WHITE PAPER

LEARNING FROM ADVERSE EVENTS

Chartered Institute of Ergonomics & Human Factors

Design & publication supported by

CARDINUS riskmanagement

PREFACE

As the final edits were being made to this white paper in early 2020, governments and the media around the world were becoming increasingly exercised by the health risks posed by the new and deadly coronavirus emerging from China. The following months, while the paper was going through design in preparation for publication, saw social and economic devastation, on top of untold personal misery and suffering on a scale that, while not unheard of or unforeseen, has not been experienced in modern times outside world war.

The scope of this white paper has intentionally been cast broadly, beyond the health and safety of industrial incidents that has been at the heart of much of the professional practice of human factors in recent decades, into events and losses affecting the public at large through health and social care practices, public welfare, and the financial and other sectors.

In the context of the scale of trauma, upheaval and change as communities emerge from the crisis, it seemed worth reflecting on what this paper has to offer in learning lessons and implementing change that will provide long term protection from future pandemics. Of the nine principles set out in this white paper, three seem especially important to society's efforts to learn from the coronavirus experience in the coming years.

Taking a systemic view (Principle 4) is of course, fundamental; seeing the events, decisions and actions taken by governments and their advisors in the context of the overall system in which they occurred. Though it seems doubtful if there has ever been a socio-technical-economic system more complex than that in which the spread of a global pandemic occurred in 2020.

The two other human factors principles in learning from adverse events that seem particularly important as we emerge from coronavirus are Principle 3: Avoid searching for blame, and Principle 5: Identify and understand both the situational and contextual factors associated with the event.

These principles are explained in this paper. If people forget, deny or otherwise ignore the facts of the situation as they were at the time decisions were made and action taken, or if they impose their own experience and overlook the reality of the complexities of the context decision makers and their advisers were in at the time, little will have been learned.

Talented people in the written, visual, musical and other art forms around the world are undoubtedly engaged in creating works that capture and express the personal and social experience for individuals, families and society of lockdown, social distancing and self-isolation. In the weeks since our personal freedoms have been curtailed, many self-appointed 'thought leaders' and opinion formers have sought every opportunity to share their wisdom and insight into how and why, in their opinion, "things went so badly wrong", and what needs to happen to put it right. With few exceptions, such opinions have been based on the principle of pointing the finger and apportioning blame.

That is not to say that our politicians and others should not be subject to scrutiny and held to account for their choices, decisions and actions – of course they must – that's the basis of our democracy. And if those decisions and actions were found to have been dominated by personal or political self-interest against clear scientific evidence or advice of what was in the common good

Front cover image: Buncefield oil depot fire, December 2005
Back cover image: Buncefield, one year on

in the face of the global pandemic, or taken without reasonable care, the grounds for criticism and sanction would be justified. But those criticisms will only have validity if they are grounded in a rich understanding and recognition of the systemic influences involved, as well as the situation and the context as they existed at the time.

One remarkable feature of recent weeks, at least from the point of view of a science-based professional society, has been the extent to which those in positions of authority have been prepared to put aside their own political opinions and interests and have listened and acted on the advice of the medical and scientific community who advise them. Historians can debate whether there has ever been a time when government action has been so dominated by scientific knowledge, even if the available 'evidence', at least in the earlier stages, was largely based on computer modelling with its inevitable assumptions.

Focusing on finding someone or some organisation to blame, outside of an adequate understanding of the enormously complex systemic forces at play, and without recognition of the situation and context people were in at the time, is guaranteed to interfere with genuine learning. If the views of those who seek to pursue blame in pursuit of their political or economic interests are allowed to dominate, the trauma and suffering imposed by Covid-19 will have been in vain.

Ronald W McLeod

Chair, CIEHF Learning from Adverse Events White Paper Working Group

May 2020

EXECUTIVE SUMMARY

This white paper represents the combined efforts of a number of CIEHF members. It shares their considerable knowledge and experience of human factors in incident prevention and management, and is designed to:

1. Help organisations understand a human factors perspective to investigating and learning from adverse events.
2. Provide key principles organisations can apply to capture the human contribution to adverse events.

How organisations learn, and fail to learn, from adverse events is discussed. Practical guidance on the application of human factors in the investigation process is presented.

Nine principles for incorporating human factors into learning investigations are identified. They are embedded throughout the document, collated in section 5 and summarised below:

1. Be prepared to accept a broad range of types and standards of evidence.
2. Seek opportunities for learning beyond actual loss events.
3. Avoid searching for blame.
4. Adopt a systems approach.
5. Identify and understand both the situational and contextual factors associated with the event.
6. Recognise the potential for difference between the way work is imagined and the way work is actually done.
7. Accept that learning means changing.
8. Understand that learning will only be enduring if change is embedded in a culture of learning and continuous improvement.
9. Do not confuse recommendations with solutions.

BACKGROUND

About this white paper

This white paper arose from concerns widely held across the Chartered Institute of Ergonomics & Human Factors (CIEHF) membership that the investigation of incidents does not fully support effective learning about the role of people in the development, response, mitigation and avoidance of incidents. Despite a sizeable knowledge base in the professional literature, there continues to be a significant number of organisations who either fail to apply good practice in this area or who seem to quickly forget the lessons that have been learned.

In late 2017, the CIEHF Executive Committee agreed to initiate an internal project to prepare a CIEHF white paper on the topic of 'Learning from Incidents'. The aim was to contribute to a significant improvement in the way in which organisations in different sectors investigate and learn from the human contribution to incidents.

The systems, tools and especially the culture and expertise that supports incident investigation, largely determine the quality of the output and learning achieved. However, the value of an investigation is only as good as the quality of the learning achieved; identifying and implementing change in a way that supports and sustains long-term improvement is the essence of effective learning.

This white paper focuses on improving organisational learning following incidents or other adverse events. It aims to do so by drawing on good practice in understanding how to enhance the reliability of complex socio-technical systems through attention to human behaviour and performance.

Terminology

CIEHF sees ergonomics and human factors as terms that can be used interchangeably. For simplicity, 'human factors' is used throughout this publication to denote both terms.

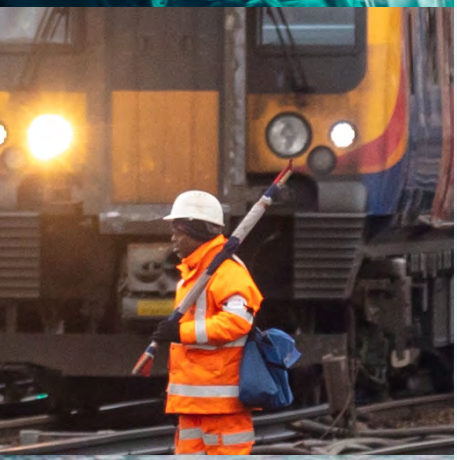
Target audience

This white paper is intended for any industry or service that needs to manage significant risk. It supports organisations that place a high value on learning from experience and continuous improvement.

It is particularly targeted at organisations that do not employ professionally trained ergonomics and human factors specialists. Or if they are employed, they may lack experience investigating and learning from adverse events. Much of the experience that forms the basis of the paper comes from the traditional high hazard industries including aviation, nuclear power, defence, rail, maritime, oil and gas and chemical manufacturing. Industries that, by the nature of the processes and activities they perform, manage significant hazards including materials as well as energy sources. Hazards that, if not properly controlled, have the potential for single events to lead to extensive loss of life or property, environmental or commercial damage. This white paper also draws on experience from sectors such as healthcare, the emergency services and public utilities tasked with managing major risks with the potential to adversely affect the health, safety or wellbeing of large numbers of people.

Structure of this paper

- Section 1 briefly explains the need to learn and the main concerns about organisational learning.
- Section 2 sets out six key concepts that form the basis of the human factors perspective on learning investigations.
- Section 3 considers the nature of organisational learning, including why organisations appear not to learn from their adverse events.
- Section 4 considers ergonomics and human factors issues in the process of conducting learning investigations.
- Section 5 draws into one place the nine principles for incorporating ergonomics and human factors into learning investigations identified in this white paper.



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1. INTRODUCTION

1.1. The need to learn

Writing in his book, *To Engineer is Human*[1], Henry Petroski expressed the view that "*...recent years have seen some of the most costly structural accidents in terms of human life, misery and anxiety, so that the record presents a confusing image of technological advancement that may cause some to ask, "Where is our progress?""*

That view was expressed in 1992. From the perspective of 2020, and considering a wider range of types of system failures such as in aircraft, spacecraft, nuclear plants, oil and gas facilities, shipping and railways, government agencies, health services and even the global financial system, the question "Where is our progress?" is one that can fairly be considered as still being on the agenda.

There has been enormous progress over the years since Petroski posed his question. Yet the frequency with which major events continue to occur across nearly every sector of the economy and the extent of the pain, suffering, loss and hardship that arises, suggests a fundamental weakness in the ability of developed societies to adequately learn from the things that go wrong and take action that is effective in preventing recurrence of similar events.

When incidents leading to significant losses do occur, organisations involved must learn and improve from the experience. It is not enough to rely on the individual experience of employees or stakeholders for improvement. What is needed is genuine organisational learning, driven by leadership commitment and a culture of continuous improvement; one that values and aspires to protect its employees, stakeholders and society at large from adverse events.

That organisational learning, based on applying good practice in understanding how and why human behaviour and performance can contribute to major adverse events in socio-technical systems, is the subject of this white paper.

> **"Most distressing of all, such failures often have a familiar ring, displaying strong similarities to incidents which have occurred before and, in some cases, almost exactly replicating them. Many could be avoided if only the lessons of experience were properly learned."**
>
> From *'An organization with a memory'* Department of Health, 2000.

[1] Petroski, H (1992), 'To Engineer is Human'. Vintage Books.


“
Success may be grand,
but disappointment can often
teach us more.
Henry Petroski, 1992
”

1. INTRODUCTION

1.2. Concerns

Development of this white paper was stimulated by a number of concerns held by many CIEHF members. These include:

- A widespread tendency to blame individuals, and to stop investigating once someone has been identified as having been in some way 'at fault'. Disciplining, changing or re-training the individual(s) found to be at fault is treated as adequate learning.
- Focusing on finding someone to 'blame', at the expense of considering the wider organisational and systemic factors that created the situation, and which, if addressed, would lead to more effective and enduring change.
- A tendency to view incidents with hindsight and to view the way people acted or the decisions they made in light of the way events unfolded, rather than in the context of the information and the situation facing the individuals at the time.
- A failure to adequately identify or understand the psychological motivations or incentives behind the ways people behave and the decisions they make. This includes assuming that trained and competent people will always make rational and informed decisions.
- A failure to adequately capture and understand the situational and contextual factors associated with adverse events, and to identify future situations with similar characteristics where learning from the incident needs to be applied.

These concerns are not new, they do not all apply to all organisations, to every industrial sector, or to every type of incident investigation. Major incidents or near misses in highly regulated industries tend to be investigated to a high standard. Though whether the learning available from even these high quality and widely publicised investigations actually lead to sustained and widespread improvement, as opposed to simply complying with new regulations, is debatable. While the quality of information gathering and analysis in these cases is usually thorough, driving others to action is a separate matter.

1.3. Objectives and scope

The paper has two objectives:

1. To help organisations understand the basis of human factors good practice in investigating and learning from adverse events.
2. To provide a set of key principles that organisations can apply to review and improve how they learn from and manage the human contribution to adverse events.

There is a substantial literature about the nature of organisational learning and approaches to incident investigation. The white paper does not review this literature, though the experience and opinions expressed draw on many ideas and knowledge from it.

The paper is focused on investigations conducted for the purpose of learning and improvement, rather than to support prosecutions or otherwise to assign blame and responsibility for loss. This is reflected in the use throughout the paper of the term 'learning investigation'.

The emphasis on learning rather than legal liability has a number of important implications, not least in the nature of the evidence, or proof, needed to support decisions and actions. In the case of learning from the human contribution to adverse events, many of the factors that motivate or contribute to decisions and actions leave little or no trace and can be extremely difficult to prove to the objective standard required in a court of law. See in particular the discussion of the difference between situational and contextual factors contributing to adverse events, and the types of evidence needed to investigate both, in sections 3 and 4 of this white paper.

To learn from incidents for the purpose of improvement, the standard of evidence needed to justify change can therefore be lower, more flexible and more open to judgement. When learning is the focus, identified gaps or opportunities for improvement are embraced, even if not directly tied to an adverse event.

Principle 1:

Be prepared to accept a broad range of types and standards of evidence.

Organisations that are genuinely seeking to learn from incidents are prepared to accept the need for action and change based on informed judgements, rather than necessarily hard 'evidence', about why people at the sharp as well as the blunt end of the organisation may have behaved and acted in the ways they did.

1.4. Adverse events

The term 'adverse event' is taken to cover two situations:

1. Events where there is actual harm or loss.
2. Near misses, where little or no actual harm or loss occurred, but where it is recognised that something went seriously wrong.

Actively identifying and learning from near misses provides a relatively low-cost opportunity for improvement. As there are far more near misses than actual events of loss or harm, there are many more opportunities to learn.

A third type of event that can justify investigation and learning involves 'weak signals'. The numerous small indications and minor signs that something is not right, or something is not as it should be. They include signs that individuals or groups are behaving in ways that are not consistent with expected risk management controls, but where those signs are not sufficiently clear and obvious that most people would realise there is a need to act. The ability to detect and act on weak signals is a characteristic of highly reliable organisations[2]. It requires a risk aware and committed leadership that resists complacency and over-confidence and is prepared to invest the time and effort not only to be sensitive to, but to investigate and learn from weak signals.

Principle 2:

Seek opportunities for learning beyond actual loss events.

Near misses, close calls, anonymised reporting systems and sensitivity to weak signals from operations all provide opportunity for learning and continuous improvement.

[2] Weick, K E and Sutcliffe, K M (2007) Managing the Unexpected: Resilient performance in an age of uncertainty. 2nd edition, John Wiley & Sons.

2. KEY CONCEPTS IN LEARNING INVESTIGATIONS

2.1. The quality of investigations

The quality of a learning investigation depends to a large extent on adopting a perspective that reflects several key concepts central to the professional practice of human factors:

1. Acknowledging that you cannot punish away error.

2. Recognising that adverse events in complex systems are nearly always systemic.

3. Understanding the difference between the situation and the context in which human performance occurs.

4. Recognising that people usually play a positive role in assuring safety and reliability.

5. Acknowledging the difference between intentional and unintentional human failure.

6. Recognising the difference between 'work-as-done' and 'work-as-imagined'.

> **Even apparently simple human errors almost always have multiple causes, many beyond the control of the individual who makes the mistake. Therefore, it makes no sense at all to punish a person who makes an error, still less to criminalise it.**
>
> The National Advisory Group on the Safety of Patients in England, 2013

2.2. You cannot punish away error

Society appears to hold a deep need to find someone to blame whenever adverse events occur. This is demonstrated by the speed with which the media ascribe the label 'human error' as the cause of virtually any major adverse event.

There is of course truth in the view that many incidents do involve people doing something – or not doing something – that contributes to the undesirable outcome. Such failures are often labelled as 'human error', especially when they occur despite the existence of rules and procedures, training and the numerous forms of controls around how work is performed.

Until relatively recently, the default approach in many organisations has been to ascribe the causes of incidents to individual characteristics such as lack of competence, non-compliance with operating procedures, lack of due care and attention or, in some cases, recklessness. This focus on the individual means that the range of interventions available to minimise the risk of future incidents is limited - essentially, 'blame, shame, or retrain'. Even worse, as the psychologist Erik Hollnagel[3] has noted: *"it is only in hindsight, when the outcome is the wrong one... that we label something as an error".*

Blaming and punishing behaviour that is judged as wrong with the benefit of hindsight inhibits the potential for learning:

- Blame creates a culture of fear, incentivising people to hide mistakes instead of reporting them.
- A blame culture makes it unlikely that those involved in an event will engage honestly with the investigation if it is seen as being likely to lead to consequences for themselves or their colleagues.

[3] Hollnagel, E (2012) FRAM: The Functional Resonance Analysis Method (pp 22-23). Aldershot: Ashgate.

- Blame does nothing to explain *why* the behaviour occurred and what influenced the actions taken; it conceals the real issues lurking in complex systems.
- Blaming people means that systemic problems, such as poor equipment design, limited training or inadequate staffing levels, as well as contracts or incentive schemes that motivate the wrong sort of behaviours, are not identified and may remain unaddressed until an incident occurs.

The role of human factors in learning investigations is to make sense of the behaviour of individuals, teams and their interactions within an overall socio-technical system, including the variations in human performance that are a natural part of everyday life. This allows consideration of ways to optimise the design of work to improve system performance. It supports the development of systems that can accommodate the normal variation in human performance rather than be toppled by them.

In summary, an approach to incident investigation that focuses on finding someone to blame is rarely an effective way of learning from adverse events. Focusing on removing or changing 'bad apples' at the front-line, provides false assurances and misses the opportunity to implement effective and sustainable improvement.

The concept of error, both in the public mind and the media, needs to be re-framed. Concluding that an incident occurred because of 'human error' is overly simplistic and reflects a fundamental lack of understanding that what is commonly labelled as an 'error' is, more often than not, a symptom of wider systemic issues, and not a cause. Learning investigations need to focus on what can be learned, not who can be blamed.

EXAMPLE:

Hindsight

Hindsight is well illustrated in the film *Sully* which dramatises how the decisions and actions of Captain Chesley 'Sully' Sullenberger, in successfully landing his crippled A320 aircraft on the Hudson River in 2009, were only seen as correct once the actual situation the aircraft was in at the time he made his critical decisions was recognised and included in flight simulations.

Principle 3:
Avoid searching for blame.

Focusing on individual failure and blame creates a culture of concealment and reduces the likelihood that the underlying causes of events will be identified.

2. KEY CONCEPTS IN LEARNING INVESTIGATIONS

“It is of course right...that individuals must sometimes be held to account for their actions – in particular if there is evidence of gross negligence or recklessness, or of criminal behaviour. Yet in the great majority of cases, the causes of serious failures stretch far beyond the actions of the individuals immediately involved.”

From *'An organization with a memory'* Department of Health, 2000.

2.3. Major adverse events are nearly always systemic

Most adverse events in socio-technical systems are systemic. They arise through the relationship and interactions between numerous functional elements involved in delivering the overall purpose of the system[4]. Human factors is about understanding human performance at work in the context of the socio-technical system in which the work takes place.

No single human failure should be capable of leading directly to a significant adverse event in any system where there is the potential for serious loss. However, the presence of multiple layers of defence can present a challenge for effective learning. For a significant adverse event to occur, multiple opportunities to prevent the incident will have failed. It is important not simply to focus solely on the 'obvious failures' (which typically involve actions or omissions by front-line personnel), even though removing any one of those failures would have prevented the event; effective learning needs to consider all of the relevant failures throughout the system.

Learning from adverse events must involve identifying and understanding the systemic factors and relationships at play. This includes taking into account

EXAMPLE:

Consequence of error

The severity of sentence for motoring offences tends to follow the severity of consequence rather than the significance of the human behaviour that led to the event. Speeding that does not result in an accident tends to be punished less severely than an accident caused by speeding; the 'error' in both cases is similar and the two events are often distinguished solely by luck.

[4] There is a considerable literature discussing the nature and characteristics of complex socio-technical systems, offering approaches to analysing and understanding them, including how they fail. See for example, Reason J, 1997, Managing the risks of organisational accidents.

the influence that management decisions, policies and even the regulatory framework can have.

The systems approach is now commonplace in most safety-critical industries. Systems-based thinking applies just as much to sectors such as finance, insurance, government and the emergency services, as it does to more engineering-based industries. They all rely on the effective and timely performance, relationships and interactions between a range of functions to achieve their purpose.

Serious adverse events usually arise from the interaction of three types of systemic factors[5] :

- **Organisational:** management systems and organisational structure, shift systems, roles and responsibilities, incentive schemes, contracts and commercial relationships etc., associated with people's jobs.
- **Job:** including the design of the workplace and work environment, and the demands the job makes on people's perceptual, cognitive and physical performance including interpersonal interactions.
- **Individual:** the skills, knowledge, attitudes, values, habits, personality and other attributes that individuals bring to their job.

The range of factors involved is rarely under the direct control of the person or team involved at the front-line. But they can be optimised or degraded by decisions made remote from the front-line in both time and space.

The human factors perspective places people at the centre of the system. It looks at the roles and interactions between people, as well as how the situation and context of work shape human performance.

There is also uncertainty in any complex situation. Identifying and understanding the uncertainties people faced in the events that preceded incidents, and how they interpreted and responded to them, is one of the most important contributions a human factors perspective can bring to investigating and learning.

Principle 4:
Adopt a systems approach.

Serious adverse events can only be understood in terms of the overall socio-technical system in which the event occurred. That means understanding and being open to the possibility of a need for change in any of the components of the system. Investigating why the controls the organisation thought it had in place were not effective in preventing the event, can bring a lot of insight and learning about systemic issues.

> **My criticisms are inevitably grounded in my findings about how various individuals acted during the course of that night, but it is right to recognise that those shortcomings were for the most part systemic in nature.**
>
> The Rt Hon Sir Martin Moore-Bick,
> Grenfell Tower Inquiry: Phase 1 Report, 2019

[5] HSG48 Reducing error and influencing behaviour. UK Health & Safety Executive, 1999.

2. KEY CONCEPTS IN LEARNING INVESTIGATIONS

2.4. The importance of situation and context

The concept of 'local rationality' means seeking to understand not simply what people did, but why they did it; 'standing in the shoes' of the individuals involved and trying to see the world as it seemed to them at the time. It means trying to 'get inside their head' and thereby anticipate how people are likely to think about future situations. Local rationality comprises two elements: the situation and the context. An investigation that seeks to adopt a human factors perspective must identify and understand both the situational and the contextual factors associated with the event.

2.4.1. Situation

Situation is the set of circumstances particular to the specific time and place in which an adverse event occurred. Situational factors are essentially factual and, in principle, are discoverable as 'evidence' of the situation the individuals involved were in *at the time the event occurred.*

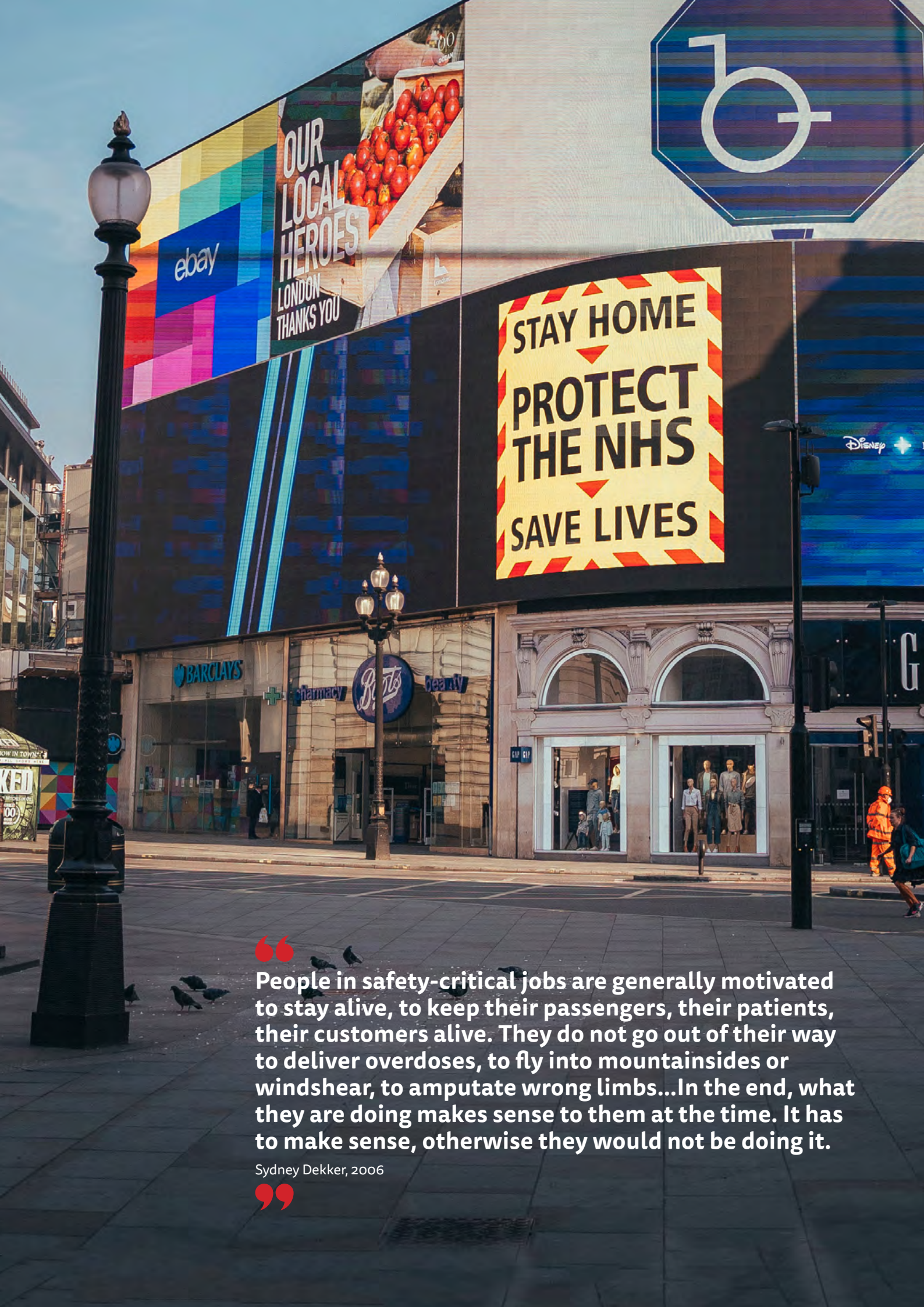
For example, the situation in a manufacturing plant might include factors such as: the state of equipment or the process (importantly, both as it actually is and as it is represented to the operators), current task demands and time pressure, objectives, staffing levels, roles and responsibilities, the state of the environment, and the availability and currency of procedures and other work aids.

EXPLAINER:

Situational factors

Situational factors are evidence of the situation at the time the event occurred, for example:

- The individuals involved were on the first of three 12-hour night shifts following four consecutive day shifts.
- The patient arrived at the hospital unaided, using public transport.
- The emergency shut-down system was known to have failed six times in the previous three months.
- The driver had driven the train on the same route at the same time of day more than 40 times; on no previous occasion had the signal been at red.
- The organisation had recently been re-structured; front-line operators now reported directly to the Shift Supervisor based in the administration building.
- The operation was one person short of required staffing at the time.
- At the time of the incident, operators were simultaneously monitoring two processes, both of which were out of their normal state.



People in safety-critical jobs are generally motivated to stay alive, to keep their passengers, their patients, their customers alive. They do not go out of their way to deliver overdoses, to fly into mountainsides or windshear, to amputate wrong limbs...In the end, what they are doing makes sense to them at the time. It has to make sense, otherwise they would not be doing it.

Sydney Dekker, 2006

2. KEY CONCEPTS IN LEARNING INVESTIGATIONS

2.4.2. Context

Context refers to the meaning ascribed to a situation by the individuals involved and the long-held beliefs they hold about the situation they are in. It means factors likely to influence what people believe about the immediate situation and what is expected of them.

Context is derived from prior knowledge, from what we have been led to believe, as well as our experience of similar situations in the past. It includes the influence of the values, priorities and goals of the organisation and society. By its nature, defining context involves some speculation in trying to ascribe meaning to people's intentions and behaviours that are not observable, and not available as factual evidence of what may have motivated decisions or behaviours.

In summary, *situation* is about the objective facts surrounding the role of people in an event. Identifying situational factors largely involves gathering objective evidence. They are often the reason why the event occurred on that particular day. *Context*, on the other hand, is about the beliefs, motivations, perceptions and values of the key individuals involved, whether at the sharp end or the blunt end of events. They frequently represent underlying weaknesses in the system.

Many incidents arise from the way situational and contextual factors interact. For example, operators performing safety-critical tasks are often subject to high levels of workload and competing task demands. Reliable performance requires the efficient and effective allocation of attention and effort between competing task demands. However, if the individual also holds an inappropriate belief that something is likely – or unlikely – to happen, or if they are motivated to allocate attention to competing tasks in a way that is not consistent with the actual risks involved, the risk of failure is higher.

Being clear about situational and contextual factors offers the potential to apply learning to a wider range of future scenarios than the one in which the failure was observed. Even if the specific equipment being used, or the specific activity or operation being performed are different, if the situational and contextual elements are sufficiently similar, the learning is likely to be relevant.

Identifying the key contextual factors that motivated how people perceived a situation, interpreted what was going on and decided what to do in the presence of uncertainty, can be extremely challenging. While it is beyond the scope of most incident investigations, it is possible to establish the influence deeper psychological and contextual factors may have played in events. It does, though, require professional skills and experience as well as good understanding and insight into operational realities.

EXPLAINER:

Contextual factors

Contextual factors relate to beliefs of individuals involved, for example:

- Earlier that day, management had emphasised the importance of achieving production targets.
- Operators knew that the contract with one of the customers included penalty clauses if targets were not met.
- Operators knew that some of the instruments had a high false alarm rate, so they tended not to trust them.
- The doctor's experience over many years had been that every patient with the condition had shown signs of extreme pain. At the time of the misdiagnosis, the patient appeared calm and relaxed.

“As is so often the case when we begin to learn the complexities of a situation, some of the issues that had seemed very clear at the outset had become more confused. Only much later would I fully understand the extent to which oversimplification obfuscates and complexity brings understanding.”

Diane Vaughan, 2016

CASE STUDY:

The space shuttle *Challenger*

Based on more than five years of deep study and research, Professor Diane Vaughan built a compelling picture of the complex context in which NASA made the decision to launch the space shuttle *Challenger* on the night of January 27th, 1986. Based on her research, Professor Vaughan was able to draw conclusions about the reasons for the loss of the shuttle the next day, and the deaths of the seven astronauts, that went significantly beyond those of the two formal enquiries that lacked the same understanding of context.

Her research included extensive analysis, using sociological as well as psychological methods and insights, of all the available evidence including records and documentation, together with transcripts of the personal testimony of those involved in making the decision. Her research covered all levels of NASA as a complex socio-technical system, from the political influence of the US Senate and Congress, the top level of NASA management, the launch team and individual project managers, senior managers in the major contractors, down to individual engineers.

Professor Vaughan’s extensive and detailed research provides a demonstration not only of just how complex the context in which critical decisions are made can be, but of how important it is to understand that context in order to properly learn from adverse events. Although few things are as complex or technically demanding as the decision to launch a space shuttle, the lessons about understanding the critical role of context in comprehending adverse events applies to every organisation that seeks to learn from its experiences.

For more details, see Vaughan, D (2016) *The Challenger Launch Decision*. Enlarged Edition. University of Chicago Press.

2. KEY CONCEPTS IN LEARNING INVESTIGATIONS

2.4.3. Standards of evidence for situational and contextual factors

For the majority of factors that define the situation when an event occurred, the evidence available should be relatively objective. In other words it can be established to a high degree of confidence without the need for speculation. There may be records or physical evidence available about the state of equipment, documentation about different people's roles and responsibilities, records of working hours or correspondence about targets, intentions or priorities preceding the event.

The kind of evidence needed to establish the *context* however, can be very different. Establishing contextual factors relevant to an event will generally rely on subjective material, often requiring some speculation and assumption. For the purpose of deep learning, this is not necessarily a bad thing as consideration of likely contextual factors leads to richer and deeper understanding of the influences behind human behaviour and performance in high risk situations.

The human factors perspective is about being prepared to apply a different level of certainty when deciding what evidence might be important about the context of people's decisions and actions. Frequently, the best that can be achieved is a standard of proof that relies on reasonable doubt, or the balance of probabilities, rather than factual certainty.

EXAMPLE:

Standard of proof

Fatigue can be a significant factor behind adverse events in many industries and is frequently cited in road traffic accidents. We know a great deal about the relationship between the quantity and quality of prior sleep and hours of wakefulness on the one hand, and the ability to pay attention and perform cognitive tasks on the other. Despite this, it can be difficult to establish to any objective standard of proof that poor decisions, lack of attention or unsafe behaviours performed by an otherwise capable and competent individual at a particular time in the past were attributable to fatigue.

CASE STUDY:

Energy industry incident

An incident in one of the energy industries led to a multiple loss of life. The investigators invited a human factors specialist to review the evidence they had gathered, including physical evidence from the scene, recordings and other data from equipment and work processes, as well as interviews with all the front-line operators working at the site at the time. At the heart of the incident was a failure of the team at the site to monitor, detect and act on evidence that they had lost control of a significant source of energy. This was despite the fact that a number of the senior members of the site team had 24 hour access to an IT system capable of displaying evidence that control over the energy was being lost.

The human factors specialist was keen to understand why none of the members of the team that could, in principle, have noticed signs of the loss of control, actually detected the signs or took action that could have prevented the incident. The specialist concluded that there were conflicts between the commercial, technical and safety responsibilities of senior team members. These conflicts were thought likely to have caused the senior team members to prioritise their time and attention to monitoring commercial, rather than technical data about the state of the operation in the key period before the incident. Consequently, no-one who had access to the critical data actually gave a high enough priority to monitoring it, given their competing responsibilities and demands on their time.

However, the formal investigation team took the view that the human factors specialist's conclusion could not be included in the formal incident investigation report because the conclusion was based on speculation about the motivations of the team members and how they had prioritised their interests and allocated their attention, rather than hard evidence about why they did not notice the signs of trouble.

2. KEY CONCEPTS IN LEARNING INVESTIGATIONS

Principle 5:

Identify and understand both the situational and the contextual factors associated with the event.

Look beyond individual performance and actions, and explore the complex interplay between psychological, social and organisational factors that influence decisions and actions. Consider how interactions between situational and contextual factors could lead to unexpected or undesirable human performance.

2.5. The positive role of people in safety management

The human factors perspective recognises the positive role and contribution of people in systems, rather than seeing them as weak links or as sources of failure, as most of the time people play a positive and active role in assuring safety and reliability.

Well-designed systems are resilient to many types of failure: human, organisational and technical. The judgement, flexibility and ability to adapt in the face of the many sources of uncertainty, conflicting organisational goals or imperfections in technology, are key elements in ensuring systems and organisations are resilient to upsets[6].

As well as identifying the potential to learn and improve from what goes wrong, this perspective provides opportunities to learn and improve by identifying what goes right and understanding how and why that is. The decisions, actions and behaviours that lead to good outcomes are frequently essentially the same as those that lead to adverse events. It is only the situation or context that is different.

[6] Hollnagel, E, Wears, R L, Braithwaite, J (2015). *From Safety-I to Safety-II: A White Paper.* Available at: https://bit.ly/Safety12WhitePaper

2.6. Intentionality

Recognising the difference between *intentional* and *unintentional* unsafe acts is important in determining the kind of changes that are needed to prevent future recurrence of similar adverse events. James Reason's classic 1990 book *Human Error* which sets out the Generic Error Modelling System, provides the most detailed explanation of what he refers to as 'unsafe acts' and the nature and characteristics of their classification into intentional and unintentional acts. The UK HSE's 1999 publication *Reducing error and influencing behaviour* (HSG48) provides guidance for managers and HSE professionals that draws on the same basic error types.

- **Intentional** unsafe acts are usually described as 'violations' and involve a deliberate deviation from an expected or prescribed course of action. Violations are usually characterised as being of three types - routine, situational or exceptional - and occur for different reasons according to the situation and motivations of the individuals involved. Importantly, they are intended to achieve successful system performance.
- **Unintentional** unsafe acts or failures are what are technically referred to as 'errors'. Errors are generally understood using the Skills-Rules-Knowledge framework of human performance[7]. Errors fall into two general types: slips and lapses (arising from failures when tasks are carried out at the skilled level of performance) and mistakes (associated with tasks carried out at respectively the rule-based and knowledge-based levels).

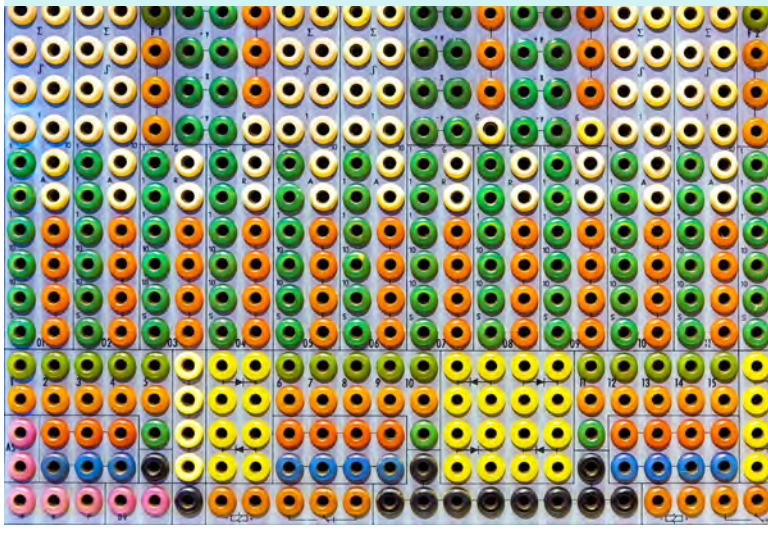
The distinction between intentional and unintentional unsafe acts can bring insight and lead to more effective learning.

EXAMPLE:

Unintentional error

Before the advent of mobile phones and computer-based telephone systems, the need to manually enter telephone numbers was a significant source of unintentional data entry errors (slips and/or lapses). The advent of modern technology, where phone numbers are stored in a system and selected without having to be manually entered, has largely removed the potential for such errors (though the potential still exists when the data are first entered into the automated system).

By contrast, recognising that an unsafe act was intentional, leads to questions about the situation and context that motivated the intention. Options for change usually involve systemic issues, from organisational change to a need for education and training, rather than automation.



[7] The Skills-Rules-Knowledge framework is based on the work of Jens Rasmussen. For a full description of the relationship between the S-R-K model and the various types of errors, see Chapter 3 'Performance levels and error types' in Reason, J. (1990). *Human Error*. New York: Cambridge University Press.

2. KEY CONCEPTS IN LEARNING INVESTIGATIONS

2.7. Work-as-done and work-as-imagined

There is frequently a major difference between the way those away from the operational front-line believe work is undertaken, and the realities of how work is actually done under the pressures, uncertainties, constraints, unexpected circumstances and so on, that are daily occurrences.

The human factors perspective focuses on understanding how work is actually performed, rather than what is documented in training, procedures, or equipment operating manuals. Investigations rarely generate significant and effective learning if they are based on limited or inadequate appreciation of how work is actually done.

An understanding of work-as-done is best achieved through active engagement at the work site with the participation and support of personnel who have recent experience of performing the work involved.[8]

Principle 6:

Recognise the potential for difference between the way work is imagined and the way work is actually done.

Investigators must be sensitive to the fact that 'work-as-done' often diverges significantly from how work is documented in formal procedures, disclosed or prescribed. The goal of learning is to improve work-as-done and then seek to better align how this is more accurately described and represented in formal procedures.

[8] The 25th Edition of Eurocontrol's 'Hindsight' magazine contains a range of articles providing the technical background to the concepts of work-as-done and work-as-imagined. Although based on application to air traffic management, the articles provide an excellent introduction to what the concepts mean, their relevance and how they can be used in applied contexts. See www.eurocontrol.int/sites/default/files/publication/files/hindsight-25.pdf

3. KEY CONCEPTS IN LEARNING AND SHARING

3.1. Learning from adverse events

This white paper is concerned with learning from adverse events; just one of many opportunities to learn and improve. A learning organisation will be constantly seeking improvement even in the absence of such events.

'Learning from adverse events' means the ability of an organisation to do two things:

1. To identify and extract the right learning from the adverse events it experiences.
2. To use that learning to make changes to the way it organises and controls its activities that are effective in reducing or preventing the recurrence of similar events.

Both of these are essential to learning from adverse events.

Effective organisational learning considers the wider system rather than the one immediately affected. It seeks to make the overall organisation robust against future events, rather than merely prevent a repetition of specific failures. It requires an understanding of how work is really done rather than how it is imagined. It also depends on a clear understanding of both the situation and the context in which the human contribution to the event took place.

Effective organisational learning also seeks to understand why the defences or controls the organisation thought it had in place were not effective in preventing the event, why those weaknesses were allowed to exist, and what changes need to be made to ensure controls are effective against future adverse events.[9]

> **Colossal disasters... are ultimately failures of design, but the lessons learned from those disasters can do more to advance engineering knowledge than all of the successful machines and structures in the world.**
>
> Henry Petroski, 1992

3.2. How do organisations learn?

Learning organisations examine all aspects of an adverse event, the context in which it happened and its precursors. They build a positive safety and learning culture; a culture where concerns and issues can be raised and evaluated fairly, without fear of blame or retribution, where behaviours, actions and motivations can be openly examined and understood. They also ensure the time and resources are available to support such examination.

Embedding learning from incident investigation activities is key to systems improvement. This can be achieved in various ways, for example:

- By documenting and sharing learning reports to make as many people as possible aware of the potential risk, as well as actions to avoid it. This applies both internally within an organisation as well as across an entire industry.
- By introducing additional checks or other controls over the way work is performed or implementing measures to improve or protect controls already in place.

[9] For an in-depth look at using barrier controls to reduce future adverse events, see CIEHF's *Human Factors in Barrier Management*, available from https://www.ergonomics.org.uk

- By incorporating learning from investigation findings into engineering standards, procedures and other elements of safety management systems.
- By using adverse events and the learning gained from them as case studies in training and competence assessments.

However, a distinction should be drawn between the above activities and the importance of also embedding a learning process into organisational design to ensure there are robust arrangements which serve as a driver of long-term improvement, for example:

- By incorporating learning into organisational design and understanding how the various parts of the organisation communicate, interact and support attainment of goals.
- By incorporating learning into business strategy, policy revision and development.
- By ensuring that learning processes and principles are evident in all aspects of the organisation's activities. This recognises that learning is a continuous process which might be triggered by an adverse event but each subsequent change should be subject to ongoing monitoring, review and improvement.

The decisions, actions, behaviours and communications of senior leaders – what they do and say, as well as what they do not do or do not say – are fundamental in promoting an effective learning culture. Much of the real challenge however lies with middle managers. Senior managers need to support and encourage the desired behaviour from lower level leaders and ensure the resources needed are available.

For an organisation to gain the maximum learning from its adverse events, leaders must be willing to ask difficult questions and to listen, learn and act on the answers - answers that can often be uncomfortable and challenging to those at the very top of the organisation. The ability and willingness to ask those difficult questions, and to

Genoa bridge collapse, August 2018

3. KEY CONCEPTS IN LEARNING AND SHARING

Figure 1: Simplified model of organisational learning from adverse events

> **The best way to reduce harm... is to embrace wholeheartedly a culture of learning.**
>
> The National Advisory Group on the Safety of Patients in England, 2013

accept and act on uncomfortable answers, is fundamental to a genuine learning organisation.

Learning can also be embedded by governments through regulations and licensing arrangements or demands for demonstrations of how specific threats are controlled. These tend to be put in place following the most extreme adverse events; those sufficiently serious that they have the potential to transform society's view and willingness to accept risk. Bodies such as insurers and finance companies also impose constraints on how companies manage different forms of risk.

Similarly, learning can be embedded through guidance and best practices produced by professional bodies and trade organisations intent on raising standards and reducing risk across an industry or professional group.

Figure 1 shows a simple model representing the relationship between adverse events and organisational learning. Learning in response to an adverse event is represented as a continuous feedback loop comprising five elements:

1. Accept the need for change.
2. Understand what needs to change.
3. Design effective change.
4. Implement, embed and communicate the change.
5. Monitor and evaluate the effectiveness of the change.

3.2.1. Accept the need for change

Organisational learning following an adverse event is driven by a recognition that there is a need to change. That depends on three things:

1. Awareness of the extent of actual harm, loss or damage associated with the event or concern over what could have happened.
2. The quality and credibility of the investigation.
3. A willingness to change within the leadership of the organisation, as well as among those who influence them (including shareholders, politicians and the general public).

The starting point for effective organisational learning is good quality and credible information about how and why the adverse event occurred. In the case of human factors, this often means recognising that there is a need to close the gap between the way work is imagined and the way work is actually done.

Closing that gap can mean accepting that the controls and other measures relied on to reduce risk and prevent adverse events are not sufficient or effective. It can mean recognising that additional measures are needed to protect and assure existing controls or that additional or different controls are needed.

Investigations often uncover anecdotal evidence that weaknesses contributing to an adverse event were known beforehand. For whatever reason, either the weakness had not been reported, recommended action had not been implemented, or the action that was taken was not effective.

The starting point for effective organisational learning is the recognition among leadership that performance can be enhanced, and that the cost of doing so is justifiable and in line with corporate values and strategic objectives.

3. KEY CONCEPTS IN LEARNING AND SHARING

Principle 7:

Accept that learning means changing.

Lessons identified (the complex interplay between the underlying factors identified) in an investigation report are not the same as lessons learned. If nothing changes in terms of the way the people in the organisation think, behave or react to future events and situations, nothing has been learned. Though change, in itself, does not mean effective learning – change must be effective in implementing the intent of recommendations, must be understood and accepted by those affected by it, and must be embedded so it is sustained.

> **It is far more difficult for effective learning to take place if the initial understanding of what has occurred is seriously flawed.**
>
> From *'An organization with a memory'* Department of Health, 2000.

3.2.2. Understand what needs to change

Investigating causes and context should not be confused with developing solutions. It is not usually difficult to identify 'quick fixes' that will at least give the appearance of learning and improvement to reduce future risk. Though simply having a list of actions or being able to demonstrate that actions have been implemented is, at best, unhelpful. Rather, the goal is to identify change that will be effective in reducing or removing the likelihood of recurrence of similar events. That can be difficult and will often be emotionally uncomfortable, challenging people's perceptions of their own abilities and how effective they are in their roles.

Sometimes it is clear what needs to change to fix an obvious weakness, sometimes called the 'low hanging fruit'. However, rapid responses should not preclude more detailed consideration of what can be learned. The most effective change, likely to bring sustainable improvement, will not always be obvious. For effective and enduring learning, the impact of change on the wider system must be understood. That means ensuring that deep lessons have been learned and that latent failures with the potential to occur in many different situations have been identified. Sometimes, change that might superficially appear to be only indirectly related to the incident is necessary to address deep systemic issues.

Good investigations will typically identify many different improvement opportunities. They can reveal weaknesses in the system which, whilst not directly implicated in the event that occurred, are nevertheless worthy of attention. Whilst it is important not to lose such opportunities, they need to be addressed as part of a coherent and prioritised improvement programme, rather than being imposed as part of the reaction to the event. Excessive numbers of recommendations can lead to poor prioritisation.

3.2.3. Design effective change

The third stage in the learning process involves deciding how to implement change that will be effective in a way that is both practical and achievable within the constraints and resources available. At the same time, change must not itself introduce or increase risk elsewhere.

As a general rule, people do not like change. Anything that involves a significant change in established ways of thinking or working, that interferes with the expectations and assumptions we hold about how the world around us works, or that interferes with or disrupts our relationship with those around us, has the potential to fail.

A key element of the human factors approach is to ensure change is properly designed and evaluated from the perspective of those who will be impacted by it. How will it change what is expected of them? This can have many dimensions, some of them subtle and many involving complex psychological and social processes, for example:

- Will a change make any aspect of working life more difficult, awkward, time consuming or be seen to be in some way unpleasant or unrewarding?
- Will it require people to learn new skills or knowledge or to stop using skills and knowledge they have invested effort in acquiring?
- Is the change consistent with the motivations and incentives that drive behaviour, or the values the individuals hold about themselves, their position in the organisation and their relationships with their peers?
- Most importantly, will people be expected to change ways of working that have been long established and to adopt ways of thinking and working that are new?

The design and evaluation of change can need to draw on many disciplines and people from across an organisation as well as, often, suppliers and other stakeholders.

If the need for change is accepted, the necessary changes have been well thought out and implementation of the change has been well managed with appropriate user engagement, the chances of success can be high. If the change makes a task easier, the reasons for the change are clear and the briefing and introduction of the change is well managed, change can be a positive experience. But where change increases the demands on staff, the effort needed to perform work, or expects people to change well-established skills or ways of working, the likelihood of failure can be high.

People do not usually like having to go to effort. We find it at least moderately uncomfortable and will go to some lengths to avoid it. If a change makes anyone's work more difficult, awkward, time consuming or unpleasant, it is unlikely to be sustained unless the reasons for the change are properly understood and accepted. So, where a necessary change unavoidably results in a task being more complex or demanding, it is even more important that the change process is managed correctly, otherwise the change is not likely to be sustained. In time, people will slip back into doing things 'the easy way' without understanding what was learned and why it is no longer acceptable.

Seeking to change aspects of an organisation's culture, such as trying to move to a culture that does not tolerate deviations or shortcuts, or expecting people to report minor events or weak signals that previously would have been considered unremarkable, needs sustained and consistent effort. It can take months and even years to see real progress.

3.2.4. Communicate, implement and embed the change

For learning to be effective, all stakeholders who need to implement or support change arising from learning must understand and accept the need for the change.

Communicating the need for change and engaging with stakeholders to ensure they understand why it is important is essential, though it alone is rarely sufficient. Support for change can also be provided by means such as redesigned work processes, equipment interfaces, support systems, training, supervision or even incentive schemes.

It is important that the knowledge gained from investigations about how work and situations can come together to lead to adverse events is properly captured and made available in a manner that influences the decisions and behaviour of future operations. The challenge is twofold. Partly it is about ensuring that knowledge about the reasons for the change is available, accessible and complete. Partly it is about ensuring that knowledge is presented in a manner that can be understood by the relevant groups in the future. Identifying respected peers, to communicate the need for change to employees, can support this.

Ensuring knowledge and learning from adverse events is accessible over time requires careful consideration and design. Differences in culture, experience, commercial and interpersonal relationships and social structures across large organisations can all mean that knowledge may need to be presented in several ways and retained in different structures. Particular effort is needed when the individuals affected by a proposed change have a high degree of discretion over how they work. In these cases, ensuring the stakeholders understand and accept the reason(s) for change is critical to effective learning. Where the 'pain' of change is borne by individuals who do not see themselves as having been directly involved in an event, it is even more important that the systems perspective is properly understood and the systemic reasons for the change are properly communicated.

Principle 8:

Understand that learning will only be enduring if change is embedded in a culture of learning and continuous improvement.

This means a culture that is open and fair, where people value and are motivated to learn and make change for the better and where the entire organisation is engaged in the learning process; learning and change are considered normal. If an organisation is defensive, learning will be inhibited.

3.2.5. Monitor and evaluate effectiveness of the change

Rather than simply measuring whether a change has been implemented, feedback means evaluating the impact of the change, whether intended or unintended. It is not sufficient simply to measure the completion of an action, for example "We have retrained 90% of staff". What is needed is to assess whether change has delivered the intended benefits, as well as whether there have been any unintended consequences.

Meaningful measures need to be identified that can be monitored through normal business processes to ensure that the benefits of change endure over time. There is always a risk that the impact of changes gradually erode until the performance of the organisation has reverted to its pre-incident state. Communicating change progress and successful goal attainment should help maintain a programme of change.

3.3. Why do organisations sometimes fail to learn?

This section illustrates how one or more weaknesses at each of the stages in Figure 1 can lead to a failure to learn effectively from adverse events:

1. Not accepting the need to change.
2. Not understanding what needs to change, by overly constraining the scope of change.
3. Not designing effective change by focusing on 'quick fixes'.
4. Failing to embed the reason for change including having a 'compliance mindset'.
5. Failing to monitor, sustain and drive continuous improvement.

3.3.1. Not accepting the need to change

When the consequences of adverse events are severe, the case for change is usually compelling. When the consequences of events are not severe however, and especially in the case of near misses and weak signals, lack of the ability to imagine what might have happened – what has been referred to as 'requisite imagination', one of the elements of a sense of 'chronic unease'[10] – can lead to resistance to change.

In the case of near misses, where the fact that some controls worked diverts attention from the fact that others failed, a reluctance to accept the need for change is even more likely. And in the case of weak signals, it takes a special kind of organisation to recognise that change is needed and to be willing to take action.

Some organisations identify a 'responsible manager' as the line manager for the work group that experienced the adverse event. It can then be challenging to extend beyond that manager's span of control when exploring potential recommendations or corrective actions.

Unwillingness to accept the need for change also occurs when there is a lack of understanding or recognition that the event was preventable. For example, it may be thought that an event only occurred due to the coincidence of a number of individually highly unlikely factors. If it is believed that the likelihood of those factors coinciding again are sufficiently remote, it can be easy to argue that there is no justification for change.

[10] Fruhen, L S, Flin, R H & McLeod, R (2013) Chronic unease for safety in managers: a conceptualisation, *Journal of Risk Research*, dx.doi.org/10.1080/13669877.2013.822924

3. KEY CONCEPTS IN LEARNING AND SHARING

Cognitive bias

Human decision making is affected by many biases and limitations[11] that can lead to failure to accept the need for change. Similarly, habituation over time can desensitise us to critical information. We start to take for granted the risks we live with on a daily basis. This is one reason why positive safety cultures are characterised by a sensitivity to risk and a healthy sense of unease that something can go wrong at any time[12] .

Two particular phenomena can lead to organisations not responding appropriately to adverse events: 'normalisation of deviance' and 'distancing by differencing'. In essence:

- Normalisation of deviance refers to situations where events that should not happen actually occur on a regular basis but nothing bad happens. Over time, they gradually become seen as 'business as usual' rather than prompting a need for investigation and possibly change.
- Distancing by differencing is where deviation from the norm is explained away as being the result of some one-off peculiarity of the situation rather than being an indicator of a significant weakness in arrangements.

With both normalisation of deviance and distancing by differencing, it becomes easy to dismiss, or fail to recognise or acknowledge, the significance of events.

EXAMPLE:

Normalisation of deviance

As an example of normalisation of deviance, consider the automatic warning system (AWS) implemented throughout the UK rail network. AWS was developed when semaphore signals were used across the rail network to alert drivers as they approached signals.

AWS is now implemented using colour light signals (similar to road traffic lights) together with an in-cab visual display (known as the 'sunflower'). There is also an audible warning the driver has to manually acknowledge.

The system is known to have a significant limitation in that the same audible warning covers both red and yellow signals so the most critical role of alerting the driver to the need to stop at a red signal is not supported by a unique alarm. Further, the single audible warning is meant to alert the driver to a variety of other events (such as speed restrictions).

This variety of uses of the audible warning increases the potential for confusion and has led to drivers passing red signals. Additional controls have been introduced to manage this risk.

Most train drivers and managers in the UK however, have grown up with the AWS system, including the multiple uses of the audible alarm. It has become a normal part of the train cab environment: the issue has become normalised. Consequently, although the weakness is well known, it can be overlooked as a contributory factor in incident investigations.

[11] For a comprehensive review and discussion of the nature and extent of cognitive bias, and the psychological processes that produce them, see Kahneman D, 2011, *Thinking, Fast and Slow.*

[12] ICSI, 2017 www.icsi-eu.org/documents/208/icsi_essentials_01_safety_culture_an.pdf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3. KEY CONCEPTS IN LEARNING AND SHARING

3.3.2. Overly constraining the scope of change

Organisations can seek to constrain the scope of change to the people, equipment and processes that were directly involved with the incident. This can lead to wider systemic contributory factors being overlooked or neglected. Such constraints may not be deliberate but they can both limit the rigour of the investigation – "what you look for is what you find" – and the scope of any learning and recommendations arising.

This is one of the reasons why many organisations still cling to the concept of 'human error' as being an acceptable explanation for the cause of adverse events rather than being an indicator of underlying issues. If the scope of failure can be restricted to an individual or small group, the scope of change needed can also be limited: remove them, retrain them or put more constraints around how they work.

While it can make life easier for management, overly constraining the scope of change to the individuals closest to the event ignores the systemic nature of most adverse events. It misses the opportunity to see events in the context of the overall system and to address systemic problems.

3.3.3. Focusing on 'quick fixes'

There can be pressure to act swiftly following an incident, and for leadership to be seen to be taking action quickly. The investigation process may not be the 'day job' for the staff involved so the time and resource available to identify and implement change are limited. This can mean action is focused on superficial, or active failures, rather than deeper underlying or latent issues which are usually systemic.

While there are often quick fixes that can help to prevent a recurrence of a specific event, they generally do not reflect all of the learning. Addressing the deep learning and identifying changes that will be enduring, sustainable and effective requires careful planning and execution. It requires adopting a system-wide perspective that includes the context of the event rather than focusing only on the immediate event and the situation and individuals involved at the time.

For example, if an investigation identifies that someone made an error in a particular step in a procedure, it might be tempting simply to add an additional check that the task has been performed correctly. This can be attractive as it is quick and easy to implement although it relies on the assumption that asking someone else to check a task will be effective. It is clear from much research and experience that relying on one person to check someone else's work is often not an effective control.

A deeper, more effective and sustainable learning might involve simplifying the whole procedure, roles and responsibilities, or the work environment where the work is carried out and building in engineered interlocks or removing the need for the error-prone task.

Even if a simple change to a procedure is the best way forward, the implications of the change must be properly evaluated and it must be implemented effectively. The change should ensure the new step does not increase effort unnecessarily. It should not make the procedure more difficult to comply with or create logistical or contractual issues, such as: who is going to make the check; will they have the necessary competence and authority; and will they be available when needed? The change process must consider how change will be introduced, implemented and monitored.

3.3.4. Failure to embed the reason for change

No amount of careful investigation will enhance learning unless the knowledge gained and the need

for improvement is understood by those expected to change. There need to be effective processes for sharing and accessing the knowledge, recognising when it is relevant, and ensuring it is brought to the attention of relevant groups at the right time.

Most investigations generate many recommendations. As long as the event is fresh in the mind of those affected and the investigation is credible, there will be an understanding of why change is needed. But over time, unless effort is made to retain it, organisational memory fades and the connection between the risk and the manner in which it is controlled is weakened. This can lead to a drift back to previous beliefs, expectations and behaviours and the change does not endure.

A compliance mindset

A compliance mindset, that is, a focus on 'ticking the regulator's box' rather than properly understanding and managing risk, encourages the wrong behaviours and can lead to failure to learn. The organisation becomes focused on external controls such as auditors and enforcement agencies and loses sight of the need to properly understand and manage the risks inherent in their activities.

A compliance mindset can be a particular issue for organisations with multinational footprints that operate essentially the same processes across regulatory boundaries. Sometimes there is cross-national consistency in regulations, such as in many areas of the aviation and maritime industries. A focus on local regulatory compliance can however interfere with the ability to learn about how success is achieved in one location, or how learning can be transferred across regimes with different regulations. Within a multinational organisation, managers in one country can overlook the organisation's own standards and requirements based on learning within the company, in favour of ticking the boxes necessary to be able to operate nationally.

EXAMPLE:

Refreshing organisational memory

A recent example of an effort to refresh memories and awareness of risk is the range of activities regarding the 30th anniversary of the Piper Alpha disaster that killed 167 workers in 1987. Through conferences, workshops and social media activities, the industry has sought to ensure that the reasons behind UK offshore safety regulations are revitalised. This helps the current generation of leaders and front-line operators understand the basis for the safety management systems and controls surrounding how they carry out their day-to-day activities.

3.3.5. Failure to monitor and evaluate the effectiveness of change

Sustained learning is not achieved simply by identifying and implementing a change. An effective learning process includes monitoring that is capable of revealing shortfalls in the new arrangements.

Frequently, what is measured is the status of actions raised and whether they have been closed by the target date. Success is judged by whether something has changed rather than whether the change has had the desired effect. What is needed are measures of system performance that show that the underlying causes of the event have been addressed.

To support monitoring, recommendations should be performance-orientated (for example, "Ensure personnel can identify the status of a hazardous or safety-critical system.") rather than solution-orientated (for example, "Provide a display that shows the valve position."). This makes it possible to identify the measures that will reveal whether the implemented change has actually reduced risk, that is, that the people involved actually do know the status of the hazardous or safety-critical system all of the time. Key performance indicators should reveal whether a change has led to the intended improvements in system performance.

Performance-based measures, however, do not always lend themselves to easy verification. The temptation simply to put in place recommendations or corrective actions where their fulfillment is easily verifiable, needs to be resisted. If learning is based on investigation of weak signals, for example, introducing a need to expend effort to verify the effectiveness of an action, it is unlikely to get the support and resource needed.

In any complex socio-technical system, and especially those that are tightly coupled, a change to one part of the system is likely to have consequences elsewhere. Ongoing monitoring arrangements should therefore include looking for signs of unintended consequences.


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4. INVESTIGATING INCIDENTS

4.1. When to investigate

Investigations are usually initiated either when the outcome of an event is sufficiently serious or is recognised as having had the potential to lead to a serious outcome. It is, however, often only good fortune that determines whether an adverse event translates into a near miss or an accident[13] . The most severe outcomes do not always prove the most reliable indicators of risk or opportunity for improvement.

The selection of adverse events for investigation is typically risk-based. However, the assessment of risk, particularly for near misses where no adverse outcome actually occurred, is inherently prone to cognitive bias. For example, there could be a tendency to assess risk based on events we can quickly bring to mind ('availability' bias); over-confidence in the ability of the organisation to deal with unexpected events; and/or a lack of imagination about what could have happened.

Incident investigations are usually structured around five stages:

1. Planning.

2. Gathering evidence.

3. Analysing the evidence.

4. Developing recommendations.

5. Reporting.

An effective risk-based approach to the selection of events for investigation should:

- Discourage outcome bias by not limiting investigation of events to those that actually had a serious adverse outcome, at the expense of those with the potential to have been much more severe.
- Encourage a 'just culture'[14] ; a culture in which people are not punished for actions, omissions or decisions commensurate with their experience and training but where gross negligence, wilful violations and destructive acts are not tolerated.[15]
- Prioritise improvement opportunities based on the collective risk picture and not merely on the most severe, embarrassing, media-worthy, challenging or expensive outcomes.
- Take into account the profile of adverse events experienced across the organisation and balance the capacity and demand for investigations.

In deciding which adverse events justify investigation, organisations should consider the opportunity for learning by considering issues such as:

- The actual and potential outcome associated with the incident.
- The number and rate of occurrence of similar events across the organisation.
- The exposure to systems, operations and situations recognisably similar to those where the adverse event occurred.
- The likelihood of recurrence.

[13] Health & Safety Executive (2014). Investigating accidents and incidents. Available at www.hse.gov.uk/pubns/hsg245.pdf Dekker, S (2017). Just Culture. Restoring Trust and Accountability in Your Organization. Boca Raton, FL: CRC Press.

[14] Dekker, S (2017). Just Culture. Restoring Trust and Accountability in Your Organization. Boca Raton, FL: CRC Press.

[15] Eurocontrol (2019). Just Culture. Available at www.eurocontrol.int/articles/just-culture

4.2. The dangers of bias

Once the outcome of an event is known, it is all too easy to allow bias to creep in when looking back, interpreting actions and viewing the chain of events through a 'retrospectoscope'.

Hindsight bias leads to counterfactual reasoning, that is, focusing on what *should* have happened or making judgements about what the actors involved *should* have known based on knowledge of how events actually turned out. This can lead to seriously deficient conclusions and learning compared to an investigation that focuses on understanding the situation faced by the individuals involved, and what they actually knew or had good reason to believe or expect at the time they acted.

Of course, investigators themselves are not immune to bias. An investigator's understanding of an incident is filtered through their own experience, mental models, beliefs and expectations. These can have a significant impact on the way evidence is converted to information and subsequently interpreted. It is therefore important to build strategies into an investigation to limit the impact of hindsight bias.

Investigations should try to capture multiple independent views on the event, avoiding the potential for one view to dominate. Any investigation must have access to individuals with practical and recent experience of the realities of the job where the event occurred. Such domain knowledge often provides insight into otherwise inexplicable events.

4.3. Planning

The human factors perspective needs to be integrated into all of these stages. Planning for an investigation needs to take into account the need to adopt good practice in human factors. For complex events, that means having adequate access to appropriate skills and competence in human factors.

In 2000, the UK Health & Safety Executive commissioned a project[16] to evaluate the tools and techniques used for incident investigation in UK industry. The research involved a telephone survey of 1500 companies, together with 100 face-to-face interviews. The telephone interviews covered a wide spectrum of commerce and industry, ranging from micro-businesses and Subject Matter Experts to large companies.

The majority of the respondents (83%) did not report any formal model of accident causation in use in their organisation. Their investigations usually involved creating narrative descriptions of the incident, with some free text descriptions setting out possible causes. The focus was on the individuals directly involved and the obvious contributing factors. Once these were identified, the investigation was typically seen as complete. Underlying causes that may have influenced behaviour or led to unsafe conditions were rarely addressed.

[16] Henderson, J, Whittington, C, Wright, K & Embrey, D (2001). Accident Investigation – The Drivers, Methods and Outcomes. Health & Safety Executive, Report No. RSU: 4002/R68.047.

4. INVESTIGATING INCIDENTS

4.4. Gathering evidence

Gathering evidence can be considered in two phases:

1. Initial information capture immediately after the event, typically at the location(s) where the event occurred. There may be time pressure associated with operational demands as well as the imperative to secure and preserve perishable evidence that could decay or be destroyed over time.
2. Subsequent information capture, exploring deeper issues in slower time such as procedures, oversight and competence management arrangements.

Both phases have challenges and opportunities. Adopting a human factors perspective will serve the investigator well in thinking about sources of evidence, going beyond the 'fallible individual' mindset, and towards searching for the underlying systemic issues.

4.4.1. Initial information capture

There are few specific human factors tools available to use during the immediate aftermath of an incident. A human factors perspective however can be helpful, both in being aware of the kinds of information that can provide insight, as well as of the value and limitations of different types of 'evidence' that can be immediately available.

Local adaptation

Experienced human factors investigators are sensitive to signs that users have adapted the work environment, equipment or tools to better support their work. These 'sticking plasters' can take many forms, such as sticky notes or hand written labels affixed to equipment or written procedures, books used to raise displays, or lighting turned off to avoid glare. Features such as these can indicate shortcomings in the design of the work environment that interfere with reliable human performance. Evidence about some situational factors such as allocation of responsibilities at the time, competing priorities or task demands, information that is ambiguous or difficult to access, background noise or distractions, can be perishable especially when events are looked at with the benefit of hindsight. It is especially important to explore and record these details as close in time to the events as is practicable.

Interviews

Interviews with those involved in the events, whether directly or indirectly, also form a core part of any investigation. As the memories on which witness evidence is based are perishable, the emphasis must be on capturing an account from those with first-hand experience as soon as possible after the incident. However, the individuals involved may be traumatised by the events or have fears of the consequences for themselves, their families or their colleagues. Sensitivity, empathy and good interpersonal skills are critical in capturing these first-hand accounts.

Eyewitness testimony is also fallible and prone to many biases and errors of perception, recall and reasoning. We frequently see, interpret or report events in terms of what we expect rather than what actually happened. If our attention and working memory are occupied, we can fail to see or detect events that otherwise appear obvious[17] . These and other fallibilities of eyewitness accounts can lead to misleading, even conflicting, accounts of the same events by different eyewitnesses.

First-hand accounts may, however, provide the only opportunity there is to gather information that will be otherwise inaccessible. This is especially true when it comes to trying to understand the local rationality, that is, why people made the decisions or took the actions they did, what motivated them and what they believed to be the situation they were in at the time[18]. First-hand accounts of eyewitnesses should be recorded verbatim.

It is essential to focus the immediate first-hand interviews on the event itself, establishing the facts of the situation as they existed at the time and as much information as possible about the context the individuals involved may have believed they were in when they took critical decisions or actions. Methods such as the critical decision method[19] and cognitive interview techniques[20] can be used to structure first-hand interviews. Techniques such as these are complex and should only be used by suitably qualified and competent people.

Fatigue

It is not possible to provide guidance on addressing all potential systemic factors here. The issue of fatigue, however, warrants mention as it is so often suspected as contributing to adverse events, particularly where shift work is involved. Prior sleep and hours of wakefulness are key determinants of fatigue. If there is reason to suspect fatigue might be a factor, interviews conducted immediately after the event can be the only opportunity to establish the sleep/wake patterns of the individuals involved over the preceding days. If this information is not captured as soon as possible after the event, it is likely to be lost forever.

EXAMPLES:

Local adaptation

In the investigation of the explosion and fire following overfilling of a fuel storage tank at the Buncefield fuel storage facility in England in 2005, investigators wondered why control room operators had brought their own alarm clock into the control room. It turned out that the operators used the alarm clock to monitor how long a fuel transfer had been underway – a critical piece of information – as there was no easy way to do this with the equipment provided.

In an investigation into the runaway of a road-rail vehicle in 2012, the UK's Rail Accident Investigation Branch identified that the vehicle concerned had a wiring irregularity in a safety system, which may have caused problems with its operation in the past. The operators had placed a handwritten note on the vehicle to remind users of its correct operation.

Report 09/2013: Collision at Bradford Interchange station, Rail Accident Investigation Branch

[17] An example of this attentional blindness is the well-known 'Moonwalking Gorilla'. There are many other examples circulating on the internet.

[18] Strauch, B (2004). Investigating Human Error: Incidents, Accidents, and Complex Systems. Ashgate

[19] Crandall, B, Klein, ., Hoffman, R R (2006). Working Minds: A Practitioner's Guide to Cognitive Task Analysis. Cambridge, MA: MIT Press.

[20] Fisher, R P, Geiselman, R E (1992). Memory Enhancing Techniques for Investigative Interviewing: The Cognitive Interview. Springfield, IL: Charles C Thomas.

4.4.2. Subsequent information capture

There are a variety of established analysis methods that can assist the investigator integrating the human factors perspective into the main investigation and inform the kind of information that might be useful. Published reviews are available that provide guidance on selecting and applying tools that support a human factors and systems perspective on incident investigation[21, 22].

As with the site phase, much of the evidence collection during the main investigation will follow established good investigation practice. Much, though not all, of the general material gathered will often have some relevance to the investigation of human performance[23], for instance, site observations, data recorders and voice recordings can provide information on aspects such as task design, workload and verbal communications.

Interviews

Interviews conducted at this stage can explore organisational issues such as how work is controlled, training and competence, supervision arrangements, roles and responsibilities, as well as things like commercial relationships, performance targets and incentive schemes. These are all factors where it should be possible to establish a basis of fact about the situation associated with the event through objective sources, without calling on opinion or speculation.

Interviews can also provide a means of exploring contextual factors such as the possible motivations behind decisions or actions, perceptions of leadership intentions and values, and culture, including whether people feel comfortable speaking up or stopping work if they have concerns or about bringing bad news to management. Interviews can be a key source of information about the daily reality of how work is actually done.

The investigation of contextual factors is complex and can be difficult. They are not directly observable, may leave little trace or evidence, and can require people to be prepared to speak about issues that make them uncomfortable or feel insecure. Special skills and competence is required of an investigator in addressing these issues during interviews, together with the insight and experience to know what questions to ask and what issues to explore, as well as, critically, knowing when to stop.

Documentation

Documentation can offer insight into an organisation's approach to safety and risk management, as reflected in rules and procedures, technical standards and

[21] Underwood, P, Waterson, P (2013). Accident analysis models and methods: guidance for safety professionals. Loughborough: Loughborough University, 28 pp.

[22] Salmon, P et al. (2011). Human Factors Methods and Accident Analysis. Practical Guidance and Case Study Applications. Ashgate

[23] ATSB (2008). Analysis, Causality and Proof in Safety Investigations. ATSB Transport Safety Report AR-2007-053. Canberra: ATSB. Available at www.atsb.gov.au/media/27767/ar2007053.pdf

methods of assurance of competence and the control of work. The focus is on identifying how effective the safety or risk management system is in optimising the situational factors that influence performance at the front-line.

Written procedures, even including the handwritten notes and amendments that often accompany them, do not necessarily reflect how a task is carried out in practice. Other useful documentation can include hazard analyses, performance records and the organisation's strategic plan, including short and long-term goals and objectives. Variations from documented procedures and analyses are, however, often implicitly condoned by line management as being necessary to deliver productivity under real-world constraints. Documentation reviews should be complemented by other evidence from observations and interviews involving staff with current experience of the task.

To be able to learn not only from what went wrong but from why things usually go right, the investigator should not only capture, record and analyse the weaknesses arising from processes and tasks associated with the incident but also their strengths. Analysis of the factors associated with strengths and weaknesses can equally result in safety learning.

4.5. Analysing the evidence

Once all evidence about what happened and the situational and contextual factors associated with the event have been collected, a thorough analysis of the information takes place.

Methods used to analyse evidence must be appropriate to the complexity of the issues and systems under investigation. In complex socio-technical systems, the tools and techniques used must go beyond single or linear causation models and allow users to map the interactions between contributory factors. Human factors offers a number of well-established methods for structuring the analysis of investigation evidence including:

- The Human Factors Analysis and Classification System (HFACS)[24, 25]
- Systems Engineering Initiative for Patient Safety (SEIPS)[26]
- Accimap[27, 28]
- Systems-Theoretic Accident Model and Processes (STAMP)[29]

[24] Shappell, S A (2000). The Human factors Analysis and Classification system – HFACS. DOT/FAA/AM-00/7.

[25] Skybrary Human Factors Analysis and Classification system (HFACS). www.skybrary.aero/index.php/Human_Factors_Analysis_and_Classification_System_(HFACS)#Further_Reading

[26] Holden, R J et al, (2013). SEIPS 2.0: A human factors framework for studying and improving the work of healthcare professionals and patients. Ergonomics 56(11), 1669-1686.

[27] Rasmussen, J (1997). Risk management in a dynamic society: a modelling problem. Safety Science, 27:2/3, 183-213.

[28] Svedung, I, Rasmussen, J (2002). Graphic representation of accident scenarios: mapping system structure and the causation of accidents. Safety Science, 40:5, 397-417.

[29] Leveson, N (2004). A new accident model for engineering safer systems. Safety Science, 42:4, 237-270.

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4.5.1. Task analysis

Task analysis is probably the most fundamental and widely used analysis technique in human factors. It provides an explicit representation of how tasks are performed, the demands and expectations of people performing tasks, as well as important characteristics of the task structure. Task analysis can take many different forms depending on the specific objectives, including the information captured and how that information is represented. Depending on how it is structured, task analysis can provide great insight into many aspects, both of how tasks are expected to be performed, as well as how they are performed in reality.

For the investigator, task analysis can support an explicit comparison of tasks as set out in a company procedure (work-as-imagined) against how the task was actually performed in the period before and during the event (work-as-done). It should be possible to build a task analysis illustrating the two perspectives from the evidence captured in the investigation phase.

A key element of the task analysis is that it should not only identify the activities undertaken but also who undertakes them and when. It is important to be able to understand not only the actions or omissions that led to the event but also the other tasks that personnel were expected to be undertaking concurrently, the clarity of roles, job demands and competence requirements.

Formal techniques such as Hierarchical Task Analysis (HTA)[30] can be used to represent the data collected. Building a formalised and structured view of the difference between the expected and actual task structures can highlight important differences. It also allows exploration of the reasons behind differences between work-as-imagined and work-as-done. Such reasons might include the realities of working conditions, availability of skills and experience or simply established custom and practice, such as social norms that have developed over time within the organisation or team.

Conducting high quality task analysis requires an analytical mindset, as well as specific competence and experience, especially when investigating complex accidents.

EXPLAINER:

Critical Path Analysis

Task analysis can support other detailed examinations of system performance. One example is Critical Path Analysis (Baber, 2004), which can be used to model performance times. Task analysis defines the sequence of task operations, and then CPA calculates the time required for those tasks based on standard performance time data. Stanton and Baber (2008) used CPA to examine the signaller's actions during the rail accident at Ladbroke Grove in 1999, in response to criticisms of the time taken to respond. They demonstrated that the response time was, in fact, in line with predicted times from CPA based on published data.

Baber, C (2004) Critical Path Analysis. In N A Stanton et al (eds), Handbook of Human Factors and Ergonomics Methods.

Stanton, N A and Baber, C (2008) Modelling of human alarm handling response times: a case study of the Ladbroke Grove rail accident in the UK, Ergonomics, 51:4

[30] Shepherd, A (2000). Hierarchical Task Analysis. London: Taylor and Francis.

4.5.2. Barrier-based approaches

Barrier-based investigation methods (such as STAMP and the Tripod method[31]) are based on the concept of understanding what controls, or barriers, were expected to prevent an adverse event, and then understanding how and why those controls failed. Figure 2 illustrates how the widely used Bowtie Analysis method, for identifying and representing the controls against major adverse events, can be used to support organisation of the evidence in terms of barrier performance.

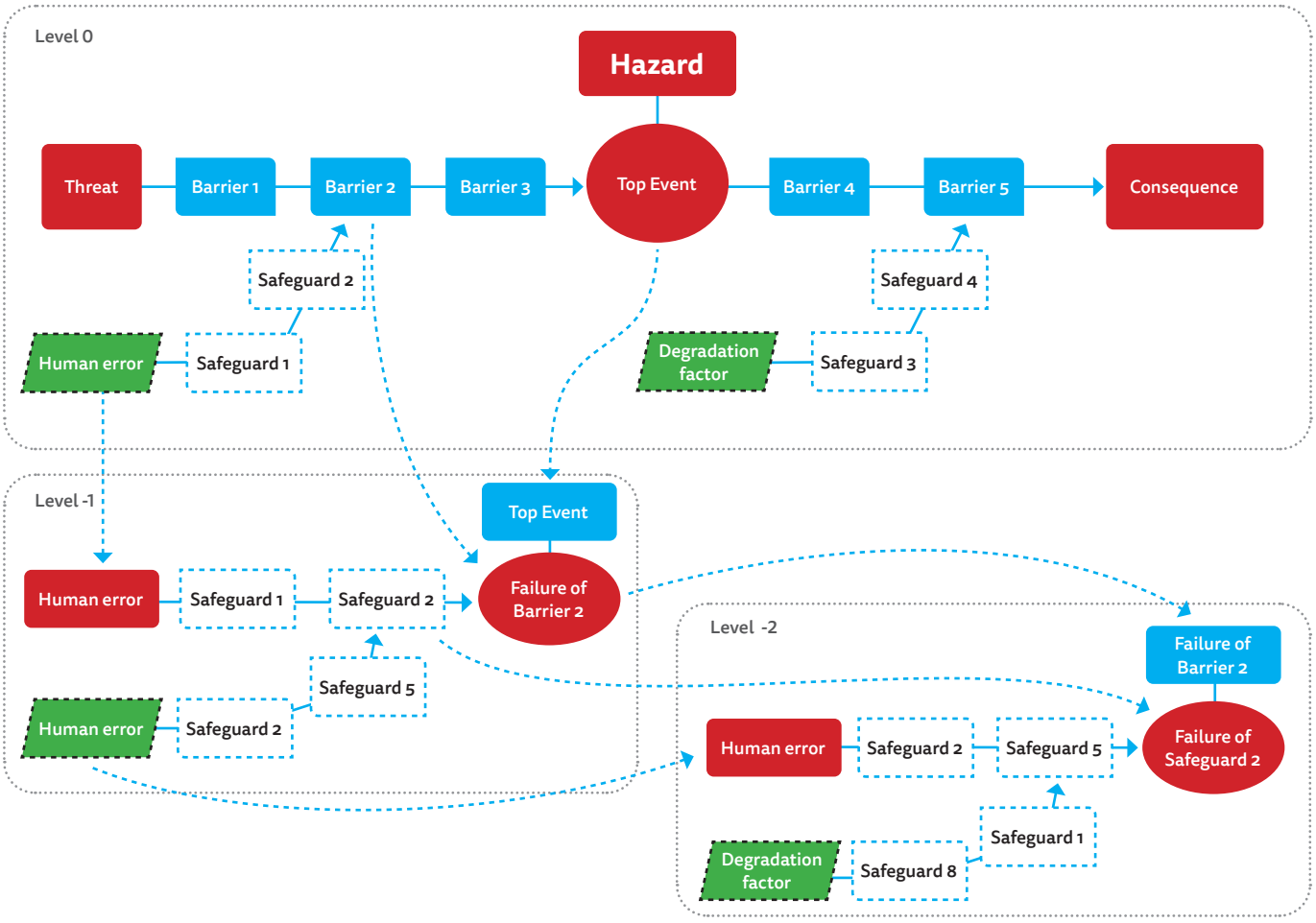

Figure 2: Illustration of how a layered approach to Bowtie Analysis can be used to identify the barriers that should have prevented adverse events, to investigate how and why those barriers failed and to identify safeguards that could be implemented to assure barrier performance[32].

[31] The TRIPOD method: https://publishing.energyinst.org/tripod

[32] Human Factors in Barrier Management, CIEHF, 2017

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4.6. Developing recommendations

The core of human factors as a scientific and engineering-based discipline is design. Human factors prioritises the design of equipment, tasks and organisations at all levels in a system. The goal is to optimise overall system performance while optimising human performance and wellbeing.

Taking the systems perspective means that the range of interventions available to minimise the risk of an adverse event recurring is not limited to issues surrounding the individual(s) at the sharp end. Human factors recommendations to embed learning can be targeted at whatever level in a system hierarchy is relevant, such as the design of equipment, interfaces and tasks, the environment within which work takes place, or the management system and organisational arrangements that create the culture and conditions for work. Raising the focus of recommendations to the systems level has a much wider impact than focusing solely on the individuals involved.

It is essential to separate *recommendations* from *solutions*. An investigation should focus on generating recommendations framed in terms of desired system performance. They should not seek to define the precise solution because solutions depend on factors and constraints outside the scope of an investigation.

For example, the explosion and fires at the Buncefield fuel storage site in 2005 occurred due to a storage tank being overfilled. In part, the overfill occurred because operators did not have a clear indication of the level of fuel in the tank, together with failure of both a warning system and an automated shut-down system. A *recommendation* based on what was learned in the investigation could include: "Ensure that control room operators can maintain effective awareness of the level of fuel in the tank at all times" without specifying how that awareness is to be achieved. A *solution* would be either to design and develop, or to procure, an effective and reliable display of the tank fuel level in the control room, together with more reliable alerting and shut-down systems. The solution eventually agreed and implemented will depend on technology, cost and other engineering and operational constraints. A more generic recommendation might be to: "Ensure that effective level control can be maintained at all times", as this might prompt examination of whether it is appropriate to have manual intervention in the filling process.

Maintaining a clear distinction between recommendations and solutions also makes it easier to define the expected performance improvement. It helps to maintain a focus on whether that improved performance has been achieved and is being maintained.

Principle 9:

Do not confuse recommendations with solutions.

Recommendations should set out what improvement is needed, without defining how that improvement is to be achieved. Solutions are concerned with satisfying recommendations in a way that is practical, effective and sustainable. Good recommendations allow opportunity for a range of solutions. Recommendations should be linked to system performance such that the reason for the change remains understood as the solution is developed and implemented.

4. INVESTIGATING INCIDENTS

4.7. Reporting

When an investigation is complete, its findings need to be disseminated. In most cases this will be via a written report, although new media provides opportunities for more inclusive or accessible presentation (see, for instance, the French national investigation body's animation of the Air France 447 crash in 2009[33]).

There are some basic principles of usability in the writing and presentation of investigation reports that are worth summarising here.

Firstly, be clear about the audience for the report. The report might be intended for the organisation involved, the wider industry or even the public. Being clear about the audience helps, for example, to judge the amount of company-specific references to use as well as ensuring the content is pitched at the right level of technical or operational understanding.

Readability is crucial in influencing the impact the investigation has on learning. Readability is partly about using plain language and partly about having a simple and clear report structure. The report should be objective and logical, describing both factual evidence and analysis in a clear and accessible manner. For the reader to understand the case for initiating change after the incident, they need to be able to see a clear relationship between the evidence, the analysis and the recommendations.

An investigation report should aim to tell a story:

- **What happened.** Factual details about the incident or accident and how these compare with what normally happens when things go well.
- **The situation** surrounding the events:
  - When it happened: not just accurate timing of the event itself but the timeline leading up to and following it.
  - Where it happened: the location of the incident as well as any related locations (for example, control rooms or the journey of a vehicle involved).
  - Who was involved: key actors, roles and responsibilities and organisations, which may include influencers remote from the front-line as well as contractors and suppliers.
- **The context** of the event:
  - What the individuals involved are likely to have believed or expected based on what they had been told or previous experience.
  - Individuals' level of situation awareness prior to the events.
  - Motivations, incentives and how individuals may have benefitted by deviating from procedures, for example.
  - How individuals are likely to have perceived and prioritised goals and objectives.
- **How it happened.** How the course of events deviated from what was expected or prescribed.
- **Why it happened.** The explanation of why the deviations from the expected events occurred, what barriers or controls failed, and why and how system functions may have interacted to produce the unwanted outcome.

Recommendations and learning points should be clearly derived from the evidence chain and analysis, identifying performance improvements intended to prevent similar events from reoccurring. Recommendations need to be presented with the context in which they have been derived, in order that the purpose of the change remains clearly visible and understood.

[33] www.youtube.com/watch?v=_rPZEPPfNCU

4.7.1. Integrating human factors into the investigation report

Human factors material should be integrated within the report as opposed to being isolated and limited to a dedicated section. In some cases, specific sub-headings addressing human factors issues relevant to the investigation will be needed, such as:

- Human performance issues, such as fatigue.
- Organisational factors, such as safety culture.
- Equipment design and layout, such as usability and accessibility.

Human factors-specific topics should be given equal prominence with other detailed technical areas of the investigation.

Careful consideration should also be given to how human factors is conveyed so that the reader understands its value. Two main challenges need to be overcome here:

- Human factors is still sometimes seen as 'common sense' and frequently considered as no more than subjective opinion.
- As with any other technical topic area, the report should recognise that the reader is unlikely to be a subject matter expert in human factors.

The human factors content of the report must be as objective as possible and conclusions reached must, as far as possible, be evidence-based. At the same time, the difference between the evidence-based analysis of the situational factors likely to have motivated human performance, and the inevitably more subjective and opinion-based analysis of the context individuals believed they were in, must be made clear.

Reference to the wider scientific and technical literature, as well as learning from previous incident investigations, can be helpful and add weight and credibility to human factors conclusions.

Jargon should be avoided and technical terms translated into plain English wherever possible. This is particularly important when describing aspects of human error. Terms such as 'mistake', 'lapse', or 'violation', whilst having specific meanings in a human factors context, can nevertheless be widely misunderstood and can have pejorative connotations that have no place in a no-blame safety investigation report. The alternative to using such terms is to adopt an entirely neutral stance and simply describe what happened in factual terms. As such, human performance should be discussed with regard to decisions, actions and behaviours, and the likely influences on them, that have been concluded to have caused or contributed to the outcome. This should be based on objective evidence in the case of situational factors, or on the balance of probabilities in the case of contextual factors. This is good practice for the human factors investigator.


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4.7.2. Knowledge management

A challenge for all organisations is the need to maintain an 'organisational memory' such that learning gained from an event can endure over time. Learning cannot be considered to be achieved unless learning about the reasons for a failure are embedded in a manner that allows it to be accessed and understood in the future.

All too often, an organisation will investigate an adverse event, understand the causes, implement change and then allow the changes gradually to revert over time because the lessons from the investigation are inadequately embedded. Years later, the same incident recurs and the same or similar lessons have to be 'learned' over again.

To overcome this, there needs to be effective knowledge management arrangements in place. Effective knowledge management is complex and beyond the scope of this white paper. It is, however, important to consider what information from the investigation report should be made accessible.

Many organisations adopt taxonomies for recording 'root causes', often to support trend analysis. Such taxonomies should be treated with caution where they seek to categorise human factors issues. Rather than rely on simple taxonomies alone, the knowledge management system needs to capture information about the human and system behaviour that led to the event, the performance improvement recommendations identified and the rationale behind those recommendations. This is particularly important to combat the likelihood that new arrangements reduce the visibility of risk, so that the new arrangements come under pressure as there is no longer a memory of why they are in place.

Knowledge management also needs to record the key performance indicators that can provide reliable monitoring of the efficacy of any new arrangements.

5. RECAP: THE NINE PRINCIPLES

Principle 1
Be prepared to accept a broad range of types and standards of evidence.

(see section 1.3)

Principle 2
Seek opportunities for learning beyond actual loss events.

(see section 1.4)

Principle 3
Avoid searching for blame.

(see section 2.2)

Principle 4
Adopt a systems approach.

(see section 2.3)

Principle 5
Identify and understand both the situational and the contextual factors associated with the event.

(see section 2.4)

Principle 6
Recognise the potential for difference between the way work is imagined and the way work is actually done.

(see section 2.7)

Principle 7
Accept that learning means changing.

(see section 3.2)

Principle 8
Understand that learning will only be enduring if change is embedded in a culture of learning and continuous improvement.

(see section 3.2)

Principle 9
Do not confuse recommendations with solutions.

(see section 4.6)

US Airways flight 1549 ditching in the Hudson River, January 2009

6. ABOUT THE CIEHF

The CIEHF has represented the interests of those engaged in professional activities in the disciplines of ergonomics and human factors for more than 70 years. With a membership drawn from over 40 countries, the CIEHF has long been recognised as one of the most influential bodies representing human factors professionals. Membership of the CIEHF covers domains as diverse as defence and aerospace, healthcare, sports and leisure, transportation, consumer products, the automotive industry, computer systems, telecommunications, and the energy, mining and petrochemicals industries.

As a technical discipline, ergonomics and human factors draws on three fundamental knowledge areas:

1. Scientific research, usually published in peer-reviewed scientific journals, in subject areas ranging from psychology, sociology and anthropology, through physiology, biomechanics and anatomy, to engineering, healthcare, medicine and management science.
2. The learning and understanding of the realities of human performance and behaviour in complex systems that comes from investigations into unwanted events as well as everyday work.
3. Practical experience applying the knowledge and methods of ergonomics and human factors in situations, honed by feedback on how successful the interventions have been and the impact they have had.

The professional practice of ergonomics and human factors has been largely focused around four issues:

1. Protecting people from risks to their health, safety and wellbeing by supporting regulatory requirements (such as, in the UK, COMAH safety cases).
2. Assuring reliable human performance in high hazard sectors.
3. Supporting capital procurement projects for major national infrastructure and capital assets in industries including defence, road, rail and air transportation and nuclear power.
4. The design and implementation of new technology and systems in ways that support human performance and wellbeing and that minimise risk.

ACKNOWLEDGEMENTS

The CIEHF would like to acknowledge the contribution of the following people, both CIEHF members and others, who contributed to the preparation of this white paper:

Steering Group

Ron McLeod (Chair)
Jon Berman
Claire Dickinson
Donna Forsyth
Tina Worthy

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The following individuals contributed to one or more of the sub-groups developing and/or reviewing content on individual topics addressed within the paper:
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Lauren Morgan
Linda Sørensen
Amanda Widdowson
Mark Young

Reviewers

The following individuals kindly contributed their time to provide review and comment on the final draft of the paper:
Lee Allford
Martin Anderson
Peter Buckle
Cheryl Mackenzie
Steve Shorrock
Patrick Waterson

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