Murdoch University

Measurement of Rail Safety Culture - an Australian Sample

A dissertation submitted for the degree of

Doctor of Philosophy

by

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DECLARATION

I declare that this thesis is my own account of my research and contains, as its main content, work which has not previously been submitted for a degree at any tertiary education institution.

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ABSTRACT

Measurement of Safety Climate and Culture in the Australian Rail Industry

Safety culture and safety climate have been a focus of heated debate for over three decades. Despite the general recognition of their importance in safety performance, many disparate views exist in their definition and theoretical framework. While some researchers stress the importance of clear distinctions between safety culture and safety climate, others seem to take a more flexible view using the terms interchangeably. One of the dominant definitions describes safety culture as “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” (Health and Safety Commission, 1993). Safety culture is based on shared underlying beliefs, values and assumptions towards work and the organisation in general. On the other hand, safety climate is defined as organisational members’ shared perceptions about their work environments, safety policies and practices. Safety culture is regarded as stable and long-enduring, while safety climate can fluctuate in response to external factors (e.g. political and socio-economic change). Safety climate is regarded as a “snapshot” of the underlying safety culture. Proponents of the culture-climate distinction maintain that safety culture cannot be quantified and that safety climate can be used as a ‘surrogate’ measure of safety culture, for example, through self-report questionnaires. Other researchers take a more pragmatic approach and claim safety culture can also be measured. For the purpose of the current study, the definitional distinction is respected with the understanding that safety climate is an integral part of safety culture.

An industry-specific questionnaire was created, utilising retrospective and prospective approaches for evaluating safety perception and culture in the rail industry in Australia. This was achieved through: a) analysis of 104 rail safety accident investigation reports based on Reason’s Generic Error Modelling System; and b) adapting items from an instrument extensively used by a large multinational organisation for assessing the level of safety culture maturity based on Westrum’s typology. This facilitated a holistic approach, which addressed both technical/structural aspects and psychological aspects of safety as perceived...
by the employees. Six rail organisations in four jurisdictions across Australia
participated, which yielded 241 responses. Factor analysis was conducted to
identify safety perception and culture factors for further statistical analyses.
Kruskal-Wallis ANOVA revealed significant differences among occupational
groups in the evaluation of the organisations’ safety measures and culture.
Predictive analyses were also conducted to investigate factors potentially
associated with safety outcomes. Hierarchical regression analyses revealed that
when the effect of occupational group was controlled for, a safety perception
factor *External Factors* and a safety culture factor *Reactivity – Blame Culture*
were significant predictors of the experience of near misses. Furthermore, when
the effect of occupational group, tenure and near miss frequency were controlled
for, *Workplace Stress* and *Reactivity – Blame Culture* were significant predictors
of the frequency of safety defect reporting. The predictive values of both
retrospective items (predominantly safety climate pertaining to employees’
perception about technical/structural aspects of safety measures) and prospective
items (safety culture) were both validated. The implications of the results are
discussed, particularly in terms of cultivating leadership attributes which embrace
organisational learning.
CHAPTER 1  Introduction

1.1  Overview

Modern technology is a double-edged sword. Despite the undeniable benefits and comfort it brings to society, complex sociotechnical systems underpinning modern technology present considerable potential for disasters. Accidents with varying degrees of consequence can eventuate when things do not proceed according to plan, or the plan itself is inadequate. The International Labour Organisation (SafeWork ILO, 2012) estimates that globally 317 million accidents occur in the workplace annually. More than 2.3 million people die as a result of occupational accidents or work-related diseases per year, amounting to 6,300 deaths every day. The human cost of this daily adversity is colossal at the enterprise, national and global levels, estimated at four per cent of global Gross Domestic Product each year. Compensation expenditures for a group of OECD countries amounted to US$122 billion for 1997 alone, with 500 million working days lost as a result of accidents or health problems (ILO, 2003). These figures, however, do not reflect the long-term human cost of immeasurable ongoing hardship that the victims and their families are confronted with (e.g. personal account by Fitzroy, 2003).

Tightly coupled, highly interdependent sociotechnical systems brought on complexities in the accident causation pathways (Perrow, 1984). Close examination of major industrial disasters in the 1970s and 1980s accelerated the sophistication of accident investigation approaches. Paradigms had to shift from evaluating the human-machine interactions at the individual level to organisational and social factors that inevitably impact decision making and actions of the frontline operators (Westrum, 1996). In this new phase, the quality of a safety culture became widely believed to be an important factor associated with safety outcomes (Cox & Cox, 1991; Cox & Flin, 1998; Flin, Mearns, O’Connor, & Bryden, 2000).

Railway accidents are no exception. Catastrophes in the United Kingdom such as Clapham Junction (1988), Southall (1997), Ladbroke Grove (1999), and Hatfield (2000) highlighted the pivotal role human factors and safety culture played in the accident causation pathways (see review by Whittingham, 2004). In
Australia a number of rail disasters that occurred in recent years led to increased legal and public scrutiny, for example, Glenbrook Rail Accident (Hopkins, 2005; McInerney, 2001) and Waterfall Rail Accident (McInerney, 2005), each resulting in seven fatalities. Public inquiries highlighted the importance of identifying contributing factors beyond active failures at the ‘sharp end’, in particular, the considerable impact of safety culture (e.g. McInerney, 2001; McInerney, 2005). This has led the rail industry to develop a strong interest in how safety culture might be associated with safety performance, how to measure it, and what type of effort could be made towards safety improvements (e.g. Clarke, 1998a; McInerney, 2005).

Following the Glenbrook crash (McInerney, 2001) and the Waterfall rail disaster (McInerney, 2005), extensive research was conducted to uncover the safety climate and culture of the rail operators involved, prior to the accident (Glendon & Evans, 2005, 2007; Hopkins, 2005). The findings highlight not only the negative safety culture prior to the accident but also reflect the low morale affected by such tragedies. In addition to the New South Wales rail organisation implicated in the Waterfall rail disaster, Glendon and Evans (2005, 2007) also investigated safety climate of rail workers in Queensland.

The current research project was undertaken in order to investigate measurement of safety culture of several rail organisations in other geographic areas within Australia, across a wide range of occupational sub-groups. This project was initiated by the Planning and Transport Research Centre (PATREC), a collaborative research centre among Curtin University, Edith Cowan University, Murdoch University and University of Western Australia with extensive support from the rail industry.

This chapter reviews previous research, knowledge and ideas relating to the studies in subsequent chapters. Section 1.2 outlines rail safety statistics in Australia. Section 1.3 describes recent developments in Australian regulatory and legal framework regarding the role of safety culture and human factors in the rail industry. Section 1.4 provides a brief overview of the historical progression of theory underpinning accident models. Section 1.5 outlines background knowledge of sociotechnical systems perspective and human factors, the discipline to which the research studies of this thesis belong. Section 1.6 outlines a sociotechnical accident model and indicators of safety health. Section 1.7 and
Section 1.8 outline the concept of culture and climate. Section 1.7 briefly illustrates the conceptual confusion over ‘safety’ culture and ‘safety’ climate. Section 1.8 provides an overview of the conceptual origins of climate and culture and theoretical approaches underlying safety culture and safety climate research. Section 1.9 introduces some other models of safety culture. Section 1.10 provides a review of literature on sub-climate and sub-cultures. Section 1.11 provides a brief summary of previous safety climate and culture research on the prediction of safety performance. Section 1.12 provides a review of previous research on rail safety climate/culture in Australia. Finally, Section 1.13 provides a summary and rationale for the studies reported in subsequent chapters.

1.2 Rail Safety Statistics in Australia

The average number of rail fatalities per annum over the past ten years (from 1 July 2002 to 30 June 2012) is 35 in Australia. Figure 1.1 and Table 1.1 outline the number of fatalities in six-month periods from 1 July 2002 to 30 June 2012 released by the Australian Transport Safety Bureau (ATSB, 2012). Despite the positive trend over the past 20 years where the total accident rate has been on a steady decline, it has recently reached a plateau.

Figure 1.2 and Table 1.2 outline the number of serious injuries in six-month periods from 1 July 2002 to 30 June 2012 (ATSB, 2012), which excludes the frequency counts from New South Wales (NSW). The annual average for jurisdictions other than NSW is 92.3 and shows a gradual decline following the particularly high frequencies between 1 July 2006 and 30 June 2008.
Note: Legend is explained in Table 1.1.

**Figure 1.1.** Biannual Count of Australian Rail Fatalities by Jurisdiction and Year, 1 July 2002 to 30 June 2012
Table 1.1
Biannual Count of Australian Rail Fatalities by Jurisdiction and Year, 1 July 2002 to 30 June 2012

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Note 1: The counts exclude NSW figures.
Note 2: Legend is explained in Table 1.2.

Figure 1.2. Biannual Count of Australian Rail Serious Injuries by Jurisdiction and Year, 1 July 2002 to 30 June 2012
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* Note: The total counts exclude NSW figures.

** The state names are as follow:

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The importance of safety culture and human factors is reflected in the legal and compliance domain. In the UK, the “Corporate Manslaughter and Corporate Homicide Act 2007” came into effect in April 2008. It leads the world in incorporating into its jury inquiry the investigation of systemic contributors to accidents and the consequent incrimination of those responsible for corporate failures (Forlin & Smail, 2013). Under the new legislations, human factors will be seen as part of management responsibility. The frontline operators will no longer be regarded as the defendants. Rather, they will be the prosecution witnesses regarding management negligence. Also, the new legislations will allow “Corporate Culture” to be admissible before a jury from an evidential perspective, particularly with regard to management’s condoning or wilfully ignoring dangerous acts or systems (Forlin, 2008).

Australia has also seen a considerable shift in her regulatory approach to mitigating the breach of duty of care and harmful corporate activities. Striking similarities can be seen between the UK “Corporate Manslaughter and Corporate Homicide Act 2007” and future national Australian legislations as exemplified in the Model Work Health and Safety (WHS) Act (Safework Australia, 2011), currently being implemented nationwide. Australian corporate criminal law, both at federal and state levels, is increasingly incorporating this important principle (Forlin & Smail, 2013). In all States and Territories, for instance, company directors and managers can be held personally liable, in corporate governance terms, for safety and environmental offences committed by their company, and the number of personal prosecutions of directors and senior managers is on the increase (Tooma, 2008).

This shift in regulatory approach can also be seen in the rail safety domain. As is signified in the revised Australian Standard 4292.1 Railway Safety Management (Standards Australia, 2006), it is now mandatory that rail operators implement systems to develop and maintain a positive safety culture. The new National Rail Safety Bill, being implemented across Australia, will supersede the revised Australian Standard 4292.1 when adopted nationally. Rail Safety
National Law Regulations 2011 (The National Transport Commission, 2011) clearly establish that human factors and safety culture are regarded as management’s responsibility. These regulations stipulate that requirements for safety management systems include the development of a positive safety culture. Railway operators must develop such systems and need mechanisms to assess their effectiveness. Regulators must ensure effective implementation of such systems during their accreditation, audit and monitoring activities. With the national harmonisation process well underway, the new National Rail Safety legislation reinforces this important principle as well as aiming to achieve consistency and continuous safety improvement.

The considerable change in the regulatory approach reflects the current paradigm of understanding accidents from a sociotechnical perspective. It recognises that errors are germane to the human condition and that it is the responsibility of the top echelon of the organisation to incorporate such considerations into their safety management system (Reason, 1991). Historical progression of theory underpinning accident causation models will be briefly outlined in the next section.

### 1.4 Historical Progression of Accident Models

An accident model is a generalised description of how an accident may have happened, aimed at identifying causal factors (Hollnagel, 1993). Major industrial disasters raised considerable interest in identifying the causes of accidents and means of future prevention, particularly in the second half of the twentieth century. Early accident models tended to regard accidents as caused either by technical failures or human errors (Reason, 1991). While technological advances increased systems reliability (T. Lee, 1998), failures of human action and judgment were increasingly identified as causal factors of accidents. In the 1960s, estimated involvement of human error in system failures was around 20%. The estimates rose to about 80% in the following three decades (Hollnagel, 1993). It is important to note, however, that this dramatic increase does not imply that people had become more fallible. Rather, it is a reflection of how technological
advances and increased scope for accident investigation brought human factors into greater prominence (Reason, 2008).

From the early 1980s, accident models went through a considerable paradigm shift, mainly due to exhaustive inquiries into major accidents in complex systems such as Tenerife (1977), Mount Erebus (1979), Three Mile Island (1979), Bhopal (1984), Challenger (1986), Chernobyl (1986), King’s Cross station fire (1987), Zeebrugge (1987), Piper Alpha (1988), and Clapham Junction rail disaster (1988) to name but a few (Reason, 1991, 2008). Inquiries into those disasters identified strikingly similar conclusions across a broad spectrum of industries and geographic areas (T. Lee, 1998) where human elements at the ‘sharp end’ and the ‘blunt end’ were implicated (Woods, Dekker, Cook, Johannesen, & Sarter, 2010).

As the systems became more complex and tightly coupled, hidden pitfalls also grew, creating more opportunities for malfunction (Perrow, 1984). Increasingly, it was recognised that a more holistic systems view was necessary to take account of the interaction between human, technical and social factors within sociotechnical systems (Hollnagel, 2006; Reason, 1991, 2008). Today the traditional approach of blaming the operators at the ‘sharp end’ (e.g. Freudenburg, 1992; Maidment, 1997), who are in direct contact with each system as the “culprit” is no longer regarded as an acceptable explanation for accident causation (Johnston, 1996; Reason, 1990, 1997, 2008; Turner, 1978; Turner & Pidgeon, 1997). This approach considers failures of organisational, administrative and managerial aspects as an important source of contributing factors in order to gain a comprehensive understanding of accidents with full regard to human-system interface (T. Lee, 1998; Pariès & Amalberti, 2000; Reason, 1991, 2008; Turner, 1978; Turner & Pidgeon, 1997). Furthermore, cultural and social aspects within the organisation have become increasingly recognised as a vital component of the systems that contribute to the health of an organisation’s safety (Cox & Cox, 1991; Pidgeon, 1998; Pidgeon & O’Leary, 2000; Reason, 1990).

Turner (1978) was one of the first to propose systematic investigation into the causes of a wide range of disasters and to understand disasters in terms of process rather than as a sudden Act of God (Flin, 1998; Turner & Pidgeon, 1997; Woods, et al., 2010). His man-made disasters theory highlighted the restrictive nature of the traditional approach to analysing large-scale industrial systems.
purely in technological terms or under the banner of the undifferentiated concept of “human error”. Rather, it brought to the fore the importance of understanding disasters as failures of a “sociotechnical” system where the human and organisational elements are recognised to also contribute to the accident pathway in complex interactions with technology (Pidgeon, 1991). Pidgeon (1991) further stresses that over time those social and technical components change each other in complex and often unforeseen ways. Turner and Pidgeon (1997) postulate that the trajectory to disasters develops unnoticed during an incubation period, until a triggering event precipitates the unnoticed situation to a cataclysmic result. Their disaster development model focuses on informational difficulties associated with the attempts of individuals and organisations to resolve uncertain and ill-defined safety problems, which are often compounded with technical malfunctions and operating errors.

Human-based deficiencies range from human error at the individual level arising from cognitive failures to violations arising from social context in group settings to large-scale organisational factors, termed latent conditions or resident ‘pathogens’ in Reason’s (1990) Generic Error Modelling System (GEMS). Failures at the group and organisational levels include inter- or intra-group communication failures, information ambiguities and perceptual rigidities which include normalisation of deviance (Turner & Pidgeon, 1997), groupthink (Janis, 1972) and bounded rationality (Simon, 1957), the disregard of warnings, rules and instructions, and eventually, overconfidence and organisational arrogance (Turner & Pidgeon, 1997).

Recent years have seen increasingly sophisticated approaches to a more comprehensive understanding of the role of human factors in the sociotechnical context in the accident causation pathway. For example, Stanton and Walker (2011) discuss potential explanations for the Ladbroke Grove rail disaster (Cullen, 2001) by combining five aspects of train operation surrounding the incident with several important human factors issues using critical path analysis. They propose that the proximal cause was a succession of several cognitive errors by the train driver in this tragic accident with 31 fatalities. Similarly, Salmon Read, Stanton and Lenné (2013), provide an exhaustive analysis of the contributory factors underlying Kerang level crossing rail crash in the state of Victoria, Australia (ATSB, 2008). They present two juxtaposed human factors approaches, which
consist of: 1) a systems analysis framework to examine the level crossing system; and 2) individual psychological schema framework (Neisser, 1976) to examine the truck driver’s cognitive failures.

The key issue that the studies of the current thesis attempt to investigate is the development of questionnaires to measure safety perception and safety culture in the Australian rail industry. It is helpful to understand the conceptual context in which these studies reside. The concept of sociotechnical systems and the discipline of human factors which contributed to the paradigm shift in accident models will be discussed in the following sections.

1.5 The Concept of Sociotechnical Systems and the Discipline of Human Factors

The Concept of Sociotechnical Systems

A system is defined as “an interacting combination, at any level of complexity, of people, materials, tools, machines, software, facilities, and procedures designed to work together for some common purpose” (Chapanis, 1999, p. 22). The sociotechnical systems model for analysing and designing organisational structures was empirically developed in a UK coal mine in the late 1940s and 1950s by psychologists Eric Trist and Fred Emery and their colleague Ken Bamforth (see reviews by Badham, Clegg, & Wall, 2006; DeGreene, 1973; Hendrick, 2006). The model proposes that the design of a work system’s structure and related processes requires consideration of three major components: 1) personnel subsystem; 2) technological subsystem; and 3) relevant external environments that permeate the organisation. One of the fundamental tenets of this model is that the four basic sociotechnical components (the three mentioned above and the fourth being organisational design, or work system) are mutually interdependent. For example, if change is introduced to some aspect of the personnel subsystem, it will impact on the technological subsystem, the work system’s interaction with the external environment, and the structure and/or processes of the work system. It is critically important to understand that if these impacts are not planned for, it is likely to impact the work system in unanticipated and sub-optimal ways (Hendrick, 2006).
The Discipline of Human Factors

Human factors (or ergonomics) is defined as “the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.” (International Ergonomics Association Executive Council, 2000, online). It is a multi-disciplinary field of inquiry, incorporating knowledge from areas including psychology, cognitive science, anthropometry, applied physiology, environmental medicine, engineering, statistics, operations research, and industrial design (Chapanis, 1996). Human factors practice is goal-oriented, and thus the precise boundaries are not tightly defined (Wickens, Gordon, & Liu, 1998).

The study of human factors is generally considered to have developed during the Second World War largely out of military necessity. Early human factors research focused mainly on personnel selection and training aimed at matching the person to the task. However, it became increasingly clear that operators made mistakes despite having been selected and trained. For example, fewer aircraft were lost due to enemy intervention than accidents caused by pilots’ own errors (see review by Woods, et al., 2010). Technological advances outpaced the people to adapt and compensate for poor designs, and it was soon recognised that designs needed to be adapted for safe and correct usage by humans (Chapanis, 1999). Thorough investigations into the human-machine interface led to a more system-based approach to understanding accidents (Woods, et al., 2010). Today human factors recognise the limitations of human performance (Edwards, 1988; Norman, 1991) as well as the ingenuity and resilience of human decision making in unexpected problem-solving situations (Rasmussen, 1983; Reason, 2008).

Contemporary researchers see human factors from sociotechnical systems design perspective. For example, Edwards (1988) developed a conceptual model ‘SHEL’, which stipulates that a system is an inter-dependent unit of three resources within an environment. Figure 1.3 provides a diagrammatic representation of this model.
Figure 1.3. The SHEL model illustrating the interrelationships between the three types of system resource and the environment (left panel) and three-dimensional model (right panel). Adapted from Edwards (1988).

SHEL stands for software - the rules, regulations, laws, orders, standard operating procedures, customs, practices and habits which govern the manner in which the system operates, operational procedures, and practices that govern a particular system; hardware – physical property such as buildings, vehicles, technology, equipment, and materials; environment – environmental conditions in which work occurs including political, economic, and social factors; and liveware - human beings, who occupy the centre of the model.

This model portrays the relationships between these four elements through complex interactions (Figure 1.3, left panel). The lines joining these components represent the interfaces through which energy and information are interchanged. For example, the hardware-liveware interface specifies that the design of instruments and other devices must factor in human capabilities and limitations. The interface between liveware-software specifies that an operator must conform to certain sets of rules, regulations, conventions and operating procedures, while the software must optimise liveware which represents human characteristics. The liveware-environment interface includes effects on individuals (e.g. economic policy of deregulation), or human operations within a broader organisational context. Edwards (1988) further suggests a three-dimensional SHEL model to describe the interactions of several units of each resource type (Figure 1.3, right panel), i.e. hardware-hardware, software-software, and liveware-liveware.
Systems deficiencies can be diagnosed and resolved using this interactive framework. Using a range of diagnostic instruments, if/when deficiencies are identified, they can be addressed in relevant areas including equipment design, task design, environmental design, personnel training and selection (Wickens, et al., 1998).

1.6 Sociotechnical Accident Model and Indicators of Safety Health

Reason’s Model of Accident Causation

With the progress of cognitive psychology and human factors research, it became an accepted fact that 1) making errors is part of the human condition (Wagenaar, Hudson, & Reason, 1990); and 2) a systems analysis of human error requires considering all of the sociotechnical system elements (Stanton, 2006). One of the key players in the paradigm shift, Reason (1990) proposes a more holistic approach to understanding causal and contributing factors to accidents from a human-systems interface perspective. Reason’s (1990) accident causation model Generic Error-Modelling System (GEMS) argues that unsafe acts committed by frontline operators (active failures) cannot be viewed in isolation.

Reason (1990) proposes that unsafe acts are caused and influenced by factors that go beyond the scope of individual psychology, and stressed the need to look at error-provoking factors at organisational and systems levels (latent conditions). They include fallible decision making and deficiencies at management level such as organisational policies and procedures. Reason (1990) uses a metaphor of “resident pathogens” in the human body to describe the insidious and cumulative nature of latent failures in complex sociotechnical systems (p. 197). This approach portrays a perspective that active failures are to be regarded more as consequences than as principal causes of negative safety outcomes. This point is succinctly captured by Reason (1990) that, “Rather than being the main instigators of an accident, operators tend to be the inheritors of system defects created by poor design, incorrect installation, faulty maintenance and bad management decisions. Their part is usually that of adding the final
garnish to a lethal brew whose ingredients have already been long in the cooking” (p. 173, underline by the current author). Reason (1997) concedes, however, that this perspective does not totally preclude the role of an individual’s psychology in the accident causation pathway on rare occasions of sabotage despite the presence of relevant and high-quality procedures.

The principles behind GEMS are shown in Figure 1.4, a diagrammatic representation of the frequently cited Swiss Cheese model (Reason, 1990). GEMS distinguishes between deficiencies in the managerial and organisational sectors failure types and individual conditions and unsafe acts failure tokens (Reason, 1990, 1991). As can be seen in Figure 1.4, failure types exert overarching effects on system safety, illustrating the importance of addressing error-provoking latent conditions upstream in order to prevent them developing into failure tokens related to individuals at human-system interface.

Failure types are classified into two sub-categories, consisting of source types and function types. Source types refer to “fallible decisions at the strategic apex of the organisation” (Reason, 1991, p. 13), which is seen as the principal systemic source of resident pathogens. On the other hand, function types refer to fallible strategic decisions at the line management level, which can be translated into functional forms and then distributed throughout the organisation along departmental pathways.

Failure tokens are similarly classified into two sub-categories, consisting of condition tokens and unsafe act tokens. Condition tokens consist of the psychological or situational states conducive to the commission of unsafe acts. They are further sub-divided into three categories: 1) information-processing factors (e.g. attention, memory and knowledge); 2) situational factors (e.g. ergonomic quality of the human-system interface); and 3) social and motivational factors (e.g. attitudes and group norms). Unsafe act tokens are also sub-divided into three categories: 1) slips and lapses; 2) mistakes; and 3) violations, which will be described in detail in Chapter 2.

Reason (1991) argues that the most effective way of managing safety is by acting on failure types rather than failure tokens. The source types, in particular, as the principal source of resident pathogens, represent the way in which top management chooses to allocate finite resources between production and safety goals (also see Reason, 1990). These decisions and their underlying attitudes
form a system-wide safety culture. *Source types* at the apex are then amplified and spread throughout the organisation through *function types*, i.e. the activities of the function specialists at line management level, for example, in areas such as operations, maintenance, training and design (Reason, 1991).

Reason (1991) specifies that the most critical onward mapping occurs at the organisational/individual interface, where *function types* are translated into *condition tokens*. The onward mapping of failures from upstream through to the unsafe acts can take many forms in complex and interactive ways. This implies that backtracking from *failure tokens* is insufficient to identify the originating *failure types*. Reason (1991) emphasises the importance of using a variety of proactive indicators to assess an organisation’s safety health.

![Diagram of accident causation, failure types and failure tokens](adapted from Reason, 1990)

**Figure 1.4.** A model of accident causation, failure types and failure tokens (adapted from Reason, 1990)

**Safety Information System**

Reason (1991) categorises five different channels of safety information system as illustrated in Figure 1.5. This was developed from the accident causation model, and together forms the safety information system of an organisation. Channel 1 consists of information regarding negative safety
outcomes, such as accidents, incidents and Lost Time Injuries (LTIs). Such information reveals a specific pathway of accident opportunity through the system’s defences. However, its utility is limited as it is information collected after negative events and tends to lead to local solutions rather than identifying contributing factors upstream. Channel 2 relates to information regarding the nature and variety of unsafe acts associated with particular types of tasks, and can be obtained by audits. Channel 3 deals with the environmental and psychological precursors of unsafe acts such as poor workplace design, high workload, unsociable hours, inadequate training and poor perception of hazards.

Reason (1991) argues that both Channels 2 and 3 are “rarely sufficient to cause accidents, particularly in complex, well-defended systems. Their adverse consequences arise through multiple and often unforeseeable conjunctions with local triggering conditions. In short, they are subject to the vagaries of chance and hazard. As such, they are neither particularly informative nor readily remediable” (p. 22).

Channel 4 deals with information pertaining to organisational failures. They are represented by general failure types (GFTs), consisting of 11 groups: 1) hardware defects; 2) design failure; 3) poor maintenance procedures; 4) poor operating procedures; 5) error-enforcing conditions; 6) poor housekeeping; 7) incompatible goals; 8) organisational failures; 9) communication failures; 10) inadequate training; and 11) inadequate defences. Details of these failure types are outlined in Chapter 2 in the description of the Rail Problem Factors (RPFs), a rail-industry specific version of the GFTs. Finally, Channel 5 deals with information regarding safety culture.

Reason (1991) argues that it is through Channels 4 and 5, that vital signs can be gained that reveal the intrinsic state of safety health of an organisation. Reason likens Channel 4 to a health check. If obtained regularly, it reveals the state of health of the system’s vital organs. Channel 5, on the other hand, reveals data pertaining to an organisation’s longer-term safety style in the form of safety culture, embodied in top-level commitment, competence and cognisance.
Indicators of Safety Health

Measurement of safety performance has traditionally been based on safety outcomes (or lagging indicators) such as the number or rate of accidents, near misses and LTIs (Herrera & Hovden, 2008). Negative safety outcomes are by no means all attributable to organisational failing. They have large stochastic elements involved and can give very peculiar sampling of the strengths and weaknesses of an organisation’s safety measures. Thus, chance conjunctions can bring catastrophe to healthy organisations, while less sound organisations can escape retribution for lengthy periods of time (Reason, 1991). A growing concern over the limited utility of lagging indicators led to a movement towards leading indicators of safety (Flin, 1998; Flin, et al., 2000; Herrera & Hovden, 2008).

On the other hand, leading indicators are associated with proactive activities which help identify hazards and assess, eliminate, minimise and control risk (Grabowski, Ayyalasomayajula, Merrick, Harrald, & Roberts, 2007). They are designed to measure potential accident precursors such as conditions and events which precede an undesirable event and have some value in predicting the arrival
of the event, whether it is an accident, incident, near miss, or undesirable safety state (Grabowski, et al., 2007).

In contrast to Reason’s (1991) stance towards the lagging indicators, other safety researchers argue that retrospective information such as near misses can be a rich data source for not only quantitative but also for qualitative analysis (Hopkins, 2005; Van der Schaaf, 1991). Based on the recommendations from the Baker inquiry (2007) following the BP Texas City refinery accident (2005), an increasing number of safety-critical industries have incorporated the concept of combining lagging and leading indicators as complementary components of dual assurance of systems integrity. They are jointly called “safety performance indicators” (SPIs). Examples of industries which have integrated this concept into their safety management systems strategy include chemical and major hazard industries (Health and Safety Executive, 2006) and the rail industry (RSSB, 2011, Appendices), which clearly states that the two types of indicators work in tandem.

Table 1.3 shows some select examples of leading and lagging indicators for the chemical industry (Health and Safety Executive, 2006).
Table 1.3
Sample Process Performance Indicators for the Whole Installation – Chemical Industry

<table>
<thead>
<tr>
<th>Control</th>
<th>Lagging Indicator</th>
<th>Leading Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection/Maintenance</td>
<td>● Number of unexpected loss-of-containment incidents due to failure of flexi hoses, couplings, pumps, valves, flanges, fixed pipes, bulk tanks or instrumentation</td>
<td>● Percentage of safety critical plant/equipment that performs to specification when inspected or tested</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Percentage of maintenance actions identified which are completed to specified timescale</td>
</tr>
<tr>
<td>Staff Competence</td>
<td>● Number of times product transfer does not proceed as planned due to errors made by staff without the necessary understanding, knowledge or experience to take correct actions</td>
<td>● Percentage of staff involved in product transfer who have the required level of competence necessary for the successful transfer and storage of products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Note: the company will determine the type of training and experience necessary to achieve competence</td>
</tr>
<tr>
<td>Operational Procedures</td>
<td>● Number of times product transfer does not occur as planned due to incorrect/unclear operational procedures</td>
<td>● Percentage of procedures which are reviewed/revised within a designated period</td>
</tr>
<tr>
<td>Communication</td>
<td>● Number of times product transfer does not proceed as planned due to a breakdown in communication systems.</td>
<td>● Percentage of product transfers where authorisation to start transfer was successfully completed before the transfer commenced.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Percentage of post-transfer checks undertaken to confirm that pumps have stopped, and valves are isolated or closed.</td>
</tr>
<tr>
<td>Permit to Work</td>
<td>● Number of incidents where plant/equipment could be damaged due to failure to control high-risk maintenance activity.</td>
<td>● Percentage of permits to work issued where the hazards, risks and control measures were adequately specified.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Percentage of work conducted in accordance with permit conditions.</td>
</tr>
</tbody>
</table>

Adapted from Health and Safety Executive (2006)

Table 1.4 outlines some examples of leading and lagging indicators for the rail industry proposed by the author of this thesis.
### Table 1.4
**Sample Process Performance Indicators for the Whole Installation – Rail Industry**

<table>
<thead>
<tr>
<th>Control</th>
<th>Lagging Indicator</th>
<th>Leading Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Track Inspection/Maintenance</strong></td>
<td>• Number of rail track irregularity (e.g. broken rail, buckled track or spread track)</td>
<td>• Number of pre-planned maintenance program completed within specified timescale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Percentage of track infrastructure which meets the age profile criteria within specified timescale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Number of potential problems identified before a broken rail occurs through ultrasonic testing</td>
</tr>
<tr>
<td><strong>Rollingstock Inspection/Maintenance</strong></td>
<td>• Number of major component failures annually on mainline locomotives (e.g. engine failures, traction motor failures, wheel defects, bogie defects)</td>
<td>• Percentage of locomotive fleet compliant with general overhaul planned maintenance programs (or Original Engine Manufacturer recommendations)</td>
</tr>
<tr>
<td></td>
<td>• Number of off-schedule repairs conducted annually on railway wagon fleets (e.g. braking system issues, wheel defects, bogie defects)</td>
<td>• Percentage of railway wagons compliant with planned maintenance programs</td>
</tr>
<tr>
<td><strong>Signalling Infrastructure Maintenance</strong></td>
<td>• Number of wrong side failures</td>
<td>• Number of pre-planned maintenance, procurement, commissioning and testing program completed within specified timescale</td>
</tr>
<tr>
<td><strong>Operational Procedures</strong></td>
<td>• Number of load shift</td>
<td>• Number of inspection for loading integrity during pre-departure inspection (e.g. twist locks left unlocked, which are rectified before departure)</td>
</tr>
<tr>
<td></td>
<td>• Number of wagon overload resulting in track or rollingstock damage</td>
<td>• Number of overloading detected and rectified during pre-departure inspection</td>
</tr>
<tr>
<td></td>
<td>• Number of hot wheels</td>
<td>• Number of pre-departure inspection which identified the handbrake left on then rectified the situation</td>
</tr>
</tbody>
</table>

**Note:** Integral to the leading indicators are the following pre-requisites:
1) Development and implementation of competency training programs in relevant areas; and
2) Comprehensive record keeping of safety management activities.
Measurement of safety climate/culture is regarded as either as: 1) a vehicle that supports the process of formulating SPIs by identifying weaknesses (RSSB, 2011, Appendices); or 2) leading indicators in their own right (e.g. Grabowski, et al., 2007) (also see reviews by Flin, 1998; Flin, et al., 2000; RSSB, 2011, Appendices).

RSSB (2011) conducted a research project (T852) to investigate the application of leading and lagging indicators to the rail industry. This report describes RSSB’s Safety Culture Toolkit as one of valuable tools that can support rail organisations with “identifying, measuring, analysing, reporting or acting upon SPIs” (RSSB, 2011, p. 36, Appendices). It further remarks that “Undertaking a safety culture assessment is considered proactive in terms of safety management and could form an SPI for overall performance. However, due to the period between assessments, other proactive SPIs will be required to measure the day-to-day activity performance. Otherwise opportunities could be missed in preventing risk control deterioration. The tool is suited to highlight areas of concern and identify issues that can be incorporated into an SPI programme. As such, the tool is already referenced in the guidance as a source of information for identifying and prioritising areas for SPIs” (RSSB, 2011, p. 38, Appendices).

Despite the face validity of safety climate/culture as a valuable indicator of safety health, research has been riddled with theoretical confusion and relative lack of empirical evidence (Flin, 1998; Guldenmund, 2000). Flin (1998) summarises the situation as “the literature groans with multiplicity of variables as each research team devises its own questionnaires and, consequently, re-labels its emergent factors” (p. 90).

In the following two sections, the concepts of climate and culture will be outlined as a general background to discussion of safety climate and safety culture.
1.7 Conceptual Confusion over Climate and Culture

The concept of safety climate and safety culture has been used interchangeably in the empirical research literature. This has added to the theoretical confusion amongst theorists and safety practitioners alike (Guldenmund, 2000; Hale, 2000; Mearns & Flin, 1999). While some researchers call for streamlining definitions for consolidating the foundation of the research area (Guldenmund, 2000, 2010), other researchers argue that conceptual diversity does not pose a barrier into this multi-faceted area of investigation (Glendon, 2008).

Despite the theoretical confusion, safety climate and culture research has been a burgeoning area of investigation since early 1980s (Glendon, 2006). Investigations have been conducted in diverse areas including nuclear (e.g. Gill & Shergill, 2004; T. Lee & Harrison, 2000), petrochemical (e.g. Hudson, 2007; Parker, Lawrie, & Hudson, 2006), manufacturing (e.g. Clarke, 2006b; Cooper & Phillips, 2004; Zohar, 1980, 2000), aviation (e.g. Ek, Akselsson, Arvidsson, & Johansson, 2007; Gill & Shergill, 2004; Gordon, Kirwan, & Perrin, 2007), rail (e.g. Clarke, 1998a, 1998b; Glendon, Clarke, & McKenna, 2006; Glendon & Evans, 2005, 2007; Itoh, Andersen, & Seki, 2004), traffic (e.g. AAA Foundation for Traffic Safety, 2007), construction (e.g. Choudhry, Fang, & Mohamed, 2007; Dedobbeleer & Béland, 1991; Niskanen, 1994), mining (e.g. Griffin & Neal, 2000; Hopkins, 2007), healthcare (e.g. Flin, 2007; Neal & Griffin, 2006), and elderly homes (e.g. Yeung & Chan, 2012). Comprehensive reviews of safety climate and safety culture literature include those by Flin et al. (2000), Guldenmund (2000), Gadd and Collins (2002), Cooper and Phillips (2004), Glendon et al. (2006), Seo, Torabi, Blair and Ellis (2004), Choudhry et al. (2007), and Glendon (2008).

Within the field of organisational research, some scholars distinguish between shared perceptions (climate) and shared assumptions (culture), and argue that culture ‘informs’ climate by helping individuals to define what is important and make sense of their experiences (e.g. Ashforth, 1985; Rousseau, 1988). Similarly, some safety theorists have converged on the view that safety climate is
a component of safety culture (Cox & Flin, 1998; Glendon & Stanton, 2000; Guldenmund, 2000). Glendon, Clarke and McKenna (2006) argue that safety culture is generally regarded as more embracing than safety climate. They specify that culture implies a notion of residing within an organisation, climate has more passive connotations, reflecting attitudes and perceptions of organisation members to both internal (e.g. management actions) and external (e.g. economic) influences. They summarise that culture is the understanding of people’s fundamental values pertaining to risk and safety, while climate is the observable, tangible part of culture. Other researchers argue that the term safety culture has gained supremacy over the term safety climate over the past two decades and that there is no alternative but to continue using it in this way and to cope with the confusion (Hale, 2000; Hopkins, 2005).

Safety culture is regarded as a subset of organisational culture pertaining to the aspects that involve maximum mitigation of risks and optimising occupational and systems safety (Clarke, 1999; Cooper, 2000). Similarly, safety climate is regarded as a subset of organisational climate, commonly defined as the shared perception about the work environment with particular reference to safety (Coyle, Sleeman, & Adams, 1995; Reichers & Schneider, 1990; Zohar, 1980). Safety climate and safety culture will thus be best understood in the context of their conceptual origins in organisational climate and organisational culture (Guldenmund, 2000; Hale, 2006). The development of the conceptual framework for climate and culture research is outlined in the next section.

1.8 Conceptual Origins – Climate vs. Culture and their Derivatives – Safety Climate vs. Safety Culture

Comprehensive reviews exist that summarise the conceptual origins and historical progression of the constructs of organisational climate and organisational culture (e.g. Hofstede, 2001; Reichers & Schneider, 1990). This chapter provides a brief outline of the constructs and development of safety climate and safety culture. In this section, organisational climate and
organisational culture will be simply termed as the core concepts: ‘climate’ and ‘culture’.

**Climate**

Climate studies originated in social psychology (e.g. 1939). The concept was later applied to industrial and organisational psychology and gathered momentum in the late 1960s. Investigation into climate research is primarily conducted within a quantitative psychometric framework such as self-administered questionnaires. Its principal aim is to obtain organisational members’ perceptions of “observable” practices and procedures that are closer to the “surface” of organisational life (Reichers & Schneider, 1990).

Climate is broadly defined as “the shared perceptions of organisational policies, practices, and procedures, both formal and informal. Climate is a molar concept that is indicative of the organisation’s goals and appropriate means to goal attainment. … Multiple climates are thought to exist in organisations, and these climates have recently been specified by identifying clusters of persons who share common perceptions (Reichers & Schneider, 1990 p. 22)”. Rousseau (1988) argues that climate as a concept has specific boundaries in its conceptualisation. Climate deals with perceptions and they are descriptive. She stated that beliefs are not merely sensory perception, but are the result of active cognitive processing making sense of reality in light of high-order schemata.

Based on Sproull’s (1981) model, Rousseau (1988) differentiates between three types of beliefs: descriptive, causal and normative. Descriptive beliefs pertain to description of the attributes and events associated with objects or entities found in nature or in social units, for example, X occurs; I am X; or People like X. Descriptive beliefs specify what has occurred, does or will occur from the believer’s perspective. Examples include beliefs such as ‘Hard workers are paid well.’ or ‘Management cannot be trusted.’

Causal beliefs express the believer’s interpretation of why particular events or states of nature, self or society occur: X happened because of Y; or if X occurs Y will occur. This type of belief specifies causal relationships between a state or an event and objects or entities. Examples include: ‘I make my boss happy by coming to work on time.’ or ‘Help others and they will help you.’
Normative beliefs specify preferred states of nature of being: X should be Y. Examples include: ‘You have to win approval from others to get ahead.’ or ‘To fit into this organization, you must appear to work long hours and never make a mistake.’ Normative beliefs reflect processes associated with social units (such as families, work groups and companies). Rousseau (1988) specifies that descriptive beliefs constitute the area of investigation in climate research, while causal and normative beliefs are components targeted by culture studies.

Climate researchers such as Reichers and Schneider (1990) agree with Schein (1985), a prominent scholar of organisational culture, that climate can most accurately be understood as a manifestation of culture, which resides at a deeper level, is a less consciously held set of meanings than most of what has been called organisational climate, despite acknowledging considerable overlap between the two concepts.

**Safety Climate**

Zohar is generally credited with the first quantitative study of workers’ attitudes with specific reference to safety (T. Lee & Harrison, 2000; Reichers & Schneider, 1990; Silva, Lima, & Baptista, 2004). Typically, safety climate measures have focused on evaluating employees’ perception of how the company is positioned with regard to safety issues. Zohar’s (1980) seminal work began the safety related survey trend, when he assessed safety climate in production companies in Israel.

Various definitions of safety climate exist based on the researcher’s conceptualisation of what it entails as is the case with safety culture (Guldenmund, 2000). Most conceptual models of safety climate address the workers’ perceptions of and attitudes towards safety, and they are commonly evaluated through self-report questionnaires, typically comprising of 5 to 7-point Likert-scale response sets (see reviews by Glendon & Evans, 2007; Guldenmund, 2000). While some researchers have focused purely on workers’ perceptions of safety, others have investigated perceptions and attitudes towards safety, such as risk-taking behaviour. In addition, a group of researchers have focused exclusively on attitudinal measures.

The disparity amongst researchers on the definition and operationalisation of safety climate led Glendon and Litherland (2001) to propose that safety climate
can be conceptualised as operating at three different levels. The first level is called *Operational*, which deal exclusively with perceptions. Research at this level evaluates safety climate factors impacting most directly on work performance as represented by a study by Glendon and Stanton (2000). The second level is called *Intermediate*, which consists of mostly perception-based measures but also includes some attitudinal items. They reflect on generic factors such as management commitment and safety systems. Studies in this category include Williamson et al. (1997), Clarke (2000) and Flin et al. (2000).

The third level is called the *Highest*. Research in this category conceptualises safety climate as operating at purely attitudinal level, which could tap into some aspects of safety culture, (as reviewed by Glendon, et al., 2006; Glendon & Evans, 2007). Research in this category includes those by Donald and Canter (1994) and Niskanen (1994).

A majority of safety climate measures belong to the intermediate-level, assessing both perception and attitudes. Typically they have identified two to seven separate factors. For example, Griffin and Neal (2000) identified five first-order factors, which consist of perceptions of: 1) *management values*; 2) *safety communication*; 3) *safety practices*; 4) *safety training*; and 5) *safety equipment*. Similarly, a review of safety climate questionnaires by Flin and colleagues (2000) revealed five emergent themes. They consist of: 1) Perceptions of management and supervisor attitudes to safety, production, or other HR or business issues; 2) Aspects of the safety systems (safety management system, safety policies, safety equipment, permit to work systems, safety officers, safety committees); 3) Perceptions of risk and risk taking behaviour (self-reported risk taking, perceptions of risk/hazards, attitudes towards risk and safety); 4) Work pressure (work pace, work load, balance between production and safety); and 5) Perceptions of workers’ competence in relation to safety and HR processes relevant to selection, training, competence standards and their assessment.

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1 Glendon and Litherland (2001) refer to Guldenmund’s (2000) notion of applying Schein’s (1992) organisational culture model, which positions attitudes at a deeper level of explicitness to the beholder. Thus, the term *Highest* is somewhat misleading. The current researcher proposes that the term *Deepest* is more appropriate.
Culture

Culture research originated from anthropology, particularly based on the symbolic interaction and social construction perspectives (see review by Denison, 1996). The first study of organisational culture can be traced back to Selznick’s *Leadership in Administration* (1957). Spurred by the emergent Japanese economy and some exceptionally profitable American corporations, organisational culture research gained momentum in the early 1980s (see reviews by Martin & Siehl, 1983; Reichers & Schneider, 1990).

In contrast to the quantitative approach for climate studies, methods of inquiry for culture research are predominantly qualitative, including ethnography, interviews, focus groups and document analysis to extrapolate the meanings shared amongst organisational members and to obtain a deep understanding of underlying assumptions (Denison, 1996; Glick, 1985; Guldenmund, 2000; Schein, 1992; Schneider, 1990). Culture is defined as: “shared philosophies, ideologies, values, assumptions, beliefs, expectations, and norms that knit a community together. All of these interrelated psychological qualities reveal a social group’s agreement, implicit or explicit, on how to approach decisions and problems: ‘the way things are done around here’ (Kilmann, Saxton, & Serpa, 1985, p. 5). An organisation’s culture is “reflected by what is valued, the dominant leadership styles, the language and symbols, the procedures and routines, and the definitions of success that make an organization unique” (Cameron & Quinn, 1999, p.15).

Schein (1992) is one of the most frequently cited contributors to the study of organisational culture. He defines culture of a group as “A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.” (Schein, 1992, p. 12). Schein (1985, 1992) argues that, through various socialisation processes over time, group members will come to take such solutions for granted. Eventually those patterns of problem solving will become embedded into shared unconscious assumptions about the nature of reality, truth, time, space, human nature, human activity and human relationships.
Based on anthropological framework, Schein (1985, 1992) posits that organisational culture can be analysed at three levels. He defines that the term *level* refers to the degree to which the cultural phenomenon is visible to the observer. They consist of: 1) visible artifacts; 2) espoused values, beliefs, behavioural norms and operational rules; and 3) tacit, basic underlying assumptions. Other researchers propose similar models (e.g. Rousseau, 1990; Trompenaars, 1993) with slight differences in terminology and the number of levels/layers (also see reviews by Glendon & Stanton, 2000; Guldenmund, 2000). This structure is metaphorically described as layers of an onion (Hofstede, 2001; Trompenaars, 1993) or concentric circles (Rousseau, 1990) as shown in Figure 1.6.

![Figure 1.6. Levels of culture (adapted from Schein, 1992).](image-url)

In Schein’s (1985, 1992) model, artifacts represent all visible physical manifestations of an organisation such as the architecture of its physical environment, its artistic creations, its language, its technology and products, its style as expressed in clothing, manners of address, emotional displays, myths and stories told about the organisation, published lists of values, observable rituals and ceremonies. This layer also includes visible behaviour of the organisation’s members and organisational process into which such behaviour is made routine. Artifacts are easy to observe, however, very difficult to decipher, thus subject to the observer’s subjective interpretations and emotional reactions (Schein, 1992).
This implies that what is seen and heard may not necessarily be a true expression of culture (Guldenmund, 2010).

The middle layer, consisting of espoused values, beliefs, behavioural norms and operational rules, gives the observer a clearer picture of the day-to-day operating principles by which the members of the group guide their behavior. Trompenaars (1993) specified that *norms* are the mutual sense a group has of what is ‘right’ and ‘wrong’. Norms can be translated into written laws/rules on a formal level and into social control on an informal level. Whether consciously or not, norms give the members a feeling of “This is how I should behave.” On the other hand, *values* determine what is ‘good’ or ‘bad’. It is closely related to the ideals shared by a group, and as such members are guided to feel: “This is how I aspire or desire to behave.” (Trompenaars, 1993).

The innermost core consists of basic assumptions, which are shared and taken for granted by the members of the group or organisation. Schein (1985) differentiated assumptions from values by specifying that assumptions take place at the unconscious level, are taken for granted and are held automatically as true and non-negotiable. In contrast, values are at a more conscious level and can be debated and discussed, implying their malleability (Schein, 1985).

Schein’s (1985, 1992) theory emphasises the important role an organisation’s founder/leader plays in forming its distinct pattern of problem-solving (1985, 1992). When an organisation has taken some joint action and its members have observed a positive outcome, a shared basis for determining what solution works then becomes the organisation’s reality. When this pattern is repeated, it will gradually pave a way towards a process of cognitive transformation. Initially, such a collective experience will be transformed into a shared value or belief, and eventually into a shared assumption, especially as successful outcomes are repeated. This will happen through social validation, where certain values are confirmed by the shared social experience of a group. As such, Schein (1985, 1992) specifies that this model applies to an organisation with a stable membership and a history of shared learning to develop a set of basic assumptions about itself.
**Safety Culture**

The term ‘safety culture’ was coined in the investigation report into Chernobyl nuclear disaster in 1986 (International Nuclear Advisory Group, 1986), and rapidly gained popularity in safety management vocabulary (Cox & Cox, 1991; T. Lee, 1998; Pidgeon, 1998). It arose from a common assumption that a positive safety culture would contribute to improved safety performance (Cox & Flin, 1998; Mearns & Flin, 1999) and other aspects of business such as quality, profitability, competitiveness (Williams, 1991). Safety culture research has proliferated since late 1980s and more recent investigations have been conducted using sophisticated statistical analysis such as structural equation modelling (e.g. Clarke & Ward, 2006; Hsu, Lee, Wu, & Takano, 2008; Johnson, 2007; Zacharatos, Barling, & Iverson, 2005). A plethora of definitions exist for safety culture. The most commonly used definition comes from the Advisory Committee for Safety in Nuclear Installations (Health and Safety Commission (HSC), 1993, p. 23):

> 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.

> A good safety culture includes effective, appropriate safety management systems; strong safety leadership & commitment from management; participation and involvement of the workforce; and organisational learning and continuous improvement.

> The broad range of components of safety culture encompassed in the definition above are captured in Cooper’s (2000) tripartite reciprocal model (see Figure 1.7). In this model, the psychological, behavioural and the structural factors are all integral and inter-related components of safety culture.
Turner, Pidgeon, Blockey and Toft (1989) define safety culture as “the set of beliefs, norms, attitudes, roles and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious” (as cited in Pidgeon, 1991, p. 135).

Based on collaboration amongst Turner and colleagues on extensive disaster analysis and field work (see review by Turner & Pidgeon, 1997), Pidgeon and O’Leary (1994) argue that a ‘good’ safety culture might both reflect and be promoted by at least four facets, consisting of: 1) senior management commitment to safety; 2) shared care and concern for hazards and a solicitude over their impacts upon people; 3) realistic and flexible norms and rules about hazards; and 4) continual reflection upon practice through monitoring, analysis and feedback systems (organisational learning).

Characteristics of effective safety culture are further identified through extensive study of ‘high reliability organisations’ (HROs) – organisations that operate under very trying conditions all the time and yet manage to function with remarkable reliability (La Porte & Consolini, 1991; Weick, 1987; Weick & Sutcliffe, 2001). Weick and Sutcliffe (2001) specify five characteristics that define HROs. They are: 1) preoccupation with failure; 2) reluctance to simplify...
interpretations; 3) sensitivity to operations; 4) commitment to resilience; and 5) deference to expertise.

The overarching tenet of these hallmarks is ‘mindfulness’, a style of collective mental functioning for successful adaptation. HROs are continually vigilant towards what could go wrong and are “wary of the potential liabilities of success, including complacency, the temptation to reduce margins of safety, and the drift into automatic processing” (Weick & Sutcliffe, 2001). HROs take deliberate steps to restrict simplifying areas that require precautions. They socialise people to notice more rather than to establish a pattern of ignoring symptoms which may indicate potential hazards. Avenues for such efforts include extensive committees and meetings, frequent adversarial reviews, selecting new employees with non-typical prior experience, frequent job rotation and re-training (Weick, Sutcliffe, & Obstfeld, 1999).

HROs have a well-developed situational awareness through maintaining attention to the frontline operations and maintaining close relationships with them. HROs cultivate diversity and flexibility in the decision-making structure. HROs distinguish between normal times where decision-making is centralised and crises, during which decision making may be decentralised or devolved to the operations level where relevant expertise resides for identifying more areas of vulnerability at closer range (La Porte & Consolini, 1991; Weick & Sutcliffe, 2001; Weick, et al., 1999). They demonstrate resilience by mobilising themselves in special ways when crises occur. For example, “knowledgeable people self-organise into ad hoc networks to provide expert problem solving, which have no formal status, dissolve as soon as normalcy returns (Weick, et al., 1999, p. 100)”. HROs place a high priority on safety and reliability whereby sufficient redundancy of technological and human resources allow for compensation when failures do occur. They have a strong organisational culture of reliability; and continuous sophisticated organisational learning through feedback from experience combined with proactive simulation of possible futures.

Reason (1997) describes an ideal safety culture as an informed culture, which serves as the engine that continues to propel the system towards the goal of maximum safety health, regardless of the leadership’s personality or current commercial concerns. Reason (1997) specifies three vital driving forces for fuelling the safety engine, often referred to as the three C’s – Commitment,
Competence and Cognisance. These forces are supported by at least four critical collective practices, which consist of a reporting culture, a just culture, a flexible culture and a learning culture. A reporting culture refers to a culture where people are prepared to report errors, incidents, near misses, unsafe conditions, inappropriate procedures and any other concerns they may have about safety. A just culture refers to a culture of trust (Reason & Hobbs, 2003) where people see a clear set of principles for distinguishing between acceptable and unacceptable actions. This sets a stage for admitting or reporting errors without the fear of retribution while reserving appropriate sanctions for wilful acts of harm – defiance, recklessness or malice (Hopkins, 2005). A flexible culture is characterised by the capacity to adapt effectively to changing demands, while a learning culture refers to the ability to process information and translate the lessons learnt into action for improvement. Together they interact to create an informed culture in which those who manage and operate the system have current knowledge about the human, technical, organisational and environmental factors that determine the safety of the system as a whole.

Summary

Despite the theoretical diversity amongst researchers, a degree of consensus is developing with regards to safely climate and safety culture (Glendon, 2008). Safety climate is conceptualised as a surface manifestation of the underlying safety culture as illustrated by observable safety behaviours and expressed attitudes of employees (Flin, et al., 2000; Guldenmund, 2000; Pidgeon, 1991). It can be “viewed as a temporal manifestation of culture which is reflected in the shared perceptions of the organisation at a discrete point in time” (Cox & Cheyne, 2000, p. 114). It is “a snapshot of the state of safety providing an indicator of the underlying safety culture of a work group, plant or organisation” (Flin, et al., 2000, p. 178). Since safety culture does not lend itself to quantitative evaluations, safety climate measures can be utilised as “a surrogate measure of safety culture at the expense of the holistic, multi-faceted nature of the concept of safety culture itself” (Cooper, 2000, p. 114, italics in the original). The relationship between safety climate and safety culture in this context is succinctly captured in a diagram by Glendon & Stanton (2000) in Figure 1.8.
1.9 Other Models of Safety Culture

Grote and Künzler (2000) criticise the existing safety culture models for not being integrated into general models of organisational culture and the lack of connection between safety-related characteristics of a system and more general characteristics such as job and organisational design and use of technology. Based on the sociotechnical approach, these researchers reiterate the need to consider safety culture as an integral part of social and technical subsystems which need to be jointly optimised to achieve maximum effectiveness of the...
production process in terms of quantity, quality and safety. They further propose that safety culture and organisational design need to be considered both at ‘material’ level (characteristics which are visible, but at difficult to decipher), and at ‘immaterial’ level (hidden, taken-for-granted beliefs and values) of an organisation (Grote & Künzler, 2000). Figure 1.9 presents their sociotechnical model of safety culture, which incorporates Schein’s (1992) three-layer model of culture (see Figure 1.6).

![Diagram of sociotechnical model of safety culture]

**Figure 1.9.** Modified conceptualisation of safety culture (adapted from Grote & Künzler, 2000).

Grote and Künzler (2000) developed a questionnaire to complement the information obtained from interviews and work observations during safety management audits. This instrument was designed to gauge the organisational members’ perceptions and needs in different departments and hierarchical levels. The items are grouped in three major categories: 1) *operational safety* (including ergonomic design, operating procedures, and safety training, implementation of safety suggestions and support from co-workers in critical situations); 2) *safety and design strategies* (regarding safety management and sociotechnical design); and 3) *personal job needs* (for good job performance, safety measures and quality of job design and general training).

In a similar vein, Baram and Schroebel (2007) differentiate between two major models of safety culture, consisting of theory-based and holistic models. The theory-based models focus on assumed psychological determinants of culture
such as attitudes, values, personal experiences and basic assumptions of organisational members. This approach enables one to gain “insights about how a safety culture is perceived by its members, insights which can then be used to determine what should be done to improve individual safety performance and the safety culture itself” (p. 634). In contrast, the holistic models consider a broad spectrum of the structural aspects of an organisation and its embedded processes by relating safety culture to the design and functioning of safety management systems and compliance programs.

The theory-based models as described by Baram and Schroebel (2007) are represented by a great majority of safety climate research to date as comprehensively reviewed by Flin et al. (2000), Guldenmund (2000), Gadd and Collins (2002), Cooper and Phillips (2004), Glendon et al. (2006), Seo et al. (2004), Choudhry et al. (2007), and Glendon (2008).

On the other hand, one of the models that represent the holistic approach is the *Hearts and Minds* program led by Shell International Exploration and Production B.V. (abbreviated as Shell hereafter) and the Energy Institute, UK, in collaboration with the University of Manchester and Leiden University. This program was initially developed for the petrochemical industry but has been put to extensive application in other industries (Bryden & Hudson, 2005; Hudson, 2007; Lawrie, Parker, & Hudson, 2006; Parker, et al., 2006).

The researchers involved in this culture change program appear to take a pragmatic approach towards the definition of safety culture. This is apparent in the way in which they are inclined not to engage in extensive discussions regarding the theoretical aspects of the safety climate/culture concept. Notably, they tend to use the two terms interchangeably (e.g. Hudson, 2007). The theoretical basis for the *Hearts and Minds* program stems from Reason’s (1997) premise that “Most of the effective solutions to human performance problems are more the province of the technical manager (and the regulator) than the psychologist since they concern the condition under which people work rather than the human condition itself (p. 191). … A safety culture … emerges gradually from the persistent and successful application of practical and down-to-earth measures… Acquiring a safety culture is a process of collective learning” (p. 192). Highlighting management’s critical role in engendering an effective
safety culture, Reason (1997) deliberately uses the expression: “engineering a safety culture”.

One of the defining characteristics of the *Hearts and Minds* program is the developmental model of safety culture. Based on Westrum’s (1993) conceptual framework further developed by Reason (1997), Hudson and colleagues constructed a five-stage model of safety culture maturity (Bryden & Hudson, 2005; Hudson, 2007; Parker, et al., 2006). The five stages consist of: 1) Pathological; 2) Reactive; 3) Calculative; 4) Proactive; and 5) Generative. A graphical representation of this model resembles a step ladder, as shown in Figure 1.10 (Bryden & Hudson, 2005). Figure 1.10 illustrates that the higher up the safety maturity ladder an organisation is situated, it demonstrates increased signs of an informed culture (see Section 1.8), and is characterised by greater trust and accountability.

![Safety Culture Maturity Ladder](image)

*Figure 1.10. The safety culture maturity ladder (adapted from 2005)*

Table 1.5 shows a detailed list of characteristic statements that describe the five stages. As can be seen in Table 1.5, an organisation’s safety health can be positioned within a continuum spanning from the worst stage “Pathological” to the most advanced “Generative” stage. It is proposed that “every organisation can find its place on the ladder, …and can break down the problem of advancement up the ladder into numbers of small feasible changes rather than one great leap forward” (Bryden & Hudson, 2005, pp. 52-53). The underlying tenet is that
culture change will be a gradual process of evolution. The “Generative” stage is
an ideal state for any organisation to strive towards, demonstrating characteristics
of High Reliability Organisations (La Porte & Consolini, 1991; Weick &
Sutcliffe, 2001; Weick, et al., 1999), as mentioned in the previous section.

Table 1.5
Statements Describing Various Dimensions of Safety Culture at the Five Maturity Levels

<table>
<thead>
<tr>
<th>Safety Culture Maturity Stage</th>
<th>Statement</th>
</tr>
</thead>
</table>
| Pathological                 | - Who cares about safety as long as we’re not caught?  
                              |   - When it comes to safety, individuals look after themselves.  
                              |   - The lawyers/regulator said it was OK.  
                              |   - Of course we have accidents, it’s a dangerous business.  
                              |   - Sack the idiot who had the accident.  |
| Reactive                     | - Safety is important - we do a lot every time we have an accident.  
                              |   - After accidents there is a voiced commitment to care for colleagues by both  
                              |   management and workforce.  
                              |   - 'Look out for yourself’ is the rule when it comes to safety.  
                              |   - Commitment to HSE and care for colleagues diminishes after a period of good  
                              |   safety performance.  
                              |   - HSE procedures are often in response to accidents.  |
| Calculative                  | - We have systems in place to manage all hazards.  
                              |   - People know how to pay lip service to safety, but practical components may  
                              |   prevent complete follow through.  
                              |   - We have our HSE-MS we cracked it!  
                              |   - We have lots and lots of audits.  
                              |   - We collect lots of statistics.  |
| Proactive                    | - We try to anticipate safety problems before they arise.  
                              |   - The feeling of pride in HSE and care for colleagues is not universal.  
                              |   - Resources are available to fix things before an accident.  
                              |   - Management is open but still obsessed with statistics.  
                              |   - Procedures are “owned” by the workforce.  |
| Generative                   | - HSE is how we do business round here.  
                              |   - Level of commitment and care are very high and are driven by employees who  
                              |   show passion about living up to their aspirations.  
                              |   - Blame is not an issue.  
                              |   - Top management is seen amongst the people involved directly after an accident.  |

Adapted from Bryden and Hudson (2005); Lawrie, Parker and Hudson (2006); and Parker, Lawrie and Hudson (2006)
The *Hearts and Minds* program uses nine instruments to facilitate the improvement process. The first instrument to be used is a brochure *Understanding your Culture* (Brochure HSE005), which allows participants to assess at which stage on the ladder their organisation stands. It is designed to facilitate interactive group discussions on the shop floor in order to take the participants through the change process. This is achieved by helping them challenge their beliefs and select actions each can personally take to improve that culture (Bryden & Hudson, 2005; Hudson, 2007).

Parker, Lawrie & Hudson (2006) describe the process of developing this brochure. It entailed semi-structured interviews with a sample of senior executives in the oil and gas industry who had extensive first-hand experience at all hierarchical levels of an organisation. They were asked to describe characteristics of an organisation at different stages of safety culture maturity in terms of 18 organisational aspects, consisting of 11 tangible and seven less tangible aspects. The concept of ‘tangible’ and ‘less tangible’ aspects correspond with ‘material’ and ‘immaterial’ aspects of safety management systems proposed by Grote and Künzl (2000).


The interviews served to identify attributes that characterise each of the five levels of safety culture maturity in the 18 dimensions specified above. The interviewees’ key responses were summarised in concise statements within an 18 X 5 matrix (Parker, et al., 2006).
Lawrie, Parker & Hudson (2006) conducted a subsequent study aimed at statistical validation of this framework. They modified a selection of statements in the safety culture matrix to suit a questionnaire format. They selected seven of the 18 organisational aspects based on their relevance to a wide range of employees within the organisation which participated in the study (Lawrie, et al., 2006). The seven aspects consist of the following three tangible (coded as “T”) and four less tangible aspects (coded as “L”): 1) Commitment Level of Workforce and Level of Care for Colleagues (L); 2) Balance between HSE and Profitability (L); 3) Competency/Training – are workers interested? (T); 4) Work-Site Job Safety Techniques (T); 5) What is the purpose of procedures? (L); 6) What happens after an accident? Is the feedback loop being closed? (L); and 7) Audits and Reviews (T).

The original statements describing characteristics of each level of maturity in the matrix were broken down into shorter core statements to form 91 items for the questionnaire. In their study, the responses were submitted to Principal Components Analysis, which revealed component structures that provided partial support to the distinctions across the five stages of safety culture maturity.

Glendon (2008), in his extensive review of the safety climate/culture research over the previous 25 years, criticises Lawrie et al.’s (2006) study on two principal grounds: Firstly, applying psychometric-style analysis appropriate for revealing categorical factors to discerning pre-designated ordinal cultural archetypes (namely, stages of safety culture maturity) is problematic. Secondly, Lawrie et al.’s (2006) investigation was conducted on a small sample ($N = 59$), which yielded factors with poor scale reliabilities.

### 1.10 Sub-Climates and Sub-Cultures

Existence of different sub-cultures or sub-climates is well documented (Lawrence & Lorsch, 1967; Schein, 1992; Trice & Beyer, 1993; Zohar, 2000), including those that run counter to a dominant culture (Martin & Siehl, 1983). Turner (1992) regarded organisations as multicultural assemblages which have a corresponding number of different reference frames for thinking and learning.
Findley et al. (2007) found group differences in safety climate scores in job positions in a nuclear decommission and demolition sector. Similar findings are reported in other industries such as petrochemical (e.g. Grote & Künzler, 2000) and health care (e.g. Neal & Griffin, 2006) sectors, as well as manufacturing and related services (e.g. Cox, Tomás, Cheyne, & Oliver, 1998; Zohar, 1980, 2000, 2002). The rail industry is no exception. Clarke (1999), McInerney (2005), and Glendon and Evans (2005, 2007) found considerable differences between several occupational groups and job levels on a safety climate measure designed specifically for the rail industry.

Major bases on which climate and cultural differentiation takes place include job function (e.g. Cooper & Phillips, 2004; Ek, et al., 2007; Glendon & Evans, 2005, 2007), geographical and hierarchical divisions., (e.g. Clarke, 1999; Findley, et al., 2007; Hofmann & Stetzer, 1996) as well as product, market or technological differences and professional background (e.g. Helmreich & Merritt, 1998) and literacy (Baram & Schoebel, 2007). Schein (1996) describes a stereotypical example of subcultures based on occupational/functional groups, consisting of operators, engineers and executives characterised by distinct differences in priorities and educational background.

Examples of professional cultures are portrayed with distinct strengths and weaknesses for ensuring safety in aviation and medical settings (Helmreich & Merritt, 1998). Extreme examples of a detrimental role played by negative safety culture can be seen in the Avianca B-747 crash in Madrid (1983) and Avianca Flight crash 052 in New York (1990). In both cases, rigid power differential in the cockpit stopped the first officer from a critical communication with the captain during emergency, thus disenabling the captain from readjusting his faulty situation awareness (see review by Helmreich, 1994). Such tragic examples highlight the critical importance of considering group differences when evaluating safety climate and safety culture.

In the current study, the participants were sought across several states in Australia, rather than from the confines of Western Australia. This strategy arises from three factors that potentially inform safety culture of the rail industry: 1) technological environment; 2) work environment; and 3) trade union involvement (National Road Transport Commission, 2003).
First, technological characteristics of the railroad operation are strongly defined by the scope of service the organisation provides; e.g. passenger rail service that entails constant human interactions in contrast with heavy industry freight operations characterised by high-tech automation and remote control procedures.

Second, the work environment of rail operations varies greatly across organisations, ranging from localised urban passenger service to interstate freight transport under several jurisdictions. Consequently, diversity exists in the general lifestyle of operations workers, e.g. rollingstock maintenance workers who live near the workplace and can go home at the end of each shift in contrast to drivers working on an interstate passenger line, who are regularly away from home for a period of several days or more. A representative sample of diverse work groups will facilitate examination of the differences among respective subcultures.

1.11 Prediction of Safety Performance based on Safety Climate/Culture

Some researchers have attempted to establish whether safety climate can predict various aspects of safety performance (see reviews by Glendon, et al., 2006; Grabowski, et al., 2007). The results have been inconclusive. A significant association between a more positive safety climate and fewer accidents has been found in chemical and nuclear processing (e.g. Hofmann & Stetzer, 1996; T. Lee, 1998), manufacturing and construction sectors (e.g. Brown & Holmes, 1986; Gillen, Baltz, Gassel, Kirsch, & Vaccaro, 2002; Zohar, 2000, 2002) and in rail (e.g. Itoh, et al., 2004). A majority of these studies appear to establish the relationship between individual or team level safety climate and accidents. For example, Hofmann and Stetzer (1996) found that at the team level of analysis, safety climate and unsafe behaviours were significantly associated with actual accidents. On the other hand, several studies have failed to support such an association in a chemical processing sector (Alexander, Cox, & Cheyne, 1994) or in road construction (Glendon & Litherland, 2001).
In a study of UK automobile manufacturing, Clarke (2006b) found that safety climate (in terms of management concern for safety, workers’ response to safety and conflict between production and safety) did not predict accident involvement. However, workers’ response to safety and conflict between production and safety were significant predictors of unsafe behaviour. Furthermore, perception of work environment (in terms of work pressure and work clarity) was a significant predictor of accident involvement and unsafe behaviour. In another study of meta-analysis, Clarke (2006a) found that safety climate showed a weak association, indicating that a more negative safety climate was associated with a higher accident rate ($\rho = .21$). Similarly, Cooper and Phillips (2004) suggest, in a study on a manufacturing facility, that a direct relationship appears to exist between safety climate and safety behaviour when sufficient data is collected, but not between safety climate and recorded accident rates. The authors propose that the use of accident rates for validation in safety climate research may not be appropriate, as historical fact (i.e. the past reality) is compared with present perceptions. Furthermore, accidents are relatively infrequent resulting in highly skewed distribution, and thus do not provide reliable data regarding an organisation’s safety health (Reason, 1991, 1998; Zohar, 2000).

### 1.12 Previous Research on Rail Safety Climate/Culture in Australia

In Australia, Edkins (1995a, 1995b) investigated whether retrospective analyses of railway accidents and past unsafe work practices are reflected in systemic faults and failures proactively identified by staff. The results revealed a moderate bi-directional relationship. Based on Reason’s (Reason, 1990) GEMS principles and Rail Problem Factors (RPFs, Reason, 1997), Edkins and Pollock (1996, 1997) identified thirteen salient factors (RPFs), which potentially have adverse effects on train-operating safety. The researchers then developed and administered a checklist Rail Safety Checklist to train drivers to rate the extent to which these factors had been a problem in carrying out their work over the previous two months. The results revealed that negative work attitude and low
morale posed a serious threat to safe train operation, particularly through attentional deficits and skill-based errors. Furthermore, factor analysis revealed three factors: 1) Policy and Decision Making; 2) Workplace Culture; and 3) Operating Conditions. Further details of the research above are discussed in Chapter 2.

Glendon pioneered the assessment of safety climate of the rail industry as exemplified in the RailCorp Safety Survey in the Special Commission of Inquiry into the Waterfall Rail Accident (McInerney, 2005). It was designed to collect the staff’s perception of the safety standards within the organisation. The RailCorp Safety Survey (Glendon, in McInerney, 2005) is a self-report paper-and-pencil questionnaire. The respondents are asked to rate the degree to which they agree with a statement/description from a 5-point Likert scale. A majority of items deals with the workers’ perceptions of the 5 core themes, as outlined above. For example, out of 48 questions in the RailCorp Safety Survey (Glendon, in McInerney, 2005), 34 questions asked how the respondent perceived the company in areas including communication, staff involvement, leadership, training, resources, environment and procedures in relation to safety, e.g.: “Staff are encouraged to consider safety as more important than keeping to schedule.” and “Operational equipment is maintained to a safe standard.”, to a response scale ranging from “Strongly Disagree” to “Strongly Agree”. Glendon and Evans (2005, 2007) conducted further safety climate studies in New South Wales and Queensland.

In recognition of the importance of a healthy safety culture, the rail industry in Australia took a safety culture measurement initiative. In 2007 the Rail Industry Safety and Standards Board (RISSB) introduced an industry-wide instrument, which was adapted from the UK rail industry’s “Safety Culture Tool” by the Rail Safety and Standards Board (RSSB). This tool has undergone extensive trials on the UK rail industry. It provides a confidential, secure, repeatable, automated platform for administering the survey within a rail organisation. It automatically provides results of statistical analysis to the user, which helps identify gaps within the safety culture of the organisation. It also benchmarks against industry averages and suggests a number of possible interventions.
Both RSSB (UK) and RISSB (Australian) versions of the ‘Safety Culture Tool’ have incorporated, to a large extent, questionnaire items from six safety climate tools reviewed by the UK’s Health and Safety Executive (2001). The six tools consist of the Health and Safety Climate Survey Tool developed by HSE, various UK universities (Aberdeen University, Robert Gordon University, and Loughborough University) and a private enterprise, Quest Evaluations and Databases Ltd. The RISSB online questionnaire addresses the following 11 dimensions: 1) Barriers and Influences; 2) Training; 3) Communication; 4) Organisational Commitment; 5) Management Commitment; 6) Supervisor’s Role; 7) Personal Role; 8) Workmates’ Influence; 9) Risk Taking Behaviours; 10) Employee Participation; and 11) Organisational Learning. These dimensions reflect the findings from the safety climate literature with strong emphasis on employees’ perception of management values/attitudes to safety, followed by safety equipment, safety training, safety practices and safety systems, safety communication, supervisor attitudes to safety and risk taking behaviour (see reviews by Flin, et al., 2000; Neal, Griffin, & Hart, 2000).

Following the literature review, the author of the current study takes no particular position on the ‘climate’ versus ‘culture’ debate. The philosophical contrast between the two concepts does not seem relevant to the data presented in the following chapters which suggest specific paths for reducing accident and injury rates.
1.13 Rationale for the Current Study and Research Questions

Identifying, resolving and monitoring deficiencies in the sociotechnical system is a vital component of good safety management. Measurement of safety climate/culture has the potential to be integrated into proactive safety management strategy with the ultimate aims: 1) assisting rail organisations to identify strengths and weaknesses in their safety management system for risk mitigation; and 2) contribute to individual rail employees’ wellbeing through improved safety standards and protection as a result of information identified as a result of the measurement process. The current study explores the utility of measuring safety climate/culture and scope for its practical application.

This thesis presents several progressive phases undertaken in order to bridge the gaps in the literature related to the measurement of safety climate/culture, in the context of the Australian rail industry. A holistic approach to safety climate/culture measurement was undertaken, while also incorporating the five-stage model of safety culture maturity.

The aim of the first phase of this study (Chapters 2 and 3) was to create a rail-specific questionnaire in the Australian context, designed to measure safety climate/culture based on a holistic model of safety culture (Grote & Künzler, 2000) as outlined in Section 1.9. This was facilitated by generating a questionnaire, which addresses both ‘material’ and ‘immaterial’ aspects of safety climate/culture. The questionnaire contains two broad sets of safety climate/culture items.

The first item set addresses predominantly ‘material’ aspects of safety in relation to structure and functioning of safety management systems. Retrospective analysis of contributing factors to accident causation was achieved through analysis of rail accident investigation reports. The conceptual bases for this process were Reason’s (1990, 1991) GEMS and the Railway Problem Factors (RPFs, Edkins & Pollock, 1996, 1997; Reason, 1997) as outlined in Section 1.12. Aspects addressed by this item set are closely aligned with the function types outlined in GEMS (1991). Administering these items represents obtaining information through Channel 4 in the safety information system model proposed.
by Reason (1991) (see Figure 1.5). In this model, Channel 4 addresses organisational failures, particularly at the line management level, translated into functional forms and then distributed throughout the organisation along departmental pathways (see Section 1.6 of this chapter).

The second item set consists of a selection of questionnaire items from Lawrie et al.’s (2006) study based on the developmental model of safety culture maturity. Specifically, these items originated from the brochure *Understanding Your Culture* (Brochure HSE005) in Shell’s *Hearts and Minds* program (Bryden & Hudson, 2005) as outlined in Section 1.9. With permission from Shell International Exploration and Production B.V. (Shell) and the Energy Institute, UK, a selection of questionnaire items were adopted specifically for the rail industry in Australia (Appendix 3).

This selection was deemed appropriate, as the items address both ‘material’ and ‘immaterial’ aspects of safety climate/culture. These items reflect characteristics of the five different stages of safety cultural maturity ranging from ‘pathological’ to ‘generative’ in 18 aspects. The author of the current thesis argues that this item set came from a more proactive approach as they were generated through observations of cultural characteristics demonstrated by organisational groups such as installations and units in the eyes of the interviewees. Administering these items represents obtaining information through Channel 4 and 5 of Reason’s (1991) safety information system (see Figure 1.3). As previously mentioned, Channel 4 addresses organisational attributes and shortcomings, particularly at the line management level, while Channel 5 addresses information regarding the overall organisation’s safety culture embodied in top-level commitment, competence and cognisance.

The composite questionnaire was administered in Western Australia, South Australia and Victoria. Three of the six participating organisations operate in multiple jurisdictions, which resulted in inclusion of a small number of participants working across the three states above, Northern Territory and in New South Wales. This geographic coverage complements Glendon and Evans’ (2005, 2007) safety climate studies, which were conducted in New South Wales and Queensland.

The aim of the second phase (Chapters 4 and 5) of this study was to examine whether the questionnaire can capture differences in safety
climate/culture among occupational groups within an organisation. As outlined in Section 1.10, sub-climates and sub-cultures are known to exist as a function of various background factors. In this examination, distinction was made between the two sets of questionnaire items due to the difference in their theoretical background: 1) retrospective analysis of rail accident investigation reports in the tradition of GEMS (Reason, 1990, 1991) and RPFs (Edkins & Pollock, 1996, 1997); and 2) Shell’s proactive approach to assess the stage of an organisation’s safety culture maturity (Bryden & Hudson, 2005; Parker, et al., 2006; Westrum, 1993). Review of relevant literature gave rise to the following two hypotheses:

Hypothesis 1a: Group differences exist between occupational groups in terms of safety climate/culture as measured by the RPFs items.

Hypothesis 1b: Group differences exist between occupational groups in terms of safety climate/culture as measured by Shell’s safety culture maturity items.

The aim of the third phase (Chapter 6) of the current study was to investigate whether safety climate/culture assessed through the two questionnaire item sets predict actual safety outcomes. Given the inconclusive evidence of predictive validity of safety climate/culture on safety outcomes as outlined in Section 1.11, the association: 1) between safety climate/culture and accidents; and 2) between safety climate/culture and near misses were investigated. On the basis of the above discussion, the following hypotheses were formulated:

Hypothesis 2a: Safety climate/culture as measured by the RPFs items would predict accidents and near misses in the two-year data from rail organisations.

Hypothesis 2b: Safety climate/culture as measured by the Shell’s safety culture maturity items would predict accidents and near misses in the two-year data from rail organisations.

The fourth aim was to examine whether safety climate/culture assessed through the two questionnaire item sets predict proactive employee involvement in accident prevention. Growing evidence suggests that proactive indicators such as involvement with safety activities may be more appropriate measures of safety health (Clarke & Ward, 2006; Neal & Griffin, 2006; Neal, et al., 2000; Stricoff, 2000). Under the assumption that employees’ reporting of safety defects in
equipment, rollingstock and infrastructure reflects their commitment to safety and proactive steps toward mitigation of risks, the following hypotheses were formulated:

**Hypothesis 3a:** Safety climate/culture as measured by the RPFs items would predict reporting of safety defects in the two-year data from rail organisations.

**Hypothesis 3b:** Safety climate/culture as measured by the Shell’s safety culture maturity factors would predict reporting of safety defects in the two-year data from rail organisations.

Finally, the fifth aim was to examine whether Shell’s safety climate/culture items support the five-stage model of safety culture maturity. The current author is not aware of any further empirical investigation into the model, since the study by Lawrie, et al. (2006). As Glendon (2008) remarked, further work is required to determine whether psychometric properties can validly be applied to the descriptors from qualitative cultural analyses.
CHAPTER 2
Analysis of Rail Accident Investigation Reports

2.1 Introduction

As outlined in Section 1.6, Reason (1990) developed the Generic Error-Modelling System (GEMS) from a sociotechnical perspective. He argues that unsafe acts committed by frontline operators (active failures) cannot be viewed in isolation. The GEMS model (Reason, 1990) distinguishes between deficiencies in the managerial and organisational sectors failure types and individual conditions and unsafe acts failure tokens. As can be seen in Figure 1.4, failure types exert over-arching effects on system safety. This model illustrates the importance of addressing error-provoking latent conditions at the higher echelon of the organisation in order to prevent them from developing into failure tokens at the individual level. The following section summarises the various elements which comprise the GEMS model (Reason, 1990).

Errors

GEMS classifies human performance problems (unsafe acts) into errors and violations. Errors are classified based on Rasmussen’s (1983, 1986) skill-rule-knowledge framework and Norman’s (1991) distinction between slips and mistakes for human information processing and task execution. It stipulates that human performance operates at three cognitive levels, consisting of: automatic (skill-based); semi-automatic (rule-based); and controlled (knowledge-based) levels.

Errors occur when well-practised tasks are carried out in familiar surroundings. They are defined as “the failure of planned actions to achieve their intended consequences”. Errors are broadly divided into two categories based on intention. The first category consists of slips and lapses, which are unintended deviations from planned action. The second category is mistakes, defined as “the departure of planned actions from some satisfactory path towards a desired goal (Reason, Manstead, Stradling, Baxter, & Campbell, 1990, p. 1315)”.


Slips and lapses happen at the skill-based level through either inattention or over-attention, and are often influenced by strong habit intrusions. Slips are observable actions, commonly associated with attentional failures. This category includes misidentification of objects and signals, e.g. a train driver perceiving a red signal aspect as green as he has been accustomed to seeing a green aspect at a certain point of the rail track. Catastrophes resulting from such errors include the Harrow train disaster (1952) and Ladbroke Grove rail disaster (1999). Lapses, on the other hand, are more internal events and generally involve failures of memory. An example can be seen in Runaway Train, Melbourne (ATSB, 2003), where a train driver did not apply the park brake before getting out of the driver’s cab.

Mistakes, on the other hand, are caused by “deficiencies in the judgmental and/or inferential processes in the selection of an objective or of the means to achieve it, or both (Reason, et al., 1990, p. 1316)”. Rule-based mistakes occur in a problem solving situation at the semi-conscious level. They can happen when some change in the situation requires adjustments of largely pre-programmed behaviour based on a rule – if (this situation) then do (these actions). Rule-based mistakes can result from either misapplication of a good rule or application of a bad rule. A rail example includes a train driver failing to adjust the train speed in a wet condition (misapplication of a good rule) or an infrastructure technician, when rewiring a signal box, habitually bending back the old wires rather than removing them (application of a bad rule) as seen in Clapham Junction rail disaster (Hidden, 1989).

Knowledge-based mistakes occur when a novel situation confronts a person who is not equipped with solutions readily available from previous experience or training. Solving such a problem requires conscious attention to the situation. It is a mode that humans employ very reluctantly. Only when we have repeatedly failed to find some solution from our pre-existing knowledge base do we resort to the slow and effortful method of thinking things through on the spot. A rail example includes Derailment of Cairns Tilt Train VCQ5 (ATSB, 2005). This involved the train driver returning to the driving position after a momentary break, going through a trial-and-error process to regain control of the train, while being confronted with an excessive train speed coupled with loss of situation awareness in the darkness of the night. Under those conditions all his trained remedial actions were of no avail.
Violations

Reason and colleagues (1990) propose violations as a further category of unsafe acts. This category denotes intentional deviation from practices, often believed necessary to maintain the safe operation of a hazardous system. In contrast to errors arising from faulty information processing at the individual level, different cognitive and psychological processes underpin violations. These researchers posit that violations “can only be described with regard to a social context in which behavior is governed by operating procedures, codes of practice, rules, norms and the like (Reason, et al., 1990, p. 1316)” Thus, they highlight the importance of including cultural aspects when examining contributing factors to negative safety outcomes.

Violations are broadly divided into four categories, and are not necessarily reprehensible. The first three violations consist of routine, optimising and necessary violations. The last category sabotage is a deliberate aberrant behavior intended to cause harm or damage. It is clearly differentiated from the former three types, and as such it is excluded from further discussion in the current study.

Routine violations are short-cuts at the skill-based level of performance. They can form a habitual part of a person’s behavioral repertoire, particularly when such actions are rarely sanctioned or compliance is not rewarded in the work environment. Two main factors are believed to play an important role in shaping routine violations:

(a) the natural human tendency to take the path of least effort; and
(b) a relatively indifferent environment (i.e., one that tolerates violations). If the quickest and most convenient way of performing a task involves deviating from an apparently trivial and rarely sanctioned safety procedure, then operators will violate the procedure routinely.

The following example from the US illustrates the nature of routine violations:

During shunting at a yard on a descending grade, the train crew and the switching crew did not secure the railcars with the handbrakes before the airbrakes were released on the railcars. A consist of 31 wagons started to roll downgrade, which resulted in a derailment and destruction of three
residential homes. The company’s operating rules stipulated that a sufficient number of handbrakes be applied on the railcars before detaching a locomotive. When asked why they did not secure the locomotive with handbrakes, the crews responded that they had expected the emergency application of the air brakes to hold the railcars stationary. Because they had assumed that the switching crew’s locomotive would quickly be attached to the opposite end of the cars, they expected the railcars would not be left unattended for too long without a locomotive attached. They had done this before at the same location. The company’s supervisors also acknowledged that they were aware of this method of exchanging railcars from one crew to the other (NTSB Report RAB-04-03, 2004).

*Optimising violations* are committed when attaining a personal goal rather than safety is prioritised. They serve a variety of motivational goals irrelevant to the original function of the task, e.g. the excitement of speed, aggressive behavior or alleviating boredom, which can develop into a person’s performance style. The following example from the US illustrates the characteristics of this category of violation.

The driver and conductor of a locomotive were reading books at the controls for 30 minutes. During that time, despite the operating rules, neither of them observed nor confirmed the signal aspects and left the train operation to an inexperienced trainee driver. The locomotive collided with another loco in motion at a junction and derailed five railcars. The driver and the trainee survived by jumping out of the locomotive in time, while the conductor was killed in the collision. In this instance, the driver and conductor were focused on alleviating boredom, even though they most probably did not intend to cause any harm (NTSB Report RAB-99-02, 1999a).

*Necessary violations* are non-compliance that is seen as an essential part of completing tasks, in some cases practiced repeatedly. They are commonly provoked by organisational failings including inadequate site, tools or equipment. They can take place at either rule-based or knowledge-based level. The following
UK example illustrates the nature of necessary violation at the rule-based level (Reason, 2008).

“The British Rail ‘Rule Book’ (amended every six months) prohibited shunters from remaining between wagons during easing up; that is, when a set of wagons is propelled by a pilot engine towards some stationary wagons to which they will be attached. Only when the wagons are stopped can the shunter compliantly get down between them to make the necessary coupling. On some occasions, however, the shackle for connecting the wagons is too short to be coupled when the buffers are at their full extension. The job can only be done when they are momentarily compressed as the wagons first come into contact. Thus, the only immediate way to join these particular wagons is by remaining between them during the easing-up process. In the last days of British Rail (prior to 1994), an unacceptable number of shunters died each year as the result of being trapped between the buffers. (p. 53)”
2.2 Background to the Current Study

Retrospective Safety Management

Edkins and Pollock (1997) conducted a retrospective analysis of 112 incidents involving train drivers in an Australian rail organisation in order to identify possible causal and contributing factors behind the frontline operation. Those incidents had initially been classified by the rail organisation as “staff error” (Edkins, 1995a) because they were regarded to have occurred primarily as a result of direct human involvement.

Edkins and Pollock (1997) used Reason’s (1990) Railway Accident Investigation Tool (RAIT), which was developed for British Rail based on GEMS principles. They extended the model by including the investigation of the psychological and other precursors to unsafe acts. The precursors are classified into five groups: 1) Attentional; 2) Unfamiliarity; 3) Violation; 4) Environmental; and 5) Organisational. The first three categories are aimed at classifying the psychological aspects of individual operators, while the latter two are designed to capture organisational/situational influences on the final negative outcomes. A diagrammatic representation of the adapted model is described in Figure 2.1.

The Attentional category addresses cognitive precursors to skill-based errors (slips and lapses) arising from inattention or over attention. Unfamiliarity is defined as precursors to rule-based and knowledge-based mistakes relating to inexperience with established tasks or procedures. Violation forms a distinct category to represent actions that ignored established rules or procedures. The Environmental category refers to weather conditions or uncontrollable location factors. Finally, the Organisational category addresses workplace conditions and/or practices such as miscommunication or inadequate training. These last two categories are included as contributing factors to the reported incidents which are beyond the control of the human operator.

Edkins and Pollock (1997) found the attention-related precursors as the most prominent contributing human factor to mishaps across all incident types. Inattentiveness was the most prominent precursor, resulting in signal past danger
(SPADs) (39%), followed by trains running through incorrectly set junction points (33%).

**Figure 2.1.** Diagrammatic representation of Reason (1990) and Edkins and Pollock’s model (1996) (Adapted)
**Prospective Safety Management**

Alongside the retrospective RAIT program, Reason (1990, 1997) also developed a proactive rail-specific diagnostic package REVIEW for British Rail. It was aimed at making latent failures more visible by drawing on input from frontline operators. Through extensive field work, Reason investigated factors which frontline operators regarded as potential contributors to unsafe working practices. This investigation addressed any aspect of the operational system, including organisational, situational, technical, social or behavioural areas. This exhaustive process identified 16 salient factors, which were called Railway Problem Factors (RPFs).

The RPFs consisted of: tools and equipment; materials; supervision; working environment; staff attitudes; housekeeping; contractors; design; staff communication; departmental communication; staffing and rostering; training; planning; rules; management and maintenance. A checklist was then created which reflected these RPFs. REVIEW’s proactive diagnosis was facilitated by administering this checklist to operational staff on a regular basis, which helped highlight areas of concern at each time of data collection.

Edkins & Pollock (1996, 1997) applied the REVIEW program to a rail organisation in Australia. Through focus groups with train drivers and managerial staff, they found 13 RPFs, which comprised of training; communication; operating equipment; maintenance; staff attitude; supervision; working conditions; rules/procedures; staffing; management; housekeeping; equipment design; and organisational policies.

Based on their findings, Edkins & Pollock (1996, 1997) developed a Railway Safety Checklist with items representing the 13 RPFs. It was administered to 454 train drivers and asked participants to rate the extent to which each RPF had posed a problem in carrying out their job over the previous 2 months.

Staff Attitude was reported as having posed a serious problem on driver performance over the previous 2 months, accounting for 66% of the respondents. This was followed by Operating Equipment (48%), and Maintenance (47%). These results indicate the substantial potential contribution of latent failures to the accident causal pathway. Furthermore, close scrutiny of the analysis revealed that
60% of the respondents drew attention to the problem of low morale. These findings served to highlight the importance of considering cultural aspects of an organisation when investigating its systems safety.

**Outline of the Current Study**

Document analysis was conducted on 104 rail accident investigation reports prepared by government investigation agencies in Australia and the US. Since the investigation reports were structured in a framework compatible with GEMS, it was deemed appropriate to apply Edkins and Pollock’s (1997) GEMS-based approach.

The purpose of the current study was twofold. The first aim was to examine the general pattern of active and latent failures to the retrospective analysis of investigation reports in a wider rail context. This was done by drawing upon Edkins and Pollock’s (1997) classification of precursors in their refined model of RAIT and the framework of the Rail Problem Factors (RPFs). While Edkins and Pollock’s (1997) investigation was focused on one specific rail organisation in Australia, the current study targeted data from a wide range of rail organisations across Australia and the US. Furthermore, in contrast to Edkins and Pollock’s (1997) study which focused on mishaps, the current study focused on accidents that had considerable consequences. The current study also extended the precursors framework by through sub-classification in order to facilitate further understanding of those important potential contributors.

The second aim of this study was to apply the findings of the analysis to constructing items for a segment of an employee questionnaire designed to measure safety perception and culture in a wide cross-section of occupational groups within the Australian rail industry.

### 2.3 Method

**Materials**

The 104 accident investigation reports featured fatalities or major safety outcomes over a period of nine years (Sept. 1998 – Jan. 2006) in Australia and the United States. They were sourced from three agencies in the public domain,
which consisted of Australia’s federal agency for investigating significant rail accidents the ATSB (The Australian Transport Safety Bureau), New South Wales’ state-based investigation body the OTSI (The Office of Transport Safety Investigations), and the US federal investigation agency the NTSB (National Transportation Safety Board). Those agencies conducted accident investigations independent of regulators, police and legal entities. Their reports were organised in accordance with international standards or instruments, with the sole focus placed on improvement of transportation safety. This was achieved through analysis of factual information and determination of probable cause(s) and contributing factors and issuing safety recommendations aimed at preventing future accidents. They specifically emphasised that in no way were the investigations intended for the purpose of apportioning blame or providing a means for determining liability.

**Design**

Document analysis was conducted in four stages. It consisted of examining the active and latent failures identified in the investigation reports. It was a retrospective process which entailed tracing the accident causation pathway backwards from individual-level unsafe acts all the way to organisational failures.

**Procedure**

The first stage focused on identifying the most proximal factors featured in the reports. Active failures were classified either as an error or a violation. Errors were categorised at the skill-based (slips and lapses), rule-based and knowledge-based levels (mistakes). Violations were classified into three categories: routine; optimising and necessary violations (Reason, 1990, 1997). Where more than one active failure was implicated, the more pervasive factor was prioritised. For some of the accidents, individual unsafe acts did not play a direct causal role. They include, for example, a derailment that took place because the driver had not been advised to implement any appropriate safeworking operation when restraining rails had not been put in place during an ongoing track maintenance work (NTSB, Report RAB-01-02, 2001). Those cases were classified based on their most prominent causal or contributing factor in organisational, environmental or external domains.
Accidents that were regarded primarily as a result of skill-based errors included one unconfirmed case (The National (NTSB, Report RAR-99-04, 1999b)). As the driver died during the accident, the investigation team could only base their judgment on peripheral evidence regarding the situational context believed to have led to the accident. The proximal cause of this collision followed by a derailment was deemed to be the failure of the of the NP-01 engineer to stop at the stop signal possibly due to fatigue-induced inattentiveness.

The second stage of analysis was conducted based on Edkins and Pollock’s (1997) precursor classification system. The attentional and environmental precursors were subdivided in the following manner in order to gain further insight into the background behind those deficiencies. As the attentional precursor category covered diverse individual conditions, it was further divided into: 1) **Fatigue & Personal Stress**; 2) **Medical Conditions & Pharmacology**; and 3) **Work-related Stress**. While the first sub-category addressed fatigue and stress arising from personal circumstances, the third sub-category encompassed workplace stress such as those caused by excessive workload and time pressure.

The environmental precursors in Edkins and Pollock’s (1997) original classification had been defined as “errors due to weather conditions or uncontrollable location factors” (p. 535). This category was further divided into 1) **Environmental** and 2) **External** factors in order to differentiate between those factors purely pertaining to the natural environment and other local factors for which some human action was implicated. For example, environmental factors included fog, excessive heat and torrential rain which compromised safe rail operations, while external factors included various acts of vandalism, trespass and level crossings with ergonomic deficiencies (e.g. level crossing signals placed in an inappropriate position which could not be sighted from a reasonable distance). External factors also include the behaviour of road vehicle drivers as a result of defective cognition, for example, as demonstrated by an exhaustive investigation into Kerang level crossing rail crash in Victoria, Australia (ATSB, 2008) by Salmon, Read, Stanton and Lenné (2013).

In the third stage of analysis, investigation was conducted to identify in which locations organisational failures manifested. This was aimed at elucidating how commonly hidden latent failures upstream in the accident causation pathway
can lead to serious negative consequences at the front line. In the first three stages, chi-square analysis was conducted to ascertain statistical significance where appropriate. However, country-based or agency-based comparisons could not be performed with any of the stages due to limited sample size.


2.4 Results

Stage 1

A profile of unsafe acts and contributing factors across accident types is set out in Table 2.1.

As can be seen in Table 2.1, a consistent pattern emerged across the three databases. The most prominent categories were organisational factors (39%) and skill-based level errors (slips and lapses) (32%). Fifty-six out of the 104 reports had been implicated as having originated either from errors or violations as the primary causal factors (54%). Within the individual-based error domain (n = 46), slips and lapses at the skill-based level were the most prominent category (72%).

Chi-square analysis was conducted to evaluate the statistical significance of the frequency across the type of unsafe acts (Slips and Lapses, Rule-based Mistakes, Knowledge-based Mistakes and Violations). When collapsed across the data source, a significant difference was found in the frequency of the four types, with the majority being due to skill-based error (slips and lapses) with $\chi^2 (2, 56) = 37.714, p < .000$.

Similarly, chi-square analysis was conducted to evaluate the statistical significance of the frequency across the latent failures (Organisational, External and Environmental factors). When collapsed across the data source, a significant difference was found in the frequency of the four types of latent failures that had been reported as predominant contributors to the accidents, with the majority being due to organisational factors with $\chi^2 (2, 48) = 12.125, p = .002$. 
Table 2.1
*Summary by Type of the Most Proximal or Causal Factors for Each Accident*

<table>
<thead>
<tr>
<th>Factors</th>
<th>ATSB</th>
<th>OTSI</th>
<th>NTSB</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual psychological factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slips &amp; Lapses</td>
<td>8</td>
<td>3</td>
<td>22</td>
<td>33</td>
</tr>
<tr>
<td>Rule-based mistakes</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Knowledge-based mistakes</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Violations</td>
<td>3</td>
<td>0</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Organisational factors**</td>
<td>11</td>
<td>7</td>
<td>23</td>
<td>41</td>
</tr>
<tr>
<td>External factors</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Environmental factors</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>12</td>
<td>65</td>
<td>104</td>
</tr>
</tbody>
</table>

* This breakdown features only the most proximal factor implicated in each accident and the frequencies are mutually exclusive.
** Accidents, in which no individual unsafe acts were implicated, were classified into one of the organisational, external or environmental categories.

**Stage 2**

Investigation of psychological precursors to individual-level unsafe acts revealed the following results as outlined in Table 2.2. As can be seen in Table 2.2, the most prominent precursor for ATSB’s slips and lapses was Fatigue & Personal Stress, followed by Medical Condition & Pharmacology, then Other Attentional Factors. On the other hand, Fatigue & Personal Stress and Other Attentional Factors were more prominent in OTSI and NTSB. In the overall sample, Medical Condition & Pharmacology was the least prominent precursor.

Analysis of the violations revealed eight routine violations (80%) and two optimising violations (20%) overall. No necessary violations were identified in this sample.

Chi-square analysis was conducted to evaluate the statistical significance of the frequency across the type of attentional precursors. When collapsed across the data source, a significant difference was found in the frequency of the three types, with the predominant majority being due to Fatigue and Personal Stress and Other Attentional Factors including workload and time pressure with $\chi^2 (2, 33) = 11.091, p = .004$. Significantly lower frequency was found in the Medical Condition & Pharmacology category.
Table 2.2  
Summary of Proximal Factors Categorised by Type of Unsafe Acts and Psychological Precursors

<table>
<thead>
<tr>
<th>Unsafe Acts</th>
<th>Psychological Precursors</th>
<th>Data Source</th>
<th>Sample Size</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ATSB</td>
<td>OTSI</td>
<td>NTSB</td>
</tr>
<tr>
<td>Attentional Factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slips &amp; Lapses</td>
<td>Fatigue &amp; Personal Stress</td>
<td>5</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Medical Condition &amp; Pharmacology</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Other Attentional Factors**</td>
<td>1</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>RK-based Mistakes***</td>
<td>Unfamiliarity</td>
<td>3</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Violations</td>
<td>Routine Violations</td>
<td>3</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Optimising Violations</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Necessary Violations</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>14</td>
<td>4</td>
<td>38</td>
</tr>
</tbody>
</table>

* Out of the 104 reports, only 56 reports had identifiable individual or team level psychological precursors. For the remaining 48 reports, the most prominent causal or contributing factor was identified for each accident in organisational, environmental or external domains, and thus they are not featured in this table.

** They include workload and time pressure.

***RK-based mistakes stand for Rule-based or Knowledge-based mistakes.

Stage 3

The third stage of analysis investigated the location where organisational failures manifested themselves as accidents. Out of the 104 reports, only 56 reports had identifiable individual or team level psychological precursors. With 40 accidents out of the remaining 48 reports, the most prominent causal or contributing factor was identified in the organisational domain. The results of the analysis pertaining to this select group of accidents are outlined in Table 2.3.

As can be seen in Table 2.3, the most prominent location across the databases was Track, accounting for 40% for ATSB, 57% for OTSI and 57% for NTSB respectively. The second prominent location was Rolling Stock (30%) for ATSB and Level Crossings (29%) for OTSI. The second prominent location for NTSB was Dangerous Goods (17%), followed by Level Crossings (13%). Level Crossings featured consistently across the three databases while Dangerous Goods were observed only in the NTSB database in this sample.
Chi-square analysis was conducted to evaluate the statistical significance of the frequency across the locations. When collapsed across the data source, a significant difference was found in the frequency of the six location types, with the predominant majority being the track, followed by level crossings with $\chi^2 (5, 40) = 40.400, p < .000$.

Table 2.3  
*Location of Accidents due to Organisational Failures*

<table>
<thead>
<tr>
<th>Location of accidents</th>
<th>Data Source</th>
<th>Sample Size</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATSB</td>
<td>OTSI</td>
<td>NTSB</td>
</tr>
<tr>
<td>Dangerous Goods</td>
<td>27</td>
<td>12</td>
<td>65</td>
</tr>
<tr>
<td>Level Crossings</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Loading Procedures</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rolling Stock</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Signals</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Track</td>
<td>4</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>7</td>
<td>23</td>
</tr>
</tbody>
</table>

**Stage 4**

The final stage of analysis focused on identifying organisational factors for each accident using the Railway Problem Factors (RPFs) framework (Reason, 1990; Edkins & Pollock, 1997). Multiple organisational factors were found to be implicated in 82 out of 104 accidents (79%). A single organisational factor was found to be implicated in 18 accidents (17%). Only 4 accidents were found to have no contributing factors at the organisational level (4%). This means that 100 out of the 104 accidents had at least one organisational factor that contributed to their occurrence (96%). All the factors identified in this analysis were counted, totaling 267 entries. Therefore the frequencies are not mutually exclusive. A summary of the allocation of organisational factors that were identified as contributors to the 104 accidents is shown in Figure 2.2.
As can be seen in Figure 2.2, latent failures which contributed to the accidents were found in Organisational policies, rule & procedures for 70 cases out of 104 (67%). The second largest frequency was found in Maintenance with 43 cases (41%), followed by: Management (32 cases, 31%); Training (29 cases, 28%) and Staffing & Rostering (23 cases, 22%). Contrary to Edkins and Pollock’s (1997) findings, Staff Attitudes were identified as contributors only in 14 cases (13%), while Tools & Equipment were implicated only in 2 cases (2%).

The details of the categorisation of the 104 accident investigation reports in this analysis are presented in Appendix 1, followed by the breakdown of the entries in Appendix 2.
2.5 Discussion

The first stage of analysis revealed that attentional factors, particularly skill-based errors (slips and lapses), and organisational factors were the predominant contributors to accidents. This supports the findings by Edkins and Pollock (1997).

The second stage of analysis of psychological precursors to errors and violations found that Fatigue & Stress and Other Attentional Factors which included Workload & Time Pressure were the most prominent psychological precursors to skill-based errors. Medical Conditions & Pharmacology was the least prevalent overall. This is noteworthy as it suggests the rarity of unsafe acts that result from a frontline operator whose task execution was interfered with either by a medical condition or the influence of pharmacological substance. This could be a result of effective safety management systems; e.g. individuals deemed unfit to perform duties are screened out through medical checks, and through effective drug and alcohol testing. In this sample, ATSB was the only database that featured Medical Conditions & Pharmacology.

The third stage of analysis revealed that Tracks were the most prominent location where organisational failures resulted in accidents. While the US database included accidents involving dangerous goods, the Australian databases showed none in this sample. This could be a reflection of different types of freight transported across the two countries. Level crossings featured prominently across the three databases, signifying that passive or unprotected level crossings are challenges common to both the US and Australia where similar geographical expanse and the cost-benefit imbalance of installing active systems in rural areas are considerations.

In the final stage of analysis, 13 RPFs were qualitatively identified, which reflected minor differences with Edkins and Pollock’s (1997) findings. Edkins and Pollock’s (1997) RPFs consisted of: 1) operating equipment; 2) supervision; 3) working conditions; 4) staff attitudes; 5) housekeeping; 6) contractors; 7) equipment design; 8) communication; 9) staffing; 10) training; 11) rules and procedures; 12) organisational policies; 13) management; and 14) maintenance. The current study identified the following 13 RPFs, consisting of: 1)
communication; 2) contractors safety management; 3) design; 4) housekeeping; 5) maintenance; 6) management; 7) organisational policies, rules and procedures; 8) staff attitudes; 9) staffing and rostering; 10) supervision; 11) tools and equipment; 12) training; and 13) working conditions. These marginal differences serve to highlight the similarity of salient factors amongst Reason’s UK sample (1990), Edkins and Pollock’s Australian sample (1997), and the Australian and US sample for the current study. In personal communication with Edkins and Pollock (1996), Reason indicated that the number of RPFs was unimportant and more factors did not equate with lower level of safety. These factors were simply “indicative of the complexity and dynamic nature of the functions that an organisation performs (p. 90)”, suggesting the generic nature of these factors.

While Edkins and Pollock (1997) found staff attitude, operating equipment and maintenance as the most pervasive problem factors, the current study found organisational policy, rules and procedures the predominant factor, followed by maintenance and management. Staff attitude and tools and equipment did not feature prominently in the current study.

This difference is most likely to have arisen from the somewhat unconventional application of the RPFs framework to the current study, as this framework was originally developed through input from frontline operators for proactive identification of potential latent failures (Reason, 1990, 1997). Similarly, Edkins and Pollock (1997) identified the 13 RPFs through focus groups with train drivers and managers with train driving experience. They then administered the Railway Safety Checklist reflecting those 13 RPFs to train drivers. In the current study, on the other hand, the RPFs were identified and quantified through tabulating the latent failures retrospectively identified as having contributed to the accidents in the investigation reports.

Substantial difference can be expected between the observation of those directly involved in rail operation and accident investigators from external agencies. The rail workers are likely to cite problems in their immediate milieu, particularly prompted by a concise checklist that includes such items as staff attitude and operating equipment. Additionally, they may not necessarily be familiar with the contributing factors framework such as GEMS. On the other
hand, investigators are removed from day-to-day direct involvement with rail operation, although they are well equipped with rail knowledge and experience.

Furthermore, the investigation reports are written from a systems perspective with a focus on what can be learned from the occurrences. Intrinsically the investigators have been trained to look deep into organisational factors for future improvement. Those investigation reports which specified staff attitudes as a contributing factor in the current study demonstrated comprehensive understanding of cultural issues. However, these represented only 14 out of the 104 reports (13%).

Retrospective accident investigation has the intrinsic difficulty of obtaining thorough and objective information from the individuals and the organisation involved. They are also reliant on the accident model employed (Hollnagel, 2004) and hindsight bias (Woods, et al., 2010). Furthermore, the investigators’ technical background may lend itself to subjectivity in the investigation process. It is plausible that some of the investigators involved in the 104 reports may have come from a more technical background. They may have placed a stronger emphasis on maintenance and engineering issues not only due to their expertise but also as these areas are the more physically obvious than organisational (e.g. policy, procedures or training issues), and the inner workings of an individual’s or a group’s psychology. Even if the investigators have good appreciation of the importance of cultural issues, safety culture would be one of many aspects they need to evaluate. Thus, unless they are confronted with clear and tangible evidence of negative safety culture, the investigators are unlikely to specify safety culture as a contributing factor.

The results indicate the complex and interrelated nature of the accident pathway in most cases. This supports the well-established argument that those who have committed active failures are generally the victims of organisational failures, and not the perpetrators (Reason, 1990). They have further elucidated the diversity of factors implicated in the accident causation pathway, which emphasised the importance of taking cultural factors into account when examining contributing factors to negative safety outcomes. The findings of the analysis outlined above were used as a foundation for generating items for an employee questionnaire, which will be discussed in the next chapter.
CHAPTER 3
Method – Questionnaire Construction and Survey Administration

As outlined in Section 1.13, a rail-specific questionnaire was created in the Australian context, designed to address both technical/structural aspects and psychological aspects of safety as perceived by the employees. Inspired by safety climate and safety culture studies, the items were generated through 1) analysis of rail accident investigation reports based on the GEMS framework (outlined in Chapter 2); and 2) modification of items from Shell’s safety culture questionnaire.

A pen-and-paper self-report questionnaire the Rail Safety Perception & Culture Employee Questionnaire (see Appendix 4) was specifically constructed for the present study to be administered to rail employees of diverse occupational groups and job levels in Australia. This chapter reviews the method applied to the development and application of this instrument. Section 3.1 outlines the structure of the questionnaire. Section 3.2 reviews the process of the construction of the questionnaire. Section 3.3 outlines its validation through pilot testing. Finally, Section 3.4 describes the survey administration and the responses.

3.1 Structure of the Questionnaire

The Rail Safety Perception & Culture Employee Questionnaire contains 163 items in a five-tiered structure spanning across Sections A to E. Its structure is outlined in Table 3.1.

Section A consists of items designed to gauge rail workers’ perception of safety risks and assess areas of concern as perceived by the employees in their workplace – in the context of their organisation’s work environment, safety management systems and external factors that impact them. Details of this conceptual framework are outlined in Section 1.12. Section A was divided into three parts: Sections A1 to A3, designed to assess the perception of safety in the participants’ workplace. They are briefly summarised as follow.
Table 3.1
Structure of the Rail Safety Perception & Culture Employee Questionnaire

<table>
<thead>
<tr>
<th>Section/Sub-Section</th>
<th>Section Name</th>
<th>No. of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sec A</td>
<td>A1 Work Environment</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>A2 Potential/Actual Safety Problems</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>A3 Evaluation of overall safety measures</td>
<td>2</td>
</tr>
<tr>
<td>Sec B</td>
<td>B1 Commitment Level of Workforce to HSE &amp; Care for Colleagues</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>B2 Balance between HSE &amp; Profitability</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>B3 Workforce Interest in Competency and Training</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>B4 Workplace Safety Controls</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>B5 Purpose of HSE Procedures</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>B6 What happens after an accident?</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>B7 Safety Audits &amp; Reviews</td>
<td>11</td>
</tr>
<tr>
<td>Sec C</td>
<td>C1 Driving Force behind Safety</td>
<td>10</td>
</tr>
<tr>
<td>Sec D</td>
<td>D1 Safety Records – Safety-related History and Participation</td>
<td>24</td>
</tr>
<tr>
<td>Sec E</td>
<td>E1 Demographics</td>
<td>11</td>
</tr>
</tbody>
</table>

Total 162 Items

Section A1

The participants were asked the following question: “How frequently would people who work in safety-critical areas in your workplace have encountered the following situation in the last 24 months?” They were then presented with 28 statements describing the situations and were asked to select their level of agreement from a 5-point Likert response scale ranging from Very Rarely to Very Frequently. Because of the diverse nature of the target participants’ occupational group and job level, it was deemed necessary to provide an additional selection Not Applicable. The statements portrayed both positive and negative aspects of safety measures and culture in the workplace. Some sample statements are presented below:

- They received support from the employer to seek medical help for conditions that interfere with restorative rest or sleep.
- They needed to overextend themselves because of poor roster scheduling (e.g. working overtime).
- They took shortcuts which could have potentially compromised safety because it had become standard practice - everyone does it all the time.
- Non-safeworking personnel were allowed access to safeworking equipment.
- They were under pressure to perform duties beyond the limits of what could have been reasonably handled by one person.
Section A2

The participants were asked the following question: “How frequently would people who work in safety-critical areas in your workplace have experienced potential or actual safety problems because of the following reasons in the past 24 months?” They were then presented with 20 statements describing the reasons and were asked to select their level of agreement from the same Likert scale as Section A1. The statements portrayed negative aspects of safety management systems in the workplace and external factors that affect safe operations of their work. Some sample statements are presented below:

- Because of lack of standardised approach to safety procedures.
- Unexpected intrusion across the track by people, animals and foreign objects.

Section A3

This section consisted of two questions asking the participants’ impression of overall safety measures of 1) their employer; and 2) the rail industry. The participants were asked to select their level of agreement with the statement from a 5-point Likert response scale ranging from Strongly Disagree to Strongly Agree. The statements consisted of:

- My employer has adequate safety measures overall.
- The rail industry in general has adequate safety measures overall.

Section B

Items in Section B are based on a collection of questions from the Hearts and Minds program designed to measure the maturity level of an organisation’s safety culture. As mentioned in Section 1.13, a total of 67 items were selected from a brochure Understanding Your Culture (HSE005). The five levels of safety culture in this ‘evolutionary’ model are characterised by the following representative phrases: 1) Pathological: Who cares about safety as long as we are not caught?; 2) Reactive: Safety is important: We do a lot every time we have an accident; 3) Calculative: We have systems in place to manage all hazards; 4) Proactive: We try to anticipate safety problems before they arise; and 5) Generative: HSE is how we do business round here (Bryden & Hudson, 2005; Parker, et al., 2006).
Details of this conceptual framework and a graphical representation of this model are outlined in Section 1.9. The process of adapting the items to suit the context of the Australian rail industry is outlined in Sub-Section 3.2.2.

**Section C**

This section addresses the employees’ perceptions of the major driving force(s) behind improving workplace safety. The participants were asked to rate how much the following 10 entities drove safety in their place of work:

1) Board of Directors  
2) Customers/Passengers  
3) Legislation  
4) Management  
5) Myself  
6) Public Opinion  
7) Rail Safety Regulators  
8) Health Safety & Environment (HSE) or OSH Department  
9) Safety-Critical Workers  
10) Trade Unions

This section was based on results of the researcher’s preliminary study in 2005 (Hart, 2005), in which considerable differences were observed in the ratings based on the frequency of the participants’ accident involvement.

**Section D**

This section contains questions regarding the participants’ personal information about their safety records. Areas they address include:

- LTIs  
- Non-LTIs that required medical treatment  
- Non-LTIs that required NO medical treatment  
- No. of near misses or hazardous incidents without injury

Other items address the participants’ level of involvement in and proactive actions for improving safety in the workplace over the previous 2 years (e.g. reporting of safety defects, participation in safety meetings, and experience of being a safety representative).
Section E

This section asked the participants’ demographic details, occupational group, job level and the number of years of service. Finally, the participants were given free writing space to voice their opinion, raise specific areas of concern or comments. While often used as an index for measuring the relative safety of an organisation in comparison with other organisations or with other industry, the highly skewed distribution of accident data (e.g. Hofmann & Stetzer, 1996) and the partly stochastic nature of accident causation (Reason, 1991, 2008) imply they are not a particularly informative indicator of the state of safety in the organisation (Reason, 2008; Zohar, 2000). Minor injuries (e.g. Zohar, 2000) and near misses (e.g. Mearns, Flin, Gordon, & Fleming, 2001) have been used in other research as more useful alternative safety indicators. For example, Zohar (2000) used ‘microaccidents’ defined as “on-the-job behavior-dependent minor injuries requiring medical attention (p. 589)” as objective injury data as recorded in the company’s infirmary. For the purpose of the current study, however, only self-reports of accidents and near misses were collected during the survey administration. Details of the process of item generation will be covered in the next section.

3.2 Item Generation

The Rail Safety Perception & Culture Employee Questionnaire was developed with the aim of measuring rail employees’ perception of their organisation’s preparedness for mitigating safety risks in terms of psychological, behavioural and structural aspects of their workplace. Based on the sociotechnical model of safety culture proposed by Grote and Künzler (2000) as outlined in Chapter 1, the questionnaire items were designed with a particular emphasis on evaluating the safety climate/culture at the ‘material’ level in relation to the structure and functioning of safety management systems as well as at the ‘immaterial’ level which reflects the psychological aspects of safety climate and safety culture.
This chapter describes the process of generating the questionnaire items. Items for Sections A1 and A2 were generated through the retrospective approach of utilising Rail Problem Factors identified through analysis of accident investigation reports based on the GEMS framework (Reason, 1990). On the other hand, Section B was created through adapting items from the Hearts and Minds program based on the Safety Culture Maturity framework (Bryden & Hudson, 2005; Parker, et al., 2006), a prospective approach to evaluating characteristics of safety culture.

3.2.1 Sections A1 and A2: RPFs – Retrospective Approach

The previous chapter outlined the process of identifying active failures and latent conditions in the document analysis of 104 rail accident investigation reports. By using the principle of Rail Problem Factors (Edkins & Pollock, 1997; Reason, 1990), the current study identified 13 Railway Problem Factors (RPFs). They consist of: 1) communication; 2) contractor safety management; 3) design; 4) housekeeping; 5) maintenance; 6) management; 7) organisational policies, rules and procedures; 8) staff attitudes; 9) staffing and rostering; 10) supervision; 11) tools and equipment; 12) training; and 13) working conditions.

The previous chapter also described the psychological and other precursors to unsafe acts (see Figure 2.1), which are identified as the more immediate contributing factors when tracing back the accident causation trajectory. These precursors are classified into: 1) Attentional Precursors; 2) Unfamiliarity; and 3) Violation. Attentional Precursors is categorised into a) Fatigue & Personal Stress, 2) Medical Condition and Pharmacology; and Others (including Workload & Time Pressure).

Items were generated based on empirical findings that fatigue and stress play a significant role affecting cognitive functioning and task performance in the workplace (Orasanu & Backer, 1996). Contributing factors to such situations include: inadequate or poor-quality sleep (Angus, Heslegrave, & Myles, 1985; D. Dawson & McCulloch, 2005; Van Dongen, Maislin, Mullington, & Dinges, 2003); the impact of shift work on the quality of sleep (Hossain et al., 2004); long hours of work and fatigue (Arnold et al., 1997; Hartley, 2006; Sherry, 2003); job
stress (Diem, 2002); psychological trauma associated with life-threatening accidents in transportation (Sherry & Philbrick, 2003); and health, life and domestic stress outside of work (Hartley & El Hassani, 1994). In an experimental study, Heslegrave and Angus (1985) found that of participants’ performance was equally sensitive to sleep deprivation for both long-duration and short-duration cognitive tasks. In particular, performance on cognitive tasks given during work sessions showed significantly more impairment than performance on tasks tested at the beginning of work sessions following short rest breaks.

Rail-specific research suggests adverse effects of irregular train driving and break hours (Roach, Reid, & Dawson, 2003; Sherry, 2003) and fatigue on cognition and train handling (Dorrian, Roach, Fletcher, & Dawson, 2006, 2007). In a study on railroad employees who have experienced critical incidents (e.g. striking a trespasser, an assault or a personal worksite injury), Sherry (2009, 2011) discusses the long-lasting detrimental effects on their mental and physical health, with serious repercussions on occupational and social functioning.

Items in the first two sub-sections were generated as a result of rigorous analysis of 104 investigation reports of rail accidents that occurred in Australia and America over a 9-year period as outlined in Chapter 2. The document analysis was based on the Generic Error-Modelling System (GEMS) framework (Reason, 1990), and further classification system for considering psychological, physical and organisational precursors (Edkins & Pollock, 1996, 1997).

A total of 48 items was generated, consisting of 28 items addressing the precursors to active failures (Section A1) and 20 items in relation to the 13 Railway Problem Factors (Section A2). These items served as statements for the participants to select their level of agreement to the guiding question: “How frequently would people who work in safety-critical areas in your workplace have encountered the following situation in the last 24 months?” The response scale ranged Very Rarely to Very Frequently. The items are presented by category below.

**Section A1**

The following 28 items served as statements for the participants to select their level of agreement to the question: “How frequently would people who work
in safety-critical areas in your workplace have encountered the following situation in the last 24 months?” The 5-point Likert response scale ranged Very Rarely to Very Frequently. The items are presented by category below.

Fatigue and Stress (nine items) [RPFs - Staffing and Rostering]:
- They were encouraged by the employer not to attend work if they had had less than 5 hours sleep in the previous 24 hours. (Item 4)
- They were allowed to be on a night shift after they had been awake for more than 14 hours prior to start of work. (Item 5)
- They were allowed to cancel their shift at short notice due to pressing domestic circumstances. (Item 6)
- They were put under pressure to report for duty despite feeling fatigued. (Item 7)
- They needed to overextend themselves because of poor roster scheduling (e.g. working overtime). (Item 8)
- They had been fully informed by the employer regarding risks posed by sleeping disorders, symptoms and available means of detecting and treating them. (Item 9)
- They received support from the employer to make effective use of off-duty time to maximise restorative rest or sleep. (Item 10)
- They received support from the employer to seek medical help for conditions that interfere with restorative rest or sleep. (Item 11)
- They received support from the employer to seek professional help (e.g. counseling, therapy) to resolve domestic concerns that interfere with restorative rest or sleep. (Item 12)

Medical Conditions and Pharmacology (three items):
- They had roster flexibility which allowed them to cancel their shift at short notice due to medical conditions (e.g. chronic sleep disorders and cardiac conditions). (Item 13)
- They performed tasks under the influence of medication (both prescribed and self-administered) which could have potentially compromised rail safety. (Item 14)
- They were allowed to/ pressured to perform tasks despite sudden sickness (e.g. flu, nausea and migraine headache) which could have affected rail safety. (Item 15)

Other Attentional Precursors [RPFs - Working Conditions] pertaining to workload and time pressure (three items):
- They rushed to complete tasks to stay on schedule or to a timetable. (Item 1)
- They were in a work environment where they were easily distracted by other tasks or people while performing their job. (Item 2)
- They were under pressure to perform duties beyond the limits of what could have been reasonably handled by one person. (Item 3)
Unfamiliarity (three items):
- They performed tasks that they had NOT been fully trained in. (Item 16)
- They performed tasks in an unfamiliar environment/situation. (Item 17)
- They made potentially unsafe compromises because of equipment failure/mismatch (e.g. taking shortcuts or deviating from procedure). (Item 18)

Violations (eight items):
- They performed tasks under the influence of alcohol or illicit drugs which could have potentially compromised rail safety. (Item 19)
- They performed safety-critical tasks without authorisation. (Item 20)
- They were allowed to perform duties without their performance being adequately monitored following unfavourable safety compliance history. (Item 21)
- Non-safeworking personnel were allowed access to safeworking equipment. (Item 22)
- They got confused about what actions to take because of unclear communication from a colleague about safety-critical tasks. (Item 23)
- They broke the monotony of the task by engaging in various forms of entertainment (reading, listening to music, talking on the mobile phone for private matters, being engaged in personal conversation with a colleague on site) while on duty. (Item 24)
- They broke safeworking rules because they were overconfident. (Item 25)
- They took shortcuts which could have potentially compromised safety because it had become standard practice – everyone does it all the time. (Item 26)

Organisational Factors (two items):
- They were allowed to perform tasks without going through regular updating of safety-critical skills through refresher training and safety compliance audits. (Item 27)
- When they raised safety concerns and/or reported potential safety risks, these were ignored by line and/or top management. (Item 28)

Section A2
The following 20 items served as statements for the participants to select their level of agreement to the question: “How frequently would people who work in safety-critical areas in your workplace have experienced potential or actual safety problems because of the following reasons in the past 24 months?” The 5-point Likert response scale ranged Very Rarely to Very Frequently. The items are presented by category below:
Communication (two items):
- Because a change of operational/infrastructure circumstances had not been
  communicated to them. (Item 30)
- Lack of communication from colleagues about potential safety risks (e.g.
  observed defect in track, equipment and rolling stock). (Item 33)

Contractor Safety Management (one item):
- Because of inadequate management of contractor safety. (Item 43)

Design (three items):
- Poor design of equipment/rolling stock which could have compromised safe
  working. (Item 34)
- Inadequate protection at level crossings (e.g. passive level crossings). (Item 37)
- Because of inadequate defences against error or inadequate train protection.
  (Item 44)

Maintenance (one item):
- Equipment failure, poor condition of track, rolling stock and/or signalling.
  (Item 35)

Housekeeping (one item):
- Because of inadequate housekeeping (e.g. cleaning of facilities/operating
  equipment, tidy working environment, recovery from vandalism and ensuring
  clear track/signal sightings). (Item 38)

Management (two items):
- Lack of the employer’s effort to ensure compliance with safety rules (including
  those for operations, signaling, loading, inspection & maintenance). (Item 39)
- Because the employer had been unable to stop unsafe work practice that had
  been around for a long time and had become a standard way of doing things –
  everyone does it all the time. (Item 41)

Management, Supervision, Staff Attitudes & Communication (one item):
- Because they were unable to challenge decisions made by more experienced
  employees in the team. (Item 32)

Organisational Policies, Rules and Procedures (four items):
- Because of lack of standardised approach to safety procedures. (Item 29)
- Because procedures did not specify appropriate safeworking actions for certain
  safety-related tasks. (Item 31)
- Inadequate safety standards and procedures (including those for operations,
  signaling, loading, inspection, maintenance and management of dangerous
  goods). (Item 36)
- Because procedure manuals and checklists were hard to understand or NOT available. (Item 42)

Tools & Equipment (one item):
- Poor design of equipment/rolling stock which could have compromised safe working. (Item 34)

Training (one item):
- Lack of training in hazard identification before commencing any task. (Item 40)

External Factors (three items):
- Unexpected intrusion across the track by people, animals and foreign objects. (Item 45)
- Reckless behaviour of pedestrians and vehicle drivers (e.g. cars and trucks) at level crossings. (Item 46)
- Aggressive behaviour by passengers. (Item 47)

Environmental Factors (one item):
- Unforeseen weather and other environmental conditions (e.g. extreme heat, cold, and other inclement weather conditions). (Item 48)

### 3.2.2 Section B: Shell’s Model of Safety Culture Maturity – Prospective Approach

As mentioned in Section 3.1, the second segment consists of a select set of questionnaire items from the brochure *Understanding Your Culture* (Brochure HSE005) of Shell’s *Hearts and Minds* program (see Section 1.9 and Section 1.13). Sixty-seven out of the 91 items from the brochure were identified as suitable for the current study, as they address both ‘material’ and ‘immaterial’ aspects of safety management systems as proposed by Grote and Künzler (2000), as outlined in Section 1.9.

Item selection was based on the following criteria. Nunnally and Bernstein (1994) suggest that factor loading of 0.3 is considered a minimum value for a salient factor. Tabachnick and Fidell (2007) indicate that loadings of 0.32 and above are interpretable. Comrey and Lee (1992) suggest that loading of 0.32 was poor (10% overlapping variance), and 0.45 (20% overlapping variance) was fair. For the current study, selection was made based on factor loadings greater than 0.45, and a minimum gap of 0.10 between loadings on multiple factors (e.g. study by Shaik, Lowe, & Pinegar, 2006). Only items with a single factor loading were
selected except for one item: “Procedures are seen as limiting people’s activities to avoid law suits or harm to assets,” which had dual loadings. This decision was made because this was the only item with satisfactory factor loading for the Pathological level within the aspect of the Purpose of Procedures. This item meets the criteria of the minimum gap of 0.10 between factor loadings on the dual factors (Factor 1 = 0.650 and Factor 2 = –0.423).

This selection process yielded a total of 67 items encompassing the five levels of maturity. Permission was obtained from Shell International Exploration and Production B.V. to use an adapted version of these items from the study above (2006), as documented in Appendix 3.

The seven aspects addressed in this selection of 67 items are outlined below. T represents ‘tangible’ (or ‘concrete) and L stands for ‘less tangible’ (or ‘abstract’, respectively based on the study by Parker, Lawrie & Hudson (2006). Details of the conceptual framework for these studies are outlined in Section 1.9. The expression of the following aspects has been partly modified for the Australian rail context:

1. Commitment Level of Workforce to HSE and Care for Colleagues (L)—(8 items)
2. Balance between HSE and Profitability (L)—(10 items)
3. Workforce Interest in Competency and Training (T)—(11 items)
4. Workplace Safety Controls (modified from the term “HSE Techniques” in the original version) (T)—(6 items)
5. Purpose of HSE Procedures (L)—(10 items)
6. Repercussion and Feedback after Accidents (L)—(11 items)
7. Audits and Reviews (T)—(11 items)

The 67 items selected from the study by Lawrie et al. (2006) are listed in Table 3.2 to Table 3.8. Also outlined are the loadings and labels of the components identified in the Principal Components Analysis, together with the safety culture maturity level to which each item was assigned within the 18 X 5 matrix (2006).

As the original items were designed for the petrochemical industry, permission was obtained to adapt 50 items to suit the idiom of the Australian rail industry. For example, Item 57 “There are fewer audits of hardware and systems and more at the level of behaviours.” was adjusted to “There are more internal
audits of behaviour (e.g. compliance) than there are of infrastructure, rollingstock, equipment and systems.” These adjustments in expressions arose as a result of consultation with 10 people. Seven were from the rail industry, mostly with extensive operations and supervisory experience, and the remaining three from academia. These modifications are underlined in the tables below, with the rationale below each table.

Table 3.2 outlines eight items taken from the first aspect Commitment to HSE and Care for Colleagues in the study by Lawrie et al. (2006). Items 5 and 7 were taken from the first component identified in their Principal Components Analysis labelled Lack of Commitment (shown as C1 in the table). Items 1, 4, 6 and 8 were taken from the second component Lip Service Paid to HSE (C2). Item 3 was taken from the third component Self-Preservation (C3). Finally, Item 2 came from the fourth component Commitment after an Accident (C4).

Table 3.3 outlines 10 items taken from the second aspect Balance between HSE and Profitability in the study by Lawrie et al. (2006). Items 9, 11, 13, 14 and 17 were taken from the first component identified in their Principal Components Analysis labelled Profitability Takes Priority over Safety (shown as C1 in the table). Items 10, 16 and 18 were taken from the second component Management Belief in HSE (C2). Finally, Items 12 and 15 came from the third component Organisational Commitment to HSE (C3).

Table 3.4 outlines 11 items taken from the third aspect Workforce Interest in Competency and Training (2006). Items 19, 23 and 25 were taken from the first component identified in their Principal Components Analysis labelled Training Seen as an Ongoing Process (shown as C1 in the table). Item 27 was taken from the second component Importance Attached to Assessment of Training (C2). Items 24 and 26 were taken from the third component Attitude towards Training & Attitudinal Change through Training (C3). Items 28 and 29 came from the fourth component Training as a Reaction to Adverse Events (C4). Item 20 and was taken from the fifth component Training as a Way of Getting Time off Work (C5). Finally, Items 21 and 22 came from the sixth component Training and Skills Required are Identified and Proposed by the Workforce (C6).
Table 3.2
Aspect 1 – Commitment to HSE and Care for Colleagues

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Original Items</th>
<th>Adapted Items</th>
<th>Maturity Level Component (Loadings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.†</td>
<td>The feeling of pride in HSE and care for colleagues is not universal.</td>
<td>The feeling of pride in Health Safety &amp; Environment (HSE)* and care for colleagues is NOT shared by everyone. **</td>
<td>Proactive C2 (0.801)</td>
</tr>
<tr>
<td>2.†</td>
<td>After accidents there is a voiced commitment to care for colleagues by both management and workforce.</td>
<td>After accidents there is a voiced commitment to care for colleagues by both management and employees.***</td>
<td>Reactive C4 (0.884)</td>
</tr>
<tr>
<td>3.</td>
<td>When it comes to safety, individuals look after themselves.</td>
<td></td>
<td>Pathological C3 (0.695)</td>
</tr>
<tr>
<td>4.</td>
<td>People know how to pay lip service to safety, but practical components may prevent complete follow through.</td>
<td></td>
<td>Calculative C2 (0.770)</td>
</tr>
<tr>
<td>5.</td>
<td>Commitment to HSE and care for colleagues diminishes after a period of good safety performance.</td>
<td></td>
<td>Reactive C1 (0.641)</td>
</tr>
<tr>
<td>6.</td>
<td>Who cares about safety as long as we don’t get caught?</td>
<td></td>
<td>Pathological C2 (0.694)</td>
</tr>
<tr>
<td>7.</td>
<td>Levels of commitment and care are very high and are driven by employees who show passion about living up to their aspirations.</td>
<td></td>
<td>Generative C1 (-0.709)</td>
</tr>
<tr>
<td>8.†</td>
<td>Pride in HSE is beginning to develop, increasing the workforce’s commitment to HSE and care for colleagues.</td>
<td>Pride in HSE is beginning to develop, increasing the employees’ commitment to HSE and care for colleagues. ***</td>
<td>Proactive C2 (-0.465)</td>
</tr>
</tbody>
</table>

† These items were modified to suit the context of the Australian rail industry. The rationale for the change is outlined below.

* “Health Safety & Environment” is spelt out in this item for clarification. In subsequent items the abbreviation HSE is used.

** “Universal” may appear ambiguous to some of the participants. A more descriptive expression was used. “NOT” was used for clarity instead of “not”. This is done throughout the questionnaire, where deemed necessary.

*** The term “workforce” is perceived as divisive in Australia. It is substituted with a more egalitarian expression “employees”.

*These items were modified to suit the context of the Australian rail industry. The rationale for the change is outlined below.*

*“Health Safety & Environment” is spelt out in this item for clarification. In subsequent items the abbreviation HSE is used.*

**“Universal” may appear ambiguous to some of the participants. A more descriptive expression was used. “NOT” was used for clarity instead of “not”. This is done throughout the questionnaire, where deemed necessary.***

***The term “workforce” is perceived as divisive in Australia. It is substituted with a more egalitarian expression “employees”.*
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Original Items</th>
<th>Adapted Items</th>
<th>Maturity Level Component Level and (Loadings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.†</td>
<td>Safety is seen as discretionary expenditure.</td>
<td>Safety is seen as an optional expenditure.*</td>
<td>Calculative C1 (0.646)</td>
</tr>
<tr>
<td>10.†</td>
<td>Management believes that HSE makes money.</td>
<td>Management believes that HSE saves money in the long term.*</td>
<td>Generative C2 (0.588)</td>
</tr>
<tr>
<td>11.†</td>
<td>The line spends most of its time on operational issues.</td>
<td>Line managers* spend most of their time on operational issues.</td>
<td>Calculative C1 (0.515)</td>
</tr>
<tr>
<td>12.†</td>
<td>HSE and profitability are in balance, so that this becomes a non-issue.</td>
<td>HSE and profitability are in balance, so that they are not competing priorities.*</td>
<td>Generative C3 (0.771)</td>
</tr>
<tr>
<td>13.†</td>
<td>The company tries to make HSE the top priority, understanding that HSE contributes to financial return.</td>
<td>My employer** tries to make HSE the top priority, understanding that HSE contributes to financial return.</td>
<td>Proactive C1 (-0.503)</td>
</tr>
<tr>
<td>14.†</td>
<td>Cost is important, but there is some investment in preventative maintenance.</td>
<td>Cost is important, but some money is put towards maintenance to prevent accidents.*</td>
<td>Reactive C1 (-0.885)</td>
</tr>
<tr>
<td>15.†</td>
<td>The company accepts delays to get contractors up to standard in terms of safety regardless of cost.</td>
<td>My employer** accepts delays to get contractors up to standard in terms of safety regardless of cost.</td>
<td>Generative C3 (0.629)</td>
</tr>
<tr>
<td>16.</td>
<td>Line managers know how to say the right things, but do not always walk their own talk.</td>
<td></td>
<td>Calculative C2 (-0.796)</td>
</tr>
<tr>
<td>17.</td>
<td>Safety is seen as costing money, and the only priority is to avoid extra costs.</td>
<td></td>
<td>Pathological C1 (0.649)</td>
</tr>
<tr>
<td>18.†</td>
<td>The company is quite good at juggling HSE and profitability but money still counts.</td>
<td>My employer** is quite good at juggling HSE and profitability but money still counts.</td>
<td>Proactive C2 (-0.702)</td>
</tr>
</tbody>
</table>

† These items were modified to suit the context of the Australian rail industry. The rationale for the change is outlined below.
* The meaning of the original statements has been expressed in more common or specific terms for clarity.
**The term “the company” is replaced with “my employer” to cater to participants in a rail organisation run by government.
Table 3.4
Aspect 3 – Workforce Interest in Competency and Training

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Original Items ➔ Adapted Items</th>
<th>Maturity Level Component and (Loadings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.† Development is seen as a process rather than an event. ➔ Training is seen as a process for enhancing skills and competency rather than a requirement.*</td>
<td>Generative C1 (0.771)</td>
<td></td>
</tr>
<tr>
<td>20.† Workers don’t mind exchanging a harsh working environment for a couple of hours off the job. ➔ Compulsory training during work hours gives employees a pleasant break from work that they carry out in a harsh working environment.*</td>
<td>Pathological C5 (0.892)</td>
<td></td>
</tr>
<tr>
<td>21. Training is attended when it is required by law.</td>
<td>Pathological C6 (-0.541)</td>
<td></td>
</tr>
<tr>
<td>22.† Training needs are beginning to be identified by the workforce. ➔ Training needs are beginning to be identified by the employees.**</td>
<td>Proactive C6 (0.796)</td>
<td></td>
</tr>
<tr>
<td>23.† Competence matrices are available and lots of standard training is given. ➔ Information on competence requirements for individual roles is available, and appropriate training is given.*</td>
<td>Calculative C1 (0.698)</td>
<td></td>
</tr>
<tr>
<td>24. Training is aimed at the person — If we can change their attitude everything will be alright.</td>
<td>Reactive C3 (0.721)</td>
<td></td>
</tr>
<tr>
<td>25. There is some on-the-job transfer of training.</td>
<td>Calculative C1 (0.769)</td>
<td></td>
</tr>
<tr>
<td>26.† The workforce is proud to demonstrate their skills in on-the-job assessment. ➔ Employees** are proud to demonstrate their skills in on-the-job assessment.</td>
<td>Proactive C3 (0.768)</td>
<td></td>
</tr>
<tr>
<td>27.† Leadership fully acknowledges the importance of tested skills on the job. ➔ Leadership fully acknowledges the importance of assessment of on-the-job skills.*</td>
<td>Proactive C2 (0.782)</td>
<td></td>
</tr>
<tr>
<td>28.† After an accident money is made available for specific training programs.* ➔ After an accident, specific training programs are made available.*</td>
<td>Reactive C4 (0.832)</td>
<td></td>
</tr>
<tr>
<td>29. Training is seen as a necessary evil.</td>
<td>Pathological C4 (0.670)</td>
<td></td>
</tr>
</tbody>
</table>

† These items were modified to suit the context of the Australian rail industry. The rationale for the change is outlined below.
* The meaning of the original statements has been expressed in more common or specific terms for clarity.
** The term “workforce” is perceived as divisive in Australia. It is substituted with a more egalitarian expression “employees”.

Note: The component and loadings are calculated based on the adapted items for clarity and context-specific importance.
Table 3.5 outlines six items taken from the fourth aspect *Work-Site Job Safety Techniques* (2006). This aspect name was modified to *Workplace Safety Controls* for the current study to suit the idiom of the Australian rail context. Items 31, 33 and 34 were taken from the first component *Acceptance of Safety Visits as Part of the HSE-Management System* (shown as C1 in the table), identified in the study by Lawrie et al. (2006). Item 35 was taken from the second component *Hazard Observation Seen as Standard Practice* (C2). Item 30 came from the third component *Maintenance of Safety Management Techniques* (C3). Finally, Item 32 was taken from the fourth component *Techniques Bought in Only after Accidents* (C4).

Table 3.6 outlines 11 items taken from the fifth aspect *Purpose of HSE Procedures* (2006). Items 36, 37, 40 and 43 were taken from the first component *Reaction to Adverse Events* (shown as C1 in the table), identified in the study by Lawrie et al. (2006). Items 38 and 44 were taken from the second component *Procedures Communicating Best Practice* (C2). Items 39, 40 and 41 came from the third component *Procedures seen as incident prevention guidelines* (C3). Item 40 had multiple loadings on Components 1 and 3. Item 45 was taken from the fourth component *Procedures Seen as a Necessary Evil* (C4). Finally, Item 42 was taken from the fifth component *Inflexibility of Procedures* (C5).

Table 3.7 outlines 11 items from the sixth aspect *Repercussion and Feedback after Accidents* (2006). Items 47, 51, 54 and 55 were taken from the first component *Focus on Active Failures* (shown as C1 in the table), identified in the study by Lawrie et al. (2006). Items 49, 50, 52 and 56 were taken from the second component *Focus on the Underlying Causes* (C2). Items 48 and 53 came from the third component *Focus on Blame and Shame* (C3). Finally, Item 46 came from the fourth component *Contractors’ Accidents Treated Separately* (C4).
### Table 3.5
Aspect 4 – Work-Site Job Safety Techniques (modified to Workplace Safety Controls)

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Original Items</th>
<th>Adapted Items</th>
<th>Maturity Level Component and (Loadings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.</td>
<td>There is little systematic use of the standard work-site management technique after its initial introduction.</td>
<td>There is little systematic use of the standard work-related safety management controls† after the initial introduction.</td>
<td>Reactive F3 (-0.889)</td>
</tr>
<tr>
<td>31.</td>
<td>Safety visits are accepted by the workforce as being in their own interest.</td>
<td>Internal safety audits** are accepted by the employees* as being in their own interest.</td>
<td>Proactive F1 (0.804)</td>
</tr>
<tr>
<td>32.</td>
<td>There are no techniques applied – “Look out for yourself”</td>
<td>There are no safety management controls† applied – “Look out for yourself”.</td>
<td>Pathological F4 (0.762)</td>
</tr>
<tr>
<td>33.</td>
<td>Safety visits, as a work-site hazard management technique, is revised regularly in a defined process.</td>
<td>Internal safety audits**, as a work-site hazard management control†, are revised regularly in a defined process.</td>
<td>Generative F1 (0.731)</td>
</tr>
<tr>
<td>34.</td>
<td>Quotas are used to check that the job safety techniques† required by the management system are working.</td>
<td>The number of inspection reports written †† is used to check that the job safety controls required by the management system are working.</td>
<td>Calculative F1 (0.499)</td>
</tr>
<tr>
<td>35.</td>
<td>People (both workers and supervisors) are not afraid to tell each other about hazards.</td>
<td>People (both team members* and supervisors) are not afraid to tell each other about hazards.</td>
<td>Generative F2 (0.782)</td>
</tr>
</tbody>
</table>

* Terms such as “workers” and “workforce” are perceived as divisive in Australia. They are substituted by more egalitarian expressions such as “team members” and “employees”.

** The rail industry equivalent of “safety visits” in Australia is “internal safety audits”.

† The rail industry equivalent of safety-related “techniques” in Australia is “controls”. In Item 34, “... work-site management technique” has been changed to “work-related safety management controls” to make it more familiar to rail employees.

†† This modification is based on the usage of the term “quotas” in the Safety Science article (Lawrie, Parker & Hudson, 2006). In their five-level safety culture maturity model, one of the defining characteristics of the calculative stage is described as “obsession with safety reports and statistics”. Thus it is interpreted here to be “the number of inspection reports written” (rather than focus on the quality of the reports).
Table 3.6  
Aspect 5 – Purpose of HSE Procedures

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Original Items</th>
<th>Adapted Items</th>
<th>Maturity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>36.†</td>
<td>HSE procedures are seen as occasionally inconvenient by a competent workforce.</td>
<td>HSE procedures are occasionally seen as inconvenient by competent employees††.</td>
<td>Proactive C1 (0.648)</td>
</tr>
<tr>
<td>37.†</td>
<td>The overall effect of procedures is not necessarily properly considered in detail.</td>
<td>The overall effect of HSE procedures is NOT necessarily properly considered in detail.</td>
<td>Reactive C1 (0.578)</td>
</tr>
<tr>
<td>38.†</td>
<td>There is trust in employees that they can recognise situations where compliance should be challenged.</td>
<td>There is trust in employees that they can recognise situations where HSE* compliance should be questioned.**</td>
<td>Generative C2 (0.617)</td>
</tr>
<tr>
<td>39.</td>
<td>The purpose of HSE procedures is to prevent individual incidents recurring.</td>
<td></td>
<td>Reactive C3 (0.701)</td>
</tr>
<tr>
<td>40.†</td>
<td>Procedures are seen as limiting people’s activities to avoid law suits or harm to assets.</td>
<td>HSE* procedures are seen as limiting people’s activities to avoid law suits or harm to assets.</td>
<td>Pathological C1 (0.650) C3 (-0.423)</td>
</tr>
<tr>
<td>41.†</td>
<td>Non-compliance to HSE procedures goes through recognised channels.</td>
<td>Non-compliance to HSE procedures is handled through recognised channels.**</td>
<td>Generative C3 (0.786)</td>
</tr>
<tr>
<td>42.†</td>
<td>It is hard to separate procedures from training.</td>
<td>HSE* procedures are taught in training but are inflexible.††</td>
<td>Calculative C5 (0.747)</td>
</tr>
<tr>
<td>43.†</td>
<td>Procedures are often written in response to accidents.</td>
<td>HSE* procedures are often crisis-oriented*** and written in response to accidents.</td>
<td>Reactive C1 (0.798)</td>
</tr>
<tr>
<td>44.†</td>
<td>HSE procedures spread best practice.</td>
<td>HSE procedures communicate best practice.**</td>
<td>Proactive C2 (0.759)</td>
</tr>
<tr>
<td>45.†</td>
<td>Procedures are refined for efficiency.</td>
<td>HSE* procedures are refined for efficiency.</td>
<td>Generative C4 (-0.863)</td>
</tr>
</tbody>
</table>

† These items were modified to suit the context of the Australian rail industry. The rationale for the change is outlined below.
†† The term “workforce” is perceived as divisive in Australia. It is substituted with a more egalitarian expression “employees”.
* HSE is added for clarity.
** The meaning of the original statements has been expressed in more common or specific terms for clarity.
*** The statement is elaborated on by adding the phrase “crisis-orientated” for clarity.
### Table 3.7

**Aspect 6 – Repercussion and Feedback after Accidents**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Original Items</th>
<th>Adapted Items</th>
<th>Maturity Level Component and (Loadings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>46. †</td>
<td>The workforce report their own accidents but maintain distance from contractor incidents.</td>
<td>Employees report their own accidents but maintain their distance from contractor incidents.</td>
<td>Calculative C4 (0.848)</td>
</tr>
<tr>
<td>47.</td>
<td>After an accident, reports are NOT passed up the line if it can be avoided.</td>
<td></td>
<td>Reactive C1 (0.547)</td>
</tr>
<tr>
<td>48.</td>
<td>Management goes ballistic when they hear of an accident — “What does this do to our statistics?”</td>
<td></td>
<td>Calculative C3 (0.773)</td>
</tr>
<tr>
<td>49. †</td>
<td>Investigation focuses on underlying causes.</td>
<td>Accident investigation focuses on all causes and contributory circumstances. ††</td>
<td>Proactive C2 (0.783)</td>
</tr>
<tr>
<td>50. †</td>
<td>Top management is seen amongst the people involved directly after an accident.</td>
<td>Top or senior †† management are involved directly after an accident.</td>
<td>Generative C2 (0.751)</td>
</tr>
<tr>
<td>51. †</td>
<td>After an accident the focus is on the employee, and they are often fired.</td>
<td>After an accident, the focus is on the employee, and they are often disciplined and/or ostracised. **</td>
<td>Pathological C1 (0.699)</td>
</tr>
<tr>
<td>52.</td>
<td>Employees take it personally when others have accidents.</td>
<td></td>
<td>Generative C2 (0.768)</td>
</tr>
<tr>
<td>53.</td>
<td>Line management is annoyed by ‘stupid’ accidents.</td>
<td></td>
<td>Reactive C3 (0.514)</td>
</tr>
<tr>
<td>54.</td>
<td>The results of accident investigation are fed back to the supervisory level.</td>
<td></td>
<td>Proactive C1 (-0.726)</td>
</tr>
<tr>
<td>55. †</td>
<td>Warning letters are sent by management.</td>
<td>Warning letters are sent by management to individuals who were involved in accidents. ††</td>
<td>Reactive C1 (0.699)</td>
</tr>
<tr>
<td>56. †</td>
<td>Top management show personal interest in individuals and the investigation process.</td>
<td>After an accident, top or senior management show personal interest in individuals and the investigation process. ††</td>
<td>Generative C2 (0.768)</td>
</tr>
</tbody>
</table>

† These items were modified to suit the context of the Australian rail industry. The rationale for the change is outlined below.

†† The meaning of the original statements has been expressed in more common or specific terms for clarity.

* The term “workforce” is perceived as divisive in Australia. It is substituted with a more egalitarian expression “employees”.

** Rail employees involved in accidents have legal protection in Australia. Dismissal is unlikely unless intentional unsafe act (sabotage) is substantiated.
Finally, Table 3.8 outlines 11 items from the seventh aspect *Audits and Reviews* (2006). Items 58, 60 and 65 were taken from the first component *Audits as a “Necessary Evil”* (shown as C1 in the table), identified in the study by Lawrie et al. (2006). Items 57 and 64 came from the second component *Audits as Learning Opportunities* (C2). Items 59 and 67 came from the third component *Audits as Part of HSE Management System* (C3). Item 63 was taken from the fourth component *System vs. Behaviour Audits*. Finally, Item 61, 62 and 66 were taken from the fifth component *Audits are Widespread* (C4).
Table 3.8  
Aspect 7 – Audits and Reviews

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Original Items</th>
<th>Adapted Items</th>
<th>Maturity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Items</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57.†</td>
<td>Management and supervisors realise they are biased and welcome outside help with audits.</td>
<td>Management and supervisors realise they are biased and welcome outside help with internal audits ††.</td>
<td>Proactive C2 (0.633)</td>
</tr>
<tr>
<td>58.†</td>
<td>The company is happy to audit others, but being audited is less welcome.</td>
<td>My employer** is happy to audit others, but being audited is less welcome.</td>
<td>Calculative C1 (0.753)</td>
</tr>
<tr>
<td>59.</td>
<td>Audits are structured in terms of management systems.</td>
<td>Internal audits †† are structured in terms of management systems.</td>
<td>Calculative C3 (0.654)</td>
</tr>
<tr>
<td>60.†</td>
<td>Audits are mainly financial.</td>
<td>Internal audits †† mainly deal with financial matters.*</td>
<td>Pathological C1 (0.757)</td>
</tr>
<tr>
<td>61.†</td>
<td>There is no schedule for audits and reviews as they are seen as a punishment.</td>
<td>There is no schedule for internal audits †† and reviews as they are seen as a punishment.</td>
<td>Reactive C5 (-0.611)</td>
</tr>
<tr>
<td>62.†</td>
<td>HSE audits are unstructured, and only take place after major accidents.</td>
<td>Internal audits †† by the HSE team are unstructured, and only take place after major accidents.</td>
<td>Pathological C5 (-0.885)</td>
</tr>
<tr>
<td>63.†</td>
<td>There are fewer audits of hardware and systems and more at the level of behaviours.</td>
<td>There are more internal audits †† of behavioural issues (e.g. compliance) than there are of infrastructure, rolling stock, equipment and systems.*</td>
<td>Generative C4 (0.875)</td>
</tr>
<tr>
<td>64.</td>
<td>There is continuous informal search for non-obvious problems with outside help when needed.</td>
<td></td>
<td>Generative C2 (0.804)</td>
</tr>
<tr>
<td>65.†</td>
<td>There is a full audit system running smoothly with good follow up.</td>
<td>There is a full internal audit †† system running smoothly with good follow up.</td>
<td>Generative C1 (-0.817)</td>
</tr>
<tr>
<td>66.†</td>
<td>There is an extensive audit program including cross-auditing within the organisation.</td>
<td>There is an extensive internal audit †† program including cross-auditing within the organisation.</td>
<td>Proactive C5 (0.586)</td>
</tr>
<tr>
<td>67.†</td>
<td>Being audited is accepted as inescapable, especially after serious or fatal accidents.</td>
<td>Regulatory audits †† are accepted as inescapable, especially after serious or fatal accidents.</td>
<td>Reactive C3 (0.784)</td>
</tr>
</tbody>
</table>

† These items were modified to suit the context of the Australian rail industry. The rationale for the change is outlined below.
†† The rail industry in Australia has two different kinds of safety audits – 1) internal audits which are organised by the organization itself; and 2) regulatory audits which are conducted on a set schedule by the state rail safety regulator. These are distinguished by specifying “internal” or “regulatory”.
* The meaning of the original statements has been expressed in more common or specific terms for clarity.
** The term “the company” is replaced with “my employer” to cater to participants in a rail organisation run by government.
3.3 Pilot Testing

A panel of 10 experts assisted in pilot testing the initial version of the questionnaire. Seven people were from the rail industry with more than 10 years’ experience. A majority of them had been associated with the industry in more than one capacity at different times of their career. Their collective experience covered a variety of occupational groups and job levels, including train driving, maintenance, engineering, health and safety management, senior management and trade union management. The remaining three consisted of two scholars specialising in human factors and safety research, and one from transport policy and management.

These experts were asked to examine the initial items drawing upon their respective industry and academic experience. Their feedback played a crucial role in ensuring the questionnaire’s ease of use and relevance to the context of the Australian rail industry. Initially, Section A2 included one statement designed to address optimising violations. This item was generated based on an investigation report of an actual rail accident, a fatality caused by a collision due to inattention as the driver and conductor of the locomotive had been reading books at the controls for 30 minutes (see Chapter 2). To the question of “How frequently would people who work in safety-critical areas in your workplace have encountered the following situation in the last 24 months?” The statement read “They break safeworking rules for the thrill of breaking them”. However, this item was later excluded as it was deemed that such violation was extremely rare (likely to lead to no response variability) and that it could be potentially offensive to the participants.

3.4 Survey Administration

A total of 1,598 mail kits were sent by post to rail workers from six rail organisations in New South Wales, South Australia, Victoria and Western Australia between Nov. 2007 and January 2008. The six organisations entailed diverse service types including above and below rail, passenger vs. freight service
and tourist heritage train operators. The questionnaire was also made available online between December 2007 and February 2008.

Twenty-nine mail kits were distributed in a training room for group administration in January 2008 in preparation for retesting, which took place in June 2008. The second round of group sessions was run on 25 June, 2008 in which 22 people participated. It was a minor extension of the study, not critical to the thesis nor conducted due to the relatively small sample size and time and business constrains from the rail organisations who responded to the survey. The results of this particular segment, therefore, are not reported.

In completing the questionnaire the participants were asked to reflect on the state of safety and safety culture in their workplace. As part of the participants’ demographic details, they were asked whether they were working in a safety-critical area. Safety-critical work was defined as “the type of work that, if not performed appropriately, may lead directly to a serious incident affecting the public, the rail network, or individual employees”.

**Materials**

The mail kit contained the following components:

- The questionnaire (Appendix 4)
- A self-addressed prepaid return envelope, attention to the researcher at Murdoch University
- A cover note from a company executive (Appendix 5)
- A consent form ensuring confidentiality and anonymity (Appendix 6)
- A prize draw entry form (Appendix 6)

**Response**

A total of 422 responses (response rate averaging 26%) were received, which consisted of 340 hardcopy by mail, 52 online and 30 additional hardcopy from group survey administration. The participants completed the questionnaire voluntarily, which they returned with a signed informed consent. Their identity was kept confidential. Details of the responses are presented in Table 3.9. Three of the participating organisations had the headquarters in Western Australia, two in South Australia, and one in Victoria. As some of these organisations operated
in several jurisdictions, the participants indicated that their work teams were based in Western Australia, South Australia, Victoria or New South Wales. The service types of the participating organisations entailed rail rollingstock operators (above rail) and rail line owners (below rail), passenger, freight, and tourist heritage train service.

As the survey was administered between late 2007 and early 2008, the Australian Census data (Australian Bureau of Statistics, 2006) collected in 2006 with regard to the rail industry is presented as a reference (see Table 3.10). The data are categorised by state and occupational group. As the survey was sent to 1598 railway workers, it represents approximately 4.8% of the total number of 33,387 rail workers in Australia as portrayed in the census data.

It is acknowledged that obtaining a truly representative sample of rail employees in Australia is beyond the scope of this study for two reasons. Firstly, the six rail organisations which participated in this research project did so totally on a voluntary basis. This is likely to reflect their proactive approach to safety matters coupled with a fair level of confidence in the efficacy of their safety management system. Similarly, individual data consist of responses by employees who responded voluntarily to the questionnaire. It is therefore likely that the employees who agreed to spend approximately an hour of their own time (with the exception of 30 participants who took part in a group session conducted during work hours) to complete the lengthy questionnaire reflect their interest in, and commitment to, safety. Hence, it is plausible that the data portray a more positive picture of rail workers’ perception of safety measures and culture in their workplace than that of the average rail employee in Australia.

Secondly, rail employees of a wide range of occupational groups and levels of seniority, in both safety-critical and non-safety-critical roles were encouraged to participate in the survey. Thus, the results of this questionnaire provide a general ‘snapshot’ of the rail industry taken at that specific time of survey administration, rather than a carefully structured sampling.

Next three chapters will outline the results of a series of statistical analyses conducted on the responses collected from the administration of the questionnaire, construction of which was described above.
Table 3.9
Record of Mail Outs and Responses (N = 422)

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Mail Dispatch Date</th>
<th>Response Deadline</th>
<th>Mail Quantity Dispatched</th>
<th>Responses</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27 Nov. 07</td>
<td>21 Dec. 07</td>
<td>233</td>
<td>Total 38</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(extended to</td>
<td></td>
<td>Hardcopy 34</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 Jan. 08)</td>
<td></td>
<td>Online 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total 38</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hardcopy 35</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Online 3</td>
<td>41%</td>
</tr>
<tr>
<td>B</td>
<td>28 Nov. 07</td>
<td>21 Dec. 07</td>
<td>93</td>
<td>Total 24</td>
<td>69%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hardcopy 22</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Online 2</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>28 Nov. 07</td>
<td>21 Dec. 07</td>
<td>35</td>
<td>Total 31</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hardcopy 31</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Online 0</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>28 Nov. 07</td>
<td>21 Dec. 07</td>
<td>55</td>
<td>Total 102</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hardcopy 91</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Online 11</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>9 Dec. 07</td>
<td>25 Jan. 08</td>
<td>607</td>
<td>Total 177</td>
<td>29%</td>
</tr>
<tr>
<td>F</td>
<td>Mail out</td>
<td>31 Jan. 08</td>
<td>Mail out 575 Group</td>
<td>Total 12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 Jan. 08</td>
<td></td>
<td>Sessions 30</td>
<td>Online 20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group sessions*</td>
<td></td>
<td></td>
<td>Group 30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29 Jan. 08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>NA (online)</td>
<td>NA (online)</td>
<td>NA (online)</td>
<td>Total 12</td>
<td></td>
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<tr>
<td></td>
<td>(online)</td>
<td>(online)</td>
<td>(online)</td>
<td>Online 12</td>
<td></td>
</tr>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>1,598</td>
<td>Total 422</td>
<td>26%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hardcopy 340</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Online 52</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Group 30</td>
<td></td>
</tr>
</tbody>
</table>

n.b. * A second round of group sessions was run on 25 June, 2008 in which 22 people participated. It was a minor extension of the study, not critical to the thesis. The results, therefore, are not reported.
Table 3.10
The Australian Census 2006 Railway Workers Categorised by State and Occupational Group

<table>
<thead>
<tr>
<th>Occupational Group / State*</th>
<th>NSW</th>
<th>VIC</th>
<th>QLD</th>
<th>SA</th>
<th>WA</th>
<th>TAS</th>
<th>NT</th>
<th>ACT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managers and Administrators</td>
<td>986</td>
<td>228</td>
<td>496</td>
<td>139</td>
<td>99</td>
<td>7</td>
<td>4</td>
<td>0</td>
<td>1959</td>
</tr>
<tr>
<td>Professionals</td>
<td>1589</td>
<td>254</td>
<td>1241</td>
<td>144</td>
<td>115</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>3347</td>
</tr>
<tr>
<td>Associate Professionals</td>
<td>1463</td>
<td>285</td>
<td>989</td>
<td>120</td>
<td>78</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2938</td>
</tr>
<tr>
<td>Tradespersons and Related Workers</td>
<td>1484</td>
<td>255</td>
<td>1645</td>
<td>80</td>
<td>151</td>
<td>39</td>
<td>0</td>
<td>0</td>
<td>3654</td>
</tr>
<tr>
<td>Advanced Clerical and Service Workers</td>
<td>272</td>
<td>47</td>
<td>120</td>
<td>92</td>
<td>18</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>554</td>
</tr>
<tr>
<td>Intermediate Clerical, Sales and Service Workers</td>
<td>1281</td>
<td>542</td>
<td>1061</td>
<td>194</td>
<td>115</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>3216</td>
</tr>
<tr>
<td>Intermediate Production and Transport Workers</td>
<td>3925</td>
<td>1675</td>
<td>2556</td>
<td>629</td>
<td>764</td>
<td>83</td>
<td>30</td>
<td>6</td>
<td>9668</td>
</tr>
<tr>
<td>Elementary Clerical, Sales and Service Workers</td>
<td>2879</td>
<td>795</td>
<td>835</td>
<td>81</td>
<td>66</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>4664</td>
</tr>
<tr>
<td>Labourers and Related Workers</td>
<td>1329</td>
<td>211</td>
<td>1062</td>
<td>93</td>
<td>89</td>
<td>21</td>
<td>4</td>
<td>0</td>
<td>2809</td>
</tr>
<tr>
<td>Inadequately described</td>
<td>273</td>
<td>70</td>
<td>163</td>
<td>11</td>
<td>17</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>539</td>
</tr>
<tr>
<td>Not stated</td>
<td>12</td>
<td>7</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>Not applicable</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Total</td>
<td>15493</td>
<td>4369</td>
<td>10188</td>
<td>1583</td>
<td>1512</td>
<td>171</td>
<td>54</td>
<td>17</td>
<td>33387</td>
</tr>
</tbody>
</table>


Note:
- Cells in this table have been randomly adjusted to avoid the release of confidential data.
- No reliance should be placed on small cells.
- For details on a classification and associated data quality information click on the blue i-links in the table.
- Cells in this table have been randomly adjusted to avoid the release of confidential data.
- No reliance should be placed on small cells.
- Table generated using ABS TableBuilder
- © Commonwealth of Australia

*The state names are as follow:

<table>
<thead>
<tr>
<th>State</th>
<th>Full Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>VIC</td>
<td>Victoria</td>
</tr>
<tr>
<td>QLD</td>
<td>Queensland</td>
</tr>
<tr>
<td>SA</td>
<td>South Australia</td>
</tr>
<tr>
<td>WA</td>
<td>Western Australia</td>
</tr>
<tr>
<td>TAS</td>
<td>Tasmania</td>
</tr>
<tr>
<td>NT</td>
<td>Northern Territory</td>
</tr>
<tr>
<td>ACT</td>
<td>Australian Capital Territory</td>
</tr>
</tbody>
</table>
RESULTS CHAPTERS 4 – 6

Introduction

The following chapters present the results of a series of statistical analyses on the data collected through the administration of the Rail Safety Perception & Culture Employee Questionnaire as outlined in the previous chapter. They relate to the hypotheses in three successive chapters.

Chapter 4 outlines the process of factor analyses, which were conducted to identify factors regarded as reflecting constructs that underlie among the safety climate/culture items in the questionnaire. The factors identified in this chapter were used for the analyses for the following two chapters. Chapter 5 presents the results of group comparisons of safety climate/culture scores for each participating rail organisations, as specified in Hypotheses 1a and 1b. They are organised into six subsections as excerpts from reports submitted to the organisations. Finally, Chapter 6 outlines the results of several prediction analyses designed to investigate whether the safety climate/culture scores would predict safety outcomes, as specified in Hypotheses 2a, 2b, 3a and 3b.

Hypothesis 1a:
Group differences exist between occupational groups in terms of safety climate/culture as measured by the RPFs items.

Hypothesis 1b:
Group differences exist between occupational groups in terms of safety climate/culture as measured by Shell’s (modified) safety culture maturity items.

Hypothesis 2a:
Safety climate/culture as measured by the RPFs items would predict accidents and near misses in the two-year data from rail organisations.

Hypothesis 2b:
Safety climate/culture as measured by the Shell’s safety culture maturity items would predict accidents and near misses in the two-year data from rail organisations.

Hypothesis 3a:
Safety climate/culture as measured by the RPFs items would predict reporting of safety defects in the two-year data from rail organisations.

Hypothesis 3b:
Safety climate/culture as measured by the Shell’s safety culture maturity factors would predict reporting of safety defects in the two-year data from rail organisations.
CHAPTER 4
Examination of Factor Structure

Exploratory factor analysis is useful for identifying factors that are thought to reflect underlying structures that have created the correlations among the variables. Its utility also includes reducing the numerous variables down to a condensed set of factors (Tabachnick & Fidell, 2007). Principal Axis Factoring (PAF) analyses were performed on nine separate sections of the Rail Safety Perception & Culture Employee Questionnaire (see Appendix 4) to identify factors that were thought to reflect underlying constructs that had created the correlations among the safety climate/culture variables. The sections consisted of Sections A1 Work Environment, A2 Actual/Potential Safety Problems, B1 Commitment to HSE & Care for Colleagues, B2 Balance between HSE & Profitability, B3 Interest in Competency & Training, B4 Workplace Safety Controls, B5 Purpose of HSE Procedures, B6 What happens after an accident?, and B7 Safety Audit. Due to the descriptive nature of the items, factor analysis was deemed unnecessary for Section A3 Safety Measures in General, and Section C Driving Force behind Safety.

The factors identified in this process were later utilised for further analyses for group comparisons as presented in Chapter 5, and in predicting safety outcomes as presented in Chapter 6. The process of data screening prior to the factor analyses is outlined in the next section.

4.1 Data Preparation

Initial Data Screening

Raw data (N = 422) were subjected to a series of data screening procedures, as specified by Tabachnick and Fidell (2007). A total of 30 cases were removed, reducing the dataset to N = 392. They were identified as follow: Twelve cases had their organisational ID unidentified. Furthermore, an additional 15 cases contained excessive missing values (over 20%) of the total number of the 127 questionnaire items. Presence of univariate outliers were evaluated by using the
criteria of more than ± three standard deviations from the mean. Two cases were found to contain an excessive number of univariate outliers. The first contained five outliers in Section C (50% of 10 items), while the second had 17 outliers across Section A to C (13% of 127 items). As both cases showed a response pattern incongruent with their self-claimed job level, they were excluded from the dataset. One further case was removed because the participant’s feedback to the researcher indicated that he came from outside the target population.

Judging from the overall pattern of responses, another 899 univariate outliers appeared to be genuine responses and were retained as original. Characteristics considered for this evaluation included how proactive the respondents have been in improving safety at their workplace (e.g. raising safety concerns) and their accident history, which may have influenced some of the ratings. They were modified by replacing the offending raw scores with one unit larger or smaller (e.g. score of 5 replaced with 4, or score of 1 replaced with 2) than the next most extreme score in the distribution (Tabachnick & Fidell, 2007). Modification of these outliers amounted to 1.8% out of a total of 49,000 cells in A1, A2, B and C (125 items).

A total of 414 missing values were identified (0.85%). As they were randomly distributed, it was deemed acceptable to substitute them with item means calculated for each organisation. Tabachnick and Fidell (2007) evaluated this method as follows:

“Mean substitution has been a popular way to estimate missing values, although it is less commonly used now that more desirable methods are feasible through computer programs. Means are calculated from available data and used to replace missing values prior to analysis. In the absence of all other information, the man is the best guess about the value of available. Part of the attraction of this procedure is that it is conservative; the mean for the distribution as a whole does not change and the researcher is not required to guess at missing values. On the other hand, the variance of a variable is reduced because the mean is closer to itself than to the missing value it replaces, and the correlation the variable has with other variables is reduced because of the reduction in variance. …. A compromise is to insert a group mean for the missing value. If, for instance the case with a missing value is a Republican, the mean value for Republican is computed and inserted in place of the
missing value. This procedure is not as conservative as inserting overall mean values and not as liberal as using prior knowledge. However, the reduction in within-group variance can make differences among groups spuriously large (p. 67, omission by the current author).

The reduced sample ($N = 392$) consisted of 341 participants (87.0%) who indicated they were working in a safety-critical area, and 49 participants (12.5%) who responded they were in a non-safety-critical area at the time of the survey administration. Two people did not answer (.5%). Three hundred and fifty-two were males (89.8%) and 37 were females (9.4%). Three people did not identify their gender (.8%). The distribution of age group is summarised in Table 4.1. Detailed profiles of the participants are shown in Appendix 7.

Table 4.1

<table>
<thead>
<tr>
<th>Age Group (years old)</th>
<th>Frequency N = 392</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 20</td>
<td>1</td>
<td>.3</td>
</tr>
<tr>
<td>20-29</td>
<td>35</td>
<td>8.9</td>
</tr>
<tr>
<td>30-39</td>
<td>85</td>
<td>21.7</td>
</tr>
<tr>
<td>40-49</td>
<td>120</td>
<td>30.6</td>
</tr>
<tr>
<td>50-59</td>
<td>102</td>
<td>26.0</td>
</tr>
<tr>
<td>60-69</td>
<td>33</td>
<td>8.4</td>
</tr>
<tr>
<td>Above 70</td>
<td>10</td>
<td>2.6</td>
</tr>
<tr>
<td>Unspecified</td>
<td>6</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Treatment of “Not Applicable” Responses

In Section A1 and A2 the participants were asked to select the frequency with which they observed certain situations at their workplace from a 5-point Likert scale, ranging from [1 = Very Rarely] to [5 = Very Frequently]. Similarly, Section A3, B and C asked the participants to select their level of agreement to a number of statements from a 5-point Likert scale, ranging from [1 = Strongly Disagree] to [5 = Strongly Agree]. Both response scales also included a [0 = Not Applicable] option, deemed necessary due to the difference in the degree of involvement with safety-critical work, and in the nature and level of exposure to safety management systems in their workplace owing to the diverse occupational category of the sample. The purpose of this option was specified in the
questionnaire as follows: “Select 0 only if the question does not apply because you do not know or you do not have an opinion.”

Table 4.2 presents a section-based breakdown of the number of cases that responded to all items vs. those that contained one or more Not Applicable (NA) responses. Different patterns of responses were seen across the organisations as well as across different sub-groups within the same organisations. Because questions in Sections A1 and A2 addressed the participants’ perception of the level of safety experienced by people who work in safety-critical areas at their workplace, most people in non-safety critical roles (e.g. Administration, Finance, Human Resources and Sales & Marketing) considered the questions “Not Applicable” (NA).

Section A3 asked about the participant’s perception of the level of overall safety measures in general, to which most people responded. Section B addressed culture issues consisting of systems, values and attitudes. Section C addressed the participant’s perceptions of the driving force behind improving workplace safety. Response rates were higher for these sections as the questions were more general in nature.

<table>
<thead>
<tr>
<th>Section</th>
<th>Sub-section</th>
<th>Cases containing NA responses</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NA = 0</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NA &gt; 1</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Sec A1</td>
<td></td>
<td>147</td>
<td>37.5</td>
<td>245</td>
</tr>
<tr>
<td>Sec A2</td>
<td></td>
<td>129</td>
<td>32.9</td>
<td>263</td>
</tr>
<tr>
<td>Sec A3</td>
<td></td>
<td>388</td>
<td>99.0</td>
<td>4</td>
</tr>
<tr>
<td>Sec B</td>
<td>B1</td>
<td>378</td>
<td>96.4</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>331</td>
<td>84.4</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>B3</td>
<td>337</td>
<td>86.0</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>B4</td>
<td>354</td>
<td>90.3</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>B5</td>
<td>368</td>
<td>93.9</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>B6</td>
<td>324</td>
<td>82.7</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>B7</td>
<td>316</td>
<td>80.6</td>
<td>76</td>
</tr>
<tr>
<td>Sec C</td>
<td></td>
<td>259</td>
<td>66.1</td>
<td>133</td>
</tr>
</tbody>
</table>
Histograms were produced for each section in order to examine the distribution of the number of NA responses. Figure 4.1, as an example, shows the distribution of the number of NA responses for Section A1 consisting of 28 items.

![Histogram showing the frequency of the number of “Not Applicable” (NA) responses in Section A1 Work Environment (28 items) for the overall data](image)

Figure 4.1. Histogram showing the frequency of the number of “Not Applicable” (NA) responses in Section A1 Work Environment (28 items) for the overall data

The frequency formed an inversely proportional curve (akin to a scree plot in factor analysis). The largest proportion of the participants ($n = 147$) had no NA responses (37.5%), followed by those ($n = 44$) who had one such response (11.2%). However, some extreme cases were also observed, who answered NA to a majority of the questions (e.g. two participants responded NA to all of the 28 questions). The number of people who had more than four NA responses diminished steadily. Histograms generated for each section showed a consistent pattern of the frequency dropping considerably beyond one standard deviation ($SD$) above the mean number.

It was decided that cases whose number of NA responses exceeded one $SD$ above the mean number would be excluded from analysis for that particular section for group analysis. Based on this principle, cut-off criteria were set for each section as outlined in Table 4.3. This pragmatic approach was taken, as the questionnaire items in Sections A1 and A2 (greater focus on physical safety measures and the external environment) and Section B (greater emphasis on safety culture) addressed qualitatively different areas. It was expected that this difference could have led to different interpretations according to the survey participants as their understanding
of the question would have been coloured by their experience of the situation described in the questionnaire. For example, death and/or injury are differently experienced personally by frontline staff from managers.

NA responses were converted into missing values so that the cases could be excluded listwise throughout the factor analysis process despite the qualitative difference between the two response options.

Table 4.3
Criteria for Filtering out Cases Containing “Not Applicable” Responses

<table>
<thead>
<tr>
<th>Section</th>
<th>Sub-section</th>
<th>Section Name</th>
<th>Mean no. of NA responses</th>
<th>SD</th>
<th>Value of 1 SD above the mean</th>
<th>Filter out cases with no. of NA responses &gt; X*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sec A</td>
<td>A1</td>
<td>Work Environment</td>
<td>4.33</td>
<td>5.90</td>
<td>10.23</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>Actual/Potential Safety Problems</td>
<td>2.74</td>
<td>4.30</td>
<td>7.05</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>Safety Measures in General</td>
<td>0.01</td>
<td>0.10</td>
<td>0.11</td>
<td>0</td>
</tr>
<tr>
<td>Sec B</td>
<td>B1</td>
<td>Commitment to HSE &amp; Care for Colleagues</td>
<td>0.05</td>
<td>0.32</td>
<td>0.37</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>Balance between HSE &amp; Profitability</td>
<td>0.32</td>
<td>0.94</td>
<td>1.26</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>B3</td>
<td>Interest in Competency &amp; Training</td>
<td>0.24</td>
<td>0.77</td>
<td>1.02</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>B4</td>
<td>Workplace Safety Controls</td>
<td>0.14</td>
<td>0.49</td>
<td>0.63</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>B5</td>
<td>Purpose of HSE Procedures</td>
<td>0.10</td>
<td>0.50</td>
<td>0.61</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>B6</td>
<td>What happens after an accident?</td>
<td>0.32</td>
<td>1.01</td>
<td>1.33</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>B7</td>
<td>Safety Audit</td>
<td>0.76</td>
<td>2.09</td>
<td>2.84</td>
<td>3</td>
</tr>
<tr>
<td>Sec C</td>
<td></td>
<td>Driving Force behind Safety</td>
<td>0.67</td>
<td>1.36</td>
<td>2.03</td>
<td>2</td>
</tr>
</tbody>
</table>

*For example, if a case contains more than 11 “Not Applicable” responses in Section A1, it will be excluded from data analysis.

Participants

As the dataset (N =392) consists of responses provided by rail workers from a wide range of occupational groups, it was decided that the factor structure be examined separately for 1) combination of safety-critical workers and non-safety-critical workers (“combined sample”) as well as 2) safety-critical workers only. As the criterion was used to exclude cases whose number of NA responses exceeded one SD above the mean number from the original dataset, the sample size varied from section to section. The participants’ profile will be discussed at the beginning of each section for both the combined sample and the safety-critical group.
Material and Procedure

The SPSS Software (Version 16.0) was used on the dataset \((N = 392)\) to examine accuracy of data, missing values and fit between their distributions and the assumptions of each factor analysis (Allen & Bennett, 2008; Tabachnick & Fidell, 2007). This included checking the presence of univariate and multivariate outliers. Only where outliers were identified, are they discussed below.

The sample size \((N = 341)\) was deemed sufficient to permit the use of factor analysis (Allen & Bennett, 2008; Coakes & Steed, 2005; Hills, 2010; Stevens, 2009; Tabachnick & Fidell, 2007). The Principal Axis Factoring (PAF) method was used for factor extraction on Section A1, A2 and B1 through to B7 to identify factors with Eigenvalues exceeding 1.0. Initially, varimax rotation was carried out. Where it revealed no clear factor structure, further analysis was performed using an oblique rotation (direct oblimin) to generate a more interpretable solution. The selection was based on the following criteria:

“Factor loadings of 0.3 or higher on a factor are considered interpretable, and 0.4 or higher are considered salient. For this study, a conservative lower bound value of 0.5, and a minimum gap of 0.10 between salient coefficients on multiple factors (Nunnally & Bernstein, 1994, as cited in Shaik, et al., 2006, p. 4).”

Where multiple factors had loadings above 0.3 and the difference between the loadings were less than 0.1, they were regarded as complex variables and thus disregarded. This process revealed a total of 16 factors for both the combined sample and the safety-critical group. The factor structure was almost identical between the two groups except for some minor difference in factor loadings.

Table 4.4 presents a summary of the factors identified in the factor analysis for both groups. It also features the internal reliability as measured in Cronbach’s alpha for each factor, alongside the variance in questionnaire items that were used for factor analysis. In the following section, detailed results of the factor analysis will be discussed for each section for both the combined and safety-critical groups.
### Table 4.4

*Factors Identified through Factor Analysis (PAF) – 87 Items Reduced to 81 Items*

<table>
<thead>
<tr>
<th>Sections and Factors (No. of Items)</th>
<th>Combined Sample†</th>
<th>Safety-Critical Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cronbach’s α</td>
<td>% of Variance</td>
</tr>
<tr>
<td><strong>Section A1 Work Environment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  Negative Workplace Culture (3)</td>
<td>.82</td>
<td>15.51</td>
</tr>
<tr>
<td>Factor 2  Roster &amp; Time Pressure (4)</td>
<td>.85</td>
<td>11.44</td>
</tr>
<tr>
<td>Factor 3  Support for Fatigue Management* (4)</td>
<td>.83</td>
<td>11.19</td>
</tr>
<tr>
<td>Factor 4  Lack of Supervision (3)</td>
<td>.70</td>
<td>9.33</td>
</tr>
<tr>
<td>Factor 5  Workplace Stress (3)</td>
<td>.71</td>
<td>7.30</td>
</tr>
<tr>
<td><strong>Section A2 Potential/Actual Safety Problems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  Organisational Latent Problems (14)</td>
<td>.92</td>
<td>42.47</td>
</tr>
<tr>
<td>Factor 2  External Factors (3)</td>
<td>.73</td>
<td>6.37</td>
</tr>
<tr>
<td><strong>Section B1 Commitment Level of Workforce to</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HSE &amp; Care for Colleagues</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  High Workforce Commitment to HSE &amp; Care for Colleagues (16)</td>
<td>.82</td>
<td>44.11</td>
</tr>
<tr>
<td><strong>Section B2 Balance between HSE &amp; Profitability</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  Balance Achieved between HSE &amp; Profitability (7)</td>
<td>.82</td>
<td>40.42</td>
</tr>
<tr>
<td><strong>Section B3 Workforce Interest in Competency &amp; Training</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  Importance of Competency and Training Recognised (7)</td>
<td>.74</td>
<td>32.67</td>
</tr>
<tr>
<td><strong>Section B4 Work-site Safety Controls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  Effective Safety Controls (6)</td>
<td>.78</td>
<td>37.28</td>
</tr>
<tr>
<td><strong>Section B5 Purpose of HSE Procedures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  Balance Achieved between HSE Procedures &amp; Efficiency (5)</td>
<td>.67</td>
<td>26.83</td>
</tr>
<tr>
<td>Factor 2  Negative Views on HSE Procedures (3)**</td>
<td>.56††</td>
<td>5.97</td>
</tr>
<tr>
<td><strong>Section B6 Repercussion &amp; Feedback after Accidents?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  Reactivity – Blame Culture** (4)</td>
<td>.77</td>
<td>23.27</td>
</tr>
<tr>
<td>Factor 2  Constructive Management Response to Accidents (4)</td>
<td>.72</td>
<td>20.77</td>
</tr>
<tr>
<td><strong>Section B7 Audits &amp; Reviews</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 1  Proactive Approach to HSE Audits &amp; Reviews (5)</td>
<td>.87</td>
<td>47.84</td>
</tr>
</tbody>
</table>

† Combined sample consists of safety-critical workers and non-safety-critical workers.
†† The low inter-item reliability (below .6) suggests that potentially it may not be a uni-factorial construct.
* Section A features predominantly negative aspects of safety measures. Only Section A-3) Support for Fatigue Management represents a positive aspect.
** Conversely, Section B comprises mainly positive areas of safety culture. Factors with double asterisks represent negative aspects within this section.
4.2 Section A – Safety Climate Factors

Factor analysis was conducted for each section of the questionnaire. Section A – Safety Climate Factors consisted of two sub-sections: 1) Work Environment (28 items); and 2) Potential/Actual Safety Problems (20 items).

Factor Analysis 1 – Section A1 Work Environment on Combined Sample

Participants

In this section the term Combined Sample refers to the sample that combines Safety-Critical and Non-Safety-Critical Workers.

Combined Sample (N = 158)

One multivariate outlier was excluded from further analysis. One hundred and forty-three participants (90.5%) indicated they were working in a safety-critical area, while 14 participants (8.9%) responded they were in a non-safety-critical area at the time of the survey administration. One person did not answer (.6%). This sample consisted of 140 males (88.6%) and 16 females (10.1%). Two people did not identify their gender (1.3%). The distribution of age group is summarised in Table 4.5. Detailed profiles of the participants are shown in Appendix 7.

Table 4.5

<table>
<thead>
<tr>
<th>Age Group (years old)</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>19</td>
<td>12.0</td>
</tr>
<tr>
<td>30-39</td>
<td>32</td>
<td>20.3</td>
</tr>
<tr>
<td>40-49</td>
<td>51</td>
<td>32.3</td>
</tr>
<tr>
<td>50-59</td>
<td>37</td>
<td>23.4</td>
</tr>
<tr>
<td>60-69</td>
<td>12</td>
<td>7.6</td>
</tr>
<tr>
<td>Above 70</td>
<td>3</td>
<td>1.9</td>
</tr>
<tr>
<td>Unspecified</td>
<td>4</td>
<td>2.5</td>
</tr>
</tbody>
</table>
**Results**

Section A1 had 28 statements that addressed the participants’ perception of safety measures and safety culture in their work environment. Three items were eliminated from the final analysis. They were Item 4 [*They were encouraged by the employer NOT to attend work if they had had less than 5 hours sleep in the previous 24 hours.*] due to low communality, Item 6 [*They were allowed to cancel their shift at short notice due to pressing domestic circumstances.*] due to a low Kaiser-Meyer-Olkin (KMO) value, and Item 19 [*They performed tasks under the influence of alcohol or illicit drugs which could have potentially compromised rail safety.*] due to no variability in the responses ($n = 217$, $79.3\%$ responded [$1 = \text{very rarely}$], $M = 1.37$, $SD = .80$).

Factor analysis based on the remaining 25 items identified five factors. They consisted of Factor A1-1) *Negative Workplace Culture*; A1-2) *Support for Fatigue Management*; A1-3) *Roster and Time Pressure*; A1-4) *Lack of Supervision*; and A1-5) *Workplace Stress*. Table 4.6 shows these factors and the questionnaire statements that formed them with the loadings from a rotated factor matrix. The “Item no.” in the table indicates the sequence at which the statements appear in the questionnaire. For example, Factor A1-1) *Negative Workplace Culture* is a composite of three statements (No. 25, 26, and 28).

As can be seen in Table 4.6, eight statements loaded across multiple factors. They were eliminated, leaving a total of 17 statements constituting the five factors. The loading for Item 1’s first factor is .622. Based on the criteria set out by Nunnally and Bernstein (1994) as cited by Shaik, Lowe and Pinegar (2006), this factor is regarded as the salient factor, as the third factor’s loading (.393) is considered borderline interpretable. Similarly, the loading for Item 3’s third factor (.568) is regarded as salient, as the fourth factor’s loading (.310) is considered borderline interpretable. Thus the paramount factors can be regarded as simple variables. Item 21’s fourth factor (loading of .532) is regarded as the salient factor, as the first factor’s loading (.393) is considered borderline interpretable. Similarly, the loading for Item 20’s fourth factor (.602) is regarded as salient, as the first factor’s loading (.313) is considered borderline interpretable. Thus the paramount factors can be regarded as simple variables. Some questions
were difficult to interpret due to multiple loadings, without a clear distinction between borderline and fundamental loadings based on previous research. By these criteria Items 16 and 23 should have been regarded as complex variables. This is addressed in the Limitation section.

Factors 1, 3, 4 and 5 addressed negative aspects of the work environment. In response to the statements for these factors, higher mean scores represented the participant’s evaluation of a greater extent of inadequacy of safety measures and/or a less healthy safety culture in the organisation. Factor 2 *Support for Fatigue Management*, on the other hand, addressed a positive aspect of the work environment. Higher mean scores represented the participants’ evaluation of a greater extent of support for fatigue management provided by the organisation.
### Table 4.6
**Section A1 – Statements Comprising the Factors and Loadings for the Combined Sample (N = 158)**

**Question:** How frequently has such a situation been encountered in the workplace in the last 24 months?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Section A1 (Items 1 ~ 3, 5, 7 ~ 18 &amp; 20 ~ 28) 25 items Rotated Factor Matrix&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Loadings</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Workplace Culture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>25.</td>
<td>They broke safety working rules because they were overconfident.</td>
<td>.744</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>26.</td>
<td>They took shortcuts which could have potentially compromised safety because it had become standard practice - everyone does it all the time.</td>
<td>.736</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>28.</td>
<td>When they raised safety concerns and/or reported potential safety risks, these were ignored by line and/or top management.</td>
<td>.622</td>
<td>.393</td>
</tr>
<tr>
<td><strong>Complex Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>18.</td>
<td>They made potentially unsafe compromises because of equipment failure/mismatch (e.g. taking shortcuts or deviating from procedure).</td>
<td>.579</td>
<td>.363</td>
</tr>
<tr>
<td>5.</td>
<td>27.</td>
<td>They were allowed to perform tasks without going through regular updating of safety-critical skills through refresher training and safety compliance.</td>
<td>.574</td>
<td>.414</td>
</tr>
<tr>
<td>6.</td>
<td>17.</td>
<td>They performed tasks in an unfamiliar environment/situation.</td>
<td>.541</td>
<td>.317</td>
</tr>
<tr>
<td>7.</td>
<td>16.</td>
<td>They performed tasks that they had NOT been fully trained in.</td>
<td>.503</td>
<td>.489</td>
</tr>
<tr>
<td>8.</td>
<td>23.</td>
<td>They got confused about what actions to take because of unclear communication from a colleague about safety-critical tasks.</td>
<td>.451</td>
<td>.445</td>
</tr>
<tr>
<td>9.</td>
<td>24.</td>
<td>They broke the monotony of the task by engaging in various forms of entertainment (reading, listening to music, talking on the mobile phone for private matters, being engaged in personal conversation with a colleague on site) while on duty.</td>
<td>.376</td>
<td>.306</td>
</tr>
<tr>
<td><strong>Support for Fatigue Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>11.</td>
<td>They received support from the employer to seek medical help for conditions that interfere with restorative rest or sleep. (R)</td>
<td>.839</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>10.</td>
<td>They received support from the employer to make effective use of off-duty time to maximise restorative rest or sleep. (R)</td>
<td>.799</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>12.</td>
<td>They received support from the employer to seek professional help (e.g. counseling, therapy) to solve domestic concerns that interfere with restorative rest or sleep. (R)</td>
<td>.717</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>9.</td>
<td>They had been fully informed by the employer regarding risks posed by sleeping disorders, symptoms and available means of detecting and treating them.</td>
<td>.645</td>
<td></td>
</tr>
<tr>
<td><strong>Roster &amp; Time Pressure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>7.</td>
<td>They were put under pressure to report for duty despite feeling fatigued.</td>
<td>.783</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>8.</td>
<td>They needed to overextend themselves because of poor roster scheduling (e.g. working overtime).</td>
<td>.690</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>15.</td>
<td>They were allowed to pressured to perform tasks despite sudden sickness (e.g. flu, nausea and migraine headache) which could have affected rail safety.</td>
<td>.568</td>
<td>.310</td>
</tr>
<tr>
<td>17.</td>
<td>14.</td>
<td>They were allowed to be on a night shift after they had been awake for more than 14 hours prior to start of work.</td>
<td>.499</td>
<td></td>
</tr>
<tr>
<td><strong>Complex Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>13.</td>
<td>They had roster flexibility which allowed them to cancel their shift at short notice due to medical conditions (e.g. chronic sleep disorders and cardiac conditions). (R)</td>
<td>.329</td>
<td>.405</td>
</tr>
<tr>
<td>19.</td>
<td>14.</td>
<td>They performed tasks under the influence of medication (both prescribed and self-administered) which could have potentially compromised rail safety.</td>
<td>.354</td>
<td>.394</td>
</tr>
<tr>
<td><strong>Lack of Supervision</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>22.</td>
<td>Non-safeworking personnel were allowed access to safeworking equipment.</td>
<td>.611</td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>20.</td>
<td>They performed safety-critical tasks without authorisation.</td>
<td>.356</td>
<td>.585</td>
</tr>
<tr>
<td>22.</td>
<td>21.</td>
<td>They were allowed to perform duties without their performance being adequately monitored following unfavourable safety compliance history.</td>
<td>.398</td>
<td>.551</td>
</tr>
<tr>
<td><strong>Workplace Stress</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>2.</td>
<td>They were in a work environment where they were easily distracted by other tasks or people while performing their job.</td>
<td>.634</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>1.</td>
<td>They rushed to complete tasks to stay on schedule or to a timetable.</td>
<td>.592</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>3.</td>
<td>They were under pressure to perform duties beyond the limits of what could have been reasonably handled by one person.</td>
<td>.583</td>
<td></td>
</tr>
</tbody>
</table>

**Factor Analysis 2 – Section A1 Work Environment on Safety-Critical Workers Only**

**Participants**

**Safety-Critical Group (N =143)**

One multivariate outlier was excluded. This sample consisted of 133 males (93.0%) and 8 females (5.6%). Two people did not identify their gender (1.4%). The distribution of age group was as summarised in Table 4.7. Detailed profiles of the participants are shown in Appendix 7.

**Table 4.7**

<table>
<thead>
<tr>
<th>Age Group (years old)</th>
<th>Frequency N = 143</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>17</td>
<td>11.9</td>
</tr>
<tr>
<td>30-39</td>
<td>29</td>
<td>20.3</td>
</tr>
<tr>
<td>40-49</td>
<td>45</td>
<td>31.5</td>
</tr>
<tr>
<td>50-59</td>
<td>33</td>
<td>23.1</td>
</tr>
<tr>
<td>60-69</td>
<td>12</td>
<td>8.4</td>
</tr>
<tr>
<td>Above 70</td>
<td>3</td>
<td>2.1</td>
</tr>
<tr>
<td>Unspecified</td>
<td>4</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Results**

As with the combined sample above, this analysis of the safety-critical group also identified Items 4 and 6 with low communalities and Item 19 with no variability in the responses. They were eliminated from the final analysis. As can be seen in Table 4.8, factor analysis based on the remaining 25 items identified the same five factors as the previous analysis presented in Table 4.6. The only difference was that *Roster and Time Pressure* had a higher Eigenvalue (2.49) than *Support for Fatigue Management* (1.68).

As shown in Table 4.8, eight additional statements loaded across multiple factors. They were almost identical to those of the previous analysis except for Items 13 (complex variable only in the previous analysis) and 15 (complex variable only in the current analysis). They were eliminated, leaving a total of 17 statements. The item configurations for the factors were almost identical to those of the combined sample with slight differences in the factor loadings.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Rotated Factor Matrixa</th>
<th>Loadings Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workplace Culture</strong></td>
<td>25.</td>
<td>They broke safeworking rules because they were overconfident.</td>
<td>.774</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26.</td>
<td>They took shortcuts which could have potentially compromised safety because it had become standard practice - everyone does it all the time.</td>
<td>.727</td>
<td></td>
</tr>
<tr>
<td></td>
<td>28.</td>
<td>When they raised safety concerns and/or reported potential safety risks, these were ignored by line and/or top management.</td>
<td>.620 .395</td>
<td></td>
</tr>
<tr>
<td>27. They were allowed to perform tasks without going through regular updating of safety-critical skills through refresher training and safety compliance audits.</td>
<td>[.560 ] .423</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. They made potentially unsafe compromises because of equipment failure/mismatch (e.g. taking shortcuts or deviating from procedure).</td>
<td>[.547 ] .393</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. They performed tasks in an unfamiliar environment/situation.</td>
<td>[.500 ] .404</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. They broke the monotony of the task by engaging in various forms of entertainment (reading, listening to music, talking on the mobile phone for private matters, being engaged in personal conversation with a colleague on site) while on duty.</td>
<td>[.435 ] .425</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Roster &amp; Time Pressure</strong></td>
<td>7.</td>
<td>They were put under pressure to report for duty despite feeling fatigued.</td>
<td>.775</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.</td>
<td>They needed to overextend themselves because of poor roster scheduling (e.g. working overtime).</td>
<td>.711</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.</td>
<td>They were allowed to be on a night shift after they had been awake for more than 14 hours prior to start of work.</td>
<td>.512</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13.</td>
<td>They had roster flexibility which allowed them to cancel their shift at short notice due to medical conditions (e.g. chronic sleep disorders and cardiac conditions). (R)</td>
<td>.436</td>
<td></td>
</tr>
<tr>
<td>15. They were allowed to/pressured to perform tasks despite sudden sickness (e.g. flu, nausea and migraine headache) which could have affected rail safety.</td>
<td>[.593 ] .302</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. They performed tasks under the influence of medication (both prescribed and self-administered) which could have potentially compromised rail safety.</td>
<td>[.348 ] .396</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Support for Fatigue</strong></td>
<td>10.</td>
<td>They received support from the employer to make effective use of off-duty time to maximise restorative rest or sleep. (R)</td>
<td>.826</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11.</td>
<td>They received support from the employer to seek medical help for conditions that interfere with restorative rest or sleep. (R)</td>
<td>.806</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.</td>
<td>They received support from the employer to seek professional help (e.g. counseling, therapy) to resolve domestic concerns that interfere with restorative rest or sleep. (R)</td>
<td>.717</td>
<td></td>
</tr>
<tr>
<td>9. They had been fully informed by the employer regarding risks posed by sleeping disorders, symptoms and available means of detecting and treating them. (R)</td>
<td>[.657 ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lack of Supervision</strong></td>
<td>22.</td>
<td>Non-safeworking personnel were allowed access to safeworking equipment.</td>
<td>.642</td>
<td></td>
</tr>
<tr>
<td>21. They were allowed to perform duties without their performance being adequately monitored following unfavourable safety compliance history.</td>
<td>[.393 ] .532</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. They performed safety-critical tasks without authorisation.</td>
<td>[.313 ] .602</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. They performed tasks that they had NOT been fully trained in.</td>
<td>[.476 ] .547</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. They got confused about what actions to take because of unclear communication from a colleague about safety-critical tasks.</td>
<td>[.407 ] .482</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Workplace Stress</strong></td>
<td>3.</td>
<td>They were under pressure to perform duties beyond the limits of what could have been reasonably handled by one person.</td>
<td>[.647 ]</td>
<td></td>
</tr>
<tr>
<td>2. They were in a work environment where they were easily distracted by other tasks or people while performing their job.</td>
<td>[.613 ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. They rushed to complete tasks to stay on schedule or to a timetable.</td>
<td>[.550 ]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(R) denotes reverse-scored items. Extraction and rotation details are identical to those of Analysis 1.
Factor Analysis 3 – Section A2 Potential/Actual Safety Problems on Combined Sample

Participants

Combined Sample (N = 224)

Five multivariate outliers were excluded. One hundred and ninety-seven participants (87.9%) indicated they were working in a safety-critical area, while 26 participants (11.6%) responded they were in a non-safety-critical area at the time of the survey administration. Detailed profiles of the participants are shown in Appendix 7.

Results

Section A2 had 20 statements that addressed the participants’ perception of factors that contributed to potential or actual safety problems in their workplace. One item was eliminated from the final analysis due to a low response rate (Item No. 19 [Aggressive behaviours by passengers.] n = 124, 55.4%). Factor analysis based on the remaining 19 items identified two factors. They were A2-1) Organisational Latent Problems; and A2-2) External Factors that contributed to potential or actual safety problems. Table 4.9 shows these factors and the questionnaire statements that formed them with the loadings from a pattern matrix.

As can be seen in Table 4.9, two statements loaded across multiple factors. They were eliminated, leaving a total of 17 statements comprising the two factors. Both factors in this section addressed negative aspects of the work environment from safety perspective. Higher mean scores represented a greater frequency at which the participants observed the contributing factors to potential or actual safety problems at their workplace.
Table 4.9  
Section A2 – Statements Comprising the Factors and Loadings for the Combined Sample (N = 224)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Statement</th>
<th>Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Factor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31. Because procedures did not specify appropriate safety actions for certain safety-related tasks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30. Because a change of operational/infrastructure circumstances had not been communicated to them.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33. Lack of communication from colleagues about potential safety risks (e.g. observed defect in track, equipment and rolling stock).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43. Because of inadequate management of contractor safety.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32. Because they were unable to challenge decisions made by more experienced employees in the team.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40. Lack of training in hazard identification before commencing any task.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36. Inadequate safety standards and procedures (including those for operations, signalling, loading, inspection, maintenance and management of dangerous goods).</td>
</tr>
<tr>
<td></td>
<td>2. External Factors</td>
<td>44. Because of inadequate defences against error or inadequate train protection.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>41. Because the employer had been unable to stop unsafe work practice that had been around for a long time and had become a standard way of doing things - everyone does it all the time.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>42. Because procedure manuals and checklists were hard to understand or NOT available.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>39. Lack of the employer’s effort to ensure compliance with safety rules (including those for operations, signalling, loading, inspection &amp; maintenance).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38. Because of inadequate housekeeping (e.g. cleaning of facilities/operating equipment, tidy working environment, recovery from vandalism and ensuring clear track/signal sightings).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34. Poor design of equipment/rolling stock which could have compromised safe working.</td>
</tr>
<tr>
<td></td>
<td>3. Complex Variables</td>
<td>45. Unexpected intrusion across the track by people, animals and foreign objects.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>46. Reckless behaviour of pedestrians and vehicle drivers (e.g. cars and trucks) at level crossings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>48. Unforeseen weather and other environmental conditions (e.g. extreme heat, cold, and other inclement weather conditions).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37. Inadequate protection at level crossings (e.g. passive level crossings).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35. Equipment failure, poor condition of track, rolling stock and/or signalling.</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Axis Factoring.  
Rotation Method: Oblimin with Kaiser Normalization.  
a. Rotation converged in 6 iterations.
Factor Analysis 4 – Section A2 Potential/Actual Safety Problems on Safety-Critical Workers Only

Participants
Safety-Critical Group (N = 197)

Five multivariate outliers were excluded. This sample consisted of 185 males (93.9%) and 10 females (5.1%). Two people did not identify their gender (1.0%). Detailed profiles of the participants are shown in Appendix 7.

Results

As with the combined sample above, this analysis of the safety-critical group also identified one item with a low response rate (Item No. 19 [Aggressive behaviours by passengers.], n = 106, 53.8%). It was eliminated from the final analysis. As can be seen in Table 4.10, factor analysis based on the remaining 19 items identified the same two factors as the previous analysis on the combined sample. Two additional statements (No. 35 and 37) were eliminated due to multiple factor loadings, leaving a total of 17 statements comprising the two factors. The item configurations for the factors were identical to those of the combined sample with slight differences in the factor loadings.
### Table 4.10

**Statement Comprising the Factors and Loadings for the Safety-Critical Group (N = 197)**

**Question:** How frequently would people who work in safety-critical areas in your workplace have experienced potential or actual safety problems because of the following reasons in the past 24 months?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td></td>
<td>29.</td>
<td>Because of lack of standardised approach to safety procedures.</td>
<td>.814</td>
</tr>
<tr>
<td></td>
<td>31.</td>
<td>Because procedures did not specify appropriate safeworking actions for certain safety-related tasks.</td>
<td>.809</td>
</tr>
<tr>
<td></td>
<td>30.</td>
<td>Because a change of operational/infrastructure circumstances had not been communicated to them.</td>
<td>.737</td>
</tr>
<tr>
<td></td>
<td>32.</td>
<td>Because they were unable to challenge decisions made by more experienced employees in the team.</td>
<td>.714</td>
</tr>
<tr>
<td></td>
<td>33.</td>
<td>Lack of communication from colleagues about potential safety risks (e.g. observed defect in track, equipment and rolling stock).</td>
<td>.705</td>
</tr>
<tr>
<td></td>
<td>40.</td>
<td>Lack of training in hazard identification before commencing any task.</td>
<td>.688</td>
</tr>
<tr>
<td></td>
<td>43.</td>
<td>Because of inadequate management of contractor safety.</td>
<td>.686</td>
</tr>
<tr>
<td></td>
<td>44.</td>
<td>Because of inadequate defences against error or inadequate train protection.</td>
<td>.642</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36.</td>
<td>Inadequate safety standards and procedures (including those for operations, signalling, loading, inspection, maintenance and management of dangerous goods).</td>
<td>.636</td>
</tr>
<tr>
<td></td>
<td>41.</td>
<td>Because the employer had been unable to stop unsafe work practice that had been around for a long time and had become a standard way of doing things - everyone does it all the time.</td>
<td>.625</td>
</tr>
<tr>
<td></td>
<td>39.</td>
<td>Lack of the employer's effort to ensure compliance with safety rules (including those for operations, signalling, loading, inspection &amp; maintenance).</td>
<td>.588</td>
</tr>
<tr>
<td></td>
<td>42.</td>
<td>Because procedure manuals and checklists were hard to understand or NOT available.</td>
<td>.576</td>
</tr>
<tr>
<td></td>
<td>38.</td>
<td>Because of inadequate housekeeping (e.g. cleaning of facilities/operating equipment, tidy working environment, recovery from vandalism and ensuring clear track/signal sightings).</td>
<td>.574</td>
</tr>
<tr>
<td></td>
<td>34.</td>
<td>Poor design of equipment/rolling stock which could have compromised safe working.</td>
<td>.509</td>
</tr>
<tr>
<td></td>
<td>46.</td>
<td>Reckless behaviour of pedestrians and vehicle drivers (e.g. cars and trucks) at level crossings.</td>
<td>.752</td>
</tr>
<tr>
<td></td>
<td>45.</td>
<td>Unexpected intrusion across the track by people, animals and foreign objects.</td>
<td>.736</td>
</tr>
<tr>
<td></td>
<td>48.</td>
<td>Unforeseen weather and other environmental conditions (e.g. extreme heat, cold, and other inclement weather conditions).</td>
<td>.468</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35.</td>
<td>Equipment failure, poor condition of track, rolling stock and/or signalling.</td>
<td>.391</td>
</tr>
<tr>
<td></td>
<td>37.</td>
<td>Inadequate protection at level crossings (e.g. passive level crossings).</td>
<td>.345</td>
</tr>
</tbody>
</table>
4.3 Section B – Safety Culture Factors

4.3.1 Safety Culture Factors within Theory-Based Categories

As outlined in Chapter 3, the questions and statements in Section B have been adapted from the *Hearts & Minds* program with permission from Shell International Exploration and Production B. V. and the Energy Institute, the UK. Section B – Safety Culture Factors consisted of a total of 67 questions. They are categorised into seven distinct conceptual categories based on previous research (Lawrie, et al., 2006; Parker, et al., 2006). They consisted of B1 *Commitment Level of Workforce to HSE & Care for Colleagues*; B2 *Balance between HSE and Profitability*; B3 *Workforce Interest in Competency and Training*; B4 *Workplace Safety Controls*; B5 *Purpose of HSE Procedures*; B6 *Repercussion & Feedback after Accidents*; and B7 *Audits & Reviews*. The participants were asked how far each of the statements provided described their place of work.

Factor analysis was carried out for each conceptual category. This process revealed a total of nine factors for both the combined sample and the safety-critical group. The factor structure was almost identical between the two groups except for some minor differences in factor loadings. In the following sections results for the combined and safety-critical groups will be shown together for easy comparison.

Five out of the seven categories generated a single factor. In the remaining two categories, two factors were identified, respectively. Thus, the process generated a total of nine safety culture factors. They were B1 *Commitment to Health Safety and Environment (HSE) and Care for Colleagues*, B2 *Balance Achieved between HSE and Profitability*, B3 *Importance of Competency and Training Recognised*, B4 *Effective Safety Controls*, B5-1) *Balance Achieved between HSE Procedures and Efficiency*, B5-2) *Negative Views on HSE Procedures*, B6-1) *Reactivity – Blame Culture*, B6-2) *Constructive Management Response to Accidents*, and B7 *Proactive Approach to HSE Audits and Reviews*. The details of the findings are outlined below.
Factor Analysis 5 & 6 – Section B1 Commitment Level of Workforce to HSE and Care for Colleagues

Participants

The distribution of age group for both groups was as summarised in Table 4. 11. Detailed profiles of the participants are shown in Appendix 7.

Combined Sample (N = 379)

Three multivariate outliers were excluded. Three hundred and thirty-two participants (87.6%) indicated they were working in a safety-critical area, while 46 participants (12.1%) responded they were in a non-safety-critical area at the time of the survey administration. One person did not answer (.3%). This sample consisted of 341 males (90.0%) and 35 females (9.2%). Three people did not identify their gender (.8%).

Safety-Critical Group (N = 332)

Three multivariate outliers were excluded. This sample consisted of 311 males (93.7%) and 18 females (5.4%). Three people did not identify their gender (0.9%).

Table 4.11

Distribution of Age Group for Factor Analysis on Section B1 – Combined Sample (left) and Safety-Critical Group (right)

<table>
<thead>
<tr>
<th>Age Group (years old)</th>
<th>Frequency</th>
<th>%</th>
<th>Age Group (years old)</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 20</td>
<td>1</td>
<td>.3</td>
<td>Under 20</td>
<td>1</td>
<td>.3</td>
</tr>
<tr>
<td>20-29</td>
<td>33</td>
<td>8.7</td>
<td>20-29</td>
<td>28</td>
<td>8.4</td>
</tr>
<tr>
<td>30-39</td>
<td>82</td>
<td>21.6</td>
<td>30-39</td>
<td>70</td>
<td>21.1</td>
</tr>
<tr>
<td>40-49</td>
<td>117</td>
<td>30.9</td>
<td>40-49</td>
<td>104</td>
<td>31.3</td>
</tr>
<tr>
<td>50-59</td>
<td>99</td>
<td>26.1</td>
<td>50-59</td>
<td>86</td>
<td>25.9</td>
</tr>
<tr>
<td>60-69</td>
<td>31</td>
<td>8.2</td>
<td>60-69</td>
<td>30</td>
<td>9.1</td>
</tr>
<tr>
<td>Above 70</td>
<td>10</td>
<td>2.6</td>
<td>Above 70</td>
<td>7</td>
<td>2.1</td>
</tr>
<tr>
<td>Unspecified</td>
<td>6</td>
<td>1.6</td>
<td>Unspecified</td>
<td>6</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Results

Combined Sample

Section B1 had eight statements pertaining to the participants’ perception of the level of commitment of the workforce to HSE and care for colleagues. Two
statements were eliminated due to low communalities. They were Item 2 [After accidents, there is a voiced commitment to care for colleagues by both management and employees.] and Item 3 [When it comes to safety, individuals look after themselves.]. This left a total of 6 statements for the final analysis.

Factor analysis identified one factor, which addressed High Workforce Commitment to HSE and Care for Colleagues. Higher mean scores represented the participants’ higher evaluation of the workforce’s commitment to HSE and care for colleagues at their place of work. Table 4.12 shows the composition of the statements that formed this factor and the loadings from a factor matrix.

Safety-Critical Group

Low communalities were found for Items 2 and 3. They were eliminated, leaving six statements for the final analysis. As can be seen in Table 4.12, factor analysis identified the same factor as the previous analysis. The item configurations were identical to those of the combined sample with slight differences in the factor loadings.

Table 4.12
Section B1 – Statements Comprising the Factor and Loading for the Combined Sample and the Safety-Critical Group

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Section B1 (Item 1 &amp; Items 4 ~ 8)</th>
<th>6 items Factor Matrix</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Loadings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Statement</td>
<td></td>
<td>Combined Sample (N = 379)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Factor 1</td>
</tr>
<tr>
<td>High Workforce Commitment to HSE &amp; Care for Colleagues</td>
<td>1.</td>
<td>The feeling of pride in Health Safety &amp; Environment (HSE) and care for colleagues is NOT shared by everyone. (R)</td>
<td>.676</td>
<td>.679</td>
</tr>
<tr>
<td></td>
<td>4.</td>
<td>People know how to pay lip service to safety, but practical factors may prevent complete application. (R)</td>
<td>.688</td>
<td>.709</td>
</tr>
<tr>
<td></td>
<td>7.</td>
<td>Levels of commitment and care are very high and are driven by employees who aspire to achieve high HSE standards.</td>
<td>.749</td>
<td>.752</td>
</tr>
<tr>
<td></td>
<td>8.</td>
<td>Pride in HSE is beginning to develop, increasing the employees’ commitment to HSE and care for colleagues.</td>
<td>.663</td>
<td>.649</td>
</tr>
<tr>
<td></td>
<td>5.</td>
<td>Commitment to HSE and care for colleagues diminishes after a period of good safety performance. (R)</td>
<td>.627</td>
<td>.623</td>
</tr>
<tr>
<td></td>
<td>6.</td>
<td>Who cares about safety as long as we don’t get caught? (R)</td>
<td>.567</td>
<td>.545</td>
</tr>
</tbody>
</table>

(R) denotes reverse-scored items. Extraction Method: Principal Axis Factoring. a. 1 factor extracted. 5 iterations required.
Factor Analyses 7 & 8 – Section B2 Balance between HSE and Profitability

Participants

Detailed profiles of the participants are shown in Appendix 7.

Combined Sample (N = 345)

Two multivariate outliers were excluded. Two hundred and ninety-nine participants (86.7%) indicated they were working in a safety-critical area, while 45 participants (13.0%) responded they were in a non-safety-critical area at the time of the survey administration. One person did not answer (.3%).

Safety-Critical Group (N = 299)

One multivariate outlier was excluded. This sample consisted of 287 males (96.0%) and 10 females (3.3%). Two people did not identify their gender (0.7%).

Results

Combined Sample

Section B2 had a total of 10 statements pertaining to the participants’ perception of their organisation’s balance between HSE and profitability. Three statements were eliminated due to low communalities. They were Item 11 [Line managers spend most of their time on operational issues.], Item 12 [HSE and profitability are in balance, so that they are not competing priorities.]), and Item 18 [My employer is quite good at juggling HSE and profitability but money still counts.]. This left a total of seven statements for the final analysis.

Factor analysis identified one factor, which addressed Balance Achieved between HSE and Profitability. Table 4.13 shows the composition of the statements that formed this factor and the loadings from a factor matrix. Higher mean scores in response to the statements represented the participants’ evaluation of a higher level of balance their organisation had achieved in this aspect.

Safety-Critical Group

As with the combined sample above, this analysis of the safety-critical group also identified Items 11, 12 and 18 with low communalities. They were eliminated, leaving seven statements for the final analysis. As can be seen in Table 4.13, factor analysis identified the same factor as the previous analysis on
the combined sample. The item configurations were identical to those of the combined sample with slight differences in the factor loadings.

Table 4.13
Section B2 – Statements Comprising the Factor and Loadings for the Combined Sample and the Safety-Critical Group

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Section B2 (Items 9, 10 &amp; Items 13 ~ 17) 7 items Factor Matrix&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Combined</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sample</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(N = 345)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Factor 1</td>
</tr>
<tr>
<td>Balance</td>
<td>17.</td>
<td>Safety is seen as costing money, and the only priority is to avoid extra costs. (R)</td>
<td>.855</td>
</tr>
<tr>
<td>Achieved</td>
<td>9.</td>
<td>Safety is seen as an optional expenditure. (R)</td>
<td>.668</td>
</tr>
<tr>
<td>between</td>
<td>13.</td>
<td>My employer tries to make HSE the top priority, understanding that HSE contributes to financial return.</td>
<td>.634</td>
</tr>
<tr>
<td>HSE &amp; Profitability</td>
<td>15.</td>
<td>My employer accepts delays to get contractors up to standard in terms of safety regardless of cost.</td>
<td>.586</td>
</tr>
<tr>
<td>Profitability</td>
<td>16.</td>
<td>Line managers know how to say the right things, but do not always walk their own talk. (R)</td>
<td>.582</td>
</tr>
<tr>
<td></td>
<td>14.</td>
<td>Cost is important, but some money is put towards maintenance to prevent accidents. (R)</td>
<td>.539</td>
</tr>
<tr>
<td></td>
<td>10.</td>
<td>Management believes that HSE saves money in the long term.</td>
<td>.527</td>
</tr>
</tbody>
</table>

(R) denotes reverse-scored items. Extraction Method: Principal Axis Factoring.
<sup>a</sup> 1 factor extracted. 7 iterations required.

Factor Analyses 9 & 10 – Section B3 Workforce Interest in Competency and Training

Participants

Detailed profiles of the participants are shown in Appendix 7.

Combined Sample (N = 356)

One multivariate outlier was excluded. Three hundred and nine participants (86.8%) indicated they were working in a safety-critical area, while 45 participants (12.6%) responded they were in a non-safety-critical area at the time of the survey administration. Two people did not answer (.6%).
**Safety-Critical Group (N = 309)**

One multivariate outlier was excluded. This sample consisted of 292 males (94.5%) and 15 females (4.9%). Two people did not identify their gender (0.6%).

**Results**

**Combined Sample**

Section B3 had 11 statements pertaining to the participants’ perception of the workforce interest in competency and training in their place of work. Four statements were eliminated due to low KMO values. They were Item 19 [Training is seen as a process for enhancing skills and competency rather than a requirement.], Item 20 [Compulsory training during work hours gives employees a break from work that they carry out in a demanding working environment.], Item 21 [Training is attended when it is required by law.], and Item 24 [Training is aimed at the person – If we can change their attitude, everything will be alright.]. This left a total of seven statements for the final analysis.

Factor analysis identified one factor, which addressed Importance of Competency and Training Recognised. Table 4.14 shows the composition of the statements that formed this factor and the loadings from a factor matrix. Higher mean scores in response to the statements represented the participants’ evaluation of a greater recognition of the importance of competency and training in their organisation.

**Safety-Critical Group**

As with the combined sample above, this analysis of the safety-critical group also identified Items no. 19, 20, 21 and 24 with low KMO values. They were eliminated, leaving seven statements for the final analysis. As can be seen in Table 4.14, factor analysis identified the same factor as the previous analysis on the combined sample. The item configurations for the factors were identical to those of the combined sample with slight differences in the factor loadings.
Table 4.14
Section B3 – Statements Comprising the Factor and Loadings for the Combined Sample and the Safety-Critical Group

<table>
<thead>
<tr>
<th>Factor no.</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Matrix</th>
<th>Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.</td>
<td></td>
<td>Leadership fully acknowledges the importance of assessment of on-the-job skills.</td>
<td>.780</td>
<td>.777</td>
</tr>
<tr>
<td>23.</td>
<td></td>
<td>Information on competence requirements for individual roles is available, and appropriate training is given.</td>
<td>.709</td>
<td>.692</td>
</tr>
<tr>
<td>26.</td>
<td></td>
<td>Employees are proud to demonstrate their skills in on-the-job assessment.</td>
<td>.630</td>
<td>.614</td>
</tr>
<tr>
<td>29.</td>
<td></td>
<td>Training is seen as a necessary evil. (R)</td>
<td>.476</td>
<td>.503</td>
</tr>
<tr>
<td>28.</td>
<td></td>
<td>After an accident, specific training programs are made available.</td>
<td>.476</td>
<td>.450</td>
</tr>
<tr>
<td>22.</td>
<td></td>
<td>Training needs are beginning to be identified by the employees.</td>
<td>.463</td>
<td>.463</td>
</tr>
<tr>
<td>25.</td>
<td></td>
<td>There is some on-the-job transfer of training.</td>
<td>.342</td>
<td>.342</td>
</tr>
</tbody>
</table>

(R) denotes reverse-scored items.
Extraction Method: Principal Axis Factoring.
a. 1 factor extracted. 7 iterations required.

Factor Analyses 11 & 12 – Section B4 Work-Site Safety Controls

Participants

Detailed profiles of the participants are shown in Appendix 7.

Combined Sample (N = 353)

One multivariate outlier was excluded. Three hundred and ten participants (87.8%) indicated they were working in a safety-critical area, while 42 participants (11.9%) responded they were in a non-safety-critical area at the time of the survey administration. One person did not answer (.3%).

Safety-Critical Group (N = 310)

One multivariate outlier was excluded. This sample consisted of 291 males (93.9%) and 16 females (5.2%). Three people did not identify their gender (1.0%).

Results
**Combined Sample**

Section B4 had a total of six statements pertaining to the participants’ perception of the work-site safety controls in their organisation. Factor analysis identified one factor, which addressed *Effective Safety Controls*. Table 4.15 shows the composition of the statements that formed this factor and the loadings from a factor matrix. Higher mean scores represented the participants’ evaluation of greater effectiveness of their organisation’s safety control.

**Safety-Critical Group**

As with the combined sample above, this analysis of the safety-critical group also identified the same factor. As can be seen in Table 4.15, the item configurations for the factors were identical to those of the combined sample in the previous analysis with slight differences in the factor loadings.

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**Table 4.15**

*Section B4 – Statements Comprising the Factor and Loadings for the Combined Sample and the Safety-Critical Group*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Section B3 (Items 22, 23 &amp; Items 25 ~ 29) 7 items Factor Matrix[^a^]</th>
<th>Loadings</th>
<th>Combined Sample (N = 353)</th>
<th>Safety Critical Grp (N = 310)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Statement</td>
<td></td>
<td>Factor 1</td>
<td>Factor 1</td>
</tr>
<tr>
<td></td>
<td>35.</td>
<td>People (both team members and supervisors) are not afraid to tell each other about or report hazards.</td>
<td></td>
<td>.651</td>
<td>.637</td>
</tr>
<tr>
<td></td>
<td>30.</td>
<td>There is little systematic use of the standard work-related safety management controls after their initial introduction. (R)</td>
<td></td>
<td>.648</td>
<td>.621</td>
</tr>
<tr>
<td>1. Effective</td>
<td>33.</td>
<td>Internal safety audits, as a work-site hazard management control, are revised regularly in a defined process.</td>
<td></td>
<td>.633</td>
<td>.636</td>
</tr>
<tr>
<td>Safety Controls</td>
<td>34.</td>
<td>The number of inspection reports written is used to check that the job safety controls required by the management system are working.</td>
<td></td>
<td>.626</td>
<td>.619</td>
</tr>
<tr>
<td></td>
<td>32.</td>
<td>There are no safety management controls applied - &quot;Look out for yourself&quot; (R)</td>
<td></td>
<td>.598</td>
<td>.625</td>
</tr>
<tr>
<td></td>
<td>31.</td>
<td>Internal safety audits are accepted by the employees as being in their own interest.</td>
<td></td>
<td>.492</td>
<td>.481</td>
</tr>
</tbody>
</table>

[^a^]: Extraction Method: Principal Axis Factoring. a. 1 factor extracted. 4 iterations required.

(R) denotes reverse-scored items.
Factor Analyses 13 & 14 – Section B5 Purpose of HSE Procedures

Participants

Detailed profiles of the participants are shown in Appendix 7.

Combined Sample \((N = 364)\)

Eight multivariate outliers were excluded. Three hundred and twenty participants (87.9%) indicated they were working in a safety-critical area, while 42 participants (11.5%) responded they were in a non-safety-critical area at the time of the survey administration. Two people did not answer (.6%).

Safety-Critical Group \((N = 320)\)

One multivariate outlier was excluded. This sample consisted of 303 males (94.7%) and 15 females (4.7%). Two people did not identify their gender (0.6%).

Results

Combined Sample

Section B5 had a total of 10 statements pertaining to the participants’ perception of the purpose of their organisation’s safety procedures. Two statements were eliminated due to low KMO values. They were Item 38 \([\text{There is trust that employees can recognise situations where compliance with HSE procedures should be questioned.}]\) and Item 39 \([\text{The purpose of HSE procedures is to prevent individual incidents recurring.}]\). This left a total of eight statements for the final analysis.

Factor analysis identified two factors, consisting of: 1) Balance Achieved between HSE Procedures & Efficiency; and 2) Negative Views on HSE Procedures. Table 4.16 shows the composition of the statements that formed these factors and the loadings from a pattern matrix. Factor 1 addressed a positive aspect of safety procedures. Higher mean scores represented the participants’ evaluation that the organisation had achieved greater balance between procedures and efficiency. On the other hand, Factor 2 addressed a negative aspect. Higher mean scores represented the participants’ evaluation of more negative views held by their organisation about safety procedures.
Safety-Critical Group

As with the combined sample above, this analysis of the safety-critical group also identified Items 38 and 39 with low KMO values. They were eliminated, leaving eight statements for the final analysis. As can be seen in Table 4.16, factor analysis identified the same two factors as the previous analysis on the combined sample. The item configurations were identical to those of the combined sample with slight differences in the factor loadings.

Table 4.16
Section B5 – Statements Comprising the Factors and Loadings for the Combined Sample and the Safety-Critical Group

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Combined Sample (N = 364)</th>
<th>Safety-Critical Grp (N = 320)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pattern Matrix\textsuperscript{a}</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section B5 (Items 36, 37 &amp; Items 40 ~ 45) 8 items</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>37.</td>
<td>The overall effect of HSE procedures is NOT necessarily properly considered in detail. (R)</td>
<td>.647</td>
<td>.662</td>
</tr>
<tr>
<td>Balance</td>
<td>44.</td>
<td>HSE procedures communicate best practice.</td>
<td>.603</td>
<td>.585</td>
</tr>
<tr>
<td></td>
<td>41.</td>
<td>Non-compliance with HSE procedures is handled through recognised channels.</td>
<td>.539</td>
<td>.533</td>
</tr>
<tr>
<td>Achieved between HSE Procedures &amp; Efficiency</td>
<td>36.</td>
<td>HSE procedures are occasionally seen as inconvenient by competent employees. (R)</td>
<td>.381</td>
<td>.422</td>
</tr>
<tr>
<td></td>
<td>45.</td>
<td>HSE procedures are refined for efficiency.</td>
<td>.336</td>
<td>.352</td>
</tr>
<tr>
<td>2.</td>
<td>43.</td>
<td>HSE procedures are often written in response to accidents.</td>
<td>.663</td>
<td>.655</td>
</tr>
<tr>
<td>Negative Views on HSE Procedures</td>
<td>40.</td>
<td>HSE procedures are seen as limiting people's activities to avoid law suits or harm to assets.</td>
<td>.585</td>
<td>.631</td>
</tr>
<tr>
<td></td>
<td>42.</td>
<td>HSE procedures are taught in training but are inflexible.</td>
<td>.389</td>
<td>.365</td>
</tr>
</tbody>
</table>

(R) denotes reverse-scored items.
Extraction Method: Principal Axis Factoring.

Factor Analyses 15 & 16 – Section B6 Repercussion and Feedback after Accidents?

Participants

Detailed profiles of the participants are shown in Appendix 7.
Combined Sample ($N = 351$)

One multivariate outlier was excluded. Three hundred and five participants (86.9%) indicated they were working in a safety-critical area, while 44 participants (12.5%) responded they were in a non-safety-critical area at the time of the survey administration. Two people did not answer (0.6%).

Safety-Critical Group ($N = 305$)

One multivariate outlier was excluded. This sample consisted of 290 males (95.1%) and 13 females (4.3%). Two people did not identify their gender (0.7%).

Results

Combined Sample

Section B6 had a total of 11 statements pertaining to the participants’ perception of repercussion and feedback after accidents in their organisations. Three statements were eliminated due to low communalities. They were Item 46 [Employees report their own accidents but maintain their distance from contractor incidents.], Item 47 [After an accident, reports are NOT passed up the line if it can be avoided.] and Item 52 [Employees take it personally when others have accidents.]. This left a total of eight statements for the final analysis.

Factor analysis identified two factors, consisting of: 1) Reactivity – Blame Culture; and 2) Constructive Management Response to Accidents. Table 4.17 shows the composition of the statements that formed these factors and the loadings from a rotated factor matrix. Factor 1 addressed a negative aspect of repercussion and feedback after accidents. Higher mean scores represented the participants’ evaluation of a more reactive style of responding to accidents characterised by a tendency to apportion blame to those who were directly involved in the accidents rather than investigating systemic issues. On the other hand, Factor 2 addressed a positive aspect of repercussion and feedback after accidents. Higher mean scores represented participants’ evaluation of a more constructive approach to dealing with accidents demonstrated by the management and in the organisation’s safety management system.
Safety-Critical Group

As with the combined sample above, this analysis of the safety-critical group also identified Items 46, 47 and 52 with low communalities. They were eliminated, leaving eight statements for the final analysis. As can be seen in Table 4.17, factor analysis identified the same two factors as the previous analysis on the combined sample. The item configurations were identical to those of the combined sample with slight differences in the factor loading.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>51. After an accident, the focus is on the employee, and they are often disciplined and/or ostracised.</td>
<td>.780</td>
<td>.784</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48. Management goes ballistic when they hear of an accident - &quot;What does this do to our statistics?&quot;</td>
<td>.703</td>
<td>.699</td>
<td></td>
<td></td>
</tr>
<tr>
<td>53. Line management is annoyed by &quot;stupid&quot; accidents.</td>
<td>.640</td>
<td>.619</td>
<td></td>
<td></td>
</tr>
<tr>
<td>55. Warning letters are sent by management to individuals who were involved in accidents.</td>
<td>.519</td>
<td>.564</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50. Top or senior management are involved directly after an accident.</td>
<td>.699</td>
<td>.681</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56. After an accident, top or senior management show personal interest in individuals and the investigation process.</td>
<td>.627</td>
<td>.614</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49. Accident investigation focuses on all causes and</td>
<td>.576</td>
<td>.548</td>
<td></td>
<td></td>
</tr>
<tr>
<td>54. The results of accident investigation are fed back to the supervisory level.</td>
<td>.545</td>
<td>.549</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Factor Analyses 17 & 18 – Section B7 Audits and Reviews

Participants

Detailed profiles of the participants are shown in Appendix 7.
**Combined Sample (N = 315)**

Nine multivariate outliers were excluded. Two hundred and seventy-seven participants (87.9%) indicated they were working in a safety-critical area, while 36 participants (11.4%) responded they were in a non-safety-critical area at the time of the survey administration. Two people did not answer (.6%).

**Safety-Critical Group (N = 277)**

Nine multivariate outliers were excluded. This sample consisted of 261 males (94.2%) and 14 females (5.1%). Two people did not identify their gender (0.7%).

**Results**

**Combined Sample**

Section B7 had a total of 11 statements pertaining to the participants’ perception of their organisation’s approach to HSE audits and reviews. Three statements were eliminated due to low communalities. They were Item 57 [*Management and supervisors realise they are biased and welcome outside help with internal audits.*], Item 64 [*There is continuous informal search for non-obvious problems with outside help when needed.*] and Item 67 [*Regulatory audits are accepted as inescapable, especially after serious or fatal accidents.*]. This left a total of eight statements for the final analysis.

Factor analysis identified one factor, which addressed *Proactive Approach to HSE Audits and Reviews*. Table 4.18 shows the composition of the statements that formed this factor and the loadings from a factor matrix. Higher mean scores represented the participants’ evaluation of a more proactive approach to HSE audits and reviews.

**Safety-Critical Group**

As with the combined sample above, this analysis of the safety-critical group also identified Items 57, 64 and 67 with low communalities. They were eliminated, leaving eight statements for the final analysis. As can be seen in Table 4.18, factor analysis identified the same factor as the previous analysis on the combined sample. The item configurations were identical to those of the combined sample with slight differences in the factor loadings.
Table 4.18  
Section B7 – Statements Comprising the Factor and Loadings for the Combined Sample and the Safety-Critical Group

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Matrix&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Section B7 (Items 58 – 63, Items 65 &amp; 66) 8 items</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proactive Approach to HSE Audits &amp; Reviews</td>
<td>62.</td>
<td>Internal audits are unstructured, and only take place after major accidents. (R)</td>
<td>.815</td>
<td>.794</td>
</tr>
<tr>
<td></td>
<td>61.</td>
<td>There is no schedule for internal audits and reviews as they are seen as a punishment. (R)</td>
<td>.780</td>
<td>.757</td>
</tr>
<tr>
<td></td>
<td>60.</td>
<td>Internal audits mainly deal with financial matters. (R)</td>
<td>.742</td>
<td>.707</td>
</tr>
<tr>
<td></td>
<td>65.</td>
<td>There is a full internal audit system running smoothly with good follow up.</td>
<td>.707</td>
<td>.687</td>
</tr>
<tr>
<td></td>
<td>66.</td>
<td>There is an extensive internal audit program including cross-auditing within the organisation.</td>
<td>.664</td>
<td>.631</td>
</tr>
<tr>
<td></td>
<td>63.</td>
<td>There are more internal audits of behaviour (e.g. compliance) than there are of infrastructure, rolling stock, equipment and systems. (R)</td>
<td>.634</td>
<td>.614</td>
</tr>
<tr>
<td></td>
<td>59.</td>
<td>Internal audits are structured in terms of safety management systems.</td>
<td>.578</td>
<td>.525</td>
</tr>
<tr>
<td></td>
<td>58.</td>
<td>My employer is happy to audit others, but being audited is less welcome. (R)</td>
<td>.570</td>
<td>.561</td>
</tr>
</tbody>
</table>

(R) denotes reverse-scored items.  
Extraction Method: Principal Axis Factoring.  
a. 1 factor extracted. 5 iterations required.

4.3.2 Global Safety Culture Factors

The Principal Axis Factoring (PAF) method was used for factor extraction on across Section B1 through to B7 (total of 67 safety culture items) to identify factors with Eigenvalues exceeding 1.0. The following two analyses were aimed at evaluating whether any global factors could be identified across the theoretically created seven categories, as outlined above. Because the large number of items generated many multiple loadings, a stringent criterion of 0.6 was applied for determining low communalities. It was inevitable to set the uncommonly high value of .6 for identifying the communalities rather than the conventional value of 0.3 (e.g. Allen & Bennett, 2008; Tabachnick & Fidell, 2007) to streamline the factor
structure. The initial factor structure without this procedure was found highly scattered across a multitude of factors with no sizable Eigenvalues, and contained many items with multiple loadings.

As in the previous PAF using theoretically generated Section B items, varimax rotation was initially carried out. Where it revealed no clear factor structure, further analysis was performed using an oblique rotation (direct oblimin) to generate a more interpretable solution, with factor loadings above 0.3. Where multiple factors had loadings above 0.3 and the difference between the loadings were less than 1.0, they were regarded as complex variables and thus disregarded (1994). This process revealed a total of three factors for both the combined sample and the safety-critical group. The factor structure was almost identical between the two groups except for some minor difference in factor loadings.

Table 4.19 presents a summary of the factors identified in the factor analysis for both groups. It also features the internal reliability Cronbach's alpha value for each factor, alongside with the variance in questionnaire items that were used for factor analysis.

Table 4.19
_Global Factors Identified through Factor Analysis (PAF) – 67 Items reduced to 13 Items_

<table>
<thead>
<tr>
<th>Sections and Factors (No. of Items)</th>
<th>Combined Sample</th>
<th>Safety-Critical Workers Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cronbach’s α</td>
<td>% of Variance</td>
</tr>
<tr>
<td>Global Factor 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discrepant Commitment to Safety by</td>
<td>.84</td>
<td>21.66</td>
</tr>
<tr>
<td>Team Members &amp; Line Management (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global Factor 2</td>
<td>.85</td>
<td>16.66</td>
</tr>
<tr>
<td>Negative Views on Internal Audits &amp;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviews (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global Factor 3</td>
<td>.76</td>
<td>14.59</td>
</tr>
<tr>
<td>Management Commitment to Safety (4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the following section, detailed results of the factor analysis will be discussed for both the combined and safety-critical groups.
Factor Analyses 19 & 20 – Global Factors (Sections B1 to B7)

Participants

Detailed profiles of the participants are shown in Appendix 7.

Combined Sample ($N = 231$)

Twenty multivariate outliers were excluded. Two hundred and one participants (87.0%) indicated they were working in a safety-critical area, while 29 participants (12.6%) responded they were in a non-safety-critical area at the time of the survey administration. One person did not answer (.4%).

Safety-Critical Group ($N = 201$)

Twenty multivariate outliers were excluded. This sample consisted of 190 males (94.5%) and nine females (4.5%). Two people did not identify the gender (1.0%).

Results

Combined Sample

Sections B1 to B7 had 67 statements pertaining to the participants’ perception of their organisation’s safety culture in various aspects. Forty-nine statements were eliminated either due to low communalities or KMO values. Factor analysis based on the remaining 18 items identified three factors, which consisted of 1) Discrepant Commitment to Safety by Team Members and Line Management; 2) Negative Views on Internal Audits & Reviews; and 3) Management Commitment to Safety. Five additional statements were eliminated due to multiple factor loadings, leaving a total of 13 statements comprising the three factors.

Factors 1 and 2 addressed negative aspects of safety culture. In response to the statements for these factors, higher scores represented the participants’ evaluation of a lesser extent of preparedness in dealing with safety measures in the organisation. Factor 3, on the other hand, addressed a positive aspect of safety culture. Higher mean scores in response to the statements represented the participants’ evaluation of a greater extent of management’s commitment to safety in their organisation. The composition of the statements is outlined in Table 4.20.
In total, this factor accounted for around 53% of the variance in the relevant section of the questionnaire.

*Safety-Critical Group*

As with the combined sample above, this analysis of the safety-critical group also identified 49 items with low communalities or KMO values. They were eliminated from the final analysis. As can be seen in Table 4.20, factor analysis based on the remaining 18 items identified the same three factors as the previous analysis on the combined sample. Five additional statements were eliminated due to multiple factor loadings, leaving a total of 13 statements comprising the three factors. The item configurations for the factors were identical to those of the combined sample with slight differences in the factor loadings.
Table 4.20
Global Factors for Section B – Statements Comprising the Factors and Loadings for the Combined Sample and the Safety-Critical Group

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Combined Sample (N = 231) Factor Loadings</th>
<th>Safety-Critical Grp (N = 201) Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Discrepant Commitment to Safety by Team Members &amp; Line Management</td>
<td>4.</td>
<td>People know how to pay lip service to safety, but practical factors may prevent complete application.</td>
<td>.794</td>
<td>.802</td>
</tr>
<tr>
<td></td>
<td>37.</td>
<td>The overall effect of HSE procedures is NOT necessarily properly considered in detail.</td>
<td>.648</td>
<td>-.377</td>
</tr>
<tr>
<td></td>
<td>16.</td>
<td>Line managers know how to say the right things, but do not always walk their own talk.</td>
<td>.643</td>
<td>.302</td>
</tr>
<tr>
<td></td>
<td>36.</td>
<td>HSE procedures are occasionally seen as inconvenient by competent employees.</td>
<td>.593</td>
<td>.636</td>
</tr>
<tr>
<td></td>
<td>1.</td>
<td>The feeling of pride in Health Safety &amp; Environment (HSE) and care for colleagues is NOT shared by everyone.</td>
<td>.575</td>
<td>.585</td>
</tr>
<tr>
<td></td>
<td>5.</td>
<td>Commitment to HSE and care for colleagues diminishes after a period of good safety performance.</td>
<td>.525</td>
<td>.497</td>
</tr>
<tr>
<td>2. Negative Views on Internal Audits &amp; Reviews</td>
<td>62.</td>
<td>Internal audits are unstructured, and only take place after major accidents.</td>
<td>.768</td>
<td>.745</td>
</tr>
<tr>
<td></td>
<td>61.</td>
<td>There is no schedule for internal audits and reviews as they are seen as a punishment.</td>
<td>.755</td>
<td>.719</td>
</tr>
<tr>
<td></td>
<td>60.</td>
<td>Internal audits mainly deal with financial matters.</td>
<td>.712</td>
<td>-.320</td>
</tr>
<tr>
<td></td>
<td>10.</td>
<td>Management believes that HSE saves money in the long term.</td>
<td>-.307</td>
<td>.521</td>
</tr>
<tr>
<td>3. Management Commitment to Safety</td>
<td>13.</td>
<td>My employer tries to make HSE the top priority, understanding that HSE contributes to financial return.</td>
<td>.599</td>
<td>.587</td>
</tr>
<tr>
<td></td>
<td>56.</td>
<td>After an accident, top or senior management show personal interest in individuals and the investigation process.</td>
<td>-.307</td>
<td>.521</td>
</tr>
<tr>
<td></td>
<td>27.</td>
<td>Leadership fully acknowledges the importance of assessment of on-the-job skills.</td>
<td>-.329</td>
<td>.501</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.
Construction of Factor Variables

As can be seen in the previous series of PAF analyses, the factor structure was similar between the combined sample and the safety-critical group for each section. Nevertheless, in case the non-safety-critical workers’ data could potentially bring in “noise”, it was decided that factor variables be constructed based on the PAF analysis results from the safety-critical workers group. This was done to ensure that safety-critical workers are represented accurately for the following between-group analyses and prediction analyses pertaining to safety outcomes. A composite of the questionnaire items identified as forming each factor was created through computing their mean scores.

The factor loadings and inter-item reliability (with the exception of Section Negative Views on HSE Procedures) indicated soundness of the factor structure. Use of those factors for a series of further analysis to predict safety outcomes was, therefore, validated.

Summary

This chapter described the process of Principal Axis Factoring analyses for: 1) Section A, consisting of 48 safety climate/culture items generated from retrospective analysis of accident investigation reports based on GEMS framework; and 2) Section B, consisting of 67 safety culture items adapted from Shell’s safety culture maturity model, which was created based on a prospective approach. Section A1) Work Environment yielded five factors, while Section A2) Potential/Actual Safety Problems yielded two factors. Two sets of analyses were conducted for Section B. When the items were separated into seven theory-based dimensions, nine factors were identified. On the other hand, when factor analysis was conducted on all the 67 items regardless of the theoretical dimensions, three global factors were identified. Comparisons were made regarding the factor structure between 1) the combined sample (consisting of safety-critical and non-safety-critical groups) and 2) the safety-critical group. Similar factor structures emerged with slight differences in the composites of the questionnaire items. It was decided to construct the factors using the items identified on the safety-
critical group to ensure that their evaluation of safety climate/culture would be represented as closely as possible in further statistical analyses.

The next chapter outlines the results of between-group comparisons for each rail organisation which participated in the current study. Each section represents excerpts from confidential reports provided to the organisations.
CHAPTER 5
Examination of Group Differences

This chapter consists of excerpts from confidential reports which were provided to each of the six rail organisations who participated in the survey as outlined in Chapter 3. Two representative organisations are presented here. Due to the confidential nature of the reports, these organisations are called Organisation A and B, respectively in the current chapter.

Select samples were matched based on the participants’ occupational characteristics, particularly in terms of the occupational group and the level of seniority. Group differences were evaluated in terms of the participants’ evaluation of the safety climate and safety culture factors, which were identified in the factor analyses as outlined in the previous chapter.

The reports first highlight areas in which significant differences were found between groups, followed by a summary of all findings. Detailed findings are presented in the latter half of each report.

In Sections A1 and A2, the results reflect the participants’ evaluation of the situation at their respective workplace during a two-year period preceding the survey administration. In Sections A3, B and C, the results reflect their evaluation at the time of the survey’s administration.

The following sections are abbreviated as they are covered in the main chapter of the current thesis:
- Preface
- Acknowledgements
- Introduction
- Method
- Questionnaire Structure
- Responses
- Safety Perception and Culture Factors

Detailed profiles of the samples were presented in an appendix in the actual reports. However, they are not included in the current thesis due to space constraints.
## Key Findings Snap Shot

<table>
<thead>
<tr>
<th>Organisation A</th>
<th>Organisation B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample Size</strong></td>
<td><strong>Sample Size</strong></td>
</tr>
<tr>
<td>• Org A Non-Frontline Staff (n = 29)</td>
<td>• Org B Non-Frontline Staff (n = 18)</td>
</tr>
<tr>
<td>• Org A Train Controllers (n = 29)</td>
<td>• Org B Operations Staff (n = 100)</td>
</tr>
<tr>
<td>• Org A Maintenance Staff (n = 25)</td>
<td>• Org B Maintenance Staff (n = 44)</td>
</tr>
<tr>
<td>• Non-Org A Maintenance Staff (n = 25)</td>
<td>• Non-Org B Maintenance Staff (n = 39)</td>
</tr>
<tr>
<td><strong>Comparison within Org A</strong></td>
<td><strong>Comparison within Org B</strong></td>
</tr>
<tr>
<td><strong>Section A</strong></td>
<td><strong>Section A</strong></td>
</tr>
<tr>
<td>❖ Compared with Non-Frontline Staff, <strong>Train Controllers</strong> observed:</td>
<td>❖ Compared with Non-Frontline Staff, <strong>Operations Staff</strong> observed:</td>
</tr>
<tr>
<td>- significantly more Roster and Time Pressure and Supervision in safety-critical areas at their respective workplace; and</td>
<td>- observed significantly more Negative Workplace Culture and Roster and Time Pressure in safety-critical areas at their workplace;</td>
</tr>
<tr>
<td>- External Factors significantly more frequently as contributing to potential or actual safety problems.</td>
<td>- thought that Support for Fatigue Management was provided significantly less frequently to safety-critical workers by their employer; and</td>
</tr>
<tr>
<td>❖ Compared with <strong>Train Controllers</strong>, <strong>Maintenance Staff</strong> observed:</td>
<td>- thought to a significantly lesser degree that their employer had adequate safety measures overall.</td>
</tr>
<tr>
<td>- significantly more Negative Workplace Culture and Lack of Supervision in safety-critical areas at their respective workplace; and</td>
<td>❖ Compared with <strong>Maintenance Staff</strong>, <strong>Operations Staff</strong> observed:</td>
</tr>
<tr>
<td>- External Factors significantly less frequently as contributing to potential or actual safety problems.</td>
<td>- significantly more Roster and Time Pressure in safety-critical areas at their workplace; and</td>
</tr>
<tr>
<td>❖ Compared with Non-Frontline Staff, <strong>Maintenance Staff</strong> thought:</td>
<td>- External Factors significantly more frequently as contributing to potential or actual safety problems.</td>
</tr>
<tr>
<td>- thought to a significantly lesser degree that their employer had adequate safety measures overall.</td>
<td>❖ Compared with <strong>Non-Frontline Staff</strong>, <strong>Operations Staff</strong> thought:</td>
</tr>
<tr>
<td><strong>Section B</strong></td>
<td><strong>Section B</strong></td>
</tr>
<tr>
<td>❖ Compared with <strong>Train Controllers</strong>, <strong>Maintenance Staff</strong> thought:</td>
<td>❖ Compared with <strong>Non-Frontline Staff</strong>, <strong>Maintenance Staff</strong> thought:</td>
</tr>
<tr>
<td>- to a significantly lesser degree that their organisation had achieved balance between Health, Safety and Environment and profitability.</td>
<td>- to a significantly lesser extent that their organisation had achieved balance between Health, Safety and Environment procedures and efficiency.</td>
</tr>
<tr>
<td>- that their organisation was significantly more reactive rather than proactive in its response to accidents.</td>
<td>- to a significantly lesser extent that their organisation demonstrated a proactive approach to HSE audits and reviews.</td>
</tr>
<tr>
<td>❖ Compared with Non-Frontline Staff, <strong>Maintenance Staff</strong> thought:</td>
<td>❖ Compared with <strong>Non-Frontline Staff</strong>, <strong>Operations Staff</strong> thought:</td>
</tr>
<tr>
<td>- observed significantly more Negative Workplace Culture and Roster and Time Pressure in safety-critical areas at their workplace;</td>
<td>- to a significantly lesser degree that their organisation had achieved balance between Health, Safety and Environment and profitability.</td>
</tr>
<tr>
<td>- thought that Support for Fatigue Management was provided significantly less frequently to safety-critical workers by their employer; and</td>
<td>❖ Compared with <strong>Non-Frontline Staff</strong>, <strong>Maintenance Staff</strong> thought:</td>
</tr>
<tr>
<td>- thought to a significantly lesser degree that their employer had adequate safety measures overall.</td>
<td>- to a significantly lesser extent that their organisation had achieved balance between Health, Safety and Environment procedures and efficiency.</td>
</tr>
<tr>
<td><strong>Inter-Organisation Comparison</strong></td>
<td><strong>Inter-Organisation Comparison</strong></td>
</tr>
<tr>
<td><strong>Section A</strong></td>
<td><strong>Section B</strong></td>
</tr>
<tr>
<td>❖ Compared with Non-Org A Maintenance Staff, <strong>Org A Maintenance Staff</strong> thought:</td>
<td>❖ Compared with Non-Org B Maintenance Staff, <strong>Org B Maintenance Staff</strong> thought:</td>
</tr>
<tr>
<td>- to a significantly lesser degree that their organisation had achieved balance between Health, Safety and Environment and profitability.</td>
<td>- to a significantly lesser degree that their organisation had effective safety controls.</td>
</tr>
<tr>
<td>- that their organisation was significantly more reactive rather than proactive in its response to accidents.</td>
<td></td>
</tr>
</tbody>
</table>
5.1 Organisation A

Report to Organisation A

Murdoch University/PATREC

Rail Safety Perception and Culture Study 2006-2009

“Results of the Rail Safety Perception & Culture Employee Questionnaire”

October 2009
Izumi Hart
PhD Candidate
School of Psychology
Murdoch
University/PATREC
Executive Summary

Terminology

Please note that throughout this report Organisation A is abbreviated as “Org A”, while a combined sample of the other rail operators that participated in this study is called the “Non-Org A Combined Sample”. They will be referred to as the “Non-Org A” in tables and figures.

Occupational Profiles

The Org A participants (N = 96 after data screening) showed the following profiles. Nearly one third of the Org A participants consisted of Train Controllers (n = 29, 30.2%), followed by Maintenance Staff (n = 25, 26.0%). The remainders consisted of Management (n = 9, 9.4%), Construction (n = 8, 8.3%), Operations with multiple roles (n = 5, 5.2%), Admin, Finance or HR (n = 3, 3.1%), Engineering Design (n = 3, 3.1%), HSE or OHS Department Staff (n = 3, 3.1%), New Project Development (n = 1, 1.0%), Technical Training (n = 1, 1.0%), and Other (n = 9, 9.4%).

On the other hand, the participants from the Non-Org A Combined Sample (N = 230 after data screening) largely consisted of Drivers (n = 89, 38.7%) and Maintenance Staff (n = 58, 25.2%). The remainders consisted of Management (n = 21, 9.1%), Admin, Finance or HR (n = 7, 3.0%), Customer Service Staff (n = 20, 8.7%), Shunters (n = 8, 3.5%), Train Controllers (n = 5, 2.2%), HSE or OHS Department Staff (n = 4, 1.7%), Technical Training (n = 3, 1.3%), Operations with multiple roles (n = 3, 1.3%), Engineering Design (n = 2, 0.9%), Sales & Marketing (n = 1, 0.4%), and Other (n = 9, 3.9%).

Due to the diverse occupational profiles covered by the Org A and the Non-Org A groups, a set of criteria was applied for selecting cases to facilitate statistical analyses between various groups.

Statistical Analysis

This report outlines the results of statistical analysis conducted to examine whether the participants’ ratings of the factors differed among the following groups. Two different methods of statistical analysis were used for group comparisons (see p. 21 for details).

a) Descriptive Statistics:

The mean scores of the following four groups were analysed:

1) Org A Non-Frontline Staff;
2) Org A Train Controllers;
3) Org A Maintenance Staff; and
4) Non-Org A Maintenance Staff.

The Org A sample was classified into the three separate groups above based on their area of responsibility. The fourth group consisted of a selection of maintenance staff from the other rail operators. The mean scores, median and the range of scores were computed for the factors and questionnaire items across the four groups for general reference. They are presented in the detailed findings in text and boxplots in the latter part of the current report.

b) Inferential Statistics:

Comparisons within Org A
Inferential statistics were used to investigate whether any significant difference could be found among the three groups within Org A. Where the result was significant, further statistical analysis was conducted in order to identify where the difference was located.

**Comparison between Org A Maintenance and Non-Org A Maintenance Staff**

The Maintenance Staff was the second largest occupational group within Org A (n = 25, 26%). As the Non-Org A Combined Sample contained 58 participants in this category, cases were selected based on strict criteria to form a matched sample with the Org A Maintenance Staff for group comparisons. Analyses were conducted to identify differences of statistical significance between the two groups.

On the other hand, Org A’s largest occupational group Train Controllers (n = 29, 30%) had only a handful of equivalent participants in the Non-Org A Combined Sample, rendering statistical comparisons with the Non-Org A untenable. Non-Org A Combined Sample’s the largest occupational group was Drivers (n = 89, 39%). As no equivalent was found in the Org A sample, this occupational group was excluded from analyses for this report.

**Sections A1 to A3 – Safety Perception**

Statistically significant, and thus meaningful, differences were found in the following areas which implied that:

Org A Train Controllers observed *Supervision* in safety-critical areas more frequently than (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff did at their respective workplace. However, they observed more *Roster and Time Pressure* in safety-critical areas than Org A Non-Frontline Staff did. They thought that *External Factors* were more frequently observed as contributing to potential or actual safety problems than (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff did.

Org A Maintenance Staff observed *Negative Workplace Culture* more frequently than (a) Org A Train Controllers; and (b) Non-Org A Maintenance Staff did at their respective workplace. They observed more *Roster and Time Pressure* in safety-critical areas than Non-Org A Maintenance Staff did at their respective workplace. They also thought their employer provided safety-critical workers with *Support for Fatigue Management* less frequently than Non-Org A Maintenance Staff thought about their respective employers.

Furthermore, Org A Maintenance Staff thought that *Organisational Latent Problems* were more frequently observed as contributing to potential or actual safety problems than Non-Org A Maintenance Staff thought about their respective workplace. They also thought that their *Employer’s Overall Safety Measures* were less adequate than (a) Org A Non-Frontline Staff; and (b) Non-Org A Maintenance Staff thought of their respective employers.

The following is a summary of the overall findings for Sections A1 to A3. Factors in which any statistically significant difference was found are denoted with an asterisk (*):

In Section A1 Factor 1, Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff thought *Negative Workplace Culture* was “Very Rarely” observed in safety-critical areas in their workplace. On the other hand, Org A Maintenance Staff rated it between “Quite Rarely” and “Sometimes”.
In Section A1 Factor 2, Org A Non-Frontline Staff and Non-Org A Maintenance Staff thought *Roster and Time Pressure* was “Quite Rarely” observed in safety-critical areas at their workplace. The ratings by Org A Train Controllers ranged between “Sometimes” to “Quite Often”. Ratings by Org A Maintenance Staff ranged from “Very Rarely” to “Sometimes”.

In Section A1 Factor 3, all Org A groups generally thought *Support for Fatigue Management* was “Quite Rarely” provided to safety-critical workers at their workplace. The ratings by Non-Org A Maintenance Staff were predominantly “Sometimes”.

In Section A1 Factor 4, Org A Train Controllers thought *Lack of Supervision* was “Very Rarely” encountered in safety-critical areas at their workplace. The evaluation by Org A Non-Frontline Staff, Org A Maintenance Staff and Non-Org A Maintenance Staff was “Quite Rarely”.

In Section A1 Factor 5, generally all groups thought that *Workplace Stress* was “Sometimes” experienced by people in safety-critical areas at their workplace.

In Section A2 Factor 1, Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff thought that *Organisational Latent Problems* were “Quite Rarely” observed as contributing to potential or actual safety problems at their workplace. The ratings by Org A Maintenance Staff tended towards “Sometimes”.

In Section A2 Factor 2, Org A Train Controllers thought *External Factors* were “Sometimes” observed as contributing to potential or actual safety problems in safety-critical areas at their workplace. The other groups’ evaluation was “Quite Rarely”.

In Section A3 Question 1, Org A Maintenance Staff moderately “Agreed” that *their employer had adequate safety measures overall, while the other groups clearly “Agreed”.

In Section A3 Question 2, all groups generally “Agreed” that safety measures of the rail industry overall was adequate.

Section B – Safety Culture

Statistically significant, and thus meaningful, differences were found in the following areas which implied that:

Org A Maintenance Staff thought their organisation had achieved less balance between Health, Safety and Environment and profitability than (a) Org A Train Controllers; and (b) Non-Org A Maintenance Staff thought of their respective organisations. They also thought people in their organisation recognised the importance of competency and training to a lesser degree than Org A Non-Frontline Staff did. Additionally, Org A Maintenance Staff thought that their organisation was more reactive rather than proactive in its response to accidents than (a) Org A Train Controllers; and (b) Non-Org A Maintenance Staff thought of their respective organisations.

The following is a summary of the overall findings for Section B:

In Section B1, all groups more or less “Agreed” that people in their workplace were committed to Health, Safety and Environment and showed care for their colleagues.

In Section B2, Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff generally “Agreed” that their organisation had achieved *balance
between Health, Safety and Environment and profitability. On the other hand, the general evaluation of Org A Maintenance Staff was “Neither Agree nor Disagree”.

In Section B3, Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff more or less “Agreed” that people in their organisation *recognised the importance of competency and training. On the other hand, Org A Maintenance Staff’s general evaluation tended towards “Neither Agree nor Disagree”.

In Section B4, all groups generally “Agreed” that their organisation had effective safety controls.

In Section B5 Factor 1, all groups generally “Neither Agreed nor Disagreed” that their organisation had achieved *balance between Health, Safety and Environment procedures and efficiency. In Section B5 Factor 2, all groups generally “Neither Agreed nor Disagreed” that their organisation and employees had negative views on Health, Safety and Environment procedures.

In Section B6 Factor 1, Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff “Neither Agreed nor Disagreed” that their organisation was *reactive rather than proactive in its response to accidents, characterised by a tendency to blame those who were directly involved. Org A Maintenance Staff, on the other hand, more or less “Agreed”. In Section B6 Factor 2, all groups generally “Agreed” that their organisation’s management demonstrated a constructive response to accidents.

In Section B7, all groups more or less “Agreed” that their organisation demonstrated a proactive approach to HSE audits and reviews.

**Section C – Who Drives Safety?**

Statistically significant, and thus meaningful, differences were found in the following areas which implied that:

Org A Train Controllers evaluated the role of the Rail Safety Regulators and Safety-Critical Workers in driving safety in the workplace more highly than (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff did. They also evaluated the role of the Legislation in driving safety in the workplace more highly than Org A Maintenance Staff did.

The following is a summary of the overall findings for Section C:

The pattern of the evaluation was generally similar among the four groups. They agreed that Legislation, Management, They Themselves, Rail Safety Regulators, HSE/OSH Department, and Safety-Critical Workers each played an important role in driving safety at their workplace.

They recognised the role of the Board of Directors, Customers/Passengers, Public Opinion, and Trade Unions to a lesser degree ranging from “Neither Agree nor Disagree” to more or less “Agree”.
**Summary Conclusion:**

The responses of the Org A participants indicate relatively high ratings of safety measures and culture overall. The employees appear to acknowledge the organisation’s commitment to safety as manifested in its safety management system and safety culture. However, as summarised above, the participants’ evaluation differed significantly among the occupational groups in a wide range of areas within the Org A. Similar trends were seen, although to a lesser degree, in matched group comparisons between Org A Maintenance Staff and Non-Org A Maintenance Staff.

Nearly one out of four participants ($n = 24, 24\%$) provided feedback regarding specific areas of safety concern or general comments. They were grouped into the following seven categories: 1) Workplace Safety Culture; 2) Management; 3) Training; 4) Work Environment, Operational Arrangements and Procedures; 5) Roster and Fatigue Management; 6) Rail Industry; and 7) Other Feedback. It is informative to reflect on their qualitative contributions within these categories, which complements the findings of the quantitative analyses of this report. (While this section provides valuable insight, it is not included in the current thesis due to space constraints.)
Safety Perception & Culture Factors

Factor Analysis  Abbreviated.
When varimax rotation revealed no clear factor structure, further analysis was performed using an oblique rotation (direct oblimin) to generate a more interpretable solution, with factor loadings above 0.3. This process revealed a total of 16* factors as outlined in Table 5.1.

Table 5.1
Factors and Questionnaire Items for Group Comparisons

<table>
<thead>
<tr>
<th>Section</th>
<th>Factor</th>
<th>No. of items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section A1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work Environment</td>
<td>1. Negative Workplace Culture</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2. Roster &amp; Time Pressure</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3. Support for Fatigue Management**</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4. Lack of Supervision</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>5. Workplace Stress</td>
<td>3</td>
</tr>
<tr>
<td><strong>Section A2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential/Actual Safety Problems</td>
<td>1. Organisational Latent Problems</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>2. External Factors</td>
<td>3</td>
</tr>
<tr>
<td><strong>Section A3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluation of Overall Safety Measures</td>
<td>1. My Employer**</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2. The Rail Industry in General**</td>
<td>1</td>
</tr>
<tr>
<td><strong>Section B1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commitment Level of Workforce to HSE &amp; Care for Colleagues</td>
<td>1. High Workforce Commitment to HSE &amp; Care for Colleagues</td>
<td>6</td>
</tr>
<tr>
<td><strong>Section B2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance between HSE &amp; Profitability</td>
<td>1. Balance Achieved between HSE &amp; Profitability</td>
<td>7</td>
</tr>
<tr>
<td><strong>Section B3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workforce Interest in Competency &amp; Training</td>
<td>1. Importance of Competency and Training Recognised</td>
<td>7</td>
</tr>
<tr>
<td><strong>Section B4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work-site Safety Controls</td>
<td>1. Effective Safety Controls</td>
<td>6</td>
</tr>
<tr>
<td><strong>Section B5</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purpose of HSE Procedures</td>
<td>1. Balance between HSE Procedures &amp; Efficiency</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2. Negative Views on HSE Procedures**</td>
<td>3</td>
</tr>
<tr>
<td><strong>Section B6</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repercussion &amp; Feedback after Accidents?</td>
<td>1. Reactivity – Blame Culture**</td>
<td>4</td>
</tr>
<tr>
<td><strong>Section B7</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audits &amp; Reviews</td>
<td>1. Proactive Approach to HSE Audits &amp; Reviews</td>
<td>5</td>
</tr>
<tr>
<td><strong>Section C</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Who drives safety?</td>
<td>1. – 10. Drivers behind Safety</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td><strong>96</strong></td>
</tr>
</tbody>
</table>

* Factors in Section A3 (2 items) and Section C (10 items) were created on a theoretical basis, not through factor analysis.

**Section A features predominantly negative aspects of safety measures. Factors highlighted in pink indicate positive aspects within Section A. Conversely, Section B comprises mainly positive areas of safety culture. Factors highlighted in light blue indicate negative aspects within Section B. The colour-coding will be applied in the graphs in the results section.

The following colour codes will be used for clarity of the section structure throughout this report:
- **Section A**: Safety Perception (highlighted in blue)
- **Section B**: Safety Culture (highlighted in yellow)
- **Section C**: Main Drivers of Safety (highlighted in green)
Sample Selection

Criteria for Case Selection

As the patterns of the “Not Applicable” responses were different across the sections, different samples were selected for analyses per section. The dataset was categorised into the following four groups:

1) Org A Non-Frontline Staff;
2) Org A Train Controllers;
3) Org A Maintenance Staff; and
4) Non-Org A Maintenance Staff.

Statistical Analysis

Two different types of analysis were conducted based on the nature of the group configuration.

a) Descriptive Statistics:

The mean scores of factors and questionnaire items were computed across the three groups for general reference. The sample size breakdown of the four groups per section is presented in Table 5.2.

<table>
<thead>
<tr>
<th>Section</th>
<th>Non-Frontline Staff (n)</th>
<th>Train Controllers (n)</th>
<th>Maintenance Staff (n)</th>
<th>Non-Org A Maintenance Staff (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>24</td>
<td>24</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>A2</td>
<td>22</td>
<td>23</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>A3</td>
<td>28</td>
<td>29</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>B1</td>
<td>29</td>
<td>27</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>B2</td>
<td>28</td>
<td>28</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>B3</td>
<td>29</td>
<td>29</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>B4</td>
<td>28</td>
<td>28</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>B5</td>
<td>27</td>
<td>27</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>B6</td>
<td>29</td>
<td>29</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>B7</td>
<td>27</td>
<td>27</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>C</td>
<td>26</td>
<td>29</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>
b) Inferential Statistics:

Comparisons within Org A

Inferential statistics were used to investigate whether any difference of statistical significance could be found among the three Org A groups 1) Non-Frontline Staff; 2) Train Controllers; and 3) Maintenance Staff. Initially, Kruskal-Wallis ANOVA was conducted to identify any difference among the three groups. When the result was statistically significant, Mann-Whitney U Tests were conducted for each pair to identify where the difference occurred.

Comparison between Org A Maintenance and Non-Org A Maintenance Staff

Group comparisons between Org A and Non-Org A samples were carried out. While the Org A sample contained 29 Train Controllers, only a handful of Train Controllers were found in the Non-Org A Combined Sample. This made inferential comparisons of this occupational category impossible between the Org A and the Non-Org A Combined Samples.

On the other hand, it was possible to form comparable groups for the Maintenance category. As can be seen in Table 5.2, the Org A Maintenance Staff sample ranged from \( n = 19 \) to 25 across the sections. On the other hand, the Non-Org A Combined Sample contained more than twice as many Maintenance Staff members (\( n = 50 \) to 57). A comparable number of cases from the Non-Org A Combined Sample were selected to form a matched sample for statistical comparisons with the Org A Maintenance Staff sample. Every attempt was made to match the cases as close to each other as possible on the basis of whether they were in safety-critical roles, gender, age, occupational groups and job levels. Mann-Whitney U Tests were used for Org A Maintenance Staff vs. Non-Org A Maintenance Staff pair to examine whether any difference was found between the two groups.

Despite the large representation of Drivers in the Non-Org A Combined Sample, no equivalent was found in the Org A sample and was thus excluded from the analyses for this report.
Detailed Findings
Sections A1 to A3

Section A1 & A2 – Safety Perception

Both Section A1 and A2 were designed to assess the perception of safety in the participants’ workplace.

Section A1 Work Environment

Demographics:
Data obtained from the following three groups were analysed. They had the following employment and demographic characteristics.

- **Org A Non-Frontline Staff (n = 24):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 1), Engineering Design (n = 2), HSE or OHS (n = 3), Management (n = 7), New Project Development (n = 1), Technical Training (n = 1) and Others in non-frontline roles (n = 9). Seventeen participants described themselves as working in a safety-critical area (74%), and 19 were males (79%). The largest number was found in the 40-49 age group (n = 9, 38%), and at management level (n = 12, 50%).

- **Org A Train Controllers (n = 24):** All of the twenty-four participants described themselves as working in a safety-critical area, and were all males (100%). The highest proportion was found in the 40-49 age group (n = 11, 46%), and a majority were Team Members (n = 19, 79%).

- **Org A Maintenance Staff (n = 22):** Twenty-one participants described themselves as working in a safety-critical area (96%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 12, 55%). More than half of this sample consisted of Team Members (n = 11, 52%).

- **Non-Org A Maintenance Staff (n = 22):** Twenty-one participants described themselves as working in a safety-critical area (96%), and were all males (100%). The highest proportion was found in the 40-49 age group (n = 10, 46%). More than half of this sample consisted of Team Members (n = 14, 64%).

**Question:**
The participants were asked to select their level of agreement to a number of statements from a Likert scale. The question and response scale are presented below.

**Question: How frequently would people who work in safety-critical areas in your workplace have encountered the following situation in the last 24 months?**

<table>
<thead>
<tr>
<th>Not Applicable</th>
<th>Very rarely</th>
<th>Quite rarely</th>
<th>Sometimes</th>
<th>Quite often</th>
<th>Very frequently</th>
</tr>
</thead>
</table>
Statements:
Section A1 had a total of 28 statements pertaining to the participants’ perception of safety measures and culture in their place of work. The responses were put through factor analysis, which identified five factors with Eigenvalues exceeding 1. Eleven statements were eliminated either due to low (below 0.3) or multiple factor loadings, leaving a total of 17 statements for group comparisons. Each factor consists of a number of statements. For example, Factor 1. Negative Workplace Culture is a composite of three questions (statement numbers 25, 26, and 28). The statement numbers indicate their sequence as they appear in the questionnaire. The composition of the statements is outlined in Table 5.3.

Table 5.3
Section A1 – Statements Comprising the Factors and their Loadings

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Negative Workplace Culture</td>
<td>25.</td>
<td>They broke safeworking rules because they were overconfident.</td>
<td>.774</td>
</tr>
<tr>
<td></td>
<td>26.</td>
<td>They took shortcuts which could have potentially compromised safety because it had become standard practice - everyone does it all the time.</td>
<td>.727</td>
</tr>
<tr>
<td></td>
<td>28.</td>
<td>When they raised safety concerns and/or reported potential safety risks, these were ignored by line and/or top management.</td>
<td>.620</td>
</tr>
<tr>
<td></td>
<td>7.</td>
<td>They were put under pressure to report for duty despite feeling fatigued.</td>
<td>.775</td>
</tr>
<tr>
<td>2. Roster &amp; Time Pressure</td>
<td>8.</td>
<td>They needed to overextend themselves because of poor roster scheduling (e.g. working overtime).</td>
<td>.711</td>
</tr>
<tr>
<td></td>
<td>5.</td>
<td>They were allowed to be on a night shift after they had been awake for more than 14 hours prior to start of work.</td>
<td>.512</td>
</tr>
<tr>
<td></td>
<td>13.</td>
<td>They had roster flexibility which allowed them to cancel their shift at short notice due to medical conditions (e.g. chronic sleep disorders and cardiac conditions). (R)*</td>
<td>.436</td>
</tr>
<tr>
<td>3. Support for Fatigue Mgt</td>
<td>10.</td>
<td>They received support from the employer to make effective use of off-duty time to maximise restorative rest or sleep.</td>
<td>.826</td>
</tr>
<tr>
<td></td>
<td>11.</td>
<td>They received support from the employer to seek medical help for conditions that interfere with restorative rest or sleep.</td>
<td>.806</td>
</tr>
<tr>
<td></td>
<td>12.</td>
<td>They received support from the employer to seek professional help (e.g. counseling, therapy) to resolve domestic concerns that interfere with restorative rest or sleep.</td>
<td>.717</td>
</tr>
<tr>
<td></td>
<td>9.</td>
<td>They had been fully informed by the employer regarding risks posed by sleeping disorders, symptoms and available means of detecting and treating them.</td>
<td>.657</td>
</tr>
<tr>
<td>4. Lack of Supervision</td>
<td>22.</td>
<td>Non-safeworking personnel were allowed access to safeworking equipment.</td>
<td>.642</td>
</tr>
<tr>
<td></td>
<td>20.</td>
<td>They performed safety-critical tasks without authorisation.</td>
<td>.602</td>
</tr>
<tr>
<td>5. Workplace Stress</td>
<td>21.</td>
<td>They were allowed to perform duties without their performance being adequately monitored following unfavourable safety compliance history.</td>
<td>.532</td>
</tr>
<tr>
<td></td>
<td>3.</td>
<td>They were under pressure to perform duties beyond the limits of what could have been reasonably handled by one person.</td>
<td>.647</td>
</tr>
<tr>
<td></td>
<td>2.</td>
<td>They were in a work environment where they were easily distracted by other tasks or people while performing their job.</td>
<td>.613</td>
</tr>
<tr>
<td></td>
<td>1.</td>
<td>They rushed to complete tasks to stay on schedule or to a timetable.</td>
<td>.550</td>
</tr>
</tbody>
</table>

*n.b. (R) denotes reverse-scored items.
What the scores mean:
In response to the statements above, the scores reflected the participants’ evaluation of the situation at their respective workplace during a two-year period preceding the survey administration.

Factors 1, 2, 4 and 5 addressed negative aspects of the work environment. In response to the statements above, higher scores represented the participants’ evaluation of a greater extent of inadequacy of safety measures and/or a less healthy safety culture in the organisation. Factor 3, on the other hand, addressed a positive aspect of the work environment. Higher mean scores in response to the statements associated with Factor 3 represented the participants’ evaluation of a greater extent of support for fatigue management provided by the organisation.

Results:
The distribution of mean scores across the items comprising each factor is presented in Figure 5.1.

![Figure 5.1. Section A1 Work Environment – Distribution of factor-based mean scores by group](image-url)
The following results reflect the participants’ evaluation of the situation in safety-critical areas at their respective workplace during a two-year period preceding the survey administration.

**Factor 1. Negative Workplace Culture:**

*Descriptive Statistics:*
The mean scores were 1.87 for Org A Non-Frontline Staff, 1.69 for Org A Train Controllers, 2.48 for Org A Maintenance Staff, and 1.77 for Non-Org A Maintenance Staff. The shape of the score distribution was positively skewed for all the samples.

*Inferential Statistics:*

**Comparisons within Org A**
The mean scores across the three questions (25, 26 and 28) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (*Mean Rank* = 31.81, n = 24), Org A Train Controllers (*Mean Rank* = 29.00, n = 24) and Org A Maintenance Staff (*Mean Rank* = 46.61, n = 22). The results indicated a significant difference in the employees’ evaluation among the three groups, *H* (corrected for ties) = 10.023, *df* = 2, *N* = 70, Asymp. Sig. *p* = .007, Cohen’s *f* = .412.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney *U* tests were conducted to examine the difference between (a) Org A Non-Frontline Staff and Org A Train Controllers; (b) Org A Train Controllers and Org A Maintenance Staff; and (c) Org A Non-Frontline Staff and Org A Maintenance Staff.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Train Controllers (*Mean Rank* = 17.65, n = 24) versus Org A Maintenance Staff (*Mean Rank* = 29.89, n = 22), *U* = 123.50, *z* = -3.121, Asymp. Sig. *p* = .002, two-tailed.

**Comparison between Org A Maintenance and Non-Org A Maintenance Staff**
A further Mann-Whitney *U* test was used to compare the ranks for Org A Maintenance Staff (*Mean Rank* = 27.84, n = 22) versus Non-Org A Maintenance Staff (*Mean Rank* = 17.16, n = 22). The results revealed a significant difference in the employees’ evaluation between the two samples, *U* = 124.50, *z* = -2.78, Asymp. Sig. *p* = .006, two-tailed.

*Interpretation:*
Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff thought Negative Workplace Culture was “Very Rarely” observed in safety-critical areas. On the other hand, Org A Maintenance Staff rated it between “Quite Rarely” and “Sometimes”.

Mann-Whitney *U* tests indicated that Org A Maintenance Staff observed Negative Workplace Culture significantly more frequently than (a) Org A Train Controllers; and (b) Non-Org A Maintenance Staff did at their respective workplace.

**Factor 2. Roster & Time Pressure:**
Descriptive Statistics:
The mean scores were 1.94 for Org A Non-Frontline Staff, 3.23 for Org A Train Controllers, 2.52 for Org A Maintenance Staff, and 1.85 for Non-Org A Maintenance Staff.

Inferential Statistics:
Comparisons within Org A
The mean scores across the four questions (5, 7, 8 and 13) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (Mean Rank = 24.04, n = 24), Org A Train Controllers (Mean Rank = 46.38, n = 24) and Org A Maintenance Staff (Mean Rank = 34.52, n = 21). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 14.986, $df = 2$, $N = 69$, Asymp. Sig. $p = .001$, Cohen’s $f = .532$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Non-Frontline Staff (Mean Rank = 16.96, n = 24) versus Org A Train Controllers (Mean Rank = 32.04, n = 24), $U = 107.00$, $z = -3.745$, Asymp. Sig. $p = .000$, two-tailed.

Comparison between Org A Maintenance and Non-Org A Maintenance Staff
A further Mann-Whitney $U$ test was used to compare the ranks for Org A Maintenance Staff (Mean Rank = 25.24, n = 21) versus Non-Org A Maintenance Staff (Mean Rank = 17.16, n = 21). The results revealed a significant difference in the employees’ evaluation between the two samples, $U = 142.00$, $z = -1.99$, Asymp. Sig. $p = .047$, two-tailed.

Interpretation:
Org A Non-Frontline Staff and Non-Org A Maintenance Staff thought Roster and Time Pressure was “Quite Rarely” observed in safety-critical areas at their workplace. The ratings by Org A Train Controllers tended towards “Quite Often”. Ratings by Org A Maintenance Staff tended towards “Sometimes”.

Mann-Whitney $U$ tests indicated that:
(a) Org A Train Controllers observed significantly more Roster and Time Pressure in safety-critical areas than Org A Non-Frontline Staff at their respective workplace; and
(b) Org A Maintenance Staff observed significantly more Roster and Time Pressure in safety-critical areas than Non-Org A Maintenance Staff at their respective workplace.

Factor 3. Support for Fatigue Management:
Descriptive Statistics:
The mean scores were 2.50 for Org A Non-Frontline Staff, 2.05 for Org A Train Controllers, 1.96 for Org A Maintenance Staff, and 2.89 for Non-Org A Maintenance Staff.

Inferential Statistics:
Comparison between Org A Maintenance and Non-Org A Maintenance Staff
The mean scores across the four questions (9 through to 12) were rank-ordered and a Mann-Whitney \( U \) test was used to compare the ranks for Org A Maintenance Staff (Mean Rank = 16.26, \( n = 21 \)) versus Non-Org A Maintenance Staff (Mean Rank = 26.74, \( n = 21 \)). The results revealed a significant difference in the employees’ evaluation between the two samples, \( U = 110.50, z = -2.79 \), Asymp. Sig. \( p = .005 \), two-tailed.

**Interpretation:**

The three Org A groups generally thought that Support for Fatigue Management was “Quite Rarely” provided to safety-critical workers at their workplace. The ratings by Non-Org A Maintenance Staff were predominantly “Sometimes”.

A Mann-Whitney \( U \) test indicated that Org A Maintenance Staff thought safety-critical workers received Support for Fatigue Management significantly less frequently from their employer than Non-Org A Maintenance Staff counterpart thought they received from their respective employers.

**Factor 4. Lack of Supervision:**

A total of seven outliers were identified across the samples. Two from Org A Train Controllers sample were found to exceed +3 standard deviations above the mean scores and thus were removed. Others were retained as they were less than +3 standard deviations above the mean scores.

**Descriptive Statistics:**

The mean scores were 1.50 for Org A Non-Frontline Staff, 1.08 for Org A Train Controllers, 1.77 for Org A Maintenance Staff, and 1.40 for Non-Org A Maintenance Staff. The scores virtually converged on the score of 1 “Very Rarely” for Org A Train Controllers sample. The score distribution was positively skewed for the other three samples, with the peak at or slightly above the score of 1 “Very Rarely”.

**Inferential Statistics:**

**Comparisons within Org A**

The mean scores across the three questions (20, 21 and 22) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (Mean Rank = 34.69, \( n = 21 \)), Org A Train Controllers (Mean Rank = 21.82, \( n = 20 \)) and Org A Maintenance Staff (Mean Rank = 37.52, \( n = 21 \)). The results indicated a significant difference in the employees’ evaluation among the three groups, \( H \) (corrected for ties) = 10.690, \( df = 2 \), \( N = 62 \), Asymp. Sig. \( p = .005 \), Cohen’s \( f = .461 \).

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney \( U \) tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Non-Frontline Staff (Mean Rank = 25.48, \( n = 21 \)) and Org A Train Controllers (Mean Rank = 16.30, \( n = 20 \)), \( U = 116.00, z = -2.845 \), Asymp. Sig. \( p = .004 \), two-tailed.

A significant difference was also found in the employees’ evaluation between Org A Train Controllers (Mean Rank = 16.02, \( n = 20 \)) versus Org A Maintenance Staff (Mean Rank = 25.74, \( n = 21 \)), \( U = 110.00, z = -3.008 \), Asymp. Sig. \( p = .003 \), two-tailed.
**Interpretation:**
Org A Train Controllers thought *Lack of Supervision* was “Very Rarely” encountered in safety-critical areas at their workplace. The evaluation by Org A Non-Frontline Staff, Org A Maintenance Staff and Non-Org A Maintenance Staff was “Quite Rarely”.

Mann-Whitney *U* tests indicated that Org A Train Controllers observed *Supervision* in safety-critical areas significantly more frequently than (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff did at their respective workplace.

**Factor 5. Workplace Stress:**

*Descriptive Statistics:*
The mean scores were 2.60 for Org A Non-Frontline Staff, 3.10 for Org A Train Controllers, 2.95 for Org A Maintenance Staff, and 2.51 for Non-Org A Maintenance Staff.

*Interpretation:*
Generally all groups thought that *Workplace Stress* was “Sometimes” experienced by people in safety-critical areas at their workplace.
Section A2 Potential/Actual Safety Problems

Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org A Non-Frontline Staff (n = 22):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 3), Engineering Design (n = 2), HSE or OHS (n = 3), Management (n = 5), New Project Development (n = 1), Technical Training (n = 1) and Others in non-frontline roles (n = 7). Sixteen participants described themselves as working in a safety-critical area (76%), and 16 were males (73%). The largest number was found in the 40-49 age group (n = 9, 41%), and at management level (n = 10, 47%).

- **Org A Train Controllers (n = 23):** All of the twenty-three participants described themselves as working in a safety-critical area, and were all males (100%). The highest proportion was found in the 40-49 age group (n = 11, 48%), and a majority were Team Members (n = 18, 78%).

- **Org A Maintenance Staff (n = 21):** Twenty participants described themselves as working in a safety-critical area (95%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 12, 57%). More than half of this sample consisted of Team Members (n = 11, 55%).

- **Non-Org A Maintenance Staff (n = 21):** All of the twenty-one participants described themselves as working in a safety-critical area (100%), and were all males (100%). The highest proportion was found in the 40-49 age group (n = 11, 52%). More than half of this sample consisted of Team Members (n = 13, 62%).

**Question:**
The participants were asked to select their level of agreement from a 5-point Likert scale. The question and response scale are presented below.

<table>
<thead>
<tr>
<th>Not Applicable</th>
<th>Very rarely</th>
<th>Quite rarely</th>
<th>Sometimes</th>
<th>Quite often</th>
<th>Very frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Statements:**
Section A2 had a total of 20 statements pertaining to the participants’ perception of factors that contributed to potential or actual safety problems in their workplace. Factor analysis identified two factors with Eigenvalues exceeding 1. Three statements were eliminated either due to low (below 0.3) or multiple factor loadings, leaving a total of 17 statements for group comparisons.

The following factors were identified in factor analysis. The first factor addressed latent conditions (or problems) in the organisation that contributed to potential or actual safety problems. The second factor addressed contributing factors from external sources. Both factors in this section addressed negative aspects of the work environment from safety perspective. Each factor consists of a number of statements. For example, **Factor 2. External Factors** is a composite of three questions (statement numbers 45, 46 and 48). The statement numbers indicate their sequence as they appear in the questionnaire. The composition of the statements is outlined in Table 5.4.
Table 5.4
Section A2 – Statements Comprising the Factors and their Loadings

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Organisational Latent Conditions</td>
<td>29.</td>
<td>Because of lack of standardised approach to safety procedures.</td>
<td>.814</td>
</tr>
<tr>
<td></td>
<td>31.</td>
<td>Because procedures did not specify appropriate safeworking actions for certain safety-related tasks.</td>
<td>.809</td>
</tr>
<tr>
<td></td>
<td>30.</td>
<td>Because a change of operational/infrastructure circumstances had not been communicated to them.</td>
<td>.737</td>
</tr>
<tr>
<td></td>
<td>32.</td>
<td>Because they were unable to challenge decisions made by more experienced employees in the team.</td>
<td>.714</td>
</tr>
<tr>
<td></td>
<td>33.</td>
<td>Lack of communication from colleagues about potential safety risks (e.g. observed defect in track, equipment and rolling stock).</td>
<td>.705</td>
</tr>
<tr>
<td></td>
<td>40.</td>
<td>Lack of training in hazard identification before commencing any task.</td>
<td>.688</td>
</tr>
<tr>
<td></td>
<td>43.</td>
<td>Because of inadequate management of contractor safety.</td>
<td>.686</td>
</tr>
<tr>
<td></td>
<td>44.</td>
<td>Because of inadequate defenses against error or inadequate train protection.</td>
<td>.642</td>
</tr>
<tr>
<td></td>
<td>36.</td>
<td>Inadequate safety standards and procedures (including those for operations, signaling, loading, inspection, maintenance and management of dangerous goods).</td>
<td>.636</td>
</tr>
<tr>
<td></td>
<td>41.</td>
<td>Because the employer had been unable to stop unsafe work practice that had been around for a long time and had become a standard way of doing things – everyone does it all the time.</td>
<td>.625</td>
</tr>
<tr>
<td></td>
<td>39.</td>
<td>Lack of the employer's effort to ensure compliance with safety rules (including those for operations, signaling, loading, inspection &amp; maintenance).</td>
<td>.588</td>
</tr>
<tr>
<td></td>
<td>42.</td>
<td>Because procedure manuals and checklists were hard to understand or NOT available.</td>
<td>.576</td>
</tr>
<tr>
<td></td>
<td>38.</td>
<td>Because of inadequate housekeeping (e.g. cleaning of facilities/operating equipment, tidy working environment, recovery from vandalism and ensuring clear track/signal sightings).</td>
<td>.574</td>
</tr>
<tr>
<td></td>
<td>34.</td>
<td>Poor design of equipment/rolling stock which could have compromised safe working.</td>
<td>.509</td>
</tr>
<tr>
<td>2. External Factors</td>
<td>46.</td>
<td>Reckless behaviour of pedestrians and vehicle drivers (e.g. cars and trucks) at level crossings.</td>
<td>.752</td>
</tr>
<tr>
<td></td>
<td>45.</td>
<td>Unexpected intrusion across the track by people, animals and foreign objects.</td>
<td>.736</td>
</tr>
<tr>
<td></td>
<td>48.</td>
<td>Unforeseen weather and other environmental conditions (e.g. extreme heat, cold, and other inclement weather conditions).</td>
<td>.468</td>
</tr>
</tbody>
</table>

What the scores mean:
Higher scores represented a greater frequency with which the participants observed the contributing factors to potential or actual safety problems at their respective workplace during a two-year period preceding the survey administration.
Results:

The distribution of mean scores across the items comprising each factor is presented in Figure 5.2.

![Box plots showing distribution of mean scores across the items comprising each factor](image)

**Figure 5.2.** Section A2 Potential/Actual Safety Problems – Distribution of factor-based mean scores by group

The following results reflect the participants’ evaluation of the situation at their respective workplace during a two-year period preceding the survey administration.

**Factor 1. Organisational Latent Problems:**

*Descriptive Statistics:*
The mean scores were 1.97 for Org A Non-Frontline Staff, 1.93 for Org A Train Controllers, 2.29 for Org A Maintenance Staff, and 1.75 for Non-Org A Maintenance Staff.

*Inferential Statistics:*
Comparison between Org A Maintenance and Non-Org A Maintenance Staff
The mean scores across the fourteen questions (29 through to 34, 36, 38 through to 44) were rank-ordered and a Mann-Whitney U test was used to compare the ranks for Org A Maintenance Staff (*Mean Rank* = 25.95, *n* = 21) versus Non-Org A Maintenance Staff (*Mean Rank* = 17.05, *n* = 21). The results revealed a significant difference in the employees’ evaluation between the two samples, *U* = 127.00, *z* = -2.353, Asymp. Sig. *p* = .019, two-tailed.
Interpretation:
Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff thought that Organisational Latent Problems were “Quite Rarely” observed as contributing to potential or actual safety problems at their workplace. The ratings by Org A Maintenance Staff tended towards “Sometimes”.

A Mann-Whitney U test indicated that Org A Maintenance Staff thought that Organisational Latent Problems were significantly more frequently observed as contributing to potential or actual safety problems than Non-Org A counterpart thought about their respective workplace.

Factor 2. External Factors:

Descriptive Statistics:
The mean scores were 2.42 for Org A Non-Frontline Staff, 3.17 for Org A Train Controllers, 2.52 for Org A Maintenance Staff, and 2.15 for Non-Org A Maintenance Staff.

Inferential Statistics:
Comparisons within Org A
The mean scores across the three questions (45, 46 and 48) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (Mean Rank = 26.59, n = 22), Org A Train Controllers (Mean Rank = 44.61, n = 23) and Org A Maintenance Staff (Mean Rank = 28.57, n = 21). The results indicated a significant difference in the employees’ evaluation among the three groups, H (corrected for ties) = 12.105, df = 2, N = 66, Asymp. Sig. p = .002, Cohen’s f = .478.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney U tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Non-Frontline Staff (Mean Rank = 16.86, n = 22) versus Org A Train Controllers (Mean Rank = 28.87, n = 23), U = 118.00, z = -3.089, Asymp. Sig. p = .002, two-tailed.

A significant difference was also found in the employees’ evaluation between Org A Train Controllers (Mean Rank = 27.74, n = 23) and Org A Maintenance Staff (Mean Rank = 16.76, n = 21), U = 121.00, z = -2.859, Asymp. Sig. p = .004, two-tailed.

Interpretation:
Org A Train Controllers thought External Factors were “Sometimes” observed as contributing to potential or actual safety problems in safety-critical areas at their workplace. The other groups’ evaluation was “Quite Rarely”.

Mann-Whitney U tests indicated that Org A Train Controllers thought that External Factors were significantly more frequently observed as contributing to potential or actual safety problems than (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff.
Section A3 Evaluation of Overall Safety Measures

Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org A Non-Frontline Staff (n = 28):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 3), Engineering Design (n = 3), HSE or OHS (n = 2), Management (n = 9), New Project Development (n = 1), Technical Training (n = 1) and Others in non-frontline roles (n = 9). Nineteen participants described themselves as working in a safety-critical area (70%), and 22 were males (79%). The largest number was found in the 30-39 age group (n =11, 39%), and at management level (n =14, 50%).

- **Org A Train Controllers (n = 29):** Twenty-eight participants described themselves as working in a safety-critical area (97%), and were all males (100%). The highest proportion was found in the 40-49 age group (n =12, 41%), and a majority were Team Members (n =22, 76%).

- **Org A Maintenance Staff (n = 25):** Twenty-four participants out of 24 who responded to this item described themselves as working in a safety-critical area (100%). All of the 25 participants were males (100%). The highest proportion was found in the 40-49 age group (n =12, 48%). More than half of this sample consisted of Team Members (n =13, 54%).

- **Non-Org A Maintenance Staff (n = 25):** Twenty-five participants described themselves as working in a safety-critical area (100%), and were all males (100%). The highest proportion was found in the 40-49 age group (n =11, 44%). More than half of this sample consisted of Team Members (n =14, 56%).

Question:
The participants were asked to select their level of agreement from a 5-point Likert scale. The questions and response scale are presented below.

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Statements:**
The participants were presented with the following statements that asked their perception of the adequacy of safety measures in their workplace and in the rail industry in general (see Table 5.5).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item No.</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My Employer</td>
<td>49.</td>
<td>My employer has adequate safety measures overall.</td>
</tr>
<tr>
<td>2. Rail Industry in General</td>
<td>50.</td>
<td>The rail industry in general has adequate safety measures overall.</td>
</tr>
</tbody>
</table>
What the scores mean:
Higher scores represented higher evaluation of the adequacy of safety measures.

Results:
The distribution of the questionnaire item scores for the three groups is presented in Figure 5.3.

![Score distribution by group](image)

**Figure 5.3.** Section A3 Adequate Safety Measures Overall? – Score distribution by group

The following results reflect the participants’ evaluation at the time of the survey administration.

1. My Employer’s safety measures:

Descriptive Statistics:
The mean scores were 4.14 for Org A Non-Frontline Staff, 4.03 for Org A Train Controllers, 3.44 for Org A Maintenance Staff, and 4.09 for Non-Org A Maintenance Staff. The scores for Org A Non-Frontline Staff sample converged on the score of 4 “Agree”.

Inferential Statistics:
Comparisons within Org A
The scores were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (Mean Rank = 45.52, n = 28), Org A Train Controllers (Mean Rank = 45.98, n = 29) and Org A Maintenance Staff (Mean Rank = 31.80, n = 25). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 7.566, $df = 2$, $N = 82$, Asymp. Sig. $p = .023$, Cohen’s $f = .321$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Non-Frontline Staff (Mean Rank = 31.36, n = 28) and Org A Maintenance Staff (Mean Rank = 22.12, n = 25), $U = 228.00$, $z = -2.582$, Asymp. Sig. $p = .010$, two-tailed.

Comparison between Org A Maintenance and Non-Org A Maintenance Staff
A further Mann-Whitney $U$ test was run to compare the ranks for Org A Maintenance Staff (Mean Rank = 20.98, n = 25) versus Non-Org A Maintenance Staff (Mean Rank = 30.02, n = 25). The results revealed a significant difference in the employees’ evaluation between the two samples, $U = 199.00$, $z = -2.401$, Asymp. Sig. $p = .016$, two-tailed.

Interpretation:
Org A Maintenance Staff moderately “Agreed” that their employer had adequate safety measures overall, while the other groups clearly “Agreed”.

Mann-Whitney $U$ tests indicated that Org A Maintenance Staff thought to a significantly lesser degree that their employer had adequate safety measures overall than (a) Org A Non-Frontline Staff; and (b) Non-Org A Maintenance Staff thought of their respective employers.

2. Safety Measures in the Rail Industry in General:
A total of twenty-three outliers were identified in the distribution of the factor mean scores across the four samples. One outlier in Org A Non-Frontline Staff sample was found to exceed $-3$ standard deviations below the mean score and thus was removed. Others were retained as they were less than $+/−3$ standard deviations from the mean score.

Descriptive Statistics:
The mean scores were 3.92 for Org A Non-Frontline Staff, 3.97 for Org A Train Controllers, 3.56 for Org A Maintenance Staff, and 3.96 for Non-Org A Maintenance Staff. The scores for Org A Non-Frontline Staff and Org A Train Controllers samples converged on the score of 4 “Agree”.

Interpretation:
All groups generally “Agreed” that safety measures of the rail industry overall was adequate.
Detailed Findings
Sections B1 to B7

Section B – Safety Culture Questions

The questions and statements in Section B have been adapted from the Hearts & Minds program by kind permission of Shell International Exploration and Production B. V. and the Energy Institute.

This section consisted of a total of 67 questions. They were categorised into seven distinct conceptual categories based on previous research (Parker et al., 2005). Factor analysis was carried out for each category.

Question:
The participants were asked to select their level of agreement to a number of statements from a 5-point Likert scale. The question and response scale are presented below.

<table>
<thead>
<tr>
<th>Not applicable</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Question: How far does each of the following statements describe your place of work? Please select the number from 0 to 5 that best expresses your response.

Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org A Non-Frontline Staff (n = 29):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 3), Engineering Design (n = 3), HSE or OHS (n = 3), Management (n = 9), New Project Development (n = 1), Technical Training (n = 1) and Others in non-frontline roles (n = 9). Nineteen participants described themselves as working in a safety-critical area (68%), and 22 were males (76%). The largest number was found in the 30-39, and 40-49 age groups (n = 11, 38%, respectively), and at management level (n = 14, 48%).

- **Org A Train Controllers (n = 27):** Twenty-six participants described themselves as working in a safety-critical area (96%), and were all males (100%). The highest proportion was found in the 40-49 age group (n = 12, 44%), and a majority were Team Members (n = 20, 74%).

- **Org A Maintenance Staff (n = 25):** Twenty-four participants described themselves as working in a safety-critical area (96%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 12, 48%). More than half of this sample consisted of Team Members (n = 13, 54%).

- **Non-Org A Maintenance Staff (n = 25):** Twenty-five participants described themselves as working in a safety-critical area (100%), and were all males (100%). The highest
A proportion was found in the 40-49 age group \( (n = 11, 44\%) \). More than half of this sample consisted of Team Members \( (n = 15, 60\%) \).

**Statements:**
Section B1 had a total of 8 statements pertaining to the participants’ perception of their organisation’s commitment to Health, Safety and Environment and Care for Colleagues. Factor analysis identified one factor with Eigenvalue exceeding 1. Two statements were eliminated either due to low (below 0.3) or multiple factor loadings, leaving a total of 6 statements for group comparisons. The statement numbers indicate their sequence as they appear in the questionnaire. The composition of the statements is outlined in Table 5.6.

Table 5.6

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>7.</td>
<td>Levels of commitment and care are very high and are driven by employees who aspire to achieve high HSE standards.</td>
<td>.752</td>
</tr>
<tr>
<td></td>
<td>4.</td>
<td>People know how to pay lip service to safety, but practical factors may prevent complete application. (R)*</td>
<td>.709</td>
</tr>
<tr>
<td></td>
<td>1.</td>
<td>The feeling of pride in Health Safety &amp; Environment (HSE) and care for colleagues is NOT shared by everyone. (R)*</td>
<td>.679</td>
</tr>
<tr>
<td></td>
<td>8.</td>
<td>Pride in HSE is beginning to develop, increasing the employees’ commitment to HSE and care for colleagues.</td>
<td>.649</td>
</tr>
<tr>
<td></td>
<td>5.</td>
<td>Commitment to HSE and care for colleagues diminishes after a period of good safety performance. (R)*</td>
<td>.623</td>
</tr>
<tr>
<td></td>
<td>6.</td>
<td>Who cares about safety as long as we don't get caught? (R)*</td>
<td>.545</td>
</tr>
</tbody>
</table>

*n.b. (R) denotes reverse-scored items.

**What the scores mean:**
In response to the statements above, the scores reflected the participants’ evaluation of the situation at their respective workplace at the time of the survey administration. Higher scores represented the participants’ evaluation of a higher level of workforce commitment to Health Safety & Environment and care for colleagues.

**Results:**
The distribution of mean scores across the items comprising this factor is presented in Figure 5.4.
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Descriptive Statistics:**
The mean scores were 3.58 for Org A Non-Frontline Staff, 3.55 for Org A Train Controllers, 3.19 for Org A Maintenance Staff, and 3.51 for Non-Org A Maintenance Staff.

**Interpretation:**
All groups more or less “Agreed” that people in their place of work were committed to Health, Safety and Environment and showed care for their colleagues.

*Figure 5.4. Section B1 Commitment Level of Workforce to HSE & Care for Colleagues – Distribution of factor-based mean scores by group*
Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org A Non-Frontline Staff** (*n* = 28): This sample consisted of the following occupational groups: Admin, Finance or HR (*n* = 2), Engineering Design (*n* = 3), HSE or OHS (*n* = 3), Management (*n* = 9), New Project Development (*n* = 1), Technical Training (*n* = 1) and Others in non-frontline roles (*n* = 9). Eighteen participants described themselves as working in a safety-critical area (67%), and 22 were males (79%). The largest number was found in the 30-39 age group (*n* = 11, 39%), and at management level (*n* = 14, 50%).

- **Org A Train Controllers** (*n* = 28): Twenty-seven participants described themselves as working in a safety-critical area (96%). All of the 28 participants were males (100%). The highest proportion was found in the 40-49 age group (*n* = 11, 39%), and a majority were Team Members (*n* = 21, 75%).

- **Org A Maintenance Staff** (*n* = 25): Twenty-four participants described themselves as working in a safety-critical area (96%). All of the 25 participants were males (100%). The highest proportion was found in the 40-49 age group (*n* = 12, 48%). More than half of this sample consisted of Team Members (*n* = 13, 54%).

- **Non-Org A Maintenance Staff** (*n* = 25): All of the 25 participants described themselves as working in a safety-critical area, and all were males (100%). The highest proportion was found in the 40-49 age group (*n* = 11, 44%). More than half of this sample consisted of Team Members (*n* = 14, 56%).

Statements:
Section B2 had a total of 10 statements pertaining to the participants’ perception of their organisation’s balance between Health, Safety and Environment and profitability. Factor analysis identified one factor with Eigenvalue exceeding 1. Three statements were eliminated either due to low (below 0.3) or multiple factor loadings, leaving a total of 7 statements for group comparisons. The composition of the statements is outlined in Table 5.7. The statement numbers indicate their sequence as they appear in the questionnaire.
Table 5.7
Section B2 – Statements Comprising the Factor and their Loadings

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>17.</td>
<td>Safety is seen as costing money, and the only priority is to avoid extra costs. (R)*</td>
<td>.852</td>
</tr>
<tr>
<td></td>
<td>9.</td>
<td>Safety is seen as an optional expenditure. (R)*</td>
<td>.658</td>
</tr>
<tr>
<td></td>
<td>13.</td>
<td>My employer tries to make HSE the top priority, understanding that HSE contributes to financial return.</td>
<td>.642</td>
</tr>
<tr>
<td></td>
<td>16.</td>
<td>Line managers know how to say the right things, but do not always walk their own talk. (R)*</td>
<td>.587</td>
</tr>
<tr>
<td></td>
<td>15.</td>
<td>My employer accepts delays to get contractors up to standard in terms of safety regardless of cost.</td>
<td>.574</td>
</tr>
<tr>
<td></td>
<td>14.</td>
<td>Cost is important, but some money is put towards maintenance to prevent accidents.</td>
<td>.559</td>
</tr>
<tr>
<td></td>
<td>10.</td>
<td>Management believes that HSE saves money in the long term.</td>
<td>.558</td>
</tr>
</tbody>
</table>

*n.b. (R) denotes reverse-scored items.

What the scores mean:
Higher scores represented the participants’ evaluation of higher level of balance their organisation has achieved between Health Safety & Environment and Profitability.

Results:
The distribution of mean scores across the items comprising the factor is presented in Figure 5.5.

![Figure 5.5. Section B2 Balance between HSE and Profitability – Distribution of factor-based mean scores by group](image)
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Balance Achieved between HSE & Profitability:**

*Descriptive Statistics:*

The mean scores were 3.57 for Org A Non-Frontline Staff, 3.64 for Org A Train Controllers, 3.20 for Org A Maintenance Staff, and 3.69 for Non-Org A Maintenance Staff.

*Inferential Statistics:*

**Comparisons within Org A**

The mean scores across the seven questions (9, 10 and 13 through to 17) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (*Mean Rank = 43.77, n = 28*), Org A Train Controllers (*Mean Rank = 47.52, n = 28*) and Org A Maintenance Staff (*Mean Rank = 30.60, n = 25*). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 7.468, $df = 2$, $N = 81$, Asymp. Sig. $p = .024$, Cohen’s $f = .321$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Train Controllers (*Mean Rank = 21.02, n = 25), $U = 200.500$, $z = -2.676$, Asymp. Sig. $p = .015$, two-tailed.

**Comparison between Org A Maintenance and Non-Org A Maintenance Staff**

A further Mann-Whitney $U$ test was used to compare the ranks for Org A Maintenance Staff (*Mean Rank = 20.48, n = 25*) versus Non-Org A Maintenance Staff (*Mean Rank = 30.52, n = 25*). The results revealed a significant difference in the employees’ evaluation between the two samples, $U = 187.00$, $z = -2.444$, Asymp. Sig. $p = .015$, two-tailed.

**Interpretation:**

Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff generally “Agreed” that their organisation had achieved balance between Health, Safety and Environment and profitability. On the other hand, the general evaluation of Org A Maintenance Staff was “Neither Agree nor Disagree”.

Mann-Whitney $U$ tests indicated that Org A Maintenance Staff thought to a significantly lesser degree that their organisation had achieved balance between Health, Safety and Environment and profitability than (a) Org A Train Controllers; and (b) Non-Org A Maintenance Staff.
Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org A Non-Frontline Staff (n = 29):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 3), Engineering Design (n = 3), HSE or OHS (n = 3), Management (n = 9), New Project Development (n = 1), Technical Training (n = 1) and Others in non-frontline roles (n = 9). Nineteen participants described themselves as working in a safety-critical area (68%) and 22 were males (76%). The largest number was found in the 30-39 and 40-49 age groups (n = 11, 38%, respectively), and at management level (n = 14, 48%).

- **Org A Train Controllers (n = 29):** Twenty-eight participants described themselves as working in a safety-critical area (97%). All of the 29 participants were males (100%). The highest proportion was found in the 40-49 age group (n = 12, 41%), and a majority were Team Members (n = 22, 76%).

- **Org A Maintenance Staff (n = 24):** Twenty-three participants described themselves as working in a safety-critical area (96%). All of the 24 participants were males (100%). The highest proportion was found in the 40-49 age group (n = 12, 50%). More than half of this sample consisted of Team Members (n = 13, 54%).

- **Non-Org A Maintenance Staff (n = 24):** All of the 24 participants described themselves as working in a safety-critical area, and all were males (100%). The highest proportion was found in the 40-49 age group (n = 11, 46%). More than half of this sample consisted of Team Members (n = 13, 54%).

**Statements:**
Section B3 had a total of 11 statements pertaining to the participants’ perception of their organisation’s balance between Health, Safety and Environment and profitability. Factor analysis identified one factor with Eigenvalue exceeding 1. Four statements were eliminated either due to low (below 0.3) or multiple factor loadings, leaving a total of 7 statements for group comparisons. The composition of the statements is outlined in Table 5.8. The statement numbers indicate their sequence as they appear in the questionnaire.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Importance of Competency &amp; Training Recognised</td>
<td>27.</td>
<td>Leadership fully acknowledges the importance of assessment of on-the-job skills.</td>
<td>.777</td>
</tr>
<tr>
<td></td>
<td>23.</td>
<td>Information on competence requirements for individual roles is available, and appropriate training is given.</td>
<td>.692</td>
</tr>
<tr>
<td></td>
<td>26.</td>
<td>Employees are proud to demonstrate their skills in on-the-job assessment.</td>
<td>.614</td>
</tr>
<tr>
<td></td>
<td>29.</td>
<td>Training is seen as a necessary evil. (Reverse scored)</td>
<td>.503</td>
</tr>
<tr>
<td></td>
<td>22.</td>
<td>Training needs are beginning to be identified by the employees.</td>
<td>.463</td>
</tr>
<tr>
<td></td>
<td>28.</td>
<td>After an accident, specific training programs are made available.</td>
<td>.450</td>
</tr>
<tr>
<td></td>
<td>25.</td>
<td>There is some on-the-job transfer of training.</td>
<td>.342</td>
</tr>
</tbody>
</table>

What the scores mean:
Higher scores represented greater recognition of the importance of competency and training in their organisation.

**Results:**

The distribution of mean scores across the items comprising the factor is presented in Figure 5.6.

*Figure 5.6. Section B3 Workforce Interest in Competency & Training – Distribution of factor-based mean scores by group*

The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Importance of Competency & Training Recognised:**

*Descriptive Statistics:*
The mean scores were 3.63 for the Org A Non-Frontline Staff, 3.47 for the Org A Train Controllers, 3.27 for the Org A Maintenance Staff, and 3.33 for Non-Org A Maintenance Staff.

*Inferential Statistics:*

**Comparisons within Org A**
The mean scores across the seven questions (22, 23, and 25 through to 29) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among the Org A Non-Frontline Staff (*Mean Rank = 49.84, n = 29*), Org A Train Controllers (*Mean Rank = 41.28, n = 29*) and Org A Maintenance Staff (*Mean Rank = 31.69, n = 24*). The
results indicated a significant difference in the employees’ evaluation among the three
groups, $H$ (corrected for ties) = 7.705, $df = 2$, $N = 82$, Asymp. Sig. $p = .021$, Cohen’s $f = .324$.
Further tests were conducted in order to identify where the difference was located. Three
separate Mann-Whitney $U$ tests were conducted for pairwise comparisons.
The results revealed a significant difference (with a Bonferroni adjusted alpha level) in
the employees’ evaluation between Org A Non-Frontline Staff ($Mean \text{ Rank} = 32.19$, $n = 29$) versus the Org A Maintenance Staff ($Mean \text{ Rank} = 20.73$, $n = 24$), $U = 197.50$, $z = -2.703$, Asymp. Sig. $p = .007$, two-tailed.

**Interpretation:**
The Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff more or less “Agreed” that people in their organisation recognised the importance of competency and training. The Org A Maintenance Staff’s general evaluation tended towards “Neither Agree nor Disagree”.
A Mann-Whitney $U$ test indicated that Org A Maintenance Staff thought to a significantly lesser degree that people in their organisation recognised the importance of competency and training than the Org A Non-Frontline Staff.

**Section B4 Work-site Safety Controls**

**Demographics:**
Data obtained from the following four groups were analysed. They had the following
employment and demographic characteristics:

- **Org A Non-Frontline Staff ($n = 28$):** This sample consisted of the following occupational
groups: Admin, Finance or HR ($n = 2$), Engineering Design ($n = 3$), HSE or OHS ($n = 3$),
Management ($n = 9$), New Project Development ($n = 1$), Technical Training ($n = 1$) and
Others in non-frontline roles ($n = 9$). Eighteen participants described themselves as working
in a safety-critical area (67%), and 22 were males (79%). The largest number was found in
the 30-39 age group ($n = 11$, 39%), and at management level ($n = 14$, 50%).

- **Org A Train Controllers ($n = 28$):** Twenty-seven participants described themselves as
working in a safety-critical area (96%). All of the 28 participants were males (100%). The
highest proportion was found in the 40-49 age group ($n = 12$, 43%), and a majority were Team
Members ($n = 21$, 75%).

- **Org A Maintenance Staff ($n = 24$):** Twenty-three participants described themselves as
working in a safety-critical area (96%). All of the 24 participants were males (100%). The
highest proportion was found in the 40-49 age group ($n = 12$, 50%). More than half of this
sample consisted of Team Members ($n = 14$, 52%).

- **Non-Org A Maintenance Staff ($n = 24$):** All of the 24 participants described themselves as
working in a safety-critical area, and all were males (100%). The highest proportion was found in the 40-49 age group ($n = 11$, 46%). More than half of this sample consisted of Team Members ($n = 13$, 54%).
Statements:
Section B4 had a total of 6 statements pertaining to the participants’ perception of the effectiveness of their organisation’s safety controls. Factor analysis identified one factor with Eigenvalue exceeding 1. All the statements were retained for group comparisons. The composition of the statements is outlined in Table 5.9. The statement numbers indicate their sequence as they appear in the questionnaire.

Table 5.9
Section B4 – Statements Comprising the Factor and their Loadings

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>35.</td>
<td>People (both team members and supervisors) are not afraid to tell each other about or report hazards.</td>
<td>.637</td>
</tr>
<tr>
<td></td>
<td>33.</td>
<td>Internal safety audits, as a work-site hazard management control, are revised regularly in a defined process.</td>
<td>.636</td>
</tr>
<tr>
<td></td>
<td>32.</td>
<td>There are no safety management controls applied - &quot;Look out for yourself&quot; (R)*</td>
<td>.625</td>
</tr>
<tr>
<td></td>
<td>30.</td>
<td>There is little systematic use of the standard work-related safety management controls after their initial introduction. (R)*</td>
<td>.621</td>
</tr>
<tr>
<td></td>
<td>34.</td>
<td>The number of inspection reports written is used to check that the job safety controls required by the management system are working.</td>
<td>.619</td>
</tr>
<tr>
<td></td>
<td>31.</td>
<td>Internal safety audits are accepted by the employees as being in their own interest.</td>
<td>.481</td>
</tr>
</tbody>
</table>

*n.b. (R) denotes reverse-scored items.

What the scores mean:
Higher scores represented the participants’ evaluation of greater effectiveness of their organisation’s safety control.

Results:
The distribution of mean across the items comprising the factor is presented in Figure 5.7.
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Effective Safety Controls:**

*Descriptive Statistics:*
The mean scores were 3.65 for Org A Non-Frontline Staff, 3.56 for Org A Train Controllers, 3.41 for Org A Maintenance Staff, and 3.53 for Non-Org A Maintenance Staff.

*Interpretation:*
All groups generally “Agreed” that their organisation had *effective safety controls*.

**Section B5 Purpose of HSE Procedures**

**Demographics:**
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics.

- **Org A Non-Frontline Staff (n = 27):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 2), Engineering Design (n = 3), HSE or OHS (n = 3),
Management (n = 9), New Project Development (n = 1), Technical Training (n = 1) and Others in non-frontline roles (n = 9). Seventeen participants described themselves as working in a safety-critical area (65%), and 21 were males (78%). The largest number was found in the 30-39 age group (n = 11, 41%), and at management level (n = 14, 52%).

- **Org A Train Controllers (n = 27):** All of the 27 participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (n = 12, 44%), and a majority were Team Members (n = 21, 78%).

- **Org A Maintenance Staff (n = 22):** Twenty-one participants described themselves as working in a safety-critical area (96%). All of the 22 participants were males (100%). The highest proportion was found in the 40-49 age group (n = 11, 50%). More than half of this sample consisted of Team Members (n = 11, 52%).

- **Non-Org A Maintenance Staff (n = 22):** All of the 22 participants described themselves as working in a safety-critical area, and all were males (100%). The highest proportion was found in the 40-49 age group (n = 11, 50%). More than half of this sample consisted of Team Members (n = 12, 55%).

**Statements:**
Section B5 had a total of 10 statements pertaining to the participants’ perception of the purpose of their organisation’s safety procedures. Factor analysis identified two factors with Eigenvalues exceeding 1. Two statements were eliminated either due to low (below 0.3) or multiple factor loadings, leaving a total of 8 statements for group comparisons. The composition of the statements is outlined in Table 5.10. One of the factors addressed a positive aspect, while the other addressed a negative aspect of the purpose of safety procedures in their work environment. For conceptual clarity, the boxplots for the negative factor is presented against a blue background.

**Table 5.10**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Balance Achieved between HSE Procedures &amp; Efficiency</strong></td>
<td>37.</td>
<td>The overall effect of HSE procedures is NOT necessarily properly considered in detail. (R)*</td>
<td>.662</td>
</tr>
<tr>
<td></td>
<td>44.</td>
<td>HSE procedures communicate best practice.</td>
<td>.585</td>
</tr>
<tr>
<td></td>
<td>41.</td>
<td>Non-compliance with HSE procedures is handled through recognised channels.</td>
<td>.533</td>
</tr>
<tr>
<td></td>
<td>36.</td>
<td>HSE procedures are occasionally seen as inconvenient by competent employees. (R)*</td>
<td>.422</td>
</tr>
<tr>
<td></td>
<td>45.</td>
<td>HSE procedures are refined for efficiency.</td>
<td>.352</td>
</tr>
<tr>
<td><strong>2. Negative Views on HSE Procedures</strong></td>
<td>43.</td>
<td>HSE procedures are often written in response to accidents.</td>
<td>.655</td>
</tr>
<tr>
<td></td>
<td>40.</td>
<td>HSE procedures are seen as limiting people’s activities to avoid lawsuits or harm to assets.</td>
<td>.631</td>
</tr>
<tr>
<td></td>
<td>42.</td>
<td>HSE procedures are taught in training but are inflexible.</td>
<td>.365</td>
</tr>
</tbody>
</table>

*n.b. (R) denotes reverse-scored items.*
What the scores mean:
Factor 1 addressed a positive aspect of HSE procedures. Higher mean scores represented the participants’ evaluation that the organisation has achieved greater balance between procedures and efficiency. On the other hand, Factor 2 addressed a negative aspect. Higher scores represent the participants’ evaluation of more negative views held by their organisation with regard to HSE procedures.

Results:
The distribution of mean scores across the items comprising each factor is presented in Figure 5.8.

Figure 5.8. Section B5 Purpose of HSE Procedures – Distribution of factor-based mean scores by group
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Balance Achieved between HSE Procedures & Efficiency:**

*Descriptive Statistics:*
The mean scores were 3.33 for Org A Non-Frontline Staff, 3.36 for Org A Train Controllers, 3.12 for Org A Maintenance Staff, and 3.04 for Non-Org A Maintenance Staff.

*Interpretation:*
In general, all groups “Neither Agreed nor Disagreed” that their organisation had achieved balance between Health, Safety and Environment procedures and efficiency.

**Factor 2. Negative views on HSE Procedures:**

*Descriptive Statistics:*
The mean scores were 3.13 for Org A Non-Frontline Staff, 3.17 for Org A Train Controllers, 3.27 for Org A Maintenance Staff, and 3.00 for Non-Org A Maintenance Staff.

*Interpretation:*
All groups “Neither Agreed nor Disagreed” that their organisation and employees had negative views on Health, Safety and Environment procedures.

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**Section B6 Repercussion & Feedback after Accidents**

**Demographics:**
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org A Non-Frontline Staff** *(n = 29)*: This sample consisted of the following occupational groups: Admin, Finance or HR *(n = 3)*, Engineering Design *(n = 3)*, HSE or OHS *(n = 3)*, Management *(n = 9)*, New Project Development *(n = 1)*, Technical Training *(n = 1)* and Others in non-frontline roles *(n = 9)*. Nineteen participants described themselves as working in a safety-critical area *(68%)*, and 22 were males *(76%)*. The largest number was found in the 30-39 and 40-49 age groups *(n = 11, 38%, respectively)*, and at management level *(n = 14, 48%)*.

- **Org A Train Controllers** *(n = 29)*: Twenty-eight participants described themselves as working in a safety-critical area *(97%)*. All of the 29 participants were males *(100%)*. The highest proportion was found in the 40-49 age group *(n = 12, 41%)*, and a majority were Team Members *(n = 22, 76%)*.

- **Org A Maintenance Staff** *(n = 24)*: Twenty-three participants described themselves as working in a safety-critical area *(96%)*. All of the 24 participants were males *(100%)*. The highest proportion was found in the 40-49 age group *(50%)*. More than half of this sample consisted of Team Members *(n = 12, 52%)*.

- **Non-Org A Maintenance Staff** *(n = 24)*: All of the 24 participants described themselves as working in a safety-critical area, and all were males *(100%)*. The highest proportion was found in the 40-49 age group *(n = 11, 46%)*. More than half of this sample consisted of Team Members *(n = 13, 54%)*.
Statements:
Section B6 had a total of 11 statements pertaining to the participants’ perception of their organisation’s response to accidents. Factor analysis identified two factors with Eigenvalues exceeding 1. Three statements were eliminated either due to low (below 0.3) or multiple factor loadings, leaving a total of 8 statements for group comparisons.

The composition of the statements is outlined in Table 5.11. The statement numbers indicate their sequence as they appear in the questionnaire. One of the factors addressed a negative aspect characterised by a reactive, rather than proactive, style of responding to accidents, while the other addressed a positive aspect that portrays a constructive and balanced way of dealing with accidents demonstrated by the management and the organisation’s safety management system. For conceptual clarity, the boxplots for the negative factor is presented against a blue background.

Table 5.11
Section B6 – Statements Comprising Factor 1 and their Loadings

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reactivity – Blame Culture</td>
<td>51.</td>
<td>After an accident, the focus is on the employee, and they are often disciplined and/or ostracised.</td>
<td>.784</td>
</tr>
<tr>
<td></td>
<td>48.</td>
<td>Management goes ballistic when they hear of an accident - &quot;What does this do to our statistics?&quot;</td>
<td>.699</td>
</tr>
<tr>
<td></td>
<td>53.</td>
<td>Line management is annoyed by &quot;stupid&quot; accidents.</td>
<td>.619</td>
</tr>
<tr>
<td></td>
<td>55.</td>
<td>Warning letters are sent by management to individuals who were involved in accidents.</td>
<td>.564</td>
</tr>
<tr>
<td>2. Constructive Management Response</td>
<td>50.</td>
<td>Top or senior management are involved directly after an accident.</td>
<td>.681</td>
</tr>
<tr>
<td></td>
<td>56.</td>
<td>After an accident, top or senior management show personal interest in individuals and the investigation process.</td>
<td>.614</td>
</tr>
<tr>
<td></td>
<td>54.</td>
<td>The results of accident investigation are fed back to the supervisory level.</td>
<td>.549</td>
</tr>
<tr>
<td></td>
<td>49.</td>
<td>Accident investigation focuses on all causes and contributory circumstances.</td>
<td>.548</td>
</tr>
</tbody>
</table>

What the scores mean:
Factor 1 addressed a negative response to accidents. Higher scores represented the participants’ evaluation of a more reactive, rather than proactive, style of responding to accidents characterised by a tendency to apportion blame to those who were directly involved in the accidents rather than investigating systemic issues.

On the other hand, Factor 2 addressed a positive aspect. Higher scores represented the participants’ evaluation of a more constructive approach by management in response to accidents.

Results:
The distribution of mean scores across the items comprising each factor is presented in Figure 5.9.
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Reactivity – Blame Culture:**

**Descriptive Statistics:**
The mean scores were 2.88 for Org A Non-Frontline Staff, 2.86 for Org A Train Controllers, 3.43 for Org A Maintenance Staff, and 2.80 for Non-Org A Maintenance Staff.

**Inferential Statistics:**

**Comparisons within Org A**
The mean scores across the four questions (48, 51, 53, and 55) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (*Mean Rank = 36.71, n = 29*), Org A Train Controllers (*Mean Rank = 36.90, n = 29*) and Org A Maintenance Staff (*Mean Rank = 52.85, n = 24*). The results
indicated a significant difference in the employees’ evaluation among the three groups, \(H\) (corrected for ties) = 7.777, \(df = 2, N = 82\), Asymp. Sig. \(p = .020\), Cohen’s \(f = .326\). Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney \(U\) tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Train Controllers (\(Mean \text{ Rank} = 22.17, n = 29\)) versus Org A Maintenance Staff (\(Mean \text{ Rank} = 32.83, n = 24\), \(U = 208.00, z = -2.512\), Asymp. Sig. \(p = .012\), two-tailed.

Comparison between Org A Maintenance and Non-Org A Maintenance Staff
A further Mann-Whitney \(U\) test was used to compare the ranks for Org A Maintenance Staff (\(Mean \text{ Rank} = 29.60, n = 24\)) versus Non-Org A Maintenance Staff (\(Mean \text{ Rank} = 19.40, n = 24\)). The results revealed a significant difference in the employees’ evaluation between the two samples, \(U = 165.500, z = -2.540\), Asymp. Sig. \(p = .011\), two-tailed.

**Interpretation:**
Org A Non-Frontline Staff, Org A Train Controllers, and Non-Org A Maintenance Staff “Neither Agreed nor Disagreed” that their organisation was reactive rather than proactive in its response to accidents, characterised by a tendency to blame those who were directly involved. Org A Maintenance Staff, on the other hand, more or less “Agreed”.

Mann-Whitney \(U\) tests indicated that Org A Maintenance Staff thought that their organisation was significantly more reactive rather than proactive in its response to accidents than (a) Org A Train Controllers; and (b) Non-Org A Maintenance Staff thought of their respective organisations.

**Factor 2. Constructive Management Response to Accidents:**

**Descriptive Statistics:**
The mean scores were 3.75 for Org A Non-Frontline Staff, 3.92 for Org A Train Controllers, 3.52 for Org A Maintenance Staff, and 3.68 for Non-Org A Maintenance Staff.

**Interpretation:**
All groups generally “Agreed” that their organisation’s management demonstrated a constructive response to accidents.

**Section B7 Safety Audits & Reviews**

**Demographics:**
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org A Non-Frontline Staff** (\(n = 27\)): This sample consisted of the following occupational groups: Admin, Finance or HR (\(n = 2\)), Engineering Design (\(n = 3\)), HSE or OHS (\(n = 3\)), Management (\(n = 9\)), New Project Development (\(n = 1\)), Technical Training (\(n = 1\)) and Others in non-frontline roles (\(n = 9\)). Seventeen participants described themselves as working in a safety-critical area (65%) and 21 were males (78%). The largest number was found in the 30-39 age group (\(n = 11, 41\%\)), and at management level (\(n = 14, 52\%\)).
• **Org A Train Controllers** (*n* = 27): Twenty-six participants described themselves as working in a safety-critical area (96%). All of the 27 participants were males. The highest proportion was found in the 40-49 age group (*n* = 12, 44%), and a majority were Team Members (*n* = 20, 74%).

• **Org A Maintenance Staff** (*n* = 21): Twenty participants out of 21 described themselves as working in a safety-critical area (96%), and all were males (100%). The highest proportion was found in the 40-49 age group (*n* = 10, 48%) and in the Team Members category (*n* = 9, 45%).

• **Non-Org A Maintenance Staff** (*n* = 21): All of the 21 participants described themselves as working in a safety-critical area, and all were males (100%). The highest proportion was found in the 40-49 age group (*n* = 10, 48%). More than half of this sample consisted of Team Members (*n* = 11, 52%).

**Statements:**

Section B7 had a total of 11 statements pertaining to the participants’ perception of their organisation’s approach to HSE audits and reviews. Factor analysis identified one factor with Eigenvalue exceeding 1. Three statements were eliminated either due to low (below 0.3) or multiple factor loadings, leaving a total of 8 statements for group comparisons. The composition of the statements is outlined in Table 5.12. The statement numbers indicate their sequence as they appear in the questionnaire.

Table 5.12

*Section B7 – Statements Comprising the Factor and their Loadings*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item no.</th>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Proactive Approach to HSE Audits &amp; Reviews</td>
<td>62.</td>
<td>Internal audits are unstructured, and only take place after major accidents. (R)*</td>
<td>.794</td>
</tr>
<tr>
<td></td>
<td>61.</td>
<td>There is no schedule for internal audits and reviews as they are seen as a punishment. (R)*</td>
<td>.757</td>
</tr>
<tr>
<td></td>
<td>60.</td>
<td>Internal audits mainly deal with financial matters. (R)*</td>
<td>.707</td>
</tr>
<tr>
<td></td>
<td>65.</td>
<td>There is a full internal audit system running smoothly with good follow up.</td>
<td>.687</td>
</tr>
<tr>
<td></td>
<td>66.</td>
<td>There is an extensive internal audit program including cross-auditing within the organisation.</td>
<td>.631</td>
</tr>
<tr>
<td></td>
<td>63.</td>
<td>There are more internal audits of behaviour (e.g. compliance) than there are of infrastructure, rolling stock, equipment and systems. (R)*</td>
<td>.614</td>
</tr>
<tr>
<td></td>
<td>58.</td>
<td>My employer is happy to audit others, but being audited is less welcome. (R)*</td>
<td>.561</td>
</tr>
<tr>
<td></td>
<td>59.</td>
<td>Internal audits are structured in terms of safety management systems.</td>
<td>.525</td>
</tr>
</tbody>
</table>

*n.b. (R) denotes reverse-scored items.*
What the scores mean:
Higher scores represented the participants’ evaluation of more proactive approach to HSE audits and reviews.

Results:
The distribution of mean scores across the items comprising the factor is presented in Figure 5.10.

The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Proactive Approach to HSE Audits & Reviews:**
*Descriptive Statistics:*
The mean scores were 3.66 for Org A Non-Frontline Staff, 3.51 for Org A Train Controllers, 3.24 for Org A Maintenance Staff, and 3.51 for Non-Org A Maintenance Staff.

*Interpretation:*
All groups more or less “Agreed” that their organisation demonstrated a proactive approach to HSE audits and reviews.
Section C  Who Drives Safety?

Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org A Non-Frontline Staff (n = 26):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 1), Engineering Design (n = 3), HSE or OHS (n = 3), Management (n = 9), New Project Development (n = 1), Technical Training (n = 1) and Others in non-frontline roles (n = 8). Seventeen participants described themselves as working in a safety-critical area (68%) and 21 were males (81%). The largest number was found in the 30-39 age group (n = 10, 39%), and at management level (n = 13, 50%).

- **Org A Train Controllers (n = 29):** Twenty-eight participants described themselves as working in a safety-critical area (97%). All of the 29 participants were males. The highest proportion was found in the 40-49 age group (n = 12, 41%), and a majority were Team Members (n = 22, 76%).

- **Org A Maintenance Staff (n = 19):** Eighteen participants described themselves as working in a safety-critical area (95%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 10, 53%) and in the Team Members category (n = 8, 44%).

- **Non-Org A Maintenance Staff (n = 19):** All of the 19 participants described themselves as working in a safety-critical area, and all were males (100%). The highest proportion was found in the 40-49 age group (n = 9, 47%) and in the Team Members category (n = 9, 47%).

**Question:**
The participants were asked to rate how much the following 10 entities drove safety in their place of work: 1) Board of Directors; 2) Customers/Passengers; 3) Legislation; 4) Management; Myself; 6) Public Opinion; 7) Rail Safety Regulators; 8) Health Safety & Environment (HSE) or OSH Department; 9) Safety-Critical Workers; and 10) Trade Unions.

The response scale is presented below.

<table>
<thead>
<tr>
<th>Not applicable</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**What the scores mean:**
Higher scores represented a higher evaluation of the role played by that particular entity in driving safety.

**Results:**
The distribution of the questionnaire item scores for the three groups is presented in Figure 5.11.
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neither Agree nor Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.11. Section C – Score distribution by group

- Org A Non-Frontline Staff
- Org A Train Controllers
- Org A Maintenance Staff
- Non-Org A Maintenance Staff
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

1. Board Directors:
One outlier was identified in the Org A Train Controllers sample. It was found to exceed -3 standard deviations below the mean score and thus was removed from the data.

*Descriptive Statistics:*
The mean scores were 3.62 for Org A Non-Frontline Staff, 3.39 for Org A Train Controllers, 3.53 for Org A Maintenance Staff, and 3.56 for Non-Org A Maintenance Staff.

*Interpretation:*
All groups generally “Agreed” that the Board of Directors was an important element for driving safety in their workplace.

2. Customers/Passengers:

*Descriptive Statistics:*
The mean scores were 3.09 for Org A Non-Frontline Staff, 3.44 for Org A Train Controllers, 3.05 for Org A Maintenance Staff, and 3.54 for Non-Org A Maintenance Staff.

*Interpretation:*
All groups moderately “Agreed” that Customers/Passengers were an important element for driving safety in their workplace.

3. Legislation:

*Descriptive Statistics:*
The mean scores were 4.32 for Org A Non-Frontline Staff, 4.41 for Org A Train Controllers, 3.95 for Org A Maintenance Staff, and 4.11 for Non-Org A Maintenance Staff. The scores for Org A Maintenance Staff sample converged on the score of 4 “Agree”.

*Inferential Statistics:*

**Comparisons within Org A**
The scores for Item C3 were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (*Mean Rank* = 39.94, *n* = 26), Org A Train Controllers (*Mean Rank* = 41.98, *n* = 29) and Org A Maintenance Staff (*Mean Rank* = 27.32, *n* = 19). The results indicated a significant difference in the employees’ evaluation among the three groups, *H* (corrected for ties) = 7.751, *df* = 2, *N* = 74, Asymp. Sig. *p* = .021, Cohen’s *f* = .345.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney *U* tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Train Controllers (*Mean Rank* = 28.31, *n* = 29) and Org A Maintenance Staff (*Mean Rank* = 18.68, *n* = 19), *U* = 165.00, *z* = -2.773, Asymp. Sig. *p* = .006, two-tailed.

*Interpretation:*
Org A Maintenance Staff “Agreed” that *Legislation* played an important role in driving safety in their workplace. The other groups “Strongly Agreed” in general.

A Mann-Whitney *U* test indicated that Org A Maintenance Staff’s level of “Agreement” was significantly lower than that of Org A Train Controllers about the role of *Legislation* in driving safety in their workplace.

4. Management:

*Descriptive Statistics:*

The mean scores were 4.19 for Org A Non-Frontline Staff, 4.07 for Org A Train Controllers, 3.84 for Org A Maintenance Staff, and 4.16 for Non-Org A Maintenance Staff. The scores for Org A Non-Frontline Staff and Org A Train Controllers virtually converged on the score of 4 “Agree”.

*Interpretation:*

All groups generally “Agreed” that *Management* was an important element for driving safety in their workplace.

5. Myself:

*Descriptive Statistics:*

The mean scores were 4.32 for Org A Non-Frontline Staff, 4.52 for Org A Train Controllers, 4.16 for Org A Maintenance Staff, and 4.16 for Non-Org A Maintenance Staff.

*Interpretation:*

All groups “Strongly Agreed” that they themselves played an important role in driving safety in their workplace.

6. Public Opinion:

*Descriptive Statistics:*

The mean scores were 3.02 for Org A Non-Frontline Staff, 3.44 for Org A Train Controllers, 3.16 for Org A Maintenance Staff, and 3.21 for Non-Org A Maintenance Staff.

*Interpretation:*

In general, all groups “Neither Agreed nor Disagreed” that *Public Opinion* played an important role in driving safety in their workplace.

7. Rail Safety Regulators:

*Descriptive Statistics:*

The mean scores were 4.13 for Org A Non-Frontline Staff, 4.62 for Org A Train Controllers, 4.05 for Org A Maintenance Staff, and 4.11 for Non-Org A Maintenance Staff. The scores for Non-Org A Maintenance Staff virtually converged on the score of 4 “Agree”.

*Inferential Statistics:*

Comparisons within Org A

The scores for Item C7 were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff (Mean Rank = 31.85, n = 26), Org A Train Controllers (Mean Rank = 47.31, n = 29) and Org A Maintenance Staff (Mean Rank = 30.26, n = 19). The results indicated a significant difference in the employees’
evaluation among the three groups, $H$ (corrected for ties) = 11.939, $df = 2$, $N = 74$, Asymp. Sig. $p = .003$, Cohen’s $f = .442$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Non-Frontline Staff ($Mean\ Rank = 21.73$, $n = 26$) and Org A Train Controllers ($Mean\ Rank = 33.62$, $n = 29$), $U = 214.00$, $z = -3.033$, Asymp. Sig. $p = .002$, two-tailed.

A significant difference was also found in the employees’ evaluation between Org A Train Controllers ($Mean\ Rank = 28.69$, $n = 29$) and Org A Maintenance Staff ($Mean\ Rank = 18.11$, $n = 19$), $U = 154.00$, $z = -2.841$, Asymp. Sig. $p = .004$, two-tailed.

Interpretation:
Org A Train Controllers “Strongly Agreed” that the Rail Safety Regulators played an important role in driving safety in their workplace, while the other groups “Agreed”.
Mann-Whitney $U$ tests indicated that Org A Train Controllers’ level of “Agreement” about the role of the Rail Safety Regulators in driving safety in their workplace was significantly higher than those of (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff.

8. Health, Safety & Environment (HSE) or OSH Department:

Descriptive Statistics:
The mean scores were 4.23 for Org A Non-Frontline Staff, 3.86 for Org A Train Controllers, 3.95 for Org A Maintenance Staff, and 4.05 for Non-Org A Maintenance Staff. The scores for Non-Org A Maintenance Staff virtually converged on the score of 4 “Agree”.

Interpretation:
All groups generally “Agreed” that the Health Safety & Environment (HSE) or OSH Department played an important role in driving safety in their workplace.

9. Safety-Critical Workers:

Descriptive Statistics:
The mean scores were 4.05 for Org A Non-Frontline Staff, 4.62 for Org A Train Controllers, 3.95 for Org A Maintenance Staff, and 4.11 for Non-Org A Maintenance Staff.

Inferential Statistics:
Comparisons within Org A
The scores for Item C9 were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org A Non-Frontline Staff ($Mean\ Rank = 31.48$, $n = 26$), Org A Train Controllers ($Mean\ Rank = 48.52$, $n = 29$) and Org A Maintenance Staff ($Mean\ Rank = 28.92$, $n = 19$). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 15.126, $df = 2$, $N = 74$, Asymp. Sig. $p = .001$, Cohen’s $f = .511$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org A Non-Frontline Staff ($Mean\ Rank = 21.10$, $n = 26$) and Org A
Train Controllers (*Mean Rank* = 34.19, *n* = 29), *U* = 197.500, *z* = -3.337, Asymp. Sig. *p* = .001, two-tailed.

A significant difference was also found in the employees’ evaluation between Org A Train Controllers (*Mean Rank* = 29.33, *n* = 29) and Org A Maintenance Staff (*Mean Rank* = 17.13, *n* = 19), *U* = 135.500, *z* = -3.247, Asymp. Sig. *p* = .001, two-tailed.

**Interpretation:**
Org A Train Controllers “Strongly Agreed” that Safety-Critical Workers played an important role in driving safety in their workplace, while the other groups “Agreed”

Mann-Whitney *U* tests indicated that Org A Train Controllers’ level of “Agreement” about the role of the Safety-Critical Workers in driving safety in their workplace was significantly higher than those of (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff.

10. **Trade Unions:**

**Descriptive Statistics:**
The mean scores were 3.29 for Org A Non-Frontline Staff, 3.36 for Org A Train Controllers, 3.37 for Org A Maintenance Staff, and 3.58 for Non-Org A Maintenance Staff.

Although the ratings by Org A Train Controllers appeared to be lower than the other Org A groups, the difference was not statistically significant.

**Interpretation:**
All the samples moderately “Agreed” that Trade Unions played an important role in driving safety in their workplace.

**Section C Summary**

As can be seen in Figure 5.11, the pattern of the evaluation was generally similar among the four groups. They agreed that Legislation, Management, They Themselves, the Rail Safety Regulators, the HSE/OSH Department, and Safety-Critical Workers played an important role in driving safety at their workplace.

They recognised the role of the Board of Directors, Customers/Passengers, Public Opinion, and Trade Unions to a lesser degree ranging from “Neither Agree nor Disagree” to more or less “Agree”.

Statistically significant differences were seen in the ratings in the following areas.

- Org A Train Controllers evaluated the role of Legislation in driving safety in the workplace more highly than Org A Maintenance Staff.
- Org A Train Controllers evaluated the role of Rail Safety Regulators in driving safety in the workplace more highly than (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff.
- Org A Non-Frontline Staff evaluated the role of Safety-Critical Workers in driving safety in their workplace more highly than (a) Org A Non-Frontline Staff; and (b) Org A Maintenance Staff.
5.2 Organisation B

Report to
Organisation B

Murdoch University/PATREC

Rail Safety Perception and Culture Study
2006-2009

“Results of the Rail Safety Perception & Culture Employee Questionnaire”

October 2009
Izumi Hart
PhD Candidate
School of Psychology
Murdoch
University/PATREC
Executive Summary

Terminology

Please note that throughout this report Organisation B is abbreviated as “Org B”, while a combined sample of the other rail operators that participated in this study is collectively called the “Non-Org B Combined Sample”. Detailed statistical analysis included comparisons between Org B’s maintenance staff and a selection of maintenance staff from other participating organisations. These two groups are called “Org B Maintenance Staff” and “Non-Org B Maintenance Staff”, respectively.

Occupational Profiles

The Org B participants (N = 162 after data screening) showed the following profiles. Over half of the Org B participants consisted of Operations (n = 100, 61.7%) which consisted predominantly of Drivers (n = 89), Shunters (n = 8) and Other Operations (multiple tasks, n = 3). The second largest group was the Maintenance Staff (n = 44, 27.2%). People who held other than frontline safety-critical roles were combined into a group “Org B Non-Frontline Staff” (combined n = 18, 11.1%). They consisted of Administration, Finance or HR (n = 2), Engineering Design (n = 2), HSE or OHS Department Staff (n = 2), Management (n = 9), Technical Training personnel (n = 2), and Others in a non-frontline role (n = 1).

On the other hand, the participants from the Non-Org B Combined Sample (N = 162 after data screening) largely consisted of Maintenance Staff (n = 39, 24.1%) and Train Controllers (n = 34, 21.0%). They were followed by Management (n = 21, 13.0%), Customer Service (n = 20, 12.3%), Administration, Finance or HR (n = 8, 4.9%), Construction (n = 8, 4.9%), HSE or OHS Department Staff (n = 5, 3.1%), Engineering Design, (n = 3, 1.9%), Technical Training (n = 2, 1.2%), New Project Development (n = 1, 0.6%), Sales and Marketing (n = 1, 0.6%), Other Operations (multiple tasks, n = 5, 3.1%) and Others (n = 15, 9.3%).

Due to the diverse occupational profiles covered by the Org B and the Non-Org B groups, a set of criteria was applied for selecting cases to facilitate statistical analyses between various groups (see p. 22).

Statistical Analysis

This report outlines the results of statistical analyses conducted to examine whether the participants’ ratings of the factors were significantly different among the following groups. Two different methods of statistical analysis were used for group comparisons (see p. 21 for details).

a) Descriptive Statistics:

The mean scores of the following four groups were analysed:

1) Org B Non-Frontline Staff;
2) Org B Operations Staff;
3) Org B Maintenance Staff; and
4) Non-Org B Maintenance Staff.

The Org B sample was classified into the three separate groups above based on their area of responsibility. The Org B Operations Staff sample consisted of Drivers, Shunters and Other Operations (multiple tasks). The fourth group consisted of combined data of Maintenance Staff from the other rail operators. The mean scores, median and the range
of scores were computed for the factors and questionnaire items across the four groups for general reference. They are presented in the detailed findings in text and boxplots (pp. 25 – 71).

b) Inferential Statistics:

Comparisons within Org B

Inferential statistics were used to investigate whether any significant difference could be found among the three groups within Org B as categorised above. Where the result was significant, further statistical analysis was conducted in order to identify where the difference was located.

Comparison between Org B Maintenance and Non-Org B Maintenance Staff

The Maintenance Staff formed the second largest occupational category within Org B \((n = 44, 27\%)\). This category had the largest representation in the Non-Org B Combined Sample containing 39 participants \((24.1\%)\). Analyses were conducted to identify differences of statistical significance between the two groups.

On the other hand, Org B’s largest occupational group Drivers \((n = 89, 55\% \text{ of } N = 162\) had no equivalent participants in the Non-Org B Combined Sample \((N = 162)\). This restricted statistical comparisons to those within Org B.

Train Controllers \((n = 34, 21\%)\), the second largest occupational group within the Non-Org B Combined Sample, had no equivalent in the Org B sample. This group was excluded from the analyses for this report.

Sections A1 to A3 – Safety Perception

Statistically significant, and thus meaningful, differences were found in the following areas which implied that:

- Org B Operations Staff observed Negative Workplace Culture more frequently than Org B Non-Frontline Staff at their respective workplace. They also observed Roster and Time Pressure more frequently than (a) Org B Non-Frontline Staff; and (b) Org B Maintenance Staff. The Operations Staff also thought their employer provided safety-critical workers with Support for Fatigue Management less frequently than Org B Non-Frontline Staff thought about their employer. They observed External Factors more frequently as contributing to potential or actual safety problems than Org B Maintenance Staff. Furthermore, Org B Operations Staff evaluated that their Employer’s Overall Safety Measures were less adequate than Org B Non-Frontline Staff thought of their employer.

The following is a summary of the overall findings for Sections A1 to A3. Factors in which any statistically significant difference was found are denoted with an asterisk (*):

In Section A1 Factor 1, Org B Operations Staff thought *Negative Workplace Culture* was “Sometimes” observed in safety-critical areas. Org B Non-Frontline Staff, Org B Maintenance Staff and Non-Org B Maintenance Staff thought it was “Quite Rarely” observed.

In Section A1 Factor 2, Org B Operations Staff thought *Roster and Time Pressure* was “Sometimes” to “Quite Often” observed in safety-critical areas. The other groups thought it was “Quite Rarely” observed in their respective workplace.
In Section A1 Factor 3, Org B Non-Frontline Staff thought that *Support for Fatigue Management* was “Sometimes” provided to safety-critical workers at their workplace. On the other hand, the ratings by Org B Operations Staff, Org B Maintenance Staff, and Non-Org B Maintenance Staff were predominantly “Quite Rarely”.

In Section A1 Factor 4, generally all groups thought Lack of Supervision was “Very Rarely” to “Quite Rarely” encountered in safety-critical areas at their workplace.

In Section A1 Factor 5, all groups thought that Workplace Stress was “Sometimes” experienced by people in safety-critical areas at their workplace.

In Section A2 Factor 1, all groups thought that Organisational Latent Problems were “Quite Rarely” observed as contributing to potential or actual safety problems at their workplace.

In Section A2 Factor 2, Org B Non-Frontline Staff and Org B Operations Staff thought *External Factors* were “Sometimes” observed as contributing to potential or actual safety problems in safety-critical areas at their workplace. On the other hand, ratings by Org B Maintenance Staff and Non-Org B Maintenance Staff tended towards “Quite Rarely”.

In Section A3 Question 1, Org B Non-Frontline Staff clearly “Agreed” that *their employer had adequate safety measures overall*. The other groups more or less “Agreed”.

In Section A3 Question 2, all groups more or less “Agreed” that *safety measures of the rail industry overall* was adequate.

**Section B – Safety Culture**

Statistically significant, and thus meaningful, differences were found in the following areas which implied that:

Org B Operations Staff thought their organisation had achieved less balance between Health, Safety and Environment (HSE) and profitability than Org B Maintenance Staff. They also thought people in their organisation recognised the importance of competency and training to a lesser degree than Org B Non-Frontline Staff did. Furthermore, Org B Operations Staff thought people in their organisation held more negative views on HSE procedures than Org B Non-Frontline Staff did. They thought their organisation was more reactive, rather than proactive, in its response to accidents than Org B Maintenance Staff.

On the other hand, Org B Non-Frontline Staff thought that their organisation had achieved balance between HSE procedures and efficiency to a greater degree than Org B Maintenance Staff thought of their organisation. Furthermore, Org B Non-Frontline Staff thought to a greater degree that their organisation demonstrated a proactive approach to HSE audits and reviews than (a) Org B Operations Staff; and (b) Org B Maintenance Staff.

Org B Maintenance Staff thought their organisation had effective safety controls to a lesser degree than Non-Org B Maintenance Staff thought of their respective organisations.

The following is a summary of the overall findings for Section B. Factors in which any statistically significant difference was found are denoted with an asterisk (*):
In Section B1, all groups more or less “Agreed” that people in their place of work were committed to HSE and showed care for their colleagues. Although Org B Operations Staff’s ratings appeared lower than the Org B Maintenance Staff, the difference was not significant.

In Section B2, Org B Operations Staff “Neither Agreed nor Disagreed” that their organisation had achieved balance between HSE and profitability. On the other hand, the other groups mostly “Agreed”.

In Section B3, Org B Operations Staff “Neither Agreed nor Disagreed” that people in their organisation recognised the importance of competency and training. The other three groups more or less “Agreed”.

In Section B4, Org B Non-Frontline Staff and Non-Org B Maintenance Staff more or less “Agreed” that their organisation had effective safety controls. On the other hand, ratings by Org B Operations Staff and Org B Maintenance Staff were mostly “Neither Agree nor Disagree”.

In Section B5 Factor 1, Org B Non-Frontline Staff moderately “Agreed” that their organisation had achieved balance between HSE procedures and efficiency. The other three groups “Neither Agreed nor Disagreed”. In Section B5 Factor 2, Org B Operations Staff and Org B Maintenance Staff tended to “Agree” that their organisation and employees had negative views on HSE procedures. On the other hand, Org B Non-Frontline Staff and Non-Org B Maintenance Staff “Neither Agreed nor Disagreed”. Although Org B Operations Staff’s ratings appeared higher than the Org B Maintenance Staff, the difference was not significant.

In Section B6 Factor 1, Org B Operations Staff generally “Agreed” that their organisation was reactive, rather than proactive, in its response to accidents, characterised by a tendency to blame those who were directly involved. The evaluation by the other three groups was mostly “Neither Agree nor Disagree”. In Section B6 Factor 2, all groups generally “Agreed” that their organisation’s management demonstrated a constructive response to accidents.

In Section B7, Org B Non-Frontline Staff generally “Agreed” that their organisation demonstrated a proactive approach to HSE audits and reviews. The other groups generally responded “Neither Agree nor Disagree”.

Section C – Who Drives Safety?

Statistically significant, and thus meaningful, differences were found in the following areas which implied that:

Org B Non-Frontline Staff evaluated the role of the Board of Directors, Legislation and Management in driving safety in the workplace more highly than Org B Maintenance Staff did. Furthermore, they evaluated the role of the Customers/Passengers in driving safety in the workplace more highly than (a) Org B Operations Staff; and (b) Org B Maintenance Staff did. In inter-organisational comparisons, Org B Maintenance Staff acknowledged the role of Trade Unions in driving safety in their workplace more highly than Non-Org B Maintenance Staff.

The following is a summary of the overall findings for Section C. Factors in which any statistically significant difference was found are denoted with an asterisk (*):
The pattern of the evaluation was generally similar across the four groups, although Org B Non-Frontline Staff’s ratings tended to be higher than the other three groups. The four groups unanimously “Agreed” that They Themselves, the Rail Safety Regulators, the HSE/OSH Department, and Safety-Critical Workers played an important role in driving safety at their workplace. On the other hand, they recognised the role of *Customers/Passengers, Public Opinion, and Trade Unions to a lesser degree ranging from “Neither Agree nor Disagree” to more or less “Agree”.

Org B Non-Frontline Staff were the only group that answered “Strongly Agree” to any of the questions. The entities they rated with the top score were the *Legislation, *Management, They Themselves and the Rail Safety Regulators.

Org B Non-Frontline Staff clearly “Agreed” with the importance of the role played by the *Board of Directors, while the other three groups more or less “Agreed”.

While Org B Non-Frontline Staff mostly “Agreed” that *Customers/Passengers played an important role in driving safety in their workplace, the other three groups tended to “Neither Agree nor Disagree”.

Org B Non-Frontline Staff, Org B Operations Staff and Org B Maintenance Staff “Agreed” that *Trade Unions played an important role in driving safety in their workplace. The evaluation by Non-Org B Maintenance Staff tended towards “Neither Agree nor Disagree”.

Summary Conclusion:
The responses of the Org B participants indicate relatively high ratings of safety measures and culture overall. The employees appear to acknowledge the organisation’s commitment to safety as manifested in its safety management system and safety culture. However, as summarised above, the participants’ evaluation differed significantly among the occupational groups in a wide range of areas within the Org B. Similar trends were seen, although to a lesser degree, in group comparisons between Org B Maintenance Staff and Non-Org B Maintenance Staff.

In terms of the ratings for Sections A and B which mainly reflect staff’s safety perception and culture of their workplace, comparisons between Org B Operations Staff and Org B Non-Frontline Staff indicated significant, and thus meaningful, differences in six areas. Similarly, comparisons Org B Operations Staff and Org B Maintenance Staff indicated significant differences in five areas. Furthermore, comparisons between Org B Maintenance Staff and Non-Org B Maintenance Staff indicated a significant difference in one area.

More than one out of four Org B participants (n = 43, 26%) responded to the last item in the questionnaire, which invited them to provide input regarding any specific areas of safety concern or comments. Despite the valuable insight offered by the qualitative data, however, this section is omitted due to space constraints.
Sample Selection

Criteria for Case Selection

The dataset was categorised into the following four groups:

1) Org B Non-Frontline Staff;
2) Org B Operations;
3) Org B Maintenance Staff; and
4) Non-Org B Maintenance Staff.

Statistical Analysis

Two different types of analysis were conducted based on the nature of the group configuration. Org B

a) Descriptive Statistics:

The mean scores of factors and questionnaire items were computed across the four groups for general reference. The sample size breakdown of the four groups per section is presented in Table 5.13.

Table 5.13

<table>
<thead>
<tr>
<th>Group Sample Size Breakdown per Section for Descriptive Statistics</th>
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<td>Section\Sample size</td>
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b) Inferential Statistics:

Comparisons within Org B – Operations vs. Maintenance

Because Org B Non-Frontline Staff’s sample size was considerably smaller than the other two, group comparisons required preliminary data selection. Representative cases were selected from the other two groups to form samples of equal size with Org B Non-Frontline
Staff sample. Initially, Kruskal-Wallis ANOVA was conducted to identify any difference among the three Org B groups. When the result was statistically significant, three separate Mann-Whitney $U$ tests were conducted to examine the difference between (a) Org B Non-Frontline Staff and Org B Operations, (b) Org B Operations and Org B Maintenance Staff, and (c) Org B Non-Frontline Staff and Org B Maintenance Staff.

**Comparison between Org B Maintenance and Non-Org B Maintenance Staff**

The Maintenance Staff was the second largest occupational category within Org B ($n = 44, 27\%$). This category had the largest representation in the Non-Org B Combined Sample containing 39 participants (24.1\%). A Mann-Whitney $U$ test was conducted to identify significant differences between Org B Maintenance and Non-Org B Maintenance Staff for each section.

Org B’s largest occupational group Drivers ($n = 89, 54\%$ of $N = 164$) had no equivalent participants in the Non-Org B Combined Sample ($N = 162$), which rendered statistical comparisons untenable for this particular occupational group.

On the other hand, Train Controllers ($n = 34, 21\%$), the second largest occupational group within the Non-Org B Combined Sample, had no equivalent in the Org B sample. This group was excluded from the analyses for this report.
Detailed Findings
Sections A1 to A3

Section A1 & A2 – Safety Perception

Both Section A1 and A2 were designed to assess the perception of safety in the participants’ workplace.

**Section A1 Work Environment**

Demographics:

Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org B Non-Frontline Staff (n = 17):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 2), Engineering Design (n = 2), HSE or OHS (n = 2), Management (n = 8), Technical Training (n = 2) and Others in a non-frontline role (n = 1). Twelve participants described themselves as working in a safety-critical area (71%). Fifteen participants were males (88%). The largest number was found in the 50-59 age group (n = 7, 41%), and at management level (n = 8, 47%).

- **Org B Operations Staff (n = 95):** All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (n = 33, 35%) followed by the 50-59 age group (n = 27, 28%). A majority were Team Members (n = 77, 82%).

- **Org B Maintenance Staff (n = 40):** Thirty-eight participants described themselves as working in a safety-critical area (95%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 16, 40%). A majority were Team Members (n = 32, 80%).

- **Non-Org B Maintenance Staff (n = 33):** Thirty participants described themselves as working in a safety-critical area (91%), and all were males. The highest proportion was found in the 40-49 age group (n = 15, 46%) followed by the 30-39 age group (n = 12, 36%). More than half of this sample consisted of Team Members (n = 17, 53%).

**Question and Statements:** Abbreviated as they are covered in the report for Organisation A.

**Results:**

The distribution of mean scores across the items comprising each factor is presented in Figure 5.12.
The following results reflect the participants’ evaluation of the situation in safety-critical areas at their respective workplace during a two-year period preceding the survey administration.

**Factor 1. Negative Workplace Culture:**

**Descriptive Statistics:**
The mean scores were 1.97 for Org B Non-Frontline Staff, 2.71 for Org B Operations Staff, 2.37 for the Org B Maintenance Staff, and 2.15 for Non-Org B Maintenance Staff.

**Inferential Statistics:**

Comparisons within Org B
Three Org B groups of equal size were used for comparisons within Org B (see p. 22). The mean scores across the three questions (25, 26 and 28) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-
Frontline Staff ($Mean\ Rank = 19.88, n = 17$), Org B Operations Staff ($Mean\ Rank = 34.38, n = 17$) and Org B Maintenance Staff ($Mean\ Rank = 23.74, n = 17$). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 8.761, $df = 2$, $N = 51$, Asymp. Sig. $p = .013$, Cohen’s $f = .461$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff ($Mean\ Rank = 12.68, n = 17$) and Org B Operations Staff ($Mean\ Rank = 22.32, n = 17$), $U = 62.50$, $z = -2.836$, Asymp. Sig. $p = .005$, two-tailed, Exact Sig. $p = .004$, two-tailed.

Interpretation:
Org B Operation Staff thought *Negative Workplace Culture* was “Sometimes” observed in safety-critical areas. The other three groups thought it was “Quite Rarely” observed.

A Mann-Whitney $U$ test indicated that Org B Operations Staff observed significantly more *Negative Workplace Culture* than Org B Non-Frontline Staff.

**Factor 2. Roster & Time Pressure:**

One outlier was identified in the score distribution in the Org B Maintenance Staff sample. It was found to exceed $+3$ standard deviations above the mean score and thus was removed from the data.

**Descriptive Statistics:**
The mean scores were 2.38 for Org B Non-Frontline Staff, 3.35 for Org B Operations Staff, 2.08 for Org B Maintenance Staff, and 2.31 for Non-Org B Maintenance Staff.

**Inferential Statistics:**
Comparisons within Org B
The mean scores across the four questions (5, 7, 8 and 13) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-Frontline Staff ($Mean\ Rank = 23.09, n = 17$), Org B Operations Staff ($Mean\ Rank = 38.82, n = 17$) and Org B Maintenance Staff ($Mean\ Rank = 16.09, n = 17$). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 20.960, $df = 2$, $N = 51$, Asymp. Sig. $p = .000$, Cohen’s $f = .850$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff ($Mean\ Rank = 11.79, n = 17$) and Org B Operations Staff ($Mean\ Rank = 23.21, n = 17$), $U = 47.50$, $z = -3.350$, Asymp. Sig. $p = .001$, two-tailed, Exact Sig. $p = .000$, two-tailed.

A significant difference was also found between Org B Operations ($Mean\ Rank = 24.62, n = 17$) and Org B Maintenance Staff ($Mean\ Rank = 10.38, n = 17$), $U = 23.50$, $z = -4.186$, Asymp. Sig. $p = .000$, two-tailed, Exact Sig. $p = .000$, two-tailed.
Interpretation:
Org B Operations Staff thought *Roster and Time Pressure* was “Sometimes” to “Quite Often” observed in safety-critical areas. The other groups thought it was “Quite Rarely” observed in their respective workplace.

Mann-Whitney *U* tests indicated that Org B Operations Staff observed significantly more *Roster and Time Pressure* than (a) Org B Non-Frontline Staff; and (b) Org B Maintenance Staff in safety-critical areas at their workplace.

**Factor 3. Support for Fatigue Management:**

*Descriptive Statistics:*
The mean scores were 3.16 for Org B Non-Frontline Staff, 2.14 for Org B Operations Staff, 2.18 for Org B Maintenance Staff, and 2.36 for Non-Org B Maintenance Staff.

*Inferential Statistics:*
**Comparisons within Org B**
The mean scores across the four questions (9 through to 12) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-Frontline Staff (*Mean Rank* = 35.65, *n* = 17), Org B Operations Staff (*Mean Rank* = 17.94, *n* = 17) and Org B Maintenance Staff (*Mean Rank* = 24.41, *n* = 17). The results indicated a significant difference in the employees’ evaluation among the three groups, *H* (corrected for ties) = 12.479, *df* = 2, *N* = 51, Asymp. Sig. *p* = .002, Cohen’s *f* = .577. Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney *U* tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (*Mean Rank* = 23.41, *n* = 17) and Org B Operations Staff (*Mean Rank* = 11.59, *n* = 17), *U* = 44.00, *z* = -3.487, Asymp. Sig. *p* = .000, two-tailed, Exact Sig. *p* = .000, two-tailed.

*Interpretation:*
Org B Non-Frontline Staff thought that *Support for Fatigue Management* was “Sometimes” provided to safety-critical workers at their workplace. On the other hand, the ratings by Org B Operations Staff, Org B Maintenance Staff, and Non-Org B Maintenance Staff were predominantly “Quite Rarely”.

A Mann-Whitney *U* test indicated that Org B Operations Staff thought their employer provided safety-critical workers with *Support for Fatigue Management* significantly less frequently than Non-Frontline Staff thought about their employer.

**Factor 4. Lack of Supervision:**
One outlier was identified in the distribution of the Org B Operations sample. It was found to exceed +3 standard deviations above the mean score and thus was removed from the data.

*Descriptive Statistics:*
The mean scores were 1.57 for Org B Non-Frontline Staff, 1.60 for Org B Operations Staff, 1.82 for Org B Maintenance Staff, and 1.58 for Non-Org B Maintenance Staff.

**Interpretation:**
Generally all groups thought *Lack of Supervision* was “Very Rarely” to “Quite Rarely” encountered in safety-critical areas at their workplace.

**Factor 5. Workplace Stress:**

*Descriptive Statistics:*
The mean scores were 2.83 for Org B Non-Frontline Staff, 2.92 for Org B Operations Staff, 2.83 for Org B Maintenance Staff, and 2.76 for Non-Org B Maintenance Staff.

**Interpretation:**
All groups thought that *Workplace Stress* was “Sometimes” experienced by people in safety-critical areas at their workplace.

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**Section A2 Potential/Actual Safety Problems**

**Demographics:**
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics.

- **Org B Non-Frontline Staff** (*n* = 18): This sample consisted of the following occupational groups: Admin, Finance or HR (*n* = 2), Engineering Design (*n* = 2), HSE or OHS (*n* = 2), Management (*n* = 9), Technical Training (*n* = 2) and Others in a non-frontline role (*n* = 1). Thirteen participants described themselves as working in a safety-critical area (72%). Sixteen participants were males (89%). The largest number was found in the 50-59 age group (*n* = 7, 39%), and at management level (*n* = 9, 50%).

- **Org B Operations Staff** (*n* = 94): All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (*n* = 33, 35%) followed by the 50-59 age group (*n* = 26, 28%). A majority were Team Members (*n* = 75, 82%).

- **Org B Maintenance Staff** (*n* = 39): Thirty-seven participants described themselves as working in a safety-critical area (95%), and all were males (100%). The highest proportion was found in the 40-49 age group (*n* = 16, 41%). A majority were Team Members (*n* = 31, 80%).

- **Non-Org B Maintenance Staff** (*n* = 32): Twenty-nine participants described themselves as working in a safety-critical area (91%), and all were males (100%). The highest proportion was found in the 40-49 age group (*n* = 15, 47%) followed by the 30-39 age group (*n* = 11, 34%). More than half of this sample consisted of Team Members (*n* = 17, 55%).

**Question and Statements:** Abbreviated as they are covered in the report for Organisation A.

**What the scores mean:**
Higher scores represented a greater frequency with which the participants observed the contributing factors to potential or actual safety problems at their respective workplace during a two-year period preceding the survey administration.

Results:
The distribution of mean scores across the items comprising each factor is presented in Figure 5.13.

![Figure 5.13. Section A2 Potential/Actual Safety Problems – Distribution of factor-based mean scores by group](image)

The following results reflect the participants’ evaluation of the situation at their respective workplace during a two-year period preceding the survey administration.

**Factor 1. Organisational Latent Problems:**

*Descriptive Statistics:*
The mean scores were 1.90 for Org B Non-Frontline Staff, 2.18 for Org B Operations Staff, 2.19 for the Org B Maintenance Staff, and 2.01 for the Non-Org B Maintenance Staff.

*Interpretation:*
All groups thought that *Organisational Latent Problems* were “Quite Rarely” observed as contributing to potential or actual safety problems at their workplace.

**Factor 2. External Factors:**

*Descriptive Statistics:*
The mean scores were 2.83 for Org B Non-Frontline Staff, 3.04 for Org B Operations Staff, 2.28 for Org B Maintenance Staff, and 2.47 for Non-Org B Maintenance Staff.

*Inferential Statistics:*

**Comparisons within Org B**
The mean scores across the three questions (45, 46 and 48) were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-Frontline Staff (*Mean Rank = 25.33, n = 17*), Org B Operations Staff (*Mean Rank = 33.64, n = 18*) and Org B Maintenance Staff (*Mean Rank = 18.00, n = 16*). The results indicated a significant difference in the employees’ evaluation among the three groups, \( H \) (corrected for ties) = 9.583, \( df = 2 \), \( N = 51 \), Asymp. Sig. \( p \) = .008, Cohen’s \( f = .487 \).

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney \( U \) tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Operations Staff (*Mean Rank = 22.39, n = 18*) and Org B Maintenance Staff (*Mean Rank = 12.00, n = 16*), \( U = 56.00 \), \( z = -3.073 \), Asymp. Sig. \( p \) = .002, two-tailed, Exact Sig. \( p \) = .002, two-tailed.

*Interpretation:*

Org B Non-Frontline Staff and Org B Operations Staff thought *External Factors* were “Sometimes” observed as contributing to potential or actual safety problems in safety-critical areas at their workplace. On the other hand, ratings by Org B Maintenance Staff and Non-Org B Maintenance Staff tended towards “Quite Rarely”.

A Mann-Whitney \( U \) test indicated that Org B Operations Staff thought that *External Factors* were significantly more frequently observed as contributing to potential or actual safety problems than Org B Maintenance Staff.

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**Section A3 Evaluation of Overall Safety Measures**

**Demographics:**
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics.

- **Org B Non-Frontline Staff** (*n = 18*): This sample consisted of the following occupational groups: Admin, Finance or HR (*n = 2*), Engineering Design (*n = 2*), HSE or OHS (*n = 2*), Management (*n = 9*), Technical Training (*n = 2*) and Others in a non-frontline role (*n = 1*). Thirteen participants described themselves as working in a safety-critical area (72%). Sixteen participants were males (89%). The largest number was found in the 50-59 age group (*n = 7, 39%*), and at management level (*n = 9, 50%*).

- **Org B Operations Staff** (*n = 100*): All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49
age group \( (n = 34, 34\%) \) followed by the 50-59 age group \( (n = 28, 28\%) \). A majority were Team Members \( (n = 80, 80\%) \).

- **Org B Maintenance Staff \( (n = 43) \):** Forty-two participants described themselves as working in a safety-critical area (98%), and all were males (100%). The highest proportion was found in the 40-49 age group \( (n = 18, 42\%) \). A majority were Team Members \( (n = 35, 81\%) \).

- **Non-Org B Maintenance Staff \( (n = 39) \):** Thirty-five participants described themselves as working in a safety-critical area (90%), and all were males. The highest proportion was found in the 40-49 age group \( (n = 17, 44\%) \) followed by the 30-39 age group \( (n = 14, 36\%) \). More than half of this sample consisted of Team Members \( (n = 21, 55\%) \).

**Question and Statements:** Abbreviated as they are covered in the report for Organisation A.

**What the scores mean:**
Higher scores represented a higher evaluation of the adequacy of safety measures.

**Results:**
The distribution of the questionnaire item scores for the four groups is presented in Figure 5.14.

![Figure 5.14. Section A3 Adequate Safety Measures Overall? – Score distribution by group](image)

The following results reflect the participants’ evaluation at the time of the survey administration.
1. My Employer’s safety measures:

A total of twenty-two outliers were identified in the distribution of the mean scores categorised by group. One outlier from the Org B Non-Frontline Staff and another from the Org B Operations Staff samples were found to exceed –3 standard deviations below the mean scores and were removed from the data. The remainders were less than +/-3 standard deviations from the mean scores and were retained.

Descriptive Statistics:
The mean scores were 4.29 for Org B Non-Frontline Staff, 3.74 for Org B Operations Staff, 3.69 for Org B Maintenance Staff, and 3.80 for Non-Org B Maintenance Staff. The scores in the Non-Org B Maintenance Staff sample almost converged on the score of 4 “Agree”.

Inferential Statistics:
Comparisons within Org B
The scores were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-Frontline Staff (Mean Rank = 34.12, n = 17), Org B Operations Staff (Mean Rank = 20.62, n = 17) and Org B Maintenance Staff (Mean Rank = 23.26, n = 17). The results indicated a significant difference in the employees’ evaluation among the three groups, H (corrected for ties) = 8.814, df = 2, N = 51, Asymp. Sig. \( p = .012 \), Cohen’s \( f = .463 \).

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney U tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (Mean Rank = 22.21, n = 17) and Org B Operations Staff (Mean Rank = 12.79, n = 17), \( U = 64.50, z = -2.932 \), Asymp. Sig. \( p = .003 \), two-tailed, Exact Sig. \( p = .005 \), two-tailed.

Interpretation:
Org B Non-Frontline Staff clearly “Agreed” that their employer had adequate safety measures overall. The other groups more or less “Agreed”.

A Mann-Whitney U test indicated that Org B Operations Staff thought to a significantly lesser degree that their employer had adequate safety measures overall than Org B Non-Frontline Staff.

2. Safety Measures in the Rail Industry in General:

Two outliers were identified in the Org B Operations Staff sample. They were found to exceed –3 standard deviations below the mean score and were removed from the data. As a result, 24 outliers below and 14 outliers above the mean score emerged. They were found to be less than +/-3 standard deviations from the mean score and were retained in the data. One outlier in the Org B Maintenance Staff sample was found to be less than +/-3 standard deviations from the mean score and were retained in the data.

Descriptive Statistics:
The mean scores were 3.72 for Org B Non-Frontline Staff, 3.81 for Org B Operations Staff, 3.58 for Org B Maintenance Staff, and 3.82 for Non-Org B Maintenance Staff. The score distribution peaked at the score of 4 for all the samples.

*Interpretation:*
All groups more or less “Agreed” that safety measures of the rail industry overall was adequate.
Detailed Findings
Sections B1 to B7

Section B – Safety Culture Questions

The questions and statements in Section B have been adapted from the Hearts & Minds program by kind permission of Shell International Exploration and Production B. V. and the Energy Institute.

This section consisted of a total of 67 questions. They are categorised into seven distinct conceptual categories based on previous research (Parker et al., 2005). Factor analysis was carried out for each category.

Question and Statements: Abbreviated as they are covered in the report for Organisation A.

Section B1 Commitment Level of Workforce to HSE & Care for Colleagues

Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org B Non-Frontline Staff (n = 18):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 2), Engineering Design (n = 2), HSE or OHS (n = 2), Management (n = 9), Technical Training (n = 2) and Others in a non-frontline role (n = 1). Thirteen participants described themselves as working in a safety-critical area (72%). Sixteen participants were males (89%). The largest number was found in the 50-59 age group (n = 7, 39%), and at management level (n = 9, 50%).

- **Org B Operations Staff (n = 98):** All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (n = 33, 34%) followed by the 50-59 age group (n = 28, 29%). A majority were Team Members (n = 78, 82%).

- **Org B Maintenance Staff (n = 44):** Forty-two participants described themselves as working in a safety-critical area (96%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 18, 41%). A majority were Team Members (n = 35, 80%).

- **Non-Org B Maintenance Staff (n = 39):** Thirty-five participants described themselves as working in a safety-critical area (90%), and all were males. The highest proportion was found in the 40-49 age group (n = 17, 44%) followed by the 30-39 age group (n = 14, 36%). More than half of this sample consisted of Team Members (n = 21, 55%).

Statements:
Abbreviated as the topic is covered in the report for Organisation A in the previous section.

What the scores mean:
In response to the statements above, the scores reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration. Higher scores represented the participants’ evaluation of a higher level of workforce commitment to Health Safety & Environment and care for colleagues.

Results:
The distribution of mean scores across the items comprising this factor is presented in Figure 5.15.

The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

One outlier was identified in the Org B Operations Staff sample. It was found to exceed +3 standard deviations above the mean score and was removed from the data. As a result, two more outliers above the mean score emerged. They were found to be less than +3 standard deviations above the mean score and were retained.

**Descriptive Statistics:**
The mean scores were 3.50 for Org B Non-Frontline Staff, 2.98 for Org B Operations Staff, 3.21 for Org B Maintenance Staff, and 3.34 for Non-Org B Maintenance Staff.

**Interpretation:**
All groups more or less “Agreed” that people in their place of work were committed to Health, Safety and Environment and showed care for their colleagues. Although Org B Operations Staff’s ratings appeared lower than the Org B Maintenance Staff, the difference was not significant.
Section B2 Balance between HSE & Profitability

Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org B Non-Frontline Staff (n = 18):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 2), Engineering Design (n = 2), HSE or OHS (n = 2), Management (n = 9), Technical Training (n = 2) and Others in a non-frontline role (n = 1). Thirteen participants described themselves as working in a safety-critical area (72%). Sixteen participants were males (89%). The largest number was found in the 50-59 age group (n = 7, 37%), and at management level (n = 9, 50%).

- **Org B Operations Staff (n = 97):** All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (n = 32, 33%) followed by the 50-59 age group (n = 27, 28%). A majority were Team Members (n = 78, 83%).

- **Org B Maintenance Staff (n = 44):** Forty-two participants described themselves as working in a safety-critical area (96%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 18, 41%). A majority were Team Members (n = 35, 80%).

- **Non-Org B Maintenance Staff (n = 39):** Thirty-five participants described themselves as working in a safety-critical area (90%), and all were males. The highest proportion was found in the 40-49 age group (n = 17, 44%) followed by the 30-39 age group (n = 14, 36%). More than half of this sample consisted of Team Members (n = 21, 55%).

Statements:
Abbreviated as the topic is covered in the report for Organisation A in the previous section.

What the scores mean:
In response to the statements above, the scores reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration. Higher scores represented higher level of balance their organisation has achieved between Health Safety & Environment and Profitability.

Results:
The distribution of mean scores across the items comprising this factor is presented in Figure 5.16.
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Balance Achieved between HSE & Profitability:**

*Descriptive Statistics:*
The mean scores were 3.67 for Org B Non-Frontline Staff, 3.04 for Org B Operations Staff, 3.40 for Org B Maintenance Staff, and 3.41 for Non-Org B Maintenance Staff.

*Inferential Statistics:*

*Comparison within Org B*
The mean scores across the seven questions (9, 10 and 13 through to 17) were rank-ordered and a Kruskal-Wallis ANOVA was used to compare the ranks Org B Non-Frontline Staff (*Mean Rank* = 33.72, *n* = 18), Org B Operations Staff (*Mean Rank* = 19.78, *n* = 18) and Org B Maintenance Staff (*Mean Rank* = 29.00, *n* = 18). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 7.356, $df = 2$, $N = 54$, Asymp. Sig. $p = .025$, Cohen’s $f = .401$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney *U* tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (*Mean Rank* = 23.00, *n* = 18).
and Org B Operations Staff (\(Mean \text{ Rank} = 14.00, n = 18\)), \(U = 81.00, z = -2.570\), Asymp. Sig. \(p = .010\), two-tailed, Exact Sig. \(p = .010\), two-tailed.

**Interpretation:**

Org B Operations Staff “Neither Agreed nor Disagreed” that their organisation had achieved balance between Health, Safety and Environment and profitability. On the other hand, the other three groups generally “Agreed”.

A Mann-Whitney \(U\) test indicated that Org B Operations Staff thought to a significantly lesser degree that their organisation had achieved balance between Health, Safety and Environment and profitability than Org B Maintenance Staff.

**Section B3 Workforce Interest in Competency & Training**

**Demographics:**

Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org B Non-Frontline Staff (\(n = 18\)):** This sample consisted of the following occupational groups: Admin, Finance or HR (\(n = 2\)), Engineering Design (\(n = 2\)), HSE or OHS (\(n = 2\)), Management (\(n = 9\)), Technical Training (\(n = 2\)) and Others in a non-frontline role (\(n = 1\)). Thirteen participants described themselves as working in a safety-critical area (72%). Sixteen participants were males (89%). The largest number was found in the 50-59 age group (\(n = 7, 39\%\)), and at management level (\(n = 9, 50\%\)).

- **Org B Operations Staff (\(n = 98\)):** All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (\(n = 34, 35\%\)) followed by the 50-59 age group (\(n = 28, 29\%\)). A majority were Team Members (\(n = 79, 83\%\)).

- **Org B Maintenance Staff (\(n = 43\)):** Forty-one participants described themselves as working in a safety-critical area (95%), and all were males (100%). The highest proportion was found in the 40-49 age group (\(n = 17, 40\%\)). A majority were Team Members (\(n = 34, 79\%\)).

- **Non-Org B Maintenance Staff (\(n = 38\)):** Thirty-four participants described themselves as working in a safety-critical area (90%), and all were males. The highest proportion was found in the 40-49 age group (\(n = 17, 45\%\)) followed by the 30-39 age group (\(n = 13, 34\%\)). More than half of this sample consisted of Team Members (\(n = 20, 54\%\)).

**Statements:**

Abbreviated as the topic is covered in the report for Organisation A in the previous section.

**What the scores mean:**

Higher scores represented greater recognition of the importance of competency and training in their organisation.

**Results:**
The distribution of mean scores across the items comprising this factor is presented in Figure 5.17.

Figure 5.17. Section B3 Workforce Interest in Competency and Training – Distribution of factor-based mean scores by group
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Importance of Competency & Training Recognised:**

*Descriptive Statistics:*
The mean scores were 3.71 for Org B Non-Frontline Staff, 3.21 for Org B Operations Staff, 3.28 for Org B Maintenance Staff, and 3.39 for Non-Org B Maintenance Staff.

*Inferential Statistics:*
**Comparison within Org B**
The mean scores across the seven questions (22, 23, and 25 through to 29) were rank-ordered and a Kruskal-Wallis ANOVA was used to compare the ranks among Org B Non-Frontline Staff (*Mean Rank* = 36.00, *n* = 18), Org B Operations Staff (*Mean Rank* = 22.92, *n* = 18) and Org B Maintenance Staff (*Mean Rank* = 23.58, *n* = 18). The results indicated a significant difference in the employees’ evaluation among the three groups, *H* (corrected for ties) = 7.955, *df* = 2, *N* = 54, Asymp. Sig. *p* = .019, Cohen’s *f* = .402.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney *U* tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (*Mean Rank* = 22.83, *n* = 18) and Org B Operations Staff (*Mean Rank* = 14.17, *n* = 18), *U* = 84.00, *z* = -2.479, Asymp. Sig. *p* = .013, two-tailed, Exact Sig. *p* = .013, two-tailed.

*Interpretation:*
Org B Operations Staff “Neither Agreed nor Disagreed” that people in their organisation recognised the importance of competency and training. The other three groups more or less “Agreed”.

A Mann-Whitney *U* test indicated that Org B Operations Staff thought to a significantly lesser degree that people in their organisation recognised the importance of competency and training than the Org B Non-Frontline Staff.

**Section B4 Work-site Safety Controls**

**Demographics:**
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org B Non-Frontline Staff** (*n* = 17): This sample consisted of the following occupational groups: Admin, Finance or HR (*n* = 1), Engineering Design (*n* = 2), HSE or OHS (*n* = 2), Management (*n* = 9), Technical Training (*n* = 2) and Others in a non-frontline role (*n* = 1). Thirteen participants described themselves as working in a safety-critical area (77%). Fifteen participants were males (88%). The largest number was found in the 50-59 age group (*n* = 7, 37%), and at management level (*n* = 9, 53%).
• **Org B Operations Staff** \((n = 96)\): All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group \((n = 33, 34\%)\) followed by the 50-59 age group \((n = 27, 28\%)\). A majority were Team Members \((n = 77, 82\%)\).

• **Org B Maintenance Staff** \((n = 44)\): Forty-two participants described themselves as working in a safety-critical area (96%), and all were males (100%). The highest proportion was found in the 40-49 age group \((n = 18, 41\%)\). A majority were Team Members \((n = 35, 80\%)\).

• **Non-Org B Maintenance Staff** \((n = 37)\): Thirty-three participants described themselves as working in a safety-critical area (89%), and all were males. The highest proportion was found in the 40-49 age group \((n = 17, 46\%)\) followed by the 30-39 age group \((n = 12, 32\%)\). More than half of this sample consisted of Team Members \((n = 19, 53\%)\).

**What the scores mean:**
Higher scores represented greater effectiveness of their organisation’s safety control.

**Results:**
The distribution of mean scores across the items comprising this factor is presented in Figure 5.18.

*Figure 5.18. Section B4 Work-site Safety Controls – Distribution of factor-based mean scores by group*
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Effective Safety Controls:**

*Descriptive Statistics:*
The mean scores were 3.67 for Org B Non-Frontline Staff, 3.31 for Org B Operations Staff, 3.26 for Org B Maintenance Staff, and 3.61 for Non-Org B Maintenance Staff.

*Inferential Statistics:*
Comparison between Org B Maintenance and Non-Org B Maintenance Staff

A further Mann-Whitney U test was used to compare the ranks for Org B Maintenance Staff (Mean Rank = 35.34, n = 44) versus Non-Org B Maintenance Staff (Mean Rank = 47.73, n = 37). The results revealed a significant difference in the participants’ evaluation between the two samples, $U = 565.00$, $z = -2.368$, Asymp. Sig. $p = .018$, two-tailed.

*Interpretation:*
Org B Non-Frontline Staff and Non-Org B Maintenance Staff more or less “Agreed” that their organisation had effective safety controls. On the other hand, ratings by Org B Operations Staff and Org B Maintenance Staff were mostly “Neither Agree nor Disagree”.

A Mann-Whitney $U$ test indicated that Org B Maintenance Staff thought to a significantly lesser degree that their organisation had effective safety controls than Non-Org B Maintenance Staff thought of their respective organisations.

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**Section B5 Purpose of HSE Procedures**

**Demographics:**
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics.

- **Org B Non-Frontline Staff (n = 17):** This sample consisted of the following occupational groups: Admin, Finance or HR (n = 2), Engineering Design (n = 2), HSE or OHS (n = 1), Management (n = 9), Technical Training (n = 2) and Others in a non-frontline role (n = 1). Thirteen participants described themselves as working in a safety-critical area (77%). Sixteen participants were males (94%). The largest number was found in the 50-59 age group (n = 6, 35%), and at management level (n = 8, 47%).

- **Org B Operations Staff (n = 97):** All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (n = 34, 35%) followed by the 50-59 age group (n = 28, 29%). A majority were Team Members (n = 78, 82%).

- **Org B Maintenance Staff (n = 43):** Forty-one participants described themselves as working in a safety-critical area (95%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 18, 42%). A majority were Team Members (n = 34, 79%).
- **Non-Org B Maintenance Staff** ($n = 36$): Thirty-two participants described themselves as working in a safety-critical area (89%), and all were males. The highest proportion was found in the 40-49 age group ($n = 16$, 44%) followed by the 30-39 age group ($n = 12$, 33%). More than half of this sample consisted of Team Members ($n = 19$, 54%).

**What the scores mean:**
Factor 1 addressed a positive aspect of HSE procedures. Higher mean scores represented the participants’ evaluation that the organisation has achieved greater balance between procedures and efficiency. On the other hand, Factor 2 addressed a negative aspect. Higher scores represented the participants’ evaluation of more negative views held by their organisation with regard to HSE procedures.

**Results:**
The distribution of mean scores across the items comprising each factor is presented in Figure 5.19.

![Figure 5.19](image-url)

**Figure 5.19.** Section B5  Purpose of HSE Procedures – Distribution of factor-based mean scores by group
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Balance Achieved between HSE Procedures & Efficiency:**

One outlier was identified in the Org B Operations Staff sample. It was found to exceed +3 standard deviations above the mean score and thus was removed from the data. Another outlier was identified in the Org B Non-Frontline Staff sample. It was found to be less than +3 standard deviations above the mean, and was retained.

*Descriptive Statistics:*
The mean scores were 3.31 for Org B Non-Frontline Staff, 3.04 for Org B Operations Staff, 3.06 for Org B Maintenance Staff, and 3.20 for Non-Org B Maintenance Staff.

*Inferential Statistics:*
Comparison within Org B
The mean scores across the five questions (36, 37, 41, 44 and 45) were rank-ordered and a Kruskal-Wallis ANOVA was used to compare the ranks among Org B Non-Frontline Staff (*Mean Rank* = 33.38, *n* = 17), Org B Operations Staff (*Mean Rank* = 22.53, *n* = 17) and Org B Maintenance Staff (*Mean Rank* = 22.09, *n* = 17). The results indicated a significant difference in the employees’ evaluation among the three groups, *H* (corrected for ties) = 6.421, *df* = 2, *N* = 51, Asymp. Sig. *p* = .04, Cohen’s *f* = .384.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney *U* tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (*Mean Rank* = 21.71, *n* = 17) and Org B Maintenance Staff (*Mean Rank* = 13.29, *n* = 17), *U* = 73.00, *z* = -2.487, Asymp. Sig. *p* = .013, two-tailed, Exact Sig. *p* = .013, two-tailed.

*Interpretation:*
Org B Non-Frontline Staff moderately “Agreed” that their organisation had *achieved balance between Health, Safety and Environment procedures and efficiency*. The other three groups “Neither Agreed nor Disagreed”.

A Mann-Whitney *U* test indicated that Org B Non-Frontline Staff thought to a significantly greater extent that their organisation had *achieved balance between Health, Safety and Environment procedures and efficiency* than Org B Maintenance Staff.

**Factor 2. Negative views on HSE Procedures:**

Two outliers were found in the Org B Non-Frontline Staff sample. They were less than +/-3 standard deviations away from the mean score and were retained. One outlier was found in the Org B Maintenance Staff sample. It was found to exceed –3 standard deviations below the mean score and was removed from the data.

*Descriptive Statistics:*
The mean scores were 3.03 for Org B Non-Frontline Staff, 3.53 for Org B Operations Staff, 3.33 for Org B Maintenance Staff, and 3.06 for Non-Org B Maintenance Staff.

**Inferential Statistics:**

**Comparison within Org B**

The mean scores across the five questions (40, 42 and 43) were rank-ordered and a Kruskal-Wallis ANOVA was used to compare the ranks among Org B Non-Frontline Staff (*Mean Rank* = 19.29, *n* = 17), Org B Operations Staff (*Mean Rank* = 33.06, *n* = 17) and Org B Maintenance Staff (*Mean Rank* = 25.65, *n* = 17). The results indicated a significant difference in the employees’ evaluation among the three groups, *H*(corrected for ties) = 7.446, *df* = 2, *N* = 51, Asymp. Sig. *p* = .024, Cohen’s *f* = .418.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney *U* tests were conducted for pairwise comparisons.

At first glance, the difference in the employees’ evaluation between Org B Non-Frontline Staff (*Mean Rank* = 13.56, *n* = 17) and Org B Operations Staff (*Mean Rank* = 21.44, *n* = 17) appeared significant with *U* = 77.00, *z* = -2.324, Asymp. Sig. *p* = .020, two-tailed, Exact Sig. *p* = .020, two-tailed. However, due to the Bonferroni adjustment, the result was regarded as not significant.

**Interpretation:**

Org B Non-Frontline Staff and Non-Org B Maintenance Staff “Neither Agreed nor Disagreed” that their organisation and employees had negative views on Health, Safety and Environment procedures. Org B Operations Staff and Org B Maintenance Staff’s ratings tended towards “Agree”. Although Org B Operations Staff’s ratings appeared higher than the Org B Non-Frontline Staff, the difference was not significant.

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**Section B6 Repercussion & Feedback after Accidents**

**Demographics:**

Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org B Non-Frontline Staff (n = 18):** This sample consisted of the following occupational groups: Admin, Finance or HR (*n* = 2), Engineering Design (*n* = 2), HSE or OHS (*n* = 2), Management (*n* = 9), Technical Training (*n* = 2) and Others in a non-frontline role (*n* = 1). Thirteen participants described themselves as working in a safety-critical area (72%). Sixteen participants were males (89%). The largest number was found in the 50-59 age group (*n* = 7, 39%), and at management level (*n* = 9, 50%).

- **Org B Operations Staff (n = 97):** All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (*n* = 33, 34%) followed by the 50-59 age group (*n* = 28, 29%). A majority were Team Members (*n* = 79, 83%).

- **Org B Maintenance Staff (n = 43):** Forty-one participants described themselves as working in a safety-critical area (95%), and all were males (100%). The highest proportion...
was found in the 40-49 age group \((n = 18, 42\%)\). A majority were Team Members \((n = 34, 79\%)\).

- **Non-Org B Maintenance Staff \((n = 38)\):** Thirty-four participants described themselves as working in a safety-critical area \((90\%)\), and all were males. The highest proportion was found in the 40-49 age group \((n = 17, 45\%)\) followed by the 30-39 age group \((n = 13, 34\%).\) More than half of this sample consisted of Team Members \((n = 20, 54\%)\).

**What the scores mean:**

Factor 1 addressed a negative response to accidents. Higher scores represented the participants’ evaluation of more reactive, rather than proactive, style of responding to accidents characterised by a tendency to apportion blame to those who were directly involved in the accidents rather than investigating systemic issues.

On the other hand, Factor 2 addressed a positive aspect. Higher scores represented the participants’ evaluation of a more constructive approach by management in response to accidents.

**Results:** The distribution of mean scores across the items comprising each factor is presented in Figure 5.20.

![Figure 5.20](image)

**Figure 5.20.** Section B6 Repercussion and Feedback after Accidents – Distribution of factor-based mean scores by group
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Reactivity – Blame Culture:**
One outlier was found in the Org B Operations Staff sample. It was found to exceed –3 standard deviations below the mean score and was removed from the data. As a result, a secondary outlier emerged. It was found to be less than –3 standard deviations below the mean score and was retained.

*Descriptive Statistics:*
The mean scores were 3.23 for Org B Non-Frontline Staff, 3.85 for Org B Operations Staff, 3.25 for Org B Maintenance Staff, and 3.16 for Non-Org B Maintenance Staff.

*Inferential Statistics:*
**Comparison within Org B**
The mean scores across the four questions (48, 51, 53 and 55) were rank-ordered and a Kruskal-Wallis ANOVA was used to compare the ranks among Org B Non-Frontline Staff (*Mean Rank* = 24.36, *n* = 18), Org B Operations Staff (*Mean Rank* = 36.03, *n* = 18) and Org B Maintenance Staff (*Mean Rank* = 22.11, *n* = 18). A Mann-Whitney *U* test indicated a significant difference in the employees’ evaluation among the three groups, *H* (corrected for ties) = 8.190, *df* = 2, *N* = 54, Asymp. Sig. *p* = .017, Cohen’s *f* = .428.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney *U* tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Operations Staff (*Mean Rank* = 23.56, *n* = 18) and Org B Maintenance Staff (*Mean Rank* = 13.44, *n* = 18), *U* = 71.00, *z* = -2.894, Asymp. Sig. *p* = .004, two-tailed, Exact Sig. *p* = .003, two-tailed.

*Interpretation:*
Org B Operations Staff generally “Agreed” that their organisation was *reactive rather than proactive in its response to accidents*, characterised by a tendency to blame those who were directly involved. The evaluation by the other three groups was mostly “Neither Agree nor Disagree”.

A Mann-Whitney *U* test indicated that Org B Operations Staff thought that their organisation was *significantly more reactive rather than proactive in its response to accidents* than Org B Maintenance Staff.

**Factor 2. Constructive Management Response to Accidents:**

*Descriptive Statistics:*
The mean scores were 3.74 for the Org B Non-Frontline Staff, 3.39 for the Org B Operations Staff, 3.45 for the Org B Maintenance Staff, and 3.66 for the Non-Org B Maintenance Staff.

*Interpretation:*
Org B Non-Frontline Staff generally “Agreed” that their organisation’s management demonstrated a constructive response to accidents. Org B Operations Staff, Org B Maintenance Staff and Non-Org B Maintenance Staff more or less “Agreed”. Although Org B Maintenance Staff’s overall ratings appeared lower than the Non-Org B Maintenance Staff, the difference was not significant.

### Section B7 Safety Audits & Reviews

#### Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics:

- **Org B Non-Frontline Staff** ($n = 17$): This sample consisted of the following occupational groups: Admin, Finance or HR ($n = 1$), Engineering Design ($n = 2$), HSE or OHS ($n = 2$), Management ($n = 9$), Technical Training ($n = 2$) and Others in a non-frontline role ($n = 1$). Thirteen participants described themselves as working in a safety-critical area (77%). Fifteen participants were males (88%). The largest number was found in the 50-59 age group ($n = 7, 41\%$), and at management level ($n = 9, 53\%$).

- **Org B Operations Staff** ($n = 90$): All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group ($n = 29, 32\%$) followed by the 50-59 age group ($n = 27, 30\%$). A majority were Team Members ($n = 71, 81\%$).

- **Org B Maintenance Staff** ($n = 40$): Thirty-nine participants described themselves as working in a safety-critical area (98%), and all were males (100%). The highest proportion was found in the 40-49 age group ($n = 16, 40\%$). A majority were Team Members ($n = 32, 80\%$).

- **Non-Org B Maintenance Staff** ($n = 34$): Thirty participants described themselves as working in a safety-critical area (88%), and all were males. The highest proportion was found in the 40-49 age group ($n = 15, 44\%$) followed by the 30-39 age group ($n = 12, 35\%$). More than half of this sample consisted of Team Members ($n = 17, 52\%$).

#### What the scores mean:
Higher scores represented a more proactive approach to HSE audits.

#### Results:
The distribution of mean scores across the items comprising this factor is presented in Figure 5.21.
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

**Factor 1. Proactive Approach to HSE Audits & Reviews:**
One outlier was identified in the Org B Operations Staff sample. It was found to exceed +3 standard deviations above the mean score and was removed from the data. As a result, a secondary outlier emerged. It was found to be less than +3 standard deviations above the mean score and was retained as it appeared to fit with the overall shape of the distribution.

**Descriptive Statistics:**
The mean scores were 3.67 for Org B Non-Frontline Staff, 2.94 for Org B Operations Staff, 3.20 for Org B Maintenance Staff, and 3.41 for Non-Org B Maintenance Staff.

**Inferential Statistics:**
Comparison between Org B Operations and Org B Maintenance Staff
The mean scores across the eight questions (58 through to 63, 65 and 66) were rank-ordered and a Kruskal-Wallis ANOVA was used to compare the ranks among Org B Non-Frontline Staff (Mean Rank = 36.59, \(n = 17\)), Org B Operations Staff (Mean Rank = 17.97, \(n = 17\)) and Org B Maintenance Staff (Mean Rank = 23.44, \(n = 17\)). The results indicated a significant difference in the employees’ evaluation among the three groups, \(H\) (corrected for ties) = 14.154, \(df = 2\), \(N = 51\), Asymp. Sig. \(p = .001\), Cohen’s \(f = .628\).
Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons.

The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff ($Mean \ Rank = 23.35, n = 17$) and Org B Operations Staff ($Mean \ Rank = 11.65, n = 17$), $U = 45.00, z = -3.438$, Asymp. Sig. $p = .001$, two-tailed, Exact Sig. $p = .000$, two-tailed.

A significant difference was also found between Org B Non-Frontline Staff ($Mean \ Rank = 22.24, n = 17$) and Org B Maintenance Staff ($Mean \ Rank = 12.76, n = 17$), $U = 64.00, z = -2.782$, Asymp. Sig. $p = .005$, two-tailed, Exact Sig. $p = .005$, two-tailed.

*Interpretation:*

Org B Non-Frontline Staff generally “Agreed” that their organisation demonstrated *a proactive approach to HSE audits and reviews*. The other groups generally responded “Neither Agree nor Disagree”.

Mann-Whitney $U$ tests indicated that Org B Non-Frontline Staff thought *to a significantly greater degree* that their organisation demonstrated *a proactive approach to HSE audits and reviews* than (a) Org B Operations Staff; and (b) Org B Maintenance Staff.
Detailed Findings
Section C

Section C  Who Drives Safety ?

Demographics:
Data obtained from the following four groups were analysed. They had the following employment and demographic characteristics.

▪ Org B Non-Frontline Staff (n = 18): This sample consisted of the following occupational groups: Admin, Finance or HR (n = 2), Engineering Design (n = 2), HSE or OHS (n = 2), Management (n = 9), Technical Training (n = 2) and Others in a non-frontline role (n = 1). Thirteen participants described themselves as working in a safety-critical area (72%). Sixteen participants were males (89%). The largest number was found in the 50-59 age group (n = 7, 39%), and at management level (n = 9, 50%).

▪ Org B Operations Staff (n = 89): All participants described themselves as working in a safety-critical area, and were males (100%). The highest proportion was found in the 40-49 age group (n = 30, 34%) followed by the 50-59 age group (n = 25, 28%). A majority were Team Members (n = 70, 81%).

▪ Org B Maintenance Staff (n = 43): Forty-one participants out of 43 described themselves as working in a safety-critical area (95%), and all were males (100%). The highest proportion was found in the 40-49 age group (n = 18, 42%). A majority were Team Members (n = 34, 79%).

▪ Non-Org B Maintenance Staff (n = 32): Twenty-eight participants described themselves as working in a safety-critical area (88%), and all were males. The highest proportion was found in the 40-49 age group (n = 14, 44%) followed by the 30-39 age group (n = 11, 34%). More than half of this sample consisted of Team Members (n = 15, 48%).

Question: Presented in the report for Organisation A in the previous section.
The response scale is presented below.

<table>
<thead>
<tr>
<th>Not applicable</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

What the scores mean:
Higher scores represented a higher evaluation of the role played by that particular entity in driving safety.

Results:
The distribution of the questionnaire item scores for the four groups is presented in Figure 5.22.
Figure 5.22. Section C – Score distribution by group
The following results reflect the participants’ evaluation of the situation at their respective workplace at the time of the survey administration.

1. Board Directors:

Descriptive Statistics:
The mean scores were 4.33 for Org B Non-Frontline Staff, 3.49 for Org B Operations Staff, 3.32 for Org B Maintenance Staff, and 3.65 for Non-Org B Maintenance Staff.

Inferential Statistics:

Comparison within Org B
The scores were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-Frontline Staff (Mean Rank = 34.92, n = 18), Org B Operations Staff (Mean Rank = 25.15, n = 17) and Org B Maintenance Staff (Mean Rank = 16.88, n = 16). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 13.547, $df = 2$, $N = 51$, Asymp. Sig. $p = .001$, Cohen’s $f = .610$.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney $U$ tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (Mean Rank = 23.19, $n = 18$) and Org B Maintenance Staff (Mean Rank = 11.09, $n = 16$). $U = 41.50$, $z = -3.680$, Asymp. Sig. $p = .000$, two-tailed, Exact Sig. $p = .000$, two-tailed.

Interpretation:
Org B Non-Frontline Staff clearly “Agreed” with the importance of the role played by the Board of Directors, while Org B Operations Staff and Non-Org B Maintenance Staff more or less “Agreed”. Org B Maintenance Staff tended to “Neither Agree nor Disagree”.

A Mann-Whitney $U$ test indicated that Org B Non-Frontline Staff’s level of “Agreement” was significantly higher than that of Org B Maintenance Staff about the role of the Board of Directors in driving safety in their workplace.

2. Customers/Passengers:

Descriptive Statistics:
The mean scores were 4.00 for Org B Non-Frontline Staff, 3.12 for Org B Operations Staff, 3.37 for Org B Maintenance Staff, and 3.17 for Non-Org B Maintenance Staff.

Inferential Statistics:

Comparison within Org B
The scores were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-Frontline Staff (Mean Rank = 32.38, $n = 16$), Org B Operations Staff (Mean Rank = 18.81, $n = 16$) and Org B Maintenance Staff (Mean Rank = 20.60, $n = 15$). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 10.417, $df = 2$, $N = 47$, Asymp. Sig. $p = .005$, Cohen’s $f = .541$. 
Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney U tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (Mean Rank = 21.00, n = 16) and Org B Operations Staff (Mean Rank = 12.00, n = 16), U = 56.00, z = -2.879, Asymp. Sig. p = .004, two-tailed, Exact Sig. p = .006, two-tailed.

A significant difference was also found between Org B Non-Frontline Staff (Mean Rank = 19.88, n = 16) and Org B Maintenance Staff (Mean Rank = 11.87, n = 15), U = 58.00, z = -2.592, Asymp. Sig. p = .010, two-tailed, Exact Sig. p = .014, two-tailed.

Interpretation:
Org B Non-Frontline Staff generally “Agreed” that Customers/Passengers played an important role in driving safety in their workplace. The other three groups’ ratings were mainly “Neither Agree nor Disagree”.

Mann-Whitney U tests indicated that Org B Non-Frontline Staff’s level of “Agreement” was significantly higher than that of (a) Org B Operations Staff, and (b) Org B Maintenance Staff about the role of Customers/Passengers in driving safety in their workplace.

3. Legislation:
One outlier was identified in the Org B Operations Staff sample. It was found to exceed –3 standard deviations below the mean score and thus was removed from the data. Eighteen extreme scores (9 below and 9 above the mean score) were found in the Org B Maintenance Staff sample. Eight extreme scores (4 below and 4 above the mean score) were found in the Non-Org B Maintenance Staff sample. They were found to be less than +/-3 standard deviations from the mean scores and were retained.

Descriptive Statistics:
The mean scores were 4.50 for Org B Non-Frontline Staff, 4.18 for Org B Operations Staff, 3.98 for Org B Maintenance Staff, and 4.00 for Non-Org B Maintenance Staff. More than half (55%) of Org B Non-Frontline Staff selected the score of 5 “Strongly Agree”. A great majority of the scores for Org B Maintenance and Non-Maintenance Staff converged on the value of 4 “Agree”.

Inferential Statistics:
Comparison within Org B
The scores were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-Frontline Staff (Mean Rank = 33.58, n = 18), Org B Operations Staff (Mean Rank = 28.00, n = 18) and Org B Maintenance Staff (Mean Rank = 20.92, n = 18). The results indicated a significant difference in the employees’ evaluation among the three groups, $H$ (corrected for ties) = 6.770, df = 2, N = 54, Asymp. Sig. p = .034, Cohen’s $f$ = .383.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney U tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (Mean Rank = 22.72, n = 18).
and Org B Maintenance Staff (Mean Rank = 14.28, n = 18), U = 86.00, z = -2.572, Asymp. Sig. p = .010, two-tailed, Exact Sig. p = .016, two-tailed.

Interpretation:
Org B Non-Frontline “Strongly Agreed” that Legislation played an important role in driving safety in their workplace. The other three groups “Agreed”.

A Mann-Whitney U test indicated that Org B Non-Frontline Staff’s level of “Agreement” was significantly higher than that of Org B Maintenance Staff about the role of Legislation in driving safety in their workplace.

4. Management:
Fourteen extreme scores were found in the Org B Maintenance sample. One was removed from the data, as it was found to exceed –3 standard deviations below the mean score. The other thirteen extreme scores (9 below and 4 above the mean score) were found to be less than +/-3 standard deviations from the mean score, and thus were retained. A majority (67.4%) of the scores converged on the value of 4.

A majority (59.4%) of the scores for Non-Org B Maintenance Staff converged on the value of 4.

Descriptive Statistics:
The mean scores were 4.33 for Org B Non-Frontline Staff, 3.87 for Org B Operations Staff, 3.90 for Org B Maintenance Staff, and 4.00 for Non-Org B Maintenance Staff.

Inferential Statistics:
Comparison within Org B
The scores were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among Org B Non-Frontline Staff (Mean Rank = 34.33, n = 18), Org B Operations Staff (Mean Rank = 27.00, n = 18) and Org B Maintenance Staff (Mean Rank = 21.17, n = 18). The results indicated a significant difference in the employees’ evaluation among the three groups, H (corrected for ties) = 8.342, df = 2, N = 54, Asymp. Sig. p = .015, Cohen’s f = .432.

Further tests were conducted in order to identify where the difference was located. Three separate Mann-Whitney U tests were conducted for pairwise comparisons. The results revealed a significant difference (with a Bonferroni adjusted alpha level) in the employees’ evaluation between Org B Non-Frontline Staff (Mean Rank = 22.83, n = 18) and Org B Maintenance Staff (Mean Rank = 14.17, n = 18), U = 84.00, z = -2.783, Asymp. Sig. p = .005, two-tailed, Exact Sig. p = .013, two-tailed.

Interpretation:
Org B Non-Frontline “Strongly Agreed” that Management played an important role in driving safety in their workplace. The other three groups “Agreed”.

A Mann-Whitney U test indicated that Org B Non-Frontline Staff’s level of “Agreement” was significantly higher than that of Org B Maintenance Staff about the role of Management in driving safety in their workplace.

5. Myself:
Descriptive Statistics:
The mean scores were 4.61 for Org B Non-Frontline Staff, 4.30 for Org B Operations Staff, 4.10 for Org B Maintenance Staff, and 4.22 for Non-Org B Maintenance Staff. More than half (65%) of Org B Non-Frontline Staff selected the score of 5 “Strongly Agree”.

**Interpretation:**
Org B Non-Frontline “Strongly Agreed” that *They Themselves* played an important role in driving safety in their workplace. The other three groups “Agreed”.

**6. Public Opinion:**
*Descriptive Statistics:*
The mean scores were 3.81 for Org B Non-Frontline Staff, 3.24 for Org B Operations Staff, 3.38 for Org B Maintenance Staff, and 3.22 for Non-Org B Maintenance Staff.

**Interpretation:**
Org B Non-Frontline more or less “Agreed” that Public Opinion played an important role in driving safety in their workplace. The other three groups’ ratings were mainly “Neither Agree nor Disagree”.

**7. Rail Safety Regulators:**
Two outliers were found in the Org B Operations Staff sample. They were found to exceed –3 standard deviations below the mean score and thus were removed. One outlier was found in the Org B Maintenance Staff sample. It was removed as it exceeded –3 standard deviations below the mean score. A total of six outliers were found in the Non-Org B Maintenance Staff sample. They were less than –3 standard deviations below the mean score, and were retained.

*Descriptive Statistics:*
The mean scores were 4.52 for Org B Non-Frontline Staff, 4.27 for Org B Operations Staff, 4.20 for Org B Maintenance Staff, and 4.06 for Non-Org B Maintenance Staff. More than half (56%) of Org B Non-Frontline Staff selected the score of 5 “Strongly Agree”.

**Interpretation:**
Org B Non-Frontline “Strongly Agreed” that Rail Safety Regulators played an important role in driving safety in their workplace. The other three groups “Agreed”.

**8. Health, Safety & Environment (HSE) or OSH Department:**
*Descriptive Statistics:*
The mean scores were 4.11 for Org B Non-Frontline Staff, 4.13 for Org B Operations Staff, 4.00 for Org B Maintenance Staff, and 4.06 for Non-Org B Maintenance Staff. Nearly half of the scores in the Org B Maintenance Staff group converged on the value of 4 “Agree”.

**Interpretation:**
All groups generally “Agreed” that the Health Safety & Environment (HSE) or OSH Department played an important role in driving safety in their workplace.

**9. Safety-Critical Workers:**
Descriptive Statistics:
The mean scores were 3.83 for Org B Non-Frontline Staff, 3.99 for Org B Operations Staff, 3.90 for Org B Maintenance Staff, and 4.03 for the Non-Org B Maintenance Staff.

Interpretation:
All groups generally “Agreed” that Safety-Critical Workers played an important role in driving safety in their workplace.

10. Trade Unions:

Descriptive Statistics:
The mean scores were 3.83 for Org B Non-Frontline Staff, 3.98 for Org B Operations Staff, 3.92 for Org B Maintenance Staff, and 3.23 for Non-Org B Maintenance Staff.

Inferential Statistics:
Comparison between Org B Operations and Org B Maintenance Staff
The scores for this question item were rank-ordered and a Mann-Whitney U test was used to compare the ranks for Org B Operations Staff (Mean Rank = 67.37, n = 89) versus Org B Maintenance Staff (Mean Rank = 61.45, n = 41). The results revealed no significant difference.

Comparison between Org B Maintenance and Non-Org B Maintenance Staff
A further Mann-Whitney U test was used to compare the ranks for Org B Maintenance Staff (Mean Rank = 43.10, n = 41) versus Non-Org B Maintenance Staff (Mean Rank = 27.77, n = 31). The results revealed a significant difference in the participants’ evaluation between the two samples, \( U = 365.00, z = -3.258, \) Asymp. Sig. \( p = .001, \) two-tailed.

Interpretation:
All Org B groups “Agreed” that Trade Unions played an important role in driving safety in their workplace. The evaluation by Non-Org B Maintenance Staff mostly ranged between “Neither Agree nor Disagree” and “Agree”.

A Mann-Whitney U test indicated that Org B Maintenance Staff acknowledged the role of Trade Unions in driving safety in their workplace significantly more than Non-Org B Maintenance Staff.

Section C Summary

As can be seen in Figure 5.22, Org B Non-Frontline Staff’s ratings tended to be higher than the other three groups. However, the pattern of the evaluation was generally similar across the four groups.

- The four groups unanimously “Agreed” that They Themselves, the Rail Safety Regulators, the HSE/OSH Department, and Safety-Critical Workers played an important role in driving safety at their workplace. On the other hand, they recognised the role of Customers/Passengers, Public Opinion, and Trade Unions to a lesser degree ranging from “Neither Agree nor Disagree” to more or less “Agree”.
- Org B Non-Frontline Staff was the only group that answered “Strongly Agree” to any of the questions. The entities they rated with the top score were the Legislation, Management, They Themselves and the Rail Safety Regulators.
Org B Non-Frontline Staff clearly “Agreed” with the importance of the role played by the Board of Directors, while the other three groups more or less “Agreed”.

While Org B Non-Frontline Staff mostly “Agreed” that Customers/Passengers played an important role in driving safety in their workplace, Org B Maintenance Staff “Agreed” to a lesser degree, tending towards “Neither Agree nor Disagree”. A majority of Org B Operations and Non-Org B Maintenance Staff answered “Neither Agree nor Disagree”.

Org B Non-Frontline Staff, Org B Operations Staff and Org B Maintenance Staff “Agreed” that Trade Unions played an important role in driving safety in their workplace. The evaluation by Non-Org B Maintenance Staff tended towards “Neither Agree nor Disagree”.

A statistically significant difference was seen between Org B Maintenance Staff and Non-Org B Maintenance Staff with regard to the role of Trade Unions. Org B Maintenance staff acknowledged the role of Trade Unions in driving safety in their workplace by answering “Agree”, while Non-Org B Maintenance Staff sample’s ratings tended towards “Neither Agree nor Disagree”. This suggested that Org B Maintenance Staff acknowledged the role of Trade Unions in driving safety in their workplace more than Non-Org B Maintenance Staff.

Summary

This chapter presented excerpts from two of the six confidential reports prepared for each organisation, who participated in the current research project. Group differences in the safety climate and culture factors were demonstrated. The following chapter presents the results of further statistical analyses for the entire sample.
CHAPTER 6
Results of Prediction Analyses

Group differences were evident in many of the safety climate/culture factors in the between-group comparisons conducted for the organisation-based reports in Chapter 5. Further statistical analyses were conducted on the total sample to examine whether group differences could be found in the evaluation of safety climate/culture factors regardless of the organisation to which the participants belonged. Furthermore, three types of prediction analysis were conducted in order to examine whether safety climate/culture scores would predict safety outcomes pertaining to the experience of accidents, near misses and the reporting of safety defects.

This chapter is structured in the following manner: Section 6.1 presents the results of the differences between occupational groups within the entire dataset. Section 6.2 presents the results of three types of prediction analyses consisting of: 1) Discriminant Function Analyses; 2) Chi-Squared Automatic Interaction Detection (CHAID); and 3) Multiple Regression Analyses.

Data Preparation

The current section outlines the process of preparing data to facilitate prediction analyses. This is followed by the results of three types of prediction analysis using the factor variables generated through the previous Principal Axis Factoring computations (Analyses 1 to 20) as outlined in Chapter 4.

In the prediction analysis, factor variables from Sections A1, A2 and B were used as predictors. The sample \((N = 392)\), generated through the initial data screening, was subjected to the NA responses cut-off criteria as outlined in Chapter 4 (see Table 4.2). Cases which met the cut-off criteria for any one or more of the sections were removed. This process reduced the dataset to 291 cases. Additionally, a total of 28 multivariate outliers identified with \(\alpha < .001\) were eliminated, reducing the dataset to 263. Furthermore, it was deemed prudent to exclude cases from strictly non-safety critical background, as they would be very unlikely to have proximal impact on/from safety occurrences.
including near misses. Occupational groups that fitted this category were Administration, Finance or Human Resources, Contracts & Procurement, Engineering Design, New Project Development and Sales & Marketing. As a result, an additional 22 cases were removed, reducing the dataset to 241 cases.

6.1 Differences based on Occupational Groups

Participants

Of the 241 participants, 53 (22%) had been involved in an accident/injury (including Lost Time Injuries, Non-Lost Time Injuries that required medical treatment and Non-Lost Time Injuries that did not require medical treatment) over the two years before the survey administration, while 188 had not (78%). One hundred and fourteen participants (47.3%) had experienced near miss, while 127 (52.7%) had not. Two hundred and twenty-four participants (92.9%) indicated they were working in a safety-critical area, while 17 participants (7.1%) responded they were in a non-safety-critical area at the time of the survey administration. The distribution of age group is summarised in Table 6.1. Detailed profiles of the participants are shown in Appendix 8.

Table 6.1
Distribution of Age Group for Prediction Analyses (N = 241)

<table>
<thead>
<tr>
<th>Age Group (years old)</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 20</td>
<td>1</td>
<td>.4</td>
</tr>
<tr>
<td>20-29</td>
<td>26</td>
<td>10.8</td>
</tr>
<tr>
<td>30-39</td>
<td>52</td>
<td>21.6</td>
</tr>
<tr>
<td>40-49</td>
<td>82</td>
<td>34.0</td>
</tr>
<tr>
<td>50-59</td>
<td>61</td>
<td>25.3</td>
</tr>
<tr>
<td>60-69</td>
<td>14</td>
<td>5.8</td>
</tr>
<tr>
<td>Above 70</td>
<td>5</td>
<td>2.1</td>
</tr>
</tbody>
</table>
**Occupational Groups**

This sample was classified into four groups to investigate group differences. A new grouping variable *Occupational Group* was created by using a classification system based on a combination of two criteria, consisting of: 1) the level of injury risk (ranging from Low to High); and 2) nature of responsibility with particular attention to frontline work versus management. The groups consisted of: Management (Very Low Risk) \((n = 42)\); Controllers (Low Risk) \((n = 31)\); Drivers and On-board Customer Service Personnel (Medium Risk) \((n = 99)\); and Maintenance and Construction Personnel (High Risk) \((n = 69)\). This grouping variable was used for CHAID and multiple regression analyses.

Different occupational groups have experienced different numbers of accidents and near misses, both personally and organisationally. It was expected that management generally represents systems-based accidents and near misses, while frontline workers experience personal accidents and near misses. This different experience based on occupational groups may colour their interpretation and the meaning attached to accidents and near misses. The rationale for using these criteria is discussed further in Future Directions in Chapter 7.

**Material and Procedure**

Data were examined through various SPSS programs (Version 18.0) for accuracy of data, missing values and fit between their distributions and the assumptions of each multivariate analysis. Presence of univariate and multivariate outliers was checked for each analysis. Only where outliers were identified, are they discussed below.

**Results**

*Descriptive Statistics for the Dataset \((N = 241)\)*

Evaluation of the mean scores for the factor variables for the entire sample \((N = 241)\) to be used for the following series of prediction analysis are outlined below. In Section A containing the safety climate factors, the following were found: Section A-1) asked the participants about how frequently people who work in safety-critical areas in their workplace would have encountered described situations (mostly negative) in the previous 24 months. The factor scores had a
possible range between 1 and 5 (score of [1 = Very rarely] and [5 = Very frequently] to all items). Mean scores were below the mid-point [3 = Sometimes] for all the seven factors. However, among them were found some subtle differences, which appear to illustrate a general trend. A particularly low mean score was seen for Lack of Supervision ($M = 1.54, SD = .66$). The following two factors had mean scores slightly above [2 = Disagree]: Negative Workplace Culture ($M = 2.16, SD = 1.01$) and Support for Fatigue Management ($M = 2.43, SD = 1.09$). The remaining two factors had mean scores slightly higher in relative terms consisting of: Roster and Time Pressure ($M = 2.70, SD = .1.07$); and Workplace Stress ($M = 2.75, SD = .97$).

Similarly, Section A-2) asked the participants about how frequently people who work in safety-critical areas in their workplace would have experienced potential or actual safety problems because of the given reasons in the previous 24 months. The factor scores had a possible range between 1 and 5 (score of [1 = Very rarely] and [5 = Very frequently] to all items). A particularly low mean score was seen for Organisational Latent Problems ($M = 1.98, SD = .73$). A relatively higher mean score was seen for External Factors ($M = 2.73, SD = .91$).

These results suggest that generally the participants felt that their organisation had a good safety management system in place, which included good on-site supervision, and adequate support from the organisation for fatigue management. Workplace culture was evaluated positively. In relative terms, the mean scores implied that the people were under roster and time pressure and stress. The scores also reflected that people who work in safety-critical areas in their workplace would have experienced external factors as potential or actual safety problems to a greater extent than latent problems residing within their organisation.

Section B asked participants to what extent the given statements described their place of work. The mean scores had a possible range between 1 (score of [1 = Strongly Disagree] and [5 = Strongly Agree] to all items). When factor analysed separately within seven theoretically generated dimensions, the following trend was observed. Mean scores of the nine resulting factors were all above the mid-point [3 = Neither Agree Nor Disagree]. Relatively lower value was seen for Balance Achieved between HSE Procedures and Efficiency ($M =$
3.18, $SD = .58$). Other factors had mean scores tending towards moderate agreement, which consisted of: Commitment to Health Safety and Environment (HSE) and Care for Colleagues ($M = 3.31$, $SD = .70$); Balance Achieved between HSE and Profitability ($M = 3.40$, $SD = .69$); Importance of Competency and Training Recognised ($M = 3.40$, $SD = .55$); Effective Safety Controls ($M = 3.47$, $SD = .59$); Negative Views on HSE Procedures ($M = 3.23$, $SD = .69$); Reactivity – Blame Culture ($M = 3.27$, $SD = .85$); Constructive Management Response to Accidents ($M = 3.58$, $SD = .64$); and Proactive Approach to HSE Audits and Reviews ($M = 3.29$, $SD = .61$).

As outlined above, descriptive statistics of the total sample portrays a surface impression of an overall positive trend. However, a closer examination of the data reveals varied trends amongst different subsets. When the dataset was dissected into four Occupational Groups, the descriptive statistics revealed considerable differences among them. Due to the non-normal distribution seen for some of the subsets, non-parametric techniques were used for evaluating statistical significance of group differences.

Firstly, the mean scores across the questions comprising each factor were rank-ordered and a Kruskal-Wallis ANOVA was conducted to compare the ranks among the four occupational groups. Because of the 19 comparisons, Bonferroni adjustment was made at $0.05 / 19 = .00263$.

Figure 6.1 and Table 6.2 outline means and standard deviations for each occupational group contrasted with those for the total sample. They also show the results of Kruskal-Wallis ANOVA analyses for each factor variable. As can be seen in Figure 6.1 and Table 6.2, the results indicated significant differences in the participants’ evaluation among the four groups, in a large majority of the factor variables with the exception of Workplace Stress, Organisational Latent Problems and External Factors.

Kruskal-Wallis ANOVA only indicates the presence of statistical difference among the groups but does not specify where the difference exists. Further investigation was conducted using Mann-Whitney $U$ tests for pairwise comparisons between 6 pairs of occupational groups with a Bonferroni adjusted alpha level of $0.05/(19 \times 6) = .000439$. Table 6.3 shows the $U$-value and statistical significance.
As can be seen in Table 6.3, significant differences were found between [Management] and [Drivers & On-board Hospitality Staff] for all of the safety culture factors and some for the safety climate factors. Similarly, significant differences were found between [Management] and [Maintenance & Construction Staff] in a large majority of the culture factors (Section B). This is in stark contrast with the other pairs, for which only a limited number (1 to 3) of factors had significant differences.
Figure 6.1. Means and Standard Deviations per Occupational Group and for the Total Sample with Results of Kruskal-Wallis Tests

* indicates significance at the alpha level of .00263.

n.b. 1 H-values were corrected for ties. n.b. 2 The variables’ description is as follows:

A1-1) Negative Workplace Culture
A1-2) Roster & Time Pressure
A1-3) Support for Fatigue Management
A1-4) Lack of Supervision
A1-5) Workplace Stress
A2-1) Organisational Latent Problems
A2-2) External Factors
B1 Commitment to HSE and Care for Colleagues
B2 Balance between HSE & Profitability
B3 Importance of Competency & Training Recognised

B4 Effective Safety Controls
B5-1) Balance between HSE Procedures & Efficiency
B5-2) Negative Views on HSE Procedures
B6-1) Reactivity - Blame Culture
B6-2) Constructive Management Response to Accidents
B7 Proactive Approach to HSE Audits and Reviews
GF-B1 Discrepant Commitment to Safety by Team Members and Line Management (Global Factor 1)
GF-B2 Negative Views on Internal Audits and Reviews (Global Factor 2)
GF-B3 Management’s Commitment to Safety (Global Factor 3)
Table 6.2
Means and Standard Deviations per Occupational Group and for the Total Sample
with Results of Kruskal-Wallis Tests

<table>
<thead>
<tr>
<th>Occupational Group</th>
<th>Management (n = 42)</th>
<th>Controllers (n = 31)</th>
<th>Drivers &amp; On-Board Hospitality Staff (n = 99)</th>
<th>Maintenance &amp; Construction (n = 69)</th>
<th>Total Sample (N = 241)</th>
<th>Kruskal-Wallis (df = 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>A1-1</td>
<td>1.70</td>
<td>0.77</td>
<td>1.54</td>
<td>0.64</td>
<td>2.50</td>
<td>1.07</td>
</tr>
<tr>
<td>A1-2</td>
<td>2.13</td>
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* indicates significance at the alpha level of .00263.

n.b. 1  H-values were corrected for ties.

n.b. 2  The variables’ description is as follows:

A1-1  Negative Workplace Culture  B5-1  Balance between HSE Procedures & Efficiency
A1-2  Roster & Time Pressure  B5-2  Negative Views on HSE Procedures
A1-3  Support for Fatigue Management  B6-1  Reactivity - Blame Culture
A1-4  Lack of Supervision  B6-2  Constructive Management Response to Accidents
A1-5  Workplace Stress  B7  Proactive Approach to HSE Audits and Reviews
A2-1  Organisational Latent Problems  GF-B1  Discrepant Commitment to Safety by Team
A2-2  External Factors  GF-B2  Negative Views on Internal Audits and Reviews
B1  Commitment to HSE and Care for Colleagues (Global Factor 1)
B2  Balance between HSE & Profitability (Global Factor 2)
B3  Importance of Competency & Training Recognised (Global Factor 3)
B4  Effective Safety Controls
Table 6.3
Mann-Whitney Tests for Six Pairs of Occupational Groups

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<th>Pair 2</th>
<th>Pair 3</th>
<th>Pair 4</th>
<th>Pair 5</th>
<th>Pair 6</th>
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<td>42 vs. 99</td>
<td>42 vs. 69</td>
<td>31 vs. 99</td>
<td>31 vs. 69</td>
<td>99 vs. 69</td>
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<td>1913.0</td>
<td>2394.0*</td>
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</tr>
<tr>
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<td>3328.5*</td>
<td>1450.0</td>
<td>1680.5</td>
<td>567.5*</td>
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n.b.1 * indicates significance at the alpha level of .000439.

n.b.2 † The pairs consist of the following occupational groups.

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<th>Pair</th>
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<tbody>
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<td>1</td>
<td>Management vs. Controllers</td>
</tr>
<tr>
<td>2</td>
<td>Management vs. Drivers &amp; On-Board Hospitality</td>
</tr>
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<td>3</td>
<td>Management vs. Maintenance &amp; Construction Workers</td>
</tr>
<tr>
<td>4</td>
<td>Controllers vs. Drivers &amp; On-Board Hospitality Staff</td>
</tr>
<tr>
<td>5</td>
<td>Controllers vs. Maintenance &amp; Construction Workers</td>
</tr>
<tr>
<td>6</td>
<td>Drivers &amp; On-Board Hospitality Staff vs. Maintenance &amp; Construction Workers</td>
</tr>
</tbody>
</table>

n.b. 3 The variables’ description is as follows:

- A1-1) Negative Workplace Culture
- A1-2) Roster & Time Pressure
- A1-3) Support for Fatigue Management
- A1-4) Lack of Supervision
- A1-5) Workplace Stress
- A2-1) Organisational Latent Problems
- A2-2) External Factors
- B1 Commitment to HSE and Care for Colleagues
- B2 Balance between HSE & Profitability
- B3 Importance of Competency & Training Recognised
- B4 Effective Safety Controls

- B5-1) Balance between HSE Procedures & Efficiency
- B5-2) Negative Views on HSE Procedures
- B6-1) Reactivity - Blame Culture
- B6-2) Constructive Management Response to Accidents
- B7 Proactive Approach to HSE Audits and Reviews
- GF-B1 Discrepant Commitment to Safety by Team
- GF-B2 Negative Views on Internal Audits and Reviews
- GF-B3 Management’s Commitment to Safety (Global Factor 3)
6.2 Results of Prediction Analyses

This section presents the results of three types of prediction analyses, and thus is divided into three parts. Specifically, Sub-Section 6.2.1 outlines the results of Discriminant Function Analyses, followed by Sub-Section 6.2.2 presenting the results of CHAID analyses. Finally Sub-Section 6.2.3 presents the results of the Hierarchical Multiple Regression Analyses.

The first two techniques were used to overcome limitations placed by the pattern of distribution of the number of accidents and near misses as criterion variables. This was done against the background of previous research where some studies have found evidence of association between safety climate and safety outcomes (see Section 1.11).

6.2.1 Results of Discriminant Function Analyses

As the first stage of the series of prediction analyses, Discriminant function analysis (DISCRIM) was first conducted to explore whether the safety climate/culture scores would predict experience or non-experience of accidents and near misses regardless of the occupational group.

Discriminant function analysis (DISCRIM) is aimed at predicting group membership from a set of predictor variables. It asks whether predictors can be combined to predict group membership reliably. Discriminant function analysis is a parametric procedure with similar assumptions to those of MANOVA including normality, linearity and homogeneity of variances (Tabachnick & Fidell, 2007).

The current study collected self-reported data about several safety-related experience and activities, which included accidents, near misses and reporting of safety defects. These data were used as criterion variables as for the following prediction analyses. The distribution of the frequency of accidents (Lost Time Injuries) for the current study highlight the rarity of such occurrences, forming an inversely proportional curve, akin to a scree plot in a factor analysis, as noted in previous research (e.g. Hofmann & Stetzer, 1996; Zohar, 2000).

Due to the non-normal distribution of the dependent variable Experience of Accidents and Experience of Near Misses (see Figure 6.2) discriminant function analysis was deemed more appropriate, as it predicts membership in one of two
categories. An example of this technique can be seen in a study of safety culture in nuclear power stations by Lee and Harrison (2000). The researchers examined safety culture variables that discriminated between accident and non-accident groups.

The following are results of a series of discriminant function analyses conducted to predict group membership based on experience of two types of adverse safety outcomes: 1) [accident group] vs. [non-accident group]; and 2) [near miss group] vs. [non-near miss group]. The predictors were the safety climate and culture factor variables from Section A and Section B of the questionnaire.

![Histogram showing the frequency of LTIs (left) and near misses (right) (N = 241).](image)

**Figure 6.2.** Histogram showing the frequency of LTIs (left) and near misses (right) \(N = 241\).

### 6.2.1.1 Prediction of Accident Experience (DISCRIM)

**DISCRIM Analysis 1 – Prediction of Group Membership in Accident Experience (16 predictors)**

A direct discriminant function analysis was conducted using 16 safety climate and culture factor variables as predictors of membership to determine whether people who had any accident could be distinguished from people who had no accident. The criterion variable was [accident group] vs. [non-accident group].
The predictors consisted of seven variables from Section A: *Negative Workplace Culture* (Sqrt); *Roster and Time Pressure*; *Support for Fatigue Management*; *Lack of Supervision* (Log); *Workplace Stress*; *Organisational Latent Problems* (Log) and *External Factors*; and nine variables from Section B: *Commitment to Health Safety and Environment (HSE) and Care for Colleagues*; *Balance Achieved between HSE and Profitability*; *Importance of Competency and Training Recognised*; *Effective Safety Controls*; *Balance Achieved between HSE Procedures and Efficiency*; *Negative Views on HSE Procedures*; *Reactivity – Blame Culture*; *Constructive Management Response to Accidents*; and *Proactive Approach to HSE Audits and Reviews*.

Distributional assumptions were evaluated (Allen & Bennett, 2008; Tabachnick & Fidell, 2007). The sixteen predictors were examined separately for the 53 participants in the accident group, and the 188 participants in the non-accident group. Because *Negative Workplace Culture* showed a moderate positive skew, a square root transformation was applied. Due to the severely positive skew, a logarithmic transformation was applied to two factor variables *Lack of Supervision* and *Organisational Latent Problems*. Following the transformation, slight positive skew was still found in both groups for all of the three factors. Distribution of scores was normal in both groups for *Balance Achieved between HSE and Profitability*. The distribution for *Roster and Time Pressure* and *Support for Fatigue Management* also showed a slight positive skew for both groups. Slight positive skew was also found in the non-accident group for *Workplace Stress*, *Commitment to HSE and Care for Colleagues* and *Proactive Approach to HSE Audits and Reviews* respectively. Slight negative skew was found in the non-accident group for *External Factors*, *Importance of Competency and Training Recognised*, and *Negative Views on HSE Procedures*. Slight leptokurtosis was found in the non-accident group for *Effective Safety Controls*, *Balance Achieved between HSE Procedures and Efficiency*, *Reactivity – Blame Culture*, and *Constructive Management Response to Accidents*. As a discriminant function analysis is considered robust with respect to univariate non-normality when group sizes exceed 30, this is not considered problematic (Allen & Bennett, 2008).
One multivariate outlier was identified in the accident group. Removal of this case reduced the total sample to \( N = 240 \), consisting of 52 in the accident group (22\%), and 188 in the non-accident group (78\%). The remaining assumptions of linearity and absence of multicollinearity were satisfied. Evaluation of homogeneity of variance-covariance matrices established that Box’s \( M \) was non-significant. However, Levene’s test of equality of error variances was significant for the factor variable *Importance of Competency and Training* Recognised \( F (1, 238) = 4.003, p = .047 \). This factor variable was excluded from further analysis. The pooled within-cell correlations among the predictors are reported in Table 6.4.

One significant discriminant function was calculated with Wilks’ lambda of \( \Lambda = .87, \chi^2 (15, N = 240) = 31.93, p = .007 \). With canonical \( R^2 \) of .13, it accounted for 13 \% of the total relationship between the predictors and the groups. The standardised coefficients and correlations of the predictor variables with the discriminant function (i.e. the structure coefficients) are shown in Table 6.5.

The structure (loading) matrix of correlations between predictors and discriminant function, suggests that the best predictors for distinguishing between the accident and the non-accident groups were *Proactive Approach to HSE Audits and Reviews, Negative Workplace Culture (Sqrt), Balance Achieved between HSE & Profitability, Commitment to HSE and Care for Colleagues, Lack of Supervision (Log), and Reactivity - Blame Culture*. Loadings of less than .30 were not interpreted.
Table 6.4
Pooled Within-Groups Matrices (N = 240)

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* n.b. Factor B3 was excluded due to unequal error variances.

** The variables’ description as follows:

Predictor Variables:
- A1-1: Negative Workplace Culture (Sqrt)
- A1-2: Roster & Time Pressure
- A1-3: Support for Fatigue Management
- A1-4: Lack of Supervision (Log)
- A1-5: Workplace Stress
- A2-1: Organisational Latent Problems (Log)
- A2-2: External Factors
- B1: Commitment to HSE and Care for Colleagues
- B2: Balance Achieved between HSE & Profitability
- B4: Effective Safety Controls
- B5-1: Balance Achieved between HSE Procedures & Efficiency
- B5-2: Negative Views on HSE Procedures
- B6-1: Reactivity - Blame Culture
- B6-2: Constructive Management Response to Accidents
- B7: Proactive Approach to HSE Audits and Reviews

Table 6.5
Correlations and Standardised Coefficients of Predictors with Discriminant Function

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Structure Coefficients*</th>
<th>Standardised Coefficients*</th>
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<td>Function 1</td>
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<td>-.10</td>
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<td>A1-4: Lack of Supervision (Log)</td>
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<td>-.16</td>
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<td>A1-5: Workplace Stress</td>
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<td>-.19</td>
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<tr>
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<td>A2-2: External Factors</td>
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<td>-.16</td>
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<td>B1: Commitment to HSE and Care for Colleagues</td>
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<td>B2: Balance Achieved between HSE &amp; Profitability**</td>
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<td>B5-2: Negative Views on HSE Procedures</td>
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<td>B7: Proactive Approach to HSE Audits and Reviews</td>
<td>.62</td>
<td>.89</td>
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</table>

* Correlations of Predictor Variables with the Discriminant Function

** Predictor variable B3 was excluded due to unequal error variances.
Group means and standard deviations are shown in Table 6.6. As can be seen in Table 6.6, participants who had experienced accidents over the previous two years prior to the survey administration (the accident group) thought that their organisations were less proactive in their approach to HSE audits and reviews than the non-accident group. The accident group observed negative workplace culture more frequently than the non-accident group at their respective workplace. They thought their organisations had achieved balance between HSE and profitability to a lesser extent than the non-accident group. The accident group thought their organisations were less committed to HSE and care for colleagues than the non-accident group. They thought their organisations lacked supervision to a greater degree and were more reactive, characterised by blame culture than the non-accident group.

Jackknifed classification showed that 188 participants (78.3%) were correctly classified, compared with 158.08 participants (66%) who would have been correctly classified by chance alone. Of the 52 participants who were misclassified, eight were from the accident group (misclassified as non-accident), and the 44 participants from the non-accident group were misclassified as accident group. This meant that the non-accident group was more likely to be correctly classified (96%) than the accident group (15%).
Table 6.6
Descriptive Statistics for the Accident and Non-Accident Groups on Each Predictor Variable

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Group</th>
<th>Accident (n = 52)</th>
<th>Non-Accident (n = 188)</th>
<th>M</th>
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<td>1.06</td>
<td>1.12</td>
<td>.94†</td>
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<td>A1-2) Roster &amp; Time Pressure</td>
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<td>2.69</td>
<td>1.06</td>
<td>1.12</td>
<td>.94†</td>
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<td>A1-3) Support for Fatigue Management</td>
<td>Accident</td>
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<td>2.45</td>
<td>1.13</td>
<td>1.08</td>
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<td>Non-Accident</td>
<td>2.45</td>
<td>1.06</td>
<td>1.12</td>
<td>.94†</td>
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<td>A1-4) Lack of Supervision (Log)</td>
<td>Accident</td>
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<td>1.50†</td>
<td>.72†</td>
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<td>1.08</td>
<td>.72†</td>
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<td>1.94†</td>
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<td>3.37</td>
<td>1.06</td>
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</table>

† denotes means and standard deviations of untransformed variables for easy comparison.
DISCRIM Analysis 2 – Prediction of Group Membership in Accident Experience (10 predictors)

As an extension to the above, direct discriminant function analysis was conducted using the same seven predictors for Section A in the previous analysis, and three global factors instead of the eight theoretically generated safety culture factors in Section B. They consisted of Discrepant Commitment to Safety by Team Members and Line Management, Negative Views on Internal Audits and Reviews, and Management’s Commitment to Safety. With Wilks’ lambda of $\Lambda = .93$, $\chi^2 (10, N = 241) = 16.63$, $p = .083$, the predictors did not discriminate between the accident and non-accident groups.

6.2.1.2 Prediction of Near Miss Experience

DISCRIM Analysis 3 – Prediction of Group Membership in Near Miss Experience (16 predictors)

A direct discriminant function analysis was conducted using 16 safety climate and culture factor variables as predictors of membership to determine whether people who had any near miss could be distinguished from people who had no near miss. The criterion variable was [near miss group] vs. [non-near miss group]. The predictors were the same as for Analysis 1.

Before analysis, distributional assumptions were tested by examining the factor variables separately for the 114 participants in the near miss group, and the 127 participants in the non-near miss group. As with the previous analyses, the following three variables were transformed, namely, Negative Workplace Culture (Sqrt), Lack of Supervision (Log) and Organisational Latent Problems (Log). Following the transformation, slight positive skew was still found for all of the variables in both groups.

Distribution of scores was normal in both groups for Commitment to HSE and Care for Colleagues, and Balance Achieved between HSE and Profitability, Effective Safety Controls, and Balance Achieved between HSE Procedures and Efficiency. The distribution for Roster and Time Pressure, Support for Fatigue Management, and Workplace Stress also showed slight positive skew for both
groups. Slight positive skew was also found in the non-near miss group for *Proactive Approach to HSE Audits and Reviews*. Slight negative skew was found in the non-near miss group for *Importance of Competency and Training Recognised*, and *Negative Views on HSE Procedures*, and in the near miss group for *Reactivity – Blame Culture*, and *Constructive Management Response to Accidents*. Slight leptokurtosis was found in the near miss group for *Negative Views on HSE Procedures*. As a discriminant function analysis is considered robust with respect to univariate non-normality when group sizes exceed 30, mild normality breaches were not considered problematic (Allen & Bennett, 2008).

One multivariate outlier was identified in the accident group. Removal of this case reduced the total sample to *N* = 240, consisting of 114 in the near miss group (47.5%), and 126 in the non-near miss group (52.5%). The remaining assumptions of linearity and absence of multicollinearity were satisfied. Evaluation of homogeneity of variance-covariance matrices established that Box’s *M* was non-significant. However, Levene’s test of equality of error variances was significant for the factor variable A2-2) *External Factors*. This factor variable was excluded from further analysis. The pooled within-cell correlations among the predictors are reported in Table 6.7.
Table 6.7
Pooled Within-Groups Matrices (N = 240)

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</table>

*n.b. Factor A2-2) was excluded due to unequal error variances.

** The variables’ description is as follows:

Predictor Variables:  
A1-1) Negative Workplace Culture (Sqrt)  
A1-2) Roster & Time Pressure  
A1-3) Support for Fatigue Management  
A1-4) Lack of Supervision (Log)  
A1-5) Workplace Stress  
A2-1) Organisational Latent Problems (Log)  
B1  Commitment to HSE and Care for Colleagues  
B2  Balance Achieved between HSE & Profitability  
B3  Importance of Competency & Training Recognised  
B4  Effective Safety Controls  
B5-1) Balance Achieved between HSE Procedures & Efficiency  
B5-2) Negative Views on HSE Procedures  
B6-1) Reactivity - Blame Culture  
B6-2) Constructive Management Response to Accidents  
B7  Proactive Approach to HSE Audits and Reviews

One significant discriminant function was calculated with Wilks’ lambda of $\Lambda = .90$, $\chi^2 (15, N = 240) = 25.23$, $p = .047$. With canonical $R^2$ of .10, it accounted for 10% of the total relationship between the predictors and the groups. The standardised coefficients and correlations of the predictor variables with the discriminant function are shown in Table 6.8.

The structure (loading) matrix of correlations between predictors and the discriminant function, as seen in Table 6.8, suggests that the best predictors for distinguishing between the near miss and the non-near miss groups were: Balance Achieved between HSE Procedures and Efficiency; Roster and Time Pressure; Workplace Stress; Organisational Latent Problems (Log); Negative Views on
**HSE Procedures;** *Negative Workplace Culture (Sqrt), Lack of Supervision (Log),
Balance Achieved between HSE & Profitability; Reactivity - Blame Culture;
Importance of Competency and Training Recognised; Commitment to HSE and
Care for Colleagues; and Effective Safety Controls.* Structural loadings of less than .30 were not interpreted.

**Table 6.8**

*Correlations and Standardised Coefficients of Predictors with Discriminant Function*

<table>
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<th>Predictor Variable</th>
<th>Correlation Coefficients*</th>
<th>Standardised Coefficients Function 1</th>
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<td>B6-2) Constructive Management Response to Accidents</td>
<td>-.18</td>
<td>.22</td>
</tr>
<tr>
<td>B7 Proactive Approach to HSE Audits and Reviews</td>
<td>-.23</td>
<td>.31</td>
</tr>
</tbody>
</table>

n.b.* Correlations of Predictor Variables with the Discriminant Function

** Predictor variable A2-2) was excluded due to unequal error variances.

Group means and standard deviations are shown in Table 6.9. As can be seen in Table 6.9, participants who had experienced near misses over the previous two years prior to the survey administration (the near miss group) thought that their organisation had achieved balance between HSE procedures and efficiency to a lesser extent than the non-near miss group. The near miss group observed more roster and time pressure than the non-near miss group. The near miss group thought that workplace stress was experienced by people in safety-critical areas at
their workplace to a greater extent than the non-near miss group. The near miss group thought that organisational latent problems were more frequently observed as contributing to potential or actual safety problems than the non-near miss group thought about their respective workplace. The near miss group observed negative workplace culture more frequently than the non-near miss group at their respective workplace. The near miss group more frequently observed lack of supervision in safety-critical areas than the non-near miss group at their respective workplace. The near miss group thought their organisation had achieved balance between HSE & profitability to a lesser extent than the non-near miss group. The near miss group thought their organisation was more reactive rather than proactive in its response to accidents, characterised by blame culture than the non-near miss group. The near miss group thought to a lesser degree that people in their organisation recognised the importance of competency and training than the non-near miss group. The near miss group thought their organisation was less committed to HSE and care for colleagues than the non-near miss group. The near miss group thought their organisation had effective safety controls to a lesser extent than the non-near miss group thought of their respective organisation.

Jackknifed classification showed that 136 participants (56.7%) were correctly classified, compared with 120.30 participants (50.1%) who would be correctly classified by chance alone. Of the 104 participants who were misclassified, 57 were from the near miss group (misclassified as non-near miss), and the 47 participants from the non-near miss group were misclassified as near miss group. This meant that the non-near miss group was slightly more likely to be correctly classified (62.7%) than the near miss group (50%).
## Table 6.9

### Descriptive Statistics for the Near Miss and Non-Near Miss Groups

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Group</th>
<th>Near Miss(^{(n = 114)})</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1-1) Negative Workplace Culture (Sqrt)</td>
<td>Near Miss</td>
<td>2.33†</td>
<td>1.08†</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>2.00†</td>
<td>.92†</td>
<td></td>
</tr>
<tr>
<td>A1-2) Roster &amp; Time Pressure</td>
<td>Near Miss</td>
<td>2.91</td>
<td>1.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>2.50</td>
<td>1.08</td>
<td></td>
</tr>
<tr>
<td>A1-3) Support for Fatigue Management</td>
<td>Near Miss</td>
<td>2.33</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>2.53</td>
<td>1.11</td>
<td></td>
</tr>
<tr>
<td>A1-4) Lack of Supervision (Log)</td>
<td>Near Miss</td>
<td>1.64†</td>
<td>.67†</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>1.46†</td>
<td>.63†</td>
<td></td>
</tr>
<tr>
<td>A1-5) Workplace Stress</td>
<td>Near Miss</td>
<td>2.93</td>
<td>.94</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>2.59</td>
<td>.98</td>
<td></td>
</tr>
<tr>
<td>A2-1) Organisational Latent Problems (Log)</td>
<td>Near Miss</td>
<td>2.11†</td>
<td>.71†</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>1.88†</td>
<td>.73†</td>
<td></td>
</tr>
<tr>
<td>B1 Commitment to HSE and Care for Colleagues</td>
<td>Near Miss</td>
<td>3.22</td>
<td>.67</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.38</td>
<td>.72</td>
<td></td>
</tr>
<tr>
<td>B2 Balance Achieved between HSE &amp; Profitability</td>
<td>Near Miss</td>
<td>3.29</td>
<td>.73</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.50</td>
<td>.65</td>
<td></td>
</tr>
<tr>
<td>B3 Importance of Competency and Training Recognised</td>
<td>Near Miss</td>
<td>3.33</td>
<td>.56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.47</td>
<td>.55</td>
<td></td>
</tr>
<tr>
<td>B4 Effective Safety Controls</td>
<td>Near Miss</td>
<td>3.40</td>
<td>.59</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.52</td>
<td>.59</td>
<td></td>
</tr>
<tr>
<td>B5-1) Balance Achieved between HSE Procedures &amp; Efficiency</td>
<td>Near Miss</td>
<td>3.03</td>
<td>.53</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.30</td>
<td>.58</td>
<td></td>
</tr>
<tr>
<td>B5-2) Negative Views on HSE Procedures</td>
<td>Near Miss</td>
<td>3.34</td>
<td>.67</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.12</td>
<td>.69</td>
<td></td>
</tr>
<tr>
<td>B6-1) Reactivity - Blame Culture</td>
<td>Near Miss</td>
<td>3.40</td>
<td>.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.16</td>
<td>.84</td>
<td></td>
</tr>
<tr>
<td>B6-2) Constructive Management Response</td>
<td>Near Miss</td>
<td>3.54</td>
<td>.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.62</td>
<td>.63</td>
<td></td>
</tr>
<tr>
<td>B7 Proactive Approach to HSE Audits and Reviews</td>
<td>Near Miss</td>
<td>3.24</td>
<td>.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Near Miss</td>
<td>3.34</td>
<td>.61</td>
<td></td>
</tr>
</tbody>
</table>

† denotes means and standard deviations of untransformed variables for easy comparison.
DISCRIM Analysis 4 – Prediction of Group Membership in Near Miss Experience (10 predictors)

Lastly, a direct discriminant function analysis was conducted using ten safety climate and culture factor variables as predictors of membership in either near miss or non-near miss group. The predictors were identical to those used for DISCRIM Analysis 2 for the prediction of group membership in accident experience. With Wilks’ lambda of $\Lambda = .94$, $\chi^2(9, N = 241) = 15.27$, $p = .084$, the predictors did not discriminate between the near miss and non-near miss groups.

Summary

The results of the discriminant function analyses using the theory-based safety culture factors as part of the predictors, namely Analyses 1 and 3, showed limited accuracy in classification. Despite the general indication that the near miss group had an overall negative view of the safety measures and climate/culture of their organisation, caution is required for their interpretation. The results of Analyses 2 and 4 which included the global safety culture factors as predictors neither discriminated between the accident vs. non-accident pair nor the near miss v. non-near miss pair. Interpretation of the results will be discussed further in Chapter 7.
6.2.2 **Results of CHAID (Chi-Squared Automatic Interaction Detection)**

The results of discriminant function analyses in the previous section showed abysmal predictive validity of the safety climate/culture factors to discriminate between the experience of and non-experience of safety outcomes. This may be partly due to the potential role of occupational groups as indicated in the between-group analyses in Chapter 5 and Chapter 6 (Section 6.1). Further analyses were made to examine the possibility of the effect of occupartional groups.

CHAID is a non-parametric segmentation modeling technique to identify the best predictors of group membership. This method was selected as a supplement to discriminant function analysis because: 1) Occupational Group could be incorporated into the computations; and 2) some of the safety climate and culture factor variables were not normally distributed. The CHAID model requires that the predictor variables are categorical-scaled (Magidson, 1994; Schmidt & Hollensen, 2006). This necessitated conversion of the safety climate/culture factor variables, so far treated as continuous variables as a result of computing mean scores from a composite of the items forming each factor, into categorical scales. The item scores were originally measured on a 5-point Likert scale. Thus, the factor scores were re-categorised into three categories. Scores ranging from [1 = Very Rarely] to [5 = Very Frequently] in Section A addressing safety climate were re-coded into [1 = Rarely], [2 = Sometimes] and [3 = Often]. Similarly, scores ranging from [1 = Strongly Disagree] to [5 = Strongly Agree] in Section B addressing safety culture were re-coded into [1 = Disagree], [2 = Neither Agree nor Disagree] (abbreviated into “Neutral” in the following text and the tree diagrams) and [3 = Agree].

The following are results of CHAID analyses conducted to predict group membership in terms of: 1) [accident group] vs. [non-accident group]; and 2) [near miss group] vs. [non-near miss group]. The predictors were safety climate and culture factor variables.

**Participants**

The same sample of 241 participants used for discriminant function analyses was used for the CHAID analyses.
Material and Procedure

Prior to analysis, the factor variables were examined through various SPSS programs (Version 18.0) for testing the assumptions for chi-square analysis. SPSS Decision Trees module was used for the CHAID computations. Decision trees were generated to describe the set of predictors that determined group membership. As the CHAID analyses tend to be complex, the results from the segmentation modelling are presented in a summary form. Subgroups with fewer than 20 cases were not split, and subgroups could not be formed with fewer than 5 cases.

The index of each segment (percentages for frequency) contrasts the responses made by the participants in the segment with responses from the whole sample. All segments with indices at least 50% greater or lower than the entire sample index were described in the text. Some analyses failed to produce segments that met these criteria. In such cases the segments with indices at least 25% greater or lower than the entire sample index were reported (Arnold, 1999).

6.2.2.1 Prediction of Accident Experience (CHAID)

CHAID Analysis 1 – Modelling of Accident Experience over the Previous Two Years (17 predictors)

Data related to the experience of accidents (including Lost Time Injuries, Non-Lost Time Injuries that required medical treatment and Non-Lost Time Injuries that did not require medical treatment) were submitted to segmentation modelling. The dependent variable was dichotomous: Accident (n = 53, 22%) and Non-Accident (n = 188, 78%) groups. A total of seventeen predictors were used. They consisted of: one grouping variable Occupational Group; seven safety climate factor variables; and nine safety culture factor variables.

Seven safety climate variables consisted of: Negative Workplace Culture; Roster and Time Pressure; Support for Fatigue Management; Lack of Supervision; Workplace Stress; Organisational Latent Problems and External Factors. Nine safety culture factor variables consisted of: Commitment to Health Safety and Environment (HSE) and Care for Colleagues; Balance Achieved between HSE and Profitability; Importance of Competency and Training
Recognised; Effective Safety Controls; Balance Achieved between HSE Procedures and Efficiency; Negative Views on HSE Procedures; Reactivity – Blame Culture, Constructive Management Response to Accidents; and Proactive Approach to HSE Audits and Reviews.

Figure 6.3 shows the tree diagram of the significant predictor variables identified by CHAID. Accidents were reported by 22% of all workers surveyed (n = 53). Negative Workplace Culture was the best predictor of the root node, $\chi^2 (1, 241) = 12.395, p = .001$. The root node was split into two groups, 1) those who thought that Negative Workplace Culture was rarely observed (n = 162); and 2) those who thought that it was often or at least sometimes observed in their workplace (n = 79).

Segmentation modelling identified the following two end segments containing rail workers who reported experience of accidents at a greater rate than the total sample of 22%, as shown in Node 0, over the previous two years:

1. Node 2: Rail workers who often or at least sometimes observed negative workplace culture in their workplace. Of this group, 35.4% reported experience of accidents, 1.61 times more than the proportion for the total sample of rail workers.

2. Node 6: Rail workers who rarely observed negative safety culture in their workplace, and thought their organisation often provided support for fatigue management, $\chi^2 (1, 162) = 5.906, p = .03$, but did not think or were ambivalent as to whether their organisation recognised the importance of competency and training, $\chi^2 (1, 35) = 5.149, p = .023$. Of these people, 66.7% reported experience of accidents, three times more than the proportion for total sample of rail workers.

Classification showed that despite the overall predictive power of 78.8% with 190 participants correctly classified only four (7.5%) of the 53 participants from the accident group were correctly classified.
Figure 6.3. Results of CHAID based on dichotomous dependent variable D3 Experience of Accidents (using 17 predictors).
CHAID Analysis 2 – Modelling of Accident Experience over the Previous Two Years (11 predictors)

A further analysis to predict experience of accidents was conducted using the global factors for safety culture in place of the seven theoretically-generated factor variables. The predictors consisted of the grouping variable Occupational Group, seven safety climate factor variables (the same as those used in the previous analysis) and three global safety culture factor variables. The three global factor variables were: Discrepant Commitment to Safety by Team Members and Line Management; Negative Views on Internal Audits and Reviews; and Management’s Commitment to Safety.

Figure 6.4 shows the tree diagram of the significant predictor variables identified by CHAID. Accidents were reported by 22% of all workers surveyed. Identical to Analysis 1, Negative Workplace Culture was the best predictor of the root, $\chi^2 (1, 241) = 12.395, p = 0.001$. However, the terminal node predictor was replaced by the global factor Negative Views on Internal Audits and Reviews.

Segmentation modelling identified the following two end segments containing rail workers who reported experience of accidents at a greater rate than the total sample of 22% over the previous two years:

1. Node 2: As in the previous analysis, rail workers who often or at least sometimes observed negative workplace culture in their workplace. Of these people, 35.4% reported experience of accidents, 1.61 times more than the proportion for the total sample of rail workers.

2. Node 6: Rail workers who rarely observed negative safety culture in their workplace, and thought their organisation often provided support for fatigue management, $\chi^2 (1, 162) = 5.906, p = .030$, but who either agreed or gave a neutral response that their workplace reflected negative views on internal audits and reviews, $\chi^2 (1, 35) = 5.850, p = .016$. Of these people, 62.5% reported experience of accidents, 2.84 times more than the proportion of the total sample of rail workers.
Classification showed that despite the overall predictive power of 78.8% with 190 participants correctly classified only five of the 53 (9.4%) participants from the accident group were correctly classified.

*Figure 6.4.* Results of CHAID based on dichotomous dependent variable D3 Experience of Accidents (using 11 predictors).
6.2.2.2 Experience of Near Misses

CHAID Analysis 3 – Modelling of Near Miss Experience over the Previous Two Years (17 predictors)

Data related to near miss experience were submitted to segmentation modelling. The dependent variable was dichotomous; Near Miss (n = 114, 47.3%) and Non-Near Miss groups (n = 127, 52.7%). The predictor variables were identical to those used in CHAID Analysis 1, namely, the grouping variable Occupational Group, seven safety climate factor variables, and nine safety culture factor variables.

Figure 6.5 shows the tree diagram of the significant predictor variables identified by CHAID. Near miss experience was reported by 47.3% of all workers surveyed over the previous two years, as shown in Node 0. The grouping variable Occupational Group was the best predictor of the root node, $\chi^2 (2, 241) = 16.766, p = .001$. As the Maintenance and Construction Staff group and the Controllers group were homogeneous with respect to the dependent variable criterion, they were merged together. Thus, the first-level segmentation process generated three groups: 1) Maintenance, Construction and Controllers (n = 100); 2) Management (n = 42); and 3) Drivers and On-Board Hospitality Staff (n = 99).

The modelling identified one end segment containing rail workers who reported near miss experience at a greater rate than the proportion of the total sample of 47.3%, as shown in Node 0:

1. Node 7: Sixty-nine of the 99 Drivers and On-Board Hospitality Staff (70%) responded that they often or at least sometimes observed External Factors as contributing to potential or actual problems at their workplace, $\chi^2 (1, 99) = 13.410, p = .001$. Fifty of these 69 those Drivers and On-Board Hospitality Staff (72.5%) had near miss experience in the previous two years, 1.53 times more than the total sample’s percentage.

On the other hand, the modelling identified the following four groups of rail workers who reported lower or higher rates of near misses than the total sample when the ±25% reporting criteria was applied.
1. Node 2: Of all Management Staff \((n = 42)\), 23.8% reported near miss experience, almost half (0.503) of the total sample’s percentage.

2. Node 3: Of all Drivers and On-Board Hospitality Staff, 60.6% reported near miss experience, 1.28 times more than the total sample’s percentage.

3. Node 5: Only 28 out of 100 Maintenance, Construction and Controllers responded that they thought their organisation had achieved *Balance between HSE Procedures and Efficiency*, \(\chi^2 (1, 100) = 5.698, p = 0.034\). Of these people, only a quarter \((n = 7)\) reported near miss experience, 0.53 of the total sample’s percentage.

4. Node 6: Only 30 out of 99 Drivers and On-Board Hospitality Staff responded that they rarely observed *External Factors* as contributing to potential or actual problems at their workplace, \(\chi^2 (1, 99) = 13.410, p = .001\). Of these people, only ten (33.3%) reported near miss experience, 0.70 of the total sample’s percentage.

Classification showed that 160 participants (66.4%) were correctly classified, compared with 120.8 participants (50.1%) who would be correctly classified by chance alone. Of the 81 participants who were misclassified, 27 were from the Near Miss group (misclassified as Non-Near Miss), and the remaining 54 were from the Non-Near Miss group (misclassified as Near Miss). This meant that the Near Miss group was more likely to be correctly classified \((n = 87, 76.3\%)\) than the Non-Near Miss group \((n = 73, 57.5\%)\).
Correct D7 Have you been involved in a near miss or hazardous incident without injury while with your current employer during the past 2 years?

<table>
<thead>
<tr>
<th>Category</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>47</td>
<td>3114</td>
</tr>
<tr>
<td>No</td>
<td>53</td>
<td>127</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>241</td>
</tr>
</tbody>
</table>

Correct Occupational Groups based on Injury Risk regrouped into 4 Nominal Groups including:
- Management
  - Adj. P-value=0.001, Chi-square=18, 766, df=2
- Drivers & On-board Hospitality Staff (Medium)
- Maintenance & Construction (High); Controllers (Low)

Node 1
- Category % n
  - Yes 44 44
  - No 56
  - Total 41 100

Node 2
- Category % n
  - Yes 23 8
  - No 76 2
  - Total 17 4

Node 3
- Category % n
  - Yes 50 6
  - No 39 4
  - Total 49 9

Section D5-1 Balance between HSE Procedures & Efficiency (3 categories)
- Adj. P-value=0.034, Chi-square=5, 668, df=1

Node 4
- Category % n
  - Yes 61 4
  - No 39 6
  - Total 29 9

Node 5
- Category % n
  - Yes 25 6
  - No 75 4
  - Total 11 10

Section A2-2 External Problems (3 categories)
- Adj. P-value=0.001, Chi-square=13, 410, df=1

Node 6
- Category % n
  - Yes 33 3
  - No 67 7
  - Total 12 4

Node 7
- Category % n
  - Yes 72 5
  - No 27 5
  - Total 28 8

*Figure 6.5.* Results of CHAID based on dichotomous dependent variable D7 Experience of Near Misses (using 17 predictors).
CHAID Analysis 4 – Modelling of Near Miss Experience over the Previous Two Years (11 predictors)

A further analysis to predict near miss experience was conducted using the global factors for safety culture. The predictor variables were identical to those used in Analysis 2.

Figure 6.6 shows the tree diagram of the significant predictor variables identified by CHAID. Identical to the previous analysis, the grouping variable *Occupational Group* was the best predictor of the root node, $\chi^2 (2, 241) = 16.766$, $p = .001$, which generated three groups: 1) Maintenance, Construction and Controllers ($n = 100$); 2) Management ($n = 42$); and 3) Drivers and On-Board Hospitality Staff ($n = 99$) in the first-level segmentation process.

The modelling showed one end segment containing rail workers who reported near miss experience at a greater rate than the total sample of 47.3% over the previous two years:

1. Node 5: A group of Drivers and On-board Hospitality Staff who often or at least sometimes observed *External Factors* as contributing to potential or actual problems at their workplace, $\chi^2 (1, 99) = 13.410$, $p = .001$, who disagreed that their organisation had *Negative Views on Internal Audits and Reviews*, $\chi^2 (1, 69) = 5.507$, $p = .038$.

Of these people, 90.9% reported near miss experience, 1.92 times more than the total sample of rail workers (Node 6). However, because of the large number of comparisons despite the application of the Bonferroni adjustments, the significance level is prone to a slightly elevated chance of a Type I error. This post-segmentation $p$ value suggests that the child node – *External Factors* – is a more conservative termination point for this branch of the CHAID tree.

Of those Drivers and On-Board Hospitality Staff who observed *External Factors* as contributing to potential or actual problems at their workplace, 72.5% had near misses in the previous two years, 1.53 times more than the total sample’s percentage.
On the other hand, the modelling revealed two groups of rail workers who reported lower rates of near misses than the total sample when the ±25% reporting criteria was applied.

1. Node 2: Management, 23.8% of whom reported experience of near misses, almost half (0.503) of the total sample’s percentage.

2. Node 4: A group of Drivers and On-Board Hospitality Staff who rarely observed External Factors as contributing to potential or actual problems at their workplace, $\chi^2 (1, 99) = 13.410, p = .001$. Of these people, 33.3% reported experience of near misses, 0.70 of the total sample of rail workers’ percentage.

Classification showed that 158 participants (65.6%) were correctly classified, compared with 120.8 participants (50.1%) who would be correctly classified by chance alone. Of the 83 participants who were misclassified, 64 were from the Near Miss group (misclassified as Non-Near Miss), and the remaining 19 were from the Non-Near Miss group (misclassified as Near Miss). This meant that the Non-Near Miss group was more likely to be correctly classified ($n = 108, 85\%$) than the Near Miss group ($n = 50, 43.9\%$).
Figure 6.6. Results of CHAID based on dichotomous dependent variable D7 Experience of Near Misses (using 11 predictors).
6.2.2.3 Frequency of Near Misses

**CHAID Analysis 5 – Modelling of Near Miss Frequency over the Previous Two Years (17 predictors)**

A further analysis was conducted in order to investigate the best predictors for membership in two groups classified based on the frequency of near misses. The dependent variable consisted of: 1) those who had up to two near misses \( (n = 198) \); and 2) those who had three or more such events \( (n = 43) \) over the two years prior to the survey administration. The predictor variables were identical to those used in Analysis 1.

The best predictor for the root node was a safety climate factor variable **External Problems**, \( \chi^2 (2, 241) = 26.107, p = .000 \). The root node was split into three, consisting of: 1) those who “Often” observed \( (n = 53) \) **External Factors** that contributed to potential or actual safety problems in their workplace; 2) those who responded “Sometimes” \( (n = 97) \); and 3) those who responded “Rarely” \( (n = 91) \).

At Node 3, the Maintenance and Construction Staff group and Management were merged together due to their homogeneity with respect to the dependent variable criterion. Similarly, [Controllers] and [Drivers and On-Board Hospitality Staff] were merged to form another group. Thus, the second-level segmentation process generated two groups: 1) Maintenance, Construction and Management \( (n = 21) \); and 2) Controllers, Drivers and On-Board Hospitality Staff \( (n = 32) \).

Figure 6.7 shows the tree diagram of the significant predictor variables identified by CHAID. Experience of three or more near misses was reported by 43 out of 241 workers surveyed \( (17.8\%) \).

The modelling showed two end segments containing rail workers who reported three or more near misses at a greater rate than the total sample of 17.8% over the previous two years:

1. Node 7: A group of Controllers, Drivers and On-Board Hospitality Staff who often observed **External Factors** as contributing to potential or actual problems at their workplace, \( \chi^2 (1, 53) = 14.738, p = .001 \). Of
these people, 59.4% (n = 19) reported three or more near misses, 3.33 times more than the total sample’s percentage.

2. Node 5: Rail workers who sometimes observed *External Factors* as contributing to potential or actual problems at their workplace, and observed often or at least sometimes that *Roster and Time Pressure* as contributing to potential or actual problems in their workplace, $\chi^2 (1, 97) = 13.017, p = .001$. Of these people, 28.1% reported three or more near misses, 1.58 times more than the total sample of rail workers.

The modelling also showed one end segment containing rail workers who reported up to two near misses at a lesser rate than the total sample of 82.2% over the previous two years:

1) Node 7: A group of Controllers, Drivers and On-Board Hospitality Staff who often observed *External Factors* as contributing to potential or actual problems at their workplace, $\chi^2 (1, 53) = 14.738, p = .001$. Of these people, 40.6% (n = 13) reported up to two near misses, nearly half of the percentage (49%) of the total sample.

Finally, the modelling showed one end segment containing rail workers who reported up to two near misses at a lesser rate than the total sample of 17.8% over the previous two years:

1. Node 1: A group of rail workers who rarely observed *External Factors* as contributing to potential or actual problems at their workplace (n = 91, 38% of the total sample). Only five (5.5%) people out of this group had three or more near misses, less than one third of the percentage of the total sample (31%).

Classification showed that 204 participants (84.6%) were correctly classified, compared with 105.8 participants (43.9%) who would be correctly classified by chance alone. Of the 37 participants who were misclassified, 13 were from the None to Two group (misclassified as Three Plus) and 24 were from the Three Plus group (misclassified as None to Two). This meant that the None to
Two group \((n = 185, 93.4\%)\) was more likely to be correctly classified than the Three Plus group \((n = 19, 44.2\%)\).

![CHAID Tree](image)

**Figure 6.7.** Results of CHAID based on dichotomous dependent variable D8 Frequency of Near Misses (using 17 predictors).

**CHAID Analysis 6 – Modelling of Near Miss Frequency over the Previous Two Years (11 predictors)**

A further analysis to predict the frequency of near misses was conducted using the global factors for safety culture. The results were identical to those of the previous analysis (see Figure 6.7).
Summary

The results of the CHAID analyses showed limited predictive values except for Analysis 3. Using the theory-based safety culture factors as part of the predictors, results of Analysis 3 showed a moderate level of accuracy (66% for the total sample) for classification of group membership (Near Miss group vs. Non-Near Miss group). The results also indicated the significant role of Occupational Group as a primary predictor of membership in the Near Miss group vs. Non-Near Miss group. Interpretation of the results will be discussed further in Chapter 7.

Results of the discriminant function analyses and the CHAID analyses both showed limited predictive values. It was shown that the global safety culture factors, which were generated through factor analysis across the 67 items regardless of the theory-based dimensions, did not predict group membership in either the discriminant function analyses or the CHAID analyses.

The limited predictive values indicate that prediction of group membership in terms of [Accident group vs. Non-Accident group] and [Near Miss group vs. Non-Near Miss group] does not provide reliable enough insight into the relationship between safety climate/culture scores and safety outcomes as defined in the dyads above. Further exploration was conducted through multiple regression using different criterion variables.
6.2.3 Results of Multiple Regression Analyses

In order to further understand the relationship between safety outcomes and safety climate and culture, four multiple regression analyses were conducted on the following two criterion variables: 1) number of near misses; and 2) reporting of safety defects. Since these variables were measured on ordinal scales, they were deemed suitable as criterion variables for multiple regression analyses. As outlined in Section 1.6, growing evidence suggests that proactive indicators of safety performance may be more appropriate as measures of safety health. The use of the additional criterion variable addressing proactive employee involvement in accident prevention was deemed suitable to explore the pattern of prediction from safety climate/culture factors from a contrasting perspective.

In order to fulfil the requirements for this parametric technique, the self-report measure of the frequency at which the participants had near misses and the frequency at which they reported safety defects over the previous two years prior to the survey administration were re-categorised in the following manner.

A new variable *Near Miss Frequency* was created as the criterion variable through the following process for the first two analyses. The responses to questionnaire Item D7 and D8 were combined so that *Near Miss Frequency* would reflect the responses to both items. Item D7 [Have you been involved in a near miss or hazardous incident without injury while with your current employer during the past 2 years?] had a [Yes] or [No] dichotomous response scale, while Item 8 [How many near misses or hazardous incident without injury have you had while with your current employer during the past 2 years?] had five response selections ranging from [1 = one] to [5 = more than four]. In order to reduce the categories and to turn the distribution close to normality, *Near Miss Frequency* was classified into four groups: [1 = None]; [2 = One]; [3 = Two to three] and [4 = Four or more].

The distribution of *Near Miss Frequency* was positively skewed with the ratio between the skewness and the standard error of skewness at 5.0, above the standard value of 3.41 (Tabachnick & Fidell, 2007). Attempts to correct the skewness through transformation did not improve the situation. It was decided to keep the variable in its original state and to run multiple regression analyses on an
exploratory basis with a proviso that the results should be treated with caution (for Analyses 1 and 2).

The other criterion variable Safety Defect Reporting was created through the following process: the responses to questionnaire Items D9 to D12 were combined so that Safety Defect Reporting would reflect the responses to all items. Item 9: [Have you reported safety defects on equipment in your current workplace during the past 2 years?] and Item 11: [Have you reported any safety defects on track infrastructure, rolling stock or electrical infrastructure while with your current employer during the past 2 years?] had a [Yes] or [No] dichotomous response scale. On the other hand, Item 10 and 12 asked the participants how many times they reported safety defects on the following items: [D10] equipment; [D12-1] track; [D12-2] rolling stock; [D12-3] electrical and [D12-4] Others. The response scale ranged from [1 = once] to [5 = more than four times]. Safety Defect Reporting was computed by adding the number of times the participants reported safety defects on those items and by incorporating [Never] derived from Items 10 and 12.

The value for Safety Defect Reporting ranged from 0 (Never) to 25 (more than 25 times). The distribution is shown in Figure 6.8. Higher frequencies were observed on either end of the distribution. Skewness was .236 and kurtosis was -1.142 with a flat (platykurtic) distribution. The Kolmogorov-Smirnov statistic with a Lilliefors significance level for testing the normality indicated that the distribution was not normal (Coakes, 2005). The pattern of distribution of Safety Defect Reporting was compared with that for each item addressing the frequency of reporting (Item D10, D12-1 to D12-4), and a similar distribution was recognised. Tabachnick and Fidell (2009) state:

“In a large sample, a variable with statistically significant skewness often does not deviate enough from normality to make a substantive difference in the analysis. In other words, with large samples, the significance level of skewness is not as important as its actual size (worse the farther from zero) and the visual appearance of the distribution. In a large sample, the impact of departure from zero kurtosis also diminishes. For example, underestimates of variance associated with positive kurtosis (distributions with short, thick tails) disappear with samples of 100 or more
cases; with negative kurtosis, underestimation of variance disappears with samples of 200 or more (Waternaux, 1976), p.80”.

Thus a decision was made to use this variable as a criterion variable on a continuous scale for multiple regression analysis (Analyses 3 and 4).

**Figure 6.8.** Distribution of combined scores for Safety Defect Reporting

The previous CHAID results (Analyses 3 and 4) demonstrated that *Occupational Group* was a significant predictor of the frequency of near misses. Thus, it was decided to use it as a control variable in the following series of analysis. *Occupational Group* was used as a control variable for both analyses. Since this variable was originally on a nominal scale, dummy variables were created through recoding in order to facilitate its inclusion into the multiple regression computations (Allen & Bennett, 2010; Field, 2009; Tabachnick & Fidell, 2007). Using Management as the baseline, the dummy variables consisted of [D1 Controller vs. Management]; [D2 Driver & On-board Hospitality Staff vs. Management]; and [D3 Maintenance & Construction vs. Management].
**Participants**

The same sample of 241 participants used for discriminant function and CHAID analyses was used for the multiple regression analyses.

**Material and Procedure**

Preliminary analysis was performed using SPSS Regression and SPSS Explore (Version 18.0) in order to test the assumptions. First, the normal probability plot of standardised residuals and the scatterplot of standardised residuals against standardised predicted values were inspected to check whether the assumptions of normality, linearity and homoscedasticity of residuals were satisfied. Secondly, the Mahalanobis distance was inspected for multivariate outliers. Thirdly, the tolerances for the predictors in the regression model were inspected to ensure that multicollinearity would not interfere with the interpretation of the analysis outcome. The outcomes of these procedures were satisfactory unless otherwise stated.

Results of the evaluation led to transformation of the variables to reduce skewness, and improve the normality, linearity, and homoscedasticity of residuals. As in the previous discriminant function analysis and CHAID, the following three variables were transformed, namely, Negative Workplace Culture (Sqrt), Lack of Supervision (Log) and Organisational Latent Problems (Log). Following the transformation, slight positive skew was still found in both groups for all of the variables.

6.2.3.1 **Prediction of Near Miss Frequency (Multiple Regression)**

**Hierarchical Multiple Regression Analysis 1 – Modelling of Near Miss Frequency over the Previous Two Years (19 predictors)**

A hierarchical multiple regression analysis was performed between the Near Miss Frequency as the criterion variable and nineteen predictor variables. They consisted of three dummy variables to represent Occupational Group, seven safety climate factor variables, and nine safety culture factor variables.

Three multivariate outliers were found using a $p < .001$ criterion for Mahalanobis distance of exceeding $\chi^2 = 43.82$. They were removed from further computations, reducing the dataset to $N = 238$. Additionally, relatively high
tolerances for the predictors in the regression model indicated that multicollinearity would not interfere with the interpretation of the analysis results (Allen & Bennett, 2008).

On step 1, *Occupational Group* was used as a control variable, represented by three dummy variables: *Controller vs. Management; Driver & On-board Hospitality Staff vs. Management; and Maintenance & Construction vs. Management*. On step 2, safety climate and culture variables were added to the regression equation. They consisted of seven safety climate variables: *Negative Workplace Culture (Sqrt); Roster and Time Pressure, Support for Fatigue Management; Lack of Supervision (Log); Workplace Stress; Organisational Latent Problems (Log) and External Factors*, and nine safety culture factor variables: *Commitment to Health Safety and Environment (HSE) and Care for Colleagues; Balance Achieved between HSE and Profitability; Importance of Competency and Training Recognised; Effective Safety Controls; Balance Achieved between HSE Procedures and Efficiency; Negative Views on HSE Procedures; Reactivity – Blame Culture; Constructive Management Response to Accidents; and Proactive Approach to HSE Audits and Reviews*.

Table 6.10 displays descriptive statistics and correlations between variables.
### Table 6.10
Descriptive Statistics and Correlations between Variables for Multiple Regression Analyses (N = 238)

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*** p < .001 ** p < .01 * p < .05

n.b. 1 † denotes means and standard deviations of untransformed variables for easy comparison.

n.b. 2 The variables’ description is as follows:

- **DV**: Number of Near Misses
- **Control Variables**
  - A1-2) Roster & Time Pressure
  - A1-3) Support for Fatigue Management
  - A1-4) Lack of Supervision (Log)
  - A1-5) Workplace Stress
  - A2-1) Organisational Latent Problems (Log)
  - A2-2) External Factors
- **Dummy Variables (D1 to D3):**
  - A1-1) Negative Workplace Culture (Sqrt)
  - A2-1) Non-compliance 
- **Predictor Variables**
  - B1 Commitment to HSE and Care for Colleagues
  - B2 Balance between HSE & Profitability
  - B3 Importance of Competency & Training Recognised
  - B4 Effective Safety Controls
  - B5-1) Balance between HSE Procedures & Efficiency
  - B5-2) Negative Views on HSE Procedures
  - B6-1) Reactivity - Blame Culture
  - B6-2) Constructive Management Response to Accidents
  - B7 Proactive Approach to HSE Audits and Reviews
In the evaluation of the significance of the regression equation, caution was exercised against potential cumulative Type I errors by using a nominal alpha level for each predictor at 0.03. In this process the three dummy variables representing *Occupational Group* were counted as one grouping variable. For Analysis 1, the gamma was set by multiplying the alpha by 17 variables 0.03 X 17 = 0.51. *R* for regression was significantly different from zero at the end of each step. *Occupational Group* accounted for a significant 10.8% of the variance in the number of near misses, $R^2 = .108$, $F (3, 234) = 9.40$, $p = .000007$. The adjusted $R^2$ value of .096 indicates that nearly 10% of the variability is predicted by the *Occupational Group*.

On step 2, four safety climate and culture variables *Balance between HSE Procedures & Efficiency, External Factors, Proactive Approach to HSE Audits & Reviews* and *Reactivity – Blame Culture*, added to the regression equation, accounting for an additional 19.2% of the variance in the number of near misses, $\Delta R^2 = .192$, $\Delta F (16, 218) = 3.747$, $p = .000004$. In combination, the five predictor variables explained 30% of the variance in the number of near misses, $R^2 = .300$, adjusted $R^2 = .239$, $F (19, 218) = 4.92$, $p = .000000$. By Cohen’s (1988) conventions, a combined effect of this magnitude can be considered “moderate” ($f^2 = .43$).

Unstandardised regression coefficients ($B$) and intercept, the standardised regression coefficients ($\beta$), the semipartial correlations ($sr^2$), $R^2$, and adjusted $R^2$ are reported in Table 6.11. Altogether, 30% (adjusted 24%) of the variability in the number of near misses was predicted by knowing the scores on these five predictor variables. The size and direction of the relationships indicate that *Occupational Group* was a significant predictor of the number of near misses experienced. In particular, significantly more near misses were experienced by train drivers or on-board hospitality staff members compared to management. Overall, people who experienced more near misses thought their organisation had not achieved a balance between HSE procedures and efficiency. Furthermore, they observed external factors as potential or actual safety problems more frequently than those who had fewer or no near misses. They thought their organisation was more reactive rather than proactive in its response to accidents, characterised by blame culture than those who had fewer or no near misses.
Although the bivariate correlation between the number of near misses and *Proactive Approach to HSE Audits and Reviews* was significant at \( p < .05 \) in the negative direction, the regression coefficient is significant at \( p < .05 \) in the positive direction.

Presence of a mediator was evaluated using the Aroian version of the Sobel test (Baron & Kenny, 1986). As specified in the Sobel test formulae (Preacher & Hayes, 2004), relationships were examined among the criterion variable *Near Miss Frequency*, the predictor in question *Proactive Approach to HSE Audits and Reviews* and other predictor variables in the set.

A significant mediation effect was deemed to be present when all of the following conditions were satisfied: (a) Variations in levels of the predictor variable significantly account for variations in the presumed mediator variable (i.e. Path \( a \)); (b) Variations in the mediator significantly account for variations in the outcome variable (i.e. Path \( b \)); and (c) when Paths \( a \) and \( b \) are controlled, a previously significant relation between the independent and dependent variables is no longer significant, with the strongest demonstration of mediations occurring when Path \( c \) is zero (Baron & Kenny, 1986). Figure 6.8 illustrates the relationships between the variables, where \( a \), \( b \), and \( c' \) are path coefficients and the values in parentheses are standard errors of those path coefficients.

![Mediation Model](attachment:mediation_model.png)

\( a = \) raw (unstandardised) regression coefficient for the association between IV and mediator.
\( s_a = \) standard error of \( a \).
\( b = \) raw coefficient for the association between the mediator and the DV (when the IV is also a predictor of the DV).
\( s_b = \) standard error of \( b \).

*Figure 6.9. Mediation model (adapted from Preacher & Leonardelli, 2010-2012).*
Applying Bonferroni adjustments (0.05 / 16 = 0.003125), the following variables were identified as mediators: *Driver & On-board Hospitality Staff vs. Management* ($p = 0.00173$); *Roster and Time Pressure* ($p = 0.00154$); *Organisational Latent Problems* ($p = 0.00229$); *Balance Achieved between HSE and Profitability* ($p = 0.00048$); *Balance Achieved between HSE Procedures and Efficiency* ($p = 0.00029$); and *Reactivity – Blame Culture* ($p = 0.00119$).

Post hoc correction using $F(19, 218), p < .01$ was carried out for all the other predictor variables as per the formula specified in Tabachnick and Fidell (2007). Despite the significant bivariate correlations with *Near Miss Frequency*, the following factor variables did not contribute significantly to regression: *Negative Workplace Culture (Sqrt)*; *Roster and Time Pressure, Support for Fatigue Management*; *Lack of Supervision (Log)*; *Workplace Stress*; *Organisational Latent Problems (Log)*; *Commitment to Health Safety and Environment (HSE) and Care for Colleagues*; *Balance between HSE and Profitability*; *Importance of Competency & Training Recognised*; *Effective Safety Controls*; *Negative Views on HSE Procedures*; and *Constructive Management Response to Accidents*. 
Table 6.11
Unstandardised (B) and Standardised (β) Regression Coefficients, and Squared Semi-Partial Correlations (sr²) for Each Predictor in a Standard Regression Model
Predicting Frequency of Near Misses (17 Predictors)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>β</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2 Driver &amp; On-board Hospitality Staff vs. Management</td>
<td>0.99***</td>
<td>0.43</td>
<td>.10</td>
</tr>
<tr>
<td>D1 Controller vs. Management</td>
<td>0.57*</td>
<td>0.17</td>
<td>.02</td>
</tr>
<tr>
<td>D3 Maintenance &amp; Construction vs. Management</td>
<td>0.42</td>
<td>0.17</td>
<td>.01</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2 Driver &amp; On-board Hospitality Staff vs. Management</td>
<td>0.97***</td>
<td>0.42</td>
<td>.06</td>
</tr>
<tr>
<td>B5-1) Balance between HSE Procedures &amp; Efficiency</td>
<td>-0.62***</td>
<td>-0.31</td>
<td>.05</td>
</tr>
<tr>
<td>A2-2) External Factors</td>
<td>0.29***</td>
<td>0.23</td>
<td>.04</td>
</tr>
<tr>
<td>B7 Proactive Approach to HSE Audits &amp; Reviews</td>
<td>0.53**</td>
<td>0.28</td>
<td>.03</td>
</tr>
<tr>
<td>B6-1) Reactivity - Blame Culture</td>
<td>0.28**</td>
<td>0.21</td>
<td>.02</td>
</tr>
<tr>
<td>D1 Controller vs. Management</td>
<td>0.57</td>
<td>0.17</td>
<td>.02</td>
</tr>
<tr>
<td>B1 Commitment to HSE and Care for Colleagues</td>
<td>0.31</td>
<td>0.19</td>
<td>.01</td>
</tr>
<tr>
<td>D3 Maintenance &amp; Construction vs. Management</td>
<td>0.40</td>
<td>0.16</td>
<td>.01</td>
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<tr>
<td>A1-3) Support for Fatigue Management</td>
<td>-0.10</td>
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<td>.01</td>
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<tr>
<td>A1-5) Workplace Stress</td>
<td>0.10</td>
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<tr>
<td>A1-1) Negative Workplace Culture (Sqrt)</td>
<td>0.34</td>
<td>0.10</td>
<td>.00</td>
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<tr>
<td>A1-4) Lack of Supervision (Log)</td>
<td>0.44</td>
<td>0.06</td>
<td>.00</td>
</tr>
<tr>
<td>B5-2) Negative Views on HSE Procedures</td>
<td>-0.10</td>
<td>-0.06</td>
<td>.00</td>
</tr>
<tr>
<td>B3 Importance of Competency &amp; Training Recognised</td>
<td>0.13</td>
<td>0.07</td>
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<tr>
<td>A1-2) Roster &amp; Time Pressure</td>
<td>-0.04</td>
<td>-0.04</td>
<td>.00</td>
</tr>
<tr>
<td>B2 Balance between HSE &amp; Profitability</td>
<td>-0.08</td>
<td>-0.05</td>
<td>.00</td>
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<tr>
<td>A2-1) Organisational Latent Problems (Log)</td>
<td>-0.18</td>
<td>-0.03</td>
<td>.00</td>
</tr>
<tr>
<td>B6-2) Constructive Management Response to Accidents</td>
<td>0.02</td>
<td>0.01</td>
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</tr>
<tr>
<td>B4 Effective Safety Controls</td>
<td>-0.02</td>
<td>-0.01</td>
<td>.00</td>
</tr>
</tbody>
</table>

Intercept = -1.488

\[ R^2 = .300 \]
\[ \text{Adjusted } R^2 = .239 \]
\[ R = .548*** \]

*** \( p < .001 \)  ** \( p < .01 \)  * \( p < .03 \)
Hierarchical Multiple Regression Analysis 2 – Modelling of Near Miss Frequency over the Previous Two Years (11 predictors)

A further analysis to predict the number of near misses was conducted using the global factors for safety culture in place of the seven theoretically-generated factor variables. A hierarchical multiple regression analysis was performed between Near Miss Frequency as the criterion variable and eleven predictor variables.

On step 1, Occupational Group was used as a control variable, represented by three dummy variables. On step 2, safety climate and culture variables were added to the regression equation. They consisted of seven safety climate variables: Negative Workplace Culture (Sqrt); Roster and Time Pressure; Support for Fatigue Management; Lack of Supervision (Log); Workplace Stress; Organisational Latent Problems (Log) and External Factors, and three global factor variables: Discrepant Commitment to Safety by Team Members and Line Management; Negative Views on Internal Audits and Reviews; and Management’s Commitment to Safety.

One multivariate outlier was found using a $p < .001$ criterion for Mahalanobis distance of exceeding $\chi^2 = 34.53$, reducing the sample size to $N = 240$. Relatively high tolerances for the predictors in the regression model indicated that multicollinearity would not interfere with the interpretation of the analysis results. Table 6.12 displays descriptive statistics and correlations between variables.

For caution against potential cumulative Type I errors, a nominal alpha level for each predictor at 0.03 was used. Counting the three dummy variables representing Occupational Group was as one, the gamma was set by multiplying the alpha by 11 variables $0.03 \times 11 = 0.33$. These were the values against which the global F significance was tested.

Similar to the previous analysis, $R$ for regression was significantly different from zero at the end of each step. Occupational Group accounted for a significant 10.8% of the variance in the number of near misses, $R^2 = .105$, $F (3, 236) = 9.24$, $p = .000008$. The adjusted $R^2$ value of .094 indicates that nearly 10% of the variability is predicted by the Occupational Group.
On step 2, in addition to Occupational Group, two safety climate and culture variables External Factors, and Negative Views on Internal Audits and Reviews, added to the regression equation. They accounted for an additional 17.9% of the variance in the number of near misses, \( \Delta R^2 = .179, \Delta F (10, 226) = 3.447, p = .000313 \). In combination, three predictor variables explained 22% of the variance in the number of near misses, \( R^2 = .224, \) adjusted \( R^2 = .179, F (13, 226) = 5.00, p = .000000 \). By Cohen’s (1988) conventions, a combined effect of this magnitude can be considered “medium” \( (f^2 = .29) \).

### Table 6.12
Descriptive Statistics and Correlations between Variables \((N = 240)\)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>DV</td>
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<tr>
<td>D1</td>
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<tr>
<td>D2</td>
<td>.29***</td>
<td>-.32***</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>D3</td>
<td>-.10</td>
<td>-.24***</td>
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</tr>
<tr>
<td>A1-1)</td>
<td>.25***</td>
<td>-.24***</td>
<td>.29***</td>
<td>.04</td>
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<td>A1-2)</td>
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<td>.39***</td>
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<td>.49***</td>
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<tr>
<td>A1-3)</td>
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<td>-.15*</td>
<td>-.03</td>
<td>-.07</td>
<td>-.31***</td>
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<td>A1-4)</td>
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<td>-.12</td>
<td>.13*</td>
<td>.14*</td>
<td>.55***</td>
<td>.34***</td>
<td>-.24***</td>
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<tr>
<td>A1-5)</td>
<td>.22***</td>
<td>.02</td>
<td>.10</td>
<td>.00</td>
<td>.46***</td>
<td>.44**</td>
<td>-.27***</td>
<td>.42***</td>
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<td>A2-1)</td>
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<td>-.10</td>
<td>.18**</td>
<td>.03</td>
<td>.70***</td>
<td>.48**</td>
<td>-.35***</td>
<td>.62***</td>
<td>.52**</td>
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<td>A2-2)</td>
<td>.31***</td>
<td>.06</td>
<td>.14*</td>
<td>-</td>
<td>.30***</td>
<td>.38**</td>
<td>-.24***</td>
<td>.24***</td>
<td>.31**</td>
<td>.41***</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>GF-B1</td>
<td>.21***</td>
<td>-.11*</td>
<td>.19**</td>
<td>.07</td>
<td>.60***</td>
<td>.41**</td>
<td>-.36***</td>
<td>.46***</td>
<td>.42**</td>
<td>.67**</td>
<td>.29**</td>
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<td>GF-B2</td>
<td>.08</td>
<td>-.06</td>
<td>.29***</td>
<td>.06</td>
<td>.43***</td>
<td>.33**</td>
<td>-.32***</td>
<td>.34***</td>
<td>.28**</td>
<td>.38**</td>
<td>.21***</td>
<td>.41***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GF-B3</td>
<td>-.19**</td>
<td>.04</td>
<td>-.25***</td>
<td>-.05</td>
<td>-.52***</td>
<td>-</td>
<td>.41***</td>
<td>-.36***</td>
<td>-</td>
<td>-.16**</td>
<td>-.48***</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( M \) 1.92 | .13 | .41 | .29 | 2.16† | 2.69 | 2.43 | 1.54† | 2.76 | 1.98† | 2.73 | 3.10 | 2.42 | 3.44 |
\( SD \) 1.13 | .33 | .49 | .45 | 1.01† | 1.06 | 1.09 | .65† | .97 | .73† | .91 | .75 | .77 | .68 |

n.b. 1 † denotes means and standard deviations of untransformed variables for easy comparison.

n.b. 2 The variables’ description is as follows:

<table>
<thead>
<tr>
<th>DV</th>
<th>No. of Near Misses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Variables</td>
<td>Dummy Variables (D1 to D3):</td>
</tr>
<tr>
<td>• D1 Controller vs. Management</td>
<td>A1-3) Support for Fatigue Management</td>
</tr>
<tr>
<td>• D2 Driver &amp; On-board Hospitality Staff vs. Management</td>
<td>A1-4) Lack of Supervision (Log)</td>
</tr>
<tr>
<td>• D3 Maintenance &amp; Construction vs. Management</td>
<td>A2-1) Organisational Latent Problems (Log)</td>
</tr>
<tr>
<td>Predictor Variables</td>
<td>A2-2) External Factors</td>
</tr>
<tr>
<td>A1-1) Negative Workplace Culture (Sqrt)</td>
<td>GF-B1 Discrepant Commitment to Safety by</td>
</tr>
<tr>
<td>A1-2) Roster &amp; Time Pressure</td>
<td>Team Members and Line Management</td>
</tr>
<tr>
<td>A2-1) Negative Views on Internal Audits and Reviews</td>
<td>GF-B2 Negative Views on Internal Audits and Reviews</td>
</tr>
<tr>
<td>A2-2) Management’s Commitment to Safety</td>
<td></td>
</tr>
</tbody>
</table>

Unstandardised regression coefficients \( (B) \) and intercept, the standardised regression coefficients \( (\beta) \), the semipartial correlations \( (sr^2) \), \( R^2 \), and adjusted \( R^2 \) are reported in Table 6.13. Altogether, 22% (adjusted 18%) of the variability in the number of near misses was predicted by knowing the scores on these three
predictor variables. The size and the direction of the relationships suggest *Occupational Group* was a significant predictor of the number of near misses experienced. In particular, significantly more near misses were experienced by train drivers or on-board hospitality staff members compared to management. Overall, people who experienced more near misses observed external factors as potential or actual safety problems more frequently than those who had fewer or no near misses.

Although the regression coefficient for Global Factor *Negative Views on Internal Audits and Reviews* was significant with \( t = 2.80, p < .01 \), its bivariate correlation with the criterion variable *Near Miss Frequency* was not significant. Furthermore, the bivariate correlation between the number of near misses and Global Factor *Negative Views on Internal Audits and Reviews* was positive, while the regression coefficient is significant at \( p < .01 \) in the negative direction.

As with the previous analysis, presence of a mediator was evaluated using the Sobel test. Relationships were examined among the criterion variable *Near Miss Frequency*, the predictor in question *Negative Views on Internal Audits and Reviews* and the other predictor variables in the set. Applying Bonferroni adjustments \( (0.05 / 10 = 0.005) \), the following variables were identified as mediators, *Driver & On-board Hospitality Staff vs. Management* \( (p = .00138) \), *Negative Workplace Culture* (Sqrt) \( (p = .00070) \), *Roster and Time Pressure* \( (p = .00101) \), and *Organisational Latent Problems* (Log) \( (p = .00102) \).
Table 6.13
Unstandardised (B) and Standardised (β) Regression Coefficients, and Squared Semi-
Partial Correlations (sr²) for Each Predictor in a Standard Regression Model
Predicting Frequency of Near Misses (11 Predictors)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>β</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2 Driver &amp; On-board Hospitality Staff vs. Management</td>
<td>0.98***</td>
<td>0.43</td>
<td>.09</td>
</tr>
<tr>
<td>D1 Controller vs. Management</td>
<td>0.53</td>
<td>0.16</td>
<td>.02</td>
</tr>
<tr>
<td>D3 Maintenance &amp; Construction vs. Management</td>
<td>0.41</td>
<td>0.16</td>
<td>.01</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2 Driver &amp; On-board Hospitality Staff vs. Management</td>
<td>0.95***</td>
<td>0.41</td>
<td>.07</td>
</tr>
<tr>
<td>A2-2) External Factors</td>
<td>0.28***</td>
<td>0.23</td>
<td>.04</td>
</tr>
<tr>
<td>GF-B2 Negative Views on Internal Audits and Reviews</td>
<td>-0.31***</td>
<td>-0.21</td>
<td>.03</td>
</tr>
<tr>
<td>D3 Maintenance &amp; Construction vs. Management</td>
<td>0.44</td>
<td>0.18</td>
<td>.01</td>
</tr>
<tr>
<td>D1 Controller vs. Management</td>
<td>0.47</td>
<td>0.14</td>
<td>.01</td>
</tr>
<tr>
<td>A1-3) Support for Fatigue Management</td>
<td>-0.11</td>
<td>-0.10</td>
<td>.01</td>
</tr>
<tr>
<td>A1-5) Workplace Stress</td>
<td>0.08</td>
<td>0.06</td>
<td>.00</td>
</tr>
<tr>
<td>A1-1) Negative Workplace Culture (Sqrt)</td>
<td>0.23</td>
<td>0.07</td>
<td>.00</td>
</tr>
<tr>
<td>A1-4) Lack of Supervision (Log)</td>
<td>0.33</td>
<td>0.05</td>
<td>.00</td>
</tr>
<tr>
<td>GF-B3 Management’s Commitment to Safety</td>
<td>-0.05</td>
<td>-0.03</td>
<td>.00</td>
</tr>
<tr>
<td>GF-B1 Discrepant Commitment to Safety by Team Members and Line Management</td>
<td>0.02</td>
<td>0.01</td>
<td>.00</td>
</tr>
<tr>
<td>A1-2) Roster &amp; Time Pressure</td>
<td>-0.01</td>
<td>-0.01</td>
<td>.00</td>
</tr>
<tr>
<td>A2-1) Organisational Latent Problems (Log)</td>
<td>0.05</td>
<td>0.01</td>
<td>.00</td>
</tr>
</tbody>
</table>

Intercept = 1.119

\[ R^2 = .224 \]
\[ \text{Adjusted } R^2 = .179 \]
\[ R = .473*** \]

*** p < .001    ** p < .01    * p < .03

Post hoc correction using F (13, 226), p < .01 revealed that, despite the significant bivariate correlations with Near Miss Frequency, the following factor variables did not contribute significantly to regression: Negative Workplace Culture (Sqrt); Roster and Time Pressure; Support for Fatigue Management; Lack of Supervision (Log); Workplace Stress; Organisational Latent Problems (Log); Discrepant Commitment to Safety by Team Members and Line Management; and Management’s Commitment to Safety.
6.2.3.2 Prediction of Safety Defect Reporting (Multiple Regression)

Two hierarchical multiple regression analyses were run to predict the number of times the participants reported safety defects. The criterion variable was Safety Defect Reporting. Predictors for the first analysis consisted of seven safety climate variables, nine theoretically-generated safety culture factor variables, and some control variables as specified below. Predictors for the second analysis consisted of seven safety climate variables, the three global safety culture factor variables, and some control variables as specified below.

Hierarchical Multiple Regression Analysis 3 – Modelling of Safety Defect Reporting over the Previous Two Years (19 predictors)

One participant did not respond to the item to indicate his tenure in the rail industry. This case was thus excluded from the analyses, reducing the dataset to N = 240. Two cases were identified with the Mahalanobis distance exceeding the critical value of $\chi^2 = 43.82$ using a $p < .001$ criterion. They were removed from further analysis, reducing the dataset to $N = 238$.

On step 1, three control variables were used: Number of Near Misses; Years Worked in the Rail Industry (Tenure); and Occupational Group. In the same manner as the previous multiple regression analyses (Analyses 1 and 2), Occupational Group was represented by three dummy variables using Management as the baseline. On step 2, the seven safety climate and nine culture variables (identical to those used for Analysis 1) were added to the regression equation. Table 6.14 displays descriptive statistics and correlations between variables.

For caution against potential cumulative Type I errors, a nominal alpha level for each predictor at 0.03 was used. Counting the three dummy variables as one grouping variable, the gamma was set by multiplying the alpha by 19 variables $0.03 \times 19 = 0.57$. This is the level against which the global $F$ significance was tested.

$R$ for regression was significantly different from zero at the end of each step. Number of Near Misses, Years Worked in the Rail Industry (Tenure), and Occupational Group together accounted for a significant 30.8% of the variance in the reporting of safety defects $R^2 = .308$, $F (5, 232) = 20.67, p = .000005$. The
adjusted $R^2$ value of .293 indicates that nearly 30% of the variability is predicted by the combination of *Number of Near Misses, Years Worked in the Rail Industry (Tenure)*, and *Occupational Group*.

On step 2, two safety climate and culture variables *Workplace Stress* and *Reactivity – Blame Culture*, added to the regression equation, accounted for an additional 14.8% of the variance in the reporting of safety defects, $\Delta R^2 = .148$, $\Delta F(16, 216) = 3.673, p = .000006$. In combination, the 5 predictor variables explained 45.6% of the variance in reporting of safety defects, $R^2 = .456$, adjusted $R^2 = .403$, $F (21, 216) = 8.63, p = .000005$. By Cohen’s (1988) conventions, a combined effect of this magnitude can be considered “large” ($f^2 = .84$).

Unstandardised regression coefficients ($B$) and intercept, the standardised regression coefficients ($\beta$), the semipartial correlations ($sr^2$), $R^2$, and adjusted $R^2$ are reported in Table 6.15.

Altogether, 46% (adjusted 40%) of the variability in the number of times safety defects were reported was predicted by knowing the scores on the three control variables: *Number of Near Misses; Years Worked in the Rail Industry (Tenure)*; and *Occupational Group*, and two safety climate and culture variables: *Workplace Stress* and *Reactivity – Blame Culture*.

The size and the direction of the relationships suggest that significant difference existed among the occupational groups in the number of times safety defects were reported. This was particularly so with train controllers who reported safety defects more frequently compared to management. People who had worked in the rail industry for longer periods reported safety defects more frequently than those with less experience. People who had experienced more near misses reported safety defects more frequently than those who had experienced fewer near misses. Furthermore, people who observed higher level of stress at their workplace tended to report safety defects more frequently. Finally, significantly more safety defects were reported by those who thought that their organisation was reactive rather than proactive in their style of responding to accidents, characterised by a tendency to apportion blame to those who were directly involved in the accidents rather than investigating systemic issues.
Table 6.14
Descriptive Statistics and Correlations between Variables (N = 238)

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| M   | 10.90 | .13  | .41  | .28  | .40  | 1.22 | 2.16 | 2.69 | 2.44 | 1.55 | 2.74 | 1.98 | 2.74 | 3.31 | 3.40 | 3.41 | 3.47 | 3.17 | 3.23 | 3.26 | 3.58 | 3.29 |       |
| SD  | 7.89  | .34  | .49  | .45  | 1.34 | 1.70 | 1.01 | 1.07 | 1.09 | .66  | .97  | .72  | .90  | .71  | .70  | .55  | .59  | .58  | .69  | .84  | .63  | .61  |       |

*** p < .001 ** p < .01 * p < .05

n.b. 1 † denotes mean and standard deviations of untransformed variables for easy comparison

n.b. 2 The variables’ description is as follows:

- DV Number of Safety Defects Reported
- Predictor Variables
- **D1** Controller vs. Management
- **D2** Driver & On-board Hospitality Staff vs. Management
- **D3** Maintenance & Construction vs. Management
- **E10** Number of Years Worked in the Rail Industry
- **D8** Number of Near Misses

B1 Commitment to HSE and Care for Colleagues
B2 Balance between HSE & Profitability
B3 Importance of Competency & Training Recognised
B4 Effective Safety Controls
B5-1 Balance between HSE Procedures & Efficiency
B5-2 Negative Views on HSE Procedures
B6-1 Reactivity - Blame Culture
B6-2 Constructive Management Response to Accidents
B7 Proactive Approach to HSE Audits
Table 6.15
Unstandardised (B) and Standardised (β) Regression Coefficients, and Squared Semi-Partial Correlations ($sr^2$) for Each Predictor in a Standard Regression Model Predicting Frequency of Safety Defect Reporting (19 Predictors)

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<th>B</th>
<th>β</th>
<th>$sr^2$</th>
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<td>0.25</td>
<td>0.02</td>
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<td>D3 Maintenance &amp; Construction vs. Management</td>
<td>-0.67</td>
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<td>E10 Years worked in rail industry</td>
<td>1.79</td>
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<td>D8 No. of Near Misses</td>
<td>2.42</td>
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<td>D8 No. of Near Misses</td>
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<td>E10 Years worked in rail industry</td>
<td>1.53</td>
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<td>B6-1) Reactivity - Blame Culture</td>
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<td>B7 Correct Proactive Approach to HSE Audits</td>
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Intercept = -14.41

$$R^2 = .46$$

Adjusted $$R^2 = .40$$

$$R = .68^{***}$$

*** $p < .001$  ** $p < .01$  * $p < .03$
Multiple Regression Analysis 4 – Modelling of the Safety Defect Reporting over the Previous Two Years (13 predictors)

A further analysis to predict the number of times safety defects were reported was conducted using the global factors for safety culture in place of the seven theoretically-generated factor variables used in Analysis 3. Unlike Analysis 1, no multivariate outliers were identified, thus the dataset remained at $N = 240$.

On step 1, the same control variables were used as in Analysis 3, consisting of Number of Near Misses, Years Worked in the Rail Industry (Tenure), and Occupational Group. On step 2, 10 predictor variables were added to the regression equation, which consisted of the seven safety climate variables and three global safety culture variables (identical to those used for Analysis 2).

Table 6.16 displays descriptive statistics and correlations between variables. For caution against potential cumulative Type I errors, a nominal alpha level for each predictor at 0.03 was used. Counting the three dummy variables as one grouping variable, the gamma was set by multiplying the alpha by 13 variables $0.03 \times 13 = 0.39$. This is the level against which the global $F$ significance was tested.

$R$ for regression was significantly different from zero at the end of each step. On step 1, Number of Near Misses, Years Worked in the Rail Industry (Tenure), and Occupational Group together accounted for a significant 31.2% of the variance in the reporting of safety defects $R^2 = .312$, $F (5, 234) = 21.22$, $p = .000002$. The adjusted $R^2$ value of .297 indicates that nearly 30% of the variability is predicted by the combination of Number of Near Misses, Years Worked in the Rail Industry (Tenure), and Occupational Group.

On step 2, safety climate and culture variables, added to the regression equation, accounted for an additional 10.4% of the variance in the reporting of safety defects, $\Delta R^2 = .104$, $\Delta F (10, 224) = 3.98$, $p = .000006$. In combination, the 13 predictor variables explained 41.6% of the variance in reporting of safety defects, $R^2 = .416$, adjusted $R^2 = .377$, $F (15, 224) = 10.63$, $p = .000004$. By Cohen’s (1988) conventions, a combined effect of this magnitude can be considered “large” ($f^2 = .71$).
Unstandardised regression coefficients ($B$) and intercept, the standardised regression coefficients ($\beta$), the semipartial correlations ($sr^2$), $R^2$, and adjusted $R^2$ are reported in Table 6.17.

Altogether, 42% (adjusted 38%) of the variability in the number of times safety defects were reported was predicted by knowing the scores on the three control variables: *Number of Near Misses; Years Worked in the Rail Industry* (Tenure); and *Occupational Group*, and one safety climate variable *Workplace Stress*. 
### Table 6.16

**Descriptive Statistics and Correlations between Variables (N = 240)**

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<td>D2 Driver &amp; On-board Hospitality Staff vs. Management</td>
<td>.06</td>
<td>- .32***</td>
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<tr>
<td>D3 Maintenance &amp; Construction vs. Management</td>
<td>-.15*</td>
<td>-.24***</td>
<td>-.53***</td>
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<tr>
<td>Number of Years Worked in the Rail Industry</td>
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<td>D4 Management’s Commitment to Safety</td>
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<td>D5 Negative Views on Internal Audits and Reviews</td>
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<td>D6 Discrepant Commitment to Safety by Team</td>
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<td>D7 Lack of Supervision</td>
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<td>Negative Workplace Culture (Sqrt)</td>
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<td>Roster &amp; Time Pressure</td>
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<td>Support for Fatigue Management</td>
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<td>Lack of Supervision (Log)</td>
<td>A1-4</td>
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<td>Organisational Latent Problems (Log)</td>
<td>A2-1</td>
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<td>External Factors</td>
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<td>Organisational Latent Problems (Log)</td>
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<tr>
<td>Negative Views on Internal Audits and Reviews</td>
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<td>Members and Line Management</td>
<td>A1-2</td>
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**Note:**
1) † denotes mean and standard deviations of untransformed variables for easy comparisons.
2) The variables’ descriptions are as follow:

**DV**: Number of Safety Defects Reported  
**Predictor Variables**:  
- A1-1) Negative Workplace Culture (Sqrt)  
- A1-2) Roster & Time Pressure  
- A1-3) Support for Fatigue Management  
- A1-4) Lack of Supervision (Log)  
- A1-5) Workplace Stress  
- A2-1) Organisational Latent Problems (Log)  
- A2-2) External Factors

**Note:**

- *** $p < .001$
- ** $p < .01$
- * $p < .05$
The size and the direction of the relationships suggest that significant
difference existed among the occupational groups in the number of times safety
defects were reported. People who worked in the rail industry for longer periods
reported safety defects more frequently than those with less experience. People
who experienced more near misses reported safety defects more frequently than
those who experienced fewer near misses. Furthermore, people who observed
higher level of stress at their workplace tended to report safety defects more
frequently. None of the global safety culture variables was found as a significant
predictor.

Table 6.17
Unstandardised (B) and Standardised (β) Regression Coefficients, and Squared Semi-
Partial Correlations (sr²) for Each Predictor in a Standard Regression Model
Predicting Frequency of Safety Defect Reporting (13 Predictors)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>β</th>
<th>sr²</th>
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</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D8   No. of Near Misses</td>
<td>2.47***</td>
<td>0.35</td>
<td>.11</td>
</tr>
<tr>
<td>E10  Years worked in rail industry</td>
<td>1.79***</td>
<td>0.30</td>
<td>.09</td>
</tr>
<tr>
<td>D1   Controller vs. Management</td>
<td>4.73**</td>
<td>0.20</td>
<td>.03</td>
</tr>
<tr>
<td>D3   Maintenance &amp; Construction vs. Management</td>
<td>-0.74</td>
<td>-0.04</td>
<td>.00</td>
</tr>
<tr>
<td>D2   Driver &amp; On-board Hospitality Staff vs. Management</td>
<td>0.12</td>
<td>0.01</td>
<td>.00</td>
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<tr>
<td><strong>Step 2</strong></td>
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<tr>
<td>D8   No. of Near Misses</td>
<td>1.90***</td>
<td>0.27</td>
<td>.06</td>
</tr>
<tr>
<td>E10  Years worked in rail industry</td>
<td>1.55***</td>
<td>0.26</td>
<td>.05</td>
</tr>
<tr>
<td>A1-5) Workplace Stress</td>
<td>1.25*</td>
<td>0.15</td>
<td>.02</td>
</tr>
<tr>
<td>D1   Controller vs. Management</td>
<td>3.78*</td>
<td>0.16</td>
<td>.01</td>
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<tr>
<td>A1-2) Roster &amp; Time Pressure</td>
<td>0.89</td>
<td>0.12</td>
<td>.01</td>
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<tr>
<td>A2-1) Organisational Latent Problems (Log)</td>
<td>6.49</td>
<td>0.13</td>
<td>.01</td>
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<tr>
<td>A2-2) External Factors</td>
<td>0.67</td>
<td>0.08</td>
<td>.00</td>
</tr>
<tr>
<td>A1-4) Lack of Supervision (Log)</td>
<td>-3.58</td>
<td>-0.08</td>
<td>.00</td>
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<tr>
<td>D2   Driver &amp; On-board Hospitality Staff vs. Management</td>
<td>-1.47</td>
<td>-0.09</td>
<td>.00</td>
</tr>
<tr>
<td>D3   Maintenance &amp; Construction vs. Management</td>
<td>-1.08</td>
<td>-0.06</td>
<td>.00</td>
</tr>
<tr>
<td>A1-1) Negative Workplace Culture (Sqrt)</td>
<td>0.83</td>
<td>0.03</td>
<td>.00</td>
</tr>
<tr>
<td>GF-B2 Negative Views on Internal Audits and Reviews</td>
<td>0.09</td>
<td>0.01</td>
<td>.00</td>
</tr>
<tr>
<td>A1-3) Support for Fatigue Management</td>
<td>0.04</td>
<td>0.01</td>
<td>.00</td>
</tr>
<tr>
<td>GF-B3 Management’s Commitment to Safety</td>
<td>0.04</td>
<td>0.00</td>
<td>.00</td>
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<tr>
<td>GF-B1 Discrepant Commitment to Safety by Team</td>
<td>-0.03</td>
<td>0.00</td>
<td>.00</td>
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</table>

Intercept = -9.08

R² = .42
Adjusted R² = .38
R = .64***

*** p < .001  ** p < .01  * p < .03
Summary

The results of Analyses 1 and 2 need to be treated with caution due to the non-normal distribution of the criterion variable Near Miss Frequency coupled with some potential meditational effects among the predictor variables. Nevertheless, for both analyses, the control variable Occupational Group was a significant predictor of the number of near misses experienced. Analysis 1 used predictors including Shell’s theory-based safety culture factors. The results indicated that when the effect of Occupational Group was controlled for, the following variables were significant predictors of the frequency of near misses: Balance between HSE Procedures & Efficiency; External Factors; Proactive Approach to HSE Audits; and Reactivity – Blame Culture. Analysis 2 used predictors including the global factors based on Shell’s safety culture model. The results indicated that when the effect of Occupational Group was controlled for, the following variables were significant predictors: External Factors and Negative Views on Internal Audits and Reviews.

On the first step of both Analyses 3 and 4, three control variables, consisting of Occupational Group, Years Worked in Rail Industry (Tenure), and Near Miss Frequency (an ordinal variable with four levels), were found to be significant predictors of safety defect reporting. The second step of Analysis 3, which used predictors including Shell’s theory-based safety culture factors, indicated that when the effect of Occupational Group, Years Worked in Rail Industry (Tenure), and Near Miss Frequency was controlled for, the following variables were significant predictors of safety defect reporting: Workplace Stress and Reactivity – Blame Culture. The second step of Analysis 4, which used predictors including the global factors based on Shell’s safety culture model, indicated that when the effect of Occupational Group, Years Worked in Rail Industry (Tenure), and Near Miss Frequency was controlled for, Workplace Stress was a significant predictor of the frequency of safety defect reporting.

Detailed discussion and interpretation of the results including a comparison of the similarities and differences among the three prediction analyses is presented in Chapter 7.
CHAPTER 7  Discussion

This chapter discusses results of the statistical analyses outlined in the previous chapters in relation to the research questions, together with implications of these findings. In Section 7.1, the results of Principal Axis Factoring reported in Chapters 4 will be discussed. In Section 7.2, results of the prediction analyses reported in Chapter 6 will be discussed. Section 7.3 will discuss implications of these findings, limitations and future direction.

7.1 Discussion of Results – Principal Axis Factoring Analyses

The following section discusses the results of Principal Axis Factoring, which was conducted to identify the constructs underlying questionnaire items in Section A1, A2 and Section B.

a) Evaluation of Section A

As outlined in Section 2.3, the items in Section A were generated through document analysis of rail accident investigation reports based on the GEMS framework (1990, 1991) and the Railway Problem Factors (Edkins & Pollock, 1996, 1997; Reason, 1997). These factors served to confirm the 13 Rail Problem Factors (RPFs), which were identified in Section 2.4 of this study.

The first part of these items, Section A1, asked the participants how frequently people who work in safety-critical areas in their workplace would have encountered certain situations in the work environment over the previous 24 months. The following five factors were identified: Negative Workplace Culture; Roster & Time Pressure; Support for Fatigue Management; Lack of Supervision; and Workplace Stress.

These five factors identified in Section A1 correspond to six of the 13 RPFs. The correspondence is shown below with the numbers taken from Figure 2.1 in Chapter 2. The first factor Negative Workplace Culture addressed staff attitude as well as supervisors’ and top managements’ response to safety concerns. These elements correspond to three RPFs, consisting of: 1) Management; 6) Supervision (in the top-level latent condition group Policy and Decision Making, as specified
in Chapter 2, Figure 2.1); and 8) Staff Attitude (in the worksite latent condition group Workplace Culture). The second factor Roster & Time Pressure is closely aligned with RPF 9) Staffing & Rostering (in the Workplace Culture in Figure 2.1). The third factor Support for Fatigue Management corresponds with RPFs pertaining to: 1) Management; 6) Supervision (in the Policy and Decision Making); 11) Working Conditions; and 12) Training (in the worksite latent condition group Operating Conditions in Figure 2.1). The fourth factor Lack of Supervision corresponds with RPF 6) Supervision (in Policy and Decision Making). Finally, the fifth factor Workplace Stress is closely aligned with an RPF 11) Working Conditions (in the Operating Conditions).

In the second part of Section A2, the participants were asked to evaluate their observation of potential or actual safety problems. These items focused on the structural and ‘material’ aspects of the safety management system, as outlined in Section 1.9. PAF revealed two broad factors. The first factor was Organisational Latent Problems and the second was External Factors.

The first factor Organisational Latent Problems encompassed eight of the Rail Problem Factors (RPFs) in terms of Policy and Decision Making at the top management level, and Operating Conditions at the supervisory and worksite level (as specified in Chapter 2, Figure 2.1). The factors corresponding to RPFs Policy and Decision Making group included: 1) Management; 2) Organisational Policies, Rules & Procedures; 3) Contractor Safety Management; 4) Design; 5) Communication and 6) Supervision. The remaining factors corresponded to RPFs in the worksite latent condition group Operating Conditions, which consisted of 7) Housekeeping, 13) Tools & Equipment.

Taken together, Sections A1 and A2 were found to address 12 out of the 13 Rail Problem Factors (RPFs) identified in Chapter 2 through document analysis. It must be noted that the pattern of correspondence between the factors identified through PAF and the Rail Problem Factors was not one-on-one. In particular, Factor 1 of Section A2 Organisational Latent Problems subsumed eight RPFs. This inclusive factor, however, did not include 10) Maintenance, one of the RPFs in the worksite latent condition group Operating Conditions. This was because Item 35, which addressed maintenance issues, was excluded due to multiple factor loadings (see Chapter 4, Table 4.9 and Table 4.10).
The second factor in Section A2, *External Factors*, addressed both *Environmental* (extreme weather conditions) and *External Factors* (e.g. intrusions by people and animals and obstruction with foreign objects on track, and reckless behaviour of pedestrians and road vehicle drivers at level crossings).

Factors identified in Sections A1 and A2 serve to support the latent conditions model identified through retrospective analysis of accident investigation reports based on GEMS framework (Edkins & Pollock, 1996, 1997; Reason, 1997), as specified in Chapter 2, Figure 2.1.

*b) Evaluation of Section B*

Section B consisted of 67 items originated from a study by Parker, Lawrie and Hudson (2006) based on Shell’s safety culture maturity model (Hudson, 2007; Parker, et al., 2006). The 67 items of the current study were adapted to suit the Australian rail context from the *Hearts and Minds* program with permission from Shell and the Energy Institute (UK), as outlined in Section 3.2.

Parker, Lawrie and Hudson (2006) generated an extensive matrix of statements describing five distinct levels of safety culture maturity classified in 18 dimensions through interviews with experienced professionals from major oil companies. In a subsequent study, Lawrie, Parker, & Hudson (2006) generated 91 questionnaire items which addressed seven dimensions out of the 18 (2006) for statistical validation of the 5-stage safety culture maturity model (see Bryden & Hudson, 2005; Parker, et al., 2006) using factor analysis. Those seven dimensions were regarded as areas commonly experienced by a broad spectrum of occupational groups in the petrochemical industry. The seven theoretically generated dimensions consist of: 1) *Commitment Level of Workforce to HSE*; 2) *Balance between HSE & Profitability*; 3) *Workforce Interest in Competency & Training*; 4) *Work-Site Safety Control*; 5) *Purpose of HSE Procedures*; 6) *Repercussion & Feedback after Accidents*; and 7) *HSE Audits & Reviews*.

In the current study, Principal Axis Factoring (PAF) was first conducted for each of these seven dimensions described above (2006). Dimension 1, *Commitment Level of Workforce to HSE* yielded a single factor *High Workforce Commitment to HSE and Care for Colleagues*. Dimension 2, *Balance between HSE & Profitability* also identified a single factor, *Balance Achieved between HSE and Profitability*. Dimension 3, *Workforce Interest in Competency &
Training identified one factor Importance of Competency and Training Recognised. Dimension 4, Work-Site Safety Control identified one factor Effective Safety Controls. Dimension 5, Purpose of HSE Procedures identified two factors. They consisted of one factor addressing a positive aspect Balance Achieved between HSE Procedures & Efficiency and the other factor addressing a negative aspect Negative Views on HSE Procedures. However, the second factor had a low inter-item reliability (.56), which suggests that potentially it may not be a uni-factorial construct. Similarly, Dimension B6, Repercussion & Feedback after Accidents identified two factors. They consisted of one factor addressing a negative aspect Reactivity – Blame Culture and the other factor addressing a positive aspect Constructive Management Response to Accidents. Dimension 7, HSE Audits & Reviews yielded a single factor Proactive Approach to HSE Audits and Reviews.

Lawrie, Parker, & Hudson’s study (2006) used principal components analysis to evaluate the components structure of the 91 safety culture maturity items. The results revealed various components for the seven theoretically generated dimensions mostly with low reliability. In most cases items representing adjacent stages emerged together on the same component. At best, the resulting components did not contradict the 5-level evolutionary safety culture model. The researchers offered the following possible explanations for the mixed pattern of results (2006). Firstly, that the questionnaire items (or statements) representing each stage of safety maturity did not accurately reflect the stages and thus were taken out of context by the participants. The second explanation was that the five-stage model was overly complex and that the emerging components seem mostly to reflect either a ‘positive’ or a ‘negative’ safety culture. Thirdly, the researchers postulated that pathological organisations might possibly be extinct in the oil industry as considerable effort had been directed towards safety improvements for a considerable period of time.

Similar to the findings by Lawrie et al. (2006), the findings of the current study provided limited support for the 5-level safety culture maturity model. Two-factor structure was identified only in Sections B5 Purpose of HSE Procedures and B6 Repercussion & Feedback after Accidents, while the other five sections consisted of a single factor. The different developmental phases proposed by the safety culture maturity model (Bryden & Hudson, 2005; Parker,
et al., 2006) were not clearly reflected in the factors identified through PAF analyses in the current study. The factors appear to reflect either a positive or a negative aspect in each of the seven dimensions.

Furthermore, results by the current study also suggest, as did the study by Lawrie et al. (2006), that the questionnaire items could have been misconstrued by the participants. Lawrie and colleagues’ (2006) questionnaire items were extracted from the extensive matrix containing detailed statements describing each phase of the 5-stage safety culture maturity model in 18 dimensions developed in a previous study (Parker, et al., 2006). The essence of the statements could be clearly understood in the presence of other statements within each section of the matrix with graduated degrees of cultural maturity. With the tool used in workshops, the participants may have been provided with some basic introduction to characteristics of organisations at each stage of safety culture maturity.

On the other hand, the items used Lawrie and colleagues’ (2006) study and the current study were extracted from the matrix into short sentences often consisting of multiple clauses and no briefing was given to the participants. It is questionable whether those items were understood in the appropriate context. For example, Item 34 in the current study [The number of inspection reports written is used to check that the job safety controls required by the management system are working.] is designed to address the Calculative stage of the maturity process. Unless the participants have some idea of the 5-stage model, it may not be so apparent that such a statement implies the mid-point in the developmental ladder. It is also possible that the number of inspection reports written is used as one of many ways of assessing whether job safety controls are working well or not. Similarly, Item 25 [There is some on-the-job transfer of training.] is categorised in the initial matrix as addressing the Calculative stage. It is not easy to gauge whether this short sentence, when taken in isolation, conveys a positive phenomenon or not.

In the second phase, the global factors were generated through factor analysis of the 67 items collapsed across the seven dimensions in Section B, regardless of the theoretical framework. The stringent elimination process using 0.6 for identifying the communalities yielded three global factors (see Chapter 4). They consisted of: 1) Discrepant Commitment to Safety by Team Members & Line Management; 2) Management Commitment to Safety; and 3) Negative View on
**HSE Audits & Reviews.** While these are broad categories, the first two represent the recurring themes in previous studies about the key factors of an organisation’s safety culture (Cooper, 2000; Glendon, 2008; Griffin & Neal, 2000; Grote & Künzler, 2000).

Overall, the factors identified in the seven theoretically generated dimensions and the global factors in Section B were found conceptually congruent with the latent conditions model based on GEMS framework (Edkins & Pollock, 1996, 1997; Reason, 1997). In particular, the seven theoretically generated dimensions serve to provide specific representative contexts to what tends to be broad and abstract constructs such as Management Commitment, Organisational Policies, Rules, and Procedures, Supervision and Staff Attitudes.

**Overall Evaluation of the Factor Variables**

As reported in Section 4.1, Principal Axis Factoring (PAF) analyses on the two datasets, namely the combined sample and the safety-critical group, identified almost identical factors, with markedly similar item structure. This may be due to the high proportion of safety-critical workers (averaging 87.7%) within the combined sample for each section. However, this does not imply that no sizable differences in safety climate/culture scores exist between the two groups. Had it been possible to run factor analysis on a non-safety-critical sample alone with sample size comparable to that of the safety-critical group, it may have yielded significantly different factor structures. While the current study identified almost identical factors and item structure, it is inconclusive whether this finding can be generalised to a non-safety-critical population.

**Group Differences in Safety Climate/Culture Scores**

The mean scores for the factor variables for the entire sample ($N = 241$), when collapsed across the occupational groups, indicated that participants were generally positive about the overall aspects of their organisation’s safety health (see Section 6.1). The mean scores for Section A, mostly addressing potential/actual safety problems in their workplace, were all below the mid-point [3 = Neither Agree Nor Disagree]. In general the participants felt that their organisation had a good safety management system in place, which included good on-site supervision, and adequate organisational support for fatigue management.
In Section B, the mean scores for the nine factors identified through the PAF analyses were all above the mid-point, although two factors represented negative aspects. This painted a paradoxical picture of the participants’ evaluation of the safety culture in their workplace and organisation. On one hand, the scores implied that the participants saw that the workforce was committed to HSE and cared about their colleagues, that their organisation had achieved balance between HSE and profitability, and balance between HSE and efficiency, that their organisation recognised the importance of competency and training, that their organisation had effective safety controls, and the management was committed to safety and responded constructively to accidents. On the other hand, they also rated relatively high scores on negative views on HSE procedures and management’s tendency to respond to accidents reactively, characterised by blaming those directly involved in the accidents rather than investigating systemic issues.

The summary above portrays a generally positive evaluation of safety measures in the sample rail sector across the safety climate/culture aspects assessed. When group differences were taken into consideration, however, a different picture emerged. Significant differences were found for many of the safety perception and culture factors, when detailed comparisons were made amongst the occupational groups. They suggest the presence of subcultures identified in previous literature (e.g. Clarke, 1998a; Hofmann & Stetzer, 1996). On the whole, Management tended to rate themselves higher than the non-Management groups. Comparisons between various dyads revealed significant differences between the Drivers and On-Board Hospitality Staff group and Management for all the safety culture factors, and between the Maintenance and Construction Workers group and Management in most of the safety culture factors.

In Section A, Drivers and On-Board Hospitality Staff observed a significantly greater degree of Negative Workplace Culture, Roster & Time Pressure and Lack of Supervision than Management did. Controllers rated significantly higher scores than Management for Roster & Time Pressure, while they rated significantly lower scores than Management for Support for Fatigue Management. Despite these group differences, the mean scores for the factors in Section A pertaining to the participants’ perception of safety measures in their
workplace were relatively uniform. This suggests that the participants generally felt that their organisation had adequate safety measures.

This positive view was not only held for their own organisation but also for the rail industry in general. Item A3_1 asked participants whether they thought their employer had adequate safety measures overall. One hundred and eighty-one out of 236 who responded, either agreed or strongly agreed their employer had adequate safety measures (75%). On the other hand, Item A3_2 asked the same question about the rail industry in general. Similar percentage (70.5%) was seen for the rail industry in general (179 out of 235).

Chi-square tests of goodness of fit were performed to examine whether the proportion of those who agreed to the above questions was greater than by chance. For both items, the percentage of people who agreed with the statements were significantly greater than by chance; $\chi^2 = 7.681, p = .000$ (2-sided) for Item A3_1 ($N = 236$), and $\chi^2 = 7.665, p = .000$ (2-sided) for Item A3_2 ($N = 235$), respectively. Chi-square tests of contingency revealed that this sample did not have a bias towards or against own their own organisation. Those who gave high ratings on the adequacy of safety measures in their own organisation also rated that of the rail industry highly in a disproportionately greater number. Similarly, those who gave low ratings on the adequacy of safety measures in their own organisation also rated that of the rail industry low in a disproportionately greater number, $\chi^2 (234, 1) = 84.601, p = .000$ (2-sided). However, bias was evident in the management group. Management rated the adequacy of safety measures in their organisation highly at a significantly greater percentage (90.5%) than non-management staff (73.7%), $\chi^2 (236, 1) = 5.429, p = .025$ (2-sided). This tendency was not found for the evaluation of the adequacy of safety measures for the industry in general.

In Section B, the mean scores for the factors pertaining to the participants’ perception of safety culture in their workplace revealed more pronounced group differences than those observed in Section A. Although relatively high ratings were given on the positive aspects of safety culture across all groups, non-management groups also gave relatively high ratings on two negative aspects. The ratings reflected: 1) the presence of negative views about safety procedures in their organisation; and 2) the non-management group’s view that their organisation was reactive rather than proactive in its style of responding to
accidents, characterised by a tendency to apportion blame to those who were directly involved in the accidents rather than investigating systemic issues.

In particular, more negative views were found amongst Drivers & On-Board Hospitality Staff and Maintenance and Construction Workers groups compared with Management on all the factors. Drivers and On-Board Hospitality Staff gave significantly higher scores than Management on: Negative Views on HSE Procedures and Reactivity – Blame Culture. On the other hand, Drivers and On-Board Hospitality Staff gave significantly lower scores than Management on Workforce Commitment to HSE & Care for Colleagues, Balance Achieved between HSE & Profitability, Importance of Competency & Training Recognised, Effective Safety Controls, Balance Achieved between HSE Procedures & Efficiency, Constructive Management Response to Accidents, and Proactive Approach to HSE Audits & Reviews.

Similarly, Maintenance and Construction Workers gave significantly higher scores than Management on Negative Views on HSE Procedures. On the other hand, they gave significantly lower scores than Management on: Balance Achieved between HSE & Profitability; Importance of Competency & Training Recognised; Effective Safety Controls; Constructive Management Response to Accidents; and Proactive Approach to HSE Audits & Reviews.

Drivers and On-Board Hospitality Staff had more negative views than the Controllers in the following areas: Negative Workplace Culture; Balance Achieved between HSE & Profitability; and Proactive Approach to HSE Audits & Reviews. Drivers and On-Board Hospitality Staff rated significantly higher scores on Roster & Time Pressure than Maintenance and Construction Workers. Controllers reported significantly higher on Roster & Time Pressure compared with Maintenance and Construction Workers. This implies that Management and Maintenance and Construction Workers groups observed significantly lower Roster & Time Pressure among safety-critical workers than Drivers and On-Board Hospitality Staff and Controllers did.

A similar trend was seen with the global safety culture factors, which were generated through collapsing the 67 items in Section B for factor analysis regardless of the theoretical dimensions assigned by Lawrie et al. (2006). The mean scores for the entire sample were both above the mid-point for: 1) Discrepant Commitment to Safety by Team Members & Line Management; and 2)
Management’s Commitment to Safety. On the other hand, the mean score for 3) Negative Views on Internal Audits and Reviews was lower than the mid-point.

Despite generally high ratings on the positive aspects of safety, the Management group’s ratings on management’s commitment to safety were significantly higher than the Drivers & On-Board Hospitality Staff and Maintenance and Construction Workers groups. Ratings on negative aspects were significantly higher for the Drivers & On-Board Hospitality Staff and Maintenance and Construction Workers groups compared with Management. Their response suggested that those operations groups regarded commitment to safety by team members and line management and the organisation’s views on internal audits and reviews more negatively than the Management group.

When compared amongst occupational groups, both Drivers & On-Board Hospitality Staff and Maintenance and Construction Workers groups gave significantly higher scores than Management on Discrepant Commitment to Safety by Team Members & Line Management and Negative Views on Internal Audits, and significantly lower scores than Management on Management Commitment to Safety.

The above results, coupled with the results of the organisation-based analyses in Chapter 5 serve to support Hypotheses 1a and 1b. Group differences were found between occupational groups in terms of safety climate/culture as measured by the RPFs items and Shell’s safety culture maturity items.

7.2 Results of the Prediction Analyses

In this section results of prediction analyses will be discussed in the following sequence: 1) Discriminant Function Analyses; 2) Chi-Squared Automatic Interaction Detection (CHAID); and 3) Multiple Regression Analyses.

**Discriminant Function Analysis**

Section 6.2 (Chapter 6) reports the results of Discriminant Function Analyses (DISCRIM), performed to examine whether safety climate/culture scores would predict membership of: 1) accident vs. non-accident groups; and 2) near miss vs. non-near miss groups. In DISCRIM Analysis 1, which used predictors including the theory-based safety culture factors in Section B, group
membership (accident group vs. non-accident group) was predicted with severely limited accuracy in classification. While the classification accuracy was high for the non-accident group with participants (96%) correctly classified, only 8 out of 52 cases in the accident group (15%) were correctly classified. This unreliable prediction model renders interpretation of results unwarranted. The results of DISCRIM Analysis 2 and 4 indicated that the predictors, which included the global safety culture factors, did not discriminate between the accident and non-accident groups.

In DISCRIM Analysis 3, which used predictors including the theory-based safety culture factors in Section B, prediction of group membership (near miss group vs. non-near miss group) also showed relatively low accuracy in classification. Jackknifed classification showed that 136 participants (56.7%) were correctly classified, compared with 120.30 participants (50.1%) who would be correctly classified by chance alone. Of the 114 people in the near miss group, only 57 were classified correctly (50%). On the other hand, of the 126 people in the non-near miss group 70 were classified correctly (62.7%). This low predictive value indicates the following interpretation of results be treated with caution.

As shown in the DISCRIM results section in Chapter 6 (Table 6.8, Sub-Section 6.2.1), compared with participants who had no near misses, those who experienced near misses over the previous two years prior to the survey administration responded in the following manner about their workplace.

The near miss group thought to a lesser extent that their organisation had achieved balance between HSE procedures and efficiency than the non-near miss group. Furthermore, compared with the non-near miss group, the near miss group observed more roster and time pressure, and thought to a greater extent that workplace stress was experienced by people in safety-critical areas. Compared with the non-near miss counterpart, the near miss group more frequently observed negative workplace culture and lack of supervision in safety-critical areas, and responded that organisational latent problems were more frequently observed as contributing to potential or actual safety problems. The near miss group thought to a lesser extent that their organisations had achieved balance between HSE & profitability. They thought to a lesser degree that people in their organisation recognised the importance of competency and training, and that their organisation was less committed to HSE and care for colleagues. They thought to a lesser
extent that their organisation had effective safety controls than the non-near miss group thought of their organisation. The near miss group thought their organisation was more reactive rather than proactive in its response to accidents, characterised by blame culture. The results suggest that the near miss group had an overall negative view of the safety measures and climate/culture of their organisation.

**Chi-Squared Automatic Interaction Detection (CHAID)**

The low predictive values of the safety climate/culture scores in the discriminant function analyses served to attest to the complex relationships amongst variables that inform safety outcomes. In order to overcome the limitations of discriminant function analyses which do not accommodate control variables, a non-parametric CHAID technique was used to explore any defining factors that characterised the two dyads, namely, 1) accident vs. non-accident groups; and 2) near miss vs. non-near miss groups. Since the presence of group differences was substantiated (see Chapters 4 and 5), a grouping variable *Occupational Group* was included in the computations. This grouping variable consisted of; [Management]; [Controllers]; [Drivers & On-Board Hospitality Staff] and [Maintenance and Construction Workers] groups. Additional Analyses 5 and 6 were conducted to examine the model for predicting the frequency of near miss in terms of [None – Two] and [Three or More].

Classification results of the CHAID analyses, with the exception of Analysis 3, revealed less than acceptable accuracy of the prediction models (see Chapter 6, Sub-Section 6.2.2). Thus interpretation for these five analyses was deemed unwarranted.

CHAID Analysis 3, which used predictors including Shell’s theory-based safety culture factors, showed a moderate level of accuracy (66% for the total sample) for classification of group membership (near miss group vs. non-near miss group). While 87 of the 114 near miss group was classified correctly (76%), 73 of the 127 participants from the non-near miss group were correctly classified (57%). This moderate predictive value implies that the following interpretation of results needs to be treated with caution.

The results can be summarised as follow. *Occupational Group* was the primary predictor of the membership in the near miss group vs. non-near miss
group in each node in the decision making tree. More specifically the following points outline the results: 1) Management reported significantly lower percentage near miss experience than the total sample’s percentage. 2) Drivers and On-Board Hospitality Staff reported a significantly higher percentage of near miss experience than the total sample’s percentage, while Maintenance, Construction and Controllers showed a percentage similar to that of the total sample. 3) Drivers and On-Board Hospitality Staff who had near misses observed significantly higher degrees of External Factors as contributing to potential or actual problems at their workplace. Finally, 4) only a significantly small group of Maintenance, Construction and Controllers (28 out of 100) thought that their organisation had achieved Balance between HSE and Efficiency. A majority (75%) of this group were without near miss experience.

It is hardly surprising that the Management group reported almost half of the percentage in near miss experience \( (n = 10 \text{ out of } 42, 23.8\%) \) than the total sample’s percentage (47.3%), which highlighted the disproportionately low percentage of management staff with near miss experience compared with the non-management groups. Demographics of this group showed that five out of these ten people were working at management level within an operations set up. Had managers involved in operations been excluded from the analysis, the proportion would have been even lower. It is acknowledged that greater clarity for defining management, i.e. corporate vs. operations would have been desirable.

It is also to be expected that a fair majority \( (n = 69, 70\%) \) of the total 99 Drivers and On-Board Hospitality Staff sometimes or often observed External Factors as contributing to potential or actual problems at their workplace. In this study External Factors referred to inclement weather conditions, unexpected intrusion across the track, and reckless behaviour at level crossings by pedestrians or road vehicles. Drivers and On-Board Hospitality Staff belong to the few groups in the railway operations who are exposed to external factors on a constant basis on board the train. They experience ever-changing environments along the train journey, which give them a unique understanding of potential hazards. This is in stark contrast to other occupational groups who are either confined to the office (management and administration) or to specific local areas (e.g. rollingstock maintenance crew in a depot, or track maintainers in isolated locations of the permanent way, yards or sidings).
Hierarchical Multiple Regression Analysis

Due to the pattern of distribution of the criterion variable Near Miss Frequency (an ordinal variable with four levels), results of Analyses 1 and 2 need to be treated with caution (see Chapter 6, Sub-Section 6.2.3). For both analyses, the control variable Occupational Group was a significant predictor of the number of near misses experienced. In particular, significantly more near misses were experienced by Drivers & On-Board Hospitality Staff compared to Management. This supports the CHAID analysis results.

Analysis 1 used predictors including Shell’s theory-based safety culture factors. The results indicated that when the effect of Occupational Group was controlled for, the following variables were significant predictors of the frequency of near misses: Balance between HSE Procedures & Efficiency, External Factors; Proactive Approach to HSE Audits; and Reactivity – Blame Culture. This implies that people who experienced more near misses gave lower ratings to the level of balance their organisation had achieved between procedures and efficiency. They also observed external factors as potential or actual safety problems more frequently. These findings support the CHAID analysis results. Furthermore, hierarchical multiple regression analysis found that compared with those who experienced fewer near misses, those people who experienced more near misses thought that their organisation was more reactive rather than proactive in its response to accidents. On the other hand, Proactive Approach to HSE Audits showed a conceptually contradictory pattern of prediction. Interpretation of its role is problematic because of the possibility of complex mediational associations with the following five variables: Driver & On-board Hospitality Staff vs. Management; Roster and Time Pressure; Organisational Latent Problems; Balance Achieved between HSE and Profitability; Balance Achieved between HSE Procedures and Efficiency; and Reactivity – Blame Culture.

Analysis 2 used predictors including the global factors based on Shell’s safety culture model. The results indicated that when the effect of Occupational Group was controlled for, the following variables were significant predictors: External Factors and Negative Views on Internal Audits and Reviews. Similar to the previous analysis, people who experienced more near misses observed external factors as potential or actual safety problems more frequently than those who had fewer or no near misses. On the other hand, Negative Views on Internal
Audits and Reviews showed similar contradictory pattern of prediction as the previous analysis, rendering interpretation of its role is problematic.

In summary, results of Analysis 1 supported both Hypotheses 2a and 2b. This is because one RPF External Factors, and Shell’s safety culture factors Balance between HSE Procedures & Efficiency, Proactive Approach to HSE Audits, and Reactivity – Blame Culture, were found to be significant predictors of near misses when the effect of Occupational Group was controlled for. Furthermore, the results of Analyses 3 and 4 revealed significant predictors of the frequency of safety defect reporting. As the distribution is not perfectly normal despite acceptable descriptive statistics, however, caution is warranted in its interpretation.

On the first step of both Analyses 3 and 4, three control variables, consisting of Occupational Group, Years Worked in Rail Industry (Tenure), and Near Miss Frequency (an ordinal variable with four levels), were found to be significant predictors of safety defect reporting. This meant that: 1) significant difference was found among the occupational groups in the number of times safety defects were reported. This was particularly so with Controllers who reported safety defects more frequently compared to Management. 2) People who had worked in the rail industry for longer periods reported safety defects within the same 2-year period more frequently than those with less experience. Finally, 3) people who had experienced more near misses reported safety defects more frequently than those who had experienced fewer near misses.

The second step of Analysis 3, which used predictors including Shell’s theory-based safety culture factors, indicated that when the effect of Occupational Group, Years Worked in Rail Industry (Tenure), and Near Miss Frequency was controlled for, the following variables were significant predictors of safety defect reporting: Workplace Stress and Reactivity – Blame Culture. This meant that people who observed higher level of stress at their workplace tended to report safety defects more frequently. Furthermore, significantly more safety defects were reported by those who thought that their organisation was reactive rather than proactive in their style of responding to accidents, characterised by a tendency to apportion blame to those who were directly involved in the accidents rather than investigating systemic issues.
The second step of Analysis 4, which used predictors including the global factors based on Shell’s safety culture model, indicated that when the effect of Occupational Group, Years Worked in Rail Industry (Tenure), and Near Miss Frequency was controlled for, Workplace Stress was a significant predictor of the frequency of safety defect reporting. As in the previous analysis it was found that people who observed higher level of stress at their workplace tended to report safety defects more frequently.

In summary, results of Analysis 3 supported both Hypotheses 3a and 3b. This is because one RPF Workplace Stress, and a factor from Shell’s safety culture maturity Reactivity – Blame Culture were found to be significant predictors of safety defects reporting when the effects of Occupational Group, Years Worked in Rail Industry (Tenure), and Near Miss Frequency were controlled for.

7.3 General Discussion

Predictive Validity of the Safety Perception and Safety Climate/Culture Items

The findings outlined above serve to support points raised by Grote and Künzler (2000) that it is important to consider safety culture as integral part of social and technical subsystems. The results of the current study identified: 1) one Rail Problem Factor Workplace Stress, which was identified as a result of retrospective analysis of accident investigation reports (more technical and structural aspects); and 2) one safety culture factor Reactivity - Blame Culture which derived from the 5-stage Shell Safety Culture Maturity model, based on a more prospective approach (more psychosocial aspects). These results highlight the importance of obtaining the employees’ evaluation of the organisation’s safety climate/culture both at ‘material’ level (characteristics which are visible, but difficult to decipher), and at ‘immaterial’ level (hidden, taken-for-granted beliefs and values) of an organisation.

In assessing the association between safety climate/culture factors and safety outcomes through discriminant function analyses, the current study serves to reinforce the findings of previous literature about the difficulties of using the
number of accidents as a criterion variable because they are relatively rare (Reason, 2008; Shannon, Mayr, & Haines, 1997; Zohar, 2000).

Prediction of Near Misses

In the prediction of near misses as the criterion variable, both CHAID and hierarchical multiple regression analyses found the Occupational Group as the primary predictor. In the hierarchical multiple regression analyses controlling for the effect of Occupational Group, it was found that people who experienced more near misses had more negative views about their organisation’s safety management system compared with people who had fewer or no near misses. Specifically, people who experienced more near misses gave significantly lower ratings regarding the level of Balance between HSE Procedures and Efficiency in their organisation. It was also observed that people who experienced more near misses observed External Factors as potential or actual safety problems to a significantly greater degree than those who had fewer or no near misses.

Several interpretations are plausible. Firstly, the significant difference between the near miss and non-near miss groups regarding Balance between HSE Procedures and Efficiency seems to reflect a view among people who had experienced more near misses that the procedures are more focused on ‘getting the job done’ rather than putting safety first. This universal conflict between commercial pressures versus safety is well documented in rail safety research. They include Hopkins’ (2005) observation of ‘obsession with on-time running’ in his analysis of an Australian example following the Glenbrook rail disaster, and an extensive qualitative study on the UK train operating companies following the privatisation in April 1994 (Jeffcott, Pidgeon, Weyman, & Walls, 2006). Jeffcott et al. (2006, p. 116) observe that middle management was frequently made “responsible for accounting for delays and cancellations of services and in many contexts it seems that their own competence is judged primarily in terms of such achievement (rather than safety performance), [parenthesis in the original text]”.

Alternatively, personality and personal experience may colour people’s interpretation of the significance of accidents and near misses. It is possible that people who had experienced more near misses were more likely to become the target for negative comments, scrutiny, investigation and other intrusive measures from the organisation as a result of their near miss history. It is plausible that
these people responded negatively to such vigilant attention directed towards them. Finally, it is also possible that regardless of near miss history, these people had personality traits that disposed them towards resentment of safety measures as they perceived them as an imposition to control or correct their behaviour and perceiving their workplace as having a blame culture.

In terms of External Factors evaluated as a potential or actual safety problem to a greater degree by people with more frequent near miss experience, the finding is in line with actual data in international and Australian rail industry. For example, European data published by the International Union of Railways (UIC, 2010) indicate that in 2009, 81% of the significant accidents reported by the then 20 member organisations had external factors as the proximal contributors. These factors primarily involved third parties such as trespassers and level crossing users (UIC, 2010). Furthermore, Australian data of level crossing accidents attest to the predominant role played by external factors. Australian Transport Safety Bureau investigated 12 significant level crossing accidents that occurred between April 2006 and December 2007. Nine of these accidents (75%) were collisions with heavy road vehicles which failed to stop at the level crossings (ATSB, 2008). The report concluded that almost every time the primary factor in the failure of the motorist to abide by the level crossing safety measures, it was combined with underlying factors such as routinisation effects on the road vehicle drivers’ cognition, their level of fatigue, medical conditions and inclement weather conditions. Although fatalities and injuries resulting from level crossings accidents comprise only a small proportion of the total fatalities and injuries that occur on Australian roads each year, level crossing accidents involving heavy road vehicles, have the potential to be catastrophic (ATSB, 2008). It is exemplified by Kerang level crossing rail crash in Victoria, Australia, which involved a loaded semi-trailer truck with fatality of eleven train passengers (Salmon, et al., 2013).

Prediction of Safety Defect Reporting

The results of the hierarchical multiple regression analyses deserve further discussion. It is noteworthy that in the first step of the analyses predicting the number of safety defect reporting, the control variables: Occupational Group;
Years Worked in Rail Industry (Tenure); and Near Miss Frequency were found to be significant predictors.

Differences among Occupational Groups

Evaluation of safety climate/culture factors’ mean scores and the results of the various prediction analyses highlight the crucial role played by Occupational Groups. It is attested to by the abysmal level of classification accuracy in the discriminant function analyses when this control variable is not factored into the computations. Furthermore, the presence of group differences in safety climate/culture is amply demonstrated in the organisation-based analyses presented in Chapter 5.

Not surprisingly, the scores given by management were higher in a wide range of areas addressing positive aspects of their organisation’s safety management system and safety climate/culture compared with the scores given by the non-management groups. This reflects the self-serving attribution bias well documented in previous literature, which established that people tend to perceive successes as a result of their own efforts, while they tend to blame others for failures for purposes of self-protection (see review by Zuckerman, 1979). In the context of safety, DeJoy (1994) reviews several studies which found that supervisors tend to assign a prominent role to workers’ unsafe behaviour to accident causation. Such a tendency, if reinforced by collective schemas whether at supervisory level or at management level, could lead to inadequate and potentially harmful ways of thinking about, interpreting, predicting and remembering safety-related events (see review by Rentsch & Zelno, 2005). The likely outcome is to block further investigation into latent conditions upstream and hindering the process of organisational learning from a rich source of information – experience of negative safety outcomes and hidden system failures and other latent conditions.

Tenure

It is hardly a surprise that tenure was found to be a significant predictor of near miss frequency. Hansen (1989) found that greater job experience is associated with more experience of accidents, as workers tend to be placed in positions requiring higher skills, which in turn expose them to greater accident potential.
Furthermore, Morrow and Crum (1998) argue that longer occupational tenure is indicative of cumulative injury risk.

Near Miss Experience

In terms of Near Miss Experience treated as a control variable, it is to be expected that people who experienced more near misses would regard External Factors as potential or actual safety problems to a significantly greater degree than those who had fewer or no near misses. This serves to support general theory that people who have experience of accidents or near misses have more acute awareness of external factors, which lie mostly beyond their personal or their organisation’s control. For example, Slovic and his colleagues state that direct experience with dramatic accidents or risk events heightens risk perception as such an exposure increases the memorability and imaginability of hazards (R. E. Kaspersion et al., 1988). Indeed, Rundmo (1995) found in his study of North Sea offshore petroleum installations that people who experienced accidents and near misses felt more at risk, more dissatisfied with safety and contingency measures and experience more job stress than those who did not experience such negative safety outcomes.

Workplace Stress and Reactivity - Blame Culture

When the effects of the three variables: Occupational Group; Years Worked in Rail Industry (Tenure); and Near Miss Frequency were controlled for in the second step of the multiple regression analysis, Workplace Stress and Reactivity – Blame Culture significantly predicted Safety Defect Reporting. This implies that safety defects were reported more frequently by: 1) people who observed a higher level of stress at their workplace; and 2) people who thought that their organisation was reactive rather than proactive in their style of responding to accidents, characterised by a tendency to apportion blame to those who were directly involved in the accidents rather than investigating systemic issues. This finding is counter-intuitive at first glance. One would presume that workers who observe a high degree of workplace stress and feel that their organisation has a blame culture would be inclined to avoid potential trouble by not reporting safety defects. Could the findings imply that those people who recognised greater degrees of workplace stress would take proactive steps by reporting safety defects
because they didn’t want to get blamed for potential negative safety events? Interpreting these results warrants careful reflection.

A closer look at the data suggests that these intriguing results may be associated with the nature of safety defects to be reported and the participants’ demographics. The current study focused on proactive reporting of mechanical safety defects, consisting of equipment, track, rolling stock, electricals and others, that did not involve immediate human (active) failures. Clarke (1998a) discussed under-reporting of a selection of hypothetical scenarios of near misses that included human failures such as Permanent Way staff (track maintenance workers) having left material by the line side, a fellow driver breaking a rule, communication failure about single line working, and Permanent Way staff not acknowledging the driver when he sounded the horn. The reluctance of people to inform on their team mates is well documented (e.g. Baram, 1997; Jeffcott, et al., 2006). In the current study, however, the operators would have been less likely to feel constrained towards reporting safety defects as they were not asked about reporting someone else’s safeworking failures. It is therefore likely that the current study addressed safety reporting of qualitatively different types from informing on fellow employees as described in Clarke’s study (1998a), and thus was not conducive to under-reporting.

In terms of the demographics, a considerable proportion of the participants were from Western Australia, averaging 65% across the occupational groups. In particular, it was the case with 79% of the Drivers and On-board Customer Service Personnel (n = 78 out of 99) and 72% of Maintenance and Construction Personnel at (n = 49 out of 68). It is plausible that the active participation in reporting safety defects was due to ‘roll-by inspections’, a rail industry custom unique to Western Australia. Roll-by inspections are a worksite safety management practice which mandates that every employee must, as far as practicable, closely examine each train as it passes. For example, if they notice any train signals not properly displayed or any abnormality which could potentially lead to compromise in rail safety, they must endeavour to stop the train and in any event report the incident to the Train Controller. Abnormality to be captured through this process includes signs of alarm by passengers, vehicles on fire or derailment, train divided, excessive noise, hot wheels, flat wheels, wheel scaling, loading irregularity (e.g. loose tarpaulin) and dragging rollingstock
equipment (e.g. loose brake pipe, cable and chain). The compulsory nature of this collective on-site inspection may imply that people are motivated to report safety defects due to fear of potential blame. That is, apprehension about failing to identify a defect which could potentially develop or which actually develops into serious problems. Workplace stress and reactivity – blame culture are discussed in further detail in the following sections.

1) Workplace Stress

The questionnaire asked about the participant’s evaluation of the level of stress they observed at their place of work. Extrapolating from the extensive body of knowledge in stress research (e.g. Lazarus & Folkman, 1984; Salas, Driskell, & Hughes, 1996), workplace stress can be defined as follows: “It is an individual’s appraisal process evoked by certain demands in the work environment.” Workplace stress occurs where demands are perceived to exceed resources, and this appraisal results in undesirable physiological, psychological, behavioural, or social outcomes. Excessive workplace stress has been found to exert adverse effects at the individual level in their work performance and overall well-being (D. Lee, 1997) and at the team level (Ellis, 2006; Pearsall, Ellis, & Stein, 2009). Diverse factors contribute to workplace stress (see review by Glendon, et al., 2006). Common sources of workplace stress include role conflict and role ambiguity (Kahn, Wolfe, Quinn, Snoek, & Rosenthal, 1964), role overload, and work overload (French & Caplan, 1970). Empirical evidence indicates the profound impact stress exerts on workplace injuries (see review by Glendon, et al., 2006; Matteson & Ivancevich, 1982).

Most stressful jobs are regarded to be those with low autonomy and high demands (Karasek, 1979). In an extensive review of workplace stress for US transport industry, Diem (2002) summarises that blue-collar workers in transport industry are considered as a high risk group for workplace stress due to their vulnerability to a diverse range of industrial stressors. They include: 1) limited autonomy and work-related decision-making and input opportunity; 2) lack of control over their task, schedule, promotion opportunity and job security; 3) exposure to arbitrary supervision and insistence on compliance with rules and regulation which they may not agree with; 4) and demanding and hazardous work environments. Diem (2002) conducted a survey on US railway yard masters and
found that sense of self-efficacy moderated the relationship between role overload and psychological strain. In the current study, the occupation group breakdown was Management \( (n = 42) \), Controllers \( (n = 31) \), Drivers and On-board Customer Service Personnel \( (n = 99) \), and Maintenance and Construction Personnel \( (n = 69) \). This means that 83\% \( (n = 199) \) of the 241 participants were in non-management, operational role. This implies that a great majority of the sample would share some characteristics of the high risk group identified in Diem’s study (2002) for suffering workplace stress.

2) **Reactivity – Blame Culture**

It is noteworthy that *Reactivity – Blame Culture* featured prominently in: the 1) discriminant function analysis predicting membership in near miss group; and the hierarchical multiple regression analyses; both predicting 2) the frequency of near misses; and 3) the frequency of safety defect reporting. Apprehension about the possibility of blame directed against them seems to be one of the motivating factors for reporting safety defects.

As outlined in Chapter 1, Reason (1997) discussed four key elements that interact together and support an *informed culture*, an epitome of optimal safety health. They consist of a *reporting culture*, a *just culture*, a *flexible culture* and a *learning culture*. A *reporting culture* is described as an organisational culture in which errors and near misses are reported willingly by people who are in direct contact with the hazards. This is a fundamental prerequisite for a fully functioning safety information system. Reason (1997) argues that an effective *reporting culture*, in turn, needs to be supported by a *just culture*. It presides over a clear distinction between acceptable (such as inadvertent errors and mistakes) and unacceptable behaviour (e.g. reckless non-compliance and sabotage). Furthermore, Reason (1997) argues, a *just culture* grows in an atmosphere of trust in which organisation members are encouraged, even rewarded for providing essential safety-related information. Reason (1997) describes a *flexible culture* as a culture which demonstrates the adaptable nature of a crisis-prepared organisation, which entails the ability to modify its operation from the conventional hierarchy to a flatter professional structure in emergency, such as those seen in high reliability organisations (La Porte & Consolini, 1991; Weick, 1987; Weick & Sutcliffe, 2001). This flexibility is crucially dependent on respect
for the expertise in skills, experience and abilities of the workforce. Finally, Reason (1997) emphasises the importance of a learning culture, characterised by the organisation’s “willingness and competence to draw the right conclusions from its safety information system, and the will to implement major reforms when their need is indicated. (p. 196)”.

Based on these central tenets, Hopkins (2005) illustrated how the absence of such cultural elements can have detrimental effects on safety practices, by drawing on Glenbrook train crash as a case study of rail culture and safety. Hopkins (2005) identified several main constellations of practices and cultural themes based on Justice McInerney’s inquiry (2001) into this fatal accident. The first aspect was that the incumbent rail system had a strong rule-focused culture. Inordinate amount of effort went into rule making to the extent that the employees were too overwhelmed to put them into their operational practice. The focus was on making the rules and not helping the employees to put them into practice or ensuring compliance. When accidents occurred, the investigations appeared to be aimed at identifying which rules had been violated and by whom. Hopkins (2005, p. 28) concludes that the obsession with rules led “… to a pronounced tendency to blame”. The second aspect was that the railway system was organisationally fragmented, as a result of privatisation in 1996.

Hopkins (2005) argues, however, that occupational fragmentation predated this change and the rail industry was characterised by a culture of “silos” where occupational groups were isolated from each other, which resulted in failures to recognise that their actions or inactions might have profound safety implications for people in other parts of the system. The third aspect was an over-riding culture of punctuality (on-time running), with the unfortunate side effect of undermining safety. The fourth aspect was that the railway culture was profoundly risk-blind, even risk-denying, a symptom recognised in diverse industrial disasters (e.g. Hopkins, 2005, 2007; Turner & Pidgeon, 1997; Vaughan, 1990). Finally, Hopkins (2005) argues that the rail culture served to disempower its employees.

Similarly, in reviewing the safety culture of the UK rail industry prior to the privatisation in April 1994, Clarke (1998b) discusses a lack of mutual trust between staff and managers, and a lack of open and honest discussion about safety, such as under-reporting of safety incidents for fear of recrimination.
Jeffcott and colleagues (2006) highlight the blame culture, which became even more pronounced in the immediate post-privatisation period. They described the type of blame culture in detail, which includes: 1) the phenomenon of management apportioning blame to the individual operator for safety occurrences rather than taking a holistic approach; and 2) cross-organisational blaming for attribution of causes of and accountability for underperformance such as delays to trains (2006).

It appears that people find it psychologically satisfying to blame someone, particularly fuelled by the influence of heuristics such as bounded rationality (Reason, 1997). Modern society has a strong tendency to blame someone for misfortune as we are no longer able to attribute it to some supernatural power (Douglas, 1992). In their Cultural Theory of Risk, Douglas and Wildavsky (1982) argue that science and technology, once seen as a source of safety, have now come to be regarded as a source of risk. They cite extensive and varied examples of pre-modern and modern societies where people explain and cope with misfortune through the blaming process (Douglas & Wildavsky, 1982).

In modern industrial settings, those who get the blame are almost invariably at the sharp end (e.g. Freudenburg, 1992; Wright, 1986). However, more than three decades of research and accident investigations have shown that latent conditions play a pivotal and overarching role in the accident causation pathway. Blaming the individual operator for their error and mindset has no legitimate part to play in a system of risk management. On the contrary, “it may even serve to sustain or increase the exposure of the overall system to future risk, by virtue of reducing feedback about systemic deficiencies (Johnston, 1996, p. 73)”. Asking why errors were made is far more meaningful than asking who is to blame for preventing recurrences (Hopkins, 2005).

In reviewing the key elements of an informed culture above – a reporting culture, a just culture, a flexible culture and a learning culture (Hopkins, 2005; Reason, 1997), a recurring theme of ‘trust’ seems to be at the core. Trust is defined as ‘the extent to which a person is confident in and willing to act on the basis of, the words, action, and decisions of another (McAllister, 1995, p. 25)’. From a sociological perspective, Lewis and Weigert (1985) argue that trust must be conceived as a property of collective units, rather than that of isolated individuals. Trust is the mutual “faithfulness” on which all social relationships...
depend. Lewis and Weigert (Lewis & Weigert, 1985) state that trust is an affectively motivated loyalty, which lays the foundation for acceptance of solidary relationships. Trust within a work group is regarded as founded on the expectation that the group will act in a considerate and benevolent manner toward the individual (Korsgaard, Brodt, & Sapienza, 2005).

In the organisational context, Jeffcott and her colleagues (2006) argue that members of a group/organisation construe trust as a set of attitudes and expectancies about other members as well as about the organisational systems within which they are embedded. Trust is generally recognised as the most critical element for the formation of cooperation within groups and organisations (see review by Korsgaard, et al., 2005), and thus for organisational effectiveness (McAllister, 1995). Sutherland and Cooper (1995) purport that trust is an essential ingredient for empowerment for blue-collar workers (Sutherland & Cooper, 1995), one of the core characteristics of high reliability organisations (Hopkins, 2005; La Porte & Consolini, 1991). Trust also features as a central theme in various models of safety culture (see review by Burns, Mearns, & McGeorge, 2006).

In the discipline of organisational psychology, trust is seen as a foundation for psychological contracts, which permeate employment relationships (Robinson, 1995; Rousseau, 1989, 1995). Psychological contracts are beliefs held by individuals towards their work group and/or organisation regarding reciprocal obligation and expectation, as opposed to written contracts (Rousseau, 1989, 1995). Trust is inevitably undermined when a psychological contract is violated, inevitably followed by intense attitudinal, behavioural and emotional reactions for the parties involved (Robinson, 1995). Trust is also undermined when a sense of procedural justice is violated within an organisation (Folger & Bies, 1989). Responses to violation take many forms, ranging from mistrust, anger, and attrition, declining organisational loyalty and litigation (see review by Rousseau, 1995).

Trust is founded on repeated cycles of reciprocity between two parties over a long time (Zucker, 1986) and is reinforced through frequent interaction (Lewis & Weigert, 1985). McAllister (1995) distinguishes between cognition-based trust and affect-based trust. He states that cognition-based trust (reliableness) is seen as more superficial and less special than affect-based trust (trustworthiness).
McAllister’s review (1995) suggests that once affect-based trust is formed, an evaluation is not easily revoked, whereby positive affect persists after a complete invalidation of its original cognitive basis. This argument could potentially be applied to a negative situation. That is, once distrust is formed, the negative evaluation is not easily revoked because of persistent affect colouring evaluation of future disconfirming events.

One of the characteristics of a pathological safety culture in Shell’s safety culture maturity model is that a person who spots a problem is silenced or ostracised, whereas generative culture welcomes whistleblowers (Hudson, 2003; Reason, 1997, 2008; Westrum, 1993, 1995). Since raising safety concerns at the workplace is closely associated with or is regarded as part of whistleblowing (see review by Jackson et al., 2011), the topic of whistleblowing deserves detailed attention.

Maidment (1997), in reviewing the effects of public inquiries into the rail industry in the UK, France and Germany, argues that the ways in which an organisation responds to its whistle-blowers gives a good indication of whether safety is taken seriously. Countless examples are given where important safety information falls on the deaf ear of management, a striking example of which is the Challenger disaster (Vaughan, 1990). In the rail context, Hopkins (2005) presents two dramatic examples with the Glenbrook inquiry. The first case concerned a driver who reported a defective signal. When an electrician inspected it and found it to be in working order, the driver was punished for having made a mischievous report. The second case concerned a driver who refused to drive a train out of the depot because water was dripping onto a dashboard near live wiring. The driver’s safety-conscious action was met with his employer taking legal action against him for refusing duty (McInerney, 2001). These illustrate the pathological culture characterised by risk denial, blame and punishment.

Whistleblowing is done predominantly with conscientious intent and is an act of disclosure by organisation members aimed at stopping illegal, immoral and illegitimate practices (Near & Miceli, 1995). In Shell’s safety culture model, one of the features of pathological culture is that messengers are shot rather than the negative message itself is taken seriously. In stark contrast to this maladaptive response, generative culture is characterised by the continuous effort to improve and to remain ever vigilant for potential safety risks (Hudson, 2003; Reason,
This means such organisations welcome concerns raised responsively by all sources available.

This takes us back to what was initially discussed by Reason (1997) regarding one of the four characteristics of a learning culture, flexibility. Reason (1997) referred to a flexible culture in terms of having the capacity to adapt effectively to changing demands, particularly in light of how high reliability organisations adapt the decision-making hierarchy during crises. The principle of flexibility can also be applied to how it responds to internal whistleblowing.

Whistleblowing can be seen as a form of crisis or at least a threat to the status quo and is frequently met with resistance (Perry), often characterised by a response which Staw, Sandelands and Dutton (1981) describe as threat-rigidity effect. Organisations have the choice either: 1) to respond constructively and deal with the real issues by adapting the mismanaged aspects of the system; or 2) to punish the messenger for bringing them up.

In light of organisations utilising incident analysis as a means to improve safety performance, Baram (1997) cautions against the tendency towards shaming and blaming of employees rather than directing their focus on organisational learning. He points out that management tends to shift the responsibility on to the employees in order to save the organisation from liability and to preserve the existing safety procedures (1997). This maladaptive practice is detrimental to the organisation’s learning process, since “safety in organisations is vitally dependent on the willingness of employees to report things which might be going wrong” (Hopkins, 2005, p. 38). This negative tendency has been long noted by various researchers. Notable concepts related to this topic include Turner’s (1978) “normalisation of deviance”, where organisations are desensitised to signs of hazard and thus the anomaly is normalised. Similarly, Slovic (1986) states in his risk perception research that hazardous events may hold a ‘signal value’, particularly in terms of serving as a warning signal for organisation and society. The seriousness and high-order impacts of a risk event are determined partly by what that event signals or portends. Based on the Social Amplification of Risk Framework (R. E. Kasperson, et al., 1988), Freudenburg (1992) describes characteristics of organisations that serve to attenuate risk signals and ultimately to increase the risks posed by sociotechnical systems. The attributes include the lack of organisational commitment to risk management, the bureaucratic
attenuation of information flow within the organisation, particularly in relation to “bad news”, specialised divisions of labour resulting in ‘corporate gaps’ in accountability, management’s condoning of operations violations and risk-taking behaviour (1992).

Retaliation towards whistleblowers is well documented in a wide range of industries (e.g. S. Dawson, 2000; Jackson, et al., 2011; Mazur, 1989; Sprague, 1993). Management has been known to express disapproval of what they see as ‘threat to the authority structure’ (Near & Miceli, 1995), as a ‘disruptive element’ (De Maria & Jan, 1997), or a stirrer who instigates potential institutional embarrassment (Mazur, 1989; Rossiter, 1992), through various means of punishment. Furthermore, it is also common for whistleblowers to become ostracised by colleagues who may perceive their disclosure as challenges to the status quo (Near & Miceli, 1995), a deviant that disturbs group conformity (Greenberger, Miceli, & Cohen, 1987). Furthermore, the colleagues’ adverse reaction may be based on fear of becoming a target for retaliation themselves because of their association with the whistle-blower (Greenberger, et al., 1987).

The author has had vicarious exposure to this important issue from real life experience of three internal meritorious whistleblowers. The first case involves a person in Company A, which encouraged its employees to voice their opinion about areas for improvement. The person took the opportunity to raise some concerns about the organisation’s practice, only to find that she had become a target for punitive measures by her immediate supervisor and social sanctioning by her colleagues. The second case is with Company B, which had implemented a confidential reporting system for concerns and malpractice. The channel for resolution was not at all confidential, as a member of the top management responsible for collating the information only passed on the reports to the informers’ immediate bosses without even removing the informers’ personal details. It is not hard to imagine what type of follow-up would have ensued. In case of Company C which runs an industrial operation, an operator alerted his colleagues’ and management’s attention to potentially serious malfunction of machinery. The matter was not attended to seriously, as the operator was never given the opportunity to explain his concerns in detail. Instead, the person was labelled a troublemaker, ridiculed and then the matter was dismissed. The situation eventually escalated to external whistleblowing, developing into a
vicious cycle of hostile social sanctioning, which has led to serious psychological and physiological health impact on the whistleblower.

The organisation needs to be mindful as to whether it takes heed of the message or punishes the internal whistleblower for bringing bad news. Typically, speaking up within the organisation is the first step and resorting to external channels is usually the last step taken driven by desperation, and one that is not widely taken (S. Dawson, 2000; De Maria & Jan, 1997). Literature on external whistleblowers shows that they have invariably exhausted internal avenues before resorting to external channels for resolution (Dawson, 2000). Rothschild and Miethe (1999) conclude that the organisation’s response to the employee’s initial concerns plays a crucial role in the whistleblower’s subsequent actions. They observe that most whistleblowers decide to report their information externally only after their employers begin to cover up the deviations/malpractice and intensify their level of retaliation against the whistleblower. Dawson (2000) reiterates how organisational and workplace culture plays a significant part in whether and how allegations are dealt with.

This important point is argued by researchers including Hudson (2003), Westrum (1995) and Reason (1997, 2008). That is, that the management is responsible for creating a culture that welcomes responsible internal whistleblowers rather than condoning a culture of secrecy and fear (De Maria & Jan, 1997). Zipparo (1999) emphasises the importance for management to ensure an organisational culture in which employees have faith, therefore trust, in their managers to respond appropriately to internal reports of deviations/malpractice. Furthermore, Dawson (2000) states that a serious commitment to transparency, openness and fair dealing needs to exist at the senior level and the necessity of a mechanism by which senior staff is held accountable for failure to implement and actively support a culture that is determined to disclose deviations/malpractice and root out reprisal regardless of at whatever level it occurs.

Apart from the profound negative effect on the individual whistleblowers, it is not hard to extrapolate the wide-ranging repercussions within the organisation that are likely to emerge as a result of whistleblowing. Empirical evidence suggests the importance of team and organisational attributes essential for cooperation and positive group performance. They include team spirit, supportive work relationships (e.g. Edmondson, 2005; Jannadi, 1995; Rentsch & Zelno,
2005) and trust in supervisors and management (e.g. Zacharatos, et al., 2005). Furthermore, the cost of whistleblowing through external channels has proven detrimental to the organisation, including public scrutiny, loss of reputation and litigation. It is in the organisation’s interest to listen attentively to safety concerns raised by its members with genuine interest to improve safety. Resolving issues at the early stage while they are relatively manageable is a wise course of action, rather than leaving the informer with no other choice but to raise the issue through external whistleblowing.

Knowledge is power, if the organisation allows it be so. Reporting of safety concerns and disclosure of safety deviations/malpractice within the organisation, in actuality, deserves serious and genuine attention. Information that alerts the organisation to potential safety problems can be a blessing in disguise, such brave acts on the part of the employees can play an important role in risk mitigation. The upward flow of vital information should be valued for its potential to provide management with a wealth of factual information. It cannot be over-emphasised that this type of information can only be obtained by members who have either firsthand exposure to/or are in a position to observe hazardous situations in close proximity.

Growing evidence suggests that human thinking is governed by dual processes, which have serious implications on risk cognition and decision making (see review by Slovic, Peters, Finucane, & MacGregor, 2005). The dual processes consist of the rational system (deliberative, effortful and analytical) and the experiential system (intuitive and automatic), driven by affect and emotions (e.g. Epstein, 2003; Pacini & Epstein, 1999). It is important for management to be mindful of the intrinsic human tendency of succumbing to self-preservation when confronted with bad news, i.e. threat. When our affective defense mechanism kicks in, it is likely to steer us towards interpreting reports of safety concerns as a challenge to the establishment. Neuroscience has taught us the powerful and instantaneous influence of affect on cognitive processes (see review by Panksepp, 2003). Strong negative affect invariably gives rise to the freeze, flight, fight or fright response in times of danger (Gray, 1988). This adaptive mechanism which served humans very well in prehistoric times, are now maladaptive in modern society underpinned by complex sociotechnical systems. Nature is indiscriminate when it comes to human cognition and managers are not
immune to this mechanism. Contemporary humans need to evolve in line with the technological advances. It is universally evident that when humans have strong affective experiences, higher cortical regions which predominantly govern cognition and thus logical thinking tend to shut down (Damasio et al., 2000; Fischer, Andersson, Furmark, & Fredrikson, 2000).

While Slovic and his colleagues (R. E. Kasperson, et al., 1988; Slovic, 1986) discuss how the public needs to be informed and educated about risks, genuine humility is essential for leaders of organisations to accept the universal human fallibility in their own thinking styles and address these issues in effective internal regulation of safety within their organisations. Trust is cultivated and reinforced through repeated exposure. It will take a disciplined reflective mind to be cognizant of such intrinsic human tendencies in the face of bad news, to rise above them through trained, conscious thinking processes and then to look at the issues at hand objectively and focus on solving the problems that have surfaced through reporting.

**Limitations**

The current study targeted a wide range of occupational groups in six rail organisations to gain a general picture of how the participants evaluate safety climate/culture in their organisations. This approach posed some methodological limitations. Firstly, a structured level-based analysis was not feasible, as the current study did not target specific work groups as seen in some studies, for example, by Hofmann and Stezer (1996) and Zohar (2000). These conditions constrained the safety climate/culture data to be analysed at the individual-level rather than at the group or organisational level.

Additionally, the definition of ‘management’ was ambiguous in hindsight and the realisation that some positions in organisations move between different roles at different times needs to be noted. The data suggest that how the participants saw themselves as management was open to interpretation. Due to the way the questionnaire asked their occupational details for management (Section E – Items 3 and 4) and the way safety-critical work was defined (on the front page of the questionnaire, Appendix 4), it is not clear whether the participants were at the front line or not. It is plausible that a sizable proportion of
the people who described themselves as in managerial role may have been superintendents at operations sites. Future research would benefit from greater clarity. Furthermore, greater clarity would be required on how people at different job levels may view the consequences of worksite death or injury. For example, a senior manager remotely engaged with the frontline workers may regard deaths or injuries as safety records while an employee closely associated with the victim may experience the occurrence as loss or harm to his/her friend.

Thirdly, the outcome variables for the current study were subjective measures. They consisted of: 1) the number of accidents; 2) the number of near misses; and 3) the frequency of safety defect reporting, as reported by the participants regarding their own experience over the two year period prior to the questionnaire administration. One of the potential drawbacks of self-reports is its reliance on the participants’ recall, which may not be as reliable as such objective records as, for instance, ‘microaccidents’ used in Zohar’s study (2000). Self-reporting of accidents and near misses may also be affected by possible under-reporting. Furthermore, accidents and near misses are potentially subject to stochastic factors unrelated to the state of safety health of an organisation. Had it been conducted in clearly defined pre-assigned work groups, it would have been possible to use objective group/organisation-based data such as LTIFR or normalised values using such units as million train kilometers travelled.

Fourthly, greater clarity on the nature of workplace stress and safety defect reporting would have been desirable. The questionnaire asked about the participants’ evaluation of the level of stress they observed at their place of work. It is therefore not clear whether their response reflected their observation of their colleagues or they answered the level of stress they experienced within themselves. In terms of safety defect reporting, ‘a roll-by inspection’ is a distinctly West Australian safety practice as mentioned in the previous section. As the reporting of safety defects were classified only in terms of equipment, track infrastructure, rolling stock, electrical infrastructure and others, it is not clear whether the reporting occurred during the mandatory ‘roll-by’ inspection or more proactive reporting of safety concerns in situations other than roll-bys. The lack of clarity has made it difficult to interpret the relationship between safety defect reporting, workplace stress and blame culture.
Fifthly, the current study could have benefitted from more sophisticated statistical analysis methodology. As comprehensively reviewed by Glendon (2008), advances in statistical packages have contributed substantially to elucidate the complex and multi-faceted relationships between inter-related clusters of variables. The current study did not adequately address the mediation or interaction effects among some of the variables in the prediction analyses. Similarly, multicollinearity is an issue that could be addressed in future research. In terms of factor analysis some questionnaire items were difficult to interpret due to multiple loadings (e.g. Items 16, 23, 36, 42 and 45). This is a limitation.

Additionally, future research needs unequivocal questions that do not ask more than one question in the same sentence. The problem of double-barrelering and the need for simplicity are discussed in survey design literature (de Vaus, 2002; Nunnally & Bernstein, 1994; Sarantakos, 1998).

Furthermore, the current study could have benefitted from exploring individual differences in personality and interpretation of risk events. However, the questionnaire was extensive and time consuming for respondents. While it could have been larger, the author suspected that the response rate would have been lower and the results less interpretable if further questions were asked.

Finally, out of the 241 participants used for the prediction analyses, 115 people (65%) indicated that they were based in Western Australia. One participant did not indicate in which state he was based. Compared with the eastern states, labour relations in the rail industry in West Australia appear to be more harmonious and trade union representation appears considerably less adversarial. This impression has been formed through the current author’s studying of media coverage, coupled with the extensive interviews conducted on rail industry experts in several jurisdictions prior to commencement of the current study. Had the participants been predominantly from the eastern states, the questionnaire could have yielded considerably different safety climate/culture scores. Thus, the lack of methodological rigour at the design stage has placed limitations on minimising potential confounding variables and consequently, of the interpretation of results.
**Future Directions**

The current study focused on quantititative evaluation of the effect of safety climate/culture on rail safety outcomes using the psychometric approach. Evaluation of the safety climate/culture both at ‘material’ level and at ‘immaterial’ level by using retrospective and prospective approaches appears to have been complementary. While the results of the current study has shown that some safety climate/culture variables are significantly associated with safety outcomes, caution needs to be exercised due to the non-normal distribution of the criterion variables, coupled with the complex inter-relationships among the predictor variables. Triangulation has been promoted as a complimentary method for organisational culture research (Hofstede, 2001), and in safety climate research (Glendon, 2008). While the results seem to support the utility of the psychometric methodology used in the current study as a means of potentially large-scale collective evaluation, valuable further insight will be gained through qualitative methods such as ethnographic and observation approaches. Further safety climate/culture studies should also include repeated measures to examine reliability and longitudinal approach which may help evaluate the volatility of safety climate and stability of safety culture.

Yule (2003) outlines a comprehensive review of the merits and drawbacks concerning the range of safety outcome measures, which have been used in safety climate research. Future research investigating the potential relationships between safety climate/culture and safety outcomes would benefit from having a set of more objective safety performance criteria combined with more clearly defined self-report measures of safety behaviour. Observation of workplace safety behaviour may help obtain valuable insight, as well as tracking the degree of participation in voluntary safety meetings and safety observations between divisions.

The current study identified blame culture as a strong recurring theme in the prediction analyses. Safety research would benefit from further investigation into the potential implication of blame culture on safety behaviour (e.g. incident reporting and raising safety concerns), performance and participation in proactive safety-enhancing activities within the rail industry, and possibly in wider industry settings. Literature review on blame culture in the rail industry was predominantly about the UK (Clarke, 1998a, 1998b; Jeffcott, et al., 2006; Reason,
1997), and Australia (Glendon & Evans, 2007; Hopkins, 2005; McInerney, 2001, 2005), and a limited amount on France and Germany (Maidment, 1997), and the US (Diem, 2002). Future research could benefit from considerations of national culture in diverse geographical regions to examine its influence on the rail safety culture.

Future research may also benefit from drawing upon interactional psychology to explore the effect of personality and interest on safety culture. Based on this subfield of contemporary personality psychology, Schneider (1987) proposes the attraction-selection-attrition (ASA) framework as an alternative model for understanding organisational climate and culture. The principle of this framework utilising personality and interest measures to be administered to the members of entire organisations may reveal new facets to safety climate/culture research.

Since the commencement of the current study, many new approaches have been introduced to assist the rail industry with the evaluation of an organisation’s safety climate/culture. They include the Safety Culture Toolkit by RSSB (Rail Safety and Standards Board, 2012) in the UK and RISSB (Rail Industry Safety and Standards Board, 2012) in Australia. Their rail industry specific toolkits measure an organisation’s safety climate/culture and provide comprehensive feedback and suggestions. They have recently incorporated assessment of safety culture maturity. It is noted that blame culture is one of the aspects measured in these online safety culture toolkits. However, this quantitative approach would only mark the beginning of the process of unraveling the nature of what seems to be a prevalent and persistent problem in the rail industry, both in the U.K. and Australia. As Glendon (2008) points out, it would be helpful for the rail industry to have a nationwide evaluation of safety climate/culture measurement. Rail safety regulators in New South Wales and Victoria have recently introduced a program for evaluating safety culture though what is called a “story-telling” interview approach, where participants are asked to describe actual examples and their decisions and behaviours in certain situations (Independent Transport Safety Regulator & Transport Safety Victoria, 2012). It would benefit the rail industry across Australia if this qualitative approach to safety culture could be combined with the quantitative measurement of safety climate to add depth and the contextual richness to the evaluation process.
Finally, the risk classification used for the occupational groups in Chapter 6 based on injury risks at the sharp end may appear to contradict the systems paradigm, which the current thesis purports to support. While it is fully acknowledged that the potential wide-ranging risks lie upstream in the organisation, the risk classification was used to address the commonly shared ‘primordial’ perception of the sharp-end risks. It is because this type of risk is much more tangible as the frontline operators are exposed to personal risks in the “here and now” and thus they have a more immediate sense of potential danger. The impact or meaning of worksite death or injury of an employee experienced by a colleague on the front line could be considerably different from the perception held by those who manage and investigate accidents. This potentially different perception among different groups within the organisation needs to be accounted for in future investigations.

**Synthesis of Findings**

As specified in Section 1.13, the aim of the first phase of this study (Chapters 2 and 3) was to create a rail-specific questionnaire in the Australian context, designed to measure safety climate/culture based on a holistic model of safety culture. The product of this process is the Rail Safety Culture Questionnaire (see Appendix 4).

The aim of the second phase (Chapters 4 and 5) of this study was to examine whether the questionnaire can capture differences in safety climate/culture among occupational groups within an organisation. The following hypotheses were evaluated:

*Hypothesis 1a:* Group differences exist between occupational groups in terms of safety climate/culture as measured by the RPFs items.

*Hypothesis 1b:* Group differences exist between occupational groups in terms of safety climate/culture as measured by Shell’s safety culture maturity items.

The results of factor analysis in Chapter 4, coupled with the results of the organisation-based analyses in Chapter 5 serve to support Hypotheses 1a and 1b. Group differences were found between occupational groups in terms of safety climate/culture as measured by the RPFs items and Shell’s safety culture maturity
items. This implies that group differences exist in terms of the personal impact of workplace conditions (e.g. roster, workplace culture and pressure).

The aim of the third phase (Chapter 6) of the current study was to investigate whether safety climate/culture assessed through the two questionnaire item sets predict actual safety outcomes. The following hypotheses were evaluated:

_Hypothesis 2a:_ Safety climate/culture as measured by the RPFs items would predict accidents and near misses in the two-year data from rail organisations.

_Hypothesis 2b:_ Safety climate/culture as measured by the Shell’s safety culture maturity items would predict accidents and near misses in the two-year data from rail organisations.

The results of hierarchical multiple regression analysis (Analysis 1) supported both Hypotheses 2a and 2b. This is because one Rail Problem Factor External Factors, and Shell’s safety culture factors Balance between HSE Procedures & Efficiency, Proactive Approach to HSE Audits, and Reactivity – Blame Culture, were found to be significant predictors of near misses when the effect of Occupational Group was controlled for. Furthermore, the results of Analyses 3 and 4 revealed significant predictors of the frequency of safety defect reporting. However, caution is warranted in its interpretation due the non-normal distribution of the variables.

Finally, the study aimed at investigating whether safety climate/culture assessed through the two questionnaire item sets predict actual safety outcomes. The following hypotheses were evaluated:

_Hypothesis 3a:_ Safety climate/culture as measured by the RPFs items would predict reporting of safety defects in the two-year data from rail organisations.

_Hypothesis 3b:_ Safety climate/culture as measured by the Shell’s safety culture maturity factors would predict reporting of safety defects in the two-year data from rail organisations.

The results of Analysis 3 supported both Hypotheses 3a and 3b. This is because one RPF Workplace Stress, and a factor from Shell’s safety culture maturity Reactivity – Blame Culture were found to be significant predictors of safety defects reporting when the effects of Occupational Group, Years Worked in
Rail Industry (Tenure), and Near Miss Frequency were controlled for. This implies that: 1) the perception of workplace stress is related to reports of near misses and involvement in accidents; and 2) the perception of a blame culture in the workplace may play a role in differentiating those who experience near misses or involvement in accidents.

**Summary of Discussion**

The current thesis was aimed specifically at testing the GEMS model and Shell’s safety culture maturity model. The questionnaire items generated for Section A of the questionnaire were aligned to factors relevant to the GEMS framework. The author concedes she cannot be sure that she has extracted all of the factors that gave rise to the 104 rail accidents, as factors are dictated by the items in the questionnaire. It is, nevertheless, an attempt to encompass as extensive a range as possible based on the GEMS framework. Clearly, as the relatively untested and unsubstantiated psychometric properties of the socio-political and cultural factors indicate as discussed in the anthropological literature by Douglas and Wildavsky (1982), factors relevant to GEMS may vary in time, space and the socio-political climate of the times. Such instances include Chernobyl (Reason, 1987), Space Shuttle Challenger (Vaughan, 1990) and Fukushima (Nakamura & Kikuchi, 2011).

The central themes that have emerged from the current study are that: 1) it is of vital importance that all possible contributing and causal factors are taken into consideration in investigating accident causation; 2) both retrospective and prospective measures can provide valuable input from the people at the sharp end; and 3) the onus is on the organisation’s management, both at top and supervisory levels, to facilitate an environment to optimise the functioning of their safety management system. This needs to be facilitated through putting internal regulatory mechanisms in place for identifying, diagnosing, prioritising and responding to risks (J. X. Kasperson, Kasperso, Pidgeon, & Slovic, 2003).

As Reason (1997, 2008) points out, the leaders need to focus on what they can do, which entails ensuring that elements of safety management systems at the organisational and worksite level as specified in the Rail Problem Factors are designed, implemented, maintained, monitored and revised in a manner conducive to safe operations. Individual psychology of the workers at the sharp end is, in
most part, beyond the control of the management. The areas within their control are largely limited to appropriate selection, training and acculturation for endorsing desirable behaviour and discouraging undesirable behaviour. Reason (1997) describes latent conditions metaphorically as a swamp of mosquitoes. It is pointless trying to deal with active failures and their negative outcomes, i.e. the “mosquitoes” one and each one. They can be swatted one by one, but they still keep coming. The best remedies are to put effective layers of defence in place and to drain the swamps in which they breed.

Schein (1992) emphasises the crucial role a leader plays in creating cultures—“Leaders create cultures by what they systematically pay attention to. This can mean anything from what they notice and comment on to what they measure, control, reward and in other ways systematically deal with (p.231)”. Hopkins (2005) reinforces this point readily by illustrating how some leaders make public statements about their organisation prioritising safety yet leaving the implementation to others to arrange without directly getting involved themselves. This tendency is particularly acute in large multinational organisations where top management is likely to have been appointed for their expertise in financial matters and may have limited technical knowledge of assets under their control. In these circumstances, such senior executives may delegate safety management to others, “inadvertently conveying a message about priorities” (Hopkins, 2005, p. 9).

The phenomenon of mixed messages is a common problem, where different parts of the organisation express divergent intentions (Rousseau, 1995) and incompatible goals (Wagenaar, et al., 1990). Examples include a mission statement conveying that the organisation rewards employees who voice their opinion for improvement, while in actual fact such messengers are shot. Another example is safety awareness billboards posted at the entrance of some plants which mention the number of hours worked without accidents, while the management continues to prioritise production above all else. Furthermore, research has shown that over-emphasising appearance of safety can lead to workers placing greater emphasis on consensus of behaviour than understanding the meanings behind the safety practice (Hopfl, 1994).

Some researchers have focused on individual attributes, including personality differences in accident involvement (e.g. Clarke, 2006a) and the effect
of management and safety climate on risk taking behaviour (e.g. Yule, Flin, & Murdy, 2007). While these studies may help identify important factors for consideration for staff recruitment and training, the major thrust within management’s control is with what Reason (1997) calls ‘engineering’ the culture. Reason (1997, p. 199) draws this deliberate usage of the word from Hofstede (1994) “Changing collective values of adult people in an intended direction is extremely difficult, if not impossible. Values do change, but not according to someone’s master plan. Collective practices, however, depend on organizational characteristics like structures and systems, and can be influenced in more or less predictable ways by changing these”.

Reason (1997) argues that “an ideal safety culture is the engine that continues to propel the system towards the goal of maximum safety health regardless of the leadership’s personality or current commercial concerns (p. 195)”. He likens such a culture to a state of grace being virtually impossible to attain, however “a goal worth striving for”. Hopkins (2005) explains the role of cognitive dissonance (Festinger, 1957) in facilitating a value change. People tend to reduce the tension and discomfort which arise from inconsistencies in our cognition through bringing conflicting elements into alignment. It follows that if an organisation focuses its efforts on ensuring safe working practices through structures, systems and conditions, then the individual will begin to value safe behaviour more highly (Hopkins, 2005).

A body of research suggests the pivotal role line management (e.g. supervisors) plays in forming and maintaining wholesome workplace safely climate/culture. This is in terms of safety participation (Clarke & Ward, 2006), safety-orientated interaction (Zohar, 2002) and safety communication, and thus indirectly related to accident reduction (Hofmann & Morgeson, 1999). Recent research has also shown that implicit trust is formed with immediate superiors (Zacharatos, et al., 2005). Line managers are in a unique position to influence the frontline operators, due to the close proximity and frequent interactions, essential ingredients for cultivating and maintaining trust. This implies that the leaders’ role is to inspire their direct reports, who in turn will inspire their subordinates, upholding and cascading the values of maximum safety health to all levels within the organisation. The value system and beliefs will need to be expressed not only through verbal or written communications, but also in other physical
manifestations that permeate the organisation, be it through policy, procedures and the technical systems. At the same time, they need to take on a position of humility and respect for the expertise of the people who work at the sharp end, and embrace the bottom-up feedback from the grass-roots of the operations about local error-producing conditions. It is fully acknowledged that a clear distinction needs to be made between culpable and non-culpable acts. This is important for stabiling clear standards of behaviour and a sense of procedural justice, which will help ensure that as much safety-related information as possible is communicated without boundaries (Reason, 1997).

This research project has also demonstrated the potential role of blame culture within the organisation and its potential link to safety outcomes. The leaders have considerable responsibility to instill a culture of safety while balancing it with profit generation. It takes genuine interest and an open-minded approach to what role the leaders can play by being cognisant of the intrinsic human tendencies of defensive response in times of threat and the enormous, and yet often untapped human potential to be resourceful, deliberative, mindful and reflective in order to overcome those boundaries and rise above them.
Please note:

The appendices (pp. 346-407) are not included in this document due to file size constraints. Should you wish to access them, please refer to the full version "Measurement of Rail Safety Culture - An Australian Sample" online via Murdoch Research Repository at: http://researchrepository.murdoch.edu.au/22907/.
REFERENCES

Note: Citations within the text are arranged alphabetically.


