Assessing safety culture in a high reliability organisation

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Southern Cross University

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Assessing Safety Culture in a High Reliability Organisation

Muna Sardoh

A research thesis submitted to Southern Cross Business School, Southern Cross University, Australia, in partial fulfilment of the requirements for the degree of Doctor of Business Administration

October 2013
Abstract

In the wake of a number of catastrophic safety related mishaps that have occurred worldwide in recent decades there has been increased interest in building a strong safety culture amongst high reliability organisations (HRO) as a way of immunising themselves against accidents in the workplace. It is thought that a strong safety culture will proactively ensure a strong safety performance in high reliability organisations. Although there is no shortage of measures of safety culture and safety climate they have yet to be causally linked to safety performance in the workplace.

One such measure of workplace safety culture is the survey questionnaire developed by the International Atomic Energy Agency (IAEA). Although the agency’s theoretical model of safety culture has been widely adopted by high reliability organisations, the model has never been subjected to empirical scrutiny.

This study set out to assess the face validity of the five characteristics and 37 attributes which comprise the IAEA model. The main research instrument was the IAEA survey questionnaire modified slightly with the permission of the IAEA. It was used to provide a quantitative safety culture assessment of a high reliability organisation. 252 completed returns were collected from the organisation's employees. Initial analyses (Pearson r) confirmed a significant and positive correlation between each of the five characteristics and an efficient workplace safety culture. While a subsequent regression analysis revealed a statistically significant level of support for the model only two of the characteristics (value and accountability) made a unique and significant contribution to the regression equation. The composite variable (integrated) seemed to be measuring something other than it was meant to. This lack of face validity along with excessive multicollinearity amongst the five independent variables served to weaken the IAEA model. In
addition, a deductive thematic analysis of the more than 607 recommendations made by the respondents as to how their workplace safety culture might be improved showed that the five characteristics of the IAEA model could only absorb 560 of those recommendations. The inability of the model and its five characteristics to accommodate the remaining 71 (12 %) recommendations is seen as a serious flaw in the IAEA model.

Subsequently a series of post hoc analyses was undertaken beginning with an exploratory factor analysis in an attempt to capture the psychometric properties of the survey as perceived by the respondents. Analyses confirmed the importance of value and learning to an effective workplace safety culture. Three new components were extracted from the factor analysis including teams, direct supervisor and autonomy. Moreover, the new set of predictor variables for the concept of efficient workplace safety culture were found to be free of multicollinearity. Hence, this newer model is seen to be more robust than the IAEA model. These new dimensions were subsequently shown to be positively related to employee beliefs, values and attitudes regarding the manner in which safety attributes were managed in their organisation. The theoretical implications of this new model are fully discussed including the conceptual blurring in the literature as to the nature and utility of the twin concepts of safety culture and safety climate. In the absence of general agreement regarding the conceptual definition of climate and culture it remains a challenge for future research as to how to operationalise these two constructs as a prelude to establishing their role in determining effective safety performance in the workplace.

**Keywords:** Safety culture, High Reliability Organisations (HROs) and IAEA’s safety culture model.
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**Abbreviations**

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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ACSNI</td>
<td>Advisory Committee on the Safety of Nuclear Installations</td>
</tr>
<tr>
<td>ATC</td>
<td>Air Traffic Control</td>
</tr>
<tr>
<td>DBA</td>
<td>Doctor of Business Administration</td>
</tr>
<tr>
<td>EFA</td>
<td>Experimental Factor Analysis</td>
</tr>
<tr>
<td>H</td>
<td>Hypothesis</td>
</tr>
<tr>
<td>HREC</td>
<td>Human Research Ethics Committee</td>
</tr>
<tr>
<td>HRO</td>
<td>High Reliability Organisation</td>
</tr>
<tr>
<td>HRT</td>
<td>High Reliability Theory</td>
</tr>
<tr>
<td>I/O</td>
<td>Industrial and Organisational Psychology theory</td>
</tr>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
</tr>
<tr>
<td>INPO</td>
<td>Institute for Nuclear Power Operations</td>
</tr>
<tr>
<td>INSAG</td>
<td>International Nuclear Safety Advisory Group</td>
</tr>
<tr>
<td>NAT</td>
<td>Normal Accident Theory</td>
</tr>
<tr>
<td>NEI</td>
<td>The Nuclear Energy Institute</td>
</tr>
<tr>
<td>PCA</td>
<td>Principal Components Analysis</td>
</tr>
<tr>
<td>SMS</td>
<td>Safety Management Systems</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences</td>
</tr>
<tr>
<td>NRC</td>
<td>Nuclear Regulatory Commission</td>
</tr>
<tr>
<td>STAMP</td>
<td>Systems-Theoretic Accident Modelling and Processes</td>
</tr>
</tbody>
</table>
Declaration of originality

I certify that the substance of this Thesis has not been already submitted for any degree and is not currently being submitted for any other degree or degrees. I certify that to the best of my knowledge any help received in preparing this work, and all sources used, have been acknowledged in this Thesis.

Muna Sardoh, 16th October 2013
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First, I must thank my supervisor whose invaluable help has made this research a reality. I am especially thankful and feel greatly privileged to have been supervised and taught by Dr Donald McMurray. His continuing efforts and care helped lay the foundations of this research. Without Dr McMurray’s professional and academic advice, this thesis would not have come to fruition.

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Finally, I would like to express my deepest gratitude to my friend Sami Darwish for all his moral support, prayers and wishes in the pursuit of this journey. I am positive that without his help and support, this work would not have been possible.
CHAPTER 1: INTRODUCTION

Don’t learn safety by accident. Unknown Author.

1.1 Background to the research

The background of this study comprises the knowledge base developed by researchers from a variety of disciplines. Collectively, they analysed some of the worst industrial disasters of the 21st century, in terms of how they were caused and how they might have been prevented. A few examples of these disasters include the Three Mile Island Nuclear Meltdown in 1979 in the US, the Bhopal gas tragedy in 1984 in India, the Chernobyl nuclear disaster in 1986 in the Ukraine and the recent Fukushima Daiichi nuclear disaster in 2010 in Japan. Research on safety culture is imperative because these kinds of accidents have dire humanitarian, economic and environmental effects: The humanitarian effect ranges from minor injury to loss of life, sometimes on a large scale. The economic effect of near misses and accidents can be high for the organisation, the community and governments, as well as future losses to the organisation as a result of a poor reputation regarding performance and work environment. Finally, the environmental impact can be disastrous in the case of nuclear plants, chemical plants and oil industry accidents, for example.

According to Dr. Mohamed El Baradei (IAEA, 2001), “Chernobyl was a tragic but important turning point for the IAEA.” Following the horrific Chernobyl incident in 1986 The International Nuclear Safety Advisory Group (INSAG) formed by the International Atomic Energy Agency (IAEA, 2002) officially introduced the term “safety culture” as common parlance for the first time (Cooper, 2002) to indicate that management and organisational factors are important to safety. Their
report (INSAG-4, 1991) maintained that ‘the establishment of safety culture within an organisation is one of the fundamental management principles necessary for the safe operation of a nuclear facility’ (IAEA, 2002, p.3). Following the accident, there was increased attention to human and organisational factors that contribute to the hazardous operation of technological systems. What follows is Table 1.1 containing an overview of the major High Reliability Theories (HRT) that relate to safety culture. These theories will be discussed in more detail in Chapter Two.
### Table 1.1 Overview of theories in this study

<table>
<thead>
<tr>
<th>Parent theories</th>
<th>Major studies</th>
<th>Methodology</th>
<th>Results</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial/organisational psychology (I/O)</td>
<td>Anderson et al. (2002); Landy &amp; Conte. (2007); Kline, (1996); Falbruch, &amp; Wilpert, (1999); Cooper &amp; Robertson, (2004); Hodgkinson &amp; Ford, (2011)</td>
<td>meta-analysis; review; different studies use different methodologies; application of theory and principles</td>
<td>complex, multiple applications and explanations of organisational behaviour</td>
<td>Broad theory and applications; Some accepted; some rejected; relevant to safety culture and safety outcomes, such as the role of supervisor behaviour in fatal transportation accidents</td>
</tr>
<tr>
<td>High Reliability Organisation Theory (HRT)</td>
<td>Roberts (2001); Libuser (1995)</td>
<td>Case analysis; examples; theory; models</td>
<td>Structure of the organisation results in high safety record</td>
<td>Debated; some supported, some rejected</td>
</tr>
<tr>
<td>Normal Accident Theory (NAT)</td>
<td>Perrow (1984; 2011); Leveson et al, (2009)</td>
<td>Case analysis; examples; literature review; theory; models</td>
<td>Accidents stem from dynamic human-machine interactions rather than human cognition and behaviour or engineering designs</td>
<td>Debated; some support; some rejected</td>
</tr>
<tr>
<td>Incubation Periods</td>
<td>Turner and Pidgeon (1997)</td>
<td>Case studies</td>
<td>In the incubation period signs of an impending hazard appear but are ignored or misinterpreted thus, permitting the disaster to progress</td>
<td>Some support</td>
</tr>
<tr>
<td>Sense-making and normalised deviance</td>
<td>Vaughan (1996)</td>
<td>Case study</td>
<td>An organisational culture that normalised deviance was responsible for the Challenger tragedy</td>
<td>Some support; further study needed</td>
</tr>
<tr>
<td>Systems approach to organisational safety</td>
<td>Rasmussen (1997), Woods (2002), Dekker (2005), and Hollnagel (2002); Leveson et al. (2009)</td>
<td>Review of literature; theory building; case analysis of major accidents</td>
<td>Emphasis on the combined socio-technical system as a whole and the interactions between the technical, organisational, and social features; Safety is a system problem</td>
<td>Some supported; some rejected</td>
</tr>
<tr>
<td>STAMP</td>
<td>Leveson et al. (2009; 2011)</td>
<td>Analysis of major accidents; analysis of the literature</td>
<td>Analyse accidents from a systems prospective to prevent future accidents</td>
<td>Some supported; some rejected</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------</td>
<td>-----------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Organisational culture</td>
<td>Schein (1992; 2010)</td>
<td>Model</td>
<td>definition including characteristics; effect on practice; a pattern of shared basic assumptions that the group learned as it solved its problems that has worked well enough to be considered valid, and, therefore to be taught to new members</td>
<td>Widely accepted</td>
</tr>
<tr>
<td>Safety culture as subculture</td>
<td>Rycraft (1997); Booth &amp; Lee (1995)</td>
<td>Literature review</td>
<td>Definition and characteristics; effect on practice; safety culture is an organisational culture that stresses safety</td>
<td>Widely accepted</td>
</tr>
<tr>
<td>Impact of organisational culture on safety culture</td>
<td>Hopkins, 2005; Cooper, (2002)</td>
<td>Survey; ethnographic; review of accident investigations</td>
<td>Organisational culture affects employee behaviour</td>
<td>Some supported; Some rejected</td>
</tr>
<tr>
<td>Safety culture and safety performance</td>
<td>Vredenburgh, (2002); Holland, (2003); DeJoy et al., (2004); Fernandez-Muniz et al., (2007); Wu, Chen, &amp; Li, (2008)</td>
<td>Surveys; Quantitative;</td>
<td>Safety culture/climate impacts safety performance</td>
<td>Some supported; Some rejected</td>
</tr>
<tr>
<td>Safety Management Systems (SMS) impact on safety culture and performance</td>
<td>Guldenmund (2010); Mearns et al. (2003); Kennedy &amp; Kirwan (1998)</td>
<td></td>
<td>SMS is a product of safety culture; However, safety culture may be changed by an effective SMS; Leadership and audits are necessary; Management and Leadership activities must be allied</td>
<td>Some supported</td>
</tr>
</tbody>
</table>
Table 1.2 Overview of current thesis

<table>
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<th>Methodology</th>
<th>Results</th>
<th>Evaluation of the new study</th>
</tr>
</thead>
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<td>This study addresses two major gaps in safety culture literature: (a) Essential factors that determine or predict safety culture and (b) A reliable safety culture assessment tool</td>
<td>Castro et al. (2013) tested the validity of the International Atomic Energy Agency (IAEA) safety culture model</td>
<td>Present study used a mixed methodology; Castro et al. (2013) also used a mixed methodology</td>
<td>Castro et al. (2013) found that a one-dimensional structure fit the data better than the five dimensions of the IAEA model.</td>
<td>The present study agrees with Castro et al. (2003) that the IAEA safety culture model could be improved but does not support a one-dimensional model.</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

1.2 Research issues

In over three decades, worldwide, four egregious accidents occurred with horrendous outcomes for organisation members and the public these critical incidents provided the impetus for safety culture research that was aimed at preventing these kinds of disasters. The major accidents and their causes are summarised below:

**Three Mile Island:** The accident at the Three Mile Island (TMI) nuclear power plant on 28 March 1979 was the most intense in the history of United States’ commercial nuclear power plant operation. A continuing loss of cooling water to the reactor’s heat-producing core led to partial melting of the fuel rod cladding and the uranium fuel, and the release into the environment of a small quantity of radioactive material. The TMI accident caused no injuries or deaths (Nuclear Energy Institute, 2010). The adverse event at Three Mile Island Unit 2 (TMI 2) in 1979 was caused by a combination of equipment failure and the failure of plant operators to comprehend the reactor’s condition owing to insufficient training and human factors (Nuclear Energy Institute, 2010).
Two weeks after the Three Mile Island accident, US President Jimmy Carter delegated a 12-member commission, led by John Kemeny, at that time president of Dartmouth College, to inspect what had occurred and to assess the potential effect on the health and safety of the community and plant personnel. The commission released its findings in October 1979. A key recommendation was that the nuclear corporation establish its own standards of excellence. The commission also mentioned a need for agency-accredited training bodies for nuclear plant operators and direct supervisors of operations. The Nuclear Regulatory Commission also acted quickly, setting up audits to analyse the accident. The group, led by attorney Mitchell Rogovin, arrived at the same conclusions as the Kemeny Commission (NEI, 2010).

**Bhopal Incident:** On the night of 2nd December 1984, a Union Carbide plant in Bhopal, India, started leaking 27 tons of the lethal gas methyl isocyanate (MIC) (Kletz, 2001). Half a million people were exposed to the toxic gas, which killed over 2,000 people and injured an additional 200,000. To date, over 120,000 people still suffer from side-effects caused by the accident and the subsequent pollution at the plant site (Greenpeace, 2001).

Not one of the six safety systems intended to contain such a leak was functional at the time of the accident, allowing the toxic vapour to spread all over the city of Bhopal. Multiple failures led to one of the worst industrial accidents in recent history. A refrigeration unit that was designed to keep the temperatures in the storage tanks at a controllable level had stopped working more than five months earlier and never been repaired. Moreover, a temperature alarm, which would have warned workers of the problem, had not been correctly repaired. A flame tower that was intended to destroy some of the escaping fumes was out of order. And a “scrubber” meant to neutralize toxic gases was not turned on until after the reaction was out of
control (Elmer-DeWitt, 1985; Greenpeace, 2001; Kletz, 2001). As a result of Three Mile Island (1979) and Bhopal disasters in (1984) the nuclear industry and the US Nuclear Regulatory Commission (NRC) explicitly recognised the importance of management and organisational factors for nuclear facility safety (Alexander, 2004).

**Chernobyl (Turning point):** On the 26th day of April 1986, a disastrous accident took place at Unit 4 of the nuclear power station at Chernobyl, Ukraine in the former Union of Soviet Socialist Republics (USSR). The accident was the most severe ever to have occurred in the nuclear industry (World Nuclear Organisation, 2010). An initial explosion resulted in the death of two workers. Thirty-one of the firemen and emergency clean-up workers passed away in the first three months after the explosion from Acute Radiation Sickness and one due to cardiac arrest (World Nuclear Association, 2010).

The entire city of Pripyat (inhabitants 49,360) which was approximately three kilometres from the plant was totally evacuated 36 hours after the accident. Throughout the subsequent weeks and months another 67,000 people were relocated from their homes in polluted regions and moved on government mandate. In total, it is estimated that about 200,000 people were forced to move as a result of the accident (IAEA, 2001; World Nuclear Association, 2010).

In excess of 100 radioactive particles leaked into the atmosphere when the Chernobyl reactor shattered. The isotopes Strontium-90 and Caesium-137 are still present in the area to this day. Strontium has the potential to cause leukaemia. However, Caesium is the element that spreads the farthest and survives the longest. This radioactive material harms the entire human body but mainly damages the spleen and liver (IAEA, 2001; World Nuclear Association, 2010).
Finally, northern Europe and other regions around the globe were affected by the radioactive emission from Chernobyl. Caesium and other radioactive isotopes were carried by wind towards Finland and Sweden and over other regions of the northern hemisphere to some degree. In the first three weeks following this disaster, the level of radioactivity in the atmosphere in many areas around the world exceeded the standard normal amount; fortunately, these levels rapidly receded. However, after Chernobyl an increased risk of cancer and a number of other medical conditions was recorded outside the directly affected Republics of Ukraine, Belarus and the Russian Federation (IAEA, 2001; World Nuclear Association, 2010).

The Chernobyl debacle was the result of a defective reactor design and an inadequately trained workforce (IAEA, 2001). An unauthorised test was executed without appropriate communication of information and coordination between the group in control of the assessment and the workers responsible for the safety of the nuclear reactor. Consequently, insufficient safety measures were adopted in the test scheme and the operating workers were not informed about the nuclear safety effects of the electrical test and its possible danger. Moreover, the Chernobyl plant did not have an operating control structure, and lacked such a safety structure. As a result, radioactive elements were released into the broader environment (BBC news, 2000; IAEA, 2001; Greenpeaceuk, 2006).

The 1986 Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident (INSAG-1) of the International Atomic Energy Agency’s (IAEA’s) International Nuclear Safety Advisory Group accepted the remark of the Soviet specialists that “the accident was caused by a remarkable range of human errors and breach of operating guidelines in combination with particular reactor
features which compounded and intensified the effects of the faults and led to the reactivity excursion” (Holla & Moricova, 2011, p.50).

**Fukushima Daiichi Nuclear Power Station:** On 11 March 2011, a massive earthquake occurred off the north eastern shore of Japan, triggering a destructive tsunami that initiated a chain of events at the Fukushima Daiichi Nuclear Power Station that ultimately resulted in the worst nuclear disaster at a power plant since Chernobyl. The 9.0-magnitude earthquake and the subsequent 14-metre tsunami temporarily paralysed north eastern Japan (Funabashi & Kitazawa, 2012).

The nuclear disaster was an accumulation of mini-disasters, with meltdowns of reactor cores at 3 units in combination with issues with the cooling of spent fuel pools at 4 units of the six-unit plant. A hydrogen explosion at Unit 1 on the second day of the emergency exposed a spent-fuel pool to the open air, resulting in a release of radioactive material into the environment, and worsened the conditions at the plant, causing delays in cooling Unit 3. A subsequent hydrogen explosion at Unit 3 then destroyed seawater injection lines and vent lines for Unit 2, creating delays in cooling there. Thus, an incident at one unit unavoidably hindered responses to the issues at another, resulting in parallel chain reactions of accidents and release of radiation.

The developing emergency at the plant was complex and it was aggravated by gaps in communication between the government and the nuclear industry (Funabashi & Kitazawa, 2012). An independent investigation panel, instituted by the Rebuild Japan Initiative Foundation studied how the Japanese government, the Tokyo Electric Power Company (Tepco), and other pertinent players reacted. The panel concluded that these participants were completely unprepared on nearly every level for the cascading nuclear debacle. This absence of preparedness was partly the result of a public myth regarding the absolute safety of nuclear power that industry advocates
had cultivated over decades. The lack of preparedness was exacerbated by the
dysfunction within and between government agencies and Tepco, especially regarding
political leadership and crisis management (Kimball, 2012). In addition, the panel
found that the tsunami that triggered the nuclear disaster could and should have been
predicted and that ambiguity regarding the roles of public and private organisations in
such an emergency was a factor in the inadequate performance at Fukushima
(Funabashi & Kitazawa, 2012).

**Inadequate safety practices at ANSTO:** On 13 August 2009, the Australian
federal government workplace regulator Comcare began an investigation regarding
the paid suspension of Mr. Reid, an employee of Australian Nuclear Science
Technology Organisation (ANSTO) (Comcare, 2011). Mr. Reid charged ANSTO with
breaching section 76 of the OHS Act, openly connecting his suspension to his job as a
Health and Safety Representative (HSR). Mr Reid, who was employed at Lucas
Heights for about 30 years, and was health and safety officer in the radio
pharmaceuticals area, has fought to uncover allegedly unreported accidents and safety
breaches at ANSTO (Trembath, 2012). The claim that allegedly resulted in his
suspension was that employees were contaminated with radioactive materials.

On 17 December 2010, a Comcare investigator gave a report on the results of
the investigation to ANSTO. The report recognized non-compliance with the OHS
Act. However, the report concluded that the findings did not warrant enforcement
action. But ANSTO was required to supply an action plan in response to the
recommendations of the report.

In response, ANSTO requested an independent review of the investigation on
24 January 2011, alleging procedural errors, that they were deprived of procedural
fairness, were given inadequate notice of the purpose of the investigation, and
misconstrued definitions under the Act. The review panel issued a report on 5 May 2011 supporting the conclusions of the original investigation but decided not to begin any further investigations on 27 May 2011.

Table 1.3 contain a list of additional man-made accidents and findings of investigation.

Table 1.3 List of some major accidents and findings of investigation

<table>
<thead>
<tr>
<th>Accident</th>
<th>Date</th>
<th>Finding</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Mile Island Nuclear Station</td>
<td>1979</td>
<td>Inadequate training</td>
<td>USA</td>
</tr>
<tr>
<td>Bhopal gas tragedy</td>
<td>1984</td>
<td>No safety system in place</td>
<td>India</td>
</tr>
<tr>
<td>Chernobyl</td>
<td>1986</td>
<td>-Inadequately trained personnel&lt;br&gt;-No proper exchange of information and coordination between the team in charge of operation&lt;br&gt;-Breach of operating guidelines</td>
<td>Russia</td>
</tr>
<tr>
<td>Space Shuttle Challenger accident</td>
<td>1986</td>
<td>Ignore or work around safety system</td>
<td>USA</td>
</tr>
<tr>
<td>Piper Alpha oil-platform explosion</td>
<td>1988</td>
<td>Inadequate safety procedures</td>
<td>UK</td>
</tr>
<tr>
<td>Near Waterfall Station, derailment of a train.</td>
<td>2003</td>
<td>Underdeveloped safety culture</td>
<td>Australia</td>
</tr>
<tr>
<td>Gas blowout at Snorre Alpha</td>
<td>2004</td>
<td>-A lack of compliance with procedures and governing documents.&lt;br&gt;-A lack of understanding of risk assessments, and deficiencies in carrying out risk assessments.&lt;br&gt;-Insufficient managing of resources&lt;br&gt;-Insufficient training&lt;br&gt;-No external audit</td>
<td>Norway</td>
</tr>
<tr>
<td>Texas city refinery</td>
<td>2005</td>
<td>Decisions made by managers</td>
<td>USA</td>
</tr>
<tr>
<td>Event Description</td>
<td>Year</td>
<td>Reason(s)</td>
<td>Country</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Australian Nuclear Science &amp; Technology Organisation (ANSTO) safety breach</td>
<td>2009</td>
<td>Non-compliance with the work health and safety Act</td>
<td>Australia</td>
</tr>
<tr>
<td>Gulf of Mexico</td>
<td>2010</td>
<td>Absence of safety management program</td>
<td>USA</td>
</tr>
<tr>
<td>Oil spill at Marshall, Michigan</td>
<td>2010</td>
<td>Lack of safety culture and -Complacency</td>
<td>USA</td>
</tr>
<tr>
<td>Fukushima Daiichi nuclear disaster</td>
<td>2011</td>
<td>Lack of safety culture and -Complacency</td>
<td>Japan</td>
</tr>
<tr>
<td>Chemical leak at Orica</td>
<td>2013</td>
<td>Lack of safety culture and -Complacency</td>
<td>Australia</td>
</tr>
<tr>
<td>Fiery train carrying crude oil derailed derailment</td>
<td>2013</td>
<td>Poorly trained personnel -Failed to work effectively in teams</td>
<td>Canada</td>
</tr>
</tbody>
</table>

Source: Assembled for current thesis.

These accidents have shifted attention from the purely technical aspects of accidents to organisational issues (Mengolini & Debarberis, 2012). Accidents do not just occur, they have a cause. The cause can be either failure of the material or failure of the human actor. According to Vredenburgh (2002), technological systems’ failure has accounted for only 10 percent of accidents. Therefore, safety culture theory can offer organisations a system to attain higher standards of safety (Hopkins, 2005) by focusing on the causes of organisational factors, human error as well as machinery. Safety culture impacts human behaviour, maintenance and supply of safe machinery as well as the nature of the organisational system.
1.3 Rationale for the Study

In spite of the general increase in the literature examining the safety culture concept, scholars and practitioners do not agree on either a conceptual or operational definition of safety culture. Several instruments have been developed to assess safety culture. Despite lack of consensus on what the concept entails and what metrics should be used to assess it. Each questionnaire possesses unique domains of culture, limited validity and reliability. Response rates ranged from inadequate (29%) to excellent (83%) (Pronovost & Sexton, 2005). As a result of the above, no general agreement on the type and number of factors that determine or guarantee safety culture in any given organisation exists.

Thus, at the macro level, this study will attempt to evaluate current culture theory, in particular, the IAEA’s theoretical safety culture model. Findings will contribute to the body of literature seeking to understand the nature of safety culture and the relationship of safety culture to the reduction of accidents and fatalities. It is hoped that findings will help to resolve current issues in this endeavour. More broadly, this research will also contribute to industrial and organisational psychology (I/O) theory regarding employee behaviour and attitudes. Safety culture theory is directly related to work safety, including psychological health, important domains of I/O theory.

At the meso level, the study will test safety culture, including the nature and identification of safety culture as well as a valid and reliable way to measure safety culture. Findings will contribute to the knowledge base regarding the validity and reliability of safety culture survey instruments, in particular the IAEA safety culture survey.
Finally, at the micro level, the IAEA model will be tested in a HRO organisation in Australia. Ultimately, future research will determine whether safety culture attributes differ between sectors.

1.3 Methodology overview

This study is predominantly a quantitative study since this research is undertaken to: (1) subject IAEA’s safety culture model (see Figure 2.4) to empirical scrutiny and (2) test hypotheses (see Figure 2.5), which have been specifically formulated for this current research. In keeping with virtues of a mixed method approach, a minor qualitative component was included to boost content validity of the study through methodological triangulation (Neuman, 2011).

The main data collection tool is a survey questionnaire which is been adopted from the IAEA and modified with the IAEA’s permission. During the modification process an open-ended question was incorporated as an attempt to ensure a high level of validity and reliability in the data obtained. Items that lacked face validity or that were redundant were omitted from the final questionnaire.

The finale survey questionnaire was made available to all levels within the organisation. Responses revealed that there was a full range of participants at all levels within an organisation who agreed voluntarily to participate in the study.

A response rate of 34% was achieved which according to Zikmund, Babin, Carr and Griffin (2013) is adequate, particularly when there is no intention to extrapolate the findings beyond the obtained sample. The collected data from the survey were screened and analysed with the SPSS version 20.0 Statistical Package.
Findings offered some support for the IAEA model although some of the characteristics lacked face validity and/or discriminant validity recent research supports these shortcomings.

1.5 Outline of the thesis

This thesis is based on the suggested standard structure for Doctor of Business Administration (DBA) thesis as proposed by Perry (2012). This constitutes a five chapter sequence as outlined in Figure 1.1.

Figure 1.1: Outline of the thesis

![Diagram of thesis outline]

Source: developed for current thesis.
1.6 Definitions

In effect, definitions adopted by researchers are often not uniform; accordingly, key terms are defined to establish positions taken in this DBA research.

**Safety Culture:** that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance (INSAG, 1991, p. 4)

**High Reliability Organisation (HRO):** High Reliability Organisations (HROs) are organisations in which errors can have catastrophic consequences but which consistently seem to avoid such errors (Roberts, Madsen & Desai, 2005)

**Accident:** Any unintended event, including operating errors, equipment failures and other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety (IAEA safety glossary, 2007, p. 12).

**Incident:** Any unintended event, including operating errors, equipment failures, initiating events, accident precursors, near misses or other mishaps, or unauthorized act, malicious or non-malicious, the consequences or potential consequences of which are not negligible from the point of view of protection or safety (IAEA safety glossary, 2007, p93).

**Near Miss:** A potential significant event that could have occurred as the consequence of a sequence of actual occurrences but did not occur owing to the plant conditions prevailing at the time (IAEA safety glossary, 2007, p127).
1.7 Delimitations of scope

This section intends to set boundaries for current study in order to provide a clear focus on the issues under investigation.

**Geographical delimitation**: delimitation of geographical region available for data collection. This study is conducted in Australia; this can be counted as delimitation of this study. However, the findings can be relevant to HROs similar to the organisation surveyed. Ultimately, future research will determine whether safety culture can be measured across organisational sectors and whether safety culture attributes differ between sectors.

**Industrial delimitation**: Given the nature of the topic (Assessing Safety Culture in High Reliability Organisation HRO) this research is restricted to High Reliability organisation (HRO) because of their special nature that is appropriate to the research.

A further delimitation of the scope of this thesis concerns Accidents, Incidents, Near Misses, Sentinel Event, Sharp End/Active Errors, Blunt End/Latent Errors and Occurrence Variance are all part of the definition/classification of an accident that can be considered in various degrees. These undesired events/accidents vary in probability and outcome and are considered precursors of accidents. Differentiation of these undesired events is beyond the scope of this thesis.

This study is assessing an international model which supposed to be applicable for HROs in member states. Since Australia is a member state in IAEA, this can be considered as justification for geographical focus on Australia in this study.
1.8 Conclusion

The background of this study comprises the knowledge base developed by researchers from a variety of disciplines that analysed some of the worst industrial disasters of the 21st century, including the Three Mile Island Nuclear Meltdown in 1979 in the US, the Bhopal gas tragedy in 1984 in India, the Chernobyl nuclear disaster in 1986 in the Ukraine and the recent Fukushima Daiichi nuclear disaster in 2010 in Japan. Research on safety culture is imperative because these kinds of accidents have dire humanitarian, economic and environmental effects.

The rationale for this study is based on the finding that in spite of the general increase in the literature examining the safety culture concept, scholars and practitioners do not agree on a definition of safety culture. Several instruments have been developed to assess safety culture. However, there is no general consensus on what metrics should be used to assess safety culture. As a result of the above, no general agreement on the type and number of factors that determine or guaranty safety culture in any given organisation exists. Moreover, the link between affective safety culture and safety performance has yet to be established.

At the macro level, this study will test safety culture theory, in particular, the IAEA’s safety culture model. At the meso level, the study will test safety culture, including the nature and identification of safety culture as well as how to measure safety culture. Finally, at the micro level, the IAEA model will be tested in a HRO organisation in Australia. Ultimately, future research will determine whether safety culture attributes differ between sectors. Chapter Two presents a review of the literature pertinent to the topic under study.
CHAPTER 2

LITERATURE REVIEW
CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This study purports to assess specific characteristics of an organisation’s safety culture in a high reliability organisation (HRO). These organisations, where even small mistakes can have tragic outcomes, include aviation, aircraft carriers, air traffic control systems, nuclear power plants, offshore oil drilling; emergency medical treatment, health care and fire fighting crews (Guldenmund, 2000; IOM, 2001; Roberts, et al., 2005; Rochlin, Porte & Karlene, 2005; Weick & Sutcliffe, 2001). In particular, this study investigates what factors determine safety culture and to what extent the IAEA’s Safety Culture Model assesses the safety culture of a HRO organisation in Australia.

Chapter “One” presented the background and rationale for the study and the organisation of the thesis. Chapter “Two” presents a review of the literature pertinent to the topic under study, safety culture and high reliability organisations (HROs). The review starts with the discussion of parent discipline-theoretical basis of the study. The application of IAEA’s safety culture model is then highlighted. The remaining sections present research domains, research questions, the research hypotheses and a conclusion. The concept map below represents the topics covered in Chapter Two.
Figure 2.1 Concept map for Chapter 2.

**Concept Map**

2.1 Introduction

2.2 Parent Discipline
- 2.2.1. High Reliability Organisation Theories
- 2.2.2. Organisational culture & safety culture
- 2.2.3. Safety culture dilemma
- 2.2.4. Safety culture and safety climate

2.3 Immediate Discipline
- IAEA’s model
- The use of questionnaires in safety culture research
- Measurement issue & IAEA’s model
- 2.3.1 Current practice
- Safety culture constructs
- The use of safety culture questionnaires in the HRO organisation

2.4 Research Domain
- Research problem
- Research questions
- Research objectives
- Research hypotheses

2.5 Conclusion

Source: developed for this thesis
2.2 Parent discipline - Theoretical basis of the study

According to The Australian Psychological Society, (2010), organisational psychology is the science of people at work. In particular, organisational psychology is a field that utilises scientifically supported psychological ethos and research methods to identify and solve workplace problems (Society for Industrial and Organisational Psychology, 2009). Industrial-Organisational psychology (I/O) encompasses a broad range of disciplines including organisational psychology, work psychology, occupational psychology, personnel psychology, human resource management and development, ergonomics, human factors, vocational psychology, managerial psychology, coaching, and consumer psychology (The APS College of Organisational Psychologists, 2011). Anderson, Ones, Sinangil and Viswesvaran, (2002) and Landy and Conte (2013) add the observation that I/O psychology extends well beyond the physical limits of the organisation since a number of factors that affect workplace attitudes are not necessarily found in the work setting. On the basis of the above conception, the present study is a social science categorised under industrial/organisational psychology.

In short, Industrial/Organisational (I/O) psychology comprises the study of organisational and work related behaviours in an organisational setting. The discipline of I/O attempts to examine employee behaviour in a context of workplace setting with a view to improved work and working conditions. The ultimate aim is to improve efficiency and employee satisfaction. Thus, I/O seeks to understand the relationship between people and their organisation; improve the work experience; and increase organisational efficiency by making the best use of human resources (Kline, 1996; Falbruch & Wilpert, 1999; Cooper & Robertson, 2004; Millward, 2005; Hodgkinson & Ford, 2011). As such, I/O may be considered the theoretical basis for this study.
2.2.1 High Reliability Organisation (HRO) Theories:

High reliability organisation theory (HRT)

High Reliability Organisations (HROs) are organisations in which errors can have catastrophic consequences but which consistently seem to avoid such errors (Roberts et al., 2005).

Roberts (1990) initially examined the structure of the organisation, how individuals achieve within the organisation, and how this affects the organisation’s response to the environment. She concluded that HROs are organisations that prevent disasters or have a high safety record over extended periods of time in spite of functioning in a hazardous setting. In her view, this safety record is realized through the structure of the organisation.

According to Roberts (1990), HROs have three elements in common:

1) They aggressively seek to know what they do not presently know;

2) They construct their reward and incentive systems to acknowledge the high price of failures as well as the rewards of reliability; and

3) They consistently communicate the general mission of the organisation, and attempt to motivate all organisational members to communicate with each other regarding their particular role in the overall mission.

Together with Carolyn Libuser (1995), she identified five characteristics of an HRO:

1) Process auditing: The organisation continually assesses itself for unanticipated issues that can result in safety faults similar to continuous quality management systems that assess for threats to quality. The HRO system easily intersections with quality as both safety faults and quality defects are the result of
errors. Distinctions are based on whether the error impacts an individual, a product, or a process. Process auditing enables HROs to find weaknesses in their systems and correct them.

2) Vigilance for quality degradation: As time passes, performance can deviate, especially during an extended period of success, and an HRO’s quality may be reduced or become substandard. Moreover, improvement in performance can become level if the organisation only views itself as the quality and safety standard for the industry. An HRO will compare itself to a referent system, usually in the same field. As time passes and expertise increases, a successful organisation might compare itself to other very different HROs.

3) Reward systems: The reward system consists of remuneration that a person or an organisation receives for performing in a particular manner. HROs are concerned with minimising risky behaviour but, reward systems can become nuanced and have unanticipated outcomes. For instance, requiring a complete documented response to an event might result in a team’s focus on paper keeping and thus a feeling of “euboxia,” an attitude defined by van Stralen as “all the boxes are filled out so we are OK” (Roberts & Bea, 2011, p. 2). The reward system that is used inter-organisationally also impacts the behaviour of organisations.

4) Perception of Risk: Risk must be identified and observed if it is to be addressed. HROs know that the concealed, latent, or missed risk might be the most hazardous and that the most hazardous risks might be the most appealing. Thus, risk must not only be recognized but must be addressed.

5) Command and Control is a concept adapted from the military that was conceived of by Roberts (1990) as several distinct factors but can be combined under this general category. Command and control refers to the capacity of an organisation
to both lead and command staff while preserving control during a crisis. The following concepts support command and control: (a) Migration Decision Making, whereby the individual with the most expertise is designated to make the decision; (b) Redundancy for individual and/or hardware performance. In other words, backup systems have been established; (c) Senior Managers who have a broad perspective on issues and do not micromanage; (d) Formal rules and procedures, standardization when appropriate, a fixed hierarchy but not bureaucratic; and (e) Authority Gradient, which means deference to the individual responsible for action in a crisis accompanied by a decrease in the authority gradient if an individual cannot contribute significant information to the leader because of the difference in levels of authority. This last concept was added by van Stralen (2005) after he moved from Fire EMS to health care.

Research from a number of academic disciplines has added to high reliability organisation (HRO) theory to create a rigorous model. The theory may be said to have been born during the High Reliability Organizations Project at the University of California at Berkeley. This project began two years after the publication of Charles Perrow’s (1984) book *Normal Accidents* (Marais, Dulac & Leveson, 2004). The HRO theory innovators included Todd La Porte, a Political Science professor, Gene Rocklin, initially a Physicist, and Karlene Roberts, an Organizational Behaviour professor (Bourrier, 2011). The developing research has a diverse lineage, including anthropology, psychology, management, political science, and sociology. Each discipline provides a distinct perspective and vision coming together to create a nuanced understanding of HRO.
Normal accident theory (NAT)

Perrow’s (1984) concept of normal accidents later evolved into Normal Accident Theory which examined how individuals interrelated with complicated technological systems to develop complete or unitary systems. His theory investigated interactive complexity and the joining of components inside complex organizations. He observed that as the complexity of the organisational systems grew, the interdependency among system components increased. As a result, when there was a failure in one area there was a cascading effect, triggering failures in other areas. He concluded that accidents stem from dynamic human-machine interactions rather than human cognition and behaviour or engineering designs. Whilst these accidents might be predicted and the risk recognised in hindsight from overlooked data, they might also be the consequence of data that is undiscoverable until events occur. Thus, the outcome might not be due to missed data but rather to unknowable data.

The fundamental concept of Perrow’s (1984) Normal Accident Theory (NAT) is that errors are inevitable in complicated, tightly joined technological systems, such as nuclear power plants. The intricate nature of these systems inevitably results in unanticipated interactions among independent system failures. Because of the interdependence among such system components, initial accidents increase quickly and practically without obstruction into a breakdown of the entire system. Moreover, efforts to increase safety will only cause more complexity and make accidents more likely (Leveson, Dulac, Marais & Carroll, 2009). Perrow (1984) concluded that these kinds of accidents were normal (Rijpma, 1997). Because these factors could not be predicted and catastrophic errors were inevitable, Perrow (1984) argued that some organisations should cease operations.
Incubation periods theory

Another theory of accidents, called incubation periods that was developed by Turner (1978; Turner & Pidgeon, 1997) proposes a sequence model of intelligence failure to explain the development of a disaster. According to this theory, in the incubation period signs of an impending hazard appear but are ignored or misinterpreted thus, permitting the disaster to progress. Actual case studies have demonstrated that there are always a large number of prior conditions leading up to a primary systems failure, a few of them beginning years before the actual incident (Pidgeon & O’Leary, 2000). A series of hidden errors and other incompletely understood occurrences accumulate in a manner that is contrary to current beliefs and norms regarding danger which leads to a growing system vulnerability. It is not a single error but the accumulation of failures that results in the disaster, according to this theory.

Organisational sense-making and culture of normalised deviance

A failure of organisational sense-making might also be involved when errors occur. According to Weick (1993), individuals attempt to make sense of organisations, and organisations attempt to make sense of their setting. Weick (1993) focuses on issues of ambiguity and doubt termed equivocality by Daft (1981). When sense-making fails, there is a challenge to expectations or norms that causes organisational members to question their own ability to perform. This can result in disaster.

Vaughan (1996) focused on misconduct by the organisation rather than individual employees when examining the challenger launch disaster. She concluded that an organisational culture that normalised deviance was responsible for the tragedy. The normalization of deviance refers to a steady process whereby intolerable
practices or standards become acceptable. When the deviant behaviour is recurrent without disastrous results, it converts into the social norm for the organisation. People who contest the deviant norm, whether external to the organisation or within it, are regarded as irritating or even as threatening.

**High reliability theory vs. normal accident theory debate**

In contrast, a number of theorists have stated that the idea of completely ceasing operations of high risk organisations to avoid disasters is impractical and unrealistic (Roberts et al. 2005). This view stimulated research on certain high risk organisations that appeared to challenge Perrow’s concept of inevitability by maintaining rates of errors that were significantly lower than their colleagues. An organisation was deemed to have high reliability if this organisation could have failed in the order of tens of thousands of times with catastrophic consequences but did not (Roberts, 1990). Naval aviation proved to be an example of an HRO. They lowered rates of fatal accidents and accidents causing serious damage from 55 per 100,000 flight hours in 1955 to only three in 1993 (Roberts & Libuser, 1995).

Based on these kinds of findings, HRO theory asserts that organisational strategies can effectively minimise and even eliminate the risks caused by complexity, tight coupling, technology, and other high risk variables in the environment (Weick & Sutcliffe, 2001). Supporters of HRT have found that the frequency and severity of organisational disasters might be greatly reduced, even eradicated by alteration of organisational culture, employee attitude, policies, procedures, and organisational mindfulness (Ericksen & Dyer, 2005). Actually, HRO theory asserts that safety must be sanctioned on the front-lines by employees who understand the technology and who are able to create new actions or evade irrational rules to preserve safety, particularly during a disaster (Leveson et al., 2009). In fact, according to HRT,
intelligently designed organisations can compensate for human weakness. The advantage of this approach for industry as well as the wider public impacted by industrial accidents is that high reliability organisations (HROs) rarely, if ever, experience a disastrous failure because they function so reliably (Roberts, 1990).

Whilst high reliability theory (HRT) and normal accident theory (NAT) were initially set forth as competing viewpoints, they are presently regarded as complementary (Tamuz & Harrison, 2006; Weick, 2004). The NAT focuses attention on the underlying causes of errors while HRT focuses on minimising these causes and resulting errors. Even though HRO theorists acknowledge that errors in high-risk operations are inevitable to some extent, they focus on the thesis that optimal organisational design can permit members to identify and avoid errors that would produce disastrous outcomes (LaPorte & Consolini, 1991).

Weick and Sutcliffe (2001) compressed these organisational design components into what they labelled the five hallmarks of highly reliable organisations as follows: (a) preoccupation with failure; (b) reluctance to simplify interpretations; (c) sensitivity to operations; (d) commitment to resilience; and (e) deference to expertise. All of these comprise an attitude of collective mindfulness.

Leveson et al. (2009) assume an engineering design approach to criticize both of these theories as inadequate and lacking in evidence. First, they maintain that highly complex industries, such as atomic energy actually are not experiencing more accidents than industries classified as less complex, such as the petroleum industry. They give the frightening example of the detonation of a nuclear bomb which has not occurred once in the last 60 years while oil refineries have high accident rates. They assert that Perrow’s (1984) theory is flawed due to incongruous comparisons between properties that are dissimilar like apples and oranges, as well as misclassification of
industries along his dimensions. They assert that comparing systems that have different hazards (events or outcomes) causes inconsistency in the theory. Any comparison of risk should include similar hazards. Secondarily, they assert that Perrow, (1984) does not distinguish between different types of complexity and coupling. In fact, all systems in a particular industry do not all have the same degree of interactive complexity and coupling (Leveson et al., 2009).

They maintain that HRO theory makes the same mistake of incorrect classification and distinction of kinds of complexity and coupling. For example, air traffic control (ATC) is so safe because the system has been intentionally designed to be tightly coupled to enhance safety. Also, whilst nuclear reactions might possess a number of the elements that Perrow connects to tight coupling, all designs for nuclear power plants are not required to have similar properties regarding the degree of complexity and coupling. Finally, engineering design aims for best or at least acceptable trade-offs between the engineered system properties, physical limitations, and numerous system objectives, such as performance. These trade-offs and ambiguity will significantly affect the probability of accidents, according to Leveson et al. (2009).

Moreover, normal accident theory (NAT) and HRO disagree regarding the function of redundancy in enhancing the safety of socio-technical systems (Leveson et al., 2009). LaPorte (2006) has described HROs as possessing flexibility and redundancy to achieve safety and performance. In this case, redundancy is defined as “the ability to provide for the execution of a task if the primary unit fails or falters” (LaPorte & Consolini 1991, p. 25).

The issue raised is that supporters of each position (NAT and HRO) are discussing entirely distinct kinds of systems and are overgeneralizing the causes of
accidents (Leveson et al., 2009). As Perrow (1984) suggests, in complex, tightly coupled systems redundancy does not defend against system design errors and, actually, in those cases redundancy may increase the risk of an incident. However, the HRO examples of the successful application of redundancy occur in loosely coupled systems where the redundancy is defending against errors precipitated by individual, random component failures rather than system design flaws. If the system designs are loosely coupled, redundancy can lower accidents resulting from component failure. However, according to Leveson et al. (2009), a large number of errors in interactively complex and tightly-coupled systems are not caused by random component failure, especially organisational, cultural, and human factors, and thus, redundancy will not protect against those failures.

In addition, Leveson et al. (2009) believe both arguments are inaccurate because they confuse component reliability with system safety, which leads to a focus on redundancy as a way to enhance reliability, without considering other ways to enhance safety. In order to clarify the distinction between these terms, they define them as follows: Reliability (in engineering) is the probability that a component fulfils its particular behavioural requirements over time and under assumed conditions. On the other hand, safety is freedom from intolerable losses (due to accidents). The theorists discuss a “culture of reliability” in which it is assumed that if each individual and component in the system functions reliably, there will be no accidents. However, in complex systems, accidents frequently are caused by the interaction among reliably functioning components. In other words, these mishaps are the result of dysfunctional interactions among reliable components. In contrast, Leveson et al. (2009) maintain safety is a system property, not a component property, and should be controlled at the system level rather than at the component level. They provide the example of
accidents like the Mars Polar Lander, where the cause was a dysfunctional interaction of non-failing, reliable components, an issue in the general system design. They add that there can also be safe systems with unreliable components if the system is designed and operated in a manner that component failures do not result in dangerous accidents. They conclude that redundancy is only one of a number of methods of defending against component failures that result in accidents.

**Systems approach to technical and organisational safety**

Additional theorists, including Rasmussen (1997), Woods & Cook (2002), Dekker (2005) and Hollnagel (2002), the majority possessing system engineering and human factors backgrounds, have supported an alternate, systems approach to technical and organisational safety. The main attributes of a systems approach are as follows:

- A top-down systems orientation that identifies safety as a developing system property rather than a bottom-up synopsis of reliable components and behaviour;
- Emphasis on the combined socio-technical system as a whole and the interactions between the technical, organisational, and social features; and
- Emphasis on offering methods to model, analyse, and design particular organisational safety configurations instead of attempting to stipulate general principles that are applicable to all organisations.

There are a variety of possible methods of reaching safety goals. According to Leveson et al. (2009), the goal of organisational safety ought to be to develop technical and organisational designs needing the least trade-offs between safety and
other system goals while taking into consideration the unique risk factors and attributes associated with the organisational mission and environment.

**Systems-theoretic accident modelling and processes (STAMP)**

In this regard, Leveson et al. (2009) suggest an improved systems model labelled STAMP (Systems-Theoretic Accident Modelling and Processes). In STAMP, accidents are not considered to be the result of component failures, but due to insufficient control or implementation of safety-related constraints on the development, design, and operation of the system. Safety is conceived of as a control issue, and accidents take place when component failures, external turbulences, and/or dysfunctional interactions among system components are not sufficiently controlled. For instance, in the space shuttle Challenger accident the O-rings did not sufficiently control propellant gas release by sealing a tiny gap in the field joint. In the Mars Polar Lander loss, the software did not properly control the descent speed of the spacecraft. Moreover, control is also enacted by organisational management. For example, the Challenger misfortune also included insufficient controls in the launch-decision process. Finally, the social and political system in which the organisation operates also involves issues of inadequate control. Thus, incidents are caused by faulty processes associated with interactions among system components, including individuals, society and organisational components.
A STAMP-based risk analysis involves creating the following:

- A model of the organisational safety structure, including the stationary safety control structure and the safety constraints that each component is designed to maintain;
- A model of the dynamics and pressures that can cause deterioration of this structure over time;
- The mental process models needed by those controlling it and the feedback and communication needed to maintain precise process models; and
- A model of the cultural and political environment in which decision-making takes place.

Then a group of factors can be considered that result in violation of safety constraints. The resulting data can be used to assess the risk in both the existing organisational culture and structure and in possible changes, to plan policies and alterations that can lower risk and assess their implications regarding other significant goals, and to develop metrics and other performance measures to identify when risk is accelerating to unacceptable levels. Since these models possess a mathematical foundation, simulation and mathematical analysis can be used (Leveson, 2004).
2.2.2 Organisation culture and safety culture:

Organisational culture

Safety culture and safety climate are subsumed under industrial-organisational psychology (I/O) (Stagner, 1982). However, the roots of the concept of culture can be traced to the disciplines of social anthropology and sociology. A generally accepted definition of culture is “the total of the shared beliefs, values, and knowledge of a group of people with a common purpose” (Hillson, 2004, p. 17). As such, it has an individual and a group character.

Two primary orientations to the study of culture appear in the literature. The first views culture as an inherent element of social interaction, whilst the second considers culture to be an unambiguous social construction (Wunthow & Witten, 1988). For example, culture can be seen as the structure of a political group or the creation of that group.

Similarly, two representations of culture have been suggested. One defines culture based on behaviour or results and one defines culture based on meaning or framework. The former views culture in terms of the habitually occurring, organised modes of behaving in technological, economic, religious, political, family and other organized areas among a particular population. Alternatively, the latter sees culture as a ‘symbolic system, an ideational system, a rule system, a cognitive system, or, briefly, a system of meanings in the minds of multiple individuals within a population’ (Rohner, 1984, p. 113).

According to Trice and Beyer (1984) culture is a system of publicly and collectively acknowledged meanings functioning for a particular group at a particular time. These conceptions of culture have been integrated into organisational theory to posit the concept of organisational culture (Brown, 1998). Basically, organisational
culture is “what employees perceive to be the pattern of beliefs, values, and expectations that guide behaviour and practice within an organisation” (Gilley & Maycunich Gilley, 2003, p. 149). In addition, levels of an organisation’s culture can be differentiated by “artifacts, espoused beliefs and values, and underlying assumptions” (Schein, 2004, p. 46). These kinds of artifacts comprise discernible structures and procedures, i.e. charts and policies that facilitate understanding of the day-to-day functioning of the organisation. In essence, artifacts are signs of organisational beliefs and values, even though they might not reflect the actual beliefs and values of particular managers.

According to Cameron and Quinn (2006, p. 146), “Culture is treated as an attribute of the organization that can be measured separately from other organizational phenomena and . . . can be very useful for predicting which organizations succeed and which do not”. The Table 2.1 below illustrates the distinction between the anthropological view of culture and the sociological view of culture:

**Table 2.1 Functional approach of organisational culture.**

<table>
<thead>
<tr>
<th></th>
<th>Anthropological</th>
<th>Sociological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus</td>
<td>Collective Behaviour</td>
<td>Collective Behaviour</td>
</tr>
<tr>
<td>Investigator</td>
<td>Diagnostician, stays neutral</td>
<td>Diagnostician, stays neutral</td>
</tr>
<tr>
<td>Observation</td>
<td>Objective Factors</td>
<td>Objective Factors</td>
</tr>
<tr>
<td>Variable</td>
<td>Dependent (Understand Culture by itself)</td>
<td>Independent (culture predicts other outcomes)</td>
</tr>
<tr>
<td>Assumption</td>
<td>Organisations are cultures</td>
<td>Organisations have cultures</td>
</tr>
</tbody>
</table>

Source: Cameron and Quinn (2006, p. 146).
Schein’s model of organisational culture

Schein’s (1992; 2010) model of organisational culture is probably one of the most inclusive and widely-accepted models in both nuclear and non-nuclear realms. Schein (1992, p. 12) defines organisational culture 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 maintains that this organisational culture comprises three layers: artifacts, espoused values, and underlying assumptions. Usually, safety culture is viewed as a particular feature of organisational culture in respect to the group’s shared attitudes, beliefs, and values that help ensure safe procedures. Artifacts characterize the outer layer of organizational culture, and comprise observable structures and processes. This layer can be seen easily during inspections or observations of employee behaviour, but it is frequently difficult to understand how these obvious elements are linked to the underlying culture without more evidence. The middle layer consists of espoused values, which comprise an organisation’s official documentation, such as policies, processes, and remedial action plans, but also beliefs articulated by organisation members. Frequently, surveys and interviews are administered with the purpose of assembling data at the espoused value layer of safety culture. Finally, Schein (2010) labels the core layer of organisational culture underlying assumptions. This layer comprises implicit, fundamental assumptions that pervade the entire organisation, including beliefs regarding the intrinsic danger of the work. The core layer is not openly apparent but these underlying assumptions form the organisation’s espoused values and artifacts. Thus, the raw data collected from surveys and
observations must be cautiously interpreted to understand the underlying assumptions of the organisation and the core of the safety culture.

The practical value of evaluating an organisation’s safety culture is that the evaluation has been typically employed as an indicator of safety performance. In addition, safety management audits or analyses of errors and near-misses are also seen as indicators. These are important issues to which we shall return in sections to follow. Furthermore, assessments of safety culture might be used to indicate where safety culture can be improved. They might also be used to inform intervention to prevent negative events.

**Safety culture as sub-culture**

A number of scholars and experts (Rycraft, 1997; Sammer, Lykens, Singh, Mains & Lackan, 2010) emphasise the idea that the safety culture of an organisation is inseparable from the entire organisation’s culture. Every feature of the institution’s ethics and systems of management affect the entire organisation and, to a degree, govern how the balance between safety and other business imperatives is achieved. Booth and Lee (1995) also assert that safety culture is a subdivision of the general organisational culture and that it basically describes the attitudes of employees regarding the organisation for which they work, their awareness of the scale of the risks to which they are exposed and their opinions regarding the necessity, practicality and efficiency of controls.

Thus, the similarities in definition and perception between organisational culture and safety culture are entrenched in the idea that safety culture is actually an organisational culture that stresses safety. Intrinsically, it will show the same attributes and relationships with other occurrences as its parent conception. For
instance, the character of an organisation’s business or its business setting also affects
the organisational system and its culture (Ott, 1989). Thus, it also impacts the
organisation’s safety culture, where, together with other factors, legal and
governmental structures have an impact (IAEA, 1991). Klein, Bigley & Roberts,
(1995) identified similarities amongst HROs, and disparities between these and other
kinds of institutions. In HROs characteristics related to the intrinsic dangers of their
technologies are shared and, as a result, the organisational culture might be shared.

Impact of organisational culture on safety culture

The culture of any given organisation is often expressed by members as
simply, “The way we do things here” and the knowledge of the way things are done
can provide insight into the dominant paradigm in a given organisation (Cooper,
2001). Actually, in the social sciences the general concept of culture and the culture
of safety, in particular, is regarded as a characteristic of groups and not of individuals.
As a result, the literature discusses the characteristics of a group not individuals
(Hopkins, 2005). At the same time, much of the safety culture literature points to the
fact that the organisational culture is known to contribute to the occurrence of errors
and accidents (Cooper, 2001). According to Cooper, (2002), the primary
organisational culture has a considerable impact on safety. Because corporate culture
might influence the efficiency of the work group and effectiveness of the system as a
whole, it might impact productivity and other aspects of organisational excellence
(Antonsen, 2009) as well. As Jacko (2009, p. 724) notes, however, “the power of
culture often goes unrecognized”.

Every organisation has a culture and assortment of subcultures (Hopkins,
2006) which in turn effect organisational commitment (Lok & Crawford, 2001). It has
been suggested that the nature of an organisation’s business or business environment
is a basic source of its culture (Klein, et al., 1995). While culture has a powerful influence on day-to-day organisational behaviour and performance (Mullins, 2013), in most organisations, upper level managers often lack a deeper understanding of how people and organisations function in terms of culture (Alvesson, 2012). This lack of insight explains failures of new policies and strategic plans that are inconsistent with the organisation’s culture (Schein, 2004). Cultural forces are powerful because they operate outside of people’s awareness (Schein, 2010). In spite of the general agreement that organisational culture affects employee behaviour and, thus, the safety and efficiency of the organisation, the question remains as to what a safety culture is and what specific aspects of safety culture prevent disasters.

**Safety culture and safety performance**

The term safety culture first appeared following the outcomes of several safety studies after Heinrich’s (1931) accident causation theory crediting 85% - 98% of all work related injuries to unsafe behaviour. According to Dilley and Kliener (1996) such unsafe behaviour is correlated with attitude, behaviour and culture (Soukeras, 2009). Moreover, a review of meta-analytic studies found that many studies expanding early research employ safety performance as an all-inclusive word to encompass the numerous kinds of safety outcomes that are considered to be dependent variables, such as self-reported safety behaviours, including adhering to procedures, wearing personal protective gear, participating in safety meetings. Safety performance is also considered to include organisation-level safety outcomes, such as accident and injury rates. These studies hypothesize that there is a correlation between measures of safety culture and these kinds of indicators of safety performance (Morrow & Barnes, 2012).
Many early studies tried to identify particular safety management behaviours that predict safety performance as measured by accidents and incidents. A number of the initial studies found shared attributes of organisations with high safety performance, but did not include organisations with low safety performance as controls (Mearns, Whitaker & Flin, 2003). Cohen, Smith and Cohen, (1977) examined four of these studies and found the following features common to at least three of the samples of organisations with high safety performance:

- safety officers had a high rank;
- management were personally involved in safety activities;
- training was superior for new employees and was offered at set intervals for current employees;
- posters were employed to pinpoint potential hazards;
- procedures for promotion and job placement were clearly defined;
- communication between supervisors and workers regarding safety was standard on a daily basis, and
- worksite inspections occurred often.

Similarly, Shafai-Sahrai (1971) studied 11 corresponding pairs of enterprises with on-site interviews and worksite assessments at each company. The firms with lower accident rates had the following characteristics:

- senior managers who were personally involved in safety activities;
- prioritizing of safety in meetings, and in decisions regarding work procedures; and
- full investigation of incidents.
In many of the previous studies, a number of general themes regarding safety practices that predicted safety performance emerged, including the following (Mearns et al., 2003):

- Genuine and reliable management commitment to safety, including prioritising safety over production;
- Emphasizing safety in meetings;
- Managers’ personal participation at safety meetings and in walkabouts;
- One-on-one meetings with workers that emphasize safety as a theme; and
- Job descriptions that contain safety contracts.

Moreover, communication regarding safety issues included ubiquitous channels of formal and informal communication and regular communication between management, supervisors and workers. Also important was participation of employees, including empowerment, allocation of responsibility for safety, and promotion of commitment to the organisation.

**Safety climate and safety performance**

More recently, Neal and Griffin (2006) found an association between safety climate and safety performance. They measured perceptions of safety climate, motivation, and behavior at two discrete points in time and related them to previous and subsequent levels of accidents over a five year period. The study was conducted in an Australian hospital that employed more than 700 people. A variety of safety problems were of concern to the employees, including manual treatment injuries, needle-stick wounds, exposure to infectious or poisonous materials, and harassment/bullying. The study consisted of a sequence of analyses scrutinizing the
influence of top-down and bottom-up procedures functioning simultaneously across time. Regarding top-down influences, average levels of safety climate inside groups at a single point in time forecast succeeding changes in individual safety motivation. In turn, individual safety motivation was correlated with succeeding changes in self-reported safety behavior. As for bottom-up effects, improving the average level of safety behavior inside groups was correlated with a succeeding decrease in accidents at the group level.

The results from these meta-analytic studies indicated a statistically significant linear relationship between safety culture and accidents/injuries, with a correlation of -.22 to -.39 (p < .05), and greater correlations between safety culture and employees’ safety behaviours, fluctuating from .43 to .61 (p < .05). In terms of Cohen’s (1988) labels, the relationship between safety culture and safety performance seems to be a medium effect, and the relationship between safety culture and safety behaviours seems to be a large effect (Morrow & Barnes, 2012). These statistics indicate that, in general, safety culture might be responsible for 5-15% of the variance in an organisation’s accident and injury rates, and 18-37% of the variance in workers’ safety behaviours. Perhaps, even more significant, the findings of this research also indicated important gaps in safety culture literature. Currently, only a small percentage of research has used prospective research designs to test for associations between safety culture and safety performance. From a practical standpoint, the value of the safety culture concept is as a possible leading indicator of safety performance. However, this hypothesis cannot be sufficiently tested unless safety culture is precisely measured prior to being linked to safety performance and can be demonstrated to predict future performance (Morrow & Barnes, 2012).
Mohamed (2002) investigated the effect of safety climate variables on safety climate in construction worksites in Australia together with the association between safety climate and workers’ safety performance. This author developed a research model founded on the theory that safe work behaviours are the result of the current safety climate that is established by specific identified independent concepts. A survey questionnaire was used to collect data from different construction sites. The model was verified by structural equation modelling. The results provided evidence for the effect of management, and systems of risk and safety on safety climate. In addition, the study findings validated the significance of management commitment, communication, employees’ involvement, attitudes, competence, and supportive managerial environments, in obtaining a positive safety climate. Finally, the study results indicated a positive correlation between safety climate and safety performance at work.

Mearns et al. (2003) found a relationship between safety climate scales and safety performance. Safety climate surveys were given to employees of 13 offshore oil and gas installations in different years (N=682 and 806, respectively), with the same nine installations included in both years. Moreover, information on management behaviours was obtained from surveys of senior management on eight installations in both years. The relationships between management behaviours and climate scores with official accident records and self-reported involvement in accidents were tested with a number of hypotheses. The study’s results indicated relationships between specific safety climate scales and official accident statistics, as well as the percentage of survey respondents reporting an accident in the preceding 12 months. Finally, skill in particular safety management practices was correlated with lower official accident
rates and a smaller number of respondents reporting accidents. While this study relied on self-reports and perceptions as does most research regarding safety culture/climate, actual accident statistics were examined to measure changes in safety performance.

There has been some debate over the nature and existence of a relationship between safety culture and safety performance. As suggested above, several researchers have found a connection between safety culture and safety performance in various industries, including sales, manufacturing, and transportation (Clarke, 2006; Zhou, Fang & Wang, 2008). However, the relationship is not always clear in other studies. For example, this relationship has not been as direct in healthcare (Olsen & Aase, 2010). In healthcare, safety culture is frequently used to signify how patient safety is understood, organised and implemented in a healthcare organization, usually a hospital. Often, safety climate is considered to be a subcategory of this environment, emphasizing staff beliefs regarding patient safety.

Recently, many studies have examined methods of assessing safety culture and safety climate in healthcare. The focus has been on interventions to improve safety culture and staff feelings about safety based on the assumption that developing a better safety culture will directly or indirectly improve patient outcomes as a result of reducing errors and accidents. The Evidence Center (2011) reviewed research investigating the connection between safety culture/climate and patient outcomes. Nine bibliographic databases and many websites were searched for literature accessible in August 2011. Over 100 studies were reviewed and 50 of these studies clearly investigated relationships between safety culture/climate and patient outcomes.
The following Figure 2.2 depicts the linear relationship that is frequently assumed to exist between safety culture and patient outcomes in studies of safety culture and performance in healthcare organisations.

**Figure 2.2: Simple model of safety culture and outcomes relationship.**

<table>
<thead>
<tr>
<th>Improvement Initiatives</th>
<th>↓</th>
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</thead>
<tbody>
<tr>
<td>Improved Safety Culture</td>
<td>↓</td>
</tr>
<tr>
<td>Better Patient Outcomes</td>
<td></td>
</tr>
</tbody>
</table>

Source: Evidence Centre (2011, p. 17).

As suggested by the Figure 2.2e above, many researchers hypothesize an association between safety culture and patient outcomes (incidents) or propose that more research on this relationship is necessary. However, not many empirical studies have really attempted to test this relationship in detail (Evidence Center, 2011). The studies that tested this relationship have had mixed results of varying quality. On the other hand, a few researchers have found a correlation between safety culture/climate and hospital morbidity, adverse events and rates of patient readmission. It is acknowledged that correlations are not necessarily causal.

At the same time, some studies found that safety culture did not affect patient outcomes. More studies indicated that refining safety culture affects staff safety behaviours and injury rates among staff members. Conversely, a number of researchers discovered that patient outcomes and better-quality safety culture concurrently followed safety improvement programs. Thus, instead of a one-way causal relationship, where safety culture influences behaviours and clinical outcomes, there might be a circular relationship, with alterations in behaviours and outcomes...
also improving safety culture (Evidence Center, 2011). This possible relationship needs to be investigated in other organisations as well.

The overall conclusion of the Evidence Centre (2011) review of the literature was that there was insufficient evidence to support an assumed relationship between safety culture and safety performance. They found almost as many studies indicating no association as studies indicating an association. Finally, they believe there probably is a complex interrelationship between safety culture and outcomes, with modification of procedures and patient outcomes both affecting the way staff members regard safety. Therefore, there is probably a two-way relationship between safety culture and patient and staff outcomes, instead of a linear causal relationship (Evidence Centre, 2011).

Groves (2013) also found inconclusive evidence of a relationship between safety culture and safety outcomes in healthcare organisations. Because few empirical studies were available, five small meta-analyses were piloted to investigate the relationship between safety culture and the following healthcare issues: pressure ulcers, falls, medication errors, nurse-impacted results, and post-operative results. The study did not find any significant association between safety culture and safety outcomes.

However, more studies have linked a lack of a safety culture to adverse incidents. For example, current research has identified a number of causes of human errors, including the following: Attitudes regarding work safety and performance; Culture of safety is lacking in vital areas, such as process compliance and reporting; Insufficient standards, training and monitoring of expert qualifications; Inadequate communications and information stream; Failure to comply with regulations and best practices; Stress, pressure to produce, and insufficient resources (Ciavarelli, 2012).
According to these studies, supervisors contribute to this atmosphere and an inadequate culture of safety.

In his study, Seo (2005) operationalised perceived safety climate as consisting of management commitment, supervisor support, co-worker support, employee participation, and level of competence. The sample consisted of 722 grain industry workers in 102 diverse locations of a multi-national grain company in the US. Data were collected via a 98-item survey questionnaire. Structural equation modelling was used to test a second-order factor model to explicate unsafe work performance. The survey data suggested that perceived safety climate was the paramount predictor of unsafe work performance. The impact of safety climate followed the following three paths concurrently: (a) indirectly via the successive influence of other mediating variables of perceived work pressure, perceived risk, and perceived barriers; (b) by means of direct influence on perceived barriers that, then, impacted unsafe work performance, and (c) through direct influence on unsafe work performance (standardised path coefficient = .73).

Focusing on error rates in an earlier study, Shannon, Mayr and Haines (1997) reviewed ten research studies that investigated the correlation between organisational attributes and rates of injury. Research was included only if the study compared 20 or more places of work. For a variable to be regarded as reliably related to the injury rate, the association had to be statistically significant in one direction in two thirds or more of the studies in which it was investigated, and not significant in the opposite direction in any other research study. Factors were labelled as follows: Joint Health and Safety Committee, Management Style and Culture, Organizational Philosophy on OHS, Post-Injury Factors, Work Force Characteristics, and Other Factors. In total, 17 factors met the conditions for being reliably associated with lower injury rates. Major
factors comprised: The amount of training the Joint Health and Safety Committee was given; Good relationships between managers and employees; Monitoring of dangerous behaviours; Low turnover of staff; and Safety controls on machinery (Shannon et al., 1997; p. 213).

On the other hand, the Institute for Nuclear Power Operations (INPO) assembled data from employees at 97% of operating nuclear power plants in the US. Separate INPO and NRC assessments revealed statistically significant correlations between safety culture survey outcomes and measurements of plant performance. Features identified in the questionnaire demonstrated reasonable association with the attributes of the NRC’s Safety Culture Policy Statement. Similar to the IAEA definition, the NRC adopted the following definition of safety culture:

Nuclear Safety Culture is defined as the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment (Morrow & Barnes, 2012, p. 2).

Regarding nuclear power plants, to Martínez-Córcoles, Gracia, Tomás and Peiró (2011) employed the empowerment leadership model, based on a behavioural approach to leadership with a sample of 566 nuclear power plant employees in Spain. Their results suggested that psychological safety climate is a mediator variable. In other words, organisational leaders affect workers’ safety behaviours via the safety climate. When managers act as empowering leaders, they generate a suitable safety climate that leads to a larger number of safety behaviours. In addition, the authors of this study found that safety culture moderates the association between leadership and safety climate. Actually, the effect of empowering leaders on safety climate was particularly significant under weak safety culture circumstances. Nevertheless, when workers perceived high levels of safety culture in the organisation, managers
generated a stronger safety climate and, as a result, workers performed more safely than when the safety culture was perceived to be weak. According to Martínez-Córcoles, et al., (2011), their study results proved that safety culture was a predictor of safety climate. There was a strong positive association between these two factors, as suggested in early scholarship. Finally, contrary to the lack of support in prior research, this study found safety culture had a positive influence on the safety behaviours of employees in their sample.

As the authors note, their study has several limitations. These limitations appear in many studies of safety culture and safety performance. First, the authors identified which behaviours a direct leader must demonstrate to promote a safe climate among his/her workers, but could not determine which behaviours are more suitable to each level of the hierarchical organisational structure, such as, the supervisor, mid-level and top-level managers. Secondly, leaders were not questioned about their subordinates’ safety behaviour. Actually, the workers were asked about their immediate supervisor’s behaviours. The questioning was constrained by the necessity of guaranteeing anonymity. Furthermore, the use of self-report survey data, where responses might be inflated due to respondents’ tendencies to answer in a consistent manner, together with the cross-sectional nature of the study, which cannot show dynamic processes over time are limitations. Also, when safety behavior is assessed by self-report, the behaviour is not tested in an objective manner, but instead, subjectively (perceived safety behaviours). The actual safety behaviours are not observed. Finally, the model used in the study only examines certain organisational and social variables, partly because the authors were testing perceived safety behaviours as outputs in the model, and perceptions about an individual worker’s own behaviour depended largely on the safety culture and safety climate. Future research
should be longitudinal, observe actual worker behavior, and measure actual safety outcomes (such as reduced errors or incidents).

According to Guldenmund (2010), safety culture has been examined in the literature from the following three distinct approaches: (a) academic, (b) analytical, and (c) pragmatic. The academic and analytical approaches are primarily motivated by the empirical sequence of scientific research. On the other hand, the pragmatic approach is normative and primarily consists of expert opinion. It has been suggested that the three represent different levels of safety culture development in an organisation.

Guldenmund (2010) maintains that these approaches reflect similar developments and arguments made in the scholarship on culture and organizational culture. Both generalists and specificists have proposed distinct research strategies to identify what they believe is the nature of culture. Thus, the three approaches ought to be joined rather than juxtaposed. Then, it would be possible to incorporate diverse culture types, signifying different levels of development, into concrete empirical study.

Several authors have proposed that the establishment of safety climate could be an alternate safety performance indicator, in addition to acknowledged indicators, such as safety management audits, near misses, incidents and accidents (Guldenmund, 2010a). If safety climate is a performance indicator, then a strong relationship should exist between all these measures. However, these types of relationships have not been frequently identified in the literature. Currently, there is not much research that has attempted to validate an association between safety performance measures and safety culture or climate. These associations must be examined in greater detail in order to make practical assertions of the utility of a safety culture or climate measure as a
substitute performance indicator. Therefore, study should not be conducted to create new safety climate assessment tools but instead should concentrate on the validity of the concept and whether it truly produces a robust indicator of an organisation’s safety performance. Table 2.2 below presents an overview of a few of the major studies of the relationship of safety culture, safety climate, and safety performance.

Table 2.2 An overview of a few of the major studies of the relationship of safety culture, safety climate, and safety performance.

<table>
<thead>
<tr>
<th>Author</th>
<th>Method</th>
<th>Independent variables</th>
<th>Predictor variables</th>
<th>Sample</th>
<th>Findings</th>
<th>Safety outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vredenburgh, 2002</td>
<td>Multiple Regression</td>
<td>Employee participation; Training; Hiring; Rewards; Management commitment; Communication</td>
<td>Management behaviour</td>
<td>62 hospitals</td>
<td>Management practices predicted injury rates.</td>
<td>Number of injuries</td>
</tr>
<tr>
<td>Holland, 2003</td>
<td>One-Way ANOVA, Cross tabulation</td>
<td>Time with co.; Experience with safety issues; Experience with teams and each other; Co-chairs time with safety team</td>
<td>Historical variables</td>
<td>5 UPS teams with highest and lowest DART rates</td>
<td>Responses varied between groups; demographic variables important for comprehending a successful safety team</td>
<td>Days Away Restricted Transfer (DART) rates</td>
</tr>
<tr>
<td>DeJoy et al., 2004</td>
<td>Hierarchical regression analysis; Partial correlations</td>
<td>Organisational climate, support, participation, &amp; communication</td>
<td>Environment; Climate; Policies &amp; procedures</td>
<td>21 retail enterprises in the US</td>
<td>Policies and procedures responsible for 45% of the variance of the perception of safety climate.</td>
<td>Perception of worksite safety</td>
</tr>
<tr>
<td>Fernandez-Muniz et al., 2012</td>
<td>Structural equation modeling</td>
<td>Organisation safety policies, inducements, Safety management system</td>
<td>455 construction, and service</td>
<td>The proposed model is</td>
<td>Respondents provided information</td>
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<tr>
<td>Year</td>
<td>Methodology</td>
<td>Research Question</td>
<td>Country/Context</td>
<td>Data Description</td>
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<td>2007</td>
<td>Communication, training, preparation, &amp; management commitment (SMS)</td>
<td>satisfactory commitment in sector organisations in Spain</td>
<td>Concerning their safety performance by rating their amount of satisfaction with:</td>
<td>(a) number of personal injuries; (b) material damage; (c) employees’ motivation;</td>
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<td></td>
<td></td>
<td>CONTINUE &gt; rating their amount of satisfaction with: (a) number of personal injuries; (b) material damage; (c) employees’ motivation; and (d) absenteeism</td>
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<tr>
<td>Wu, Chen, &amp; Li, 2008</td>
<td>Multiple regression path analysis, Canonical correlation analysis</td>
<td>Safety Commitment by CEO, managers, and workers; Responses to emergencies; perception of risk, coaching, and managing</td>
<td>Faculty and staff of four universities in Taiwan</td>
<td>Safety climate impacts safety performance; one factor of safety leadership, safety controlling had main effect on CEOs and managers’ safety commitment and action in safety climate, and on safety organization and management, safety equipment and measures, and accident investigations in safety performance.</td>
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</table>

Source: Adopted and modified from Chenhall, (2010).
Safety management systems

Guldenmund (2010) suggests that a clearer emphasis on the development of safety management systems (SMS) is necessary and promising for the improvement of safety culture study. He maintains that a strong emphasis on organizational processes and/or structure will eventually impact the organisational culture. In addition, an SMS can, as a minimum, partially supply a structure for individuals to give meaning and direction to their safety activities. However, the SMS should be continuously supported by suitable leaders of management, including supervisors. Guldenmund (2010) adds that the idea of safety culture development or maturity can be replaced slowly by SMS development, as an organisational variable to implement its SMS framework and procedures efficiently with dynamic systems.

According to Mearns et al. (2003), it has been argued that safety climate and safety management are at lower levels of abstraction than safety culture and are regarded as indicators of the general safety culture (Kennedy & Kirwan, 1998). In other words, the safety culture is reproduced via the efficacy of the safety management system and the safety climate. Alternatively, the safety management system is only as strong as the safety culture.

This idea may be related to the theory that the type of systems found in an organisation can be viewed as a product of its organisational culture. Organisational culture can influence and affect organisational outcomes, such as production, interest, staffing, retention, employee satisfaction, and worker welfare. In addition, the literature suggests that organisations with a flexible culture have a tendency to realize their goals to a greater extent than those with a non-adaptive rigid culture (Weick, 1993). Regardless, a number of organisational elements affect the development of
culture, including the following: Organisational hierarchy, management values, governing entities and personalities.

A contradiction in types of organisational systems complicates safety/reliability theory (Leveson et al., 2009). Specifically, in a number of systems safety is an important aspect of the mission or even the reason the organisation exists. Air traffic control (ATC) and health care are obvious examples. However, in other systems safety is not part of the mission but, rather is a restriction on how the mission can be accomplished. For instance, a chemical manufacturing plant’s mission is to manufacture chemicals. Avoiding the exposure of neighbours to toxins or preventing environmental contamination is not part of that mission. In fact, the latter goals are restraints on how the mission can be accomplished. The optimal method of guaranteeing that safety and environmental constraints were met would be to not construct or operate such a plant. Otherwise, a chemical plant might be extremely reliable in manufacturing chemicals but poison its neighbours. The point of this argument is that at all times there are numerous goals and constraints for any system. The challenge is to make trade-offs among various requirements and constraints in designs and operational procedures for best meeting requirements that conflict with constraints.

Scholars have also argued that leadership is the primary factor impacting a safety culture (Burman & Evans 2008). Broadbent (2007) emphasised the importance of transformational leadership in the development of a safety culture and introduced the expression “transformational safety leadership” to describe the implementation of these values. Williams (2010) posited critical attributes of an ideal safety culture into the following five main constituents that include:

- Systems/Conditions;
• Leadership;
• Communication;
• Behaviour; and
• Person Factors/Attitudes.

Considering the kind and amount of accidents that happen due to inadequate safety management (Reason, 1998), researchers note that it is critical that audit tools are created to guarantee that safety management practices are effective (Parker, Lawrie, & Hudson, 2006; Hudson, 2007). Mearns et al., (2003) declare that the assessment of safety management practices should supplement the evaluation of the safety climate. On the other hand, Burman and Evans (2008) deliberate on the limits of safety management systems (SMS) in association with organisational culture and demonstrate that leadership has a more direct impact on safety than management. They also emphasise that management and leadership are distinct.

According to Burman and Evans (2008), people are the focus of leadership which ultimately influences their behaviour whilst the focus of management is analysis, control and scheduling of resources. In this regard, management controls the SMS whilst leadership drives the safety culture. There are connections between strategy and culture, goals and teamwork, as well as tasks and people. In a safety culture, management and leadership activities must be allied.

**Gaps in safety culture literature**

There are many gaps in the literature regarding the safety culture construct and its measurement. This study intends to address two major gaps in the safety culture literature: (a) Quintessential factors that determine safety culture and (b) A reliable safety culture assessment tool.
2.2.3 Safety culture dilemma:

As a concept, safety culture has generated some debate in the literature that may be subsumed under the label of safety culture dilemma, as follows:

Safety culture definition

In spite of the general increase in the literature examining the safety culture concept, scholars and practitioners do not agree on a definition of safety culture. Researchers frequently adopt idiosyncratic definitions that fit the purposes of their studies, but that are difficult to compare (Lee & Harrisons, 2000) as will be seen from the subsequent discussion in this section of the literature review.

Culture or climate?

Before attempting to differentiate between safety culture and safety climate it may be useful to briefly consider the umbrella concepts organisational climate and culture. Ostensibly, these organisational variables differ in both their conceptual and operational characteristics. On a conceptual level organisational culture has been described as an internal variable in the organisation (Calás & Smircich, 1999) that reflects the shared values and assumptions about the way things are done in the organisation. Schein (1992, p. 10) regards culture as the 'accumulated shared learning of a given group covering behavioural, emotional and cognitive elements of the group members psychological functioning.' Culture in many respects is more diffuse than climate which is a multidimensional construct that is based on the aggregated perceptions of organisational members regarding practices, policies and procedures of an organisation (Schneider & Snyder, 1975). It is a descriptive not an evaluative concept. To the extent there is commonality amongst the perceptions of organisational members regarding organisational event the perceptions tend to be accorded an
objective reality. This explains the extensive use of surveys and other qualitative techniques when collecting climate data. Organisational culture on the other hand is seen to be more elusive and harder to grasp and normally can only be surfaced with qualitative data collection techniques such as in-depth interviews or focus groups. In spite of these differences the two concepts are thought to be reciprocally related in the eyes of some researchers (e.g. Turnipseed, 1988) who claim climate is derived from and ultimately shaped by culture.

The situation is somewhat similar at the level of workplace safety. Scholars tend to use safety culture, safety climate and sometimes safety management interchangeably, as the terms are not clear cut (Kennedy & Kirwan, 1998 cited in Farooqui & Ahmed, 2008, p. 221). Some scholars unambiguously separate safety climate from safety culture (Wiegmann, Zhang, von Thaden, Sharma & Gibbons, 2004), while others do not regard them as distinct entities, but instead as dissimilar approaches to the same objective of identifying the significance of safety in an organisation (Guldenmund, 2007). In this regard, a sampling of culture and climate research is also presented in this section.

As already noted, scholars tend to use safety culture, ‘safety climate and sometimes safety management interchangeably, as the terms are not clear cut’ (Kennedy & Kirwan, 1998 cited in Farooqui & Ahmed, 2008, p. 221). Some scholars unambiguously separate safety climate from safety culture (Wiegmann et al., 2004).

**Safety culture assessment tool**

Several instruments have been developed to assess safety culture. Initial work started with Zohar in 1980. A pioneer in this field, Zohar developed a 40-item questionnaire covering eight factors associated with safety culture. The questionnaire was administered to 20 production workers in different workplaces. Since then,
several researchers have developed different safety culture questionnaires. However, there is no general consensus on what metrics should be used to assess safety culture. Each questionnaire possesses unique domains of culture, limited validity and reliability, and response rates that range from inadequate (29%) to excellent (83%) (Pronovost & Sexton, 2005).

**Factors that comprise safety culture**

As a result of the above, no general agreement on the type and number of factors that determine or guarantee safety culture in any given organisation exists. Nevertheless, several factors have been repeated in a number of studies.

**Table 2.3 Summary of safety dilemmas and this study’s stance regarding each dilemma**

<table>
<thead>
<tr>
<th>Safety culture dilemmas</th>
<th>Stance in this current study</th>
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<tbody>
<tr>
<td>Safety culture definition</td>
<td>IAEA safety culture definition.</td>
</tr>
<tr>
<td>Culture or Climate?</td>
<td>Culture; to be parallel with IAEA used terminology.</td>
</tr>
<tr>
<td>Safety culture assessment tool</td>
<td>IAEA’s modified for this study-survey questionnaire</td>
</tr>
<tr>
<td>Factors that comprise safety culture</td>
<td>Five IAEA’s characteristics as presented in IAEA’s safety culture model.</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

As noted previously, the concept of “safety culture” was first used in 1986 by INSAG of the IAEA (2002) and (Cooper, 2002) to emphasize that management and organisational factors are important to safety after analysing the Chernobyl accident. The ensuing report (INSAG-4, 1991) maintained that ‘the establishment of safety culture within an organisation is one of the fundamental management principles
necessary for the safe operation of a nuclear facility’ (IAEA, 2002, p. 3). Since then, the term safety culture has acquired a variety of definitions but no single universal definition of safety culture exists (Guldenmund, 2000; Rao, 2007). Moreover, debate has swirled around the concept from time to time.

The United Kingdom Health and Safety Commission set forth one of the most frequently used definitions of 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 organization’s health and safety management” (HSC, 1993, p. 23). Another widely accepted definition of safety culture is that developed by the Advisory Committee on the Safety of Nuclear Installations (ACSNI) (HSC, 1993; Lee & Harrisons, 2000):

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 (HSC, p. 23).

The UK and IAEA definitions are the two definitions that are used most often (Yule, 2003). Nevertheless, a number of common attributes are shared by additional definitions. A few shared attributes related to safety culture include the integration of beliefs, values and attitudes that are common to a group. Glendon, Clarke and McKenna (2006) emphasize that many definitions of safety culture rely on the individuals’ views being shared within a group, organisation, or social setting. For instance, Cox and Cox (1991) and Schein (1992) all refer to ‘shared perceptions of safety’.

A concise and practical definition of safety culture has been proposed by von Thaden and Gibbons (2008) who define safety culture as the continuing value and
prioritizing of employee and public safety by each member of each group and at every level of an organisation. Safety culture denotes the degree to which people and groups will commit to individual responsibility for safety; maintain, improve and communicate safety issues; attempt to actively learn, adjust and adapt, both personal and organisational behaviour based on evidence from past errors; and endeavour to be privileged by association with these values. This definition includes primary attributes such as personal commitment, responsibility, communication, and learning as well as the actions of every member of the organisation. It also suggests that most organisations have some kind of safety culture, but this culture is communicated with variable degrees of quality and action.

Table 2.4 summarises some of the leading sources of safety culture definitions that followed the pioneering definition by the International Atomic Energy Agency (IAEA) (INSAG, 1991, p. 4), which is the definition used in the present study: “that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance” (p. 4).
### Table 2.4 Source of safety culture definitions.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Definition of safety culture</th>
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<tbody>
<tr>
<td>Kennedy and Kirwan (1998)</td>
<td>An abstract concept, which is underpinned by the amalgamation of individual and group perceptions, thought processes, feelings and behaviours, which in turn gives rise to the particular way of doing things in the organization. It is a sub-element of the overall organizational culture</td>
</tr>
<tr>
<td>Hale (2000)</td>
<td>Refers to ‘the attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems’</td>
</tr>
<tr>
<td>Glendon and Stanton (2000)</td>
<td>Comprises attitudes, behaviours, norms and values, personal responsibilities as well as human resources features such as training and development</td>
</tr>
<tr>
<td>Guldenmund (2000)</td>
<td>Those aspects of the organizational culture which will impact on attitudes and behaviour related to increasing or decreasing risk</td>
</tr>
<tr>
<td>Cooper (2000)</td>
<td>Culture is ‘the product of multiple goal-directed interactions between people (psychological), jobs (behavioural) and the organization (situational); while safety culture is ‘that observable degree of effort by which all organizational members directs their attention and actions toward improving safety on a daily basis’</td>
</tr>
<tr>
<td>Mohamed (2003)</td>
<td>A sub-facet of organizational culture, which affects workers’ attitudes and behaviour in relation to an organization’s on-going safety performance</td>
</tr>
<tr>
<td>Fang et al. (2006)</td>
<td>A set of prevailing indicators, beliefs and values that the organization owns in safety</td>
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</table>

In the literature, safety culture tends to be described in terms of attitudes or behaviour. Glendon et al. (2006) note that the approach of some scholars is to emphasize attitudes, whilst others focus on safety culture as communicated by behaviour and activity related to work. Basically, an organisation’s safety culture functions as a guide to employees’ behaviour at work. Additionally, it is assumed that their behaviour will be affected by what behaviours are rewarded and accepted in their place of work. For instance, Clarke & Ward (2006) maintain that the safety culture is not only evident in the “general state of the premises and conditions of the machinery but in the attitudes and behaviours of the employees towards safety” (p. 278).

2.2.4 Safety culture and safety climate

Safety culture

According to O'Dea, O'Connor, Kennedy and Buttrey (2010) safety culture has been measured primarily with the use of lag indicators such as critical incidents. Because it has traditionally taken place in the wake of a mishap it offers little value as a metric of safety performance. Currently, the focus adopted by HROs is squarely on leading indicators of safety and the capacity to predict future safety performance. Usually they take the form of surveys of safety culture or climate and are useful in identifying areas that require immediate improvement.
Safety climate

Like organisational climate, safety climate in the aggregated perceptions of employee beliefs and attitudes about safety related issues (Mearns & Flin 1999). As its name suggests it measures the mood of an organisation at a particular point in time with respect to its safety practices, policies and processes. It is therefore subject to change unlike culture which is more diffuse in nature and therefore less likely to change rapidly. Thus culture is underpinned by shared assumptions about what is valued and tacitly held beliefs about what shall be done and by whom (Sackmann, 1991; Schein, 1992).

There are many similarities between these two organisational constructs. Whilst some researchers have rejected the notion of these twin concepts are synonymous (Schneider & Synder, 1975; Moran & Volkwein, 1992) others believe that ‘it is not such a large conceptual step from shared assumptions (culture) to shared perceptions (climate).’ (Ashforh, 1985, p. 841).

In general, a number of researchers distinguish climate from culture according to the level of study. Climate is the focus of the team or micro level of the group, whereas, culture encompasses the entire organisation (Gilley & Maycunich Gilley, 2003; Burke, 2008). Safety climate is an element of organisational culture that is linked directly to the mission, strategy, and performance of the organisation. The micro work group climate is associated with managerial performance and organisational procedures, including decision-making and communication.

Climate is distinct from culture when it denotes employee attitudes and opinions impacting colleagues’ daily work related interactions in the workplace (Burke, 2008). On the other hand, culture involves shared meanings, assumptions, and fundamental values (Schneider, 1990) of the entire organisation. A differentiation can
also be made between climate and culture on the basis of time, i.e. brief attitudes and beliefs in contrast with more enduring organisational characteristics (Burke, 2008). Thus, safety climate can be viewed as a part of safety culture associated with individual and group attitudes and behaviours connected to safety practices.

Thus according to many researchers safety culture is the result of individual and group values, attitudes, and perceptions with an addition of climate to encompass a complete “commitment to safety, values, and trust” (Diaz-Cabrera, Isla-Díaz, Rolo-Gonzalez, Villegas-Velasquez, Ramos-Sapena, & Hernández-Fernaud, 2008, p. 85).

According to Findley, Smith, Gorski and O'Neil (2007) “safety climate describes the safety attitudes and perceptions of employees at a single point in time in an effort to identify system weaknesses and opportunities for safety improvements” (p. 876). Definitions of both culture and climate emphasize shared beliefs and values regarding safety.

More recently, O'Dea et al., (2010 ) reviewed 18 safety climate surveys and identified six common themes including:

- management/supervision;
- safety systems;
- risk;
- work pressure;
- competence/training; and
- procedures/rules.

One conclusion reached is that there is little likelihood of establishing a 'universal and stable set of safety climate factors' (Zohar, 2002, p. 29).

**Attributes associated with safety culture**

Reason (1997) found the following attributes associated with a safety culture:
1) A knowledgeable culture, which is one in which managers and system operators have up-to-date information regarding the human, technical, organisational and environmental variables that determine the safety of the whole system;

2) A reporting culture, which is a culture where individuals are ready to report errors and near misses;

3) A just culture, which is a culture that does not assign blame and promotes an atmosphere of trust. In a just culture, participants are encouraged or even rewarded for supplying necessary safety-related information. Also, there is an unambiguous line between acceptable and unacceptable behaviour. Later developed into a key concept by safety culture theorists, a just culture exists when frontline employees are at ease reporting errors, even theirs. A just culture knows that people should not be blamed for the failure of systems they could not control. A just culture also understands that anyone can make mistakes as a result of predictable relations between individuals and the systems where they are working. On the other hand, a just culture does not permit conscious disregard of regulations, careless behaviour or wrongdoing (Ciavarelli, 2012);

4) A flexible culture which can assume diverse forms but is characterised as shifting from the conventional hierarchical style to a more horizontal professional structure.

5) A learning culture which possesses the readiness and the capability of forming the right conclusions based on its safety information system. Moreover, a learning culture has the determination to institute major reforms when necessary. According to these characteristics, beliefs and behaviours are
more important than a general statement of organisational values which might not be followed in practice.

Pidgeon and O’Leary (2000) assert that a good safety culture may display and encourage the following four attributes:

- a commitment to safety by upper level management,
- common care and apprehension of dangers and an attentiveness to their effect on individuals,
- realistic and flexible norms and rules regarding hazards, and
- continual thinking about practice by means of checking, analysis and feedback systems (organisational learning).

Barling, Louglin, and Kelloway (2002) established a direct mathematical relationship between the implementation of transformational leadership and the occurrence of injuries at work. Subsequently, Broadbent (2004) demonstrated how particular safety leadership characteristics can help organisations characterise their prevalent safety culture and safety leadership. They accomplished this using The Transformational Safety Culture and Leadership Assessment Systems.

According to Reason (1998), an organisation’s culture takes time to evolve and cannot be produced instantaneously. Similar to organisms in the biological world, organisations adapt. An organisation’s safety culture evolves as a result of historical experiences, the work environment, the labour-force, health and safety practices, as well as managerial leadership. An adaptation of Reason’s (1997) Swiss Cheese Model of Accident Causation illustrates how safety culture can influence the occurrence of adverse events (Morrow & Barnes, 2012).
An important aspect of safety culture and understanding how to prevent disasters involves mitigating risk. The field of risk management is devoted to this goal. According to Pitzer (1999), risk management has created a false impression with the idea that risk can be quantified based on probability, exposure to danger, and the probable outcomes of possible incidents. Risk management experts are able to generate highly technical and mathematically sophisticated models of the probabilistic character of a particular danger. The issue with this approach is that risk is not a physical property. Rather, it is a social construction. Everybody has their own assumptions and experiences that influence their understanding of entities or incidents. According to this author, individuals have a tendency to ignore, misunderstand or refute events that do not fit their understanding of the world.

Pitzer (1999) maintains how people view risk is critical. If people see risk as a physical entity, they are unavoidably led to the belief that management when
functioning as an ‘amoral calculator’ is accountable for accidents. After analyzing a tragedy, management is frequently judged accountable. It is believed that they understood the risks, they did not follow safety regulations, but instead pursued financial aims at the cost of human life. On the other hand, if people believe that risk is a social construction, a totally different view of errors and tragedies arises.

According to Pitzer (1999), the employee, his/her supervisor or managers are frequently blamed for tragic accidents over which they had little or no actual control.

Based on Perrow’s (1984) theories of tight and loose coupling, this author asserts there are two primary reasons why workers, supervisors or managers cannot be held responsible routinely for these incidents. The first reason is related to the complexity of even the most inconsequential events, a complexity that reduces any employee or manager instantaneously inept regarding the emergency. Second, it has to do with a situation in which people, whether they are workers or managers, frequently find that they are forced to continue working as if nothing is wrong even when they repeatedly encounter evidence that something is wrong. They are participants in a process where abnormalities have become ‘normalised’.

Finally, the majority of businesses, at some point, try to quantify the cost of accidents, if only to demonstrate that accidents are expensive, or prove the assertion that safety is good business. However, evaluating physical risk without also evaluating sociological risk (or human cost), the thought patterns of the organisation, the forces, and the effects within the organisation will result in the development of an extremely inadequate, limited and potentially harmful definition of risk, which is only a step away from disaster (Pitzer, 1999). Pitzer’s (1999) conclusion expresses the importance of balancing business interests with human welfare when calculating risk and creating a safety culture. Moreover, the habitual way of conducting business this
author describes highlights the need for creating a safety culture that ensures knowledgeable and creative reactions to unanticipated events.

2.3 Immediate discipline

The immediate discipline involves the application of IAEA’s safety culture model in a HRO organisation in Australia. IAEA’s survey instrument and safety culture framework have not been tested in HROs in Australia. Currently, the IAEA has developed a generic model of safety culture in nuclear organisations. Although there is widespread interest in the safety culture concept, this IAEA model and questionnaire have not yet been empirically scrutinised. It would be useful if this model could be tested in Australia’s HROs. In this regard, the researcher was encouraged by the IAEA to test the instrument in another setting, i.e. other than the one chosen because of its HRO status. However, it was decided that this course of action was beyond the scope of the present project. Moreover, the nature of participating organisation was deliberately concealed beyond the fact that it was designated as an HRO organisation.

IAEA’s model

The IAEA safety culture model, proposes five characteristics and 37 attributes; each of five characteristics has typically six to eight attributes that have been identified by IAEA as essential for achieving a strong safety (IAEA, 2006, Taylor, 2012). See Appendix 2.1.

Followings are IAEA five characteristics for strong safety culture:

1) Safety is a clearly recognized value.
2) Leadership for safety is clear.
3) Accountability for safety is clear.
4) Safety is integrated into all the activities in the organization.

5) Safety is learning driven.

The IAEA model below depicts the five characteristics:

**Figure 2.4 IAEA’s safety culture model shows five characteristics of safety culture.**

![Safety Culture Model Diagram]

Source: IAEA safety standards (2009, p. 8)

Following is description of five IAEA’s characteristics as described in IAEA safety standard Guide (2009):

In what follows there has been a deliberate attempt to capture the precise nature of the five IAEA’s safety culture characteristics. Accordingly, the description of each of the following five characteristics has been included verbatim from IAEA safety standard guide.
**Safety is a clearly recognized value.** The following behaviours indicate that this attribute of safety culture is operative: Safety is given high priority as demonstrated in documentation, communications and decision-making. Safety is a primary consideration in the allocation of resources. The strategic business importance of safety is reflected in the business plan. Organisation members believe that safety and production are allied. A proactive and long-term approach to safety issues is evident in decision-making. Safety conscious behaviour is socially accepted and supported on both formal and informal levels (IAEA safety standard Guide, No.GS-G-3.1 2006, p. 9).

**Leadership for safety is clear.** The following attributes indicate this element of safety culture is present. Senior management is clearly committed to safety. Commitment to safety is evident at all management levels. Visible leadership demonstrates involvement of management in safety related activities. Leadership skills are systematically developed. Management assures that there is sufficient and competent staff. Management seeks the active involvement of staff in improving safety. Safety implications are considered in the change management process. Management shows a continuous effort to strive for openness and good communications throughout the organization. Open reporting of deviations and errors is encouraged. Management has the ability to resolve conflicts as necessary. Relationships between management and staff are built on trust. Internal and external assessments are used (IAEA safety standard Guide, No. GS-G-3.1 2006, p. 10).

**Accountability for safety is clear.** The following characteristics indicate this attribute of safety culture is present: An appropriate relationship with the relevant regulatory
body exists, ensuring that the accountability for safety remains with the licensee.
Roles and responsibilities are clearly defined and understood. There is a high level of compliance with regulations and procedures. Management delegates responsibilities with appropriate authority to enable accountabilities. Ownership of safety is evident at all organizational levels and by all organization members (IAEA safety standard Guide, No. GS-G-3.1 2006, p. 10).

**Safety is integrated into all the activities.**
The following attributes indicate this element of safety culture is present. Trust permeates the organization. Consideration for all types of safety, including industrial and environmental safety and security, is evident. The quality of documentation and procedures is good. The quality of processes, from planning to implementation and review, is good. Individuals have the necessary knowledge and understanding of the work processes. Factors affecting work motivation and job satisfaction are considered. Good working conditions exist with regard to time pressures, workload and stress. There is cross-functional and interdisciplinary cooperation and teamwork. Housekeeping and material conditions reflect commitment to excellence (IAEA safety standard Guide, No. GS-G-3.1 2006, p. 10).

**Safety is learning driven.** The following attributes indicate this element of safety culture is present. A questioning attitude prevails at all organizational levels. Internal and external assessments, including self-assessments are used. Organizational and operating experience (both internal and external to the facility) is employed. Learning is enabled through the ability to recognize and diagnose deviations, formulate and implement solutions and monitor the effects of corrective actions. Safety performance
indicators are tracked, trended, evaluated and acted upon. There is a systematic development of staff competencies (IAEA safety standard Guide, No. GS-G-3.1 2006, p. 10).

According to the IAEA conception, safety culture is further divided into two components. The first is the essential organisational framework and is the responsibility of the management hierarchy. The second is the approach of staff members at all levels to the organisational framework. The concept of safety culture also depends upon a definition of commitment to safety by everyone involved (Haage, n.d.). Table 2.5 below displays the components of this definition.

**Table 2.5 Components of safety culture.**

<table>
<thead>
<tr>
<th>Safety Culture Defined as Commitment of People</th>
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<tbody>
<tr>
<td><strong>Policy level commitment</strong></td>
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<tr>
<td>Statement of safety policy</td>
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<tr>
<td>Management structures</td>
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<tr>
<td>Resources</td>
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<tr>
<td>Self-regulation</td>
</tr>
<tr>
<td><strong>Managers’ commitment</strong></td>
</tr>
<tr>
<td>Definition of responsibilities</td>
</tr>
<tr>
<td>Definition of control and safety practices</td>
</tr>
<tr>
<td>Qualifications and training</td>
</tr>
<tr>
<td>Rewards and sanctions</td>
</tr>
<tr>
<td>Audit, review and comparison</td>
</tr>
<tr>
<td><strong>Individuals’ commitment</strong></td>
</tr>
<tr>
<td>Questioning attitude</td>
</tr>
<tr>
<td>Rigorous and prudent approach</td>
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<tr>
<td>Communication</td>
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</tbody>
</table>

The use of questionnaires in safety culture research

Measurement issues and IAEA’s model

Wahlström (2009) argues that a number of dangers exist in attempting to measure safety culture based on particular attributes. The first difficulty encountered is developing a measuring instrument that has the attributes of reliability and validity. In the behavioural sciences it is necessary that measuring instruments possess reliability and validity. To be reliable different individuals executing a measurement should obtain the same results. To be valid the measuring tool must actually measure what it is supposed to measure. Reliability places conditions on objectivity that might be difficult to attain when measuring safety culture. At the same time, validity necessitates a shared agreement on the definition of safety culture.

Another danger considered by Wahlström (2009) is complacency based on success validated by accumulated assessments and measurements. This reliance on instrument scores removes the focus from open ended reflections on safety. It is dangerous if attention to potential safety threats diminishes over time. For safely operating organisations the main challenge to preserving optimal safety appears to be how to sustain vigilance. In this regard, organisation members must be conscious of and plan for the possibility of unexpected hazards. It has been proposed that the development of issues in complex interconnected systems relies more on the unexpected than on known drivers.

As well as the questions discussed above, Wahlström (2009) considers other methodological problems, noting that if interviews are used as the primary method of gathering data, the selection of interviewees is significant since the number of participants normally must be limited. Moreover, random assignment is not practical
since managers probably would be underrepresented in the sample in comparison with the effect they are believed to have on safety culture.

Another problem is how to count outliers because in any organisation there are individuals that have attitudes that are not typical of the entire organisation. A related question is whether the interview samples are derived from distinct populations in the organisation and which types of distributions are expected within these populations? Thus, it is apparent that any combination of the data gathered to characterise the entire organisation might be ambiguous.

Another issue is related to the honesty of individuals who answer a questionnaire related to their own self-interest. This problem arises with regulatory evaluation of safety culture. Assessment of safety culture is usually accomplished using questionnaires and interviews that cannot offer an accurate picture of the organisation if the participants intentionally attempt to give “correct” responses to questions. Thus, the risk that a plant will be closed due to poor performance might result in conscious dishonesty and misunderstanding, nullifying the assessment of safety culture.

Regarding the IAEA model, Wahlström (2009) concludes the IAEA definition of safety culture based on various attributes and characteristics has received widespread recognition. But he cautions that if it becomes a norm, it should be defended from literalist interpretations that might suppress further examination of the content and meaning of safety culture. In addition, he argues that it is better not to provide excessively comprehensive definitions of attributes and characteristics so that the concept of safety culture is more easily modified to fit local languages and practices, which is critical for the development of an understanding of essential
conditions for safety. According to Wahlström (2009), this suggests that safety culture should be reflected on in a more open-ended manner.

Due to these kinds of concerns, this researcher aims to improve the psychometric properties of the IAEA safety culture survey to produce a psychometrically sound/reliable instrument to meet the increasing demand for safety culture assessment. In particular an open-ended question was added to allow employees to express their safety concerns in an effort to obtain a holistic view of the factors that affect safety (i.e. there might be factors that are not covered in the instrument). Determining whether the instrument measures safety culture in an Australian HRO facility will contribute to the assessment of the validity and reliability of the instrument. It will also contribute to knowledge regarding the current safety culture in this type of organisation.

2.3.1 Current practices

Frequently, safety culture is measured by interviews and observations. However, three primary attributes of safety culture - behavioural, psychological, and situational - can be measured in other ways (Cooper, 2002). The situational attributes of safety culture can be found in the structure of the organisation, such as policies, processes, management structures, and more. The behavioural attributes can be assessed by means of peer comments, self-reports and measures of results. Acknowledged safety behaviours can be entered on observational checklists, and trained observers can note relevant behaviours of employees which can then be converted into a percentage of safety scores to supply feedback to the employees that were observed. On the other hand, the psychological aspect is most frequently
assessed by safety climate questionnaires designed to measure individuals’ perceptions of safety (Choudhrya, Fanga & Mohamed, 2007).

A number of safety climate/culture questionnaires have been created, but their usefulness relies on their psychometric quality (Flin, Burns, Mearns, Yule, & Robertson, 2006) and the ability to replicate their measurements (Netemeyer, Bearden & Sharma, 2003). The fundamental concept of psychometrics is the gathering and understanding of facts regarding social and psychological phenomena by quantifying them. To accomplish this measurement instruments must have the qualities of validity, reliability, and sensitivity (Hale, 2009). Surveys are the most prevalent measurement tool used in the psychometric method and factors employed are usually part of a wider theoretical structure (Olsen, 2009). Whilst psychometrics is frequently utilised in safety climate research, research on safety culture also uses a diversity of alternative approaches and methods (Guldenmund, 2000; IAEA, 2002).

To develop, confirm, correct, compare, and model theory and measurement it is necessary to establish the validity of these instruments. Over the years substantial work has contributed to the development of valid and reliable safety culture questionnaires that measure organisational culture at the climate level, a section of the organisation believed to provide a snapshot of the safety culture (Guldenmund, 2007). Questionnaires have been the primary measurement instrument in safety culture research (Collins & Gadd, 2002). However, safety culture/climate questionnaires merely provide a hint of what a particular safety culture might consist of. The challenge is to create a survey that collects sufficient relevant and valid data to determine if and where any remedial measures or actions are needed (Guldenmund, 2007).
Questionnaire surveys frequently consist of a sequence of thematic questions that seek individuals’ assessments of numerous features believed to be related to safety climate/culture (Mearns, Whitaker & Flin, 2003; Guldenmund, 2007). Following survey completion, the researchers process the data, which can consist of the development of two or more scales by means of Principal Components Analysis (PCA) or obtaining the scores of the organisation on scales that have already been validated in prior research. A third kind of safety culture questionnaire could be validating whereby the researchers attempt to confirm the scales found in previous studies. All three kinds of research have resulted in a wide variety of scales (Flin, Mearns, O’Connor & Bryden 2000; Guldenmund, 2007). An ultimate effort of such study also may be to find a correlation between one or more scales and some criterion variable, such as rates of accidents or safety performance.

According to Guldenmund (2007), whilst safety culture researchers aim to expose an underlying trait termed culture, the climate questionnaires ask respondents to express aspirations, rationalisations, attitudes or cognitions, labelled espoused values by Schein (1992). Clearly, it could be argued that true shared values underlie these espoused values, but to comprehend these is difficult. Even if they provide an indication of the safety culture they do not explain why it exists in the indicated form (Guldenmund, 2007).

Research using safety climate questionnaires has had two general outcomes, according to Guldenmund (2007). First, analyses have found several distinct variables that are difficult to replicate. Secondly, the majority of the analyses yield one or more higher management related or organisational variables that explain most of the variance in the data.
Nevertheless, in addition to work-related procedures, values are influential at all levels of the organisation. In this regard, the IAEA stresses the importance of safety as a value being present throughout the entire organisation in their SCART-guidelines (IAEA, 2005). Though values about safety appear to be vital they have not been effectively assessed with self-administered questionnaires thus far (Guldenmund, 2007).

**Safety culture constructs**

Two meta-analyses of safety culture examined a large number of safety culture questionnaires, identifying shared constructs they measured (Flin et al., 2000; Guldenmund, 2000). An ubiquitous construct that appeared in each survey examined was the awareness of management/supervisors’ attitudes and behaviours regarding safety (Flin et al., 2000). This perception included managers’ concern for safety of employees, caring for employees, and implementing safety policies and rules in their respective industry. According to Dollard and Bakker (2010), affirmative safety culture values can spread throughout an organisation if senior management directs safety strategies by communicating and demonstrating the significance of safety. Branham (2010) indicated that management and supervisors must devote more time on the ground with workers.

In several safety culture questionnaires, it is not apparent whether workers were responding to senior executives or their immediate superiors when responding to survey items regarding management (Flin et al., 2000). To address this kind of issue, the present survey used the term *Direct Supervisor*. An additional concern that was measured by a number of surveys was whether production goals were favored over safety or viewed as mutually important. Safety culture requires that safety be at least as important as production goals (Reason, 1998; IAEA, 2009; Guldenmund; 2010).
Work pressure and over load can result in unsafe practices. In this regard, personal responsibility for safety and risk taking were also constructs that appeared in safety culture surveys. However, peer support for safety did not seem to be a construct of the surveys reviewed (Frazier, 2011).

Another construct that appeared in the surveys was safety systems (Flin et al., 2000). Safety systems comprised the procedures organisational management employed to enforce safety. These procedures consisted of activities as creating safety officials, instituting safety committees, implementing policies, or designing preventative plans. In spite of the pervasiveness of the safety systems construct in the surveys reviewed, the construct was not well-defined (Flin et al., 2000; Guldnemund, 2000). The constituents of safety systems have not been consistently measured either (Fernández-Muñiz, Montes-Peón, & Vázquez-Ordás, 2007). A more refined concept of safety management systems (SMS) was subsequently proposed. While Flin et al. (2000) asserted that SMS might not be essential for evaluating safety culture, other researchers have shown SMS scales can advance the measurement of a general safety culture if the system is organised and defined precisely (Bottani, Monica, & Vignali, 2009; Cooper & Phillips, 2004). Fernández-Muñiz et al. (2007) have broadened this construct recently, proposing an effective system should include six significant elements: safety policy, incentives for employee participation, training, communication, planning, and control. They added the distinct factor of employee involvement as well.

According to Dennis Ryan (2009), President of Compass Health & Safety, Ltd., obtaining feedback from employees is necessary to improve organisational safety culture. In this regard, the most cost effective method of obtaining information from all members of the organisation is to conduct some type of survey or
questionnaire. Survey responses, in combination with action, have been shown to alter organisational dynamics. Nevertheless, according to Beer (1980), the information obtained from questionnaires is not sufficient. It is necessary to intervene on the basis of survey responses, but the intervention must be relevant, involve commitment, and real feedback for successful improvement of safety.

**The use of safety culture questionnaires in the HRO organisation**

According to the IAEA model safety culture might be characterised by numerous attributes and measured using a variety of methods (Corcoran, 2010). Usually, researchers have used questionnaires and surveys to measure the characteristics of leaders; the attitudes, beliefs, values, and behaviours of staff and managers; and perceptions of risk, stress, and decision-making, which all impact employee performance and the safety culture (Reiman, 2007; Corcoran, 2010). Classic survey research in a nuclear organization was conducted at the Sellafield Nuclear Power Station, which had experienced disastrous contamination in the past (Lee, 1997, 1998). Ostrom, Wilhelmsen and Kaplan (1993) also created a mixed questionnaire/interview method that encompassed 13 groups of safety norms intended for use in US nuclear plants (Lee & Harrison, 2000).

As discussed previously, The Nuclear Energy Institute (NEI) sponsored a study led by the Institute for Nuclear Power Operations (INPO) to measure safety culture by means of a survey of employees at nuclear power plants throughout the United States (US) (Morrow & Barnes, 2012). The main purpose of the research was to examine the factors that encompass safety culture in the atomic energy industry, evaluate the degree to which they are similar to the characteristics recognized in the NRC’s Safety Culture Policy Statement, and assess the relationships among the safety
culture factors identified from the survey and other assessments of organisational and safety performance. Morrow and Barnes (2012) discussed the construct validity of the survey used in this research. The term “construct” was employed in the traditional manner to designate a theoretical idea, such as safety culture, intelligence, or personality. Construct validity was used to designate the degree to which the survey instrument measuring the construct appeared to measure what it was meant to measure. Construct validity was established by evaluating whether the survey possessed:

- content validity, i.e. covered the extent of the construct (safety culture) under examination;
- reliability, i.e. measured the construct consistently; and
- criterion-related validity, i.e. had a relationship with results it should have in theory.

The factor analysis of the INPO survey demonstrated reasonable correspondence between most of the questionnaire factors and the traits in the policy statement. Moreover, the INPO safety culture survey factors were significantly correlated with a few signs of safety performance at the time and a few a year following the administration of the survey. Morrow and Barnes (2012) concluded that INPO’s safety culture survey had rigorous psychometric properties, reliability and validity, and a factor structure that was reinforced by other safety culture studies. There was also strong support for construct validity of the instrument. Nevertheless, the authors caution that the findings should be understood within the setting of the research that examined data from a cross-sectional survey administered to employees at a single point in time. This case does not support conclusions about the causal relationship between safety culture and safety outcomes. They note that further
longitudinal and experimental studies are needed to establish sufficient evidence of a causal relationship between safety culture and safety performance in a nuclear power organisation.

2.4 Research domains

Research problem

There is insufficient research designing and measuring safety culture models across sectors. For example, a persistent research question concerns the possibility of measuring safety culture factors in HRO organisations. Flin (2007) has noted the possibility of a common safety climate model across other sectors, but there is a lack of research regarding this possibility. Empirical support for the IAEA model would improve knowledge about safety and contribute to the prevention of disasters. In this regard, the research problem of this study consists of determining the validity of the five IAEA characteristics associated with safety culture in an Australian HRO. A version of the IAEA survey questionnaire that has been modified with permission from the IAEA will be used to establish the construct validity of the five characteristics.

Research question

This research aims to answer the following research question:

What are the determinants of an effective safety culture in a HRO organisation?

Research Aim

The main aim of this study is to empirically validate the IAEA safety culture model.
**Research objectives**

The research objective is to assess IAEA’s five characteristics and 37 attributes of safety culture in a HRO organisation in Australia. See Appendix 4.1 for a detailed description of the characteristics along with the 37 attributes of safety culture.

**Research hypotheses**

This study is predominantly quantitative study in which the researcher seeks to identify the extent to which IAEA’s five characteristics are associated with the perception of a well-managed safety culture in a HRO organisation in Australia.

As a result following hypotheses were formulated based on the five characteristics that constituted the theoretical framework of the IAEA’s model:

**H**₁: there is a positive relationship between the variable *safety is a clearly recognised value* and the ‘perception of the organisation's overall safety culture’.

**H**₂: there is a positive relationship between the variable *leadership for safety is clear* and the ‘perception of the organisation's overall safety culture’.

**H**₃: there is a positive relationship between the variable *accountability for safety is clear* and the ‘perception of the organisation's overall safety culture’.

**H**₄: there is a positive relationship between the variable *safety is integrated into all activities* and the ‘perception of the organisation's overall safety culture’.

**H**₅: there is a positive relationship between the variable *safety is learning driven* and the ‘perception of the organisation's overall safety culture’.
It is important to understand that the hypotheses in this study are derived from IAEA’s model and not derived directly from the literature. The IAEA informed the researcher that additional feedback was gleaned from member states based on their field experience.

**Figure 2.5 Theoretical framework with hypotheses explicitly identified.**

Source: Articulated for this research.
The theoretical framework illustrated in Figure 2.5 is developed to be able to assess the IAEA’s model. Each independent variable within the Figure 2.5 denotes a cluster of dimensions rather than a single concept. For example, the variable ‘value’ may be looked on as representing a set of concepts including: Safety is given high priority as demonstrated in documentation, communications and decision-making. Safety is a primary consideration in the allocation of resources. The strategic business importance of safety is reflected in the business plan. Organisation members believe that safety and production are allied (IAEA safety standard Guide, No.GS-G-3.1 2006, p. 9).

This theoretical framework is graphical representation of relationships between the independent variables which are also believed to be measurable variables (value, leadership, accountability, integrated and learning) employed to operationalize the abstract concept (workplace safety culture). According to Manning and Munro, (2007, p.1) ‘abstract concept (or construct) is often something which we all agree exists but is not necessarily something we are able to directly measure’. Each latent construct in this theoretical framework is operationalized by a survey questionnaire items which records workers perception of work place safety culture. The arrows in the figure represent positive relationships between variables. In other words, Figure 2.5 represents an explicit representation of the hypotheses of the current study.

2.5. Conclusion

This study purports to assess specific characteristics of an organisation’s safety culture in a high reliability organisation (HRO). I/O may be considered the theoretical basis for this study. Related theories examined included high reliability
organisation (HRO) theory, Normal Accident Theory (NAT), general causes of human errors, incubation periods, sense-making failure, and the culture of normalised deviance. Even though HRO theorists acknowledge that errors in high-risk operations are inevitable to some extent, they focus on the thesis that optimal organisational design can permit members to identify and avoid errors that would produce disastrous outcomes. However, Leveson et al. (2009) assume an engineering design approach asserting that NAT and HRO theory is flawed due to incongruous comparisons between properties and imprecise definitions. They maintain that safety is a system property, not a component property. Moreover, methods of meeting safety requirements probably differ according to type of organization and mission. In contrast, organisational culture can influence and affect organizational systems, outcomes, employee behaviour and the safety culture.

In spite of these issues, the literature indicates a correlation between safety culture and safety behaviour as measured by accident and injury rates. However, only a small percentage of research has used prospective research designs to test for associations between safety culture and safety performance. Safety culture needs to be clearly defined and measured prior to testing for a relationship between safety culture and safety performance.

The next chapter discusses the methodology used in the conduct of the research. Sufficient information will be provided to allow an independent investigator to replicate the study.
CHAPTER 3

METHODOLOGY
CHAPTER 3: METHODOLOGY

...the validity of scientific claims is always relative to the paradigm within which they are judged; they are never simply a reflection of some independent domain of reality (Hammersley & Atkinson, 1994, p. 12).

3.1 Introduction

The previous Chapter “Two” presented a review of the literature pertinent to the topic under study, Safety Culture and High Reliability Organisations (HROs). The review started with the background and rationale for the study. A discussion of theory followed. The application of IAEA’s safety culture model was then examined. The remaining sections presented research domain, research questions, the research hypotheses and a conclusion. Chapter “Three”, the methodology chapter attempts to present and rationalise the steps to be undertaken in the conduct of the research and furnishes enough pertinent information to permit an independent investigator replicate the study. The concept map that follows (see Figure 3.1) represents the topics covered in Chapter Three.
Figure 3.1 Concept map of Chapter 3

Concept Map

3.1 Introductions

3.2 Research Paradigms

Positivism  Phenomenology  Constructivism  Critical Theory  Realism

3.3 Different Research Paradigms

3.4 Methodology

Exploratory research  Descriptive research  Causal research

3.5 Choice of Methodology

Rationale  Mixed methodology  Survey questionnaire

3.6 Protocols

Unit of Analysis  Questionnaire design  Survey instrument  Instrument modification  The purpose of using IAEA survey

Collection: Data collecting method

Sampling strategy  Target population

Data analysis

3.7 Research hypotheses

Quantitative data analysis  Descriptive analyses

3.8 Qualitative data analysis

3.9 Ethical issues

3.10 Conclusion

Source: developed for this thesis
3.2 Research paradigms

*If we knew what it was we were doing, it would not be called research, would it?*  
*Albert Einstein.*

Salkind (2000) indicates that new knowledge is discovered through a practice called research. Cooper and Emory (1995) imply that social science research is a systematic scientific investigation designed to provide knowledge and or identify and define problem(s).

Business research is perceived by some researchers and practitioners as a management tool (Ticehurst & Veal, 2000). Business research is undertaken to minimise ambiguity through the collection of data about organisational and environmental phenomena (Zikmund, 2000). Additionally, business research is also conducted to name problems and/or opportunities, to identify causal factors, to examine existing models and courses of action, to comprehend what went wrong in the past, to predict future settings and to propose some advisable changes (Ticehurst & Veal 2000; Zikmund, 2000).

Zikmund (2000) and Sekaran (2000) also mention that there are two broad types of research, basic (pure) and applied research, and they are distinguished from each other by their different aims and purposes. Basic research is the research used to explore and increase our understanding of the relationship between theoretical variables and constructs (Zikmund, 2000; Sekaran, 2000). According to Johnson and Christensen (2010) basic research can be abstract or theoretical. Sekaran, (2000) and Paul and Paul, (2001) indicate that the main motivation of basic research is about learning more and might have little apparent and immediate application or obvious commercial value. Unlike basic research, Zikmund (2000) believes that, applied
research aims to resolve practical, real-world concerns; related to social or organisational actions, performance and policy needs.

Hair, Celsi, Money, Samouel and Page (2011) points out that applied business research is conducted to find answers to questions because they can be immediately applied in a workplace context. With this in mind when making a distinction between basic compared to applied research, it is equally important to understand that, researchers often involve themselves in both types of research whereby basic research provides the tools and raw materials for applied research (Bickman & Rog 1998; Quinn, 1990; Zikmund, 2000; Sekaran, 2003). The present study is consistent with this line of thought.

3.3 Different research paradigms

In attempting to design this study it was deemed useful to develop a broad appreciation of the different philosophical viewpoints and methodologies in the circles of social science research. In social science, researchers employ a wide range of methods to analyse social phenomena. Ultimately, the choice of which method to employ is closely related to the paradigm the researcher adopts from the outset.

According to Hairston (1982) Thomas Kuhn was of the view that a paradigm was akin to a mental model of the world, but one that is capable of change as a new zeitgeist (spirit of the time) evolves. In adopting a particular mental model the researcher needs to choose from amongst the differing research paradigms one which best embodies their ontological and epistemological assumptions about the nature of reality and the relationship between the researcher and their informants. Having positioned oneself as researcher vis-a-vis these considerations the choice of methodology is made relatively simple. Accordingly, what follows is a brief overview
of the different philosophical viewpoints and methodologies in social science research.

Each research method has a philosophical foundation as to how social reality is conceptualised (ontology); what contribution to knowledge is expected (epistemology); and what method, procedures and materials the researcher is using (methodology) (Easterby, Thorpe & Lowe, 2002). Each method has its given advantages and disadvantages. For the purpose of this current study, a brief overview of alternative research methods and their respective merits is presented before selecting the one considered most appropriate for this research:

**Positivism**

Positivist social science adopts a quantitative methodology as described by some researchers (Denzin & Lincoln, 2000) is one of four major approaches to social research. Broadly defined, it is as similar to the approach adopted by of the physical science in its search for cause-and-effect relationships and universal laws. It follows that positivists generally attempt to employ the same research principles and procedures as those used in the physical sciences. Positivists believe that there is an objective reality that can be observed and measured. Positivists in opting for an objective and detached view of the world emphasise the notion that all research should be ‘value-free’ (Easterby, Thorpe & Lowe 2002, p. 22; Neuman, 2011). Primarily, since this research is about empirically testing an established model with a view to confirming a relationship between a set of variables, positivism is considered to be suitable for this research. Table 3.1 summarises main strengths and weaknesses of quantitative research.
Table 3.1 Strengths and weaknesses of quantitative research

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
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<tbody>
<tr>
<td>Testing and validating already constructed theories about how and why phenomena occur</td>
<td>The researcher’s categories that are used might not reflect local constituencies’ understandings</td>
</tr>
<tr>
<td>Testing hypotheses that are constructed before the data are collected</td>
<td>The researcher’s theories that are used might not reflect local constituencies’ understandings</td>
</tr>
<tr>
<td>Can generalize research findings when the data are based on random samples of sufficient size</td>
<td>The researcher might miss out on phenomena occurring because of the focus on theory or hypothesis testing rather than on theory or hypothesis generation (called the confirmation bias)</td>
</tr>
<tr>
<td>Can generalize a research finding when it has been replicated on many different populations and subpopulations</td>
<td>Knowledge produced might be too abstract and general for direct application to specific local situations, contexts, and individuals</td>
</tr>
<tr>
<td>Useful for obtaining data that allow quantitative predictions to be made</td>
<td></td>
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<tr>
<td>The researcher may construct a situation that eliminates the confounding influence of many variables, allowing one to more credibly establish cause-and-effect relationships</td>
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<tr>
<td>Data collection using some quantitative methods is relatively quick (e.g., telephone interviews)</td>
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<tr>
<td>Provides precise, quantitative, numerical data</td>
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<tr>
<td>Data analysis is relatively less time consuming (using statistical software)</td>
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<tr>
<td>The research results are relatively independent of the researcher (e.g., statistical significance)</td>
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<tr>
<td>It may have higher credibility with many people in power (e.g., administrators, politicians, people who fund programs)</td>
<td></td>
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<tr>
<td>It is useful for studying large numbers of people</td>
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Source: [http://www.southalabama.edu/coe/bset/johnson/oh_master/Ch14/Tab14-01.pdf](http://www.southalabama.edu/coe/bset/johnson/oh_master/Ch14/Tab14-01.pdf)
**Phenomenology**

There is another view which rejects positivism and instead argues that reality is socially constructed, not objectively determined, and arises out of social interaction (Berger & Luckman 1967). This philosophical position has come to be known as social constructionism or phenomenology (Easterby, Thorpe & Lowe 2002).

Phenomenology attempts to capture peoples’ subjective reality (Crotty, 1998) and provides a hermeneutic approach with an in-depth enquiry of the issue, to relate its parts to the whole to reveal deeper meanings (Neuman, 2011). It also argues that human experience is unique and can only be understood as a subjective reality by “putting oneself in the place of the other”. Research of this kind is categorised as exploratory in nature and involves collecting, analysing and interpreting data on subjective knowledge of social phenomena (Gitterman & Germain, 2008; Crotty, 1998).

Easterby, Thorpe and Lowe (2002, p. 22) quote Morgan and Smircich who recognise six different ontological views about the make-up of reality (see Figure 3.2 below).
Figure 3.2 Different assumptions about nature of reality.

Subjectivist

- Projection of human imagination
- Social construction
- Symbolic discourse
- Contextual field of information
- Concrete process
- Concrete structure

Objectivist


This subjective-objective continuum shown in Figure 3.2 produces four scientific paradigms namely: positivism, realism, critical theory and constructivism. As noted above a paradigm can be looked upon as the organising framework for the research that encompass techniques, models, values, beliefs, and basic assumptions. These factors combine to guide the investigator in their search for answers (Neuman, 2011). Table 3.2 presents an overview of quantitative and qualitative research methods.

Table 3.2 Overview of qualitative and quantitative research paradigms.

<table>
<thead>
<tr>
<th>Quantitative Research</th>
<th>Qualitative Research</th>
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<tbody>
<tr>
<td>Test hypothesis that the researcher begins with.</td>
<td>Capture and discover meaning once the researcher becomes immersed in the data</td>
</tr>
<tr>
<td>Concepts are in the form of distinct variables.</td>
<td>Concepts are in the form of themes, motifs, generalisations, and taxonomies.</td>
</tr>
<tr>
<td>Measures are systematically created before data collection and are standardised.</td>
<td>Measures are created in an ad hoc manner and are often specific to the individual setting or researcher.</td>
</tr>
</tbody>
</table>
Data are in the form of numbers from precise measurement. | Data are in the form of words and images from documents, observations, and transcripts.
---|---
Theory is largely causal and is deductive | Theory can be causal or non-causal and is often inductive.
Procedures are standard, and replication is frequent. | Research procedures are particular, and replication is very rare.
Analysis proceeds by using statistics, tables, or charts and discussing how what they show relates to hypotheses. | Analysis proceeds by extracting themes or generalisations from evidence and organising data to present a coherent, consistent picture.


**Constructivism**

The major alternatives to positivism in the social sciences are constructivism and critical theory (Sobh & Perry, 2006). Constructivists assume ‘truth is a particular belief system held in a particular context, and they are interested in the values which underpin the findings’ (Healy & Perry, 2000, p. 120). In the other words, constructivists’ approach to research is about a relativist’s ontology, a subjectivist’s epistemology and a naturalist’s methodological procedures (Denzin & Lincoln, 2000). This method is inclined to question the existence of a single external reality. This research at accepts that the aggregated perceptions by employees of their organisation's safety culture can be seen as a form of objective reality.

**Critical theory**

Critical theory is dialectical, lies within the constructive paradigm (subjective) and attempts to bring about change through a process of empowerment and helps people take action and be committed to social change (Neuman 2011). Critical theory ‘may be the most appropriate paradigm when the study is attempting to intervene in
the transformation of the respondents from their mental, emotional and social structure’ (Christie, Perry & Chamard, 2000, p. 6). However, this present study does not seek to influence the consciousness of participants but rather to identify the extent to which they draw on the IAEA’s five characteristics when determining the safety culture in an HRO organisation in Australia. Accordingly, the critical theory paradigm is not considered to be a suitable for this research.

Realism

Realism is a paradigm that takes a particular ontological stance in the sense that social reality is seen to exist independently of the researcher's mind but that it also exists independently of the subjects who are being researched. Thus, there is an external reality but according to some, (Bhaskar, 1978; Harre & Madden, 1975), it exists independently of any one person. According to this position realism is closely aligned with the physical sciences and accordingly there is a search for the absolute truth. Inevitably, there is some doubt about the veracity of the findings of a piece of social science research and this is brought about by the fact each person’s perspective in the research arena regarding the nature of that external reality is blurred by the differing values, beliefs and attitudes they bring to that situation (Magee, 1985).

Because of this, those who opt to work within the realism paradigm are cautioned to consider whether the results they report are free from the effects of extraneous influences. This last point is particularly pertinent for this study which sets out to validate variables put forward by a community of scholars who have sought to identify the determinants of workplace safety culture. The use of hypothetico-deductive approaches by social researchers are in line with the physical sciences. Here the intent is to empirically test hypotheses with a view to confirming cause-effect
relations concerning effective safety culture and ultimately effective safety performance. As we shall see this is a formidable task but one feels that the realist paradigm attempting as it does to render visible important organisational variables has a good deal to offer.

Consequently, this research attempts to capture the lived experiences of the participants in a HRO organisation. In so doing, it acknowledges that reality is as much constructed in writing and in spoken words as it is ‘out there’ (Rice & Ezzy 1999, p.22). The various paradigms discussed above are summarised in Table 3.3 that follows.
Table 3.3 Comparative overview of the four major paradigms evaluated for this research.

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<tbody>
<tr>
<td>Assumption (Ontology)</td>
<td>Social facts have an objective reality independent of the researcher</td>
<td>Reality is socially constructed and arises out of social interaction</td>
<td>Reality is socially constructed in such a way as to constrain human action</td>
<td>Reality is real but only imperfectly and probabilistically so</td>
</tr>
<tr>
<td>Purpose (Epistemology)</td>
<td>Objective findings - value free</td>
<td>Subjective findings</td>
<td>Interactive/value mediated findings</td>
<td>Modified/objective findings which are probably true</td>
</tr>
<tr>
<td>Methodology</td>
<td>Predominantly quantitative such as verification of hypotheses, experiments and surveys</td>
<td>In-depth interview, participant observation and grounded theory research</td>
<td>Action research, focus groups and participant observation</td>
<td>Predominantly qualitative methods such as action research, convergent interview, and case study research</td>
</tr>
<tr>
<td>Research Inquiry Direction</td>
<td>Measurement and analysis of cause-and-effect relationship of variables generalisable across context and time</td>
<td>Reconstruction, revision of belief, interpreting multiple realities constructed through pattern matching</td>
<td>Contradictions leading to change revealed through the critique of contextual or historical insights</td>
<td>Development of knowledge about reality which is otherwise difficult to apprehend</td>
</tr>
<tr>
<td>Researcher’s Role</td>
<td>Objective and remote</td>
<td>Up close and personal</td>
<td>Empathetic understanding</td>
<td>Neither independent nor involved</td>
</tr>
<tr>
<td>Respondent’s Role</td>
<td>Respondent is remote from the data</td>
<td>Respondent is close to the data</td>
<td>Respondent is close to the data</td>
<td>Respondent is part of the research process</td>
</tr>
<tr>
<td>Data Collection</td>
<td>Reduction/aggregation of data to numbers</td>
<td>Capture lived experience of informants</td>
<td>Data gathered to support argument for change</td>
<td>Triangulate multi-source data to express an identified process/discovery oriented</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>Falsify null hypothesis with statistical tests</td>
<td>Identify recurring themes and patterns in the search for meaning</td>
<td>Present recommendations to empower members of oppressed groups</td>
<td>Information rich, contextual, and non-statistical</td>
</tr>
<tr>
<td>Quality Assurance</td>
<td>Rigor, reliability, internal and external validity</td>
<td>Authenticity, trustworthiness</td>
<td>Theoretical consistence, historical insights</td>
<td>Credibility, confirmability, transferability and construct validity</td>
</tr>
<tr>
<td>Generalisation</td>
<td>Limited ability to generalise</td>
<td>Limited ability to generalise</td>
<td>Only tentative explanations for one time and place are possible</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Neuman (2011, p119).
3.4 Methodology

Business research studies can be classified as exploratory research, descriptive research or causal research (Churchill, 2010). Each is discussed briefly below.

Exploratory research

Exploratory research usually occurs in the initial stage of research to gain familiarity with a phenomenon. Zikmund (2003) describes exploratory research as early research piloted to draw a picture and define the nature of a problem before further research is undertaken.

Exploratory research as its name suggests is undertaken to explore a phenomena when not much is known about the issue or little information is available on how similar problems or research issues have been resolved in the past. For example, qualitative researches where data is assembled by means of interviews, experiences surveys, focus groups or observations are exploratory in nature (Sekaran, 2003). Thus, exploratory studies are useful to better understand the nature of a problem that earlier studies have not addressed.

As a result researcher will formulate a more precise problem or develop hypotheses that are subsequently tested. Furthermore, exploratory studies are also useful when some information is available, but more facts are needed before developing a viable theoretical framework (Sekaran, 2003).

Descriptive research

Descriptive research as the name implies is conducted to ascertain and define the characteristics of the variables of interest in a research context. The aim of a descriptive study is to describe certain features of the phenomena of interest from the
perspective of an individual, organisational, industry-oriented or some other unit of analysis (Sekaran, 2003). In other words: descriptive research seeks answers to questions like who, what, when, where and how (Zikmund, 2003). This research design is often used to estimate what proportions of a population share characteristics of interest and to learn more about the relationships among the variables under observation (Cooper & Emory, 1995).

The most frequently used research technique for descriptive research is a survey questionnaire (Davis, 2004). Wong (1999) outlines the importance of a large, representative sample that can only be achieved with the adoption of strict sampling procedures to minimise systematic errors and to maximise data reliability.

In summary, descriptive studies help to (1) comprehend the characteristics of a group in a given situation, (2) ponder systematically about some features in a given case, (3) propose thoughts for further investigation and analysis and (4) make certain decisions (Sekaran, 2003).

**Causal research**

Causal research is undertaken to identify cause-and-effect relationships among variables where the research problem has already been narrowly defined (Zikmund, 2003). When a positive relationship has been established between two variables, an increase in one leads to the prediction of an increase in the other. The present research plans to adopt a formative approach to the identification of the structural relationships between a latent construct and its hypothesised indicators. In this research the latent construct is the aggregated perceptions of a group of employees regarding their workplace safety culture and as such it represents the dependent measure. The independent variables were hypothesised by the IAEA to have a structural relationship
with the latent construct (workplace safety culture). They were seen as contributing to an effective workplace safety culture. Here causality flows from the independent variables (or a set of composite variables which act as indicators) to the latent construct which is usually not observable. In this formative approach, however, the indicators define the construct. The indicators were derived from the composite variables thought to determine an effective workplace safety culture and were formed by mapping the particular items from the questionnaire to the five conceptual characteristics and their attributes. Thus each composite variable was based on conceptually similar items drawn from the survey questionnaire.

The exclusion of one or more items from the composite variable does not materially impact on the content validity of the latent construct. This means we do not need to use all of the indicators as contained within the IAEA model as long as each of the composite variables conceptually represents an independent variable of interest and be capable of predicting shifts in the dependent measure.

To sum up, in this research the formative approach adopts the view that causality flows from the indicators to the latent construct. (Coltman, Devinney, Midgley & Venaik, 2008).
3.5 Choice of methodology

Rationale

Hacker in Gálvez (2009) believes that the research question itself influences the selection of a research methodology. The majority of safety culture research has been conducted from a positivistic approach. This tendency is driven by two factors: First it reflects a desire, by regulatory bodies for numerically supported metrics and, second, by a perceived need for objective findings (Ferroff, Mavin & Murraya, 2012). The purpose of this research is deductive in nature, since it was undertaken to:

- subject IAEA’s safety culture model to empirical scrutiny and
- test hypotheses, which have been implicitly formulated for this current research. As Neuman (2011) indicated that variables and their relationships are central to the idea of quantitative research.

While it is accepted that the findings from this single case study cannot be readily generalised beyond its present context, nevertheless it may be of interest to similar high reliability organisations.

Mixed methodology

In the last 25 years there has been a steady growth in mixed methods research. According to Cresswell, Shope, Plano, Clark and Green (2006) mixed methods research is both a methodology and a method since it involves mixing both qualitative and quantitative approaches in a single study. In some circles this has come to be regarded as the emergence of a new paradigm (Cameron & Miller, 2007) to take its place alongside quantitative and qualitative research as a natural complement. One of the many consequences of this shift has been a diffusion of the traditional quantitative-qualitative debate and that in itself has proven to be a useful outcome.
In the opinion of the writer, mixed methods research is conceptually similar to that of methodological triangulation (Neuman 2011) wherein there is a blending of qualitative and quantitative methods. According to Denzin (1978, p. 291) triangulation refers to “the combination of methodologies in the study of the same phenomenon.” Twenty years ago Greene, Caracelli and Graham (1989) claimed that triangulation is one of five empirically derived general purposes of mixed methods research. Basically, it is a technique that seeks convergence, and collaboration of findings using different methods.

The term triangulation has its origins in navigation history where mariners would triangulate their position by taking compass readings from multiple perspectives. The point where they converged determined the position of the vessel at sea. It is the notion of multiple perspectives being used to arrive at a converged point that has been adopted by mixed methods researchers. The more closely you look at something from different angles the more likely it is that what you see will be both valid and reliable.

Blending these seemingly disparate methodologies can take place in a number of ways. For example, the two methods may be employed simultaneously wherein we might attempt to gauge the effectiveness of an organizational leader by initially, observing his or her behaviour in the workplace, conducting an in-depth interview with the leader and at the same time consulting with recent performance records concerning that leader’s behaviour. To the extent that the multiple and independent measures allow the researcher to reach the same conclusions about the organizational leader this goes a long way to ensuring the validity of the findings.
The approach adopted here is a sequential process (Marschan-Piekkari & Welch, 2004) where one method is adopted ahead of the other. Clearly, the administration of the survey questionnaire is the quantitative component and the open ended question at the conclusion of the survey allows for the collection of qualitative data issues in and around a designated research question (see Appendix 3.1).

To sum up, Onwuegbuzie and Johnson (2006, p. 53) claim “mixed method research generally follows philosophical and methodological pragmatism (with a very broad and inclusive ontological realism where virtually everything a qualitative or quantitative researcher deems to be real can be considered, in some sense, to be real, including subjective realism, intersubjective realism and objective realism)”. This synthesis of techniques has the capacity to address research questions in considerably more depth than could otherwise be accomplished using a single method (Tashakkori & Teddlie, 2003). Simply put, mixed methods research is the application of different but complementary and compatible techniques within the same study.

Survey questionnaire

According to Herbst and Coldwell, (2004) a survey questionnaire is a common and reliable method for obtaining data based on the perceptions, beliefs and, attitudes. The data collected in this study are not captured from direct observation of behaviour but, rather, is the self-reported data that accumulatively depicts the way safety culture is managed in a given institution.
3.6 **Protocols**

**Unit of Analysis (UA):**

A theory usually adopts a certain unit of analysis, which could be the artefact, the system, relationships, the organisation, individual people, communities, countries, a team or something else (Yin, 2009; Neuman, 2011; Hasan & Banna, 2010). In this study the UA is at an organisation level since it reflects the aggregated workers’ perceptions of an effective safety culture. Thus, this study aims to infer the characteristics of an entity (organisation) through the statistical analyses following the individual data collection.

In addition, the insertion of an open-ended question at the conclusion of the questionnaire survey will enable the researcher to conduct a thematic analysis of the qualitative data collected. It is anticipated that the use of methodological triangulation (Neuman, 2011) will increase the face validity of the constituent constructs used in the study.

The literature review identified a gap in the literature relating to safety culture assessment tools (Biggs, Dingsdag, Kirk & Cipolla, 2010). Since the authors were concluded there were no reliable and valid instruments to measure safety culture perceptions, this research aims to assess the psychometric properties of the IAEA safety culture survey as a measure of safety culture.

**Questionnaire design**

The most common method in safety culture studies is the questionnaire survey method based on psychometrics measurement techniques to establish sound culture constructs enabling analysis of safety dynamics within organisations. The questionnaire survey method will be one of two data collection methods to be used for
the study on safety culture. The other, as mentioned above, will be the data derived from an open-ended question.

**Survey instrument**

The International Atomic Energy Agency (IAEA, 2012) designed a safety culture questionnaire to assess the effectiveness of the workplace safety culture in high reliability organisations. In asking the respondent's to provide an overall grade for their workplace safety culture it should be noted that this is based on their perceptions only. They were asked whether they would grade their organisation on nuclear safety as ‘Excellent’, ‘Very Good’, ‘Acceptable’, ’Poor’ or ‘Failing’. Clearly these ordered ranks reflected the aggregated perceptions of individual organisational members.

Further, a strong association between the individual’s perceptions of safety related characteristics and their overall perception of their workplace safety culture would go some way towards validating the model which has as yet been untested.

Finally, the last item in the IAEA’s questionnaire is where the respondents grade their workplace safety culture according to the criteria outlined above. Despite its widespread use, to date there have been no concerns raised as to the conceptual clarity of this important organisational variable

The questionnaire was jointly developed by IAEA safety culture experts along with academic researchers is from Saint Mary University in Canada. Specifically, the survey was designed to assess the following five characteristics and 37 attributes of IAEA’s safety culture model: ‘value, leadership, accountability, integration, and learning’ (see Figure 3.3 and Appendix 2.1 for a detailed description of the five characteristics along with the 37 attributes of safety culture). As can be seen, the
items in this questionnaire were intended to reflect employees’ perceptions of various aspects of the organisation thought to be related to the achievement of an effective safety culture.

The initial questionnaire was obtained from the IAEA for the purpose of this study. The IAEA’s safety culture model was the product of a business literature review conducted by IAEA safety culture experts with further input from member states based on their field experience.

**Figure 3.3 IAEA’s five characteristics of safety culture**

Source: IAEA safety standards (2009, p. 8)

**Instrument modification**

The original questionnaire obtained from the IAEA consisted of 105 items plus an additional six demographic questions. As an attempt to improve the face validity, the questionnaire was scrutinized to ensure items were measuring what they claimed to measure. An example of an item that lacked face validity and which was subsequently deleted was item 4 (‘people in this
organisation are valued’) since it was deemed to be too general. That is, it could apply to other variables besides safety culture. Items beginning with ‘I’ (e.g. ‘I use the correct safety procedures for carrying out my job’) were deemed to be too subjective. Moreover, they represented a shift from an organisational to an individual unit of analysis.

The survey was also judged to be redundant with respect to some indicators For example item 16 (The high priority placed on safety reflects in our business plans), item 26 (The way safety included in business plans shows that safety is high priority), item 31 (Our organisation shows that safety is important by including safety goals in safety plans), and item 36 (The high priority of safety is reflected in documentation) were deleted in favour of item 21 (The long term business strategy of our organization reflects the high priority we place on safety) which was deemed to have more face validity.

These modifications to the questionnaire were made with permission from the IAEA. In shortening the survey instrument further it was hoped reduce response set on the part of the respondents, a common feature of overly long questionnaires. Final feedback was also sought from the participating organisation to ensure question clarity. As a result 47 questions were eliminated from the original questionnaire and 10 items were reworded.

The final safety culture questionnaire was composed of 52 items and additional six demographic questions (see Appendix 3.1). These demographic features can be employed to describe the characteristics of the respondents who comprised the sample (Sekaran, 2003). Items were written for use with a 7-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (7), reflecting the degree of agreement. In addition an open-ended question was
added in an attempt to provide respondents with an opportunity to raise further issues. These issues are to be compared with the results of quantitative analysis.

The purpose of using IAEA safety culture survey

The literature review identified a gap in the literature relating to the availability of an effective safety culture assessment tool. It is recognised that an effective safety culture does not necessarily translate into safety performance in a given organisation (Biggs, Dingsdag, Kirk & Cipolla, 2010). Since there are no reliable and valid instruments to measure safety culture perceptions, this research aims to assess the psychometric properties of the IAEA safety culture survey to produce psychometrically sound/reliable instrument to meet the increasing demand for effective safety culture assessment.

Collection: data collecting method

Data collected for this study was carried out within an applied setting, using mainly quantitative methods. Data were collected in two parts; paper-based collection and web-based questionnaire. In paper-based questionnaire; surveys were administered by the researcher in an auditorium setting. An introduction and a brief explanation were used to inform respondents of the aim of the questionnaire and the researcher was present on site to clarify any queries related to the completion of the survey.

For those employees and unable to attend the paper-based questionnaire session, due to professional commitments (such as shift workers) a web-based questionnaire was made available to maximize response rates.
Sampling strategy

While this quantitative research used a relatively large sample of respondents there is no attempt to claim that the sample was representative of any larger population (Davis, 2004). Hence there is no intention to generalise the findings of the present study to some wider population (Herbst & Coldwell, 2004). Accordingly, in this study the whole working population was targeted and therefore no categorical sampling technique was employed.

The target population included all employees who agreed voluntarily to participate in the study. These included: Engineers, Quality Assurance officers, Technicians, Scientist, Physicist, Managers, General Managers, Radiation Protection officers, Risk Management, Work Health and Safety officers, Maintenance, Operations, Human Resources, electrician, Quality Control officers, Project Manager, Advisory/strategist, Safety Advisor, Quality Assurance/Auditing, Government Risk Compliance and Assurance, CEO and others.

Data analysis

Quantitative data analysis

Data analysis is a key step in research endeavour. Most positivist research projects analyse empirical data to support or refute hypothesised relationship between two or more variables. Accordingly, this section describes the different statistical techniques which are part of the Statistical Package for Social Sciences’ (SPSS) Version 20.0 for Windows.
Descriptive analyses:

Descriptive analyses such as frequencies, means and percentages will be used to summarise the demographic characteristics of the respondents. For example a series of contingency table analyses will be undertaken to assess whether or not there are any significant relationships between the demographic characteristics of the respondents. It may well be, for example, older employees or those who have been in the organisation for a long time have different perceptions of their workplace safety culture.

3.7 Research hypotheses

The final survey questionnaire contains items thought to be related to each of the five characteristics (see Appendix 4.2). It is planned to sum together these items to form a composite variable. To ascertain whether there is any significant positive relationship between each newly formed composite variable and the dependent measure (perception of workplace safety culture) a series of Pearson product moment correlation coefficients will be calculated as set out in hypotheses that follow:

$H_1^o$: there is no relationship between the variable safety is a clearly recognised value and the perception of the organisation's overall safety culture.

$H_2^o$: there is no relationship between the variable leadership for safety is clear and the perception of the organisation's overall safety culture.

$H_3^o$: there is no relationship between the variable accountability for safety is clear and the perception of the organisation's overall safety culture.

$H_4^o$: there is no relationship between the variable safety is integrated into all activities and the perception of the organisation's overall safety culture.
**H₅°**: there is no relationship between the variable *safety is learning driven* and the perception of the organisation's overall safety culture.

If all correlations are positive and significant the above mentioned hypotheses can be rejected which opens the way for the use of multiple linear regression analysis that will allow us to predict the dependent variable (the perception of work place safety) with a set of independent variables (i.e. the five composite variables representing each of the characteristics thought to be the determinants of an effective workplace safety culture).

Moreover, multiple linear regression allows us to determine the relative importance of each of the independent variables.

As we shall see, multiple regression can also be used to compare the relative predictive power amongst competing models with differing sets of independent variables (Hair & Anderson, 2010). More of this discussed later under the heading Post Hoc Analyses in Chapter Four.

In concluding this section it should be made clear that all the necessary checks will be made related to the formation of the composite variables (i.e. the shape and spread of the distribution of each composite variable along with tests for outliers.) Similarly the regression analysis will include these tests as well as a test for multicollinearity (Chiswick & Miller, 2007).
3.8 Qualitative data analysis

Thematic analysis will be used by researcher to identify the themes that arise from the recommendations made in response to the open-ended question at the conclusion of the survey. This analysis represents an attempt to utilise methodological triangulation (Neuman, 2011) as a way of establishing the content validity of the survey questionnaire.

For a data analysis procedure to be regarded as adequate, the methodology for the thematic analysis needs to be clearly documented, so that the analysis could be replicated for any future studies or for comparisons to be made with other studies. This also allows for the correct use of the methodology to be critiqued or questioned through peer review. The data analysis and subsequent interpretation of the data collected needs to show how the researcher arrived at the findings of their research. In this study the technique of utilising multiple comparisons was instrumental in uncovering relevant themes. For qualitative research, demonstrating which paradigm the researcher is approaching the analysis is also important. The identification of potential biases, strengths and weaknesses of the data analysis procedure enables the researcher to discuss the findings of the research. It also allows the scientific community to critique the robustness of the research by understanding the use of the methodology and to ascertain how significant the findings of the research are.
3.9 Ethical issues

The Oxford dictionary defines ethics as a branch of knowledge that control moral behaviours and conducted activities (Oxford Dictionaries, 2013). Penslar (1995) believes that research ethics revolve around “shoulds” “oughts” “rights” “wrongs” of research conduct with aims to constitute operative (not theoretical) moral norms and standards for the conduct of the research. Ethical dilemmas are perhaps not that evident in the social sciences as in other fields of research, such as within biomedical or the natural sciences. No physical, individual or environmental experiments are performed, and there is generally no risk of personal or environmental harm. But taking a closer look, it can be seen that social research involves cooperation and coordination among many different people from different disciplines and organisations. Therefore, it is important to acknowledge and conform to ethical codes of conducts in research, because the moral integrity of the investigator is important in ensuring the trustworthiness and validity of the findings. Such behaviour also ensures confidentiality (the most important aspect to participants) and holds the researcher accountable to the public generally and co-operating bodies specifically. To ensure the above mentioned criteria, a contract is established between the researcher and the respondent (Vilcox & Mohan 2007).

Cooper and Schindler (2013) proposed the following ethical guidelines:

- Address projects benefits and advantages
- Clarify informant’s rights and protection procedures
- Attain informed consent
To conduct this research all the above mentioned criteria were addressed. The informants from participating organisation were provided an ‘Information Sheet and informed consent.’ (see Appendices 3.2 & 3.3) which identifies the aims of the study, what is expected from the informants, the type of the survey and time anticipated to complete the survey. Since no name and date of birth questions were included in the demographic section of the survey this ensured the confidentiality of the respondents. Further, gender related question was deliberately excluded from the survey to protect minority groups. As found in participating organisation the number of females were low making it easy to identify them. Additionally, other demographic information was not to be attached to data collected as all data is presented in aggregate and anonymous form. Additionally, participants were informed that participation in the survey was voluntary and participants were free to discontinue participation at any time. Participants may also elect not to answer any or some of the questions asked.

Finally, the researcher is aware of the fact that safety data forms a crucial indicator of corporate identity. Consequently, no organisation or installation names were revealed.

The Information Sheet along with the Safety Culture Questionnaire were reviewed and approved by the Southern Cross University Human Research Ethics Committee (HREC). The Approval Number is ECN-12-075. Furthermore, the study was approved by the participating organisation management and research committee before commencing data collection.
3.10 Conclusion

This chapter of the research addressed the rationale of the research methodology that was used to empirically address the research issues raised in the previous chapters. It addressed the Questionnaire design, Survey Instrument, Instrument Modification, Data Collecting Method, Sampling Strategy, Data analysis strategy. Ethical considerations as well as limitations pertinent to the study are also addressed. The next chapter will proceed to report on the data analysis and findings employed in the study.
CHAPTER 4
DATA ANALYSES
CHAPTER 4: DATA ANALYSES

4.1 Introduction

The previous chapter discussed the research methodology applied in this study. This chapter presents data collected from the survey questionnaire in tables and provides a detailed analysis of the data collected using statistical tools to test the hypotheses formulated in Chapter Two.

The modified survey was concerned with assessing safety culture in a High Reliability Organisation (HRO) in Australia. This research primarily utilises quantitative data gathered from a survey questionnaire (see Appendix 3.1) along with qualitative data collected as a result of an open-ended question at the end of the questionnaire.

The concept map that follows represents the topics covered in Chapter Four.
Figure 4.1 Concept map for Chapter 4.

- Introduction
- Quantitative data collection and data analyses
  - 4.2.1 Quantitative data collection
  - 4.2.2 Data cleaning and screening
- 4.3 Descriptive analyses
- 4.4 Inferential statistics
  - Composite variable
  - Validity of composite variable research
  - Reliability of composite variables
- 4.5 Hypothesis testing
- 4.6 Multiple linear regression
- 4.7 Post Hoc Analysis
- 4.8 Qualitative data analysis
  - Deductive thematic analysis
  - Inductive thematic analysis
- 4.9 Thematic analysis
- 4.10 Conclusion

Source: developed for this thesis
4.2 Quantitative data collection and data analyses

The questionnaire in this research was administered in two modes:

- paper-based; and
- Online.

The paper-based surveys were administered by the researcher in an auditorium setting in the participating organisation. An introduction and brief explanation were also used to inform the respondents about the aim of the questionnaire. The researcher was present on site to clarify any queries related to the survey items. The distribution and collection of the completed survey instrument was conducted by the researcher.

The online survey questionnaire was hosted on SurveyMonkey™ and conducted by directing participants to the survey using a web-link.

The first section of the questionnaire presents a brief description of the project and specific instructions on how to complete the questionnaire.

The survey questionnaire itself consisted of four parts. Part I: contained six demographic questions to identify the following information from each respondent:

- department/work role;
- type of work most frequently performed;
- whether they held a management or supervisory position;
- age category;
- length of time in current position and;
- overall experience in this industry.
These items were preceded by the following instructions:

_The information you provide below will be used to see how various groups of employees differ in their opinions about safety. The information will be used for descriptive purpose only. The information will only be reported in terms of large groups, ensuring that your responses remain completely anonymous._

Gender related questions were deliberately excluded from the survey to ensure the protection of individuals in the organisation which in this case had relatively few females.

Part II of the survey questionnaire consisted of 51 items that were preceded by the following instruction:

_The following statements are related to how workplace safety is managed in your organisation. Please rate the extent to which you agree with each statement._

Items in Part II were written for use with a 7-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (7), reflecting the degree of agreement.

During the modification of the initial survey an open-ended question was added in Part III, namely: ‘What are your top three recommendations for improving safety in your Organisation’. A thematic analysis of this qualitative data was undertaken to summarise employee recommendations related to enhancing workplace safety culture at an organisational level.

The survey questionnaire ends with a single question in Part IV asking participants to give the organisation an overall grade on workplace safety according to a 5-point Likert Scale where 1 = ‘failing’ and 5 = ‘excellent’.
4.2.1 Quantitative data collection

Surveys were made available to 750 employees at the participating organisation. Completed returns were received from 252 respondents: 22 were paper-based and the remaining 230 respondents completed the survey online. Overall this represented a response rate of 34% which according to Zikmund, Babin, Carr and Griffin (2013) is adequate, particularly when there is no intention to extrapolate the findings beyond the obtained sample.

The data from the 58 variables were entered using SPSS (see Appendix 4.1).

4.2.2 Data cleaning and screening

After entering the data into Statistical Package for the Social Sciences (SPSS), the data was scrutinized for errors through data cleaning and screening. The intention of this procedure was to ensure that the collected data had been entered accurately by identifying inconsistent responses, missing data and outliers (Malhotra, 2004). A few missing data were found in this data set, but they were randomly distributed and SPSS was programmed to delete those few from the analysis. It may be noted that the missing values were confined to those who worked in small departments. It is likely that these respondents were concerned about being identified.

4.3 Descriptive analyses

An analysis of the demographic data collected at the beginning of the survey suggests that there were no significant differences between respondents and non-respondents. This conclusion is based on the fact that all levels and departments of the organisation were reasonably equally represented.
The analysis of descriptive statistics and frequency distributions for the first six demographic items showed that no out-of-range values were present in the data (Tabachnick & Fidell, 2012). Accordingly, further descriptive analyses for the six demographic questions were conducted as follows:

**Item 1- Please indicate your department/work role**

Item 1 revealed that there was a range of participants at various levels and occupations within an organisation. Following are examples of the target population who agreed voluntarily to participate in the study. These included: Engineers, Quality Assurance officers, Technicians, Scientist, Physicist, Mangers, General Managers, Radiation Protection officers, Risk Management, Work Health and Safety officers, Maintenance, Operations, Human Resources, electrician, Quality Control officers, Project Manager, Advisory/strategist, Safety Advisor, Quality Assurance/Auditing, Government Risk Compliance and Assurance, CEO and others.

**Item 2- Please select the type of work you most frequently perform**

The options were:

1. Hands-on department related work
2. Office/administration work

Table 4.1 below contains a breakdown of the most frequently performed work
Table 4.1 Type of work most frequently performed

<table>
<thead>
<tr>
<th>Please select the type of work you most frequently perform</th>
<th>Frequency</th>
<th>%</th>
<th>Valid %</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hands-on department related work</td>
<td>164</td>
<td>65.1</td>
<td>65.1</td>
<td>65.1</td>
</tr>
<tr>
<td>Office/administration work</td>
<td>88</td>
<td>34.9</td>
<td>34.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>252</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

Two-thirds of employees (65.1%) are technical or field-workers who are the firsthand observer as opposed to the remaining third who are Office/administration workers.

**Item 3- Do you hold a management or supervisory position?**

Table 4.2 Percentage of those holding a management and/or supervisory position

<table>
<thead>
<tr>
<th>Do you hold a management or supervisory position?</th>
<th>Frequency</th>
<th>%</th>
<th>Valid %</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>138</td>
<td>54.8</td>
<td>54.8</td>
<td>54.8</td>
</tr>
<tr>
<td>Yes</td>
<td>114</td>
<td>45.2</td>
<td>45.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>252</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

45% of respondents hold a management position while the rest (55%) do not hold any management or supervisory position. The proportion of respondents reflected above suggests that there was a reasonably even balance of management and non-management perceptions reflected in the data collected.
Item 4- Age category

31 % of respondents were between 46-55 years old and a further 18.7 % were 56 years or older. In other words approximately 50 % of the work force were older than 46 years. The different age groups of the respondents are summarised in Table 4.3 below.

Table 4.3 Age category

<table>
<thead>
<tr>
<th>Age category</th>
<th>Frequency</th>
<th>%</th>
<th>Valid %</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 years or below</td>
<td>11</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>26-35 years</td>
<td>64</td>
<td>25.4</td>
<td>25.4</td>
<td>29.8</td>
</tr>
<tr>
<td>36-45 years</td>
<td>52</td>
<td>20.6</td>
<td>20.6</td>
<td>50.4</td>
</tr>
<tr>
<td>46-55 years</td>
<td>78</td>
<td>31.0</td>
<td>31.0</td>
<td>81.3</td>
</tr>
<tr>
<td>56 years or older</td>
<td>47</td>
<td>18.7</td>
<td>18.7</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>252</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

These figures are suggestive of a mature age workforce. This is supported by the data from item 5 contained in Table 4.4 below.

Item 5- How long have you held your current position?

Table 4.4 Mean number of years in current position

<table>
<thead>
<tr>
<th>Yrs in position</th>
<th>N</th>
<th>Valid</th>
<th>Missing</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>251</td>
<td></td>
<td>5.18</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

The respondents’ mean years in current position is 5.18 years.
Item 6- Your overall experience in this industry?

The respondents had significant work experience (Mean=14 years) in their current field as Table 4.5 exhibits.

Table 4.5 Years of industrial experience.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>overall_experience</td>
<td>237</td>
<td>0</td>
<td>46</td>
<td>14.00</td>
<td>11.063</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>237</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

The final descriptive statistic to be reported concerned each respondent’s rating of the organisation's workplace safety culture (Abbreviated as ‘Grd_Org’). This is an important variable since it will be used as the dependent measure in subsequent analyses.

The mean rating of the organisation’s workplace safety culture (Grd_Org) by all respondents was 3.78 on a scale of 1 to 5 where 1 was ‘Failing’ and 5 was ‘Excellent’ (see Table 4.6).

Table 4.6 Mean rating of organisation’s workplace safety culture (Grd_Org).

<table>
<thead>
<tr>
<th>Grd_Org</th>
<th>N</th>
<th>Valid</th>
<th>Missing</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>3.78</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

To ascertain if the distribution of these scores is normal, Manning and Munro (2007) suggest using standardised Z scores as a way of identifying potential univariate outliers. As Appendix 4.1 shows in the column marked ‘Zgrd_Org’, all standardised Z scores...
scores lay within +3.29 and -3.29 standard deviations from the mean. However, it should be noted that three standardised scores of 3.28 were detected which probably explains why the distribution of organisational rating scores was slightly negatively skewed. To confirm this suspicion the skew statistic (.605) was divided by the standard error of skewness (.15) to produce a negative skew of 3.8 which is greater than the absolute value of 3.29 which means the skew is significant. Yet, on the basis of the calculations above it was decided not to discard any data points as being outliers.

**Perceptions of the organisation’s workplace safety culture by position type**

This analysis examined the relationship between the rating of organisation’s workplace safety culture as a function of position type (mng_position). As Table 4.7 shows those occupying a managerial or supervisory role tended to rate the organisation’s workplace safety culture slightly less favourably (Mean = 3.74) than ordinary employees (Mean = 3.81).

To test whether the difference between the means (3.74 for managers and 3.81 for ordinary employees) was statistically significant the researcher chose to use a one way ANOVA over a two means t-test since with a relatively high N (249) the outcome would be virtually the same.

**Table 4.7 Mean rating organisational safety culture by management position.**

<table>
<thead>
<tr>
<th>Do you hold a management or supervisory position?</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grd_Org</td>
<td>135</td>
<td>3.81</td>
<td>.868</td>
<td>.075</td>
</tr>
<tr>
<td>Yes</td>
<td>114</td>
<td>3.74</td>
<td>.821</td>
<td>.077</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.
However, a One Way ANOVA showed there was no significant statistical difference in the ratings by those in managerial positions compared to those with no management experience as the following analysis shows:

**Table 4.8 One way ANOVA with Pos Type as IV and Grd Org as DV.**

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Groups</strong></td>
<td>.308</td>
<td>1</td>
<td>.308</td>
<td>.429</td>
<td>.513</td>
</tr>
<tr>
<td><strong>Within Groups</strong></td>
<td>177.098</td>
<td>247</td>
<td>.717</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>177.406</td>
<td>248</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

**Perceptions of organisation’s workplace safety culture by age**

The only other analysis of interest was to determine if perceptions of the organisation’s workplace culture differed according to age. Consequently we used an analysis of variance to examine whether there were differences amongst different age groups in terms of the way they view their workplace safety culture. The results of an analysis are in Table 4.9 below.

**Table 4.9 ANOVA for age groups as a between subjects variable**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>8.718*</td>
<td>4</td>
<td>2.179</td>
<td>3.152</td>
<td>.015</td>
<td>.049</td>
<td>12.610</td>
<td>.916</td>
</tr>
<tr>
<td>Intercept</td>
<td>2361.852</td>
<td>1</td>
<td>2361.852</td>
<td>3416.320</td>
<td>.000</td>
<td>.933</td>
<td>3416.320</td>
<td>1.000</td>
</tr>
<tr>
<td>Age</td>
<td>8.718</td>
<td>4</td>
<td>2.179</td>
<td>3.152</td>
<td>.015</td>
<td>.049</td>
<td>12.610</td>
<td>.916</td>
</tr>
<tr>
<td>Error</td>
<td>168.689</td>
<td>244</td>
<td>.681</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3726.000</td>
<td>249</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>177.406</td>
<td>248</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .049 (Adjusted R Squared = .034)  
b. Computed using alpha = .05

Source: developed for this thesis.
The main effect for Age produced an F statistic of 3.15 with degrees of freedom of 1 and 244. This is significant ‘Sig.’=.015 which tells us there are differences in responses from various age groups. At first glance it would appear that the ‘Under 25’ category had the highest rating of the organisation’s workplace safety culture. Those in the age category ‘46 to 55’ had the lowest rating of their workplace safety culture. To establish whether these groups differed significantly from one another a Tukey HSD was calculated based on multiple comparisons.

Table 4.10 shows the mean rating of each age group of the overall workplace safety culture.

**Table 4.10 Mean Rating of Grd_Org by Age category.**

<table>
<thead>
<tr>
<th>Age Category</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 years or younger</td>
<td>4.45</td>
<td>.522</td>
<td>11</td>
</tr>
<tr>
<td>26-35 years</td>
<td>3.83</td>
<td>.747</td>
<td>64</td>
</tr>
<tr>
<td>36-45 years</td>
<td>3.68</td>
<td>.957</td>
<td>50</td>
</tr>
<tr>
<td>46-55 years</td>
<td>3.61</td>
<td>.976</td>
<td>77</td>
</tr>
<tr>
<td>56 years or older</td>
<td>3.91</td>
<td>.775</td>
<td>47</td>
</tr>
<tr>
<td>Total</td>
<td>3.78</td>
<td>.948</td>
<td>249</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

Post Hoc comparisons (Tukey HSD) in Table 4.11 found the age group ‘46 to 55’ (Mean = 3.61, SD = .876) to display significantly lower mean ratings of organisational safety culture than those in the youngest age category ‘under 25’ (Mean = 4.45, SD = .522) p = 02.
Table 4.11 Tukey HSD Post Hoc Comparisons.

<table>
<thead>
<tr>
<th>Source: developed for this thesis.</th>
</tr>
</thead>
</table>

### 4.4 Descriptive statistics – Survey Items

Table 4.12 below contains the means and standard deviations for the survey items. Clearly, what is highly valued in this organization are factors such as a strong safety culture enshrined in policy documents and supported in a team context and bolstered by their relationships with their direct supervisor. We will return in Chapter 5 to consider these factors in greater detail.
Table 4.12 Descriptive statistics for the survey items

<table>
<thead>
<tr>
<th>Item</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy_q7</td>
<td>252</td>
<td>6.32</td>
<td>1.034</td>
</tr>
<tr>
<td>T_responsibilitiesq9</td>
<td>252</td>
<td>6.27</td>
<td>.911</td>
</tr>
<tr>
<td>DS_committedq8</td>
<td>252</td>
<td>6.26</td>
<td>1.144</td>
</tr>
<tr>
<td>encourgetoreport53</td>
<td>252</td>
<td>6.21</td>
<td>1.129</td>
</tr>
<tr>
<td>T_encourageeachother14</td>
<td>252</td>
<td>6.16</td>
<td>.961</td>
</tr>
<tr>
<td>DS_Respondsquickly18</td>
<td>252</td>
<td>6.10</td>
<td>1.205</td>
</tr>
<tr>
<td>T_authority19</td>
<td>252</td>
<td>6.06</td>
<td>1.115</td>
</tr>
<tr>
<td>DS_encourageopennes13</td>
<td>252</td>
<td>6.05</td>
<td>1.315</td>
</tr>
<tr>
<td>RaiseQ_q11</td>
<td>252</td>
<td>6.04</td>
<td>1.480</td>
</tr>
<tr>
<td>T_safetyprocedures51</td>
<td>252</td>
<td>5.98</td>
<td>1.064</td>
</tr>
<tr>
<td>safetyhighpriority57</td>
<td>252</td>
<td>5.93</td>
<td>1.238</td>
</tr>
<tr>
<td>mng_establishhespectation21</td>
<td>252</td>
<td>5.92</td>
<td>1.266</td>
</tr>
<tr>
<td>T_improvesafety34</td>
<td>252</td>
<td>5.92</td>
<td>.960</td>
</tr>
<tr>
<td>DS_communicates23</td>
<td>252</td>
<td>5.91</td>
<td>1.284</td>
</tr>
<tr>
<td>T_ownership46</td>
<td>252</td>
<td>5.90</td>
<td>1.003</td>
</tr>
<tr>
<td>mng_committed55</td>
<td>252</td>
<td>5.89</td>
<td>1.366</td>
</tr>
<tr>
<td>report_errors26</td>
<td>252</td>
<td>5.85</td>
<td>1.440</td>
</tr>
<tr>
<td>expectationsdefined50</td>
<td>252</td>
<td>5.82</td>
<td>1.235</td>
</tr>
<tr>
<td>safetytopriority38</td>
<td>252</td>
<td>5.82</td>
<td>1.401</td>
</tr>
<tr>
<td>Quick_Response12</td>
<td>252</td>
<td>5.74</td>
<td>1.481</td>
</tr>
<tr>
<td>business_strategy22</td>
<td>252</td>
<td>5.72</td>
<td>1.378</td>
</tr>
<tr>
<td>T_followrules29</td>
<td>252</td>
<td>5.71</td>
<td>1.215</td>
</tr>
<tr>
<td>Planningworkwellq10</td>
<td>252</td>
<td>5.70</td>
<td>1.361</td>
</tr>
<tr>
<td>operatingexperience33</td>
<td>252</td>
<td>5.68</td>
<td>1.123</td>
</tr>
<tr>
<td>compliance40</td>
<td>252</td>
<td>5.67</td>
<td>1.163</td>
</tr>
<tr>
<td>sharing_knowledge20</td>
<td>252</td>
<td>5.66</td>
<td>1.303</td>
</tr>
<tr>
<td>easytoreporterror58</td>
<td>252</td>
<td>5.64</td>
<td>1.420</td>
</tr>
<tr>
<td>responsibilitiesdefined39</td>
<td>252</td>
<td>5.64</td>
<td>1.369</td>
</tr>
<tr>
<td>mng_respondsquickly56</td>
<td>252</td>
<td>5.63</td>
<td>1.358</td>
</tr>
<tr>
<td>Access_training17</td>
<td>252</td>
<td>5.61</td>
<td>1.294</td>
</tr>
<tr>
<td>equipment35</td>
<td>252</td>
<td>5.60</td>
<td>1.318</td>
</tr>
<tr>
<td>imp_decision37</td>
<td>252</td>
<td>5.58</td>
<td>1.379</td>
</tr>
<tr>
<td>mng_communicates49</td>
<td>252</td>
<td>5.50</td>
<td>1.346</td>
</tr>
<tr>
<td>reporting_sys52</td>
<td>252</td>
<td>5.46</td>
<td>1.465</td>
</tr>
<tr>
<td>self_assessment25</td>
<td>252</td>
<td>5.45</td>
<td>1.195</td>
</tr>
<tr>
<td>Ask_Q16</td>
<td>252</td>
<td>5.40</td>
<td>1.487</td>
</tr>
<tr>
<td>trainingprogram32</td>
<td>252</td>
<td>5.39</td>
<td>1.303</td>
</tr>
<tr>
<td>Variable</td>
<td>N</td>
<td>Mean</td>
<td>Std. Dev.</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----</td>
<td>------</td>
<td>-----------</td>
</tr>
<tr>
<td>safety_assessment</td>
<td>252</td>
<td>5.36</td>
<td>1.459</td>
</tr>
<tr>
<td>investigation36</td>
<td>252</td>
<td>5.36</td>
<td>1.428</td>
</tr>
<tr>
<td>challengedecion48</td>
<td>249</td>
<td>5.35</td>
<td>1.562</td>
</tr>
<tr>
<td>DS_Disagreements28</td>
<td>252</td>
<td>5.29</td>
<td>1.509</td>
</tr>
<tr>
<td>recognition54</td>
<td>252</td>
<td>5.20</td>
<td>1.515</td>
</tr>
<tr>
<td>correctiveaction31</td>
<td>252</td>
<td>5.18</td>
<td>1.410</td>
</tr>
<tr>
<td>Time30</td>
<td>252</td>
<td>5.15</td>
<td>1.605</td>
</tr>
<tr>
<td>DS_consults45</td>
<td>252</td>
<td>5.11</td>
<td>1.547</td>
</tr>
<tr>
<td>resources_allocation44</td>
<td>252</td>
<td>4.99</td>
<td>1.478</td>
</tr>
<tr>
<td>mng_pressure15</td>
<td>252</td>
<td>4.92</td>
<td>1.897</td>
</tr>
<tr>
<td>independentviews41</td>
<td>252</td>
<td>4.88</td>
<td>1.385</td>
</tr>
<tr>
<td>staffing42</td>
<td>252</td>
<td>4.69</td>
<td>1.564</td>
</tr>
<tr>
<td>info_communicated27</td>
<td>252</td>
<td>4.47</td>
<td>1.706</td>
</tr>
<tr>
<td>mistakesheld43</td>
<td>252</td>
<td>4.13</td>
<td>1.720</td>
</tr>
<tr>
<td>shortcuts47</td>
<td>252</td>
<td>3.60</td>
<td>1.521</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>249</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: developed for this thesis

### 4.5 Inferential statistics

The following section contains a series of data analyses designed to address the primary research question i.e. to what extent does the workplace safety culture of a high reliability organisation depend on the five variables contained in the IAEA model?

The address this question, the Likert scale items in the survey were grouped according to the criteria associated with each of the five hypothesised indicators of an efficient workplace safety culture namely *values, leadership, accountability, integration* and *learning*. In order to evaluate the IAEA model, a number of composite variables were formed based on these five characteristics as set out in the IAEA framework.

**Composite variable**
In designing the questionnaire, items were constructed based on the five characteristics and the attributes found in the IAEA model. By mapping each item against its relevant characteristic and attribute in, the following composite variables were derived from the various questionnaire items.

**The first composite variable was named** value **and a summative scale was derived by computing the arithmetical mean of the following 10 items:**

1. **Item 7** - the content of our safety policy demonstrates that safety is a high priority
2. **Item 12** - the quick response to important safety concerns shows that safety is a high priority
3. **Item 14** - people on my team encourage each other to work safely
4. **Item 22** - The long term business strategy of our organization reflects the high priority we place on safety
5. **Item 37** - The high priority of safety is reflected in important decisions.
6. **Item 38** - our management make safety a top priority.
7. **Item 44** - The way resources are allocated shows that safety is a high priority
8. **Item 48** - I feel free to challenge a safety related decisions
9. **Item 54** - The recognition given for safety conscious behaviour shows safety is a high priority
10. **Item 57** - the high priority of safety is clearly communicated.

**The second composite variable was named** leadership **and was comprised of the following 12 items:**

1. **Item 8** - my direct supervisor is committed to safety
2. **Item 13** - My direct supervisor encourages openness within the team
3. **Item 18** - My direct supervisor responds to safety concerns quickly
4. **Item 21** - Our management establishes clear safety expectations
Item 23- My direct supervisor communicates effectively about safety
Item 27- Information is effectively communicated across teams in this organization
Item 28- My direct supervisor helps resolve disagreements between teams (i.e. not who is right but what is best for safety)
Item 45- My direct supervisor consult us when making decisions
Item 49- Our management communicates effectively about safety
Item 50- In this organization safety expectations are clearly defined
Item 55- Our management is committed to safety
Item 56- Our management responds to safety concerns quickly

The third composite variable was named *accountability* and was comprised of the following eight items:

Item 9- In my team we are clear about our safety responsibilities
Item 19- In my team we are given enough authority to perform our work safely
Item 34- In my team we work to improve safety procedures
Item 39- In this organization safety responsibilities are clearly defined
Item 40- In this organization there is a high level of compliance with procedures
Item 43- Workers feels like their mistakes are held against them
Item 46- People on my team accept ownership for safety
Item 51- In my team there is a high degree of adherence to safety procedures

The fourth composite variable was named *integrated* and was comprised of the following five items:

Item 10- In our organization we maintain high safety standards by planning work well
Item 29- People on my team always follow safety rules
Item 30- In our organization we maintain high safety standards by giving people enough time to complete critical tasks.

Item 35- In our organization we ensure everyone has access to the equipment needed

Item 58- It is easy to report safety errors

The fifth composite variable was named learning and was comprised of the following thirteen items:

Item 11- I feel free to raise questions about unusual conditions

Item 16- I feel free to ask questions in any forum

Item 17- We have access to the training we need

Item 24- We improve our safety performance by learning from safety assessments

Item 25- Self-assessment provide important information that helps us improve our safety performance

Item 26- I feel free to report errors

Item 31- Our corrective actions are effective at preventing repeat events

Item 32- Our training program helps us improve our performance

Item 33- We use operating experience to improve our safety performance

Item 36- Incident investigations identify the underlying causes

Item 41- We continuously improve by seeking independent views of our safety performance

Item 52- Our reporting system is effective where safety issues are concerned

Item 53- We are encouraged to report any safety problems.

Validity of composite variable
The next step was to check the validity of each of the composite variables to ensure that each one is made up of component items that are internally consistent with one another. According to Gliner, Morgan & Leech (2009, p. 108) an acceptable method of evaluating internal consistency of a composite variable is to calculate the item to total correlations as well as the inter item correlations. Appendix 4.3 contains the correlations for the composite variable value. It can be seen that the correlation between each of the items and the composite variable itself all exceed the criterion of .50. Similarly, each of the inter item correlations is greater than .30 which reflects adequate homogeneity or internal consistency (Manning & Munro, 2007). Appendix 4.3 also contains acceptable correlations needed to establish the validity of each of the composite variables.

**Reliability of composite variables**

The next step was to examine the reliability of each composite variable with all items included. Reliability of each composite variable is evaluated via coefficient alpha or Cronbach’s alpha (Manning & Munro 2007). Coefficient alpha for the ten item value scale was found to be good at ($\alpha=0.899$). This new variable value was found to have an excellent reliability and was used as the measure of value in the analysis that follows.

---

**Table 4.13. Reliability statistics for the variable value.**
The second composite variable (*leadership*) was also assessed in term of its reliability. (see Table 4.14 below) Coefficient alpha for the twelve item scale was found to be excellent at ($\alpha=.936$). This new variable *leadership* was found to have an excellent reliability and was used as the measure of leadership in the analysis that follows.

**Table 4.14 Reliability statistics for variable *leadership*.**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>N of Items</td>
</tr>
<tr>
<td>0.936</td>
<td>12</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

The third composite variable (*accountability*) was also assessed in term of its reliability (see Table 4.15 below). Coefficient alpha for the eight items scale was found to be good at ($\alpha=.850$). This new variable *accountability* was used as the measure of accountability in the analysis that follows.

**Table 4.15 Reliability statistics for variable *accountability*.**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>N of Items</td>
</tr>
<tr>
<td>0.850</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

The fourth composite variable (*integrated*) was also assessed in term of its reliability (see Table 4.16. Coefficient alpha for the five item scale was found to be good at ($\alpha=.820$). This new variable value was found to have an excellent reliability and was used as the measure of integration in the analysis that follows.
Table 4.16 Reliability statistics for variable integrated.

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.820</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

The fifth composite variable (learning) was also assessed in term of its reliability. Coefficient alpha for the thirteen item scale was found to be good at (α=.933). This new variable value was found to have an excellent reliability (see Table 4.17 below) and was used as the measure of learning in the analysis that follows.

Table 4.17 Reliability statistics for variable learning.

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.933</td>
<td>13</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

Tests for Normality of the Distributions of the Composite Variables

Table 4.18 below contains the measures of skewness and kurtosis for each of the composite variables. The presence of a moderate negative skew for most of composite variables was to be expected when as the data in Table 4.12 reveals, almost 90% of the individual survey items were rated at 5 or better on a 7 point Likert scale. Obviously the respondents were favourably disposed to various characteristics of the organisation’ workplace safety culture.

According to Manning and Munro (2007, p.65) in deciding whether to transform the scores a researcher ‘may chose not to transform if the original scale of the variable was well understood.’ The presence of positive kurtosis for each of the composite variables suggested that the ‘distribution is more sharply peaked or narrower than the normal curve’ (Francis 2007, p. 19). This provides evidence for high levels of
agreement amongst the respondents regarding each of the variables. This near ceiling effect is a further reason for not applying a transformation to fix the skew since ‘no matter what transformation you apply you will still have a large number of respondents with the same extreme scores’ (Manning & Munro 2007, p. 64).

### Table 4.18 Skewness and Kurtosis of the Composite Variables

<table>
<thead>
<tr>
<th>Composite Variable</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVALUE</td>
<td>-7.6</td>
<td>4.5</td>
</tr>
<tr>
<td>MLEADERSHIP</td>
<td>-9.3</td>
<td>9.8</td>
</tr>
<tr>
<td>MACCOUNTABILITY</td>
<td>-6.4</td>
<td>5.1</td>
</tr>
<tr>
<td>MINTEGRATED</td>
<td>-7.3</td>
<td>4.5</td>
</tr>
<tr>
<td>MLEARNING</td>
<td>-8.3</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Source: developed for this thesis

Hypotheses testing

We are now in a position to test the five main research hypotheses that follow each of which is now expressed in its null form in Table 4.19. To determine whether there is a significant relationship between the two variables in each hypothesis a Pearson product–moment correlation (Pearson r) was been conducted and the results were all positive and significant (see Table 4.19 below and also Appendix 4.4).

### Table 4.19 Summary of research hypotheses

<table>
<thead>
<tr>
<th>Research Variables</th>
<th>Research Hypotheses</th>
<th>Pearson r</th>
<th>Research Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>( H_1^0: ) there is no positive relationship between the variable ‘safety is a clearly recognised value’ and the ‘perception of the organisation's overall safety culture’.</td>
<td>.753, ( p &lt; .05 )</td>
<td>Null Rejected</td>
</tr>
<tr>
<td>leadership</td>
<td>( H_2^0: ) there is no positive relationship between the variable ‘leadership for safety is clear’ and the ‘perception of the organisation's overall safety culture’.</td>
<td>.683, ( p &lt; .05 )</td>
<td>Null Rejected</td>
</tr>
</tbody>
</table>
The next task was to explore the overall relationship between the five characteristics as reflected in the five composite variables and the dependent measure of interest (the employees’ perception of their workplace safety culture).

Because the correlations contained in Table 4.19 above were all positive and statistically significant, it is acceptable to go ahead and conduct a multiple linear regression analysis using all five characteristics as independent variables (value, leadership, accountability, integrated and learning) and the perception of workplace safety culture (Grd_Org) as the dependent variable.

### 4.6 Multiple linear regression

Multiple linear regression is a multivariate statistical technique designed to reveal the relationship between a single dependent measure of interest and a set of independent variables. It is useful in those cases where the researcher and is attempting to predict the dependent variable using a set of independent variables (Hair et al 1998).

A standard multiple regression analysis was conducted using Grd_Org as the
dependent measure and \textit{MVALUE}, \textit{MLEADERSHIP}, \textit{MACCOUNTABILITY}, 
\textit{MINTEGRATED} and \textit{MLEARNING} as the independent variables. Appendix 4.6 contains the regression analysis while the Model Summary appears below in Table 4.20. The multiple correlation coefficients (R) were .766 and this represents the combined correlation of the five independent variables with the dependent variable. R square, or more accurately the adjusted R square, of .57 means that 57% of the variation in the dependent measure can be accounted for by the variation in the employee ratings of the five independent measures.

\textbf{Table 4.20 Model summary}

\begin{center}
\begin{tabular}{|c|c|c|c|}
\hline
Model & R & R Square & Adjusted R Square & Std. Error of the Estimate \\
\hline
1 & .766* & .567 & .578 & .651 \\
\hline
\end{tabular}
\end{center}

a Predictors: (Constant), MLEARNING, MACOUNTABILITY, MINTEGRATED, MLEADERSHIP, MVALUE

Source: developed for this thesis.

The next table, labelled ANOVA contains a significant F statistic which allows us to conclude there is a significant relationship between the five independent variables as a set and the dependent variable. Thus it is reasonable to conclude that the size of the multiple correlation coefficient (R) between these variables in the population is greater than zero $F(5,240) = 68.14$, $p = .000$ (see Table 4.21 below).

\textbf{Table 4.21 ANOVA}
Turning to the table headed Coefficient (Table 4.22) we can see that there is a significant regression coefficient for \textit{MVALUE} ($t = 4.75, p = .000$) and \textit{MACOUNTABILITY} ($t = 2.05, p = .04$) which means these variables uniquely contribute to the regression equation whilst the other three independent variables do not provide a unique contribution although each adds something to explaining the variance in the dependent variable. The negative $t$ value for \textit{MLEADERSHIP} was unexpected and a discussion of this anomaly is reserved for later.

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Regression</td>
<td>103,346</td>
<td>5</td>
<td>20,669</td>
<td>68,140</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>72,800</td>
<td>249</td>
<td>0.303</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>176,146</td>
<td>245</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

Of greater concern are the multicollinearity figures in the Coefficients Table. Multicollinearity occurs when there are high correlations between the various independent variables which causes a loss in the predictive power of each of the independent variables. Ideally the independent variables should have low correlations.
with other independent variables but have high correlations with the dependent variable. Appendix 4.7 shows the correlations between each of independent variables. The highest is .91 between value and learning. The lowest correlation was .772 between leadership and integrated.

As can be seen from the figures in the Coefficients table (Table 4.22) SPSS produces a ‘tolerance’ statistic which can be used to establish the interdependency of the independent variables. If the tolerance figure is less than .30 there are grounds for excluding the predictor variable. In this particular regression analysis all of the independent variables have tolerance levels less than .3.

### 4.7 Post Hoc Analysis

Although the foregoing statistical analyses provide some empirical support for the IAEA framework, a few of the characteristics were ill-defined which probably explains why they did not figure prominently in the regression analysis. MINTEGRATED provides a case in point wherein its BETA weight was quite low (.003). Consequently it was decided to conduct an exploratory factor analysis on the entire survey to ascertain its psychometric properties in terms of the number of generalised factors that could be extracted.

Hair et al (1998) consider the relative merits of common factor analysis and principal components analysis. They note that both methods are widely used and yield essentially the same results. There is however a growing preference for the use of principal components analysis due to some complications associated with the use of common factor analysis. The main problem with common factor analysis is that it results in factor indeterminancy. This means that it does not yield a unique solution as is the case with principal components analysis and what results is a number of
different factors scores that can be calculated from the factor analysis. Moreover, Hair et al (1998, p.102) stipulate that principal component analysis “is appropriate when the primary concern is about prediction or the minimum number of factors needed to account for the maximum portion of variance represented in the original variables.” This was the case in this study.

Consequently, a principal components analysis with a Varimax rotation was conducted and the correlation matrix as shown in Appendix 4.8 suggested it was appropriate to proceed to factor analyse the correlation matrix. Seven factors with eigen values greater than one (see Appendix 4.9) were extracted. Together these components accounted for almost two thirds of the overall variance.

After carefully inspecting the item loadings in Table 4.21(below), the first component was called Value since the item with the biggest factor loading (.741) was item 38 Our management make safety a top priority. The second component was called Learning since the item with the highest loading (.695) was item 41- We continuously improved by seeking independent views of our safety performance. The two biggest components (value and learning) accounted for 54% of the variance and nicely replicate the biggest two factors in the IAEA model.

Only three of the remaining five factors were interpretable due to items loading on multiple components. These three components departed markedly from the IAEA model and together represented a further 8.3% of the variance.

The first of these was labelled direct supervisor since the highest loadings were recorded for item 23 (My direct supervisor communicates effectively about safety-.760), item 28 (My direct supervisor helps resolve disagreements between teams (i.e. not who is right but what is best for safety-.751) and item 45 (My direct supervisor consults us when making decisions -.723).
The second new component derived from the experimental factor analysis was termed *Team* because of the following item loadings - item 14 (*People on my team encourage each other to work safely* - .763), item 51 (*in my team there is a high degree of adherence to safety procedures* - .748), item 9 (*in my team we are given enough authority to perform our work safely* - .730) and item 29 (*People on my team always follow safety rules*. - .708).

The final factor extracted was named *autonomy* because it loaded highly on the following items, 48 (*I feel free to challenge a safety related decision* - .748), item 26 (*I feel free to report errors* - .635) and item 16 (*I feel free to ask questions in any forum* - .572).

Table 4.23 Experimental Factor Analysis – Rotated Component Matrix
Factors derived from the exploratory factor analysis were used to generate a
new set of composite variables. For example, a new composite variable (value) was calculated by taking the arithmetic mean of items 38, 7, 57 and 50. The same process yielded new composite variables based on the remaining four factors.

**Reliability of New Composite Variables**

The next step was to examine the reliability of each new composite variable with all items included. Reliability of each composite variable is evaluated via coefficient alpha or Cronbach’s alpha (Manning & Munro 2007). Coefficient alpha for the four item vvalue scale was found to be very good at (α=.891 - see Table 4.24 see below). This new variable vvalue was used as the measure of value in the analysis that follows.

**Table 4.24 Reliability statistics for the variable vvalue.**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s Alpha</td>
</tr>
<tr>
<td>N of Items</td>
</tr>
<tr>
<td>0.891</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

Source: developed for this thesis

The second new composite variable (vlearning) was also assessed in term of its reliability. (see Table 4.25 below) Coefficient alpha for the six item scale was found to be very good at (α=.882). This new variable vlearning was used as the measure of learning in the analysis that follows.

**Table 4.25 Reliability statistics for variable vlearning.**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s Alpha</td>
</tr>
<tr>
<td>N of Items</td>
</tr>
<tr>
<td>0.882</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

The third composite variable (vdirsup) was also assessed in term of its reliability (see Table 4.26 below). Coefficient alpha for the five item scale was found to be excellent
at \((\alpha=0.898)\). This new variable \(vdirsup\) was used as the measure of the relationship with the direct supervisor in the analysis that follows.

**Table 4.26 Reliability statistics for variable \(vdirsup\).**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>0.898</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

The fourth composite variable \((vteams)\) was also assessed in term of its reliability (see Table 4.27 below). Coefficient alpha for the five item scale was found to be very good at \((\alpha=0.854)\). This new variable \(teams\) was found to have an excellent reliability and was used as the measure of teams in the analysis that follows.

**Table 4.27 Reliability statistics for variable \(vteams\).**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>0.854</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

The fifth composite variable \((vautonomy)\) was also assessed in term of its reliability. Coefficient alpha for the five item scale was found to be excellent at \((\alpha=0.893)\). This new variable \(vautonomy\) (see Table 4.28 below) was used as the measure of autonomy in the analysis that follows.

**Table 4.28 Reliability statistics for variable \(vautonomy\).**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>0.893</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.
Having established the reliability of each of the new composite variables, a standard multiple regression analysis was carried out with (Grd_Org) as the dependent variable and \( v_{\text{learning}} \), \( v_{\text{teams}} \), \( v_{\text{dirsupstyle}} \), \( v_{\text{autonomy}} \) and \( v_{\text{value}} \) as the independent values. The model summary is contained in Table 4.29.

### Table 4.29 Multiple Regression Analysis of Composite Variables derived from EFA as Independent variables

#### INDEPENDENT VARIABLES

\[ v_{\text{value}} = \frac{\text{Policy}_q7 + \text{safetytoppriority}_38 + \text{responsibilitiesdefined}_50 + \text{safetyhighpriority}_57}{4}. \]

\[ v_{\text{learning}1} = \frac{\text{independentviews}_41 + \text{self_assessment}_25 + \text{trainingprogram}_32 + \text{safety_assessment}_24 + \text{correctiveaction}_31 + \text{operatingexperience}_33}{6}. \]

\[ v_{\text{dirsup}} = \frac{\text{DS_communicates}_23 + \text{DS_Disagreements}_28 + \text{DS_consults}_45 + \text{DS_Respondsquickly}_18 + \text{DS_encourageopennes}_13}{5}. \]

\[ v_{\text{teams}} = \frac{\text{T_encourageeachother}_14 + \text{T_safetyprocedures}_51 + \text{T_responsibilitiesq}_9 + \text{T_followrules}_29 + \text{T_ownership}_46}{5}. \]

\[ v_{\text{autonomy}} = \frac{\text{challengedecision}_8 + \text{report_errors}_26 + \text{Ask_Q}_16 + \text{RaiseQ}_q11 + \text{easytoreporterror}58}{5}. \]

ENTR \( v_{\text{value}} \) \( v_{\text{dirsup}} \) \( v_{\text{teams}} \) \( v_{\text{autonomy}} \) \( v_{\text{learning}1} \).

#### DEPENDENT VARIABLE

Grd_Org

#### Variables Entered/Removed\(^a\)

<table>
<thead>
<tr>
<th>Model</th>
<th>Variables Entered</th>
<th>Variables Removed</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( v_{\text{learning}1} ), ( v_{\text{teams}} ), ( v_{\text{dirsup}} ), ( v_{\text{autonomy}} ), ( v_{\text{value}} )(^5)</td>
<td>.</td>
<td>Enter</td>
</tr>
</tbody>
</table>

\(^a\) Dependent Variable: Grd_Org.

\(^b\) All requested variables entered.

#### Model Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>( R )</th>
<th>( R^2 )</th>
<th>( \text{Adjusted } R^2 )</th>
<th>( \text{Std. Error of the Estimate} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.770(^*)</td>
<td>.003</td>
<td>.594</td>
<td>.540</td>
</tr>
</tbody>
</table>

\(^a\) Predictors: (Constant), \( v_{\text{learning}1} \), \( v_{\text{teams}} \), \( v_{\text{dirsup}} \), \( v_{\text{autonomy}} \), \( v_{\text{value}} \)
The multiple correlation coefficient (R) is .776 and represents the combined correlation of the five independent variables with the dependent variable. The adjusted R square, of .59 means that 59% of the variation in the dependent measure can be accounted for by the variation in the employee ratings of the five independent measures.

Table 4.29 also contains the results of the ANOVA analysis which allows us to conclude that the relationship between the five independent variables and the dependent measure is significant. Consequently the size of the multiple correlation coefficient (R) between these variables in the population is seen to be greater than zero italics F (5, 240) = 72.78, p=.000.

The next part of Table 4.29 is labelled Coefficients and here there is a significant regression coefficient for the vvalue (t=8.72,p<.000), vteams (t=1.92, p=< .05) and vlearning (t=2.26, p=< .02) which means these variables uniquely and significantly contribute to the regression equation. The other two independent variables (vautonomy and vdirsupstyle ) whilst they do not provide a unique
contribution to the regression equation each adds something to explaining the variance in the dependent measure.

Of particular importance in this table are the figures relating to collinearity. None of the Tolerance figures fall below .3 and none of the VIF figures are greater than 3. These figures signal a lack of multicollinearity amongst the independent measures. Thus, it may be seen that the second regression analysis produced strong support for the model it was analysing.

4.8 Qualitative data analysis

The qualitative analyses conducted in this study examined the recommendations from the respondents as to how their workplace safety culture may be improved. This was in response to the last question on the survey. The qualitative section of the research project was underpinned by the theory of social phenomenology (Schutz, 1970), which takes the view that people living and reflecting on their everyday lives are able to ascribe subjective meaning to the world of work they participate in. The task of the researcher is to uncover those subjective meanings in a way that demonstrate the trustworthiness and credibility of the researcher (Lincoln & Guba, 2005). In this regard, it is important that the researcher be able to transparently describe the process by which an overarching themes were extracted from the participant recommendations. Specifically, overarching themes distilled from the analyses should be able to be supported by raw data to ensure the interpretation of the researcher is directly linked to the actual words of the respondents. The complete list of recommendations from all respondents is contained in Appendix 4.11.
4.9 Thematic analysis

To assist with the analysis of the recommendations put forward by the respondents in the participating organisation this study adopted a template approach devised by Crabtree and Miller (1999) as a way of coding the textual data in a code book that contained a priori categories, based on the research framework adopted by the IAEA.

This is essentially a deductive approach and will be used here to assess the extent to which a qualitative analysis of the recommendations triangulates with the quantitative findings described above. This is a form of methodological triangulation (Neumann 2011) and is essentially a deductive process.

The same raw data can be looked at through qualitative lenses where it is possible to assess the level of support for the data driven model described above which evolved out of the Exploratory Factor Analysis. According to Daly, Kellehear & Glicksman (1997) this use of thematic analysis involves the identification of themes that emerge in the wake of 'careful reading and rereading of the data' (Rice & Ezzy, 1999, p. 258). The process is essentially a data driven one involving an inductive approach wherein the researcher proceeds from the particular to the general. Thus in making the recommendations for an improved safety culture the respondents made suggestions about particular aspects of workplace safety culture that subsequently could be grouped together because of particular patterns or themes they have in common with other similar recommendations.

Fereday and Muir-Cochrane (2006) acknowledge to the usefulness of both inductive and deductive approaches in their study of the perception of nurses.
regarding performance feedback. Hence this study has adopted both an inductive and deductive thematic analysis which represents a hybrid process of identifying themes.

**Deductive thematic analysis**

The deductive thematic analysis used codes developed a priori (i.e. the five theoretical variables thought to be indicative of a strong workplace safety culture - values, leadership, accountability, integration and learning). Thus, the code book was based on the five characteristics set within the theoretical framework adopted by the IAEA.

The series of recommendations from the respondents as to how to improve the workplace safety culture were transcribed from the questionnaires and placed into one of the five a priori codes where applicable (see Table 4.30 below).
Table 4.30 Examples of respondent's recommendations related to the a priori code - *value*.

<table>
<thead>
<tr>
<th>Name of A Priori Code</th>
<th>Attribute</th>
<th>Examples of A Priori Code</th>
</tr>
</thead>
</table>
| Act in a Timely Manner | • Safety issues as brought forward by employees and the HS Committee should be action within 2 calendar months.  
• Speed up decision making process as regards urgent safety issues  
• Timely corrective actions of malfunction of equipment or safety events.  
• Management to be more proactive and responsive to rectifying safety issues after they are identified  
• Safety issues should be addressed and fixed before plant goes back to power |
| Communication | • Continued communications- don’t just rely on broadcast emails or intranet along  
• Information Communication.  
• We are really bad communicators on decisions, on lessons learnt, on changes  
• communicate meaningfully - not PR  
• Communicate effectively  
• Improve communication |
| Production | • Do not let production deadlines & reactor use be so important that it affects worker safety  
• Importance reflected in safety as well as productivity  
• Ensure safety is given priority over production  
• More achievable deadlines |
| Resources for better safety | • More resources for the Safety team  
• Correct financial resourcing  
• Management treats safety seriously - with required resources  
• Ensure funding is available for maintaining the facilities  
• Resource appropriately  
• more safety resources (personnel and equipment)  
• Adequate resourcing |
The allocation of respondent recommendations to all five characteristics is to be found in Appendix 4.11 and is summarised in Table 4.31 below.

**Table 4.31 Coding of respondent recommendations according to the five IAEA characteristics.**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Emergent Attributes</th>
<th># Recommendation per attribute</th>
<th>Total</th>
</tr>
</thead>
</table>
| **Value** (6-emerging attributes) | 1. Resources  
2. Communication  
3. Production  
4. Timely manner  
5. Rewards & Recognition  
6. Value | 47  
40  
16  
13  
13  
11 | 140 |
| **Leadership** (7-emerging attributes) | 1. Consultation & involvement  
2. Safety discussion  
3. Staffing  
4. Competency  
5. Visible Leadership  
6. Openness  
7. Management commitment | 32  
24  
22  
18  
9  
5  
3 | 113 |
| **Accountability** (2-emerging attributes) | 1. Accountability  
2. Compliance with regulations | 36  
26 | 62 |
| **Integrated** (4-emerging attributes) | 1. Documentation & Procedures Quality  
2. Housekeeping  
3. Planning  
4. Workload & Stress | 43  
23  
9  
7 | 82 |
| **Learning** (5-emerging attributes) | 1. Effective Training  
2. Knowledge Sharing Culture  
3. Reporting  
4. Safety Feedback  
5. Complacency | 58  
32  
33  
11  
5 | 139 |

Source: developed for this thesis.
The following 71 recommendations could not easily be allocated to the five IAEA characteristics. Accordingly, they were grouped together in a category called ‘Other’ and were further allocated into five subthemes as depicted in Table 4.32.

Table 4.32 ‘Other’ recommendations not capable of being absorbed the IAEA model.

<table>
<thead>
<tr>
<th># Recommendations</th>
<th>Category: Other</th>
<th># responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>1. Management- walk the talk</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>2. Risk Assessment</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>3. Blame free culture</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>4. root cause investigation</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>5. Auditing</td>
<td>10</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.

Grand Total (536+71) = 607.

As can be seen from the figures in the tables above, of the 607 recommendations made 536 were easily identified as belonging to one of the five characteristics. As Table 4.32 clearly shows the most significant predictor variable from the regression analysis (value) also attracted most of the recommendations.

Inductive thematic analysis

A thematic analysis was conducted using an inductive approach with the same raw data to ascertain the level of support for the alternative model derived from the exploratory factor analysis which proved to be more robust than the IAEA model. A thematic analysis is a search for themes thought to be relevant to the description of a particular phenomenon such as ‘workplace safety culture’. The analytic process adopted here is based on the data driven inductive approach claimed by Boyatzis (1998, p. 8) to produce codes that illustrate the ‘qualitative richness of the
phenomenon’. The emphasis during the initial coding stages is for the researcher to be on the lookout for potential themes or recurring patterns contained in the raw data.

As can be seen in Table 4.33 the initial phase of the thematic analysis was guided by but not constrained by the identification of preliminary codes. Additional codes were grouped together wherever they seemed to represent a subtheme. For example, in the table below it can be seen that the initial coding of items that shared attributes of the theme value could be grouped together to form a new subtheme.
Table 4.33 Data driven (inductive) analysis of respondents’ recommendations for improved safety culture.

<table>
<thead>
<tr>
<th>Component</th>
<th>Sub-themes</th>
<th># Recommendations per sub-theme</th>
<th>Total recommendations per component</th>
</tr>
</thead>
</table>
| Safety communicated as top priority \((\textit{value})\) | • Safety communication  
• Additional resources  
• Practical and streamlined processes  
• Knowledge sharing and safety  
• More staff/workforce  
• Management commitment to lead by example  
• Competency  
• Pressure to produce  
• Prioritise safety related jobs  
• Incentives  
• Continuous improvement of safety  
• Management by wandering around (MBWA)  
• Transparency | 60  
47  
43  
32  
24  
23  
21  
18  
16  
13  
13  
13  
11  
5 | 307 |
| Training, Feedback and Evaluation | • Effective training  
• Reporting  
• Safety feedback | 58  
33  
19 | 120 |
| Empowerment through Consultation and Involvement | • Accountability  
• Consultation & involvement  
• Regulatory compliance – work to rule  
• Complacency and self-satisfaction | 36  
36  
26  
5 | 104 |
| Planning and Monitoring Safety | • Proactive assessment and evaluation  
• In-depth problem analysis  
• External assessment/review  
• Effective and efficient planning | 17  
10  
10  
9 | 46 |
| Specific Safety Practices | Specific safety practices | 23 | 23 |
| Stress | Workload strain and workplace anxiety | 7 | 7 |

Source: developed for this thesis.
4.10 Conclusion

This chapter set out to subject a theoretical model of workplace safety culture to empirical scrutiny. The theoretical framework has been put forward by the International Atomic Energy Agency.

Employees at a high reliability organisation in Sydney, Australia completed a survey questionnaire that allowed respondents to register their level of agreement with a series of statements thought to constitute an effective workplace safety culture. The original survey instrument was modified in order to remove items that were inappropriate and/or redundant.

Following administration of the survey the data were entered into SPSS where initial screening was conducted to ascertain their readiness for further analysis. At the descriptive level it was found that there were marked differences between the perception of the organisation’s workplace safety culture by those in management positions and older employees. These two categories tended to rate the effectiveness of the workplace safety culture somewhat less favourably than those younger employees in non-management positions.

The next stage of the data analysis involved creating composite variables based on attributes for each of the five characteristics. Next, we tested the relationship between each of the five composite variables (independent variables) that formed the theoretical framework for the organisation's workplace safety culture (dependent variable). The use of a Pearson product moment correlation coefficient (Pearson's $r$) showed that the relationship between each of the independent variables and the dependent measure were both significant and positive. In order to establish the strength of each of the predictor variables a multiple linear regression analysis was conducted. Results confirmed general support for the five composite variables.
representing the five characteristics of the IAEA model. The most significant predictor variable was *value* while the weakest predictor was *integrated*. Upon closer inspection of the regression analysis it was found that there was high multicollinearity between the five independent variables which was a cause for concern.

Consequently, in order to ascertain whether the separate survey items were measuring a generalised factor it was decided to undertake an exploratory factor analysis to evaluate the psychometric properties of the survey questionnaire. The results of the principal components analysis with a Varimax rotation suggested a seven factor solution but due to cross loadings only five were deemed interpretable. Of these five, *value* and *learning* replicated the findings of the initial analysis. The item loadings on each of the five components were summated to form a new set of composite variables which were subsequently used in a multiple linear regression analysis to assess the strength of these new predictor variables. Not only was there an increase in the amount of variance accounted for by these five components but the multicollinearity that was present in the earlier analysis was absent.

Finally, a qualitative analysis was conducted on the recommendations put forth by the respondents as to how their workplace safety culture may be improved. The use of both deductive and inductive coding techniques produced general support for both the IAEA model as well as the alternative model. A fuller discussion of these and other findings will follow in Chapter Five.
CHAPTER 5
DISCUSSION and CONCLUSIONS
CHAPTER 5: DISCUSSION and CONCLUSIONS

5.1 Introduction

This research project began by identifying a research problem related to the IAEA’s theoretical framework for assessing safety culture. Despite its widespread adoption by a number of high reliability organisations, up until now it has never been empirically validated. In an attempt to overcome this problem which surfaced as a gap in the literature, the researcher designed the study from within a paradigm that allowed for a mixed methods approach with regard to the collection and analysing the data. The sequence is detailed in the following chapter reviews.

Chapter One “Introduction” provided the background to the research which was intended to assess specific characteristics of safety culture in a high reliability organisation (HRO). The chapter discussed the background to the proposal to investigate what factors determine safety culture and to what extent the IAEA’s Safety Culture Model (2009) measures the safety culture of a HRO in Australia.

Chapter Two “Literature Review” examined the literature pertinent to safety culture and high reliability organisations (HROs). The application of IAEA’s safety culture model was examined in the context of HRO theory. Research questions and hypotheses were formulated.

Chapter Three “Methodology” depicted the methods used in the conduct of the research. Sufficient information was provided to allow an independent investigator to replicate the study.
Chapter Four “Data Analysis” presented the data obtained from the questionnaire. Responses summarised in tabular form offered a detailed analysis of the data collected using statistical tools to test the hypotheses formulated in Chapter Two.

Chapter Five attempts to utilise the findings to shed light on the main research question. The findings will be analysed in relation to the literature reviewed in Chapter Two to identify their contribution to the current body of knowledge. However, the literature review was completed June 26, 2013 and the survey data collection process began at that time. Subsequently, more recent supportive literature was incorporated into Chapter Five to assist in the analysis of the findings. Implications for policy and practice are also discussed. Additionally, the study’s limitations are discussed and further research proposed. The final conclusion summarises the study’s findings, implications and future directions.

**Chapter objectives**

The intent of this chapter is to collate and review the main findings of the study in light of the stated research problem and the research question.

**Chapter outline**

This final chapter contains 13 sections including a Postscript. Following the introductory section, the next section 5.2 provides a general overview of the research findings which are reviewed in relation to the five research hypotheses. In section 5.3 post hoc analyses are discussed in various sub sections of 5.3. Section 5.4 draws conclusions from the findings of the quantitative analyses.

The qualitative findings are discussed in section 5.5 while section 5.6 reviews the overall findings in the light of the research problem. Sections 5.7, 5.8 & 5.9 look at the implications of the research findings for theory, practice and policy. Section 5.10 outlines the
limitations of the study while section 5.11 contains suggestions for future research. Section
5.12 provides a brief conclusion followed by a Postscript to the overall study.

An illustrative overview of the whole chapter is depicted in the concept map in Figure
5.1.
Figure 5.1 Concept map of Chapter 5.

5.1 Introduction

5.2 Main research findings

5.3 Post Hoc Analyses

Rationale for EFA

Value and learning

Direct supervisor

Team

Autonomy

Conclusion about research findings using quantitative analyses

5.5 Qualitative findings

Deductive thematic analysis

Inductive thematic analysis

5.6 Conclusion about the research

5.7 Implications for theory
5.8 Implication for practice

5.9 Implication for policy

5.10 Limitations of the study

5.11 Suggestions for future research

5.12 Conclusion

Postscript

Source: developed for this thesis.
5.2 Main research findings

The purpose of this research was to conduct an empirical test of the validity of the factors comprising the IAEA’s safety culture model. The data came from a survey based on organisational members’ perceptions of various attributes of safety culture. The research question and hypotheses (see section 2.4) were formulated based on this purpose. The five characteristics embodied by IAEA’s theory driven model were analysed based on quantitative data gathered from a modified version of the International Atomic Energy Agency (IAEA) safety culture survey questionnaire. The survey was designed to assess the following five characteristics and 37 attributes of IAEA’s safety culture model: value, leadership, accountability, integration, and learning.

In keeping with the virtue of methodological triangulation (Neuman, 2011) qualitative data was collected from an open-ended question at the end of the questionnaire. The open-ended question was ‘What are your top three recommendations for improving safety in your Organisation?’ A thematic analysis of this qualitative data was undertaken, and recommendations related to the enhancement of safety at the organisational level were grouped into themes (Fereday & Muir-Cochrane, 2006). The results are discussed in section 5.5.

Returning to the main purpose of the survey, organisational members’ perceptions of safety culture were used as the dependent variable; abbreviated as (Grd_Org) in Chapter Four. Five composite variables, representing the five IAEA characteristics were used as independent variables as a precursor to addressing the main research question. That is, to what extent are the variables (value, leadership, accountability, integrated, and learning) related to the perception of the way in which workplace safety is managed? A series of Pearson $r$s confirmed a positive and significant relationship between each composite variable and the aggregated perceptions of employees with respect to the way in which the safety
culture of the organisation was being managed. Having confirmed the five working hypotheses. The next step was to conduct a multiple linear regression analysis which revealed the strength of support for the relationship between the dependent measure (i.e. workplace safety culture) and each of the five predictor variables which had been derived from the five characteristics of the IAEA safety culture model (*value, leadership, accountability, integrated and learning*).

The regression analysis identified two of the five characteristics as making a significant and unique contribution to the determination of an effective workplace safety culture *value* (*t* = 4.75, *p* = .000) and *accountability* (*t* = 2.05, *p* = .04). The other three independent variables did not provide a unique contribution although each contributed to the variance in the dependent variable (see Table 4.20).

In assessing the discriminant validity of each of the characteristics, a number of high correlations between these variables was discovered. In fact SPSS identified significant problems of multicollinearity amongst the five independent variables (*value, leadership, accountability, integrated and learning*). Subsequently, Pearson product- moment correlation coefficients were calculated between the five independent variables. The highest was between *value* and *learning* (.91) and the lowest correlation was between *leadership* and *integrated* (.77).

Overall, the results suggest the presence of a single factor rather than five discrete variables. Recent research by Castro, Gracia, Peiro, Pietrantoni and Hernandez (2013) similarly found that a one-dimensional structure provided a simpler solution than the five characteristics suggested by the IAEA model. Leaving aside for the moment the problem of multicollinearity, the finding that *value* and *accountability* made a unique and significant contribution to the regression equation was seen as partial support for the IAEA model. Certainly, there is strong support in the literature for
both of these variables and some support for leadership, integrated and learning as Table 5.1 below shows.

Table 5.1 Literature related to the main findings of this study

<table>
<thead>
<tr>
<th>Findings</th>
<th>How Derived</th>
<th>Reference example</th>
</tr>
</thead>
</table>

Source: developed for this thesis.

What follows is an attempt to locate support in the literature for each of the five hypotheses.

**Variable: value**

**Working hypothesis (H1):** there is a positive relationship between the variable safety is a clearly recognised value and the 'perception of the organisation's overall safety culture'.

Safety values are beliefs that are shared among the employees and management of an organisation. Safety values drive an organisation’s safety culture and provide the framework in which decisions that affect the safety of employees are made (McKinnon, 2013).

According to Cooper (2002) values consist of a set of core beliefs and attitudes that a person uses to determine how s/he should behave in particular context. At an organisational level these beliefs become shared as a consequence of socialisation and learning experiences.
It comes as no surprise, therefore, that the characteristic *safety is clearly valued* received the most support in both the ratings and recommendations of the respondents. *Value* also had the largest Beta weight in the regression analysis reinforcing the notion that what a culture values will flourish.

In the workplace, it means that safety as a value is not simply viewed as a top priority comparable to other organisational variables such as leadership; rather, it is an ethic that guides everything employees do. Safety is never compromised. In other words, safety as a priority means that in challenging circumstances, priorities of necessity may change but safety as a value forms stable and secure part of the organisation and its prominence does not change with changing circumstances.

(McKinnon, 2013).

**Variable: leadership**

**Working hypothesis** ($H_2$): there is a positive relationship between the variable *leadership for safety is clear* and the ‘perception of the organisation's overall safety culture’.

Leadership is the second characteristic from the IAEA model and it received ambivalent support in this study returning a negative $t$ value in the regression analysis. One possible explanation is that the respondents were rating the performance of the incumbent leadership in the participating organisation rather than rating the importance of leadership to workplace safety. The negative $t$ score seems to suggest that leadership in the participating organisation actually detracts from the way in which the safety culture is managed. This flies in the face of the review of the literature (Chapter Two) which showed that people often emulate the behaviour and espoused philosophies of those they respect. The more such
behaviour is reinforced by their experiences, the more habitual it becomes – and the more philosophies evolve into deeply held values.

Because senior managers are company’s most-highly regarded people, they must actively demonstrate that safety is a high priority value if others to embrace safety as a value. To achieve this, senior management in particular must commit to the vision and spread it throughout their sphere of operations; they must “walk the talk” and lead by example. The concept of management ‘walking the talk’ is nicely explained by Mathis and Galloway (2013) who suggest “that if safety is a core value, your employees will test it. Ask yourself, can we pass the test” (p. 8) ‘and walk the talk’?

Such actions reinforces management’s commitment and rebuts any contention that the company offers only lip-service to safety. As a result, employees believe that safety is taken seriously and will follow suit.

To extend this point further, the IAEA Safety Guide (2009, p. 6) claims that the “ways that decisions are made and communicated are very important aspects of an organization’s safety culture because decisions represent ‘values in action’”. The stated goals, strategies and plans for the organization establish its objectives and priorities in the short and longer terms. The IAEA (2009, p. 7) states “Safety shall be paramount within the management system, overriding to extend all other demands”. According to IAEA (2009, p. 8), managers should “consider safety when establishing goals, strategies and plans, and should align the declared priorities and objectives when allocating resources”.

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Variable: accountability
Working hypothesis ($H_3$): there is a positive relationship between the variable accountability for safety is clear ‘perception of the organisation's overall safety culture’.

According to von Thaden and Gibbons (2008), safety culture denotes the degree to which people and groups will commit to individual responsibility for safety; maintain, improve and communicate safety issues; attempt to actively learn, adjust and adapt, both personal and organisational behaviour based on evidence from past errors; and endeavour to be privileged by association with these values. This definition includes primary attributes such as personal commitment, responsibility, communication, and learning as well as the actions of every member of the organisation. Moreover, personal accountability for safety and risk taking were also constructs that appeared in safety culture surveys.

Most literature mentions responsibility and accountability in some way but not all state it as a core element of safety culture (Flin et al., 2000). It seems logical that each organizational member must feel individually responsible for safety if a safety culture is to thrive. Findings of this research lend support to that belief.

Variable: integrated
Working hypothesis ($H_4$): there is a positive relationship between the variable safety is integrated into all activities ‘perception of the organisation's overall safety culture’.

Benjaoran and Bhokha (2010) created an integrated system for safety and construction management that initially incorporates safety procedures into designs and plans. According to the authors, the system can expedite efficient and successful implementation of safety management during the construction process and it assists in the creation of a safe worksite. The assessment of this model took place on a construction site. The results
demonstrated that the system can be a teamwork tool for designers, project engineers, safety officers, and other project members. It can increase safety awareness of the team and it results in amendments of design and plans to be safe. However, the success of the system necessitates that participant value safety as the most important matter. This finding returns to the idea that individual and cultural values are important. Both the organisational leadership and all organisational members need to value safety. There is probably a relationship between valuing safety and integrating it into all organisational activities, but the findings of this study suggest it was an ill-defined construct that lacked face validity. This finding was also advanced by Castro et al., (2013). Further research might explore this shortcoming in greater detail.

**Variable: learning**

**Working hypothesis (H₃):** there is a positive relationship between the variable safety is learning driven ‘perception of the organisation's overall safety culture’.

Clearly, as with other four characteristics of the IAEA model there is ample support for a connection between empowering leadership and learning and safety behaviours  (Haage, n.d; Cooper &Phillips, 2004; IAEA, 2006; O’Dea et al., 2010; Martinez-Córcoles, Schöbel, Gracia, Tomás, & Peiró, 2012). Based on a study conducted in two Spanish HROs, the findings showed that empowering leadership has a significant relationship with safety participation that is mediated by collaborative team learning. Additionally, the results revealed that the relationship between empowering leadership and collaborative learning is partially mediated by the promotion of discussion and open communication. The authors concluded that an empowering leadership style improves employees’ safety performance, especially safety participation behaviours. Learning from past errors as well as from a successful model is an important element in this process (Martínez-Córcoles, et al., 2012).
5.3 Post Hoc Analyses

Rationale for Exploratory Factor Analysis (EFA)

As reported earlier there were concerns associated with the high correlations between the independent variables in the initial regression analysis. One interpretation that is cautiously advanced is that the five characteristics were virtually measuring the same thing. Accordingly, it was decided to conduct an exploratory factor analysis to see to what extent the item groupings (factor loadings) represented independent variables in the minds of the respondents. A secondary aim was to see whether the psychometric properties of the EFA aligned with the five characteristics which formed the framework of the IAEA model.

An exploratory factor analysis, like a principal components analysis, is the method used when the researcher is attempting to reduce a large number of variables to a smaller number of components (Neuman, 2011).

After inspecting the correlation matrix several items were discarded due to low loadings. Based on the components derived from the exploratory factor analysis an alternative model was built and the findings were used to generate a new set of composite variables. Two of these variables (value and learning) were virtually identical to the respective variables in the IAEA framework but the factor analysis revealed three new variables, namely, direct supervisor, team and autonomy. These three components departed from the IAEA model and together represented an additional 8.3% of the variance. In all, the five variables accounted for more of the variance in the dependent measure than did the five theoretical constructs based on the IAEA model. These unexpected results were incorporated into the existing model and, as a result, advanced its measurement ability. Once a stable component structure was established multiple linear regression was used to confirm this structure and point to evidence of construct validity (Neuman, 2011).

As with other studies of safety culture (e.g. Brittingham, 2006) in this study the
extraction of a large initial principal component accounted for approximately half of the variance. In most cases this component could be labelled ‘culture’.

A possible reason for the loading of many items on a single component is the tendency for respondents to rate the survey items as being highly desirable rather than record a rating that reflects the way in which a particular aspect of safety is being managed. In this study 44 of 51 items relating to attributes of safety culture were rated five or more on a seven-point scale.

Importantly, the results of the factor analysis and subsequent regression analysis indicated that there is some agreement with the IAEA model for two of the characteristics (values and learning) while the other three components (direct supervisor, teams and autonomy) were different and thought to be relevant to the variable safety climate. These themes will be identified and discussed in Section 5.5.

The original aim of this research was to empirically validate the IAEA a safety culture model. It has been made clear in several places that this model has not been properly subjected to empirical scrutiny. Accordingly an attempt was made to measure the safety culture of a high reliability organisation in Australia which produced some unexpected outcomes. Although the model received some support it was evident from the analyses undertaken that there were serious issues with the face validity of some of the five characteristics that constitute the original IAEA model.

This new model with three new components was able to predict 59% of the variance in workplace safety culture compared to the IAEA’s model which accounted for 57%. Consequently, it might be concluded that this newer model is slightly more robust than the IAEA model. More importantly the regression analysis revealed the absence of collinearity suggesting the five independent variables are independent of each other. Taken together, these findings suggest that future studies may use the new instrument to measure safety
culture perceptions in HRO organisations. Moreover, this model could be used to further modify the IAEA model.

Table 5.2 below list the components extracted from the EFA and a summary of the relationship they have with workplace safety follows the Table.

### Table 5.2 Components extracted from the EFA and supported by the extant literature.

<table>
<thead>
<tr>
<th>Findings</th>
<th>How Derived</th>
<th>Reference example</th>
</tr>
</thead>
<tbody>
<tr>
<td>supervisor</td>
<td>EFA</td>
<td>Cohen, Smith, &amp; Cohen, (1977); Mearns et al., 2003; Seo (2005); Dingsdag; et al., (2008); Guldenmund (2010); Branham (2010); Martínez-Córcoles, et al., (2011); Ciavarelli, 2012.</td>
</tr>
<tr>
<td>team</td>
<td>EFA</td>
<td>IAEA (2007); Burman &amp; Evans (2008); IAEA (2009); Sammer et al. (2010); Roberts &amp; Bea (2011).</td>
</tr>
<tr>
<td>autonomy</td>
<td>EFA</td>
<td>Bishop &amp; Scott, (2000); Martínez-Córcoles et al. (2012)</td>
</tr>
<tr>
<td>learning</td>
<td>EFA</td>
<td>Haage (n.d); Cooper &amp; Phillips (2004); IAEA, (2006); O’Dea et al., (2010)</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.
**Value and learning**

The exploratory factor analysis replicated *value* and *learning* from the main study. Since their importance has already been established it is not necessary to revisit that body of literature all over again (see section 5.2). The remaining three components (*direct supervisor, team and autonomy*) are linked to the extant literature and are briefly reviewed below.

**Direct supervisor**

The importance of the relationship between an employee and his/her direct supervisor has been clearly established by the data collected for this research and this finding is well supported in the literature as discussed in Chapter Two. For example, Van Vuuren, de Jong and Seydel (2007) found that what was fundamentally important to securing a commitment to the organisational goals and values was feedback from the supervisor along with a disposition to listen to the employee. This finding adds to I/O theories (Falbruch & Wilpert, 1999; Cooper & Robertson, 2004; Hodgkinson & Ford, 2011) of management and leadership with particular reference to a HRO organisation.

In earlier safety related studies (Hinze, 1987; Barling, Louglin & Kelloway, 2002) it was found that the relationship between the supervisor and worker has an impact on the injury rate. Clearly managerial practices play a vital role in achieving better safety performance. This finding was supported by Andriessen (1978) and Dale (2000) who reported that workers display greater safety initiative when supervisors react positively to the initiative. A further finding was that safety behaviour and safety motivation are enhanced by group cohesion which as has already been established in this thesis as a feature of organisational climate (Koys & DeCotiis, 1990; Seo, 2005; Dingsdag, et al., 2008).

In summary, the importance of the relationship an employee has with his/her direct supervisor cannot be overemphasised as was established in Chapter Two and well documented in the literature (Cohen, Smith & Cohen, 1977; Mearns, et al., 2003; Seo, 2005;
Dingsdag, et al., 2008; Guldenmund ,2010; Martínez-Córcoles, et al., 2011; Ciavarelli, 2012).

In this study it was clear from the results of the experimental factor analysis of employees in the participating organisation regarded management participation and involvement in safety related activities as important behaviours. This finding also featured strongly in the recommendations tabled by the participants at the end of the survey. Overall the identification of the employee-direct supervisor relationship served to underline the importance of management's commitment to workplace safety.

**Team**

Organisational members of the participating HRO in this study saw themselves as part of a team. This was reflected in the exploratory factor analysis where at least six team related items from the survey loaded on single factor. The importance of teamwork in an HRO setting was clearly supported in the literature. For example, Griffin, Burley and Neal (2000) advocated a decentralised approach to the management of safety. Cooperative relationships, an indicator of positive team spirit, allowed team members to achieve organisational goals.

In general, commitment to the organisation/team is a function of the comparative strength of a member’s identification with, and involvement in the organisation/team (Bishop & Scott, 2000). This commitment can be demonstrated by a strong belief in, and approval of, the team’s values and goals; a readiness to employ substantial efforts in support of the team; and a strong desire to sustain membership in the team.

In particular, self-directed work teams are those organisational entities where staff share operationally interconnected tasks and are jointly responsible for outcomes. Individual team members possess the diversity of skills needed to accomplish tasks that are the joint responsibility of the team; and employees obtain feedback and assessments regarding team performance as a group (Bishop & Scott, 2000). Moreover, self-directed teams possess a high
degree of autonomy that encompasses control of the work pace, allocation of tasks, breaks from work and input into the hiring and training of new members.

The factors of team and autonomy revealed by this study support the concept of self-directed teams in general and expand their application to self-directed teams in a HRO organisation where they have been shown to be significant for the perception of safety culture.

A recent study by Martínez-Córcoles, Gracia, Tomás, Peiró and Schöbel (2013) examined how the behaviours of team leaders affected the safety performance of team members in HROs in Spain. The researchers analysed a multilevel model which divided safety performance into three kinds of behaviours. They used a sample of 479 workers in 54 groups from two HROs. The results indicated that the empowering behaviours of team leaders produced higher safety compliance and higher safety participation by team members, whilst risky behaviours decreased. These authors concluded that the outcome provided empirical support for a link between leadership and safety performance behaviours.

**Autonomy**

Closely related to the concept of teamwork was the identification of autonomy in the exploratory factor analysis as another significant factor to emerge. The management of participating organisation need to devolve more autonomy to work groups at lower levels of the organisation. Participants registered concern regarding the need for more autonomy (Give actual authority and responsibility to conduct risk assessment and Ensure people feel empowered to take an active role in safety). This finding is also supported by the literature (e.g. see Hofmann & Morgensen, 1999; Bishop & Scott, 2000; Martínez-Córcoles et al., 2012).

To sum up, findings regarding the factors of teamwork and autonomy/empowerment add to I/O theory (Falbruch & Wilpert, 1999; Cooper & Robertson, 2004; Hodgkinson &
Ford, 2011), especially in regards to the importance of the self-directed team in a high reliability organisation.
5.4 Conclusion about research findings using quantitative analyses

The three new themes uncovered in this study by the EFA (*autonomy, teams and direct supervisor*) are thought to make a substantial contribution to the assessment of workplace safety culture. A case will be made towards end of this chapter for regarding these variables as dimensions of safety climate not safety culture.

5.5 Qualitative findings

From the outset the design of this research project was always going to use a mixed methods approach. We have dealt with quantitative analyses and now turn to a thematic analysis of the recommendations from the respondents as to how the workplace safety culture may be improved. In so doing a methodological triangulation (Neuman, 2011) is utilised to improve the validity of the study.

Two separate thematic analyses (Fereday & Muir-Cochrane, 2006) were conducted (deductive and inductive) using the same raw data (i.e. recommendations from the respondents as to how to improve their organisation’s safety culture).

**Deductive thematic analysis**

Beginning with the deductive analyses it was found that of the 636 recommendations tabled, 565 were easily identified as belonging to one of the five characteristics that formed part of theoretically derived IAEA model of workplace safety culture. The characteristics receiving the most items were *value* (140) and *learning* (139) closely followed by *leadership* (113).

71 recommendations (12%) could not be accommodated by the IAEA framework. Half of these recommendations were related to the establishment of a *blame free culture* and
the necessity of the leadership to *walk the talk*. Of the remaining categories there were 15 recommendations assigned to the category *risk assessment* and the rest were *auditing, root cause analysis* and *complacency*.

**Inductive thematic analysis**

A second thematic analysis was conducted using an inductive approach whereby multiple comparisons resulted in a creation of particular themes. The following table (Table 5.3) depicts the main themes along with some supportive literature.

**Table 5.3 Inductively derived themes.**

<table>
<thead>
<tr>
<th>Findings</th>
<th>Example references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety communicated (value) as top priority</td>
<td>Haage (n.d.); INSAG (1991); Reason (1998); Barling et al. (2002); Sorensen (2002); IAEA (2007, 2009); Burman &amp; Evans (2008); Sammer et al. (2010).</td>
</tr>
<tr>
<td>Training, Feedback and Evaluation</td>
<td>Glendon and Stanton (2000); Fernández-Muñiz et al. (2007); IAEA (2009); Nuclear Energy Institute (2010); NEI (2010); Ciavarelli (2012).</td>
</tr>
<tr>
<td>Planning and Monitoring Safety</td>
<td>Haage (n.d.); Fernández-Muñiz et al. (2007); IAEA (2009)</td>
</tr>
<tr>
<td>Stress</td>
<td>Pitzer (1999); IAEA (2007); Frazier (2011); Ciavarelli (2012).</td>
</tr>
</tbody>
</table>

Source: developed for this thesis.
5.6 Conclusion about the research problem

Whilst a number of instruments have been developed to measure safety culture; there is no general consensus on what metrics should be used to assess safety culture (Guldenmund, 2000; 2007; Dingsdag, Biggs & Sheahan, 2008). The research question was: What are the determinants of an effective safety culture in a HRO organisation? The results of this research represent progress in reaching broad agreement regarding the type and number of factors that determine the perception of safety culture. The relationship between the five IAEA characteristics and perception of a safety culture was affirmed. A relationship was found between each of the five characteristics (value, leadership, accountability, integrated, learning) and the perception of a safety culture. Because published research regarding perceptions of the IAEA model dimensions had not existed before this study was undertaken, this finding provides a significant addition to the known literature.

Finally, the EFA of the relationship between the five characteristics and perception of safety culture revealed three additional factors were important for the perception of an organisation’s overall safety culture: 1. Direct Supervisor; 2. Team; and 3. Autonomy. These factors support and extend variables found in a number of previous studies. In general, the factors identified by this study support a number of the factors identified in previous safety culture surveys by Flin et al. (2000) and Guldenmund (2000), including the following:

- Management Concern
- Personal Responsibility
- Peer Support for Safety
In addition, several of Roberts’ (1990) factors categorised under the general label “Command and Control” as follows: (a) Migration Decision Making, whereby the individual with the most expertise is designated to make the decision; (b) Senior Managers who have a broad perspective on issues and do not micromanage; and (c) Formal rules and procedures, standardization when appropriate, a fixed hierarchy but not bureaucratic correspond to these factors as well. Williams (2010) also noted the importance of leadership.

In fact, The IAEA (2007) citation of teamwork as a part of the overall integration of safety into organisational activities is supported by this finding. Furthermore, these factors support the importance of the IAEA conception of safety culture as commitment of people. According to the IAEA conception, safety culture is divided into two components. The first is the essential organisational framework and is the responsibility of the management hierarchy. The second is the approach of staff members at all levels to the organisational framework. The concept of safety culture depends upon a definition of commitment to safety by everyone involved (Haage, n.d). Teamwork and empowerment represent this commitment.

Several themes important to safety culture also emerged from the qualitative data gleaned from the open-ended questions. These included the following: (a) accountability; (b) communication; (c) consultation, involvement and autonomy; (d) documentation and procedures; (e) effective training; (f) following safety rules; (g) housekeeping; (h) root cause investigation; (i) management/leadership; (j) safety is a clearly recognized value; (k) recognition and reward; (l) reporting; and (m) resources for better safety.
5.7 Implications for theory

The research findings have been shown to reinforce specific findings of previous research regarding the perception of safety culture. For example, the majority of safety culture researchers are in agreement that the aspects of safety culture consist of the following: (a) organisational communication; (b) organizational learning; (c) management commitment to safety; and (d) an environment that rewards acknowledgment of safety issues (Sorensen, 2002). A participative style of leadership has also been noted in some of this research.

Similarly, this list of characteristics has been expanded to include related as well as additional dimensions: (a) organizational commitment; (b) management involvement; (c) employee empowerment; (d) reward systems; and (e) reporting systems (Wiegmann et al., 2004). A just culture (blame free culture) and a learning culture have also been cited by several authors (e.g. Reason, 1998; Cooper &Phillips, 2004; HSE, 2005; IAEA, 2006; O’Dea et al., 2010). In their meta-review, Choudhry et al. (2007) listed the following five attributes appearing in the safety culture literature: (a) management commitment to safety; (b) management support for the labour force; (c) mutual trust between workers and management; (d) empowerment of the labour force; and (e) constant reviewing; including, when necessary, corrective action; system auditing, and frequent improvements. The below Table 5.4 summarises these common theoretical attributes of safety culture:
Table 5.4 Common themes or dimensions of safety culture identified by safety culture reviews.

<table>
<thead>
<tr>
<th>Source</th>
<th>Themes or Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorensen, 2002</td>
<td>Good organizational communication</td>
</tr>
<tr>
<td></td>
<td>Good organizational learning</td>
</tr>
<tr>
<td></td>
<td>Senior management commitment to safety</td>
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<tr>
<td></td>
<td>Working environment that rewards identifying safety issues</td>
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<td></td>
<td>Participative management leadership style</td>
</tr>
<tr>
<td>Wiegmann et al., 2004</td>
<td>Organizational commitment</td>
</tr>
<tr>
<td></td>
<td>Management involvement</td>
</tr>
<tr>
<td></td>
<td>Employee empowerment</td>
</tr>
<tr>
<td></td>
<td>Reward systems</td>
</tr>
<tr>
<td></td>
<td>Reporting systems</td>
</tr>
<tr>
<td>INPO, 2004</td>
<td>Everyone is personally responsible for nuclear safety</td>
</tr>
<tr>
<td>WANO, 2006</td>
<td>Leaders demonstrate commitment to safety</td>
</tr>
<tr>
<td></td>
<td>Trust permeates the organization</td>
</tr>
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<td></td>
<td>Decision-making reflects safety first</td>
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<td></td>
<td>Nuclear technology is recognized as special and unique</td>
</tr>
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<td></td>
<td>A questioning attitude is cultivated</td>
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<tr>
<td></td>
<td>Organizational learning is embraced</td>
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<tr>
<td></td>
<td>Nuclear safety undergoes constant examination</td>
</tr>
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<td>HSE, 2005</td>
<td>Leadership</td>
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<tr>
<td></td>
<td>Two-way communication</td>
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<td></td>
<td>Employee involvement</td>
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<td></td>
<td>Learning culture</td>
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<tr>
<td></td>
<td>Just culture</td>
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<tr>
<td>IAEA, 2006</td>
<td>Safety is a clearly recognized value</td>
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<tr>
<td></td>
<td>Leadership for safety is clear</td>
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<td></td>
<td>Accountability for safety is clear</td>
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<td></td>
<td>Safety is integrated into all activities</td>
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<tr>
<td></td>
<td>Safety is learning driven</td>
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<td>Choudhry et al., 2007</td>
<td>Management commitment to safety</td>
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<td></td>
<td>Management concerns for the workforce</td>
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<tr>
<td></td>
<td>Mutual trust and credibility between management and employees</td>
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<td></td>
<td>Workforce empowerment</td>
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<tr>
<td></td>
<td>Continuous monitoring, corrective action, review of system and continual improvements to reflect the safety at the work site</td>
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<tr>
<td>NRC, 2011</td>
<td>Leadership safety values and actions</td>
</tr>
<tr>
<td></td>
<td>Problem identification and resolution</td>
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<td></td>
<td>Personal accountability</td>
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<td></td>
<td>Work processes</td>
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<td></td>
<td>Continuous learning</td>
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<td>Environment for raising concerns</td>
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<td></td>
<td>Effective safety communication</td>
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<td></td>
<td>Respectful work environment</td>
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<td></td>
<td>Questioning attitude</td>
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Source: adopted from Castro et al. (2013, p. 12)
Safety culture and its relation to safety performance

As O'Dea et al (2010) suggest the challenge in recent years has been to develop an instrument that not only purports to measure safety culture or climate but to do so in such a way that predicts the likelihood of mishaps and incidents occurring. In an attempt to address this issue the authors discuss a number of lag indicators including company accident statistics, identifying organisations that have achieved best practice as well is a range of measures including self-reported safety behaviours. They conclude that the latter measure is a much more reliable indicator of safety and effectiveness than accident rates.

The relationship between safety culture and safety performance has been difficult to demonstrate. As was firmly established in Chapter Two perceptions of safety culture (cognitions) do not readily translate into anything more than a disposition to behave in a congruent fashion. This issue is revisited in the section on future research directions to follow.

Safety culture or safety climate

In spite of the majority of studies listed above which ostensibly concern themselves with attributes of safety culture there is much conceptual blurring in the literature regarding the measurement of safety culture and safety climate. This study purportedly set out to measure a high reliability organisation’s safety culture based on the aggregated perceptions of some 252 respondents to the modified IAEA safety survey. The survey was based on five characteristics derived from the safety culture literature. The five characteristics were subject to empirical scrutiny to assess their potential as lead indicators of the way in which an organisation's safety culture is managed. The question remains as to whether the IAEA survey is a measure of safety culture or safety climate.
Perhaps one of the distinctions between climate and culture has to do with characteristics of the methodological tool employed to measure these latent constructs. Typically, efforts to uncover aspects of safety culture ought to employ qualitative tools such as in-depth interviews whereas attempts to capture aspects of climate are able to adopt a more quantitative approach such as is found with surveys.

This study used a quantitative tool (survey questionnaire) to measure a qualitative construct (safety culture). The only way to resolve this issue is to make the case that climate and culture are flip sides of the same coin and that climate is the empiricist substitute for culture. There is some support for a kind of reciprocity between these two variables (Cox & Cheyne, 2000; Turnipseed, 1988). Elsewhere Ashforth (1985, p. 63) suggests that climate and culture can be located on the same continuum with “climate being more grounded in consciousness (attitudes, beliefs) whereas culture is largely pre-conscious or more to do with tacitly held values”. In light of the above it could be argued that the IAEA model is more suited to safety climate than safety culture. The emergence of teams, direct supervisor and autonomy in this study’s post hoc analyses fits well with Koy’s and Decotiiis’s (1991) and Seo, (2005) dimensions of organisational climate.

To the extent this view finds consensus it may be conceded that the modified survey based as it was on the aggregated perceptions of some 252 employees of an HRO was attempting to measure the organisation's safety climate. In light of possible support for this view (i.e. it would appear more likely that the survey was attempting to identify and validate aspects of safety climate) such a conclusion is reinforced because the IAEA model primarily employed a positivist methodology (survey questionnaire) that set out to assess the members' perceptions of safety related organisational events which is not the best way to uncover deeply held values and assumptions about what shall be done and by whom. If one wanted to retreat from this view then one only needs to accept the suggestions that climate and culture
are reciprocal in nature. The argument has already been put that it is all right to assess safety climate as an acceptable approach to identifying the underlying safety culture (Cox & Cheyne 2000).

Martínez-Córcoles et al. (2011) found evidence that supported a structural model linking leadership and safety behaviour to safety culture and safety climate. Their findings suggested that when safety culture was strong, leader behaviour produced a higher safety climate among organisational members that predicted their perceived safety behaviours.

To reconcile these competing views is beyond the scope of this thesis. It is touched upon here as evidence of the conceptual blurring of these two important organisational variables. No wonder there is confusion regarding how best to measure safety culture, there is no general agreement regarding its conception.

5.8 Implication for practice

Major findings suggest incorporation in the measurement of safety culture several factors that IAEA recommends as safety guidance (IAEA, 2002). These factors, i.e. management walk the talk, auditing, risk assessment and root cause analysis were emphasized in several documents but not in the safety culture model itself. The former documents provide guidance to be used in the IAEA’s Safety Culture Services that offer assistance to Member States in their efforts to develop a rigorous safety culture in their organisations. The factors relevant to the findings of the present study are presented as follows, first practice then policy in the subsequent section:

Top management commitment to safety (IAEA, 2002, p. 10). Both the quantitative and qualitative results of the study point to the importance of this factor – in particular, the leadership attribute of management commitment and “Management- walk the talk”. The
IAEA guidance document notes that this characteristic is critical. Moreover, absence of this characteristic will hinder the development of safety culture. Additionally, it is stated that executive level managers must show their commitment in their conduct, approach to safety and in the distribution of resources, including the time allocated to address safety concerns, particularly the improvement of safety. The emerging attributes of the leadership factor refer to this kind of activity, though the direct supervisor is perceived by employees to be more important than executive level leadership in the present study.

The sub-theme of the value attribute concerning management’s commitment to resources suggests that when formulating objectives management should articulate in quantifiable precise language what is to be accomplished and what resources must be included to complete the job safely. For instance, the Gas blowout at Snorre Alpha, Norway determined that one of the contributing factors was insufficient managing of resources. Resources could include staff, time, tools, and/or financial accounts. (Roughton & Mercurio, 2002).

*Sufficient and competent staff:* Workers confront greater risks if their numbers are inadequate for the work needed or if they do not possess the skills demanded by the work. The number and quality of employees are equally important. The leadership sub-theme of staffing would reflect this factor. Additionally, trained staff assigned to appropriate areas is critical to workplace safety. Staff members need to have a fine grained knowledge of safety related matters as well as their fields of expertise (Burke, Sarpy, Smith-Crowe, Chan-Serafin, O. Salvador & Islam, 2006; IAEA, 2009).

The leadership sub-theme of competency also fits with this attribute. The general level of employees’ credentials, skills and knowledge is evidence of this competence. This insistence of competent workforce should be linked to selection, training, competence
standards and their evaluation. Competence is also affected by wider economic conditions such as the labour market for a specific manufacturing sector and accessible funds for training. The introduction of multi-skilling is risky or prudent contingent upon whether it is correctly applied and resourced, and this feature of competence might be pertinent to evaluate when measuring safety climate (Haas, Rodriguez, Glover & Goodrum, 2001).

Involvement of all employees: Workers will not feel responsible for safety if they are not included in the identification of safety issues and their resolution. Everyone is capable of contributing to safety in an organisation. The follows that the organisation must possess procedures for including workers in safety concerns.

The leadership sub-themes of consultation and involvement are directly related to involvement of all employees and management commitment. Enthusiastic worker participation in safety is significant to develop ownership of safety at all levels and benefit from the exclusive knowledge that workers possess regarding their own tasks. Examples that offer this type of involvement include workshops, risk assessments, worksite design. In enterprises with an effective safety culture, employees and management tell the same story, i.e. safety is viewed as a joint endeavour (HSE, 2012). The sub-theme of safety discussion will be a part of this involvement as well (Choudhrya et al. 2007).

Good housekeeping: When housekeeping is inadequate, probably the employees lack self-confidence, and their managers are not concerned with the material condition of the plant. This situation is a formula for inadequate safety. A sub-theme of the attribute of integrated, housekeeping is critical to preventing accidents. Many companies and individual workers recognize this but too often workload and work pressure can result in poor housekeeping and increased accident rates (Gittleman, Ellenberger, Stafford, Gillen & Kiefer, 2008).
High priority to safety: “Safety breaches probably occur most often in organisations where the tacit attitudes and beliefs signify that production and profit-making goals are more important than goals relating to safety.” (Reason, 1998, p. 29). The sub-theme of production found in this study also supports the importance of this factor to the organisation’s employees. This factor obviously is related to policy but it has to translate into practice otherwise it is little more than rhetoric. A large number of organisations maintain that safety is their highest priority, but, in reality, the behaviour and activity of their members do not support this stated value at all times. The integrity of the organisation is reduced if the actual practice contradicts the value that is advocated.

Moreover, when management is committed to safety and values safety, conflicts between production and safety are minimised. The manner in which the organisation will handle competing pressures and priorities, such as production versus safety, must be clearly articulated, e.g. safety before production. According to Guldenmund (2010) the majority of incidents (72%) are associated with production disturbances. For example, one of the contributing factors in Piper Alpha oil-platform explosion, UK was production versus safety conflicts.

The sub-theme of the integrated attribute, workload & stress, is related to the conflict between production and safety. Variables associated with pace of work and workload appear in many surveys and have been labelled work pressure. An ancillary theme that overlays this factor as well as the management and supervision factors is the equilibrium sustained between pressure for production and safety broadly acknowledged as a key element of a safety culture (ACSNI, 1993). In a global economy of amplified competition, cost reduction and organisational restructuring, work pressure is very likely to impact safety climate at the workplace when time and resources are scarce. This sub-theme shows the significance of
including work climate factors in the overall evaluation of the state of safety (Falbruch & Wilpert, 1999).

The sub-theme of communication also supports the importance of management’s reinforcement of safety culture by their actual practice. Scientific study reflects the truth of the saying, “Actions speak louder than words” (Gillmeister, Badets & Heyes, 2008). Frequently, individuals automatically imitate behaviour and not what is actually spoken. Indicating a possible reason for the significance of direct supervisors in this regard, Thompson, Hilton and Witt (1998) found a contrast between the way managers and supervisors influence safety. They found that managers affect safe behaviours via announcements about anything that comes to their attention. On the other hand, supervisors impact safe behaviours by how fairly they relate with employees. Other aspects of communication namely openness and honesty are critical to safety culture and safety outcomes. Rewards and recognition can also play a role (Choudhrya et al., 2007).

To sum up, most researchers (Thompson et al., 1998; Sawacha, Naoum & Fong 1999; Flin et al., 2000; Sorensen, 2002) agree that the components of safety culture comprise upper management’s commitment to safety, clear communications, organisational learning, a workplace environment that provides incentives for the recognition of safety problems, and a participative leadership style (Choudhrya et al., 2007).
5.9 Implication for policy

*Safety can always be improved:* Organisations should never be content with their safety performance but continuously try to improve. The identification of the sub-theme of *complacency* is related to this. Complacency was one of the main contributing factors in Fukushima Daiichi nuclear disaster, Japan. The broad application of self-assessment will reflect this goal of continuous improvement and underline that safety policies carry with them priority value.

*Openness and communications:* Open communication is essential in an organisation for workers to act efficiently. Moreover, organisation members need to feel confident that supervisors trust them with information. At the same time, they must have the chance to express their concerns, either as a group or on an individual basis. There are many communication channels that organisational leaders can use to create dialogue with their employees. Open communication must be promoted and supported as a part of organisational policy.

Factors emerging in the present study that are related to this policy include the encouragement of a *blame free culture* where employees are not afraid to report errors or areas that need improvement. The *learning* sub-themes of *knowledge sharing* and *reporting* would be a part of this culture. Moreover, to identify areas that need improvement and plan effectively requires a policy of *risk assessment*. *Auditing* to correct mistakes and potential risks must be incorporated into this culture. When incidents occur, *root cause analysis* is necessary to prevent future occurrences.

*Organizational learning:* The approach to any issue is considered as a chance to learn. Moreover, organisational members are willing to learn from each other and share experiences. Organisation members frequently re-evaluate the environment and adjust
in expectation of environmental changes. Learning from safety issues is essential, especially the identification of their true root causes. The learning sub-theme of effective training addresses this factor, as well. It should be noted that the effective training sub-theme was the second biggest sub-theme after value. And it was one of the main factors exhibited in many accident investigations, including Three Mile Island Nuclear Station, Chernobyl and most recently (July, 2013), the derailment of a fiery train carrying crude oil in Canada. Based on the findings of this study, recommendations for effective training include the following: (a) Offer more specific safety training, avoiding training that is too general; (b) Provide practical experience for the safety personnel and not just theoretical training; (c) Streamline training; (d) Provide qualified staff/training; (e) Provide hazard training; (f) Share more in depth knowledge; and (g) Online safety training for practical tasks is inadequate. Therefore, provide professional practical training on how to undertake hazardous activities that includes hands-on practice.

View of mistakes: Errors can be considered opportunities for learning or occasion for reprimand. The perception depends on the wider social culture. Organisational leaders are capable of influencing how employees view errors. For safety, it is essential that workers feel that they can point out safety errors without fear of reprisal. If they fear punishment, the information will be hidden. As a result, the error might be repeated in the future. Again, the blame free culture factor is significant. However, the existence of a blame free culture needs to be balanced with culture of accountability (O'Connor, Kotze & Wright 2011).
5.10 Limitations of the study

Though this research study used a relatively large sample (N= 252) of respondents the sample is not representative of a particular population and cannot be generalised to a wider population (Herbst & Coldwell, 2004). The population included all employees who agreed voluntarily to participate in the study. The views of those who did not participate are unknown. Furthermore, the findings were also limited to the data that could be collected via a survey questionnaire. Finally, the study was conducted in Australia, where the findings are relevant to HROs similar to the organisation surveyed.

In general, survey research is limited by the willingness of participants to honestly answer questionnaires and open-ended questions. Fear of reprisal can be a factor discouraging responses to surveys regarding safety culture. This is especially true in organisations where anonymity of respondents is difficult or impossible to guarantee (Chua & Tsui, 2000).

Whilst this study found a positive and significant correlation between specific safety culture variables and perception of safety culture, these perceptions do not establish that safety practices are causally related to these perceptions. Moreover, the logical question of whether a strong safety culture is correlated with the avoidance or mitigation of hazards and catastrophic events is not answered by these findings. In fact, Antonsen (2009) evinced evidence to suggest that safety culture surveys possess little predictive ability. Elsewhere, (Biggs et al., 2010) doubt the existence of a link between safety culture and improved safety performance. This point is explored in more detail in the following section.

Nevertheless, evidence that particular factors are correlated with the perception of a strong safety culture abounds in the literature and is reinforced by the findings of this study.
5.11 Suggestions for future research

The findings of this study provide a foundation for future research. The new variables (direct supervisor, team and autonomy, management walk the talk, auditing, risk assessment, root cause analyses and blame free culture) factors associated with the perception of a safety culture point to the need to include these factors in future survey questionnaires of safety culture. Moreover, these factors may be used in future research regarding the association of safety culture with safety practices and the prevention and/or mitigation of hazards and catastrophic events in HRO organisations. As Flin et al. (2000) note, the actual test of safety culture assessments resides in their ability to predict organisational safety behaviour. To date no such study has been able to demonstrate a causal nexus between these two important organisational variables.

Validation of safety culture surveys has been attempted in several research studies, usually by contrast with past accident data either regarding self-reported accidents or accident rates for organisational sites. Though findings are promising, further research is needed to determine which factors predict safety performance and could be included in future safety culture models (Flin et al., 2000). To end with, connecting safety culture models to safety practices and safety outcomes will contribute to the overall improvement of safety.

Due to the importance of the role of organisational leaders, studies regarding the role of leadership styles are in abundance, especially direct supervisor’s leadership style. In future research the question may well be asked ‘is transformational leadership more effective than transactional leadership in establishing a safety culture?’ Perhaps both forms are necessary (Zohar, 2002). Additionally, it is hoped that future research would extend the findings of the present study to include additional organisational settings such as healthcare where safety is critical to health outcomes and the achievement of organisational goals.
Another suggestion to improve understanding safety culture dimensions could be to study the same organisation over different periods of time, for instance during periods of stability compared with results obtained when going through periods of great change. Since operating in a stable environment may give prominence to daily working practices, while phases of change might be dominated by problem-solving processes. It would be informative to examine the safety culture in relation to these distinctive responses to different challenges.

Finally, one of the main criticisms of safety culture/climate assessments is that researchers favour quantitative tools, which do not necessarily capture actual behaviour. One of the reasons for this inclination is that it is extremely difficult for external/doctoral researchers to obtain open access to HROs to interview or observe employees. As a result, a survey instrument is the most feasible. In order to improve this methodology, HROs need to be more transparent and adopt an open-door policy to help the research community. The result of improved research and valid findings should be a win-win situation for all the parties involved as valid findings can lead to improved safety.

The road leading to the achievement of the ideal state of safety culture might be long and arduous, but, as they say, a journey of a thousand miles begins with a single step. The benefits ultimately gained most certainly will outweigh the costs of navigating the prevailing disagreements and fragmentation of the concept.
5.12 Conclusion

To the best of the researcher’s knowledge this is the first study that has attempted to assess perceptions of the IAEA’s safety culture model in a HRO organisation in Australia from an empirical as well as a theoretical perspective. Empirically, this research explored links between the IAEA’s five characteristics of the model and organisational members’ perceptions of the way in which their safety culture is managed.

This researcher agrees with Guldenmund, (2010) that future research should focus on the validity of the construct ‘safety culture’ and its ability to predict an organisation’s safety performance. Understanding the relationship between an organisation’s fundamental values and behaviour and subsequent rates of incidents and accidents is critical to the improvement of safety.

Postscript

It should be noted that during the conduct of this study and unknown to the researcher a study testing the validity of the International Atomic Energy Agency (IAEA) safety culture model was underway and was submitted online as of 30 August, 2013 (Castro et al., 2013). This yet to be published study became known to the researcher only after the above research was completed. Some consideration of their main findings are thought to be relevant to the present study.

The findings of the study conducted by Castro et al. (2013) are directly relevant to the present study. Actually, these researchers carried out three independent corresponding studies with the goal of empirically validating the safety culture model of the IAEA. Initially, they surveyed 290 students to obtain data regarding the face validity of the model. Next, they asked 48 experts in organizational behavior to evaluate the content validity of the model. Finally, 468 employees of a nuclear power plant in Spain responded to a questionnaire.
containing 37 items corresponding to the 37 attributes of the IAEA model. Their responses indicated how closely the theoretical five-dimensional model could be duplicated. Resulting large correlations among the five dimensions of the IAEA model suggested that a one-dimensional structure fit the data better than the five dimensions of the model. According to Castro et al. (2013), the results of these studies indicated that a number of the IAEA model’s attributes might not be associated with their corresponding dimensions. They added that the IAEA model appears to have rather moderate content validity and low face validity.

The findings of the present study supported the reliability and validity of the IAEA survey construct dimensions but suggested the model needs improvements where perceptions were problematic. Actually, these problematic areas may dovetail with the findings of Castro et al. (2003) in their study. In the process of examining the psychometric properties of the IAEA safety culture model, a number of unanticipated issues with multicollinearity arose, i.e. there was a high correlation between each of the five independent variables, indicating that these variables were virtually measuring the same element. In our research, we found additional factors that were perceived important for safety culture. The present study agrees with Castro et al. (2003) that the IAEA safety culture model could be improved but stops short of supporting their preference for a one-dimensional model.
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Appendices