IMPROVING THE EFFECTIVENESS OF SAFETY REPORTING SYSTEMS
IN AVIATION ORGANISATIONS

A thesis submitted
in fulfilment of the requirements for the degree of
Master of Engineering

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August 2018
DECLARATION

I, Muhammad Jausan, certify that the work completed is mine alone, that this research has not been submitted previously to qualify for an academic award, that the content of this thesis is the result of work which has been carried out since the official commencement date of the approved research program, that any editorial work undertaken by a third party is acknowledged, and relevant ethics procedures and guidelines have been followed.

Muhammad Jausan

August 2018
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# TABLE OF CONTENTS

Title ......................................................................................................................... i
Declaration ................................................................................................................. ii
Acknowledgements ..................................................................................................... iii
Table of Contents .......................................................................................................... iv
List of Figures ............................................................................................................... vi
List of Tables .............................................................................................................. vi
List of Appendices ...................................................................................................... vii
List of Acronyms and Abbreviations ........................................................................... vii

1. **INTRODUCTION**

1.1 Introduction ............................................................................................................. 1
1.2 Study background .................................................................................................... 2
1.3 Research gaps and significant contributions ......................................................... 4
1.4 Research questions ................................................................................................. 5
1.5 Research aims and objectives ................................................................................ 6
1.6 Summary ................................................................................................................. 6

2. **LITERATURE REVIEW**

2.1 Introduction ............................................................................................................. 7
2.2 Risk management ..................................................................................................... 7
2.3 Safety reporting systems ........................................................................................ 8
2.4 Safety reporting culture .......................................................................................... 9
2.5 Overview of safety reporting systems ...................................................................... 11
  2.5.1 Reporting systems in civil aviation organisations ............................................ 11
  2.5.2 Safety reporting systems in military aviation organisations ........................... 13
2.6 Effective reporting system ..................................................................................... 14
2.7 Previous research on safety reporting systems ....................................................... 16
2.8 Previous frameworks ............................................................................................. 24
2.9 Relevant theoretical approaches in aviation ............................................................ 25
2.10 Developing the conceptual framework and generating hypotheses ...................... 32
  2.10.1 Organisational barriers .................................................................................... 33
  2.10.2 Working environment barriers ......................................................................... 37
  2.10.3 Individual barriers ........................................................................................... 41
  2.10.4 Safety reporting performance indicators ......................................................... 44
  2.10.5 The conceptual framework and hypotheses .................................................... 45

3. **METHODOLOGY**

3.1 Introduction ............................................................................................................. 47
3.2 Research approach .................................................................................................. 47
3.3 Data analysis approach .......................................................................................... 50
  3.3.1 Introduction to the Partial Least Squares method .............................................. 50
  3.3.2 The path diagram ............................................................................................ 53
3.4 Survey research method ........................................................................................ 54
4. VALIDATION AND RELIABILITY

4.1 Introduction ................................................................. 67
4.2 Normality tests ............................................................. 67
4.3 Assessment of measurement model .................................... 68
  4.3.1 The convergent validity ............................................. 70
  4.3.2 The reliability test .................................................. 72
  4.3.3 Discriminant validity ............................................... 74

5. RESULTS AND DISCUSSION

5.1 Introduction .................................................................... 76
5.2 Descriptive statistics of respondents .................................. 76
  5.2.1 Roles ................................................................. 76
  5.2.2 Tenure .............................................................. 77
  5.2.3 Rank ................................................................. 78
5.3 Testing of hypotheses – Partial Least Squares structural model
  evaluation ..................................................................... 79
  5.3.1 Hypothesis H1 ..................................................... 81
  5.3.2 Hypothesis H2 ..................................................... 83
  5.3.3 Hypothesis H3 ..................................................... 84
  5.3.4 Hypothesis H4 ..................................................... 84
  5.3.5 Hypothesis H5 ..................................................... 85
  5.3.6 Hypothesis H6 ..................................................... 86
5.5 Predictive power of the structural model ............................. 86
5.6 Discussion of the results .................................................. 88
  5.6.1 Implications ............................................................ 92

6. CONCLUSIONS AND LIMITATIONS

6.1 Introduction ..................................................................... 99
6.2 Conclusions ..................................................................... 99
6.3 Limitations and recommendations for future research .......... 101

7. REFERENCE LIST .............................................................. 103
LIST OF FIGURES

Figure 2.1: Safety Assessment Criteria (adapted from ICAO, 2013) .................................................. 7
Figure 2.2: Heinrich’s safety pyramid (Heinrich, 1931) ................................................................. 9
Figure 2.3: Effective Reporting Systems (adapted from ICAO, 2013) ................................. 15
Figure 2.4: Reason’s accident causal model (ICAO, 2013) ................................................................. 26
Figure 2.5: The taxonomy of human factors (Shappell & Wiegmann, 2000) ............. 27
Figure 2.6: The level of hierarchy in the socio-technical system (Rasmussen, 1997) ... 28
Figure 2.7: Organisational barriers influencing the effectiveness of reporting system .. 33
Figure 2.8: Working environment barriers influencing the effectiveness of reporting system .................................................................................................................. 38
Figure 2.9: Individual barriers influencing the effectiveness of reporting system ....... 41
Figure 2.10: Conceptual framework to assess the concomitant effect of organisational, environment and individual barriers in the performance of reporting system .......... 45
Figure 3.1: Research Framework .................................................................................................. 49
Figure 3.2: Variables and Indicators ............................................................................................... 53
Figure 5.1: Respondents’ roles percentage ..................................................................................... 77
Figure 5.2: Respondents’ tenure percentage .................................................................................... 78
Figure 5.3: Respondents’ rank percentage ....................................................................................... 79
Figure 5.4: Representation of the path coefficients for the structural model ................. 81
Figure 5.5: Three pathways corresponding to the indirect effects of organisational Barriers (OB) on safety reporting performance (SRP) ......................................................... 82
Figure 5.6: The pathway of indirect effects of working environment barriers (WEB) On safety reporting performance (SRP) .................................................................................. 83
Figure 5.7: The pathway of indirect effect of organisational barriers (OB) On individual barriers (IB) ........................................................................................................ 85
Figure 5.8: The total effects model .................................................................................................. 87
Figure 5.9: Priority map of main barriers affecting the performance of the reporting system ................................................................................................................. 94
Figure 5.10: Priority map showing individual barriers to safety reporting performance ......................................................................................................................... 95
Figure 5.11: Radar plot showing comparison of barriers to safety reporting performance ................................................................................................................................. 96
Figure 5.12: An alternative representation of Reason’s accident causation model in light of the model proposed in this study ................................................................. 98

LIST OF TABLES

Table 2.1: Summary of significant research on safety reporting barriers in aviation and other industries ................................................................................................. 18
Table 3.2: Variables and their descriptions .................................................................................. 54
Table 3.1: Determining Minimum Returned Sample Size .......................................................... 56
Table 4.1: Normality tests ............................................................................................................. 68
Table 4.2: The results of the first stage measurement ................................................................. 71
Table 4.3: The results of the second stage measurement ............................................................. 72
Table 4.4: The results of the reliability test .................................................................................. 73
Table 4.5: Psychometric properties of the measurement model ............................................. 74
Table 4.6: Cross-Loading Analysis ............................................................................................... 75
Table 4.7: Fornell-Larcker criterion analysis ............................................................................... 75
Table 5.1: The role of respondents ............................................................................................... 77
Table 5.2: The tenure of respondents ................................................................. 78
Table 5.3: The rank of respondents ................................................................. 79
Table 5.5: VIF values for the collinearity test .................................................. 80
Table 5.6: Direct and indirect effects used to assess the relationships amongst
variables ........................................................................................................... 81
Table 5.7: Assessment of the predictive power and relevance of the model ........ 87
Table 5.8: Pathways corresponding to the indirect effects in the structural model .... 91

LIST OF APPENDICES

Appendix A1: The questionnaire (English version)
Appendix A2: The questionnaire (Indonesian version)
Appendix B1: PLS algorithm Analysis (Complete Model)
Appendix B2: PLS algorithm Analysis (Model without WEB2 and IB5)
Appendix C: Bootstrapping Analysis
Appendix D: Blindfolding Analysis
Appendix E: Importance-Performance Map Analysis (IPMA)

LIST OF ACRONYMS AND ABBREVIATIONS

ADF Australian Defence Force
AMOS Analysis of a Moment Structures
ANOVA Analysis of Variance
ASI-NET Aviation Safety Information Network
ASRS Aviation Safety Reporting System
ATC Air Traffic Controller
ATSB Australian Transport Safety Biro
AVE Average Variance Extracted
BCL Battelle Memorial Institute's Columbus Laboratories
CA Cronbach's Alpha
CAHRS Confidential Aviation Hazard Reporting System
CASRP Confidential Aviation Safety Reporting Program
CB-SEM Covariance-based Structural Equation Modelling
CHIRP Confidential Human Factors Incident Reporting Program
CR Composite Reliability
EASA European Aviation Safety Association
ECR European Central Repository
FAA Federal Aviation Administration
HFACS Human Factor Analysis and Classification System
ICAO International Civil Aviation Organisation
IDAF Indonesian Air Force
KAIRS Korean Aviation Voluntary Incident Reporting System
LISREL Linear Structural Relations
NASA National Aeronautics and Space Administration
NTSB National Transportation Safety Board
PLS Partial Least Square
RCSV Confidential Flight Safety Report
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>REPCON</td>
<td>Report Confidentially</td>
</tr>
<tr>
<td>REX</td>
<td><em>Retour d'Expérience</em></td>
</tr>
<tr>
<td>SA</td>
<td>Safety Assurance</td>
</tr>
<tr>
<td>SCASS</td>
<td>Sino Confidential Aviation Safety Reporting System</td>
</tr>
<tr>
<td>SEM</td>
<td>Structural Equation Modelling</td>
</tr>
<tr>
<td>SINCAIR</td>
<td>Singapore Confidential Aviation Incident Reporting</td>
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<tr>
<td>SMS</td>
<td>Safety Management Systems</td>
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<tr>
<td>SNS/SRS</td>
<td>Safety Occurrence Reporting System</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences</td>
</tr>
<tr>
<td>SRM</td>
<td>Safety Risk Management</td>
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<td>TACARE</td>
<td>Taiwan Confidential Aviation Safety Reporting System</td>
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<tr>
<td>TWA</td>
<td>Trans World Airlines</td>
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<td>USAF</td>
<td>The United States Air Force</td>
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<tr>
<td>VIF</td>
<td>Variance Inflation Factor</td>
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CHAPTER ONE
INTRODUCTION

1.1 Introduction

Safety Management Systems (SMS) have been widely adopted by civil and military organisations to minimise risks in the aviation sector. One of the fundamental tools required for the correct implementation of a safety management system is the adoption of an effective safety reporting system. The reporting system allows an organisation to collect in a timely manner accurate information related to hazards, incidents or accidents (ICAO, 2013). Those reports are very useful as they can provide critical information to determine the factors contributing to the many safety-related occurrences within an organisation. Based on these findings, adequate recommendations and pre-emptive actions can then be put in place to prevent the same occurrences in the future, thus contributing to the improvement of the safety level of the organisation.

One of the roles of a safety reporting system is to raise awareness about every single safety concern within an aviation organisation among those people who have the power to effect changes or implement a suitable initiative to address the safety issues (O'Leary & Chappell, 1996). In order to deliver safety information from the frontline operation personnel to the decision makers, the establishment of an effective safety reporting system for workers who are either directly or indirectly involved in daily aviation operations, should be pursued by aviation organisations.

This research aims to identify the key barriers that influence the effectiveness of reporting systems in aviation organisations. The effectiveness of a reporting system in this context refers to its capacity to collect safety information as an internal objective of the organisation (i.e., internal effectiveness). Given both the professional background of the author and the safety performance history of the IDAF (Indonesian Air Force), the information relevant to this study will be collected mainly via surveys and questionnaires conducted in several units in this organisation, and covering all levels of personnel who are involved either directly or indirectly in any type of flight activity (thereby addressing different operational scenarios). Data collected from these surveys will be quantitatively analysed using the structural equation modelling technique to provide an accurate assessment of the barriers and their corresponding level of impact that concurrently influence the performance of the existing reporting system. This thorough analysis will contribute to a better understanding of improved approaches to the implementation of more
effective reporting systems, thereby supporting the ultimate objective of any SMS: to enhance safety culture at all levels of an organisation.

1.2 Study background

One of the objectives of any aviation organisation should be to prioritise the improvement of safety levels in the context of all activities undertaken within the organisation, as well as those involving third parties. This also applies in particular to military aviation organisations, which might face more complex risk assessment processes due to the inherent nature of their operations. Military aviation organisations that have low safety levels leading to higher accident rates risk could face serious consequences such as fatalities, lack of fighting readiness, the high cost of replacement, poor morale and low credibility.

In order to manage safety in an aviation organisation, a Safety Management System (SMS) should be implemented to ensure safe operations through the effective management of risk. In fact, Risk Management (RM) is a core component of any SMS designed to provide a systematic approach to hazard identification, risk analysis, risk evaluation and risk control (ICAO, 2013). The collection of data pertaining to potential circumstances affecting flight safety is a critical factor for the success of an SMS, as it constitutes the main feeder for the first element of a Risk Management process, i.e., hazard identification. This information should comprise all types of occurrences (such as hazards, non-critical safety events, near misses, incidents, serious incidents or even accidents) related to a flight activity, and it should be proactively provided by all intervening entities directly or indirectly engaged with a flight activity as a means of implementing accurate and expeditious risk-mitigation actions. Hazards may result from operational systems that are flawed in their design or result from technical, human, and/or environmental factors. Furthermore, failure to conduct risk assessment will lead to various events with both lower-consequence occurrences (incidents) and greater consequences (serious incidents and accidents). Hence, it is crucial to capture both the hazards and their corresponding potential consequences in all sectors of an aviation organisation. However, the next important question is how to collect this information efficiently and effectively.

There is substantial evidence to show that safety reporting systems in both civil and military aviation organisations have not been able to adequately provide sufficient information/data (ATSB, 2014; EASA, 2012), which is essential for identifying hazards and investigating safety occurrences in different operational environments. These facts will
affect both the quality and quantity of recommendations for reactive, proactive and pre-emptive actions for the prevention of reoccurrences.

Sub-optimal performance remains a major issue of most reporting systems, even in aviation organisations that have more mature safety reporting systems. A number of organisations worldwide have reported this underperformance trend. For example, the Australian Transport Safety Bureau (ATSB, 2014) stated that under-reporting of safety matters had been identified as a Safety Watch Priority for improving transport safety in Australia. Similarly, the European Aviation Safety Agency (EASA, 2012) reported that a significant 48% of all occurrences went unreported in EASA member states during 2005-2012. In the particular case of the Indonesian Air Force (IDAF), the ineffectiveness of the existing reporting system has been identified as an obstacle to the implementation of adequate preventive actions which would improve safety performance at all levels of the organisation. The IDAF’s reporting mechanism showed poor performance for the period between 2006 and 2014, demonstrated by the low number of occurrences reported annually (i.e., approximately 100 reports concerning incidents and hazardous situations) (IDAF, 2014). This outcome was well below the expected level considering the high number of fatal accidents that occurred during the same eight-year period. With an average rate of more than two fatal accidents per year, and considering that for each accident there are approximately 300 minor occurrences (Heinrich, 1931), the expected number of safety reports should be at least around 600 per year. James Reason (1997) demonstrated that there is a clear relationship between the number of minor safety-related events (e.g., near misses or minor incidents) and accidents, as the former typically lead to a chain of events that culminate in the latter.

Furthermore, other authors have clearly stated that there is a high degree of under-reporting of safety concerns in aviation (Darveau, 2015; Gilbey, Tani, & Tsui, 2015; Tani, 2010). Only 13% of actual incidents involving air supply contamination in aircraft were reported by members of the Association of Flight Attendants (Murawski & Supplee, 2008). Other evidence at different operational levels corroborates the poor performance of current reporting systems. For instance, several wire strike occurrences had not been reported by either the pilot or the operator and, subsequently, it was found that 40% of wire strikes had gone unreported (ATSB, 2012).

Learning from the aviation industry, safety reporting systems have also been applied in other industries including health care, chemical, energy, and land and sea transportation.
However, all these sectors face identical under-reporting issues, which is a result of the concomitant effect of numerous barriers (Ashcroft, Morecroft, Parker, & Noyce, 2006; Barach & Small, 2000b; Clarke, 1998; Cullen et al., 1995; Grootheest, 1999; Mahajan, 2010; Pronovost et al., 2009). In Chapter 2, we will elaborate further on the various barriers found in other industry sectors.

1.3 Research gaps and significant contributions

A comprehensive literature review was conducted to establish the context and theoretical background of safety reporting based on previous studies in the broader context (i.e., across different industries) and in the aviation sector in particular. The review also covered main theoretical concepts for identifying the barriers to effective safety reporting, enabling the identification of the knowledge gaps in this area. By addressing these gaps, this research aims to make a significant contribution to the body of knowledge, relying on a holistic approach to the problem of the under-reporting of safety occurrences.

Firstly, most studies in this area focused mainly on the identification and significance of each barrier and how it influenced the performance of reporting systems as a separate contributory factor (Chen, 2010; Darveau, 2015; Gilbey et al., 2015; Tani, 2010). However, and to the best of the author’s knowledge, the way(s) in which the various barriers simultaneously affect the performance of the reporting system has never been addressed in previous studies. The main advantage of the method applied in this study is that it enables an accurate quantification of the concurrent effects of safety barriers in the performance of safety reporting system, allowing for a more effective and efficient use of resources and application of bespoke tools. These unique features offer decision makers an accurate and systematic model for prioritising issues according to their significance in the safety domain, allowing the timely implementation of adequate preventive actions in order to avoid accidents.

Furthermore, the literature review revealed that barriers to reporting are affected by the multiple levels of the organisational hierarchy of systems (Holden & Karsh, 2005, 2007), which also explicitly appears in the organisational accident model proposed by James Reason (1997), the modelling problem level suggested by Rasmussen (1997) and the human factors analysis and classification system developed by Shappell and Wiegmann (2000). However, the previous research focusing on the aviation sector did not clearly assess and specify the barriers to reporting that exist at each level. Additionally, several aspects of the barriers to
safety reporting related to leadership, financial support, the use of information technology, organisation structure, code of silence, high workload, and team culture, have not been fully assessed. Therefore, in order to acquire a more thorough understanding of these barriers, there is a need for a more comprehensive research that considers the concurrent effect of all major barriers: organisational, working environment and individual.

Finally, it is important to assess the perception or behaviour of aviation industry employees in the context of different cultures (e.g., different countries) and various organisational environments, as the results of a given study applicable to a particular organisation will not necessarily represent the whole aviation community. The importance of additional research in this area has been highlighted in several previous studies (Darveau, 2015; Tani, 2010). By investigating the perceptions and behavioural characteristics of local workers, this will lead to recommendations for a successful reporting system since its design must be relatively compatible with the characteristics of the workplace (its users, tasks, environment, and organisational factors) (Holden & Karsh, 2005, 2007; Karsh, Escoto, Beasley, & Holden, 2006). To the best of this researcher’s knowledge, no studies to date have investigated the opinions and behaviours, regarding safety reporting, of personnel who work in military aviation organisations. The military organisations represent a specific occupational culture that is relatively isolated from society (J. Soeters, Winslow, & Weibull, 2006) as they are considered to have users, environments, and organisational structures that are distinct from those in the civilian domain. Therefore, research based on data sourced from participants working in a military organisation (including mechanics, pilots, and support personnel) will help to identify the specific characteristics of that organisation. Since this study may be influenced by the local context of the organisation (e.g., national culture), the extrapolation of findings to other aviation organisations in other countries, for example, should take into consideration local factors that might lead to different outcomes.

1.4 Research questions

Based on the research gaps identified in the previous section, this research intends to address the following questions in the context of the IDAF:

- RQ1: What are the barriers to the reporting of safety issues, taking into consideration all the dimensions of this organisation?
- RQ2: How do the identified barriers concurrently influence the performance of the safety reporting system in this organisation?
• RQ3: How can the performance of the safety reporting system in this organisation be predicted based on the identification of barriers?

1.5 Research aims and objectives

Considering that under-reporting is a common problem in many voluntary reporting systems, the overarching goal of this research is to investigate the concurrent effects of the key barriers that affect the performance of safety reporting systems. The specific objectives of this research are to:

• Identify the key theories linked to safety reporting systems and their implementation, envisaging the identification of the key barriers for reporting in broader contexts.
• Investigate the best method for identifying the barriers that influence the performance of a safety reporting system.
• Develop an analytical model to quantify the contribution of each identified variable to the performance of safety reporting systems.
• Identify the performance of the reporting system based on the information provided by the analytical model.
• Develop recommendations and suggestions for further improvements to future safety reporting systems.

1.6 Summary

This chapter has introduced the subject of interest of this thesis. Specifically, it has provided the background of the study, identified the gap that has emerged from the literature review (to be further elaborated in the following chapter), explained the significance of the study, formulated the primary research questions, and stated the primary aims and objectives of the research.
CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter will present a view of the pertinent literature on safety reporting, not just in the aviation sector but also in other relevant industries. This chapter will lead to the establishment of the conceptual model or framework and statement of hypotheses that will guide this study.

2.2 Risk management

In many industries (including the aviation sector), the magnitude of risk is conventionally assessed using two parameters: likelihood and consequences. Alexander (2003) defined risk as a combination of the probability of the occurrence of a hazard and its severity. This complex combination can never be removed completely from real operational scenarios due to the inevitable involvement of human factors at all levels of an organisation. However, it can be reduced or mitigated to an acceptable risk level by implementing adequate safety risk management.

Safety risk management is a key component of the safety management process, which assesses potential hazards and risks, developing and implementing an effective and appropriate mitigation strategy (ICAO, 2013). Eventually, it will determine whether a safety risk is acceptable or unacceptable according to certain criteria, as illustrated in Figure 2.1.

<table>
<thead>
<tr>
<th>TOLERABILITY DESCRIPTION</th>
<th>SUGGESTED CRITERIA</th>
</tr>
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<tbody>
<tr>
<td>Intolerable region</td>
<td>Unacceptable under the existing circumstances</td>
</tr>
<tr>
<td>Tolerable region</td>
<td>Acceptable based on risk mitigation (which may require a management decision)</td>
</tr>
<tr>
<td>Acceptable region</td>
<td>Acceptable</td>
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Figure 2.1: Safety Assessment Criteria (adapted from ICAO, 2013)
By determining the risk appropriately, preventive actions can be effectively implemented in order to reduce the likelihood that hazards will become occurrences with negative consequences. However, the successful outcome of this system will rely totally on the whole risk management process comprising the collection of accurate information, which will feed in the subsequent phases of the Risk Management process, namely hazard identification, risk assessment, risk control and monitoring. In the first step of the process, the most common means of collecting information is via mandatory reporting and voluntary reporting systems.

2.3 Safety reporting systems

Safety reporting systems play an important role in an SMS as they provide the system with key information on safety occurrences which enables a more accurate and comprehensive risk management process. This process generates feedback to decision makers who in turn will be able to implement recommendations or action plans proactively.

A reporting system is a fundamental element of a safety management system as it enables the accurate and timely collection of pertinent information related to hazards, incidents or accidents (ICAO, 2013). Information about occurrences is normally gathered and stored in a database, enabling classification according to the nature of events. Then, based on the frequency and significance of events, various actions can be taken to prevent recurrences, such as alert messages, quick response, dissemination of information via specific literature (e.g., newsletters, technical magazines), focus studies/research, and online database searches (NASA, 2014).

It has been conclusively shown by safety experts that collecting safety-related information is a crucial element of a mature safety system. James Reason (1997) argued that information pertaining to hazards, near misses, incidents, and serious incidents is critical because these occurrences constitute a chain of events that lead to an accident, particularly at the level of the underlying causes. Moreover, statistics show that often there are approximately 300 incidents and 29 serious incidents before the occurrence of an accident, which serves as the basis for the well-known Heinrich safety pyramid illustrated in Figure 2.2 (Heinrich, 1931). This corresponds to a ratio of 90.9% of incidents, 8.3% of serious incidents, and only 0.3% of accidents. More recently, a similar study noted that one fatal accident occurs for every 600 incidents, corresponding to a ratio of 1 to 600. This study found a higher ratio of accidents than the one determined by Heinrich, but it made a similar point: many
minor incidents occurred before culminating in an accident (Bird & Loftus, 1976). Regardless of the source of the accident-to-number-of-occurrences ratio, the following can be inferred: that the identification of unsafe practices and unsafe environments will contribute to a reduction in the number of accidents and their consequences.

![Heinrich’s safety pyramid](image)

**Figure 2.2: Heinrich’s safety pyramid (Heinrich, 1931)**

Studies in other industries/sectors revealed various ratios of accidents and incidents which may have been influenced by different environments, the adoption of distinct definitions of major and minor safety occurrences, research methods, and procedures (Hubbard & Neil, 1985, 1986). In the case of the aviation industry in particular, the percentage of accidents from all occurrences gathered by the ECR (European Central Repository) escalated to 2% (EASA, 2012), which is significantly higher than the ratio proposed by Heinrich (0.3%). In short, despite the various statistics and corresponding ratios found by these studies, the key point is that there are a significant number of incidents or near misses before a catastrophic event occurs. This valuable information should be captured by effective reporting systems that can play an active role in the implementation of preventive actions.

### 2.4 Safety reporting culture

Culture is defined in various ways depending on the context, time, and place. ICAO (2013) states that culture is characterised by the beliefs, values, biases and their resultant behaviours that are shared by members of a society, group or organisation. The Confederation of British Institute (1991) argues that culture is “the way we do things around here”. Hence, a safety reporting culture can be defined as the way (beliefs, values, biases,
behaviour) in which safety reporting is conducted within an organisation, workplace or environment.

ICAO (2013) stated that a reporting culture emerges from personal beliefs and attitudes toward the benefits and potential detriments associated with reporting systems and the ultimate effect on the acceptance or utilisation of such systems. Therefore, reporting cultures are greatly influenced by organisational, professional, and national cultures as these have an enormous influence on the way people perceive safety from a broader perspective. As such, it could be simply said that all the elements fostering a sound reporting culture will inevitably lead to a better performance of existing reporting systems, thus facilitating the gathering of more information on hazards and safety occurrences.

An effective reporting system also helps to foster a reporting culture among members of an aviation organisation whereby they understand and recognise the hazards inherent to their operations and are aware of ways in which the defence systems can be breached. James Reason (1998) concluded that at the heart of any safety culture lies an informed culture which requires the creation of an effective reporting culture that is underpinned by a just culture. This, in turn, entails a good understanding of the line between acceptable and unacceptable behaviours. In other words, the creation of an effective reporting system will inevitably contribute to the development of a safety culture in any aviation organisation.

Hofstede (1980) stated that culture is not a characteristic of individuals; it encompasses a number of people who have been conditioned by the same education and life experience. The culture of a group, tribe, a geographical region, a national minority, or a nation, comprises the collective mental programming that these people have in common. This mindset might be different from that of other groups, tribes, regions, minorities or majorities, or nations. Hofstede believes that culture is often difficult to change and if it does change, it does so slowly. This suggests that every management effort to develop safety culture or reporting culture in aviation organisations will have a correlation with the existing local culture, organisation culture and even with a national culture.

An important question is how local culture influences the implementation of the theory of management, which is developed in countries having different cultures. For instance, will a safety reporting system developed in the USA work just as well in Asian countries? Hofstede (1980) strongly believes that theories of management reflect the cultural environment in which they were written, and its policies can lose their effectiveness when the
cultural environment changes. According to Hofstede, an important implication of this issue is that identical personnel policies may have different effects in different countries.

Therefore, in order to determine the effectiveness of a safety reporting system, it is essential to determine how a local culture, including organisational, professional and national sub-cultures, influences the safety reporting culture.

2.5 Overview of safety reporting systems

2.5.1 Reporting system in civil aviation organisations

The first structured reporting system was established in 1975, known as the ASRS (Aviation Safety Reporting System). This system was developed by NASA and its contractor, BCL (Battelle Memorial Institute's Columbus Laboratories) with the recommendation and endorsement of the FAA. The objective of this system is to encourage the reporting and identification of safety deficiencies and discrepancies in aviation organisations before they can cause accidents or incidents.

According to Reynard, Billings, and Cheaney (1986), the establishment of the system itself was motivated by a tragic accident on 1st December 1974, when a Trans World Airlines (TWA) aircraft collided with a mountain top in Virginia because of misinterpretation of an approach chart and miscommunication with the ATC on duty during this flight. The NTSB investigation found that just six weeks before the accident, a United Airlines crew had very narrowly escaped the same fate using the same approach procedure in the same location. United Airlines itself had established an internal reporting procedure one year earlier in January 1974 called “Flight System Awareness Program” whereby crew members were encouraged to report anonymously to the company any incident they experienced. The crew member who was involved in a similar incident before the TWA flight crash followed this procedure. As a result, other United Airlines pilots became aware of the hazard, and the FAA was notified as well. Unfortunately, there was no system in place that could broadcast and raise awareness of this hazard worldwide.

The ASRS was equipped with a disclaimer exempting it from criminal actions, reportable accidents offering limited immunity and anonymity to reporters. These features were intended to address the old problem of fear of consequences such as concerns about liability, incrimination, disciplinary action, and publicity. Additionally, a significant feature of this system was the involvement of a third party, NASA and its contractor BCL, in this
project. Because the FAA acted as both regulator and enforcer, it could not be considered as an appropriately impartial referee.

The immunity principle in the ASRS program experience was the subject of much debate among stakeholders in 1979, leading to its modification. The previous immunity system offered blanket immunity to all people involved in a certain event, even though only one person reported to the ASRS. However, in the new system, the immunity was given only to those people who sent in a report. A positive advantage of this change is that a number of reports with various viewpoints and perspectives would be submitted for a single occurrence which is considerably useful for investigation purposes (Reynard et al., 1986). The concept of immunity was strengthened by Federal Aviation Regulation 91.57, which stated that the FAA would not use information submitted to NASA via ASRS in any enforcement action, except for information that is not included in the program.

The other important feature of the ASRS system is that it is a voluntary system which is characterised by higher quality reporting by individuals motivated by a genuine intention to resolve a safety issue or "filling-in the blank" (Reynard et al., 1986). On the other hand, mandatory reporting systems are prone to treating a problem superficially and may produce less data (Reynard et al., 1986).

According to NASA (2014), "ASRS has securely processed over one million reports in its 38-year history. The process contains critical elements that ensure each report is handled in a manner that maintains reporter confidentiality while maximising the ability to accurately assess the safety value of each report. ASRS report processing begins with the receipt of reports through electronic submission or from the post office, and ends with the final coded report entering the ASRS Databases".

Therefore, the ASRS system was widely known as a notably successful reporting system regarding the amount of data collected.

At least 12 countries in the world have adopted analogous voluntary systems in their organisations including:
- United Kingdom: Confidential Human Factors Incident Reporting Program (CHIRP) [1982]
- Canada: Confidential Aviation Safety Reporting Program (CASRP) [1985], (SECURITAS) [1995]
Despite those reporting systems being inspired by the same source, ASRS, their application varies in terms of inclusion of the intended community, ways of reporting, promotion, accessibility, language, funding, and operating agencies.

2.5.2 Safety reporting system in military aviation organisations

There are no tangible differences between the safety reporting system of a military aviation organisation and that of a civil/commercial aviation organisation. However, in some respects, a military aviation organisation has more specific criteria relating to occurrences that need to be reported.

Both civil and military aviation organisations have introduced the notion of confidentiality and non-punitive action in order to encourage the reporting of matters related to safety. Safety reporting in military organisations is also intended to be a means of collecting safety-related information such as mishaps (USAF, 2016) and incidents (ADF, 2012; IDAF, 2011), which can be used for investigative purposes and to develop recommendations for preventive actions. Furthermore, the expected outcomes of this program in military aviation are the preservation of lives and resources, and the maintaining of combat readiness (IDAF, 2011; USAF, 2016).

In military aviation, some occurrences are not related to safety matters that need to be reported. Such occurrences may be the result of the direct action of enemies or by intended or anticipated damage, including missile and ordnance firing or destruction of property, in-flight jettison of external stores or release of canopies, cargo, doors, drag chutes, hatches, life rafts, auxiliary fuel tanks, aerial refuelling hoses/drogues, missiles, drones, rockets, payload fairing, and explosive munitions.
A notable feature of safety reporting in military aviation is that the system has several levels and is centralised. Generally, military organisations have three main levels: tactical, operational, and strategic. This hierarchy influences the way in which they implement their safety reporting system, this being distinctive from reporting systems in the civil domain. For instance, IDAF’s safety reporting system has three main levels when dealing with occurrences. The bottom level, usually called "Home base operation, wing and unit", is responsible for investigating hazards and occurrences, which are classified as incidents with minor or no consequences. The next level is the operational level called the “Operational Command”, which is responsible for investigating any safety reports of incidents which are considered as serious with major consequences such as repairable damage or non-fatal injuries. The highest level is the strategic level called “IDAF safety services”, responsible for conducting investigations into fatal accidents. Moreover, they collect any safety reports from all levels of the organisation, including supervised incident investigation reports in units, or warnings sent of possible hazards based on the safety reports statistics. The hierarchical levels of a safety reporting system are also evident in the USAF and RAAF reporting systems, although these organisations have a greater number of levels.

Within the IDAF, safety reports can be submitted by all personnel within a unit, wing, home base and command organisation throughout the IDAF’s safety reporting system by means of phone, fax or email. Similarly, the US military provides more avenues for safety reporting, including the direct reporting of mishaps to safety personnel via phone calls, authorised forms or handwritten reports submitted to safety officers for action, or through direct entry of mishap data into the safety data system (Mark, 2015).

2.6 Effective reporting system

The collection of information about hazards, incidents or accidents has been unanimously recognised as a fundamental activity in the safety management system, particularly in supporting SRM (Safety Risk Management) and SA (Safety Assurance); therefore, every aviation organisation is encouraged by the ICAO to implement a safety reporting system.

As shown in Figure 2.3, an effective reporting system has five characteristics: information, flexibility, learning, accountability, and willingness (ICAO, 2013).
1. Information means that people are knowledgeable regarding the human, technical, and organisational factors that determine the safety of the system as a whole.

2. Flexibility means that people can adapt their reporting mode when facing unusual circumstances, shifting from the established mode to a direct mode, thus allowing information to quickly reach the appropriate decision-making level.

3. Learning means that people have the competence to draw conclusions from safety information systems and the will to implement major reforms.

4. Accountability means that people are encouraged (and rewarded) for providing essential safety-related information. However, there is a clear line that differentiates between acceptable and unacceptable behaviour.

5. Willingness means that people are willing to report their errors and experiences.

A mature organisation will report not only the occurrences with significant consequences but also the events having less serious consequences (ICAO, 2013) because, as explained in Section 2.3, this allows for the monitoring and addressing of all minor events with a potential for high-consequence outcomes.

Rodrigues and Cusick (2015) stated that a successful reporting system is characterised by trust, confidentiality, independence, ease of reporting, acknowledgement, motivation and promotion. According to these authors, trust means that the recipient organisation must be trusted by the person(s) reporting the incident(s) to ensure that any information they provide will not be used against them by fostering a non-punitive system, while confidentiality is a
guarantee that the reporter will not be identified. In order to avoid conflict of interests, the
declaration principle requires a third party to manage a safety reporting system. The ease
of reporting principle stipulates that the task of submitting reports should be user-friendly,
and the reporting form is readily available and simple with adequate space for a descriptive
narrative. The acknowledgement principle stresses that the reporter should be appropriately
acknowledged, as reporting takes considerable time and effort and, in some instances, it may
need the courage to challenge the status quo. Lastly, motivation and promotion principles
courage the provision of a safety system as soon as possible, and it should be periodically
promoted to the entire organisation.

Similarly, James Reason (1997) revealed five factors which could encourage a
reporting culture: indemnity against disciplinary proceedings; confidentiality or de-
identification; separating from the regulatory authority the agency that collects and analyses
the reports; rapid, useful, accessible and intelligible feedback to the reporting community;
and finally, the ease of making the report. The first three items are designed to foster a feeling
of trust, which is paramount for any incident reporting to be effective. Without trust, the
report will be selective and will probably conceal important human factor information
(O’Leary & Chappell, 1996).

Organisational factors also contribute significantly to the success or failure of a
reporting scheme. Some authors have stressed the importance of this factor. One of them is
Lucas (1991), who mentioned five organisational factors influencing the effectiveness of a
safety reporting system: firstly, the nature of the information collected (simply descriptive, or
also causal); secondly, the use of information in the database (feedback, statistics, and error
reduction strategies); thirdly, the level of help provided (in the form of analyst aids) to collect
and analyse the data; fourthly, the nature of the organisation of the scheme (centralised or
local, mandatory or voluntary); and lastly, the acceptability of the scheme to all personnel.

2.7 Previous research on safety reporting systems

Surprisingly, there has been relatively little published literature assessing the key
barriers that influence the effectiveness of safety reporting systems among users in the
aviation industry, even though the aviation industry was instrumental in the introduction of
reporting systems. A few studies were conducted to identify the behaviour of workers who
currently work or desire to work in the aviation industry, including pilots and students
(Gilbey et al., 2015; Tani, 2010) and mechanics (Chen, 2010; Darveau, 2015).
A recent study by Gilbey et al. (2015) investigating the human factor barriers to reporting summarised that the knowing of bad outcomes of safety events and immediate reporting (fear of consequences) could increase people's reporting intention. Gilbey et al. (2015) explained that the incidents that led to bad outcomes were perceived as significantly more serious, more likely to be reported and more deserving of punishment, while a prompt report has a greater chance of being reported compared with a tardy report. However, it was also revealed that the participants, mainly students with the expectation of eventually working in the aviation industry, might have a different response from that of people currently working in this sector. This study’s findings are consistent with those of Tinsley et al. (2011) which revealed that most people interpret an incident with a good outcome as system defences to treat; as a result, there is no need for a report on the incident.

Another study conducted in New Zealand investigated the barriers to the reporting of aviation incidents (Tani, 2010). Tani investigated the motivation and psychological issues of people working in or desiring to work in the aviation industry. They used six variables (see Table 2.1) that may influence individuals’ perception of safety issues in the workplace, and their intention to report unsafe practices. These variables were developed from ethical decision-making theories and models, including those of Kohlberg and Gilligan. The main finding of this research is that aviation workers are often confused regarding the matters that should be reported to the regulatory authorities and to whom those reports should be made. On the other hand, as this study involved participants who were not yet aviation employees (i.e., students), and used a non-probability sampling method, it may not be a genuine representation of the whole aviation community in New Zealand. Hence, any similar study in future would need to comprise participants who actually work in the aviation industry. Lastly, Tani also suggested conducting additional research on the same topic in other countries since it has been found that there is a relationship between national cultures and the reporting of unsafe acts.

Another relevant study was conducted by Darveau (2015) to investigate the reporting behaviour of workers in the aviation industry by comparing the different perceptions of mechanics (30 persons) and their managers (27 persons). This study uses eight variables (see Table 2.1) based on the literature review and interviews. Rather than assessing individual barriers such as blindness, trust, lack of knowledge and error reporting, it also investigated organisational barriers such as the development of corrective action, commitment, and lack of procedure definitions. In this study, lack of trust and awareness
were determined as the main barriers to reporting, which is consistent with previous studies in other industries. Moreover, Darveau revealed that the number of participants should have been larger, even though it was adequate for chi-square analysis. Lastly, similar to previous research recommendations, Darveau (2015) also suggested that the additional data collection targeting specific airlines would allow the assessment of mechanic-management agreement within an organisation, as well as a comparison of airlines with unique organisational practices.

Other research has assessed the degree of acceptance of safety reporting systems by workers in Taiwan’s aviation industry, which revealed that unfamiliarity with the reporting procedures is the most significant barrier (Chen, 2010). Other contributing barriers revealed by this study are: an inappropriate reporting procedure for the company's context, the possibility of disciplinary action, lack of confidence in the immunity of the system, and the users’ lack of trust in the usefulness of the system. Table 2.1 lists the main barriers to safety reporting identified in previous research in aviation and other industries such as healthcare, chemical, and transportation.

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>Participants</th>
<th>Method</th>
<th>Finding/Variables</th>
</tr>
</thead>
</table>
| 1   | Under-reporting in aviation: an investigation into factors that affect reporting of safety concerns (Tani, 2010) | Pilots, non-pilots, and students | Quantitative (Correlation and ANOVA) | - Seriousness of wrongdoing  
- Direct and indirect involvement in wrongdoing  
- Working environment  
- Legal protection of the reporter  
- Motive of the wrongdoer  
- Relationship with wrongdoer |
| 2   | Roadmap to the implementation of best practices in human factors voluntary reporting for safety (Darveau, 2015) | Mechanics and Manager          | Quantitative (Correlation and chi-square) | - Blindness  
- Safety culture commitment  
- User trust  
- Training techniques  
- Personal changes  
- Policy and procedure |
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<th>Table</th>
<th>Title</th>
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| 3     | The Taiwan Civil Aviation Safety Reporting (TACARE) system in aircraft maintenance: an evaluation of the acceptance of voluntary incident reporting programs (Chen, 2010) | Mechanics Survey and interview | -Voluntary error reporting interviews  
-Analysis of error reports and development of corrective actions  
-The probability of disciplinary action  
-The lack of confidence in the immunity of system  
-Unfamiliarity with the reporting procedures  
-User trust  
-The reporting procedure is not suitable for the company |
| 4     | Feedback from incident reporting: information and action to improve patient safety (Benn et al., 2009) | Subject matter experts from civil aviation, maritime, energy, rail, offshore production and healthcare Semi-structured interview | -The role of leadership  
-The content of feedback  
-Effective of feedback dissemination  
-Rapid response to provide feedback  
-Feedback at all level organisation |
| 5     | Factors determining hospital nurses' failures in reporting medication errors in Taiwan (Chiang, Lin, Hsu, & Ma, 2010) | Nurses Group solidarity Survey Quantitative | -Fear of punitive action  
-Individual competence  
-Professional development  
-Administrative barrier  
-Management and leadership |
| 6     | Attitudes and barriers to incident reporting: a collaborative hospital study (S. M. Evans et al., 2006) | Doctors and Nurses Survey Quantitative | -Lack of feedback  
-That need to be reported  
-Inefficient procedures  
-Too trivial  
-Lack of trust  
-High workload |
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<th>Title</th>
<th>Participants</th>
<th>Methodology</th>
<th>Challenges</th>
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</thead>
</table>
| 7 | Attitudinal survey of voluntary reporting of adverse drug reactions (Grootheest, 1999). | Medical practitioners | Survey Quantitative  | - Uncertainty  
- Too trivial/too well known  
- Lack of knowledge  
- High workload  
- Too bureaucratic  
- Lack of competence in how to report  
- Fear of consequences |
| 8 | Barriers to incident reporting in a healthcare system (Lawton & Parker, 2002) | Doctors, nurses and midwives | Semi-structured interview Qualitative | - Fear of consequences (litigation)  
- Professional culture |
| 9 | Patient safety incident reporting: a qualitative study of thoughts and perceptions of experts 15 years after to Err is Human (Mitchell, Schuster, Smith, Pronovost, & Wu, 2016) | Safety reporting experts | Semi-structured interview Qualitative | - Poor processing  
- Inadequate funding  
- Inadequate of institutional support  
- Inadequate usage of information technology  
- Lack of feedback  
- Lack of engagement |
| 10 | Factors affecting incident reporting by registered nurses: the relationship of perceptions of the environment for reporting errors, knowledge of the nursing practice act, and demographics on intent to report errors (Throckmorton & Etchegaray, 2007) | Nurses | Survey Quantitative | - Climate for reporting  
- Demographics  
- Knowledge of reporters  
- Intention to report |
| 11 | Beyond blame cultural barriers to medical incident reporting (Waring, 2005) | Specialist physicians | Semi-structured interviews | - Fear of blame  
- A fear of retribution  
- The perceived inevitability |
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<th>Title</th>
<th>Methodology</th>
<th>Qualitative of error</th>
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<tr>
<td>12</td>
<td>Critical incident reporting and learning (Mahajan, 2010)</td>
<td>-</td>
<td>- Lack of trust&lt;br&gt;- Anti-bureaucratic sentiment&lt;br&gt;- Rejection of excessive administrative duties</td>
</tr>
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<td>13</td>
<td>Reasons for not reporting adverse incidents: an empirical study (Vincent, Stanhope, &amp; Crowley-Murphy, 1999)</td>
<td>Obstetricians and Midwives</td>
<td>- Fear of punitive action&lt;br&gt;- Group/team culture&lt;br&gt;- What has to be reported&lt;br&gt;- Lack of trust&lt;br&gt;- Lack of feedback</td>
</tr>
<tr>
<td>14</td>
<td>Reporting and preventing medical mishaps: lessons from non-medical near-miss reporting systems (Barach &amp; Small, 2000a)</td>
<td>Directors of reporting system</td>
<td>- Lack of competence how to report&lt;br&gt;- Fear of disciplinary action&lt;br&gt;- Lack of trust&lt;br&gt;- Highworkload&lt;br&gt;- Peer unsuppotive&lt;br&gt;- What has to be reported</td>
</tr>
<tr>
<td>15</td>
<td>Are hospital incidents being reported? (Elnitsky, Nichols, &amp; Palmer, 1997)</td>
<td>Nurses</td>
<td>- Fear of consequences&lt;br&gt;- Lack of trust&lt;br&gt;- Code of silence&lt;br&gt;- Sceptism&lt;br&gt;- Extra work&lt;br&gt;- Fear of getting colleagues into trouble&lt;br&gt;- Local policies&lt;br&gt;- More bureaucracy</td>
</tr>
<tr>
<td>16</td>
<td>Organizational factors affecting incident reporting by train</td>
<td>Train drivers</td>
<td>- Lack of trust in the reporting system&lt;br&gt;- Fear of litigation and discrimination&lt;br&gt;- Lack of knowledge&lt;br&gt;- Part of the job (macho perspective)</td>
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<tr>
<td>ID</td>
<td>Study Title</td>
<td>Methodology</td>
<td>Findings</td>
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| 17 | Near-miss incident management in the chemical process industry (Phimister, Oktem, Kleindorfer, & Kunreuther, 2003) | Interviews Qualitative | - Potential recriminations  
- Peer pressure  
- Fear of disciplinary action  
- Lack of incentives  
- Individual confusion  
- Lack of management commitment |
| 18 | Accident under-reporting among employees: Testing the moderating influence of psychological safety climate and supervisor enforcement of safety practices (Probst & Estrada, 2010) | Survey Quantitative | - Poor safety climate  
- Lack of trust in reporting system  
- Fear of consequences  
- Inadequate Supervision |
| 19 | Biases in incident reporting databases: an empirical study in the chemical process industry (van der Schaaf & Kanse, 2004) | Survey Quantitative | - Fear of disciplinary action  
- Fear of other people’s reaction  
- Risk acceptance  
- Lack of commitment  
- Practical reason |
- Extra workload  
- Lack of trust  
- Fear of being blamed |
Lack of information on how to report an error
- Lack of information technology

Meanwhile, there are numerous journal articles related to safety reporting systems in the healthcare, chemical, transportation, energy industries, etc. Several authors have investigated the differences in perceptions and behaviours among healthcare workers such as doctors, nurses, and midwives, in terms of safety reporting systems (Benn et al., 2009; Chiang et al., 2010; S. M. Evans et al., 2006; Grootheest, 1999; Lawton & Parker, 2002; Mitchell et al., 2016; Throckmorton & Etchegaray, 2007). Other researchers have examined the behaviour of specialists in areas such as surgery, general medicine, elderly care, orthopaedics, urology, and other specialist domains (Sari, Sheldon, Cracknell, & Turnbull, 2007; Waring, 2005). Lastly, in the most recent study, semi-structured interviews were conducted with leading international authorities on patient safety who were familiar with the US healthcare system (Mitchell et al., 2016). Furthermore, in the chemical, transportation and other industries, researchers investigated the behaviour of employees such as drivers and operators (Clarke, 1998; Phimister et al., 2003; Probst & Estrada, 2010; van der Schaaf & Kanse, 2004).

Those studies also investigated the barriers preventing workers in the healthcare industry from reporting unsafe behaviours and unsafe conditions within the existing reporting system framework. One of the barriers could be a fear of punitive action (Chiang et al., 2010; Mahajan, 2010; Phimister et al., 2003), fear of recriminations (Phimister et al., 2003), fear of retribution (Waring, 2005), fear of disciplinary action (van der Schaaf & Kanse, 2004; Vincent et al., 1999), fear of peer ridicule and fear of being involved in an investigation (Phimister et al., 2003), and fear of being blamed (Uribe et al., 2002). Other reasons which have been identified include the possible risk of litigation and discrimination in the workplace (Elnitsky et al., 1997; Lawton & Parker, 2002), and unfamiliarity with the reporting process or poor reporting practices (Barach & Small, 2000a; S. M. Evans et al., 2006; Grootheest, 1999; van der Schaaf & Kanse, 2004; Vincent et al., 1999). Furthermore, other barriers identified are a lack of understanding about what needs to be reported (S. M. Evans et al., 2006; Grootheest, 1999; Mahajan, 2010; Throckmorton & Etchegaray, 2007; Vincent et al., 1999), how it can improve the existing system, and believing that near-misses are not important enough to be reported for learning purposes (Barach & Small, 2000b;
Clarke, 1998; S. M. Evans et al., 2006; Mahajan, 2010; Probst & Estrada, 2010; Uribe et al., 2002; Vincent et al., 1999; Waring, 2005). Lastly, lack of knowledge and skill, a blame culture and anti-bureaucratic sentiment (Waring, 2005), demographic factors (Throckmorton & Etchegaray, 2007), risk acceptance (van der Schaaf & Kanse, 2004), motivational issues and individual confusion (Phimister et al., 2003) are other barriers to safety reporting.

Other barriers have been investigated, such as fear of getting colleagues into trouble, codes of silence, local policies, lack of communication and supervision, team culture (Barach & Small, 2000b), high workload and insufficient time to report (van der Schaaf & Kanse, 2004), and the way that errors are perceived by different groups (J Firth-Cozens, 2002). Those barriers are mainly related to the working environment.

Furthermore, several other factors were identified as significant barriers to reporting, including lack of management commitment to support the system (Phimister et al., 2003), safety culture policies (Barach & Small, 2000b), and type of leadership (Vincent et al., 1999). Other reasons were also pointed out as having a significant impact on safety reporting, such as lack of professional development (Chiang et al., 2010), financial priority, and inadequate application of evolving health information (Mitchell et al., 2016). Additionally, inadequate feedback (Benn et al., 2009), lack of incentives and the development of new guidelines (J Firth-Cozens, 2002; Phimister et al., 2003) are also considered as barriers to safety reporting.

A notable feature of these studies is their effort to identify the behaviour of employees or users of reporting systems in order to understand the contextual barriers and develop recommendations for the best safety reporting systems appropriate for the local context and organisation. A successful reporting system design must be relatively compatible with the characteristics of the workplace, such as the profile of its users, nature of tasks, the working environment, and organisational factors (Holden & Karsh, 2005, 2007; Karsh et al., 2006).

2.8 Previous frameworks

Having a theoretical framework is crucial as it provides a guide for understanding and directing the reporting system design and research. No particular guiding framework applicable to safety reporting systems in the aviation industry was found; fortunately, a few have been developed by and for other industries. This will be explained briefly in the following paragraph.

To demonstrate how theory can be used to develop a framework for safety reporting issues, several relevant theories such as theories of motivation and decision-making can
provide a socio-psychological perspective of reporting behaviour, whilst theories of technological change/acceptance can describe reporting systems as technologies that are integrated into complex social-technical systems (Holden & Karsh, 2005). Holden and Karsh (2005) stated that no one theory could satisfactorily describe the complex nature of reporting. However, several distinct theories that have emerged from the fields of psychology, management, and human factors are quite applicable and even compatible with one another. They proposed a theoretical framework for interpreting and predicting a reporting behaviour that can specify the theoretical process and factors by which reporting behaviour might be determined. The proposed framework stated that the characteristics of the reporting system interact with those of the individual user, the task, the organisation, and the environment. The individual users have individual needs, abilities, and attitudes; the task involves complexity, task goals, and time constraints; the organisation comprises policy, structures, and resources; while the environment is related to social norms, other behaviours, and culture.

Another proposed framework for a safety reporting system was introduced two years later. The model explicitly depicts the contribution made by different levels of the organisational hierarchy to the success or failure of a reporting system (Holden & Karsh, 2007). The hierarchy process needs to be investigated through research and designed in practice, as the previous discussions of error reporting systems have asserted that organisational support of reporting is essential for reporting system success. In other words, reporting is affected by the multiple levels of the organisational hierarchy of systems; for instance, individuals choose whether they will report an error, whether individual behaviours are affected by the higher-level group, or by organisational and industry factors.

2.9 Relevant theoretical approaches in aviation

A number of theoretical approaches can be used to classify safety-related factors contributing to accidents. These include Reason’s accident causation model (James Reason, 1997), the level of hierarchy in the socio-technical system (Rasmussen, 1997), the System-Theoretic Accident Model and Processes (STAMP) (N. Leveson, 2004, 2015), and the Functional Resonance Analysis Method (FRAM) (E Hollnagel, 2004; Erik Hollnagel, 2012). At taxonomy level, the Human Factor Analysis and Classification System (Shappell & Wiegmann, 2000) is one of the commonly used tools for assessing the human factors influence in accident investigations.
The organisational model of accident indicates that accident factors arise from the concatenation of several contributing factors originating at many levels of the system. According to James Reason (2004), the combination of local triggers opens a window of opportunity in which the hazards are allowed to pass unchecked through successive weaknesses, as illustrated in Figure 2.4. Because of the many layers of protection, such accidents are rare events. They require the simultaneous alignment of gaps or absences within what are usually diverse and redundant defences.

![Figure 2.4: Reason’s accident causation model (ICAO, 2013)](image)

Reason (2004) stated that the defensive layers would be intact in an ideal world, but, in reality, they are more like Swiss cheese, i.e., full of holes. These gaps, weaknesses, and failures occur for two reasons:

- Active failures. These are unsafe acts such as errors or violations by individuals or teams. These people have direct contact with the system and their actions create weaknesses or absences in or among the protective layers. Errors can be classified according to three types: decision, skill-based and perception errors; while the violation is divided into two types: routine and exceptional violation.

- Latent conditions. Latent conditions have two characteristics: firstly, their effects are usually longer lasting than those created by active failures; and secondly, they are present within the system before an adverse event occurs, and they can be detected and rectified before causing harm. The latent conditions are unwittingly created as the result of earlier decisions made by the designers, builders, regulators, and/or managers of the system.
According to Reason (2004), failures begin with unsafe actions taken by people who have direct contact with the system, but unsafe acts rarely arise solely from wayward psychological processes or negligence. They are most often the direct consequence of error-provoking circumstances within the local workplace. Moreover, in turn, these are the result of higher-level latent conditions such as prior decisions made by equipment designers, senior managers, the writers of protocols, and the like.

The taxonomy of the “Swiss cheese” model was described more clearly by using over 300 US Navy aviation accident records obtained from the U.S. Naval Safety Centre (Shappell & Wiegmann, 1997, 2000). This is known as the Human Factor Classification System (HFACS), which has four main categories: unsafe acts, pre-condition for unsafe acts, unsafe supervision and organisational influences (see Figure 2.5).

![Figure 2.5: The taxonomy of human factors (Shappell & Wiegmann, 2000)](image-url)
Similarly, Rasmussen (1997) stated that, due to the dynamic environment of a modern workplace, the analysis of the work environment of the various decision makers cannot be based on a traditional approach. Instead, an analysis of the requirements and constraints of the problem space should be conducted, and these should be formulated for the several various levels of a means-ends hierarchy. Additionally, Rasmussen revealed that a careful identification of the problem formulation and performance criteria should be included in an analysis for individual decision makers.

**Figure 2.6:** The level of hierarchy in the socio-technical system (Rasmussen, 1997)

Rasmussen stated that the levels of hierarchy in the socio-technical system involved in the control of safety are:

- Government. Society seeks to control safety through the legal system. Safety has to be considered as a high priority, but so has the balance of employment and trade. Then, the legislation makes explicit the priorities of conflicting goals and sets boundaries of acceptable human conditions.
• Regulator and Associations. The level of authorities and industry associations, workers’ unions and other interested organisations contribute to interpreting the laws which then result in regulation.

• Company. The regulation is interpreted by the company and rules are implemented to control activities in certain kinds of workplaces.

• Management. In order to be operational, the rules have to be interpreted and implemented in the context of a particular company or organisation and take into consideration the work processes and the equipment being used.

• Staff (human-machine interaction). The specific local conditions and processes have to be considered when making and modifying the rules.

• Work. This is the bottom level involved in the design of the product and potentially hazardous outcomes.

While Rasmussen created more levels of hierarchy (see Figure 2.6) than the Reason and HFACS models, they all revolved around the same concept of how to identify weaknesses and failures that contribute to a safety occurrence. According to all of these concepts, the sources of problems have to be assessed from the bottom to top levels, in a hierarchy comprising at least three levels: individual, work environment and organisation/institution. The problems experienced by people who are directly involved in the system or operational area are just the result of the higher-level problem, or in other words, its weakness or deficiencies. If all the dimensions that comprise the hierarchy of an organisation are not considered, only an isolated issue will be resolved, and the problem has the potential to recur in the future.

More recently, a few alternative approaches to the widely-known Reason model have emerged, such as the FRAM and STAMP. These approaches are not based on cause-effect analysis but rather on a ‘system thinking’ approach. Since the system’s complexity had increased over time, many accidents could not be thoroughly analysed by using a simple cause-effect model approach (N. Leveson, 2004). In fact, an accident might not be caused only by trigger events, but could emerge as a complex phenomenon within the normal operational variability of the system (De Carvalho, 2011). Explaining an accident in terms of a series (causal-effect) of events can lead to equipment or a human at the sharp end of the system being wrongfully blamed for an accident (Underwood & Waterson, 2014). This could
prevent information from being obtained on dynamic conditions that are having an impact on the system and which might indirectly contribute to the accident.

The probability factor has been widely used in risk analysis (Kaplan & Garrick, 1981) although some researchers, including Leveson and Hollnagel, have underestimated the use of probabilities in relation to complex socio-technical systems (Erik Hollnagel, 2012; N. Leveson, 2011, 2015). The two approaches, FRAM and STAMP, have been complementary more so than traditional risk analysis approaches (Belmonte, Schön, Heurley, & Capel, 2011; Kazaras, Kirytopoulos, & Rentizelas, 2012) and also have been used in the planning and execution of various complex systems and operations (Underwood & Waterson, 2014).

The FRAM approach comprises four elements (Bjerga, Aven, & Zio, 2016; E Hollnagel, 2004; Erik Hollnagel, 2012):

1. Identify and describe essential system functions. The model provides a qualitative representation of the system to be investigated and how it operates on a daily basis. Instead of focusing on the individual components, the approach is built around the concept of “functions”. Dependencies (coupling) between functions are not fixed in the model but can couple in many ways under given circumstances. There are six function components: inputs (used to deliver the output), output (the end result of a given function), preconditions (conditions that must be fulfilled prior to executing a function), resources (what is needed or consumed), time (which is often used as a constraint), and control (what supervises or adjusts the function).

2. Assess variability for each function. The functional variability could be the sources and outcomes of this variability and how the multiple variabilities can be related to each other and cause an accident. The FRAM method has eleven common performance conditions that are used to obtain the potential variability: (1) availability of personnel and equipment; (2) training, preparation, competence; (3) communication quality; (4) human–machine interaction, operational support; (5) availability of procedures; (6) work conditions; (7) goals, number, and conflicts; (8) available time; (9) circadian rhythm, stress; (10) team collaboration; and (11) organizational quality.

3. Assess how the variability of multiple functions can be coupled and lead to non-linear outcomes (what is referred to as functional resonance). Investigate the potential realistic accident scenarios as excessive variability under some realistic assumptions and individual variability. The realistic conditions and variability
assumption is based on broad knowledge and experience comprising an understanding
of the system and situation.

4. Identify countermeasures. Further identification of hazardous control can lead
to a list of scenarios requiring hazardous control actions, conditions that signal an
unsafe environment, and causes and mitigation of these hazards.

The STAMP model differs from the FRAM as it uses a mathematical model to
describe the system dynamics, instead of a qualitative analysis based on connections of
functional blocks. This model is structured as follows (N. Leveson, 2011; N. G. Leveson et
al., 2005):

1. Identify the accidents to be considered, the system level hazards, safety
   constraints and functional requirements.
2. Create a model of the functional control structure for the system that needs to
   be investigated.
3. Identify the potential unsafe control actions (unsafe control of the system).
   Identify any potentially inadequate control actions that could lead to hazardous states,
   such as control actions not provided or not followed, unsafe control actions,
   potentially safe control actions provided too late or too early or in the wrong
   sequence, and a control action stopped too soon or applied for too long.
4. Determine how each potentially hazardous control action from step 3 could
   occur, i.e. the scenarios that can lead to a hazardous system or unsafe control.

Both approaches have in common one important concept: that the problem needs to be
identified taking into consideration all aspects (functions) of the system and how the
functions relate to each other. The authors of both models claim that these provide a more
comprehensive approach to accident investigation, thereby contributing to a more effective
prevention of failures and avoidance of unexpected events.

Notwithstanding the advantages offered by the aforementioned models, the
framework developed in this study relies essentially on Reason’s model. This decision is
based on the following considerations:

1. The application of the ‘system thinking’ approach. The main criticism of the
   Reason model was its application of the system thinking approach. However, the
difference between the James Reason model and the FRAM/STAMP approach is
   negligible in terms of system thinking application (Underwood & Waterson, 2014). In
fact, the Reason model can be used as a heuristic explanatory device for communicating the interactions and concatenations that occur when a complex, well-defended system suffers a catastrophic breakdown (J Reason, Hollnagel, & Paries, 2006). Thus, the model has the ability to identify the unlikely and often unforeseeable conjunction of several contributing factors arising from different levels of the system (J Reason et al., 2006), and therefore it provides a suitable framework for this study.

2. The Reason model is easier to understand. The model is essentially a high level representation of a system which, in most cases, has proven to lead to an accurate determination of safety deficiencies contributing to accidents. It is also an effective conceptual tool which has been widely used by numerous high-risk industries or major stakeholders in the safety domain owing to its simplicity and flexibility enabling it to adapt to different organisational contexts.

3. J Reason et al. (2006) explained that the model can be used in two different ways, *retrospectively* or *prospectively*. The former is the basis for explaining or understanding something which has occurred, while the latter is the basis for predicting something, including measurements of present states as indicators of possible future states. This model is thus a convenient way of referring to the shared sets of axioms, assumptions, beliefs, and facts about a phenomenon that make it possible to form an understanding of what goes on and to make predictions about what will happen.

4. The Reason model is the accepted standard in the aviation sector and it is endorsed by major stakeholders worldwide, including the International Civil Aviation Organisation (ICAO, 2013; J Reason et al., 2006). Furthermore, J Reason et al. (2006) explained that most organisations generally function in a hierarchical fashion which means that actions, decisions and directives made at a higher level are passed on to a lower level, where they either are implemented directly or interpreted in some way before they are passed on to the next level below. This is the very basis for the principle used to explain obstacles or failures which stem from organisational influences, which is an element of particular importance for this study.

2.10 Developing conceptual framework and generating hypotheses

In order to measure the influence of the various barriers on the performance of a safety reporting system, this study sought to develop a model and to investigate and summarise the common barriers that emerged from the literature pertaining to the aviation
industry and other industries that had developed similar reporting systems. The identification of weakness, failures and sources of a safety system’s inadequacies should be considered across the several levels of the system or hierarchy (Rasmussen, 1997; James Reason, 1997; Shappell & Wiegmann, 2000). Therefore, the researcher concluded that the barriers to safety reporting could be caused by factors at different levels and from different sources. Hence, the barriers were divided into three main categories: organisational, individual and working environment.

2.10.1 Organisational barriers

Organisational barriers that were examined in this research involved all the obstacles created by top management (strategic level) who develop and publish policies and procedures, and allocate resources comprising equipment and funding, promote the organisational climate for reporting errors, and process all the safety reports submitted. James Reason (1993) argued that the organisational factor is divided into sources and functions. Sources are associated with fallible decisions at the strategic apex of the organisation (Mintzberg, 1979) while the function is related to the line management element.

Several main organisational barriers found in the literature review, which then become indicators of the organisational barriers construct are: a lack of commitment, inadequate financial priority, the absence of an independent third party, inadequate feedback, inadequate use of information technology, and inadequate professional development (see Figure 2.7).

![Organisational barriers influencing the effectiveness of reporting systems](image)

**Figure 2.7:** Organisational barriers influencing the effectiveness of reporting systems
It should be noted that the six barriers represented in Figure 2.7 might be correlated to each other. For example, lack of commitment often affects the financial support or resources required to develop a reporting system. An inadequate financial priority also has an impact on the professional development in any organisation. In short, the barriers shown in Figure 2.7 indicate all dimensions of organisational barriers, but they might also be correlated to each other. This distinct condition will influence the selection of measurement models, reflective or formative, explained later in this study.

a. Lack of commitment

Commitment by top-level management could be in the form of motivation and the provision of resources. Motivation is related to such things as the degree to which management seeks to be an industry leader in safety within its particular sphere of operation, or merely its wish to keep one step ahead of the regulators (Westrum, 1988).

Failure of management to remain committed to safety reporting can decrease an employee's intention to make a report (Phimister et al., 2003). According to Phimister et al. (2003), a commitment failure can be passive, where management stops emphasising program participation due to inattention, or it may be active, where management actively seeks to reduce program participation. Similarly, one of the reasons for the lack of reporting mentioned by the safety staff of a chemical plant was the lack of management commitment with regard to the aviation domain (Bridges, 2000).

b. Inadequacy of financial priority

The availability of adequate funding for the operation of safety reporting systems is vital to the effectiveness of such systems. Financial priority given by top management is another form of management commitment (Westrum, 1988). It will be more visible than motivational commitment since it can be calculated by the amount of funding that has been allocated for the purpose of safety reporting.

Inadequate financial support has unintended consequences such as the inability to deal with the volume of reports, which inevitably leads to a delay in analysing them and making detailed recommendations for dissemination (Mitchell et al., 2016). To handle the countless incidents or safety reports within an organisation, management needs to develop a sophisticated system that can process the data quickly and accurately before issuing a
recommendation or warning to the relevant personnel. Such a system usually needs the allocation of considerable funds by management to ensure that it is efficient and effective.

On the other hand, the benefits of a safety reporting system might not be immediately obvious, since the safety reporting process takes a long time as it involves an ongoing collection of information about hazards, near misses, and safety occurrences before producing results such as alert messages, quick responses and call-back. Therefore, this might be one of the reasons why decision makers are reluctant to allocate adequate funding for a safety reporting system.

c. The absence of an independent third party

A separate agency for conducting safety reporting has been considered since the ASRS program was established in 1975 with the main purpose of ensuring an impartial management of the program, thereby eliminating the classic problem of “fear of consequences” in the aviation community in terms of reporting. The FAA was not generally seen as a totally uninterested referee since it functioned as both lawmaker and enforcer. Hence, it works collaboratively with NASA to collect, process and analyse the safety reports submitted by the aviation community.

The use of a third party or the separation of the agency or department collecting and analysing the reports from those bodies with authority to institute disciplinary proceedings and impose sanctions, is also a useful means of engendering trust (James Reason, 1993). When a third party is involved in collecting safety or hazards information, most likely this will increase the trust of the user (of the safety reporting system). Without trust, according to O’Leary and Chappell (1996), any safety reporting system will not be effective in revealing the failures which contribute to an incident, and the report will most probably be selective and gloss over vital human factor information. Additionally, the nature of a reporting scheme in an organisation – that is, whether it is local and centralised – will determine its effectiveness.

d. The lack of feedback

Effective feedback from reporting systems is paramount if aviation organisations are willing to learn from failures in their operations. The feedback is a key factor in achieving a successful reporting system (Lucas, 1991) and also will decide the future of promoting the safety reporting system itself (Benn et al., 2009). Additionally, both action and information
feedback mechanisms have the function of improving safety awareness and employee motivation (Benn et al., 2009).

The feedback could be provided to users in the form of statistics and error reduction strategies. The statistics provided freely via an online database or by request will allow organisations to evaluate the various risks around them and determine the possible corrective actions. Accurate statistics will help scientists to better conduct research into safety issues.

Benn et al. (2009) suggest that feedback for incident reporting systems consists of five types based on the intended receiver and the types of action. These include the feedback/information, which is sent specifically to persons who submit the safety report, to local work systems for giving a rapid response and improving work systems, to all front-line personnel, and to the wider reporting community.

On the other hand, the failure by management to provide feedback will affect the employees’ willingness to submit a safety report. The lack of feedback can take any of the following forms: the corrective actions focus more on local conditions, rather than systemic solutions; inadequate knowledge of work environment/task; management postponement of corrective actions; cost-benefit analysis not conducted or poorly conducted; and the implemented corrective actions are not effectively disseminated (Bridges, 2000; Darveau, 2015).

e. Inadequate using information technologies

The larger an aviation organisation, the greater will be the risk associated with its daily operations. A larger organisation means that more people are interacting with equipment and the local environment, which has the potential to generate more incidents and hazards. If a great amount of information regarding incidents and hazards is reported simultaneously, the processing of data information will require information technology that can process it automatically and systematically after the manual process has been done.

This problem has been aggravated by inadequate information technologies, or their inadequate use, which could otherwise contribute to improving the effectiveness of the reporting system (Mitchell et al., 2016). However, a better interface environment and enhanced data management capability could lead to a more effective safety reporting system. With the support of information technologies, every report can be treated properly and quickly, beginning with the initial submission of information by members or workers, to data processing and analysis, and returning the result(s) to users. The full automation of this
process may be impossible, and some manual intervention will be required at some stage. Nevertheless, the integration of appropriate information technology in a safety reporting system will make it more effective.

f. Inadequate professional development

The organisational competence to conduct safety practices will rely on professional development delivered within organisations. James Reason (1993) argued that one of the main organisational factors is competence, which can be seen in the way organisations collect the safety-related information, how and to whom it is disseminated, and how safety issues are dealt with.

The ability to provide a modern reporting system will be useless without personnel who are competent to run the whole system. Individual competence can vary within organisations in terms of not only the incompetence of users, but also the inadequate competence of those who manage the safety data information such as how to recognise a safety issue, know how to report on it, how to treat the data/safety information, and how best to disseminate it. This issue can be resolved by offering professional development within the organisation to ensure that every member acquires the necessary skills and knowledge regarding the safety reporting process. Hence, the ability to conduct training in effective safety reporting as part of an integrated safety system is another factor that influences the effectiveness of this system.

2.10.2 Working environment barriers

Working environment barriers are defined as all barriers caused by local leaders, colleagues, and workplace conditions including inadequate supervision and guidance regarding the making of safety reports, codes of silence regarding reporting, high workload environment within the units, and the reporting habits of teams or crews. James Reason (1993) created three categories for these conditions: first, information processing factors which are related to attention, memory and knowledge; second, situational factors related to the ergonomic quality of the human-system interface, workload, distractors and the like; and lastly, social and motivational factors which include attitude and group norms.

In the context of this study, the researcher decided to include some barriers in this category as well as some indicators of the working environment barriers, including the code of silence, inefficient procedures, high workload, group or peer influence and inadequate
local supervision (see Figure 2.8).

**Figure 2.8:** Working environment barriers influencing the effectiveness of reporting system

a. **Code of silence**

The sharing of accident information in order to reduce a future risk level by learning from past experience is a requirement of both good corporate governance and professional engineering ethics. This is very important in every industry, not just in the aviation sector, but the result is not often as expected, as similar accidents recur and people are injured (Bond, 2009).

A fundamental change is necessary to ensure that innovations such as new technologies or methodologies are introduced to improve reporting systems. However, (Nieva & Sorra, 2003) argued that an analytical method will not succeed in revealing latent sources of error if staff or members are bounded by an implicit “code of silence”. Most professional groups such as firefighters, pilots, nurses, physicians, nuclear power plant operators, inspectors, and air traffic controllers have enforced and propagated the code of silence in various ways (Dekker, 2012). According to Dekker’s experience with a senior pilot in a large and respectable airline, it is not easy to voluntarily make a report because professionals seem to believe that "if they do not report the mistake and keep their fingers crossed that nobody else will do so either". Similarly, Phimister et al. (2003) argued that employees may feel pressure from colleagues not to report, while Clarke (1998) found that worry about colleagues getting into trouble is another reason for not reporting.

Therefore, a code of silence can be triggered by a fear of getting colleagues into trouble and a fear of consequences. The first fear is one of the working environment variables
since it is considered as a group norm within the workplace, which influences the intention to undertake safety reporting, whereas the latter relates to individual barriers.

b. **Inefficient procedures**

Inefficient procedures frequently appeared in the literature review as one of the barriers to safety reporting. This issue commonly appears at the operational level in the workplace, which involved reporters and the reporting procedure available within the organisation.

According to van der Schaaf and Kanse (2004), several practical reasons influence the intention to report near misses; for instance, it is considered to be time-consuming or too difficult to submit a safety report. Similarly, practical reasons for failing to report are found in other literature, such as the amount of time and effort involved in reporting, since reporting can often be too bureaucratic (Grootheest, 1999). The persons who should be involved in reporting more often than not have insufficient information about an incident to be able to adequately fill out an incident report form. Studies have found that quite often, formal reporting is tedious because a lot of unnecessary information is required, which frustrates those filling out the report forms (van der Schaaf & Kanse, 2004). Hence, the inefficient procedure was identified as one of the barriers to safety reporting in the workplace.

c. **High workload**

Aviation workers, especially the aircrew, are kept very busy performing tasks during working hours. Hence, it is almost impossible for them to report a concern immediately after it arises, and this has to wait until all jobs are finished. For instance, when pilots experience an incident during a flight, they can make a safety report only after the aircraft lands. Moreover, in some situations such as military missions, they have to wait until the mission has been completed. This situation, according to Gilbey et al. (2015), influences personnel’s intention to submit a safety report.

Other research in the healthcare industry also found that a challenging or high workload or excessive administrative duties might account for the reluctance of workers to make reports (Jenny Firth-Cozens, Redfern, & Moss, 2004; Vincent et al., 1999; Waring, 2005). Similarly, S. M. Evans et al. (2006) found that some workers forget to report incidents when they are very busy on the job. Therefore, a high workload is a working environment variable that can influence the safety reporting performance.
d. The group or peer influence

There are three aspects to psychological safety: the characteristics of the individual which are shaped by a priori differences in personality, the face-to-face working group which is shaped by interpersonal experiences and shared mental models that accumulate over time, and the broader organisation which is shaped by corporate culture (Thompson & Choi, 2006).

Team or group influence occurs when members of a team have shared beliefs about the safety of their working environment, and other teams have different shared beliefs (Thompson & Choi, 2006). Thomson & Choi stated that the member interaction should influence the extent to which members of the team feel that others are accepting and respectful of agreements, criticism, or new ideas. Similarly, it was found in the previous research that each member of staff is part of a team, and his/her performance may be influenced by other members of the team (Mahajan, 2010), and this becomes more challenging particularly when they face their superiors (Jenny Firth-Cozens et al., 2004). In addition, the team’s performance is influenced by managerial decisions made at a higher level in the organisation (Mahajan, 2010). Hence, the group or peer influence can be considered as a barrier to safety reporting in terms of the working environment variable.

e. Inadequate of local supervision

Senior staff and managers can affect a team’s performance by influencing the work environment which includes factors such as staffing level, working hours, equipment availability and maintenance, provision of guidelines and protocols, and education and training.

Past research suggests that the interaction with team leaders, who have greater positional power and status than other members, is a powerful influence on psychological safety according to Edmonson’s diary as cited in Thompson and Choi (2006). Similarly, it was found that leaders influence the implementation of a safety program, and this can have a significant effect on individual employee behaviour in relation to safety. Hence, leadership development would be an effective means of encouraging employees’ participation in a safety program (Clarke & Ward, 2006). In other words, the performance of the teams relies on how they are organised and supervised (Mahajan, 2010).

The involvement of members or workers in safety reporting systems as reporters when they experience safety issues is likely to be influenced by the supervision of the
manager or leader. In other words, the inadequate supervision and guidance regarding the submission of a safety report will decrease the employees’ intention to make such a report.

2.10.3 Individual barriers

Individual barriers are defined as all those barriers which are centred on the performance of individuals at various levels in the organisation. These barriers include: fear of litigation, retribution and disciplinary action, lack of trust in the usefulness of safety reporting, inadequate knowledge, skill and competence to report, and individual motivation for reporting. Although individual factors are directly associated with active failures of individuals or teams, it must be noted that they typically stem from deficiencies which are rooted in the organisation (James Reason, 1997; Shappell & Wiegmann, 2000). As individuals have a direct interface with the reporting system, it is important to take into consideration the various individual barriers that might have an impact on safety reporting.

In this category, the researcher also included several barriers as well as indicators of individual barriers including fear of consequences, lack of trust, macho perspective, acceptable norms, inadequate knowledge of what has to be reported, and inadequate competence in reporting procedure (see Figure 2.9).

![Diagram of Individual Barriers](image-url)

**Figure 2.9:** Individual barriers influencing the effectiveness of reporting system

a. **Fear of consequences**

Fear of consequences has been identified as one of the major reasons why members/workers are reluctant to submit a safety report. Waring (2005) argued that people
are disinclined to be open and honest about their experiences of error because of the deep-seated assumption that they will be found at fault and held individually responsible or punished for the event. The feared consequences can vary and may include fear of recrimination or punitive action (Chiang et al., 2010; Jenny Firth-Cozens et al., 2004; Mahajan, 2010; Vincent et al., 1999), fear of blame and retribution (Waring, 2005), fear of disciplinary action (van der Schaaf & Kanse, 2004), possible risk of litigation and discrimination in the workplace (Barach & Small, 2000b; Elnitsky et al., 1997).

Phimister et al. (2003) argued that the potential recriminations could be in the form of lengthy investigations that require employee participation, concern about receiving a verbal warning, the documenting of the incident in the employee’s record (which ultimately can lead to job dismissal), and unintended disciplinary actions, which may assume different forms such as additional job tasks or the need to wear some PPE (personal protector equipment). All of these consequences may be perceived as punishments for reporting. More often, the notification of the accident is imprecise and rarely coded as important or secret; therefore, it might be selectively filtered before being transferred to higher hierarchical levels to avoid blame and liability issues (Adams & Hartwell, 1977). Similarly, the explanation suggested by Elwell’s diary as cited in van der Schaaf and Kanse (2004) is that human errors, especially when they have not been observed by others, are under-reported in aviation reporting systems because flight crew members may be too embarrassed to report their mistakes, or they expect to be punished.

Hence, a fear of consequences could be one of the individual barriers that can influence the performance of a safety reporting system.

b. Lack of trust

A distrust of the usefulness of a reporting system has been found to be one of the reasons for not reporting. Without such trust, employees are less inclined to make reports. Some studies in the literature have dealt with this lack of trust.

Members may experience doubt if they do not understand how the system works to improve the safety level within their organisation. According to (Benn et al., 2009; Clarke, 1998; S. M. Evans et al., 2006; Jenny Firth-Cozens et al., 2004; van der Schaaf & Kanse, 2004), the reason for not reporting may be that the issue is seen as “useless or too trivial”. This was linked to the perception that management would take no notice or action regarding the safety report submitted by workers/members. Other literature mentioned that scepticism
regarding the usefulness of a reporting system is another reason for not reporting (Barach & Small, 2000b). Similarly, Powell et al.’s diary as cited in (van der Schaaf & Kanse, 2004) also observed that people soon find incident reporting useless when no-one ever reads and acts on the reports. Hence, the reporting rate decreases when those to whom one has to report do not understand the roles of the persons involved in the incidents. It was concluded from these findings that one of the individual barriers is a distrust of the usefulness of the safety reporting system as a means of improving the safety level in an organisation.

b. Risk acceptance (macho perspective and acceptable norm)

One of the four dimensions that Hofstede (1980) utilised for characterising national culture is ‘uncertainty avoidance’. He explained that any individual or organisation threatened by uncertain and ambiguous situations tries to avoid these situations by providing greater career stability, establishing more formal rules, not tolerating deviant ideas and behaviours, and believing in absolute truths and the attainment of expertise. Furthermore, Hofstede (1980) suggested that the characters who have a weak uncertainty avoidance would be more relaxed, with less stress and more willingness to take risks, even with their lives.

Past research has shown that risk acceptance might influence the intention to submit a safety report. For instance, van der Schaaf and Kanse (2004) described risk acceptance as the perception of members or workers that an incident is a part of the job, and is therefore inevitable. Another form of risk acceptance can be attributed to the macho factor, especially in certain industries such as construction (Jenny Firth-Cozens et al., 2004; Glendon, 1991; van der Schaaf & Kanse, 2004). Furthermore, it has been found that certain levels of incidents are viewed as the acceptable norm and therefore do not need to be reported (Clarke, 1998; Jenny Firth-Cozens et al., 2004; Webb, Redman, Wilkinson, & Sanson-Fisher, 1989). Some errors/minor incidents are accepted as the norm for various reasons: they are not perceived as dangerous; they will not occur again; and, everyone else has made similar errors (Jenny Firth-Cozens et al., 2004).

Therefore, the risk acceptance factor can be divided into two barriers: the macho perspective and the acceptable norm. Both of them are included as indicators of individual barriers in this study.

c. Inadequate knowledge (What has to be reported and how to report)

In the literature review in adequate individual knowledge has been found frequently as
one of the reasons why people are unwilling to report safety information. This barrier has two aspects: not knowing what has to be reported and not understanding how to make or submit a report.

Several researchers found that a lack of clear definitions as to what constitutes a reportable incident made workers reluctant to submit a report (Benn et al., 2009; Jenny Firth-Cozens et al., 2004; Grootheest, 1999). On the other hand, the inadequate knowledge may be due to unfamiliarity with the process resulting in poor reporting practices, which also contributes to the ineffectiveness of safety reporting (Grootheest, 1999). These two barriers are closely related to inadequate individual knowledge as a consequence of inadequate personal development.

Despite both barriers being caused by an inadequacy of individual knowledge, they are different barriers. The first relates to how events, incidents, or hazards are recognised, whereas the second barrier relates to the reporting procedure. Hence, the two barriers have been classified individually.

### 2.10.4 Safety reporting performance indicators

An effective safety reporting system in the aviation industry has the following features as detailed in Section 2.7: learning, flexibility, willingness, accountability and information.

Learning means that people have the competence to draw conclusions from safety information systems and the will to implement major reforms (ICAO, 2013; Lucas, 1991; James Reason, 1997). The second characteristic, flexibility, enables organisations to adapt their reporting mode when facing unusual circumstances, shifting from the established mode to a direct mode, thereby allowing information to quickly reach the appropriate decision-making level (ICAO, 2013; Lucas, 1991; James Reason, 1997; Rodrigues & Cusick, 2015). Even though it is important to make all staff accountable for their actions with a direct or indirect impact on safety, it is also crucial to encourage people throughout all levels of an organisation to proactively report their errors and experiences (ICAO, 2013; Rodrigues & Cusick, 2015). Lastly, an informed organisation ensures that personnel or employees have a knowledge of the human, technical and organisational factors that determine the safety of the system as a whole (ICAO, 2013; Rodrigues & Cusick, 2015).

Hence, given the relevance of these five characteristics, they have been incorporated in the model as indicators of the performance of the safety reporting system, which has been
analysed in this thesis.

2.10.5 The conceptual framework and hypotheses

After summarising the barriers to safety reporting and the key features of safety reporting performance, the researcher established a strategy in order to achieve the main objective of this research, namely to investigate the concurrent effects of the barriers on the performance of safety reporting systems. Therefore, after summarising the theoretical assumptions made in previous theory and frameworks, including the concept of organisational factors (James Reason, 1997), the taxonomy of human factors (Shappell & Wiegmann, 2000), the level of hierarchy in the socio-technical system (Rasmussen, 1997), and the theoretical frameworks for interpreting and predicting a reporting behaviour (Holden & Karsh, 2005, 2007), the researcher proposed a conceptual framework to describe the relationship between the three major barriers and the performance of safety reporting systems (see Figure 2.10).

![Conceptual Framework](image)

**Figure 2.10:** The conceptual framework to assess the concomitant effect of organisational, environment and individual barriers in the performance of safety reporting system

It is important to consider cross-level feedback since safety reporting is influenced by the interactions of multiple levels within a hierarchy (Holden & Karsh, 2007). For instance, the deficiencies of organisational barriers may potentially influence both the working
environment and the individual barriers, while the working environment is likely to affect the individual barriers. The literature review revealed that previous research has identified and evaluated various barriers to safety reporting, which this study classified as individual barriers, working environment and organisational barriers. Previous studies provide a good understanding of the impact of each barrier on safety reporting but, unfortunately, they fail to give a comprehensive picture of the simultaneous effect of the barriers to safety reporting and the interplay thereof.

In fact, the multi-level barriers within a hierarchy could affect the safety reporting performance differently, and their relationship and interaction with each other may be distinctly different. However, in the literature, no study has been conducted to determine the extent to which each barrier affects safety reporting performance and how the barriers are related to each other.

Thus, a concurrent assessment of all barriers found in the literature is paramount in order to identify not only the implication of each barrier but also to determine the contribution of the major barriers in each category, i.e., organisational, individual and working environment barriers.

Finally, based on the framework proposed in this research, three general hypotheses were put forward and restated as follows:

H1: There is a direct and negative relationship between organisational barriers and safety reporting performance.
H2: There is a direct and negative relationship between working environment barriers and safety reporting performance.
H3: There is a direct and negative relationship between individual barriers and safety reporting performance.

To investigate how the proposed constructs relate to each other, three additional hypotheses were formulated:

H4: There is a direct and positive relationship between organisational barriers and working environment barriers.
H5: There is a direct and positive relationship between organisational barriers and individual barriers.
H6: There is a direct and positive relationship between working environment barriers and individual barriers.
CHAPTER THREE
METHODOLOGY

3.1 Introduction

Chapter One of this study introduced the pertinent research questions and objectives, and the anticipated contribution of this study. Chapter Two presented an overview of the literature, providing a conceptual framework, a consolidation of a set of underlying constructs, and clear guidelines to direct this research, which culminated in a set of hypotheses guided by the literature reviewed in Chapter Two, this section describes the research methodology, the development of the data collecting instrument, and the implementation process.

3.2 Research approach

The two essential elements of any research are the research design and research method. The researcher needs to develop a research design initially since it will provide a framework for the further stages of the research, whereas the research method is the technique (or combination of techniques) used by researchers to provide an answer to the research question that has been formulated initially (Bryman & Emma, 2011).

There are two different research approaches: namely qualitative and quantitative research, each of which has distinctive characteristics (Bahari, 2010). Qualitative research is where the researcher usually builds knowledge claims based on constructivist perspectives (Creswell, 2013). Strategies used in this research design involve inquiry via narratives, phenomenologist, ethnographies, grounded theory studies, and case studies. On the other hand, with quantitative research, the researcher primarily uses post-positivist claims for developing knowledge, for instance, cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurements and observations, and the testing of theories (Creswell, 2013).

Quantitative analysis is used to test a theoretical construct (Jonker & Pennink, 2010) or to acquire a clearer and more precise theory about relations among predictor variables to obtain meaningful insights into hypothesised relationships and verify or validate the existing relationships (Lukas, Hair, Bush, & Ortinau, 2004). Given the chosen research approach, it was necessary to identify the critical variables and the relationship proposed between these variables. This enables conclusions to be drawn from measurements conducted on samples of subjects (Tabachnick & Fidell, 2007).
A quantitative approach is more directly related to descriptive and causal research than to exploratory designs. This approach was reflected in this thesis whereby a causal research design was combined with exploratory research. Exploratory research was relevant in the preliminary stage of designing the measurement instrument that would generate qualitative data as a means of gaining insights and understanding of constructs. Item generation for scale development constituted the first phase of exploratory research, whereas early validation of the measurement instrument through pre-testing constituted the second phase. Figure 3.1 illustrates the steps and procedures that have been conducted to address the research questions.
Figure 3.1: Research Framework
As previously mentioned, this research adopted a causal approach through quantitative data analysis. As can be seen in Figure 3.1, the overall approach of the study was to use a priori theories/frameworks, develop hypotheses based on the theories, and test the hypotheses through empirical data. The framework and hypotheses were tested using data collected from a survey of a sizeable sample from a population of users of a safety reporting system in a military aviation organisation. This type of research design is based on the assumption that reality can be objectively measured and is independent of that being researched. This research approach follows the hypothetic-deductive process (Bryman, 1984; Creswell, 2013). Hence, this study adopted the deductive research approach of the positivist paradigm.

3.3 Data analysis approach

Descriptive and exploratory factor analysis was conducted as the first data analysis step by describing, summarising and grouping the data before conducting a multivariate analysis. Descriptive analysis is used to provide an understanding of the sample, the sample distributions and the demography of participants, whilst Confirmatory Factor Analysis (CFA) provides the measurement model for testing theories specified a priori to describe the sample data; the exact number of factors and relationships are initially specified from a strong theoretical and/or empirical foundation.

After conducting descriptive and exploratory factor analysis to address the first research question (RQ1), multivariate analysis was conducted to answer the other two research questions (RQ2 and RQ3). Multivariate analysis is a statistical approach that simultaneously computes multiple measurements of each of individuals or objects under study (Hair, Anderson, Tatham, & Black, 1998).

3.3.1 Introduction to the Partial Least Squares method

PLS (Partial Least Squares) is one of the methods in causal modelling techniques that have made it possible for researchers to simultaneously examine theory and measures (Kotrlik & Higgins, 2001). It is one of two main approaches in Structural Equation Modelling (SEM), which has been widely known as a ‘second generation’ technique.

Unlike first-generation techniques such as regression and path analysis in which causal relationships are modelled using only directly observed variables, SEM allows the researcher to combine multiple observed measures of a latent construct (through factor
analysis) and then model the causal relationships amongst these latent constructs, rather than amongst single observed variables which are merely proxies for the latent constructs (Bobe, 2012). Hair, Sarstedt, Ringle, and Mena (2012) suggested that causal models such as SEM have several advantages: (1) they make the assumptions, constructs, and hypothesized relationships in a theory explicit; (2) they add a degree of precision to a theory, since they require clear definitions of constructs, operationalization, and functional relationships; (3) they permit a complete representation of complex theories; and (4) they provide a formal framework for constructing and testing both theories and measures.

The two approaches used for estimation in a structural equation modelling are covariance-based SEM (CB-SEM) and variance-based SEM (PLS-SEM). These techniques can be implemented with the aid of specific software for statistical analysis. For example, CB-SEM can be utilised by using the AMOS or LISREL software whereas variance-based SEM can be used by running the PLS Smart software. When choosing either CB-SEM or PLS-SEM, the characteristics and objectives that distinguish the two methods should be considered (Hair et al., 2012). In the situation where theory is less developed, and the primary objective of applying structural equation modelling is the prediction and explanation of target constructs, the researcher should consider using PLS-SEM as an alternative for structural equation modelling (Hair Jr, Hult, Ringle, & Sarstedt, 2013).

There are four critical issues relevant to the application of PLS-SEM: the data, model properties, the PLS-SEM algorithm and model evaluation issues (Hair et al., 2012; Hair Jr et al., 2013). The following paragraphs will elaborate further on these critical issues (Hair, Ringle, & Sarstedt, 2011)

a. Data characteristics. The PLS-SEM approach applied in this study has some data characteristics which differ from CB-SEM. A high level of statistical power can be achieved with small sample sizes, although large sample sizes will increase the precision of PLS-SEM estimation. Unlike covariance-based SEM, there is no distributional assumption required since PLS-SEM is a non-parametric method (Hair et al., 2011; Henseler, Ringle, & Sarstedt, 2012). Furthermore, it is highly robust as long as missing values are below a reasonable level and it works with metric data, quasi-metric (ordinal) scaled data and binary-coded variables (Hair, Ringle, & Sarstedt, 2013; Handajani, 2011; Henseler et al., 2012; Ringle, Wende, & Will, 2005). The application of PLS-SEM for analysing Likert scale (ordinal) data is valid and has been widely used in the scope of several research studies in various areas such as
health, marketing, information technologies, management and human behavior (Blackman et al., 2015; Darestani, Ismail, & Heng, 2016; Lu, Yu, Liu, & Wei, 2017; Rahman, Memon, Abdullah, & Azis, 2013; Udo, Bagchi, & Kirs, 2012; Yoon, 2009).

b. Model characteristics. The PLS-SEM can handle constructs measured using single and multi-item measures. In terms of relationships between constructs and their indicators, it easily incorporates reflective and formative measurement models. It can also handle a complex model with many structural model relations, and larger numbers of indicators are helpful in reducing the PLS-SEM bias. However, no causal loops are allowed in the structural model.

c. PLS-SEM algorithm properties. The objective is to minimise the amount of unexplained variance or maximise the R-square value. Even when there are complex models and/or large sets of data, it can converge efficiently after a few iterations to arrive at an optimum solution: an efficient algorithm. The construct scores estimated as linear combinations of their indicator, used for predictive purposes, can be used as input for subsequent analyses and are not affected by data inadequacies. Lastly, structural model relationships are generally underestimated, measurement model relationships are generally overestimated, consistency at large, and a high level of statistical power.

d. Model evaluation issues. The evaluation of reflective measurement models uses a reliability and validity assessment of multiple criteria, whereas the formative measurement model uses validity assessment, significance and relevance of indicator, weight, and collinearity. Then, the evaluation of the structural model can be measured by collinearity sets of constructs, the significance of the path coefficient of determination (R square), effect size (f square), predictive relevance (Q square and Q square effect size).

e. Additional analyses. There are several additional analyses that can be done by adopting PLS-SEM such as impact-performance matrix analysis, mediating effects, hierarchical component models, multigroup analysis, uncovering and treating unobserved heterogeneity, measurement model invariance, and moderating effects.
3.3.2 The path diagram

Based on the proposed framework, structural equation modelling has been developed as depicted in the following path diagram (Figure 3.2):

The path diagram plays a fundamental role in structural modelling since it shows variables interconnected with lines that are used to indicate causal flow, and also those variables that cause changes in other variables. There are different types of variables in the path diagram, namely:

a. A latent variable is a variable that cannot be measured directly but is hypothesised to underlie the observed variables and is represented by a variable name enclosed in an oval or circle. There are three (exogenous) independent variables in the path diagram in Figure 3.2: organisational barriers (OB), working environment barriers (WEB), and individual barriers (IB). On the other hand, there is one endogenous (dependent) variable, which is the safety reporting performance (SRP) variable.

b. The observed variable is usually known as a manifest variable that can be directly observed or measured and is usually represented by enclosing the variable
name within a square or a rectangle. Based on the path diagram above, every latent variable has several observed variables as shown in the following table.

**Table 3.2: Variables and Their Descriptions**

<table>
<thead>
<tr>
<th>No</th>
<th>Latent Variables (Exogenous/Independent Variables)</th>
<th>Latent Variables (Endogenous/Dependent Variables)</th>
<th>Observed Variables/Barriers</th>
<th>Description of Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Organisational Barriers</td>
<td></td>
<td>OB1</td>
<td>Lack of commitment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OB2</td>
<td>Inadequate funding</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OB3</td>
<td>Independence/absence of an independent third party</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OB4</td>
<td>Lack of feedback</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OB5</td>
<td>Inadequate use of information technologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OB6</td>
<td>Inadequate professional development</td>
</tr>
<tr>
<td>2</td>
<td>Working Environment Barriers</td>
<td></td>
<td>WEB1</td>
<td>Code of silence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WEB2</td>
<td>High workload</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WEB3</td>
<td>Inefficient procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WEB4</td>
<td>Peer influence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WEB5</td>
<td>Inadequate supervision (local unit)</td>
</tr>
<tr>
<td>3</td>
<td>Individual Barriers</td>
<td></td>
<td>IB1</td>
<td>Fear of reprisal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IB2</td>
<td>Distrust</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IB3</td>
<td>Personal competence re. how to report</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IB4</td>
<td>Macho perspective</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IB5</td>
<td>Acceptable norm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IB6</td>
<td>Personal skills regarding what has to be reported</td>
</tr>
<tr>
<td>4</td>
<td>Safety Reporting Performance</td>
<td></td>
<td>SRP1</td>
<td>Ease/flexibility of accessing the reporting system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SRP2</td>
<td>The ability to learn from data collected from the reports</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SRP3</td>
<td>People are encouraged to report and rewarded</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SRP4</td>
<td>The willingness to report</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SRP5</td>
<td>The existing safety culture</td>
</tr>
</tbody>
</table>

3.4 **Survey research method**

3.4.1 **Purpose and design of the survey**

This study relied on the data collected by means of a survey since controlled experimentation was unfeasible in terms of time and cost effectiveness. Chambers and Clark (2012) stated that a survey could be defined as the planned observation of objects that are not themselves deliberately treated or controlled by the observer. According to them, nature is assumed to have applied the treatments, and all the analyst can do is to observe the
consequences. There are two kinds of surveys: census and sample. The first involves all the population of interest, while the sample survey takes only a subset of the population. The latter was used for this study.

Van der Stede, Young, and Chen (2006) stated that a well-designed survey should be conducted with clear objectives, which guide the appropriate selection of respondents, and the design and use of relevant survey questions. The purpose of a survey can be to describe or explain. Descriptive studies have the objective of discovering the characteristics of a given population, whereas explanatory surveys are used to investigate the relationship between exogenous (independent) and endogenous (dependent) variables guided by theoretical explanations.

### 3.4.2 Population definition and sampling

In order to obtain a representative sample, a researcher should identify the target population which is defined as the group or the individuals to whom the survey applies (Kitchenham & Pfleeger, 2002; Van der Stede et al., 2006). A population is the entire set of elements about which the researcher wishes to make generalisations (Diamond, 2000), while a representative sample is a subset of the population that closely resembles the population in terms of key characteristics (Van der Stede et al., 2006). Then, it can be said that what is true for the sample is also true for the population within a calculable margin of error if the sample is representative of the population (Van der Stede et al., 2006). In addition to the target population, the sample size and response rates also affect the validity of the inferences made from the sample about the population.

This research relied upon the collection and subsequent collation of data obtained from anonymous surveys/questionnaires conducted in several units of a military aviation organisation in Indonesia. The cluster sampling method was used for this study. The cluster-based sampling is the term given to surveying individuals that belong to defined groups such as members of a family group. Randomization procedures are based on the cluster, not the individual, and then researchers could expect members of each cluster to give more similar answers than they would expect from members of different clusters (Kitchenham & Pfleeger, 2002).

In this case, participants were grouped according to the following criteria: the first group comprised the users of the safety reporting system who were directly involved in the operational area; the second group were team/group leaders, who were involved in and
managed the local working environment and who also use the safety reporting system; the third group were the users and also the middle leaders who managed the whole unit and had interactions with the top management. Furthermore, the collected data would cover various operational scenarios, working environments, and specific roles such as aircrews (pilot and navigator, mechanics (technician and avionics), and support (ATC, fire fighters and other aviation support).

3.4.3 Sample size

Determining an adequate sample size and dealing with non-response bias is essential in a quantitative survey design. One of the real advantages of quantitative methods is that smaller groups of people can be used to make inferences about larger groups that would be prohibitively expensive to study (Holton, 1997).

**Table 3.1: Determining Minimum Returned Sample Size**

<table>
<thead>
<tr>
<th>Population Size</th>
<th>Sample size</th>
<th>Alpha=. 10 t=1. 65</th>
<th>Alpha=. 05 t=1. 96</th>
<th>Alpha=. 01 t=2. 58</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>46</td>
<td>55</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>72</td>
<td>96</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>77</td>
<td>106</td>
<td>173</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>83</td>
<td>112</td>
<td>189</td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td>83</td>
<td>119</td>
<td>198</td>
<td></td>
</tr>
<tr>
<td>6000</td>
<td>83</td>
<td>119</td>
<td>209</td>
<td></td>
</tr>
<tr>
<td>8000</td>
<td>83</td>
<td>119</td>
<td>209</td>
<td></td>
</tr>
<tr>
<td>10000</td>
<td>83</td>
<td>119</td>
<td>209</td>
<td></td>
</tr>
</tbody>
</table>

Developed by Kotrlik and Higgins (2001)

The alpha value represents a significant level, while the t-value is used to determine whether the mean of a population significantly differs from a specific value (see Table 3.1). In this study, given a population of around 4000 people (which corresponds to the total staff in the organisation where the survey was conducted, the minimum sample size is 119 samples for Alpha 0.05 and t=1.96 (see Table 3.1). This population size equates to a confidence interval of 95% (5% margin of error).

Kotrlik and Higgins (2001) stated that one other condition should be considered by researchers when they wish to use multiple regression analysis in a study: the ratio of observations to independent variables should not fall below five. Furthermore, these authors recommended the same ratio with multiple regressions if researchers plan to use factor
analysis in their research. In this case, for the three (exogenous) independent variables used in this study, both of the conditions were met.

One of the benefits of adopting PLS-SEM analysis is the requirement for a relatively small sample. The complexity of a structural model has little influence on the sample size requirement for PLS-SEM since it uses OLS regression to estimate the model's partial regression relationship. The rule regarding minimum sample size for PLS-SEM is that it should be equal to or larger than ten times the largest number of indicators or the largest number of arrows to a particular construct in the structural model (Barclay, Higgins, & Thompson, 1995) which means that only a minimum sample of 60 was required for this study. According to the guideline provided by Cohen (1992), the researcher found that the sample size recommendation is 130 samples to achieve a minimum $R^2$ of 0.10 in any endogenous construct for a significance of 5%, with the assumption of the commonly used statistical power of 80% and considering the maximum numbers of arrows in this model.

Other researchers who have used covariance-based SEM recommended that 100 samples are sufficient with a model that has two or more indicators per factor, but the sample size should be 150 samples in order to obtain a convergence and appropriate solution (Anderson & Gerbing, 1984). In short, when using PLS-SEM or CB-SEM, anything between 130 and 150 samples should be sufficient to provide an admissible solution, although a bigger sample size is always better.

Furthermore, another consideration before conducting data collection is the response rate. Previous research has found that a response rate of 65% is likely to be achieved (Kotrlik & Higgins, 2001). Salkind (1997) also recommended increasing the sample size by 40%-50% to account for lost mail and uncooperative respondents. Therefore, the response rate for data collection should be no less than 50%.

Therefore, taking into consideration both the required minimum sample size and response rate, a total of 400 questionnaires were distributed throughout the organisation, resulting in 202 questionnaires being returned for subsequent analysis. The researcher found that 15 of the returned questionnaires had various missing data. Eleven respondents failed to reveal their professional background but had completed the rest of the questionnaire, whilst four respondents had omitted both the professional background and several other questions. Nevertheless, the eleven incomplete responses were accepted since they were valid and would not influence the statistical outcomes. The four samples with a greater amount of
missing data were discarded. In all, 198 samples were considered for further analysis (the statistics regarding the description of respondents will be explained in Chapter Five).

3.4.4 Survey instrument development

The following paragraphs explain the processes followed in designing the survey questionnaire. The survey instrument was developed according to the following series of steps:

Step 1 - Development of an initial draft.

The questionnaire was based on a set of selected statements addressing the barriers, which presumably influence the performance of the reporting system as explained in Chapter Two. The participants’ responses to each question were transformed into a quantitative score. The Likert scale was used to obtain ordinal data, which were also suitable for the multivariate method used in this study, namely Partial Least Squares (PLS) and Structural Equation Modelling (SEM).

Step 2 – Experts’ comments.

After developing the initial draft of the questionnaire, the researcher discussed it with three experts who examined and evaluated its adequacy during several meetings. Moreover, several comments made by the ethics committee at RMIT were also taken into consideration when preparing the final version of the questionnaire. The experts’ feedback led to modifications of the questionnaire content in order to ensure the objective of this study could be achieved. The comments from the ethics committee representative were used as a guide to confirm that the questionnaire did not violate any of the existing ethic requirements, namely the values of respect for human beings, research merit and integrity, justice, and beneficence.

After the experts’ comments and the ethics concerns had been addressed, the questionnaire was translated into the Indonesian language by the researcher under the supervision of one expert from the School of Business (RMIT University) as an additional reviewer of the questionnaire, both of whom are Indonesian native speakers.

Step 3 - Pilot runs

After improving the first draft of the questionnaire based on the experts’ comments and the ethics concerns, a second version of the questionnaire was produced in two
languages: English and Indonesian. The researcher conducted a pilot study using this latter version. The questionnaires were sent via email to the relevant safety officer who then distributed them to 10 participants in the field. After collecting the questionnaires from participants, the safety officer returned the questionnaires to the researcher. The purpose of this pilot run was to ensure the validation of the instrument. The feedbacks from the participants in the pilot run led to some conceptual modifications and shortening, and reordering and rewording of the statements in the questionnaire.

Step 4 - Final survey instrument.

Based on the outcomes from the pilot study, the content of the questionnaire was modified under the guidance of the supervisor. After several modifications, the final questionnaire was ready to be used for data collection in the field (Appendix A1 and A2 contain the final versions of the questionnaire used in this research).

3.4.5 Structure and content of the survey questionnaire

The final survey instrument consisted of two pages organised in five parts. The contents of each part are discussed in the following sub-sections. In part 1, which asked about the participants’ professional background, respondents were given a question with three alternative answers and then asked to choose one of them. In parts 2, 3, 4, and 5, the respondents were given a question corresponding to each of the indicators in the proposed model, which offered five options. The respondents answered by circling one of the five options using a Likert-type scale, ranging from "Strongly disagree" to "Strongly agree."

The five parts of the questionnaire are: 1) the professional background of respondents (3 questions), 2) Organisational Barriers (6 questions), 3) Working Environment Barriers (5 questions), 4) Individual Barriers (6 questions) and 5) Safety Reporting Performance (5 questions). The questions were formulated using a neutral statement to minimise the possibility of biased answers. The following statement is an example of one of the questions pertaining to Individual Barriers: "Fear of consequences after submitting a safety report makes members/workers more reluctant to report". The following section explains each part of the questionnaire in more detail.
Part 1: Professional background

Part 1 had three questions designed to collect information regarding the professional background of the respondents. The first three questions were concerned with the roles, tenure and position in the organisation. In order to classify the respondents according to their roles, one question was asked concerning their role in the organisation such as aircrew (pilot/navigator), maintenance (technician, avionics), and support (ATC, fire fighter and other aviation support). In order to determine whether any possible differences among the respondents were due to their experience, they were asked about their length of service in this organisation (i.e., below five years, between five and ten years, and more than ten years. Lastly, to determine the difference between respondents based on their managerial experience, they were asked to state their position within the organisation such as senior officer, junior officer or non-commissioned officer (NCO). This section of the instrument was intended to ensure that respondents who were involved in this study were valid respondents.

Part 2: Organisational barriers

This part was concerned with the extent to which the organisational barriers could influence the intention of the user or respondents to make and submit a safety report as found in the literature review and the research framework presented in the previous chapter. In order to obtain the respondents’ opinions regarding the extent to which organisational barriers existed in their organisation according to their experience as users of the safety reporting system, six questions were asked. Each question corresponded to an indicator of organisational barriers. These were: a lack commitment from top level management toward a safety reporting system; the inadequacy of funding for the infrastructures and management of a safety reporting system; the absence of an independent third party to manage the safety reporting process; the lack of feedback given to users; the absence of modern information technologies (IT) used in the process; and the inadequacy of training on how to submit a safety report.

Part 3: Working Environment barriers

This part was intended to determine the extent to which the working environment barriers influenced the intention of the user or respondents to submit a safety report, as explained in the literature review and the research framework. The respondents were asked
five questions to obtain their opinions regarding the extent to which they believed that working environment barriers existed in their organisation. The five questions corresponded to all barriers or indicators in this variable. They included: the existing code of silence (fear of negative implication to my peer) after submitting a safety report; the excessive workload that prevented members/workers to report safety information; extensive or complex reporting procedures that prevented members/workers to report; whether the culture of colleagues who did not care to report safety occurrences had a strong negative influence on the other members’/workers’ intention to report; and whether inadequate local manager/leader supervision for submitting a safety report decreased members’ or workers' intention to report a safety issue.

**Part 4: Individual barriers**

This part is concerned with the extent to which the performance of individuals could influence the intention of the user or respondents to submit a safety report as was explained in the both the literature review and conceptual framework. The respondents were asked six questions, all related to the indicators of individual barriers. They include: fear of consequences (being blamed) after submitting a safety report; a distrust of the practical benefits of submitting a safety report; not fully understanding the safety reporting procedure; the perception that risk is an inherent part of their work (macho perspective); the occurrences are an act of God (acceptable norm); and not understanding what needs to be reported.

**Part 5: Safety reporting performance indicators**

This part is concerned with the level of performance of the existing safety reporting system according to the participants’ experience as explained in the literature review and presented in the research model. The respondents were asked to evaluate the performance of safety reporting procedures in their organisation according to five indicators. Respondents were asked five questions, each of which corresponded to one of the five indicators of the effectiveness of the safety reporting system. They included: the ease of submitting a safety report on incidents and hazards (Flexibility); the ability of existing system to learn from the data collected and then taking action for improvement (Learning); whether they are encouraged and rewarded when submitting a safety report (Accountability); whether they are willing to report their errors and experiences of safety occurrences voluntary
(Willingness); and whether members or workers have a knowledge of human, technical and organisational factors that determine the safety of the system as a whole (Informed).

3.4.6 Administration of the data collection

One of the requirements established by the ethics committee was that prior permission would need to be sought from the organisation where the data collection was to be conducted. This requirement was fulfilled by obtaining formal approval from the organisation before conducting the survey.

The data were collected through a self-administered written questionnaire. The researcher visited the target sample population in their workplace during working hours. There were 25 units in the organisation which in turn can be categorised according to four main operational areas: 8 fighter aircraft, 6 transport aircraft, 4 helicopter fleet and 7 base ops units. The reseacher decided to collect data from one unit in each of these categories. In collaboration with the local safety officer of the intended units, all participants were invited to meet in the unit briefing room. The researcher explained the purpose of the research, the contribution and significance of the research, and how to complete the questionnaires that were distributed by the safety officer. Participants were given the opportunity to ask questions related to any issues regarding both the research and questionnaire, and they were informed that they could leave the room if they had decided not to participate. Lastly, the participants were informed that they would not need to disclose their identity and that they could place the completed questionnaire on a table in the briefing room upon completion. Then, the researcher left the participants to decide whether or not they wanted to remain in the room. Participants who decided to remain were given ample time to complete the questionnaire. After all participants had left the briefing room, the researcher returned to collect all questionnaires – whether completed or left blank. This data collection procedure was repeated for the four units involved in this research.

3.4.7 The consideration of data instrument development

The main objectives when designing a questionnaire should be the maximization of the proportion of individuals answering the questionnaire and the accuracy of the information collected. To maximise response rates, the researchers have to consider carefully how to administer the questionnaire, clearly explain the purpose of the survey, and ensure its length is appropriate. To obtain accurate, relevant information, the questions should be judiciously
formulated, including their form/style, their order of appearance and how this reflects the overall layout of the questionnaire.

In this study, the most important issue pertaining to the questionnaire development was the type of questions needed for data collection purposes. To be more specific, two issues had to be considered carefully. Firstly, the researcher intended to obtain the personal opinions of participants in a military aviation organization. Secondly, the personal opinions were in regard to the weakness/barriers of the system of the organization which could be considered as sensitive topic in a military environment (in the context of IDAF). Therefore, given these two matters, the researcher needed to pay particular attention when formulating the most appropriate questions for this study.

Military organisations are characterized by bureaucracies or procedures which strongly rely on a rigid hierarchy governed by numerous rules and regulations (J. Soeters et al., 2006). This means that personnel at the higher levels in the hierarchy control what happens at lower levels; in other words, all policies and directives issued by top-level management are implemented directly or interpreted in some way before they are passed on to the next level below. As bureaucratic organisations, military cultures tend to be more coercive than those of business organisations (J. Soeters & Recht, 1998; J. L. Soeters, 1997). Coerciveness can be described as a high degree of asymmetry of power between managers and employees where, on an everyday basis, no or only a few "reality checks" are provided by external influences (Adler & Borys, 1996). Similarly, J. Soeters et al. (2006) revealed that the level of power distance (hierarchy) in the military organization is much more significant than in other sectors. This result is hardly surprising since military organisations are traditionally known for having a strong social order based on vertical, power-related classifications and regulations (Douglas, 1973).

Furthermore, Indonesian culture itself is also characterized for having a large power distance (Hofstede, 1983). Since national culture permeates military life (J. L. Soeters, 1997), it is hardly surprising that Indonesian military organisations have a higher power distance which is likely to have a negative impact on the level of professionalism. The power distance dimension means that the culture has some characteristics such as the acceptance that power in institutions and organisations is distributed unequally which is reflected in the values of the less powerful members of the society as well as in those of the more powerful ones (Hofstede, 1980). For instance, subordinates consider superiors as different kinds of people,
often regarded as inaccessible and powerful. Meanwhile, superiors consider subordinates as the objects of blame when something undesirable happens, such as an accident.

The concomitant effect of Indonesian culture and characteristics of military organisations lead to the assumption that it would be certainly hard to obtain an unbiased individual attitude toward their system and organization. The participants would not give an honest and appropriate response to a questionnaire if the researcher did not provide suitable questions. This assumption is even more relevant when considering the type of information targeted by this research, i.e., any eventual weaknesses in the reporting system currently in use at the IDAF. Also, previously it has been found that respondents are often unwilling or unable to report accurately on sensitive topics in order to avoid criticism, gain social approval or make an impression on management (Fisher, 1993; Huang, Liao, & Chang, 1998; King & Bruner, 2000). For instance, asking military members to judge their superiors' supervision in a military organization might influence the accuracy of their responses. As a result, it represents a potential threat to the validity of the research since the data are systematically biased by respondents' attitudes (King & Bruner, 2000; Van de Mortel, 2008).

The application of indirect questioning is a strategy used to circumvent the aforementioned circumstances. Hence, the researcher adopted an indirect approach to obtaining sensitive data, as recommended by Chaudhuri (2016); (Chaudhuri & Christofides, 2013). In this situation, the assurance that the information provided would be treated as strictly confidential is just not enough so it is very likely that people would provide untruthful answers just to be on the safe side (Chaudhuri & Christofides, 2013). On the other hand, responses to direct questions may not reflect an individual’s true status (Moshagen, Hilbig, Erdfelder, & Moritz, 2014). A respondent may distort his/her responses in order to appear more favourable in the eyes of senior managers or to avoid (legal) sanctions (Birkeland, Manson, Kisamore, Brannick, & Smith, 2006; McFarland & Ryan, 2000; Tourangeau & Yan, 2007). These are further arguments to justify the use of indirect questioning in this study.

Indirect questioning is a projective technique that asks subjects or respondents to answer structured questions from the perspective of another person or group (Anderson, 1978). For instance, one of the questions in the questionnaire is “A lack commitment from the top-level management toward safety reporting system degrade the willingness of members/workers to report safety information, such as incidents and hazards”. In the context of IDAF, the “members/workers” term represents friends or colleagues in the organization. Therefore, in this question, the researcher has opted to ask the subjects the
perception their colleagues would most likely have regarding the influence of a lack of commitment towards the willingness to report.

The indirect procedure can reduce the distortion of "private" opinions that are revealed to the researcher by asking respondents to "report on the nature of the external world" rather than about themselves (Westfall, Boyd, & Campbell, 1957). It is expected that respondents project their unconscious biases into ambiguous response situations and reveal their own attitudes (Sherwood, 1981). For another example in this study, a respondent predicts "other people’s" perception of the influence of the code of silence on the willingness to submit a safety report in this organization. This answer would be interpreted to mean that the respondent is likely to behave in this manner (Fisher, 1993; Huang et al., 1998; King & Bruner, 2000). Furthermore, indirect questioning allows respondents to give information about a situation based on a fact rather than an opinion, and so they respond behind a facade of impersonality (Simon & Simon, 1974).

Although it has been widely used in some research involving sensitive issues (John, Edwards-Jones, Gibbons, & Jones, 2010), the indirect questioning strategy has been criticised by some researchers. Maccoby and Maccoby (1954) argued that rather than provide insights into the self, indirect questions might actually reveal what respondents predict a "typical other" might do or think. Other authors argued that the response to indirect questioning might be an objective judgment that is independent of the respondent’s own intentions and behaviours (Fisher, 1993). Some researchers also suggested that predictions about others do not accurately reflect what respondents would have reported had they been asked directly (Fisher & Tellis, 1998; Hoch, 1988). For example, a respondent’s prediction about the drug use by others may not be contaminated by social desirability bias, but it may contain little information about the self if the individual giving the prediction is a non-drug user. In this situation, the degree of similarity between the respondent and the typical other decreases since non-drug respondents are less likely to project themselves into an indirect response situation in which the typical other is a heavy drug user. As a result, the respondent's answer may be irrelevant to the purpose of the questionnaire.

Considering that both direct and indirect questioning strategies have valid arguments, the best scenario would be to resort to the two types of questions in different questionnaires. This would not only increase the validity of the questionnaire and certainly the results of this research, but it would also allow a comparison between the two procedures. Unfortunately, this was unfeasible due to budget and time constraints, so the researcher had to opt for just
one type of questioning. Upon weighing the pros and cons of each side, the researcher decided to adopt indirect questioning as it minimizes the chances of biased responses as per the argument in previous paragraphs. This is particularly important considering the very unique culture at the IDAF as perceived by the researcher stemming from his empirical experience during nearly 20 years of service in this organization.
CHAPTER FOUR
VALIDATION AND RELIABILITY

4.1 Introduction

PLS-SEM analysis deals with two models simultaneously, the outer model and the inner model. The outer model, also known as the measurement model, relates the observed variables (indicators) to their respective unobserved variables (latent variables or constructs). The second part is the inner model, usually known as the structural model, that can be used to estimate the relationships between latent variables (independent and dependent variables), as hypothesised by the researcher. The structural model measurement is explained in Chapter Five, which also presents the results. This section encompasses the assessment of the measurement model reliability and validity tests. This assessment was conducted by using the default setting of PLS algorithm calculation in SmartPLS 3 software.

4.2 Normality tests

One aspect of multivariate statistics that researchers should consider is the normality assumption. This assumption is that the interval response variables across the groups must be multivariate and normally distributed (Burdenski Jr, 2000). If the data set is not normally distributed, the outcome of the parametric statistical method will not reach an optimal value. Therefore, the researcher conducted an initial normality test to determine the most suitable method for this data set. There are several ways of assessing the multivariate normality. For example, the software SPSS uses two well-known normality confirmation methods, namely, Kolmogorov-Smirnov and Shapiro-Wilk. Table 4.1 presents the results of the application of these two methods to the data set obtained from the surveys.
Table 4.1: Normality tests

<table>
<thead>
<tr>
<th></th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>SRP1</td>
<td>.340</td>
<td>190</td>
</tr>
<tr>
<td>SRP2</td>
<td>.315</td>
<td>190</td>
</tr>
<tr>
<td>SRP3</td>
<td>.349</td>
<td>190</td>
</tr>
<tr>
<td>SRP4</td>
<td>.331</td>
<td>190</td>
</tr>
<tr>
<td>SRP5</td>
<td>.315</td>
<td>190</td>
</tr>
<tr>
<td>OB1</td>
<td>.325</td>
<td>190</td>
</tr>
<tr>
<td>OB2</td>
<td>.315</td>
<td>190</td>
</tr>
<tr>
<td>OB3</td>
<td>.284</td>
<td>190</td>
</tr>
<tr>
<td>OB4</td>
<td>.338</td>
<td>190</td>
</tr>
<tr>
<td>OB5</td>
<td>.288</td>
<td>190</td>
</tr>
<tr>
<td>OB6</td>
<td>.346</td>
<td>190</td>
</tr>
<tr>
<td>WEB1</td>
<td>.254</td>
<td>190</td>
</tr>
<tr>
<td>WEB2</td>
<td>.251</td>
<td>190</td>
</tr>
<tr>
<td>WEB3</td>
<td>.240</td>
<td>190</td>
</tr>
<tr>
<td>WEB4</td>
<td>.219</td>
<td>190</td>
</tr>
<tr>
<td>WEB5</td>
<td>.297</td>
<td>190</td>
</tr>
<tr>
<td>IB1</td>
<td>.263</td>
<td>190</td>
</tr>
<tr>
<td>IB2</td>
<td>.298</td>
<td>190</td>
</tr>
<tr>
<td>IB3</td>
<td>.268</td>
<td>190</td>
</tr>
<tr>
<td>IB4</td>
<td>.225</td>
<td>190</td>
</tr>
<tr>
<td>IB5</td>
<td>.270</td>
<td>190</td>
</tr>
<tr>
<td>IB6</td>
<td>.274</td>
<td>190</td>
</tr>
</tbody>
</table>

After processing all variables using the two tests above, the outcome showed that all variables had a non-normal distribution (a value of Sigma less than 0.05 is considered non-normal). Therefore, the data set was not suitable for a parametric statistical analysis. Since the covariance-based SEM which is usually found in AMOS and LISREL package requires a normal data distribution (parametric statistic), the data set should be processed using other statistical approaches that include a non-parametric statistical method (Fornell & Bookstein, 1982). One such method is provided by smartPLS3 software, one of the SEM methods that are based on the analysis of variance.

4.3 Assessment of measurement model

Like the other SEM method, PLS-SEM has two types of measurement specifications: reflective and formative measurement models. The first type represents the manifestations of
an underlying construct or a representative sample of all the possible items available within the conceptual domain of construct (Hair Jr, Hult, Ringle, & Sarstedt, 2016; Nunnally & Bernstein). The indicators for a particular construct should be highly correlated to each other, interchangeable, and any item should be able to be removed without changing the meaning of the construct. Conversely, the formative measurement model is the assumption that causal indicators combine to create the construct through linear combination (Hair Jr et al., 2016). The indicators are not interchangeable, and each indicator reflects a particular aspect of the constructs, which suggests that the removal of an indicator has the potential to change the original meaning of the construct. Furthermore, in a reflective measurement model, the arrows point from the latent variable to the indicators while in a formative measurement model, the arrows point from the indicators to the latent variable. For example, the scales designed to measure the organisational barriers consisted of six indicators. The six items described the same construct in different forms. If, for example, one of the items was not included in the questionnaire or was not reliable according to a measurement model evaluation after data collection, the other items that described the nature of organisational barrier would remain reliable and valid.

Each indicator in a reflective measurement model represents an error-afflicted measurement (Götz, Liehr-Gobbers, & Krafft, 2010). A measurement error can be caused by two types of errors, namely random error and systematic error. The random error is the result of all error factors that unsystematically influence a construct’s measurement while the systematic error occurs at each repetition and always at the same level. Reliability of a measurement item is assured when an item is free from random errors, and validity is obtained when an item is free from systematic errors (Churchill, 1987).

This study adopted a reflective measurement model since the characteristics of the constructs and indicators met the aforementioned criteria for this model. Hence, all of the scales for the current study were formulated and written in a reflective format when the survey questionnaire was developed.

To evaluate the measurement model, the researcher conducted the most important measurement in PLS-SEM: the convergent validity, reliability, and discriminant validity test. The purpose of this test is to reduce the measurement errors as much as possible that have resulted from a poorly worded question or statement in the questionnaire, a misinterpretation of the scaling approach, or the incorrect application of a statistical method which can lead to random and/or systematic errors (Hair Jr et al., 2016).
4.3.1 The convergent validity

In order to evaluate the convergent validity, the researcher should consider the outer loading indicator and the average variance extracted (AVE). The convergent validity indicates the extent to which a measure correlates positively with alternative measures of the same construct (Hair Jr et al., 2016). The common rule of thumb is that outer loadings should be equal to or greater than 0.708, but indicators with outer loadings of 0.40 and 0.70 could be retained if the indicator increases the composite reliability (Hair Jr et al., 2016), while a low outer loading indicator (below 0.40) should be eliminated from the construct (Bagozzi, Yi, & Phillips, 1991; Hair et al., 2011).

In this case, the outer loading in the organisational barriers (OB) and the safety reporting performance (SRP) are within the acceptable criteria. The lowest outer loading of organisational barriers (OB) indicator is 0.748 for OB6 (Inadequate professional development) while the highest is 0.854 for OB2 (lack of commitment) (see Table 4.2). A better outer loading value was shown for the indicators of safety reporting performance (SRP) with the lowest of 0.920 for SRP4 (the willingness to report) and the highest of 0.948 for SRP1 (the ability to learn from the reports).

However, it was found that two outer loading values were below the acceptable criteria. The first one was WEB2 (high workload) for the working environment barriers (WEB) and IB5 (acceptable norm) for the individual barriers (IB), with outer loading factors of 0.347 and 0.270 respectively (see Table 4.2), but all other indicators in these groups were well within the acceptable threshold. To be more specific, the lowest outer loading was 0.769 for WEB4 (peer influence) in the working environment barriers (WEB), and 0.780 for IB4 (masculine perspective) in the individual barriers (IB) construct. The outer loading values of all these indicators, apart from the two aforementioned barriers (WEB2 and IB5), exceeded the minimum threshold and were therefore acceptable.
Table 4.2: The results of the first stage measurement

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>Loading</th>
<th>AVE</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisational Barriers</strong></td>
<td>OB1 (Lack of commitment)</td>
<td>0.854</td>
<td>0.662</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB2 (Inadequate funding)</td>
<td>0.797</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB3 (The absence of independence)</td>
<td>0.816</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB4 (Lack of feedback)</td>
<td>0.842</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB5 (Inadequate use of information technology)</td>
<td>0.820</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB6 (Inadequate professional development)</td>
<td>0.748</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Working Environment Barriers</strong></td>
<td>WEB1 (Code of silence)</td>
<td>0.823</td>
<td>0.554</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEB2 (High workload) (The item is deleted)</td>
<td>0.347</td>
<td></td>
<td>discarded</td>
</tr>
<tr>
<td></td>
<td>WEB3 (Insufficient procedure)</td>
<td>0.821</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEB4 (Peer influence)</td>
<td>0.769</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEB5 (Inadequate supervision in the local unit)</td>
<td>0.839</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Individual Barriers</strong></td>
<td>IB1 (Fear of reprisal)</td>
<td>0.821</td>
<td>0.564</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB2 (Distrust)</td>
<td>0.842</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB3 (Personal competence how to report)</td>
<td>0.836</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB4 (Macho perspective)</td>
<td>0.780</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB5 (Acceptable norm) (The item is deleted)</td>
<td>0.270</td>
<td></td>
<td>discarded</td>
</tr>
<tr>
<td></td>
<td>IB6 (Personal skill regarding what has to be reported)</td>
<td>0.788</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Safety Reporting performance Indicators</strong></td>
<td>SRP1 (The ability to learn from the reports)</td>
<td>0.948</td>
<td>0.871</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP2 (Flexibility to access the reporting system)</td>
<td>0.932</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP3 (People are encouraged and rewarded to report)</td>
<td>0.927</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP4 (The willingness to report)</td>
<td>0.920</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP5 (The existing information culture)</td>
<td>0.938</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Since the two indicators, WEB2 and IB5, did not meet the acceptable criteria, they were removed from their constructs (variables). Furthermore, the new model without WEB2 and IB5 was re-calculated using the PLS algorithm with the same default setting in smartPLS3 software. In this second stage of measurement, little change was observed in the value of the outer loading factor indicators and all more than adequately met the acceptable criteria. Some of them had an even better outer loading indicator than the first stage measurement as shown in Table 4.3. The lowest outer loading factor for working environment barriers is 0.769 for WEB 3 (peer influence), and the highest is WEB 5 (Inadequate supervision in the local unit). Meanwhile, all remaining indicators of individual barriers ranged from 0.780 to 0.851, with the lowest being IB4 (macho perspective) and the highest being IB2 (distrust).
Table 4.3: The results of the second stage measurement

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>Loading</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational Barriers</td>
<td>OB1 (Lack of commitment)</td>
<td>0.855</td>
<td>0.662</td>
</tr>
<tr>
<td></td>
<td>OB2 (Inadequate of funding)</td>
<td>0.797</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB3 (The absence of independence)</td>
<td>0.816</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB4 (Lack of feedback)</td>
<td>0.842</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB5 (Inadequate use of information technology)</td>
<td>0.820</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB6 (Inadequate professional development)</td>
<td>0.748</td>
<td></td>
</tr>
<tr>
<td>Working Environment Barriers</td>
<td>WEB1 (Code of silence)</td>
<td>0.820</td>
<td>0.670</td>
</tr>
<tr>
<td></td>
<td>WEB3 (Insufficient procedure)</td>
<td>0.827</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEB4 (Peer influence)</td>
<td>0.769</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEB5 (Inadequate supervision in the local unit)</td>
<td>0.856</td>
<td></td>
</tr>
<tr>
<td>Individual Barriers</td>
<td>IB1 (Fear of reprisal)</td>
<td>0.820</td>
<td>0.664</td>
</tr>
<tr>
<td></td>
<td>IB2 (Distrust)</td>
<td>0.851</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB3 (Personal competence how to report)</td>
<td>0.839</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB4 (Macho perspective)</td>
<td>0.780</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB6 (Personal skill regarding what has to be reported)</td>
<td>0.783</td>
<td></td>
</tr>
<tr>
<td>Safety Reporting performance Indicators</td>
<td>SRP1 (The ability to learn from the reports)</td>
<td>0.948</td>
<td>0.871</td>
</tr>
<tr>
<td></td>
<td>SRP2 (Flexibility to access the reporting system)</td>
<td>0.933</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP3 (People are encouraged and rewarded to report)</td>
<td>0.927</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP4 (The willingness to report)</td>
<td>0.920</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP5 (The existing information culture)</td>
<td>0.938</td>
<td></td>
</tr>
</tbody>
</table>

Another common measure used to evaluate convergent validity is the Average Variance Extracted (AVE) which is defined as the grand mean value of the squared loadings of the indicator associated with the construct (Hair Jr et al., 2016). The threshold value for this metric is 0.50 or higher (Hair Jr et al., 2016); hence, all the values of constructs in this data were above the acceptable level since the lowest AVE value was 0.554 for working environment barriers in the first stage measurement (see Table 4.2). After the second measurement, the value of AVE was better than that for first stage measurement, with the lowest AVE value being 0.662 for organisational barriers (OB) (see Table 4.3). Lastly, the safety reporting performance (SRP) value (0.871) was the highest AVE value among the constructs for both the first and second measurements.

4.3.2 The reliability test

The items used for a scale need to have internal consistency. The items should all measure the same thing, and they should be correlated with one another. Cronbach's Alpha (CA) is the most common measure of internal consistency, which provides an estimate of the reliability based on the intercorrelations of the observed indicator variables (Hair Jr et al., 2016; Santos, 1999). Since Cronbach's Alpha (CA) has limitations as it is sensitive to the
number of items and tends to underestimate (Hair Jr et al., 2016), the Composite Reliability (CR) measure was applied. To assess the internal consistent reliability, both the Cronbach's Alpha(CA) and Composite Reliability(CR) values range between 0 and 1, and the acceptable reliability value should be more than 0.7 (Hair Jr et al., 2016; Tavakol & Dennick, 2011) although lower thresholds are sometimes used in the literature (Hair Jr et al., 2016; Santos, 1999).

In this case, all the construct values are above an acceptable level both in the first and second stages of measurement. The Cronbach's Alpha (CA) for organisational barriers (OB) and safety reporting performance (SRP) constructs remain the same in the first and the second measurement at 0.897 and 0.963, respectively. On the other hand, the Cronbach's Alpha (CA) for working environment barriers increased from 0.780 in the first stage measurement to 0.835 in the second stage, while the Cronbach's Alpha (CA) of individual barriers also increased slightly from 0.828 to 0.874 (See Table 4.4).

Table 4.4: The results of the reliability test

<table>
<thead>
<tr>
<th>Constructs</th>
<th>First Stage</th>
<th>Second Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CR</td>
<td>CA</td>
</tr>
<tr>
<td>(OB) Organisational Barriers</td>
<td>0.921</td>
<td>0.897</td>
</tr>
<tr>
<td>(WEB) Working Environment Barriers</td>
<td>0.853</td>
<td>0.780</td>
</tr>
<tr>
<td>(IB) Individual Barriers</td>
<td>0.878</td>
<td>0.828</td>
</tr>
<tr>
<td>(SRP) Safety Reporting Performance</td>
<td>0.971</td>
<td>0.963</td>
</tr>
</tbody>
</table>

Similarly, the Composite Reliability (CR) value shows that Composite Reliability for organisational barriers (OB) and safety reporting performance (SRP) constructs were steady at 0.921 and 0.971 respectively both in the first and the second measurement. On the other hand, the Composite Reliability (CR) for working environment barriers (WEB) increased from 0.853 in the first stage to 0.890 in the second stage measurement while the Composite Reliability (CR) of individual barriers (IB) changed from 0.878 to 0.908 (see Table 4.4).
Table 4.5: Psychometric properties for measurement model

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>Loading</th>
<th>AVE</th>
<th>CR</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational Barriers</td>
<td>OB1 (Lack of commitment)</td>
<td>0.855</td>
<td>0.662</td>
<td>0.921</td>
<td>0.897</td>
</tr>
<tr>
<td></td>
<td>OB2 (Inadequate funding)</td>
<td>0.797</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB3 (The absence of independence)</td>
<td>0.816</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB4 (Lack of feedback)</td>
<td>0.842</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB5 (Inadequate use of information technology)</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OB6 (Inadequate professional development)</td>
<td>0.748</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working Environment Barriers</td>
<td>WEB1 (Code of silence)</td>
<td>0.820</td>
<td>0.670</td>
<td>0.890</td>
<td>0.835</td>
</tr>
<tr>
<td></td>
<td>WEB3 (Insufficient procedure)</td>
<td>0.827</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEB4 (Peer influence)</td>
<td>0.769</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEB5 (Inadequate supervision in the local unit)</td>
<td>0.856</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual Barriers</td>
<td>IB1 (Fear of reprisal)</td>
<td>0.820</td>
<td>0.664</td>
<td>0.908</td>
<td>0.874</td>
</tr>
<tr>
<td></td>
<td>IB2 (Distrust)</td>
<td>0.851</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB3 (Personal competence how to report)</td>
<td>0.839</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB4 (Macho perspective)</td>
<td>0.780</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IB6 (Personal skill regarding what has to be reported)</td>
<td>0.783</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Reporting performance</td>
<td>SRP1 (The ability to learn from the reports)</td>
<td>0.948</td>
<td>0.871</td>
<td>0.971</td>
<td>0.963</td>
</tr>
<tr>
<td>Indicators</td>
<td>SRP2 (Flexibility to access the reporting system)</td>
<td>0.933</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP3 (People are encouraged and rewarded to report)</td>
<td>0.927</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP4 (The willingness to report)</td>
<td>0.920</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SRP5 (The existing information culture)</td>
<td>0.938</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In short, the second stage measurement (without WEB2 and IB5) indicated that the outer factor loading values, average variance extracted (AVE), Composite Reliability (CR) and Cronbach's Alpha (CA) were within an acceptable level, which means that the model fulfilled both the convergent validity and reliability tests. Finally, the researcher decided that the final model used for this study would omit WEB2 and IB5 as seen in the final results in Table 4.5. Then, the data without WEB2 and IB5 was calculated for the next measurement, which was discriminant validity and structural model assessment.

4.3.3 Discriminant validity

The other validation for this model is the discriminant validity that indicates the extent to which a construct is truly distinct from other constructs by empirical standards. The common measures for this validation are Cross-Loading Analysis and the Fornell-Lacker criterion (Hair Jr et al., 2016).

To evaluate the cross-loading, an indicator’s outer loading on the associated construct should be greater than any of its cross-loadings (Hair Jr et al., 2016). In this case, as shown in Table 4.6, all indicators for each construct are greater than the outer loading indicators of other constructs.
The second approach for assessing discriminant validity is the Fornell-Larcker criterion analysis which compares the square root of the AVE values with the latent variable correlations (Hair Jr et al., 2016). The standard value for the Fornell-Lacker criterion is that the square root of each construct’s AVE should be greater than its highest correlation with any other construct (Hair Jr et al., 2016). In this study, the result of Fornell-Larcker criterion analysis can be seen in Table 4.7, which shows the AVE value of each construct is greater than its correlation with other constructs.

Finally, the measurement model was considered satisfactory with the evidence of adequate reliability, convergent validity, and discriminant validity. This result established a good prior condition before testing the hypotheses and evaluating the structural model.
CHAPTER FIVE
RESULTS AND DISCUSSION

5.1 Introduction

The previous chapter presented the assessment of the criteria for validity and reliability. Specifically, it assessed principal component analysis of some of the variables, which were measured using a multi-item survey instrument to determine the dimensionality of the items as part of the validity test process. After validity and reliability assessment, the item screening continued through the evaluation of the PLS measurement model which established further the validity and the reliability of all indicators and variables.

This chapter proceeds to statistical analyses of the results in two main parts. The first part presents the descriptive statistics for the profile of the respondents, whereas the second part presents the results of the testing hypotheses, which were formulated in Chapter Three. The PLS inner (structural) model analysis was the main technique used for testing the hypotheses of this study, as explained previously. This procedure involved the computation of PLS algorithms using the SmartPLS3 software, and evaluation of the model by testing the significances of the path coefficients, and the relationships between exogenous (independent) and endogenous (dependent) variables by means of a bootstrapping technique. This chapter also gives an overview and detailed explanations, as appropriate, of the assessment criteria for the structural model by using additional techniques: Blindfolding and Importance-Performance Map Analysis (IPMA). After presenting the analysis of the structural model, the chapter discusses the results in more detail to derive theoretical and practical meanings from the results.

5.2 Descriptive statistics of respondents

5.2.1 Roles

The respondents who were involved in this survey comprised aircrew, maintenance and support personnel. The diversity of roles allows for a broad characterization of the distinct safety barriers, which are eventually populated across the several layers of the organisation, as depicted in Figure 2.4. The number of respondents according to their role in the organisation can be seen in Table 5.1:
### Table 5.1: The roles of respondents

<table>
<thead>
<tr>
<th>Roles</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Crews</td>
<td>36</td>
<td>18.28</td>
</tr>
<tr>
<td>Maintenance</td>
<td>85</td>
<td>43.15</td>
</tr>
<tr>
<td>Supports</td>
<td>66</td>
<td>34.50</td>
</tr>
<tr>
<td>Missing</td>
<td>11</td>
<td>5.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>198</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

According to the table above, most respondents (85 or 43.15%) work in maintenance, 36 people (18.27%) work as air crew, 66 (33.50%) have support roles, and 11 respondents (5.08%) did not reveal this information on the questionnaire. The percentage of respondents according to their roles can be seen in Figure 5.1.

![Respondents' Roles](image)

**Figure 5.1:** Respondents' roles percentage

#### 5.2.2 Tenure

The respondents’ number of years in service has been placed under three categories: tenure of fewer than five years, tenure between five and ten years, and tenure of over ten years. These categories allow the inclusion of distinct experience levels of participants, with the assumption that the longer tenures will equate to more experienced staff, hence allowing a more profound understanding of the weaknesses as well as the strengths of the existing reporting system. The number of respondents for each tenure category is shown in Table 5.2 below.
Table 5.2: The tenure of respondents

<table>
<thead>
<tr>
<th>Tenure</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 years</td>
<td>9</td>
<td>4.55</td>
</tr>
<tr>
<td>5 - 10 years</td>
<td>80</td>
<td>40.40</td>
</tr>
<tr>
<td>&gt; 10 years</td>
<td>99</td>
<td>50.00</td>
</tr>
<tr>
<td>Missing</td>
<td>10</td>
<td>5.05</td>
</tr>
<tr>
<td>Total</td>
<td>198</td>
<td>100.00</td>
</tr>
</tbody>
</table>

According to the table above, 99 respondents (50%) had a tenure of more than ten years, 80 respondents had a tenure of five to ten years (40.40%), and ten respondents had less than five years (5.05%). The pie chart in Figure 4.2 shows the periods of tenure for all respondents.

Figure 5.2: Respondents’ tenure percentage

5.2.3 Rank

Based on their rank in the organisation, respondents in this study were placed into three categories: NCOs (Non-Commissioned Officers), First Officers and Senior Officers. Table 5.3 presents the percentage of respondents according to rank.
Table 5.3: The rank of respondents

<table>
<thead>
<tr>
<th>Rank</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCO</td>
<td>107</td>
<td>54.04</td>
</tr>
<tr>
<td>First Officer</td>
<td>76</td>
<td>38.38</td>
</tr>
<tr>
<td>Senior Officer</td>
<td>5</td>
<td>2.53</td>
</tr>
<tr>
<td>Missing</td>
<td>10</td>
<td>5.05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>198</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

According to the table above, most respondents (107 or 54.04%) have the rank of NCO, 76 respondents are First Officers (38.38%), and five respondents are Senior Officers (2.53%). The percentage of respondents according to rank can be seen in the pie chart in Figure 5.3.

Figure 5.3: Respondents’ rank percentage

5.3 The testing of hypotheses – Partial Least Squares structural model evaluation

The partial least squares (PLS) analysis provides results for both the outer (measurement) model and the inner (structural model) simultaneously. However, the two models are discussed separately as the measurement model precedes the structural model. Accordingly, the evaluation of the measurement model was reported in Chapter Four. Following the bivariate correlations analyses reported in the previous section, this section presents the results of the PLS structural model.

The PLS structural model enables the examination of the relationships between the latent variables which focus on prediction and theory development (Götz et al., 2010;
Reinartz, Haenlein, & Henseler, 2009). In other words, it represents the relationships between the latent variables as predicted in the hypotheses (Chin, 2010). Latent variables or constructs are classified into two groups: exogenous latent variables and endogenous latent variables. The exogenous (independent) variables can predict only other latent variables, whereas the endogenous (dependent) variable is a dependent variable that is predicted by at least one latent variable.

Before evaluating the structural model, an assessment of collinearity issues was conducted separately for each set of predictor constructs for each subpart of the structural model. Collinearity describes the situation where two or more predictor variables in a statistical model are linearly related which raise some issues such as parameters may be unstable, standard errors on estimates inflated and consequently inference statistics biased (Dormann et al., 2013). The Variance Inflation Factor (VIF) is a powerful tool to assess the degree of collinearity as it depends on how much the variance of the estimated coefficients increases due to collinear independent variables (Craney & Surles, 2002). The VIF values should range from 0.20 to 5; otherwise one should consider eliminating, merging or creating a higher-order construct (Hair Jr et al., 2016).

Table 5.5: VIF values for the collinearity test

<table>
<thead>
<tr>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>OB-SRP 2.243</td>
</tr>
<tr>
<td>WEB-SRP 2.518</td>
</tr>
<tr>
<td>IB-SRP 2.762</td>
</tr>
<tr>
<td>OB-WEB 1.000</td>
</tr>
<tr>
<td>OB-IB 1.848</td>
</tr>
<tr>
<td>WEB-IB 1.848</td>
</tr>
</tbody>
</table>

In this case, the VIF values for the set of constructs range from 1 to 2.762, which is within the acceptable threshold (see Table 5.5) since, as explained previously, the VIF value between should be between 0.20 and 5. As a result, it indicated that the collinearity did not exist in this set of data; hence, the next assessment of the structural model could be done.

A summary of the PLS structural model results for the total effects is presented in Table 5.6. The table has three columns, direct, indirect and total effects. The statistical significances of the path coefficients have been tested using a bootstrapping technique, with 5,000 re-samplings. The finding for each hypothesised relationship is interpreted in turn.
Table 5.6: Direct and indirect effects used to assess the relationships amongst variables

<table>
<thead>
<tr>
<th></th>
<th>Direct Effects (P Value)</th>
<th>Indirect Effects (P Value)</th>
<th>Total Effects (P Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OB -&gt; SRP</td>
<td>-0.490 (0.000)</td>
<td>-0.290 (0.000)</td>
<td>-0.782 (0.000)</td>
</tr>
<tr>
<td>WEB -&gt; SRP</td>
<td>-0.120 (0.126)</td>
<td>-0.145 (0.001)</td>
<td>-0.265 (0.000)</td>
</tr>
<tr>
<td>IB -&gt; SRP</td>
<td>-0.295 (0.000)</td>
<td></td>
<td>-0.295 (0.000)</td>
</tr>
<tr>
<td>OB -&gt; WEB</td>
<td>0.677 (0.000)</td>
<td></td>
<td>0.677 (0.000)</td>
</tr>
<tr>
<td>OB -&gt; IB</td>
<td>0.378 (0.000)</td>
<td>0.334 (0.000)</td>
<td>0.712 (0.000)</td>
</tr>
<tr>
<td>WEB -&gt; IB</td>
<td>0.492 (0.000)</td>
<td></td>
<td>0.492 (0.000)</td>
</tr>
</tbody>
</table>

Additionally, Figure 5.4 illustrates the path coefficients between the latent variables considered in this model.

![Path Coefficients Diagram]

Figure 5.4: Representation of the path coefficients for the structural model

5.3.1 Hypothesis H1

Hypothesis H1 suggested a direct and negative relationship between organisational barriers (OB) and safety reporting performance (SRP). This hypothesis was supported, i.e., the organisational barriers (OB) are directly related to safety reporting performance (SRP) with a P value of 0.00 and path coefficient of -0.490 (see Table 5.6 and Figure 5.4).

On the other hand, it also has been found that there is an indirect effect via working
environment barriers (WEB) and individual barriers (IB), which influence the relationship between organisational barriers (OB) and safety reporting performance (SRP). The indirect effect, in this case, has a path coefficient of -0.290 with a significant P value of 0.00. The indirect value of OB on SRP is obtained through a simple measurement as explained below.

(Pathway 1)
\[ (\text{OB} \rightarrow \text{IB}) \cdot (\text{IB} \rightarrow \text{SRP}) = (0.378) \cdot (-0.295) = (-0.111) \]

(Pathway 2)
\[ (\text{OB} \rightarrow \text{WEB}) \cdot (\text{WEB} \rightarrow \text{SRP}) = (0.677) \cdot (-0.120) = (-0.081) \]

(Pathway 3)
\[ (\text{OB} \rightarrow \text{WEB}) \cdot (\text{WEB} \rightarrow \text{IB}) \cdot (\text{IB} \rightarrow \text{SRP}) = (0.677) \cdot (0.492) \cdot (-0.295) = (-0.098) \]

Total = (-0.290)

The measurements above also revealed that the indirect effect of the organisational barriers (OB) corresponds to the sum of three pathways as depicted in Figure 5.5. This indirect effect enhances the total effect of the organisational barriers (OB) on safety reporting performance (SRP).

![Figure 5.5: Three pathways corresponding to the indirect effects of organisational barriers (OB) on safety reporting performance (SRP)](image)

Note:
- Yellow = Pathway 1
- Black = Pathway 2
- Blue = Pathway 3
Therefore, the total effect of organisational barriers (OB) on safety reporting performance (SRP) is -0.782 (see Table 5.6 and Figure 5.8), which is obtained from the sum of direct and indirect effects.

5.3.2 Hypothesis H2

Hypothesis H2 suggests a relationship between working environment barriers (WEB) and safety reporting performance (SRP). It has been found that there is a direct and negative relationship between two latent variables, with a path coefficient of -0.120 and a P value of 0.126 (See Table 5.6 and Figure 5.4).

However, it was also found that there is an indirect effect through individual barriers (IB), which enhances the relationship between working environment barriers (WEB) and safety reporting performance (SRP). The indirect effect of working environment barriers (WEB) has a path coefficient of -0.145 with a significant P value of 0.01. The indirect effect of working environment barriers (WEB) on safety reporting performance (SRP) is obtained as follows:

\[
(\text{Pathway}) \rightarrow (\text{WEB} \rightarrow \text{IB}) \cdot (\text{IB} \rightarrow \text{SRP}) = (0.492) \cdot (-0.295) = (-0.145)
\]

Unlike the latent variables of organisational barriers (OB), there is just one pathway of indirect effects, which increases the total effects of the working environment barriers (WEB) on the safety reporting performance (SRP) as can be seen in Figure 5.6. The indirect effect of working environment barriers (WEB) is higher than its direct effect, which then cumulates to a significant total effect on safety reporting performance (SRP).

Figure 5.6: The pathway of indirect effect of working environment barriers (WEB) on safety reporting performance (SRP)
Therefore, by adding the indirect and direct effects, it can be seen that the total effect of working environment barriers (WEB) on safety reporting performance (SRP) is -0.265 with significant P value (see Table 5.6 and Figure 5.8).

5.3.3 Hypothesis H3

Hypothesis H3 concerns the relationship between individual barriers (IB) and safety reporting performance (SRP). It has been found that the hypothesis was supported; i.e. the individual barriers (IB) have a direct and negative relationship to safety reporting performance (SRP) with a significant P value of 0.00 and path coefficient of -0.295 (see Table 5.6 and Figure 5.4).

Unlike the two previous latent variables, individual barriers (IB) do not carry any indirect effect on to safety reporting performance (SRP), as can be seen in Table 5.6. Therefore, besides their direct effect, individual barriers (IB) also play a role as a mediating variable over two latent variables (OB and WEB) that have been proven to increase their impact on safety reporting performance. This mediating effect will be explained in greater detail in Section 5.6.

5.3.4 Hypothesis H4

Hypothesis H4 concerns the relationship between organisational barriers (OB) and working environment barriers (WEB). The result showed that the hypothesis was supported: i.e., there is a direct and positive relationship between organisational barriers (OB) and working environment barriers (WEB) with a significant P value of 0.00 and path coefficient of 0.677 (see Table 5.6 and Figure 5.4).

Based on the result of the structural model assessment, this relationship does not have an indirect effect that can influence the impact of organisational barriers (OB) on working environment barriers (WEB). However, a notable finding regarding this relationship is that it has the highest path coefficient (direct effect) compared to the other direct effects within the inner structural model. The relationship between these two latent variables will be explained in greater detail in Section 5.6.
5.3.5 Hypothesis H5

Hypothesis H5 was intended to investigate the relationship between two exogenous (independent) variables: the organisational barriers (OB) and individual barriers (IB). It was found that the hypothesis was supported: i.e., the organisational barriers (OB) have a direct and positive relationship to individual barriers (IB) with a significant P value of 0.00 and path coefficient of 0.378 (See Table 5.6 and Figure 5.4).

Additionally, the organisational barriers (OB) also have an indirect effect that influences the relationship between organisational barriers (OB) and individual barriers (IB). The indirect effect goes through working environment barriers (WEB) with a path coefficient of 0.334 with a significant P value of 0.00, which is obtained using the following measurement:

(Pathway)→(OB ->WEB). (WEB ->IB) = (0.677). (0.492) = (0.334).

The model shows that there is only one pathway of indirect effect between two variables which, in fact, has significantly increased the total effects of organisational barriers (OB) on individual barriers (IB) (See Table 5.6 and Figure 5.7).

Figure 5.7: The pathway of indirect effect of organisational barriers (OB) on individual barriers (IB)

Therefore, similar to the two previous hypotheses having an indirect effect, the total effect of Organisational Barriers (OB) on individual barriers (IB) is the sum of the direct and
indirect effects, which in this case equates to 0.712 with a significant P value of 0.00 (see Table 5.6 and Figure 5.8).

5.3.6 Hypothesis H6

Hypothesis H6 was intended to investigate the relationship between two exogenous (independent) variables, the working environment barriers (WEB) and individual barriers (IB). The results supported the hypothesis that there is a direct and positive relationship between (WEB) and individual barriers (IB) with a significant P value of 0.00 and path coefficient of 0.492 (see Table 5.6 and Figure 5.4).

Although there is no indirect effect that can increase the relationship between the two latent variables, it is considerably the second highest path coefficient (direct effect) compared to the other direct effects in the inner structural model (see Table 5.6). The next section discusses this in more detail.

In summary, the analysis of the path coefficients, which represent a direct impact, showed that five hypotheses were supported with a significant P value except for the relationship between WEB and SRP (see Table 5.6 and Figure 5.4). However, after considering the cumulative effect of both the direct and indirect impacts of each construct relationship, all hypotheses have a significant relationship (see Table 5.6 and Figure 5.8).

5.5 Predictive power of the structural model

One of the important measures used for the evaluation of this structural model was the coefficient of determination (R² value) which represents the model's predictive power or the extent to which the endogenous (dependent) variables can be explained by the exogenous (independent) variables. There is no acceptable threshold for R² but, as a general guideline, it can be said that the greater the value of the R², the greater is the amount of the variance of the endogenous (dependent) variable explained by the exogenous (independent) variable(s) (Götz et al., 2010). The values of R² range from 0 to 1, as it is a normalised term. The R² values of 0.67, 0.33 and 0.19 in the path model are considered substantial, moderate and weak, respectively (Chin, 1998).
In the structural model, the $R^2$ value for SRP is 0.680 (substantial) which means that 68% of safety reporting performance (SRP) can be explained or predicted by organisational barriers (OB), working environment barriers (WEB) and individual barriers (IB). The other variables with an $R^2$ value are WEB and IB. The working environment barriers (WEB) have organisational barriers (OB) as an exogenous (independent) variable, whereas individual barriers (IB) have two exogenous (independent) variables: organisational barriers (OB) and working environment barriers (WEB). The result showed that the $R^2$ values for WEB and IB are 0.459 (moderate) and 0.638 (moderate) respectively, indicating that the working environment barriers (WEB) and individual barriers (IB) can be explained or predicted by their exogenous (independent) variables at 45.9% and 63.8%, respectively.

Table 5.7: Assessment of the predictive power and relevance of the model

<table>
<thead>
<tr>
<th></th>
<th>R Square</th>
<th>Q Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRP</td>
<td>0.680</td>
<td>0.589</td>
</tr>
<tr>
<td>IB</td>
<td>0.638</td>
<td>0.417</td>
</tr>
<tr>
<td>WEB</td>
<td>0.459</td>
<td>0.302</td>
</tr>
</tbody>
</table>
Furthermore, another analysis method used in this study was the blindfolding technique to obtain the $Q^2$ (predictive relevance) value. The $Q^2$ was computed in order to determine the magnitude of $R^2$ values (Geisser, 1974; Stone, 1974) and as an indicator of the model’s out-of-sample predictive power (Hair Jr et al., 2016). If the $Q^2$ value is greater than 0, this means that the model has predictive relevance for a certain construct; a value of 0 or less indicates a lack of predictive relevance. In this case, the $Q^2$ value for SRP, IB and WEB is 0.589, 0.417, and 0.302 respectively, indicating that all $Q^2$ values had good predictive relevance.

5.6 Discussion of the results

This section discusses the results reported in the previous sections from both the conceptual and practical standpoints. The discussion is in reference to the theories used to guide the study and as a comparison with relevant prior conceptual and empirical literature.

The descriptive statistics analysis in Section 5.2 has provided insights into the experience and professional profile of the respondents to the questionnaire survey conducted for this research. The results revealed that the highest numbers of respondents are NCOs (non-commissioned officers) who are naturally much more involved in daily routine operations owing to the nature of their jobs. They work on the first line of maintenance and flight support and therefore confront potential hazards and incidents directly. Moreover, it is likely that these personnel will encounter safety issues more than junior personnel or senior officers. Furthermore, having a significant number of junior officers involved in this study was advantageous since they work alongside the NCO in the first line as well as the first managers of NCOs. They normally also have a better knowledge about systems and rules in place in the organisation compared to NCOs, including the existing safety reporting system. Hence, these characteristics of respondents were deemed appropriate since this study targeted the users of the existing reporting system.

Another notable finding is that the majority of respondents involved in this study had a tenure of more than five years. To be more specific, 90% of respondents had worked in this organisation for more than five years, and half of these had a service record of over ten years. Hence, the researcher assumed that the majority of respondents would be in a position to clearly address every statement in the questionnaire owing to their experience in this organisation. Given their long experience, they could recognise the weaknesses as well as the strengths of the existing reporting system. Therefore, their responses to the questionnaire
items were most likely to be appropriate, thereby reducing the likelihood of systematic respondent-induced errors in this study.

The descriptive statistics also revealed that the respondents represented three positions and roles within the organisation: maintenance, support, and aircrew with a proportion of 43%, 33% and 18%, respectively. This proportion is a perfect representation of the whole population since this particular organisation has more maintenance and support workers compared to aircrews. This meant that the data could be derived from various perspectives of employees in different work environments: maintenance, support, and flight. This also meant that respondents would have had different experiences and perspectives in regard to using the safety reporting system in this organisation.

Turning to the discussion of the findings from the PLS structural model, at the outset, more attention was given to the three main barriers, organisational barriers (OB), working environment barriers (WEB) and individual barriers (IB). The results showed that the three main categories of barriers have different effects on the performance of the safety reporting system currently in place in the organisation. In fact, the organisational barriers (OB) and individual barriers (IB) have a significant direct and negative influence on the performance of safety reporting, whereas the working environment barriers (WEB) seem to have just a minor direct influence. The marginal weight of the working environment barriers (WEB) was quite unexpected as this barrier has been demonstrated by other authors as being one of the most significant in the performance of reporting systems (Clarke, 1998; Clarke & Ward, 2006; S. M. Evans et al., 2006; Jenny Firth-Cozens et al., 2004; Gilbey et al., 2015; Grootheest, 1999; Mahajan, 2010; Phimister et al., 2003; James Reason, 1993; Thompson & Choi, 2006; van der Schaaf & Kanse, 2004; Vincent et al., 1999; Waring, 2005). Despite this outcome, it cannot be unequivocally stated that the working environment barriers (WEB) do not influence the reporting system as this is indirectly related to several of the organisational issues included in the model. These, in turn, have proven to have a significant bearing on the effectiveness of the reporting system. Therefore, the interpretation of results should take into consideration any indirect effects of the three exogenous (independent) variables.

The model also shows that each of the exogenous (independent) variables has a different impact on the performance of safety reporting, with the highest impact corresponding to organisational barriers (OB), followed by individual barriers (IB) and working environment barriers (WEB). When measuring the direct impact of three exogenous (independent) variables (see Figure 5.4), the organisational barriers (OB) were considered to
be nearly two times more significant for safety reporting performance than individual barriers (IB) and more than four times than working environment barriers (WEB). Similarly, when comparing the total effects (direct and indirect effects), the contribution of those three exogenous (independent) variables changes slightly, but essentially remain to have the same ratio (See Figure 5.8). In fact, the total effect of organisational barriers (OB) was found to be two and half times more significant for safety reporting performance (SRP) than the total impact of individual barriers (IB); this is slightly less than the direct effects ratio of these two variables. On the other hand, the total effects of organisational barriers (OB) are nearly three times greater than the total effects of working environment barriers (WEB), which also have a smaller ratio than the direct effect comparison between these variables. Therefore, all these facts indicate two important findings: firstly, the important role of organisational barriers (OB) in indicating a pathway to improve the performance of a safety reporting system compared to the other two barriers; and secondly, how the indirect effect that exists in this model could influence the total effect of organisational barriers (OB) and working environment barriers (WEB) on the overall performance of the reporting system.

The other significant finding from this model is the way in which the three main barriers influence each other. The organisational barriers (OB) have a significant direct and positive influence on the other two exogenous (independent) variables, the working environment barriers (WEB) and individual barriers (IB), while the working environment barriers (WEB) have a significant direct and positive influence on the individual barriers (IB). What can be concluded about this relationship is that the greater the contribution of organisational barriers (OB), the more prevalent are both the working environment barriers (WEB) and the individual barriers (IB). In addition, the working environment barriers (WEB) and individual barriers (IB) have a positive direct relationship (i.e., a positive increment of the former will lead to an increase of the latter). This distinctive relationship might be one of the reasons why the working environment barriers (WEB) have an insignificant direct impact on the performance of the reporting system, yet significant regarding the total effects.

Now, we move to a more detailed discussion of the three indirect effects that exist in this model, namely the indirect effect of organisational barriers (OB) on safety reporting performance (SRP), the indirect effect of working environment barriers (WEB) on safety reporting performance (SRP), and the indirect effect of organisational barriers (OB) on individual barriers (IB). Table 5.8 shows the pathways of three indirect effects in the structural model and how they were accumulated.
Table 5.8: Pathways corresponding to the indirect effects in the structural model

<table>
<thead>
<tr>
<th>Indirect Effects</th>
<th>Pathway 1</th>
<th>Pathway 2</th>
<th>Pathway 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational Barriers (OB) to SRP</td>
<td>OB -&gt; IB -&gt; SRP (0.378). (-0.295)= (-0.111)</td>
<td>OB -&gt; WEB -&gt; SRP (0.677). (-0.120)=(-0.081)</td>
<td>OB -&gt; WEB -&gt; IB -&gt; SRP (0.677).(0.492). (-0.295)=(-0.098)</td>
<td>-0.291</td>
</tr>
<tr>
<td>Working Environment Barriers (WEB) to SRP</td>
<td>WEB -&gt; IB -&gt; SRP (0.492). (-0.295)=(-0.145)</td>
<td>-</td>
<td>-</td>
<td>-0.145</td>
</tr>
<tr>
<td>Organisational Barriers (OB) to Individual Barriers (IB)</td>
<td>OB -&gt; WEB -&gt; IB (0.677).(0.492 = (0.334)</td>
<td>-</td>
<td>-</td>
<td>0.334</td>
</tr>
</tbody>
</table>

As we can see from Table 5.8 and Figure 5.5, the indirect effect of organisational barriers (OB) on safety reporting performance (SRP) can be associated with three distinct pathways, namely: 1) OB-IB-SRP, 2) OB-WEB-SRP, and 3) OB-WEB-IB-SRP. In other words, the impact of the organisational barriers (OB) on the performance of the reporting system can be attributed to both the mediating effect of individual barriers (IB) and working environment barriers (WEB) (pathways 1 and 2, respectively) and a longer pathway corresponding to the mediating effect of a combination of the individual barriers (IB) and working environment barriers (WEB) (pathway 3). Each pathway makes a different contribution to the indirect effect, namely 38% (-0.111) for pathway 1, 28% (-0.081) for pathway 2 and 34% (-0.098) for pathway 3. Hence, we can conclude that the individual barriers (IB) (pathway 1) are the ones contributing most to the indirect effect of organisational barriers (OB) on the performance of the reporting system, followed by the combination of working environment and individual barriers (IB) (pathway 3) and working environment barriers (WEB) (pathway 2).

Furthermore, the second indirect effect in this model is the one pertaining to the impact of working environment barriers (WEB) on safety reporting performance (SRP) as can be seen in Figure 5.6 and Table 5.8. This indicates the effect of working environment barriers (WEB) on safety reporting performance (SRP) is mediated by individual barriers (IB). As it can be seen in Table 5.6, the contribution of this indirect effects to the total effects (-0.265) is -0.145, whereas the direct effects have a lesser contribution (-0.120). This shows that the indirect effect of working environment barriers (WEB) contributes 10% more than its direct effect or, in other words, the individual barriers (IB) increase the influence of working environment barriers (WEB) on the safety reporting performance (SRP) compared to the direct effect of working environment barriers (WEB).
The last indirect effect is the one corresponding to the effect of organisational barriers (OB) to individual barriers (IB) as can be seen in Figure 5.7 and Table 5.8. One interesting finding of this indirect effect is that it contributes to nearly the same weight compared to its direct effect, at 0.334 (47%) for indirect effect and 0.378 (53%) to the total effect of 0.712. This data shows that working environment barriers (WEB) have significantly mediated the effect of organisational barriers (OB) on individual barriers (IB), which again corroborates the important role of this variable in the structural model.

Another important conclusion drawn from the model is the reduced impact of two barriers, namely high workload (WEB2) and acceptable norm (IB5). A possible explanation for the apparently low effect of a high-workload scenario on the likelihood of reporting is the nature of the activities carried out by the respondents in this particular military organisation. The fact that the model has enabled us to identify this unexpected outcome clearly illustrates its strength as it allows results to be generated that are unique to the particular circumstances of each organisation, rather than adopting preconceived and generalised ideas about contributing factors that might be the norm for other organisational structures and operational scenarios (e.g., civil vs. military contexts). Furthermore, other quantitative results yielded by the model allow us to infer that there is a prevailing macho perspective amongst a high number of respondents, as opposed to other risk acceptance barriers that resulted in much lower impact factors (e.g., acceptable norm). The possibility of having a clear understanding of particular personality traits and organisational behaviours constitutes a significant advantage of this model as it provides decision makers with the opportunity to implement tailor-made risk mitigation strategies, as well as to channel adequate resources into safety promotion campaigns addressing these particular issues. Unfortunately, no interviews were conducted in this research for the purpose of gathering more information on these matters, although this approach presents an opportunity for further studies.

5.6.1 Implications

The most important implication of these findings for the current body of knowledge is that they provide a clear explanation of how these barriers concurrently influence the performance of the safety reporting system. As stated in the literature review (see Chapter Two), previous research in this area (i.e., barriers to safety reporting in aviation and others industries) relied mainly on qualitative methods and did not provide an accurate weighting of
the various barriers contributing to the underperformance of reporting systems. However, the findings presented here have the benefit of providing a holistic perspective on this problem as they give us an insight into how the barriers influence concomitantly the effectiveness of the safety reporting system.

Furthermore, and as previously mentioned, this study was based on the classification of the distinct barriers under three main categories: Organisational, Working Environment, and Individual Barriers which essentially are the main sources of under-reporting as suggested by previous researchers (Rasmussen, 1997; James Reason, 1997; Shappell & Wiegmann, 2000). These classifications have been confirmed through the validation measurement model which demonstrated that the barriers in each of the three main categories have similar characteristics. The barriers within each group are a representative sample of all the possible barriers that emerged from the existing literature with the exception of high workload and acceptable norm barriers. In other words, the manifestations of the organisational, working environment and individual barriers that influence the performance of a safety reporting system can be seen through the group of corresponding barriers that exist in a particular organisation.

From a practical perspective, the model proposed in this paper provides managers and personnel responsible for the establishment of safety policies and corresponding implementation programs with a powerful tool that can provide scientific advice regarding the areas with safety concerns in most need of adequate actions. In the particular case of the organisation considered in this study, one can confidently conclude that the organisational barriers (OB) have the most significant influence on the performance of its safety reporting system, as depicted in Figure 5.9. This statement is supported by two considerations: firstly, the organisational barriers (OB) have a total effect on the reporting performance that is nearly three times greater than that of the other two main barriers; secondly, these barriers have a vertical influence (top down) on the other two main barriers, namely working environment barriers (WEB) and individual barriers (IB). Hence, any change in the organisational barriers (OB) would affect the other two types of barriers as well.
As a consequence, safety managers should consider eliminating the organisational barriers (OB) as a matter of priority before addressing the other barriers, which as we have previously seen, also end up being indirectly affected. This can be achieved, for example, by enhancing managerial commitment at the top level. This would certainly affect how line managers supervise their assigned staff and, at the same time, would express and broadcast the top leader's commitment to safety across the entire organisation. This could be perceived by staff as a corporate motto that must be adopted by all regardless of their position/rank and function. This applies in particular to organisations, such as the military, that have strict structural hierarchies.

Dealing with the organisational barriers (OB) is sometimes a challenging endeavour since those responsible for the management of safety issues need to ensure that the top decision-makers will allocate adequate funding and resources for the implementation of safety measures. However, the model proposed in this paper presents a strong argument to safety managers when approaching the decision-makers or top managers as it provides clear and objective data that can be readily interpreted at an executive level.

Furthermore, when dealing with working environment barriers (WEB) and individual barriers (IB), safety managers should take into consideration the relationships identified in the model proposed in this paper. Firstly, and as depicted in Figure 5.8 and Figure 5.9, the total contribution of these barriers to the performance of the reporting system has nearly the same order of magnitude, despite the less direct effect of working environment barriers (WEB) relative to that of individual barriers (IB), i.e., -0.12 and -0.295 respectively. This is a consequence of the mediating effect of individual barriers (IB) to working environment barriers (WEB), as indicated in Figure 5.6 and Table 5.8. Secondly, the working environment barriers (WEB)
barriers (WEB) have a significant and positive influence on individual barriers (IB), as shown in Figure 5.4 and Table 5.6 (0.492 (p < .001)). Thirdly, both these barriers have a mediating effect on organisational barriers (OB), which might result from either an individual or combined effect (corresponding to the three pathways in Table 5.8).

Therefore, one can conclude that any efforts to address safety deficiencies pertaining to working environment barriers (WEB) will result in the improvement of individual barriers (IB) as well. This is an interesting conclusion as it clearly demonstrates how the various barriers are intertwined, thereby leading to a more challenging decision-making process at the managerial level. In fact, safety managers often tend to focus their efforts on improving the performance of reporting systems regarding isolated issues either at an individual, working environment or organisational level. However, and as demonstrated by the model proposed in this paper, a holistic approach that integrates the simultaneous effect of the different barriers across the three aforementioned categories leads to a much more effective solution to the problem of underperformance of existing reporting systems.

Figure 5.10: Priority map showing individual barriers to safety reporting performance
Considering this, the model proposed in this study was developed with a view to offering a comprehensive and integrated tool for safety managers, assisting them to appropriately address those barriers that have the most significant impact on the safety reporting performance. This is especially important for organisations with limited resources, which are financially unable to address all barriers simultaneously. By using the priority map (see Figure 5.10 and Figure 5.11), safety managers have clear information about the barriers that are having a greater impact, thereby allowing them to act immediately to rectify a particular safety deficiency that most surely will lead to tangible outcomes within reasonable cost-benefit parameters. For example, of the various organisational barriers, lack of commitment (OB1) stands out as the most influential factor amongst all the variables included in the model, whereas the inadequate of professional development (OB6) has the lowest impact. On the other hand, within the working environment barriers (WEB), inadequate supervision (WEB5) have the highest impact, whereas peer influence has the least influence (WEB4). Moreover, of the individual barriers (IB), the top three which have the most significant impact are personal competence in relation to reporting (IB3), fear of reprisal (IB1) and
distrust (IB2), whereas personal skills are the least impacting factor regarding reporting performance (IB6).

Previous research has highlighted the impact of fear of reprisal in different forms as the main reason preventing members of organisations from voluntarily reporting safety issues (Barach & Small, 2000b; Chiang et al., 2010; Elnitsky et al., 1997; Jenny Firth-Cozens et al., 2004; Mahajan, 2010; van der Schaaf & Kanse, 2004; Vincent et al., 1999; Waring, 2005). However, in the context of this particular study, results indicated that this barrier has a less significant impact compared to most of the organisational barriers and even some of the barriers pertaining to the working environment (see Figure 5.10). This is an interesting conclusion, as we would expect a greater influence of this barrier given the hierarchical structure of the military organisation examined in this study.

Furthermore, Figure 5.10 and Figure 5.11 demonstrate that the lack of commitment not only has the highest impact of all organisational barriers (OB), but it is also the most significant barrier of all according to the findings of this study. This conclusion indicates that management commitment is a strong influence on the willingness of the members of an organisation to report safety information. This is in line with what has been concluded by other authors: i.e., management commitment is a key factor in fostering both the safety culture (Helmreich, 1999) and safety climate (B. Evans, Glendon, & Creed, 2007; O’Connor, O’Dea, Kennedy, & Buttrey, 2011) in aviation organisations. Hence, this factor is not only correlated to the performance of the reporting system itself, but it also has a broader effect by contributing to the development of an informative culture as an important element of a mature safety culture.

Lastly, the additional significant contribution of this study is that the proposed model could be used to understand not only the complex barriers to safety reporting but also the relationship between three main layers in an aviation organisation. These three layers - organisational, working environment and individual factors - are widely acknowledged as the main layers in the accident causation model proposed by Reason (James Reason, 1997). This model arguably presents a clear explanation of how these layers relate to each other. The results defined a positive and direct relationship from organisational factors to working organisational factors before going through individual factors. In addition, the results also revealed a positive and direct relationship between organisational factors and individual factors.
Figure 5.12: An alternative representation of Reason’s accident causation model in light of the model proposed in this study.

As can be seen in Figure 5.12, Reason’s model shows that the factors contributing to an accident often start at a higher level corresponding to the organisational deficiencies, then progress downward through working conditions, individual active failures (people), and safety defences. The results obtained from the model proposed in this research not only support this flow of events through the main three layers but also found significant evidence of another loop from organisational layers to individual layers. Hence, this could lead to a modification of Reason's accident causation model (see Figure 5.12).
CHAPTER SIX
CONCLUSIONS AND LIMITATIONS

6.1 Introduction

This chapter presents a summary of the main conclusions emerging from the discussion of the results in the previous chapters. These are followed by a discussion of the limitations of the study and recommendations for future research.

6.2 Conclusions

The main aim of this study was to investigate the concurrent effects of the key barriers that affect the performance of safety reporting systems in a military aviation organisation. This research was motivated by a knowledge gap pertaining to the under-reporting problem that influences many of the current voluntary reporting systems in aviation organisations, both civil and military, and even in other industries that make use of similar systems. To achieve the research goal, the researcher created a model and formulated several hypotheses that have been successfully verified. The innovativeness of the model proposed herein arises from the fact that it considers the concomitant effect of organisational, environment and individual barriers on the performance of aviation safety reporting systems, constituting a straightforward, systematic and comprehensive framework that enables decision-makers to implement effective actions tailored to the specificities and operational contexts of their organisations. The application of this model allows the impact of each barrier, as well as its influence on other concomitant barriers, to be estimated. A set of scores is generated by the model, which can then be used to assist decision-makers to identify any deficiencies influencing the effectiveness of an existing reporting system.

The following paragraphs will explain in detail the achievements of this research.

- The obtained results corroborate the idea that the barriers to safety reporting are due to various, multilevel factors which range from the bottom to the top levels in aviation organisations. The top level in this context contains organisational barriers (OB) which consist of six sub-barriers including lack of commitment, inadequate funding, The absence of independence, lack of feedback, inadequate information technologies and Inadequate of professional development. In the middle level are the working
environment barriers (WEB) which consist of four sub-barriers: code of silence, insufficient procedure, peer influence and inadequate supervision within the local unit. The last major barrier group comprises individual barriers (IB) which are typically present at the bottom level of the organisational hierarchy. This group consists of six barriers: fear of reprisal, distrust, personal competence on how to report, macho perspective, and personal skills in regard to what has to be reported.

- By means of a measurement model, the researcher concluded that two barriers were not discernible in this research, namely High Workload and Acceptable Norm. The former is an indicator of the working environment barriers (WEB) whereas the latter is an individual barriers (IB) indicator. Though these two barriers were eliminated from the original model, the remaining indicators or barriers remained reliable and valid for the purposes of this research.

- From the three main categories of barriers considered in the model, it was found that the organisational barriers (OB) were the most significant, followed by the individual barriers (IB) and working environment barriers (WEB). Even though the direct effect of working environment barriers (WEB) does not significantly influence the performance of the reporting system, its indirect effect has a significant impact on safety reporting performance. Hence, one can conclude that the total effect of working environment barriers (WEB) (i.e., the combination of direct and indirect effects) significantly influences the performance of the reporting system.

- The multiple barriers correlate positively and vertically with each other, with organisational barriers (OB) at the top level, working environment barriers (WEB) at the middle level and individual barriers (IB) at the bottom level. The organisational barriers (OB) positively influence both the working environment barriers (WEB) and the individual barriers (IB), while the working environment barriers (WEB) also have a significant and positive influence on individual barriers (IB).

- The organisational barriers (OB) have two indirect effects. The first indirect effect is the influence on safety reporting performance (SRP) through three pathways including pathway OB-WEB-SRP, pathway OB-IB-SRP, and pathway OB-WEB-IB-SRP. The second indirect effect is the influence of the individual barriers (IB) through pathway OB-WEB-IB. These indirect effects have a critical influence when simultaneously
determining the total weight of each barrier in relation to the performance of the reporting system.

- From the broad spectrum of barriers considered in the model, the researcher concluded that the lack of commitment is the most significant factor influencing the performance of a reporting system, whereas personal skills in regard to what has to be reported play the least significant role.

- Despite the particular context of the military organisation that provided the data for this research, the model proposed herein can be easily adapted to other organisational structures and operational contexts, thereby constituting an excellent tool to ensure a more effective and efficient allocation of resources to address safety shortcomings in both civil and military organisations. This would provide decision-makers with an accurate and systematic tool for the prioritisation of issues according to their significance in the safety domain, facilitating the implementation of adequate mitigating actions to prevent accidents.

6.3 Limitations and recommendations for future research

This study has applied indirect questions in the survey instrument for the reasons presented in Section 3.4.7. However, the use of direct vs. indirect questioning is a matter of controversy amongst researchers as each technique can have distinct impact on results. Hence, it would be advantageous to apply an alternative questionnaire making use of direct questions so a comparison between the two survey styles could be made, thereby confirming whether there is a significant discrepancy between the two sets of results. Further to the impact of the type of questions in the questionnaire in the results, it should also be noted that alternative approaches to the analysis of data (e.g., restricting the analysis within each exogenous/endogenous variable) could have led to different outcomes in terms of the dependencies between the variables in the model.

Secondly, despite the broad spectrum of barriers considered in the development of the conceptual framework proposed in this research, it is possible that this study has omitted to consider other barriers to safety reporting, the inclusion of which could broaden the scope of the model. Clearly, barriers to safety reporting are driven mainly by organisational barriers, working environment barriers, and individual barriers, however; future research could
consider investigating other pertinent constructs such as social factors that can potentially influence the three main categories of barriers investigated in this study.

Thirdly, the sample on which the research is based is drawn from a specific military aviation organisation. Therefore, the conclusions drawn from the application of the model are bounded to the specificities of the said organisation and cannot be generalised to other operational contexts. Therefore, it would be advantageous to broaden the scope of the study in future research initiatives as to allow an assessment of the effect of identical barriers on safety reporting changes because of distinct operational scenarios and organisational structures.

Finally, this study has opened up an avenue for a better understanding of the vertical relationship between the three layers in Reason's causation accident model. Hence, it would be an interesting goal for future research to investigate an enhanced representation of Reason's model so as to better incorporate the interplay between the main layers in the model, particularly by emphasizing the indirect effects spanning all levels of an aviation system, from the latent to the active factors contributing to an accident.
Reference List


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