SUMMARY

In all safety critical industries, catastrophic accidents can happen, and have happened in the past. These accidents are not industry specific and the obvious commonality is the high inherent risk associated with the activities undertaken. However, other common themes can be identified in the root causes of the ten accidents in seven different industrial sectors reviewed in this paper. These are: leadership, cost and business pressure, safety culture, control and enforcement, contractors’ management, and communication.

These findings clearly point out the importance of the commitment to safety and its associated control at all levels of the organisation but also stress the crucial role that corporate governance is playing in setting up safety as a core value and priority of an industry, an organisation, and its stakeholders.

The review of the Railway Management Maturity Model, published by the Office of Rail Regulation, demonstrates that this model is aligned with all the findings from the case studies except for one: Financial and Investment strategy. This criterion is for us essential in guaranteeing the success of a safety management system as it reveals the true commitment of the leadership to safety. Based on this, we conclude that the railway industry seems to have the right guidance to achieve safety excellence.

1 INTRODUCTION

A number of catastrophic accidents affected the UK railway industries in last decades, such as that at Ladbroke Grove in 1999. However, this type of accident is not unique to the railway industry - catastrophic accidents happen in all safety critical industries. This paper explores ten accidents in seven different industrial sectors: railway, space, aeronautic, nuclear, oil and gas, chemical, shipping and identifies the common themes in the accidents’ root causes.

The presentation of the findings is structured around the most common five factors: leadership, cost and business pressure, safety culture, control and enforcement, contractors’ management, and communication.

Based on these findings, we reflect on the importance of the commitment to safety and the control of its implementation at all level of the organisation from the Chief Executive Officer (CEO) to the shop floor - including contractors - which leads us to consider the importance of corporate governance. Finally, we consider what these findings mean for the railway industry by comparing these findings to the Railway Management Maturity Model, published by the Office of Rail Regulation.

2 LITERATURE REVIEW

2.1 Risk topology in organisation

An organisation is exposed to risk as a result of a combination of a number of factors which can be classified in three categories, e.g. organisation, system, and people. The organisational dimensions that influenced risk have been the object of numerous pieces of research, articles, and books. All these aim through different methodologies and disciplines to understand how the organisational factors influence risk. For example, Reason (1997) identifies eight organisational factors: organisational structure, people management, provision and quality of tools and equipments, training and selection, commercial and operational pressures, planning and scheduling, maintenance of building and equipment, and communication. Based on these studies and researches, we proposed to summarise the organisational factors in six main factors: Vision / Goals / Strategy, Leadership / management, Financial / Investment strategy, Human Resource Management (people management internal and external, e.g. contractors), and Communication, which are represented on Figure 1 (Quayzin 2011). Culture is identified in figure 1 by an ‘enveloping’ arrow to illustrate the fact that culture is defined and indeed defines all the factors. The next section looks in more detail into safety culture.
2.2 Safety culture

The term ‘safety culture’ first made its appearance in the International Atomic Energy Agency’s initial report following the Chernobyl disaster (IAEA, 1986). A number of definitions of safety culture exist but one that is most widely used is that developed by the Advisory Committee on the Safety of Nuclear Installations (ACSNI, 1993):

‘The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation’s health and safety management. Organisations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures.’

Like for organisational culture and climate, safety culture and safety climate differ. Safety climate can be viewed as the artefacts of the safety culture. Figure 2 shows the hierarchy between these notions. It also identifies that safety culture is more difficult to change than safety climate or behaviour.

2.2.1 Safety culture and safety performance

A strong culture doesn’t necessarily lead to strong economical performance (Channon, 1997). In safety, numerous authors try to link a strong safety culture to strong safety performance based on specific case studies. However, the relationship between a weak safety culture and accidents seems to exist. But it is not proven that the weak safety culture is statically the dominant factor or that it couldn’t be overcome by another factor such as leadership.

2.2.2 Safety culture and leadership

Previous research suggests that employees’ positive perception of management’s commitment to safety can result in reduced incidents that lead to injury. Thus research on safety culture places a strong emphasis on managers and leaders as important role models. For example Mearns & Yule (2009) reviews the literature on cross-cultural differences in attitudes, perceptions and beliefs regarding safety and presents details of a study examining the relationship between Hofstede’s cultural values dimensions (Hofstede, 1984) and safety climate and risk-taking behaviour in workforce members of a multi-national engineering organisation operating in six countries. The conclusion of these studies is: ‘there are no consistent predictors of risk taking behaviour and
safety performance across cultures. Management commitment is a more important determinant of behaviour at work than national culture.' Therefore, it seems that management and leadership are emerging as more significant determinants of safety performance than safety culture.

3 PRESENTATION OF THE CASE STUDIES

This section provides a brief overview of each of the selected case studies which are:

1. **Space industry**: shuttle Challenger disaster, 28th January 1986, and Space Shuttle Columbia disaster, 1st February 2003,
2. **Nuclear industry**: Chernobyl nuclear power plant disaster, 26th April 1986,
3. **Shipping industry**: Herald of Free Enterprise, 6th March 1987,
4. **Oil and gas industry**: Piper Alpha oil platform accident, 6th July 1988, and BP Deep Water horizon explosion and oil spill in the Gulf of Mexico, 20th April 2010,
5. **Rail industry**: Ladbroke Grove rail crash, 5th October 1999,
6. **Chemical industry**: BP Texas city refinery accident, 23rd March 2005, and Buncefield major incident, 11th December 2005,

3.1 Space Shuttle Challenger Disaster

On the 28th January 1986, the mission STS51-L of the Challenger space shuttle ended up with the explosion of the shuttle 73 seconds after the launch. The seven members of the crew were killed. The technical cause of the explosion was the failure of the O-ring seal on one of the rocket boosters which allowed flames to escape and lead to the ignition and explosion of the entire rocket.

The Rogers commission was set up to investigate the disaster by the USA president at the time; Ronald Reagan. The commission reported in 1986 (Rogers Commission report, 1986) which made a number of recommendations on organizational problems. These recommendations were the object of two follow-up reports by the NASA (1986) and by the Rogers Commission for a second time (1987). Since these reports, the Challenger disaster has been the subject of many books, and articles, and has been used as a case study on a variety of subjects. The most detailed analysis of the disaster was performed by Diane Vaughan. Her work (Vaughan, 1996) is also analysed as a part of this case study.

3.2 Space Shuttle Columbia Disaster

On the 1st February 2003, the mission STS-107 ended up tragically when the Columbia space shuttle disintegrated during its re-entry into the atmosphere, leading to the loss of the seven crew members. This accident’s technical causes have been explained by a breach of the Thermal Protection System on the leading edge of the left wing, caused by a piece of insulating foam which separated from the left bipod ramp section of the External Tank (CAIB, 2003). The inquiry in this accident revealed that this type of incidents couldn’t be considered as random and found its root causes within the culture and decision making of NASA. The Columbia Accident Investigation Board (CAIB, 2003) report is used as the basis of our case study.

3.3 Chernobyl Nuclear Power Plant Disaster

On the 26th April 1986, during a system test, a sudden power surge was inadequately managed which led to a series of explosions at reactor number four of the Chernobyl nuclear plant, which released a significant amount of radioactive material into the atmosphere. The plume of radioactive materials affected most of Eastern, Western and Northern Europe. The explosion resulted in the contamination of about 400 square miles within the vicinity of the plant which led to the evacuation of hundreds of thousands of people. The accident resulted in the immediate death of 30 people, however the total death toll is still increasing and experts talk of a potential total death toll of 2000 to 4000 due to the increase cancer risk.

The Chernobyl accident is the only level 7 nuclear accident on the IAEA accident gradation (7 being the maximum). Numerous articles and books have been written on Chernobyl, but the prime material for our case study is the IAEA reports (IAEA, 1986, 1991, 1992). These reports are often considered as the first publications to use the term safety culture (Antonsen, 2009).
3.4 Herald of Free Enterprise

The Herald of Free Enterprise was a car and passenger ferry which capsized on the night of 6th March 1987, moments after leaving the Belgian port of Zeebrugge, killing 193 passengers and crew. The main cause of the accident was that the bow doors were left open. A public Court Inquiry into the accident was held under Lord Justice Sheen in 1987, which produced a report (Department of Transport, 1987) which is the base for this case study.

3.5 Piper Alpha Oil Platform Accident

Piper Alpha was an oil and gas platform situated in the North Sea. On the 6th July 1988, a massive gas leak took place which then ignited resulting in an explosion which led to large fires. These fires led to the rupture of the riser of a gas pipeline from another rig. As a result, a second explosion occurred which produced a fireball that engulfed the entire Piper Alpha platform. This accident resulted in 167 deaths and lasted only 22 minutes. The report of the public enquiry in this disaster, led by Lord Cullen (Cullen, 1990), is the basis of this case study.

3.6 Deep Water Horizon Explosion and Oil Spill

In 2010, BP suffered another major accident when the Deep Water Horizon drilling rig exploded on the 20th April. The explosion and subsequent fire killed 11 people and injured 16. This accident lead to a major offshore oil spill in the Gulf of Mexico. It took 3 months to stop the leak and an estimated 4.9 million barrels of crude oil was released. This accident has been selected as it is interesting to understand how BP suffered another major accident 5 years after the Texas City Refinery explosion.

BP produced its own report on the accident (BP, 2010). However, due to the scale of the disaster, a national commission was set up and they reported in January 2011 (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011).

3.7 Ladbroke Grove Rail Crash

The Ladbroke Grove rail crash, also known as the Paddington train accident, was a collision between two trains which happened on the 5th October 1999 at Ladbroke Grove Junction, about two miles west of London Paddington Station. This crash lead to the death of 31 people and 523 injured.

The public enquiry was lead by Lord Cullen who decided to divide the inquiry into two parts. Part 1 enquired into the crash (Cullen, 2001a) while Part 2 inquired into the general question of how safety on the railways is managed and regulated (Cullen, 2001b).

3.8 BP Texas City Refinery Accident

On the 23rd March 2005, an explosion and fires at BP Texas City Refinery lead to the death of 15 people, more than 180 more were injured and financial losses exceeded $1.5 billion. The BP Texas City refinery is the third-largest oil refinery in the United States. The refinery was previously owned by Amoco and was taken over by BP and later merged with Amoco in 1999.

BP produced its own report on the accident (BP, 2005). A more detailed and independent report was subsequently produced by the Chemical Safety Board (CSB, 2007). In 2005, the CSB recommended to the BP Global Executive Board of Directors that it commissioned an independent panel to assess and report on the effectiveness of BP North America’s corporate oversight of safety management systems at its refineries and its corporate safety culture. The panel was lead by James Baker was subsequently named the Baker panel. They produced a report named the Baker panel report in 2007 (Baker, 2007).

3.9 Buncefield Major Incident

Following, an explosion at the Buncefield Oil storage and transfer depot, near Hemel Hempstead, on the 11th December 2005, a subsequent fire in the 23 large fuel storage tanks that lasted five days lead to significant damage to the properties near the site and the destruction of the site itself. There were no fatalities but 43 people were injured.

The Buncefield Major Incident Investigation Board lead by Lord Newton of Braintree produced a final report in 2008 which is the basis of this case study (Buncefield Major Incident Investigation Board, 2008).
3.10 Loss of the RAF Nimrod MR2 Aircraft XV230 in Afghanistan

On the 2nd September 2006, following a fuel leak while in mid-air, the Nimrod aircraft XV230 caught fire and subsequently one wing exploded which led to the explosion of the entire aircraft. The 14 people on-board were killed in this accident.

Following this accident, the RAF produced a report (RAF, 2007) which focused on the technical causes of the accident. However, due to the media and public pressure, the Secretary of State for defence set up an independent review into the accident. This review, led by Charles Haddon-Cave, QC, produced a report in 2009 (Haddon-Cave, 2009) which is the basis of the analysis for this case study.

4 FINDINGS AND DISCUSSION

This section presents the findings of the analysis of the 10 case studies and then discussed their implications for the safety of an organisation and the implications for the railway industry.

4.1 Findings

The root causes identified in each of the cases studies were mapped to the factors identified within the literature review. The most common five factors are: leadership (in all case studies), cost and business pressure (in nine case studies), safety culture (in eight case studies), control and enforcement (in eight case studies), contractors’ management (in eight case studies), and communication (in seven case studies).

Leadership: The common factor identified in all of the ten case studies is leadership and the importance of the influence of leadership on safety.

Cost and business pressure: The second common theme is the role of cost and business pressures. These are directly linked to the occurrence of the accidents. In those cases, the role of leadership, executives and board members as the source of this pressure is pointed out. In addition, in the Challenger, Columbia, Nimrod, and BP Texas city case, this cost pressure is linked to the risk paradox (production vs protection) and success engendered optimism, e.g. you invest less on safety, your bottom line improves and nothing happens so you start to believe that investing less on safety is acceptable and repeat the exercise until an accident happens and corrects the deviance.

Safety culture: The third common theme is the importance of the safety culture of the organisation and the importance of making safety the highest priority of the business. The role of the leadership in driving and shaping the culture of the organisation is also stressed in all of the cases. It is also interesting to review the findings of the Columbia’s reports against those from the Challenger enquiry and the BP Deepwater Horizon against the BP Texas city. Both sets of cases reveal that organisational culture has a strong resilience and that it requires a continuous effort from the leadership to transform it.

Control and enforcement: The fourth common theme is the importance of control and enforcement of the corporate strategies and priorities. It is also clear from the case studies that the leadership of the companies is in charge of implementing these control mechanisms. However, one should be cautious of assuming that an improvement of occupational safety indicators translates into a system or process safety improvement. This is pointed out in the Nimrod and BP cases.

Contractors: The fifth common theme is the role of contractors. With the exception of Chernobyl and the Herald of Free Enterprise, contractors are identified in all the case studies. In some as directly contributing to the accident, in others as a third party that should align its practices with the company’s governance.

Communication: The last of the common themes is communication and the importance of communicating effectively with all stakeholders.

4.2 Discussion

Based on these findings, this section reflects on the importance of the commitment to safety and its associated control at all levels of the organisation but also of the crucial role that corporate governance is playing in setting up safety as a core value and priority of an industry, an organisation, and its stakeholders.
4.2.1 Defining Safety as a core value

All the case studies identified the commitment of the leadership to safety but also the influence of the leadership as a role model in term of safety as most important factor of the safety level in an organisation. In addition, safety culture is also identified as an important factor. This clearly supports the views expressed in the literature that the leadership of an organisation by committing to safety as a core value and communicating it can improve the safety level and improve the safety culture.

4.2.2 Enforcing Safety as a core value

The other common factors relate more on how to enforce safety as a core value. The importance of cost and business pressures as a root cause demonstrate that the aim for “cheaper, better, quicker” in a safety critical industry is detrimental to safety, if safety doesn’t remain as the number one priority then that safety can be overruled by this aim.

The importance of control and enforcement as a root cause demonstrate that defining safety as a core value is not sufficient as it needs to be enforced and controlled across the organisation. The controls need obviously to follow the right indicators. This is for example illustrated by BP: ‘BP mistakenly interpreted improving personal injury rates as an indication of acceptable process safety performance at its U.S. refineries.’ (Baker, 2007, pXII).

Finally, the importance of the contractors in the root causes, demonstrate that all stakeholders need to align their values with the organisation and enforcement and control are of particular importance in making sure that they do.

These three common factors demonstrate that making safety a core value is not sufficient and the control and enforcement with all the stakeholders is crucial to guarantee that the safety is really a core value.

4.2.3 The role of corporate governance

Leadership attitude to safety is shaping the safety culture and as a result the risk taking of an organisation as leadership can define the priority and enforce it. However, the question is how to make sure that the leadership of an organisation does not prefer short term gain to safety. This is where we think corporate governance is playing an important role. Corporate governance is by definition the “system by which companies are directed and controlled” (Cadbury Report, 1992). It is therefore Corporate Governance that can define and enforce priorities. Corporate Governance is usually viewed as having 3 functions: forming (influencing the definition of the corporate mission), performance (influencing the implementation of the strategy), and conformance function (controlling and enforcing the implementation of the strategy). Based on these definitions of corporate governance, it is obvious that corporate governance has an obvious role to play in setting up safety as a priority and in controlling and enforcing it. This is also in line with Reason (1997) who concluded that for major accidents, the root causes are at organisational, regulatory and societal levels. Corporate governance is of course the main means of defining, controlling and enforcing business priorities which takes into account these levels.

A related issue is to who the organisation is accountable to: to the stockholder or stakeholders. If the latter, safety is obviously a core value but if it is the former, safety is also obviously a core value for long term investors who don’t want to see their investment blowing up but it is less obvious for short term investors looking for quick financial gain. In this case, we recognised that the role of customers and regulations is essential in controlling and enforcing safety values.

As a result even if corporate governance is not identified in the case studies, we support the idea that corporate governance is essential to make safety a core value of the organisation and to control and enforce it.

All the factors identified in Figure 1 have been identified as key contributing factors with exception of vision, goals, strategy which in fact is included in the leadership and safety culture in the case studies. In addition, the role of control and enforcement is reinforced in the case studies, thus figure 1 is reviewed to integrate the findings of the analysis as shown by figure 3.
4.3 Implications for the Railway Industry

Although we have only used one case study from the railway industry, all of the case studies have common root causes which are close to what was expected from the literature review, as discussed above. It is of course difficult to generalise these findings into generic rules as the number of case studies is small.

In 2011, the Office of Rail Regulation (ORR) published the Railway Management Maturity Model (RM³) (ORR, 2011). This model sets criteria to assess an organisation ability to achieve excellence in controlling risk. It is based on safety management guidance, accidents reports, and academic research. It also integrates the requirements of the Railways and other Guided Transport Systems (Safety) Regulations 2006 (ROGS) and the Management (Health and Safety at Work) Regulations 1999. This model breakdowns an effective safety management system into 5 areas: Governance, policy and leadership; Securing the co-operation and competence of employees at all levels; Organising for control and communication; Planning and implementing risk control through coordinated management arrangements; Monitoring, audits and review.

In their details these 5 criteria cover the same attributes that the 7 criteria identified in the case studies with the exception of financial & investment strategy. Even corporate governance is included in one of the sub-criteria of Governance, policy and leadership.

The fact that Financial & investment strategy is not included in the model is a concern as how much money is invested on safety but also on providing and maintaining the production equipments is a true expression of the commitment of the leadership to achieving safety excellence as it illustrates if “they put their money where their mouth is”. In a way, it is not an issue that the financial strategy is not a criterion in the Railway Management Maturity Model as long as it is something that it is looked at when auditing the criteria of the models. But this is currently missing from the guideline.

Thus, despite the fragmentation of the partial privatisation model, the conflicting needs of TOCs, FOCs, Infrastructure Providers, the contractors for each of them, it seems that the ORR is providing all the required guidance to allow these different bodies to achieve safety excellence.

5 CONCLUSION

This paper reviewed ten accidents in seven different safety critical industries in order to identify common causes in the root causes of these accidents. In all or at least 8 of the case studies, the following common points could be identified: leadership, cost and business pressure, safety culture, control and enforcement, contractors’ management, and communication.
These clearly point out the importance of the commitment to safety at all levels of the organisation but also of the importance of enforcement of this value internally but also to external stakeholders such as contractors. This paper also discussed the crucial role that corporate governance has to play in setting up safety as a core value and priority but also in enforcing it due to its ability to influence leadership.

The review of the Railway Management Maturity Model, published by the Office of Rail Regulation, demonstrates that this model is aligned with all the findings from the case studies except for one: financial and Investment strategy. This criterion is for us essential in guaranteeing the success of a safety management system as it reveals the true commitment of the leadership to safety. Based on this, we conclude that the railway industry seems to have the right guidance to achieve safety excellence.

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The views expressed in this paper should be understood as the personal opinions of the author, and should not be taken as those of Invensys Rail.

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