1.0 Introduction

In this talk I want to stand back and look at how we think about responsibility for safety on a big canvas. You already know my answer from the title, but I want to examine the issue in some detail as what the word responsibility means changes depending on our point of view and the type of question we are asking. I want to contrast the concepts of responsibility and accountability and will use examples from a wide range of high-hazard industries and occupations to make my case. Finally I want to consider the difference between outcomes and actions because that creates considerable problems in areas such as the law and the public perception of what safety is and what it involves.

I start by looking at how we all think about responsibility for an accident. The typical interpretation, still most common amongst managers as well as the media and the general public, is that the person closest to the final event is the one who caused it, either by their action or inaction. We find this commonly described as Human Error when it implies that we have reached the end of the story, we have found who to blame! The whole problem here is that we have the benefit of hindsight, after the incident. we can see what was coming and, steered by a number of cognitive mechanisms, we easily assume that the person must have seen it coming too, as well as being able to foresee the actual consequences. Because they obviously did the wrong thing, despite knowing all this, most people then blame them for causing the accident or at least allowing it to happen. Now as specialists in the safety area, armed with professional investigation skills, we know that this picture, that they saw what was coming and deliberately chose to act that way, is rarely, if ever, true, but the further we stand off from the events, the more that our natural cognitive mechanisms drive us to this interpretation.

So first, what are those mechanisms and why are they so powerful? Why do other people so often accept an overly simplistic account of how accidents happen?

1.1 Cognitive biases

1.1.1 Attribution bias

Blame, attribution and hindsight bias are all linked together in the way people go about assigning responsibility to people after accidents. Blame is a basic human response to events or states we do not like. We feel that someone has caused an accident and we feel dissatisfied if there is no-one to blame. We do not blame machinery for failing, nor do we even apportion much blame, if any, to non-human species. When a dog does something unpleasant we do not blame the dog, after all ‘they’re only a dog’, but we might well blame the owner for their dog’s acts. Those of us who are sufficiently sophisticated know that while we may not blame machinery, we may blame its designer, the owner, its operators or the maintainers, any or all of whom who we feel should not have allowed it to break down. In each case we feel comforted when we finally find a person to blame. Social determinism - It’s a fair cop, but society’s to blame – is never very personally satisfactory even when we

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1 This is the basis of much of John Cleese’s humour when he lays into both animate objects, such as Manuel in Fawlty Towers, as well as inanimate objects like the car in Clockwork. We recognise that such behaviour does not help a lot, if at all, but it makes us feel temporarily better.

2 See Monty Python: The Church Policeman sketch.
feel we should be progressive enough to accept it as a hypothesis; furthermore, as the accident gets closer to home the urge to blame gets greater.

The Fundamental Attribution Error is where people attribute the behaviour of others as caused more by internal personal factors than by external ones, whereas they attribute their own behaviour as being caused more by external factors. An individual involved as the driver in a car crash, for instance, when asked about why an incident occurred, will describe the causes with reference to external factors, such as the traffic density, low visibility, other drivers etc. An outside observer, in contrast, will tend to feel that the person is just a bad driver. This is a reliable mechanism in people that ensures that they shift blame from themselves, while at the same time blaming others for personal failure.

This bias reverses when the outcomes are good. We attribute our good luck to personal characteristics, while outside observers see someone who has profited from situational forces rather than any inherent ‘goodness’. Part of this phenomenon is caused by an underlying belief in the ability of individuals to exercise control over their environment, so that if something bad does happen to someone, it represents an example of how they must have failed to exercise the control they are perfectly capable of. Such lack of control is a weakness that deserves to be treated accordingly, for instance by punishment.

When it comes to explaining the roles of others in the causal pathway to an accident, the fundamental attribution error means that those not personally involved, in particular managers and supervisors, both attribute the causes of the accident to personal failings in someone, frequently the victim, rather than the circumstances. At the same time they persuade themselves that they personally would not have acted in the same way and there is an important extra factor that is often overlooked. Those external factors are actually more likely to be under their control, so accepting an ‘external’ set of causes is likely to reflect badly upon their management whereas blaming the individual absolves them of further responsibility.

1.1.2 Hindsight and Availability biases

The second reason why managers stay with simple models is the effect of hindsight (Figure 1) on their beliefs of how accidents are caused. Fischhoff (1975,1986) described the problem of Hindsight Bias very clearly.

“Hindsight bias is the tendency to exaggerate in hindsight what one knew in foresight. The feeling that one knew all along what was going to happen leads one to be unduly harsh on past decisions (if it was obvious what was going to happen, then failure to select the best option must mean incompetence) and to be unduly optimistic about future decisions (by encouraging the feeling that things are generally well understood, even if they are not working out so well).”

There is some evidence that attribution bias is stronger in individualistic cultures, such as the USA, than in collectivist cultures such as Japan or China. The latter cultures appear to blame for other reasons.
How this operates is that individuals can generate a small number of scenarios about what could happen given a description of the situation prior to an event. Armed with the benefit of hindsight they know of one specific scenario, the one leading to the actual outcome. If they start by knowing the outcome the number of scenarios they can develop is usually fewer, often because knowing one for certain suppresses the invention of more ‘unrealistic’ alternatives. If, however, they do not know the outcome (or are given a false outcome), then it is often likely that they will not even generate the ‘actual’ outcome scenario at all. The problem of hindsight bias now interacts with another cognitive bias, that we interpret the ease of recall as a measure of the likelihood that what is recalled is true or will happen⁴. Knowing a scenario makes it seem straightforward and fully determined, because we can trace the sequence from initial to final state.

1.1.3 The Just World Bias

The Just World bias reflects the belief that most of us have that the world is fundamentally fair so that if something untoward happens then there must be a good reason. In the case of an individual to whom something bad happens a common way of keeping our beliefs consistent is to imagine that they, in some sense, deserved what they got. As the world is actually neutral, neither just nor unjust, fair nor unfair, the Just World bias may help us put up with life’s indignities when combined with the attribution error that means we explain our own misfortunes by reference to the environment we found ourselves in. Individuals who, because of hindsight bias, apparently knowingly let an accident happen, are clearly not people we want to have around; without such people we would not have any more accidents!

1.2 Blame the Management

So we can understand why most people would point the finger at someone close to the accident, often the victim themselves, and blame them for failing to prevent the accident and, quite possibly, feeling that they must have brought it upon themselves anyway. But as safety professionals, armed with the facts, we know that the external environment is important and that external environment is put in place and maintained by supervisors and managers.

1.2.1 Front line supervisors

First we look towards front-line supervisors who are on hand and line management, who typically make up the short-term planning and who should hire the right people, equip them with the necessary competences and the equipment to do their work both effectively and safely. With their greater experience and larger-scale view supervisors actually stand a better chance to see bad things coming and to be able to generate more of the scenarios we see reduced with hindsight. Supervisors actually form a higher risk group for fatal accidents than the workers they supervise⁵, probably as a result of a common tendency to lead from the front. This suggests that may not actually be any better than those they supervise at seeing dangerous situations for what they really are. So, just as we had to move up from the individual worker as the individual primarily responsible for their own safety, and that of their immediate colleagues, so we may have to absolve their supervisors who are subject to many of the same issues and who, unsurprisingly, will always be biased towards production over safety, especially when they have the strong feeling that they have the ability to perform the work and do it safely as well.

1.2.2 Management – The Line

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⁴ More generally ease of recall, availability, is interpreted as probability, even though there may be no empirical relationship at all.
⁵ The evidence for this comes from a confidential major accident review I performed for a large Oil and Gas company.
Middle managers, unlike the supervisors and workers they manage, are almost invariably removed from the hazards they have managed by their staff. Nevertheless they are the ones who allocate resources, such as training and equipment, as well as sending the messages about where the real priorities lie, in the way the task their supervisors and what they reward and devote their time and attention to. These individuals, even more than their front-line supervisors, create the conditions under which people work. They set the priorities, they design the production schedules, and they reward, hire and fire. Middle managers should be intellectually more capable of seeing danger before it happens, of using established processes to make sure that safety, both process and personal, is taken seriously and actions are taken accordingly. This suggests that these individuals therefore bear primary responsibility when something goes wrong as they create the situations that their workers inherit. Middle managers, however, are themselves put into situations by senior management who typically set broad targets and leave middle managers to work out how to achieve them. If these targets create incompatible goals then we already have the makings of an accident.

The next group we turn our attention to is senior management. It is their organization; they set the tone, they provide the resources, they require work to be performed and they have a duty of care to their employees and any third parties who come in the way of their organisation’s activities. Whereas front-line workers may provide the immediate physical cause of an accident, everything they do is performed in the context set from the top of the organization. Middle management transmit the demands from senior management and front-line supervisors are, or can be, in place to intervene. In a high-hazard industry it seems reasonable that the ‘buck stops’ at the desk of the CEO.

2.0 Responsibility

Given the discussion so far it seems quite reasonable to shift responsibility further up the line from the front-line worker, often the victim but otherwise a hands-on individual such as a pilot or surgeon or plant operator. If we see those at the ‘sharp end’ as being placed into intolerable positions we may absolve them of responsibility, rather seeing them as the inheritors of poor conditions and unfortunate events. There are, nevertheless, a number of professions where individual responsibility may have the bar set higher than elsewhere. The importance of professional ‘competence’ was highlighted in the UK by Lord Bowen in defining “the 'reasonable man' as the man on the 'Clapham omnibus'6.

"Nobody expects the man on the Clapham omnibus to have any skills as a surgeon, a lawyer, a doctor or a chimney sweep unless he is one; but if he professes to be one, then the law requires him to show such skill as an ordinary member of the profession or calling to which he belongs, or claims to belong".

The issue at the heart of Lord Bowen’s comment is that possessing a level of competence requires the skills acquired to be exercised, while he says that there is no requirement that this be taken any further than that. But members of some of those professions have what we may called the God Complex, the feeling that as a result of their ability and training, they can and should perform even in situations when they would not expect others to be able to cope. In the aviation sphere this has been labeled the ‘Right Stuff’.

What this tells us is the answer to the question: Who is responsible? will invariably be everyone, but that responsibility becomes so spread out that we need to rephrase the question to: Who is responsible for what? Responsibility is a heavy burden if, like the doctors and the pilots, you take it upon yourself to overcome problems created by others and even when you are not equipped to solve those problems except by your won willpower and native ability.

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6 The notion of the reasonable man is central to much of the legal system in the UK and related jurisdictions such as the USA and Australia that reflect their original British colonial status.
What I am going to do next is to try and pick out the notions of responsibility, and later accountability, by examining the thinking about how responsibility in the context of industrial safety is considered in the legal system, where such notions might be considered to be treated to a more rigorous scrutiny than that of the safety professional who is easily tempted to look to the uncaring top of the organization or the manager who is equally tempted to look to the unthinking worker.

2.1 Corporate Manslaughter legislation

If we take the legal point of view the perhaps we should start at the top. The offence of Corporate Manslaughter was created in the UK in 2007 after many years in the drafting. This act was quite specifically intended to point towards senior managers in the case of industrial fatalities. By being framed as manslaughter this means that there need be no specific intention to kill (that would be murder), but allows for the prosecution of “companies and other organizations where there has been a gross failing, throughout the organization, in the management of health and safety with fatal consequences”. This offence is specifically targeted at the organization, which in the UK includes Individual officers of a company can already be prosecuted in the UK under pre-existing civil negligence and Health and Safety legislation. The problem is that such prosecutions have proven extremely difficult to pursue successfully and this may continue for both individuals and organizations. A major construct, defined by Lord Denning, then the Master of the Rolls, the most senior appeal judge in England, was that of the Guiding Mind, also known as the Identification Doctrine. Denning wrote in a judgment in 1957:

“A company may in many ways be likened to a human body. It has a brain and a nerve centre which controls what it does. It also has hands which hold the tools and acts in accordance with directions from the centre. Some of the people in the company are mere servants and agents, who are nothing more than hands to do the work and cannot be said to represent the mind or will. Others are directors and managers who represent the directing mind and will of the company and control what it does. The state of mind of these managers is the state of mind of the company and is treated in law as such.”

The problem with this is that, straightforwardly interpreted, it is easy to argue that the controlling mind did not intend and was not aware of the specific events that led to the consequences in the case of an accident. The very few prosecutions that have been successful have been in such small organizations that the person at the top was usually personally involved in the disastrous activity. The defense, one that worked when the directors of Townsend Thoreson were prosecuted after the sinking of the Herald of Free Enterprise, is a combination of ignorance and an inability to see, in advance, the exact circumstances and the subsequent consequences. In short, ignorance is bliss at the top, or at least it has been.

In the United Kingdom, where many of these major disasters seem to happen, legislation was finally enacted in 2007 and coming into force in 2008 allowing corporations (including government departments!) to be prosecuted for the crime of corporate manslaughter in the case of fatalities. The argument was made that existing health and safety legislation already permitted the prosecution of individual officers of a company so the new offence represented an extension to corporate bodies. The new legislation does not require the prosecution to establish failure on the part of particular individuals or managers. It is instead concerned with how an activity was being managed and the adequacy of those arrangements. The information attached to the law stated the following about such notions as duty of care.

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7 The length of the process in the UK indicates how difficult this issue actually is.
8 H L Bolton (Engineering) Co Ltd v. T.J. Graham (1957) 1 QB 159
9 In the case of the Lyme Bay Canoe accident, where 4 schoolchildren died, Mr Kite, the managing director was sentenced to three years imprisonment. Regina v. OLL Ltd [1994]
10 The information here is based on the UK Ministry of Justice’s guide to the Corporate Manslaughter and Corporate Homicide Act 2007. Items in italics are taken from the guidance material for the Act.
A duty of care is an obligation that an organisation has to take reasonable steps to protect a person’s safety. These duties exist, for example, in respect of the systems of work and equipment used by employees, the condition of worksites and other premises occupied by an organisation and in relation to products or services supplied to customers. The offence is one of gross negligence, in all such cases, that requires that the way in which activities were managed or organized must have fallen far below what could reasonably have been expected. The failure to manage or organize activities properly must also have caused the victim’s death.

The offence is concerned with the way in which an organisation’s activities were managed or organised. Under this test, courts will look at management systems and practices across the organisation, and whether an adequate standard of care was applied to the fatal activity.

A substantial part of the failing must have occurred at a senior management level. Juries will be required to consider the extent to which an organisation was in breach of health and safety requirements, and how serious those failings were. They will also be able to consider wider cultural issues within the organisation, such as attitudes or practices that tolerated health and safety breaches.

The ability to consider wider issues such as the organizational culture represents a major step forward in thinking, and one that appears to place responsibility in law directly at the feet of the senior management and board. The problem is that this latter requirement also leaves considerable opportunity to claim that senior management was under the reasonable impression that what was being done was, to their knowledge, adequate to prevent major accidents. Nevertheless, altogether this legislation has led to a tightening up of legislation in the case of industrial accidents, not just in the UK but also in a wider setting. The way is still left open to prosecute those lower in the chain of command and it is here that the evidence becomes progressively easier to collect and use in prosecutions that can be expected to be successful.

In Australia there has also been a tectonic shift in the legal environment with the introduction in 2012 of a unified work Health and Safety Act. This legislation is primarily based upon the New South Wales Occupational Health and Safety legislation that always started with the top of the organization. The intention to direct attention to the top of organizations must be seen in the context of actually using the legislation where such laws are tested, in the courts, and here the crucial issue is the status and nature of the evidence that can serve to prove guilt and, accordingly, responsibility.

2.2 Evidence

The problem of evidence takes us back down the chain. At the bottom we will have the acts and omissions of individuals that, as we showed at the start, are directly related to the final outcome. The classical test is that of the counterfactual, the “but for” test which, when applied, means that but for the specific actions or conditions the accident would not have happened or the outcome would not have been so bad. The counter-argument for the defence of those being prosecuted could be what you might call the “even if” test. Even if management had provided the training or specific safety equipment, the individual worker might well have still acted the way they did, such as by not wearing safety equipment provided or, most commonly, by not complying with company rules and procedures. This argument seems to apply to the management of BP in the case of the Texas City refinery disaster. Even with a requirement for a 25% across-the-board cost cutting target, which led to savage cuts in training, management were covered by making strong, if effectively meaningless, statements about safety. In fact those were aimed directly at the workers’ and supervisors’ efforts for personal safety, such as guidelines on lids for hot coffee cups and holding the handrails in the offices. BP top management then took those safety performance figures seriously, proving to their satisfaction.

So we can come down from senior management knowing that it is not always easy to prove, rigorously in a court of law at least, that senior managers and directors were grossly negligent when it is perfectly possible to construct counterfactual arguments. The “even if” can often serve to balance the “but for” requirement and the reasons underlying the success of such an argument will be those we already identified; attribution bias, hindsight bias, availability bias and the Just World bias – a set
of cognitive biases that make it hard not to believe that someone did what they did with full knowledge, thereby making them culpable and, all too often, excusing those above them. The same argument can be played out for line managers and, in many cases, for front line supervisors, leaving us back where we started, with the individual who is all too often the victim.

2.3 The Herald of Free Enterprise disaster

What happens in an actual case? In the judicial investigation into the Herald of Free Enterprise disaster Lord Justice Sheen wrote:

At first sight the faults which led to this disaster were the aforesaid errors of omission on the part of the Master, the Chief Officer and the assistant bosun, and also the failure by Captain Kirby to issue and enforce clear orders. But a full investigation into the circumstances of the disaster leads inexorably to the conclusion that the underlying or cardinal faults lay higher up in the Company. The Board of Directors did not appreciate their responsibility for the safe management of their ships. They did not apply their minds to the question: What orders should be given for the safety of our ships? The directors did not have any proper comprehension of what their duties were. There appears to have been a lack of thought about the way in which the Herald ought to have been organised for the Dover-Zeebrugge run.

All concerned in management, from the members of the Board of Directors down to the junior superintendents, were guilty of fault in that all must be regarded as sharing responsibility for the failure of management. From top to bottom the body corporate was infected with the disease of sloppiness.

Sheen penalised a number of individuals, up to the Captain, but could go no higher up despite his clear interpretation that the problem lay at the top. In fact he even commended Mark Stanley, the assistant bosun, despite having to fine him. After Sheen’s investigation the senior managers were prosecuted but the case was thrown out of court before it was even concluded. This case demonstrated the difficulty in proving that senior management could be held responsible, at least in Law. While Lord Justice Sheen had commented extremely unfavourably on Townsend Thoreson’s management, he was restricted to the deck officers, from the Captain to the Assistant Bosun, as targets for penalties. Mr Justice Taylor threw out the criminal case against the senior management essentially using the Guiding Mind principle. As the senior management, despite several clear indicators like letters from the collected ships’ masters that there were problems and that bow doors were impossible to see, claimed that they did not believe such a disaster was possible, and behaved accordingly, he had no alternative to stopping the case and letting them off. So in the end those at the top walked free, those at the site were penalised.

There is another related reason why, in a court of law, prosecuting the front line worker is attractive. The evidence that can be collected is most concrete at the site of the incident and this is where agencies like the police concentrate. There can, typically, be little or no doubt that an individual was present at the scene and that they were involved in the activity. As soon as one moves away from the physical scene the evidence becomes less obvious, more ambiguous and generally more technical. Emails are legally ‘discoverable’ in many jurisdictions but one has to know where to look and what an often cryptic email actually means; this is even without the problem of showing that behaviour falls far below what can be reasonably expected. Prosecuting authorities often need a high degree of professional competence to both discover useful information from supervisors and managers and then to be able to make it usable as proof before a court. Unless a manager actually writes along the lines of actually requiring someone to do something dangerous with appropriate controls, then it will always be hard to pass the “but for” test. By the time we reach senior management it has become almost impossible to treat anything except completely explicit instructions as evidence for a successful criminal prosecution.

There is, however, an alternative, based upon the concept of duty of care, that could be used to prosecute senior managers and this forms the core of the more recent law-making. Unlike the

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11 mv HERALD OF FREE ENTERPRISE. Report of Court No. 8074. Formal Investigation (July 1987)
requirement that senior managers knowingly require or permit excessively dangerous activities, this
does not need any specific predictions of what might happen which was what proved the problem
with Townsend Thoreson. The diligent and adequate exercise of a duty of care can be seen as an
effective way of preventing accidents without the necessity of defining which accidents are being
prevented.

2.4 So who is responsible?

So who is responsible then? While we may agree that most front-line people are the inheritors of the
situations within which they find themselves, and as such cannot be held truly responsible, the legal
system will nevertheless tend to settle preferentially against them, both because the evidence is easier
to find and their actions (or inactions) will be more irrefutable. Senior managers, on the other hand,
may well be recognised, even in the court of public opinion, as the creators of the situations victims
find themselves in, but in a court of law their responsibility is at best hard to prove. The best remedy
makes explicit reference to duty of care, but these requirements are invariably undefined or so vague
in practice that multiple interpretations of exactly how an adequate duty of care might be exercised
are available. So, yet again, pinning senior management down as either individuals or as the body
porate is often extremely difficult. So what can we do?

The way out appears to require an analysis of what activities individuals can be reasonably required to
perform. At the bottom of the pile individual workers are those who can see what needs to be done,
who make the decision to be compliant or not. They have to follow the procedures, use the training
they have had and understand the situation as they find it. Similarly there are things only a front-line
supervisor can actually ensure, such as the details of job planning, selection and much on-the-job
training. Line managers do create the working environment and can and should be aware of what
determines priorities. If any one of these levels does not provide important information, then even
the most willing senior managers may be found surprised and wanting. The reality is that everyone is
responsible for something, no one is responsible for everything, except in as much as the CEO is the
ultimate authority, so how ca we identify what specific individuals are responsible for and where we
can call those individuals to account in the case of failure to perform?

3.0 The bow tie as a structure of accountability

The Bow-tie methodology provides a way of solving the problem (See Fig. 2). Bow-ties are based
round a Top Event, the event or situation at which no adverse consequences have yet occurred, but
where control over the process has been lost. There are a number of Threats, ways in which the
birates can be released leading to a top event and on to the undesirable consequences. Threats can be
seen as scenarios that describe how the top event, and subsequent consequences, might be achieved.
An initial analysis of the Top Event, the Threats that can cause that Top event to be achieved and the
Consequences that can arise from that Top Event can be described as a basic or Zero-Level
representation L0. At this point we know what the problems are but not how they are to be managed
(Fig. 3).
Figure 2. The general Bow Tie diagram. Barriers can be preventative, on the left, and mitigating on the right. There are often more than one consequence, including reputation and legal consequences, as well as personal consequences for individuals.

To prevent hazards being released and the unwanted consequences happening, we can place barriers on the threat Pathway. These barriers may depend on hard controls, such as non-return valves, on procedures, such as requiring the presence of two people when lifting work takes place, on a mixture, such as requiring the use of non-destructive testing techniques, and training delivering specific competence. If the top event happens, such as a person falling off scaffolding or a chemical reaction going outside pre-set parameter values, then there may be recovery measures that can still prevent the outcomes from being realised, or realised in full. A full bow-tie represents a risk analysis, with all the threat pathways and barriers identified. If the frequencies of threats and the effectiveness of the barriers are quantified, then we have a form of risk assessment. The bow-tie can be directly related to the Swiss Cheese model, as we can now see that every barrier can be treated as a ‘slice of cheese’, with the implication that it may fail, represented by having a hole in the slice.

Figure 3. A Basic or Zero-Level representation L0 Bow-tie. At this level only the Top Event, Threats and Consequences are identified so we can see the extent of the problem to be managed, but not how that management takes place.
A bow-tie analysis with the barriers added between threats and top event and top event and consequences describes how the risks are being managed at the active, day-to-day level. We can define this (see Fig. 4) as a primary level of description L₁. An L₁ description covers the hard barriers and activities intended to prevent (left-side) or allow recovery (right-side). “Hard” barriers typically involve design to contain the hazard, while “soft” barriers are usually what people can do to either prevent the hazard from being released, such as following specific procedures or watching to ensure a process stays within acceptable parameter values.

3.1 Escalation factors – the second level of analysis

Barriers are intended to stop threats from progressing to top events and on to consequences. Those barriers can have holes and they too should be managed. For instance, if the level in a column should not exceed a certain height, then there should be a detection mechanism that implements high levels in the column. There also needs to be a procedure for what to do if any of these preset values are exceeded. But it may be the case that a high-level alarm does not function correctly, that the operator in charge misses the signal, or the operator takes the wrong action. These may themselves all be caused by a variety of causes, such as poor alarm design or skipped maintenance, operator fatigue or temporary overload, and incorrect procedures or operator lack of competence. Essentially there are threats to barrier integrity, such as reducing maintenance frequency, having inadequate design standards, or having insufficient or untrained staff, who may be too busy to check everything or do not know what to look for. These all form threats to barrier integrity and effectiveness and can be seen as scenarios showing how it is possible to negate an otherwise perfectly effective barrier. These threats to the effectiveness of barriers are called escalation factors, and they can also be managed by barriers, typically management and administrative controls. Now we can see that a threat is targeted upon a point where control should be exercised, and to ensure that we place one or more barriers between the threat and its target to retain control. At L₁ the threats are targeted on the Top Event and we wish to avoid reaching the that top event; that is when we have lost control and have to start recovery mechanisms. At the level of the escalating factors, these now operate identically, so that an escalating factor is a threat on a L₁ barrier. We can call this second level of analysis L₂, that is when the escalation factors that reduce the effectiveness of barriers are identified.

We need to identify whether there are sufficient effective barriers in place and also know what we are doing to ensure that those barriers are not degraded. This is a crucial point in my argument because this type of analysis is what allows us to identify responsibilities and then define personal accountabilities.
The underlying responsibility for ensuring adequate integrity of the way in which safety is managed lies at the top. Only when the underlying conditions for the effectiveness of a barrier have been adequately provided can we look lower in the chain, so the requirement for vigilance by an individual first requires that that individual be capable of vigilance, not being at the end of a double shift due to an inadequate staffing policy. When we require a level of technical competence from an individual, we need to be assured that they have received sufficient and adequate training. Workers, and even supervisors and junior managers, do not define staffing policy, young engineers do not provide their own training. Those areas are the responsibility of senior individuals who can then be held accountable for the timely provision of such management support functions. The reality in many high hazard operations has all too often been that the pilot, the operator or the junior doctor have been blamed for failing to exercise a sufficient level of care even when the conditions in which they were placed by others were below the standard required for effective management of the risks being run.

If the barriers at the first level of analysis $L_1$ can be seen as slices of cheese, then escalation factors are what put the holes in the cheese; identifying those threats and associated barriers provides a second level of analysis $L_2$. Identifying the escalation factors, and their associated management barriers, provides us with a way of identifying what turn out to be the underlying causes of incidents and, at the same time, making it possible to associate and then allocate individual responsibilities to those barriers.

### 3.2 Management controls at Level 2

![Diagram](image)

*Figure 5. A simple $L_2$ description, with escalating factors acting on some of the $L_1$ controls. A full $L_2$ description would include all escalating factors and their associated controls.*

The escalation factor barriers turn out to be what we would identify as the controls the organisation should put in place to ensure that the $L_1$ barriers are in place and in operation. So a hard barrier such as a containment vessel needs to be properly designed, to an agreed or calculated standard, to have been correctly manufactured and tested and then to be adequately maintained. Inadequate design, construction or maintenance all form threats to the effectiveness of the vessel that is serving as a barrier for those threats that would allow the hazard, such as a flammable gas, to be released. These are all ensured by activities that the organisation performs, such as engineering, contracting out or procurement for design and construction, and by appropriate maintenance management for the maintenance of the vessel once it is in use. Similarly a specific procedure has to be designed and
checked for fitness for purpose, those who are expect to use it should know what it is and entails and be provided with working conditions that mean that it is physically possible to follow the procedure properly. Where individual or team competence is required for a barrier then that competence has to be provided and checked.

3.3 Distinguishing Cultural and Organisational factors

We can now identify a third level of analysis which includes the threats to those managerial controls, typically the organizational culture and regulatory failures, and how they are managed in turn. We can call this third level L₃ (Figs 6 & 7.), the level where we see what ensures that the organisational controls are themselves operating effectively. We can have engineering standards and design processes, but they have to be followed properly, or at all, if we wish to ensure that the original L₁ barriers are not full of holes. While we generally have identified the L₂ level of analysis as providing us with the information about latent conditions, we can go one stage further. There appear to be two sources of control at this third level:

1. The organisation has a culture that means that it takes its own processes seriously, what we could identify with a safety culture in this context;
2. There are regulatory powers that will force compliance even when the organisation’s culture is not advanced enough to do the job properly without external coercion. The L₃ level, therefore, provides us with the location to put cultural and regulatory factors.

![Figure 6](image-url)

Figure 6. The full L₂ analysis for some of the threats and associated controls at L₁. An L₃ analysis would add an extra level of threats and controls to the controls identified for the escalating factors (threats to L₁ barriers) shown here.

Distinguishing between L₁, L₂ and L₃ analyses means that we can develop a quite rigorous
method for assigning threats and barriers within a fully articulated bow-tie. In practice these are often conflated, so we might find a cultural factor, like not breaking rules, attached to procedural front-line barriers. For most day to day purposes an analysis to this level will be excessive, but it can serve to support major incident investigations by providing a clear pathway for the identification of the cultural and regulatory failures underlying such an incident. Previously such analyses have been ad hoc, which reduces the impact of any findings when there is no strict method used to identify problems.

Figure 7. A full L3 bow-tie with controls inserted to manage the cultural and regulatory threats. L3 controls make

4.0 Individual accountabilities in the bow-tie

The analysis using the bow-tie allows us for the first time to be quite explicit about the barriers defending against the hazards and the potential consequences. Every barrier that controls a threat can now be associated with a named individual who either

- Exercises the control – e.g. performs a cross-check, follows a protocol etc
- Exercises supervision
- Delivers a product or skill – e.g. training delivers a specific skill or knowledge
- Provides resources – e.g. so that training can take place.

If an activity is supposed to take place, or a condition is expected to exist, then there should always be some identifiable individual who is responsible for that performance and can, therefore, be called to account in the case of non-delivery. This means, for instance, that if a member of the junior staff is expected to possess a certain skill or knowledge, then it has to be made clear who gives them that skill and who ensures that the skill or knowledge has actually been acquired and can be practiced. Simply assuming that things will happen, a common source of incidents, can be identified and countered. Often this requirement is met by accreditation systems and examinations, but there are also local and highly specific issues that may need to be identified.
<table>
<thead>
<tr>
<th>L₁</th>
<th>L₂</th>
<th>L₃</th>
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<tbody>
<tr>
<td>Front line operators</td>
<td>Line Management</td>
<td>Culture and Regulation</td>
</tr>
<tr>
<td><strong>Threats (Escalating factors)</strong></td>
<td>• Improper operations</td>
<td>• Non-compliance</td>
</tr>
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<td></td>
<td>• External conditions</td>
<td>• Low or inappropriate priority setting</td>
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<td></td>
<td>• Variability in process</td>
<td>• Hands-off regulation</td>
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<td></td>
<td>• Design problems</td>
<td>• Incompatible goals</td>
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<td>• Poor procedures</td>
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<td>• Lack of training</td>
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<td>• Insufficient necessary</td>
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<td>pre-conditions for operation</td>
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<td>pre-conditions for operation</td>
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<tr>
<td><strong>Barriers types of control</strong></td>
<td>• Detection</td>
<td>• Support for best practice</td>
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<td></td>
<td>• Competence</td>
<td>• Enforcement</td>
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<td></td>
<td>• Design &amp; construction</td>
<td>• Mindfulness</td>
</tr>
<tr>
<td><strong>Accountable individuals</strong></td>
<td>• Front line individuals e.g.</td>
<td>• Executive management</td>
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<tr>
<td></td>
<td>driller, driver, pilot, doctor,</td>
<td>• Regulatory bodies</td>
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<tr>
<td></td>
<td>nurse, maintenance engineer</td>
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<td></td>
<td>• Line management, supervisors,</td>
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<td></td>
<td>back-room staff</td>
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Table I. The relationship between examples of threats, controls and accountability over the three levels of description.

Table I lists possible threats, barriers and accountable individuals at each of the three levels. Executive management, such as senior managers as well as directors of the company, has a quite clear set of roles, backed up by regulators, for ensuring that the threats at lower levels are themselves managed effectively. This is finally what we have been looking for, an explicit description of what the term duty of care means in a specific operation. Armed with this information it is possible for a prosecutor to determine whether an officer of the company has performed adequately or whether they can be shown to have fallen sufficiently far below what is required of them to constitute gross negligence. Ignorance is no longer bliss, ignorance constitutes prima facie evidence of negligence! But the lower orders do not escape their own accountabilities. Now we can state clearly what they are responsible for and who above them is responsible if they are not adequately resourced to perform the tasks for which they are to held accountable.
5.0 Conclusion

The issue of responsibility for safety, especially in high hazard industries, turns out to be difficult to pin down when submitted to the rigorous test of a court of law. The intuitive approach to responsibility taken by many safety professionals can lead to diffusion, with no clarity about who is responsible for what. This approach may pin final responsibility on the top of an organization, but all too often the line becomes tenuous. The problem is compounded with front line individuals in a number of professions, such as doctors and pilots, who feel fully responsible even when conditions are against them. The analysis presented in this paper suggests that the rigorous approach represented by a more legalistic analysis still runs into difficulties and will, unless there is strong evidence to the contrary, still come back to blaming those who were closest to the scene of the accident and whose actions, or inactions, can most easily be taken to prove their negligence, especially when those actions are also the easiest to discover and link to the final outcome. As we progress up the line to top management and directors, evidence becomes harder to find and the link to the eventual outcome becomes increasingly tenuous, where the test of but for can be easily countered by even if arguments. The solution has been to introduce explicit requirement at the top for a duty of care, but yet again exactly what that means may be hard for outside agencies, such as prosecutors, to understand. What that leaves for successful prosecution are only the most obvious and egregious shortcomings; a state of affairs that is unsatisfactory for those most frequently blamed, at the front line, and unclear for those at the top who seek clarity in exactly what their responsibilities are, in practice.

The bow-tie analysis provides us with a way out and makes what duty of care means much more concrete. Everyone is responsible for safety, but only for what they can effectively control. What cannot be controlled moves up the line, until we reach the top. There the final responsibility rests with decisions such as whether certain activities are to be carried out at all. This analysis replaces the standard one driven by hindsight, attribution error and the Just World without letting people off for their failings.

References


