervisor |
| **Social/team factors** | • Social pressure  
• Group dynamics, team interaction |
<table>
<thead>
<tr>
<th>Organisational/system failures</th>
<th>Factors associated with complex organisational and social systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>• Lack of systems for planning work</td>
</tr>
<tr>
<td></td>
<td>• Planning systems inappropriate/insufficient</td>
</tr>
<tr>
<td>Systems failures</td>
<td>• Systems for identifying and managing risk not in place</td>
</tr>
<tr>
<td></td>
<td>• Systems for identifying managing risk not working</td>
</tr>
<tr>
<td>Role responsibilities conflicts</td>
<td>• Competing job demands resulting from conflicting organisational demands</td>
</tr>
<tr>
<td>Organisational learning (from incidents)</td>
<td>• No systems in place for applying lessons from previous incidents</td>
</tr>
<tr>
<td></td>
<td>• System for applying lessons from previous incident failed</td>
</tr>
<tr>
<td>Safety culture</td>
<td>• Organisational values, attitudes, and perceptions encourage unsafe behaviour</td>
</tr>
<tr>
<td>Organisational change</td>
<td>• Poor management of change leads to unmanaged risks or introduces new risks related to the change itself</td>
</tr>
<tr>
<td>Corporate communication</td>
<td>• Systems not available or failed to communicate risk and safety management systems appropriately (top down)</td>
</tr>
<tr>
<td></td>
<td>• Known risks or safety concerns not communicated or addressed at the corporate level (bottom up)</td>
</tr>
<tr>
<td>Interfaces</td>
<td>• Interfaces (between organisations or departments etc) lead to gaps or overlaps which introduced risk</td>
</tr>
<tr>
<td>Resource allocation</td>
<td>• Resources not available</td>
</tr>
<tr>
<td></td>
<td>• Resources not sufficient</td>
</tr>
</tbody>
</table>
### Appendix B  Human causes of SPADs

Some of the human factor causes of SPADs are described in the table below:

<table>
<thead>
<tr>
<th>Cause</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Although the driver sees the red signal and correctly identifies that it applies to them, they then make the assumption that the signal will change to a less restrictive aspect before they get to it.</td>
<td>Assumptions like these are made as a result of the driver's past experience of driving on that line.</td>
</tr>
<tr>
<td>When starting away from a location (typically a station) the driver forgets to check the signal before moving off, immediately resulting in a SPAD. This can occur because the driver simply forgets to check the signal, is given conflicting information from other staff (eg station staff giving the driver the instruction to depart) or is distracted by events happening in the driving cab or outside the train.</td>
<td></td>
</tr>
<tr>
<td>When a number of signals are displayed in one location the driver may select a signal which is inappropriate for their track. Contributory factors to this type of SPAD include the signal's position in relation to the track the driver is travelling on and the driver's route knowledge.</td>
<td></td>
</tr>
<tr>
<td>The driver's task has become more monotonous over recent years, partly as a result of limited routes and little variation in the type of rolling stock being used. Other factors include the improvement in driving conditions (more comfortable cabs) and standardisation of cab equipment. The driver's attention may therefore wander away from the task and be diverted for long enough to miss a signal when it is within their potential visual field.</td>
<td></td>
</tr>
<tr>
<td>Poor communication between the driver and signaller can also cause SPADs, particularly in engineering sites (‘possessions’), in railway yards and sidings. The failure of the driver and signaller to come to a clear and complete understanding then results in the driver believing that it is safe to proceed through a red light.</td>
<td></td>
</tr>
<tr>
<td>Weather and lighting conditions (eg fog, sun, rain, snow) can distort brightness, contrast and the driver's perception of distance. This increases the possibility of the driver mistaking the signal colour or not taking action in sufficient time to stop at a red signal.</td>
<td></td>
</tr>
<tr>
<td>Personal stress can reduce the driver’s ability to concentrate. Stress may be caused by events at work or at home, coupled with lifestyle factors (eg sleep patterns, diet, general health).</td>
<td></td>
</tr>
</tbody>
</table>

SPAD incidents are rarely simple incidents that can be attributed to a single root cause. The rail industry classifies the immediate causes of SPADs into these groupings:

1. Miscommunication due to wrong information given
2. Miscommunication due to ambiguous/incomplete information given
3. Miscommunication due to information not given
4. Miscommunication due to correct information being given
5. Correct information given but misunderstood, but being misunderstood
6. Not monitoring for a signal
7. Failure to check signal aspect
8. Failure to locate correct signal
9. Anticipation of clearance of signal
10. Ignorance of rules/instructions
11. Violation of rules/instructions
12. Failure to react to a caution signal
13. Viewed correct signal, misread aspect
14. Viewed wrong signal, read through
15. Viewed wrong signal, read across
16. Misjudged train behaviour
17. Misjudged environmental conditions.

[Source: ‘Signals Passed at Danger (SPADs) Railway Group Standard GO/RT 3252 Issue 5, October 2003’] [16]
Appendix C  Recognising behavioural change - checklist

Human behaviour is influenced by many different factors. For example, people differ according to personality type, experience and attitudes. Changes in behaviour might suggest an emotional, welfare issue or reaction to a traumatic event, factors which, if left untreated, may lead to human error. It is important, therefore, to identify when an individual’s behaviour has changed from what you would normally expect and to manage the underlying issue appropriately. This may involve the initiation of the ‘specially monitored driver’ process to develop an action plan to correct sub-standard performance and/or the ‘Driver Care and Support System’ to sensitively address any behavioural issues.

1) General changes in appearance

Specifically, the following changes might be indicative of problems of domestic violence and of drugs and alcohol abuse, for example. Also, if an individual is getting involved in fights, this might indicate some emotional problem that is being expressed through increased aggression. If an individual is in pain because of back problems, for example, this can be a source of distraction.

Factors to be observed include:

a) Changes in appearance (e.g. untidy/dishevelled where previously tidy/smart)
b) Injuries or bruises
c) Noticeable back problems
d) Difficulty in walking or moving limbs (e.g. gingerly getting off the unit).

2) Changes in communication/sociability

Factors to be observed include:

a) Changes in sociability (e.g. previously lively and outgoing, now quiet and withdrawn)
b) Seeking out colleagues or friends for support or comfort
c) Increased desire to talk to anybody about the problem or in general.

3) Changes in expressed emotions

Factors to be observed include:

a) Increase in the number of petty arguments with colleagues (i.e. becomes more sensitive)
b) Changes in anger, irritability
c) Change from mild-mannered to being angry and aggressive
d) Seeks out arguments
e) Resistance to conform to work standards (e.g. wearing high visibility vests, use of driver-reminder appliance)
f) Increased restlessness where previously calm
g) Uncooperative in dealing with work problems or difficulties
h) Unjustified resistance to change
i) Indifferent where previously enthusiastic about work
j) An exaggeration of the effects/difficulties encountered in problems, disputes and grievances
k) Increased hostility (e.g. more likely to negatively evaluate people and events).
4) Changes in performance

Factors to be observed include increased incidence of:

a) Unusual number of incidents or breaches in rules
b) Relieving people late
c) Indecisive and lacking confidence
d) Problems concentrating
e) Failure to put in reports
f) Absences from work or lateness
g) Changes in attitude to working overtime
h) Persistent shift swapping
i) Turning up in the wrong place
### Appendix D  Examples of different error types

<table>
<thead>
<tr>
<th>Incident</th>
<th>Type of error</th>
</tr>
</thead>
<tbody>
<tr>
<td>There has been an operating irregularity involving a train leaving a</td>
<td>This is an example of a lapse type error. The PICOP knew he should have told</td>
</tr>
<tr>
<td>worksite and travelling over a crossing with the barriers still up.</td>
<td>the driver about the crossing but simply missed this piece of information out.</td>
</tr>
<tr>
<td>The engineering train was given permission to leave the worksite and</td>
<td></td>
</tr>
<tr>
<td>continue to the possession limit boards but the PICOP forgot to tell</td>
<td></td>
</tr>
<tr>
<td>the train driver to stop at the crossing.</td>
<td></td>
</tr>
<tr>
<td>A driver has a SPAD because he is preoccupied with some personal</td>
<td>This is a most probably a lapse. The driver forgot to check and respond</td>
</tr>
<tr>
<td>problems at home.</td>
<td>to the signal because he/she was not fully attending to the driving task.</td>
</tr>
<tr>
<td>A set of points are run through. The signaller was experiencing a</td>
<td>This would be an example of a knowledge based mistake if the investigation</td>
</tr>
<tr>
<td>track circuit failure and was having to set points manually. He did</td>
<td>revealed that the signaller did not know he should have used the route cards</td>
</tr>
<tr>
<td>not set them correctly. He had not used the route cards.</td>
<td>in this instance. If however, the signaller knew he should have used them</td>
</tr>
<tr>
<td>A signaller wrongly routes a late running train. He routes as if it</td>
<td>and simply did not this is an example of a violation, probably a routine</td>
</tr>
<tr>
<td>is the next scheduled train.</td>
<td>violation if non-use of route cards is a common problem.</td>
</tr>
<tr>
<td>A train is routed inadvertently into a possession. The signaller has</td>
<td>Using reminders for regulating is a controversial practice due to the</td>
</tr>
<tr>
<td>removed the reminders believing he had put them there for regulating</td>
<td>confusion that can arise between whether it is a regulating or protecting</td>
</tr>
<tr>
<td>reasons, having not switched the automatic route setting (ARS) off.</td>
<td>reminder. It is an example of a situational violation because the signallers</td>
</tr>
<tr>
<td>A train ran away incident occurred as a result of ineffective cab</td>
<td>believe that if they were not permitted to use reminders in this way they</td>
</tr>
<tr>
<td>traction disposal arrangements.</td>
<td>would not be able to operate the agreed timetable.</td>
</tr>
<tr>
<td>A lookout is hit by a train because he is not standing in a position</td>
<td>This is an example of a situational violation. The lookout has knowingly</td>
</tr>
<tr>
<td>of safety. He has moved to a position whereby he can lookout for trains</td>
<td>moved to an unsafe position but has done so because it allows the gang to</td>
</tr>
<tr>
<td>coming off the branch line as well as the mainline and therefore allow</td>
<td>continue working and complete the job more quickly.</td>
</tr>
<tr>
<td>the gang to carry on working and not suspend work until another person</td>
<td></td>
</tr>
<tr>
<td>can be found to lookout for the branch line trains</td>
<td></td>
</tr>
</tbody>
</table>
References


[2] Understanding Human Factors: a guide for the railway industry. Rail Safety & Standards Board. enquiries@rssb.co.uk


