CRANFIELD UNIVERSITY

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Airline Safety Management:

The development of a proactive safety mechanism model for the evolution of safety management system

COLLEGE OF AERONAUTICS
AIR TRANSPORT GROUP

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Abstract

The systemic origins of many accidents have led to heightened interest in the way in which organisations identify and manage risks within the airline industry. The activities which are thought to represent the term "organisational accident", "safety culture" and "proactive approach" are documented and seek to explain the fact that airlines differ in their willingness and ability to conduct safety management. However, an important but yet relatively undefined task in the airline industry is to conceptualise the safety mechanism in proactive safety, and its influential factors. What is required is a model of a proactive safety mechanism which builds upon existing knowledge of what is thought to contribute to safety by adding an increased knowledge of the organisational factors. These factors not only serve to influence the safety mechanism, but also serve to be the predictors of the performance of safety management system.

This thesis aims to fill that gap. It firstly conducts an overview of the current airline safety management system literature and identifies the strengths and weaknesses of the current system. Given the need to explore the important but undefined field, a proactive safety mechanism model is then developed and tested to identify the organisational factors which exert an influence upon the safety mechanism.

Four hypotheses were set out to be tested in an attempt to justify the multi-dimensional and complex nature of the safety mechanism model. The model is then tested by applying it to a past accident (case study) and a survey of opinions with questionnaire. The results of this research work show that the safety mechanism model is a model of the evolution of safety management system in the context of proactive safety management. Further study can apply the proposed model to the re-organisation of an airline safety management system and evaluate the impact upon the company's system. It leads to the suggestion that an airline's safety health and performance needs the co-ordination of both retroactive and proactive safety management, and concludes that the ultimate contribution of this research is to provide airlines with reliable data, applicable references and a practicable methodology to enable their safety management system to evolve at a fundamentally "genetic" level.

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Glossary of Abbreviations

AHI	Aviation Health Institute
ALARP	As Low As Reasonably Practicable
ANOVA	Analysis of Variance
APU	Auxiliary Power Unit
ATC	Air Traffic Control
ASRS	Aviation Safety Reporting System
ATA	Air Transport Association
ATI	Air Transport Intelligence
BA	British Airways
BASI	Bureau of Air Safety Investigation
BASIS	British Airways Safety Information System
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CAIR	Confidential Aviation Incident Reporting Network
CEO	Chief Executive Officer
CMT	Crisis Management Team
CFIT	Controlled Flight Into Terrain
CP	Check Pilot
PCA	Principle Component Analysis
CRM	Crew Resource Management
CST	Central Standard Time
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
ECAC	European Civil Aviation Conference
ERCs	Error Reducing Conditions
ERP	Emergency Response Procedures
EGPWS	Enhanced Ground Proximity Warning System
EM	Error Management
EST	Eastern Standard Time

EUCARE	European Confidential Aviation Safety Reporting System
FAA	Federal Aviation Administration
FARs	Federal Aviation Regulations
FSF	Flight Safety Foundation
FORAS	Flight Operation Risk Assessment
FOQA	Flight Operation Quality Assurance
GAIN	Global Aviation Information Network
GDP	Gross Domestic Product
GPWS	Ground Position Warning System
GMT	Greenwich Mean Time
HF	Human Factors
HEAR	Human Error and Accident Reduction
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFA	International Federation of Airworthiness
INDICATE	Identifying Needed Defences In the Civil Aviation Transport Environment
ILU	Institute of London Underwriters
JAA	Joint Airworthiness Association
JARs	Joint Aviation Requirements
KAL	Korean Air
LAUA	Lloyd's Aviation Underwriters Association
LIRMA	London Insurance Reinsurance Market Association
LOSA	Line Operation Safety Audit
LSD	Least Significant Difference
MEDA	Maintenance Error Decision Aid
MESH	Managing Engineering Safety Health
MRM	Maintenance Resource Management
MORs	Mandatory Occurrence Reports
MRO	Maintenance, Repair and Overhaul
NATS	National Air Traffic Services

NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
PERS	Proactive Errors Reduction System
PFC	Passenger Facility Charge
QAR	Quick Access Recorder
RPKs	Revenue Passenger Kilometres
SARPs	Standards and Recommended Practices
SAS	Scandinavian Airlines System
SCQ	Safety Climate Questionnaire
SECURITAS	The Confidential Transportation Safety Reporting System Program
SMS	Safety Management System
SOPs	Standard Operating Procedures
SRG	Safety Regulation Group
VOR	VHF Omnidirectional Range

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CHAPTER 1

Introduction

"How, then, do we get this company ahead of change,
ahead of these strong global players, permanently out in front
in the '90s? How do we set the pace."

~ Jack Welch, 1989

1.1 Research Background

Air transport is experiencing increasing growth year by year, with passenger air transport, in particular, becoming more affordable and feasible for both short journeys and long haul flights (Shorrock and Kirwan, 2002). During the past decade, although the growth in air travel varied from region to region, global demand for air travel increased strongly according to the statistics of IATA (2001). Doganis (2001) stated that long-term traffic growth from 2000 to 2010 will average close to 5 percent per annum. Boeing, too, predicts that world air traffic, measured in Revenue Passenger Kilometres (RPKs)[1], will grow by 4.7 % annually over the next 20 years[2] (Boeing, 2001).

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[1] Revenue Passenger Kilometres (RPKs) are obtained by multiplying the number of fare paying passengers on each flight stage by the distance of that stage.

[2] IATA (2002) has stated in its new interim five-year forecast that the global airline industry will recover by 2003 from the effects of September 11th, and traffic demand might return to the long-term predictions based on the relationship with GDP (Gross Domestic Product), which is forecasted to grow by 3 percent over the next 20 years, during which period air travel will grow about 2 percentage points faster than economics will grow.

Advanced aeronautical technology and the reliability of aircraft constitute great achievements of human ingenuity, but the increasing demand for air travel presents the air transport industry with some of its greatest challenges. Statistics showed that aviation industry has achieved a remarkable safety record, making it currently the safest form of mass transportation in the world today (Muir and Thomas, 2003). However, if the risks are measured by comparing numbers of casualties with the number of trips made, rather than the miles covered, air transport is less safe than ground transport (The Economist, 1997). As passenger numbers rise, at least one major accident is predicted to occur every week by 2010 (IFA, 1998), and this is unlikely to be acceptable.

For the airline industry, transport and safety constitute value; each is mutually dependent on, and worthless without, the other. It is taken for granted that the airline has done everything practically possible to maintain safety standards by proper maintenance, operations and training. Nonetheless, even following the greatest advances in airframe designs, and the hardware and electronics in commercial aircraft, accidents still occur. With each accident, public fears about air safety are magnified, regardless of the cause of the accident. Moreover, risks in the aviation industry are usually associated with threats to life and body, so an aircraft accident always attracts a great deal of public interest, frequently resulting in enormous media coverage and a high impact on the airline's performance. The possibility of a serious and costly impact on business, perhaps including the company's demise, makes safety an airline's largest area of concern.

Profit (1995) summarised the situation clearly: "Aircraft accident rates are usually expressed as accidents per million flying hours, aircraft or passenger kilometres flown, and there has been a dramatic reduction in the commercial air transport accident rate since the 1950s. However, ... as air traffic is expected to double over the next decade in terms of annual passenger hours flown, the number of accidents per annum due to all causes could rise, even though the accident rate remained constant. Hence there is a perception that flying is becoming more dangerous. The downward trend in accident rates must therefore be maintained if high public confidence in air transport safety is to be sustained."

Given the concerns of carriers in this decade, Hollnagel (1993) claimed that past accidents should be studied more closely, to see whether something can be learned that can prevent future accidents. Maurino (2001) also noted that the most widely used tool for documenting operational performance and defining remedial strategies is the investigation of accidents. Fatal or serious accidents/incidents often catalyse the improvement of a safety system, because a thorough accident investigation can reveal how specific behaviours, including errors and error management, can generate an unstable or catastrophic situation. Such events can cause an airline either temporarily or permanently to change the management of its safety system.

Consequently, the analysis of the behaviour of operational personnel in accidents and incidents was traditionally adapted to assess the impact of human performance on safety. Investigators seek to discover the potentially detrimental behaviours of operational personnel, in order to identify and manage risks. Such investigations of human performance enjoy the benefit of hindsight. Risk management tools have been accordingly developed to collect safety information and prevent the recurrence of identified errors.

However, looking only at data after the fact (i.e. after an accident) is a little like trying to design a good celebration by focusing on the "sweeping up after the parade" (Maurino, 2001), and is a retroactive approach to safety. The causes of accidents and the primary contributory factors that are identified through accident investigation do constitute a form of risk management, especially if the lessons learned are properly applied. However, so few accidents occur that analysing trends and patterns with such limited data is difficult. Savage (1999) indicated that another way of preventing the next accident is needed. One must look beyond the visible manifestations of errors in designing remedial strategies, to uncover the mechanism that underlies human contributions to failure (and success) in aviation safety.

It is increasingly recognised that organisational risk management requires the active support of managers and employees at all organisational levels. Effective prevention strategies must focus upon the identification, removal or amelioration of systematic risk factors. The control of operational risk in the aviation system may require greater proactive intervention by airline management in the future. Reason (1995a) and Johnston (1996) proposed that proactive and systematic risk management approaches will be more effective in preventing accidents than ad hoc reactions to individual failures or, than reactive interventions directed towards individual workers.

Within the airline industry in particular, systematic study of the origins of accidents and incidents have led to heightened interest in the way in which organisations identify and manage risk. The activities which are thought to represent the term "organisational accident", "safety culture" and "proactive approach" are well documented in the literature, and have been used to explain the fact that airlines differ in their willingness and ability to manage safety. However, an important but yet relatively undefined area in the airline industry is to conceptualise the 'safety mechanism' in proactive safety, and the factors that influence the mechanism.

1.2 Research Objectives

Accordingly, this thesis is designed to contribute to the pool of knowledge, by meeting the following objectives:

- ✈ To evaluate current airline safety management systems and become a reference text which can be used by academics and industry.
- ✈ To investigate retroactive and proactive approaches to safety and their application within the airline industry.
- ✈ To develop a model for a 'safety mechanism' in the context of proactive safety management.

- ✈ To verify organisational factors which affect the safety mechanism, and investigate the relationship between the factors.

- ✈ To make recommendations concerning how airlines can fit the proposed safety mechanism model to the industry for the evolution of a safety management system.

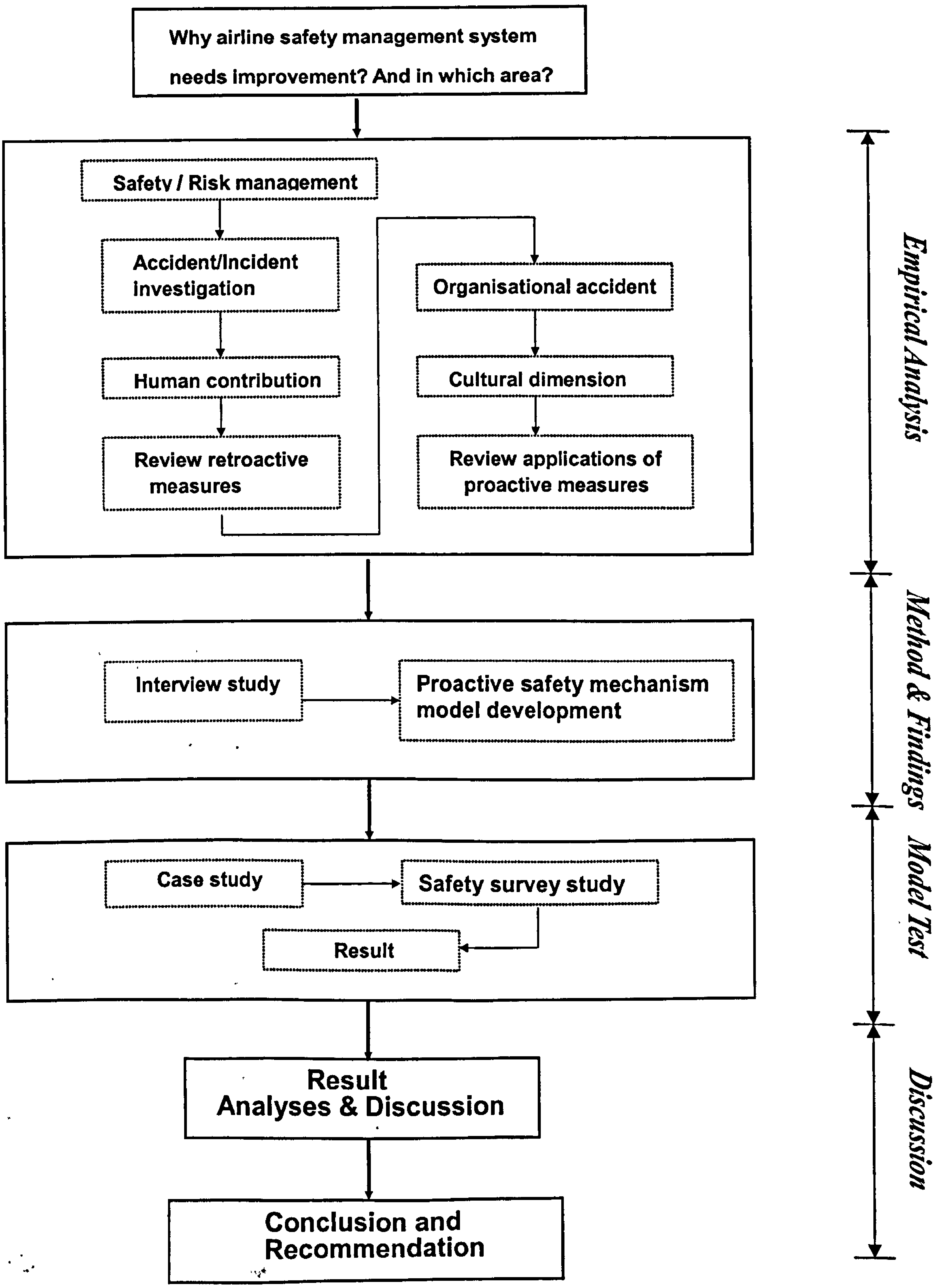
1.3 Thesis Structure

In keeping with the aims of this research project, this thesis is divided into seven chapters. Chapter 2 is the literature review and empirical industry analysis. The rationale behind this section is to explore the framework of the airline safety management system. The results of the analysis serve to explore what has been done in airline safety management, to identify the problem generated from the current system, and to verify what is needed for the continual improvement of airline safety services.

Chapter 3 states the methodologies applied in the research, such as the interview study and how the safety survey is designed and conducted, in the thesis in order to achieve the aims stated in Chapter 1 and the problem identified in Chapter 2. Chapter 4 is designed to develop the safety mechanism model and further determine its influential factors by employing a safety survey. Chapter 5 presents a qualitative and quantitative study to test the model and the results, including a case study and a survey of opinions with questionnaire. Chapter 6 serves to analyse the survey results, to discuss the structure underlying the model and the implication of results. It also probes into the applications and limitation of this model. Chapter 7 summarises the knowledge obtained from this study project as a whole with respect to the development of proactive safety mechanism, as well as the recommendations for future research areas to improve airline safety management system.

Figure 1-1 demonstrates the research structure and methods used in thesis.

Figure 1-1 Research Structure and Methods Used



CHAPTER 2

Literature Review & Empirical Analysis

"Disasters do not cause effects.
The effects are what we call disasters."

~ W. R Dombrowsky, 1995

2.0 Role and Definition of Safety

The primary objectives of an airline are associated with profitability, namely providing services and receiving monetary remuneration. While flying is widely accepted as an extremely efficient means of quickly transporting people, cargo or equipment, and performing a wide range of various other activities, safety is not only the compulsory responsibility of an airline but "safety" also supports airline profitability, for example through brand image.

However, exactly defining safety is rather difficult. According to the Flight Safety Foundation (1999a): "Safety is an abstraction, and in a sense a negative one - the absence of accidents and incidents - which makes safety difficult to visualize". Indeed, compared with risks and hazards, hazards are usually easier to identify than risks, and thus are easier to measure through practical approaches.

Previous literature defines safety as freedom from danger or risk (Profit, 1995). Prof J Reason notes that "safety is a dynamic non-event, so we have to work hard to make nothing happen" (IFA, 1998). Moreover, McIntyre (2002) argues that safety is more than the absence of accidents. Safety is also a goal of reducing the levels of risk that are inherent in all human activity.

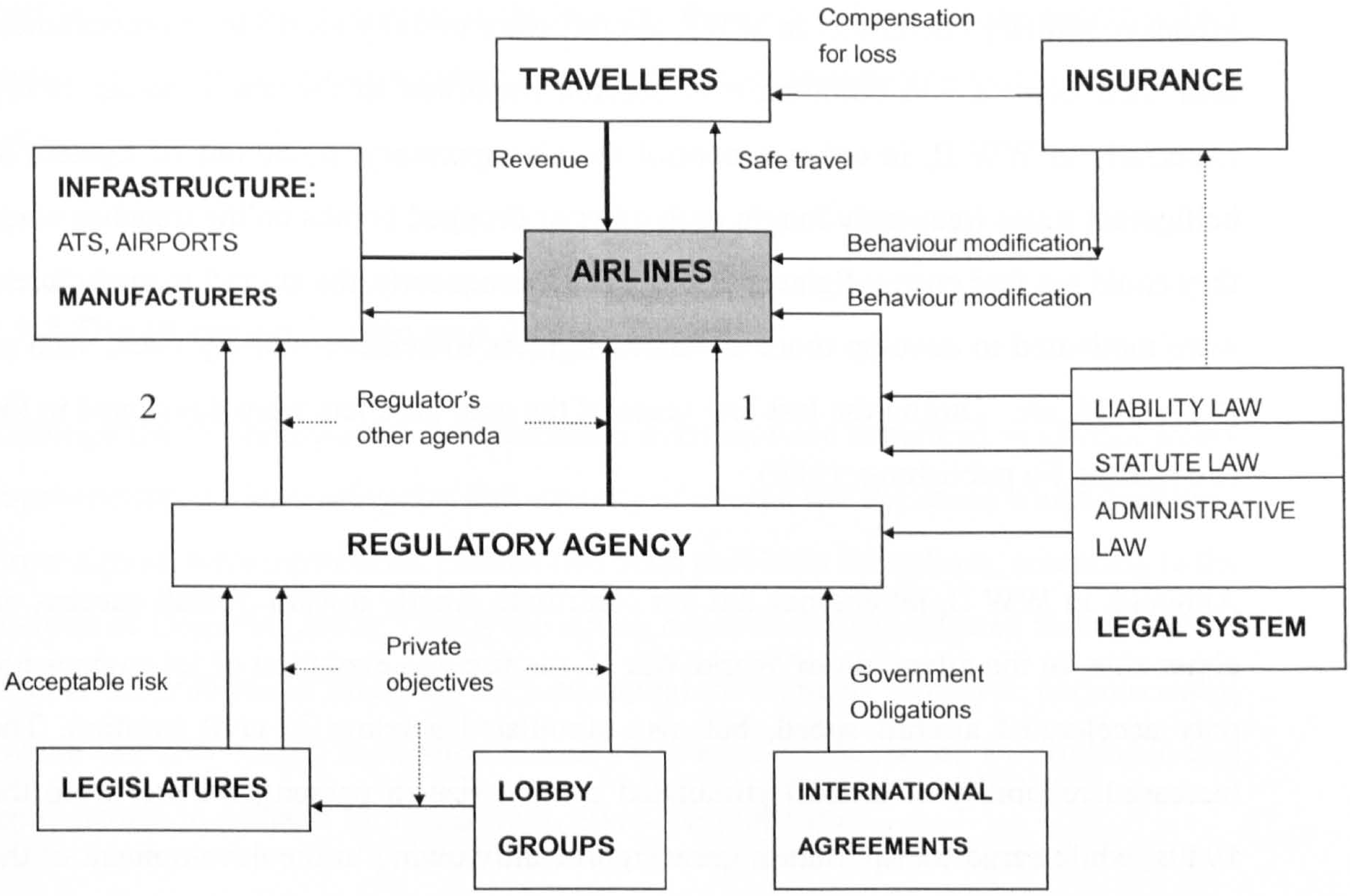
It is a fact that no human activities or man-made systems are absolutely safe. Instead, all that can be discussed is **relative safety** and **acceptable risk.** This concept is reflected in Lowrance's (1976) argument that "safety is a judgment of acceptability of risk" and the definition of safety of the International Civil Aviation Organisation (ICAO) that holds that safety is where: **"risks are minimized to an acceptable level"**. This ICAO definition of safety is commonly adopted in the modern aviation world.

2.1 External Impact on Airline Safety

Figure 2-1, developed by Dannatt (2000), is used as a guide to understanding the complexity of the variables that determine the effectiveness of the government regulation of air transport safety. It illustrates the systematic interactions between airlines and government, the regulatory agency, airlines, air travellers, the legal system, the insurance industry, and infrastructure, which, in turn, determine the safety relationship in the air transport system. The safety relationship concept in this diagram is found to be useful as a guide to understanding the organisations which exert an influence on airline safety services.

Most of these organisations in Figure 2-1 have differing, and sometimes conflicting objectives. However, these relationships also reveal the *supply and demand* relationships within this system, which decide the sustainability of the air transport industry. As airline services have gone through a period of historical development and have therefore formed through a process in which professional, political and economic interests have played a part, there is no easy solution to the question of the right way to manage airline safety. Therefore, following sections will firstly discuss the external impact of these organisations which are categorised from all elements in Figure 2-1 including manufacturers, travellers (the public), and regulatory agencies, on airline safety.

Figure 2-1 Safety Relationships in the Air Transport System



Note:
1: Quality assurance for underinformed travellers + paternalism
2. Quality assurance for underinformed airlines + remedy for monopoly supply

Source: Adapted from Dannatt, 2000

2.1.1 Technological Innovation and Its Impact

The most important milestone in the history of aviation occurred in 1903, when the Wright brothers flew a heavier-than-air craft for almost one minute, thus launching the era of the power plane (Kuang Fu publishing, 1988). By 1910, numerous aircraft manufacturers were already in business. Sixteen years after the Wright Brothers flight, the first scheduled air transportation service was launched in Germany in 1919 (Chang, 1998). However, during this period the development of aircraft engines was mainly driven by speed competitions and trials rather than human transportation.

World War I & II further drove the development of aircraft capabilities, and caused increased attention to be paid to expand their function. It was because military victory depended on faster speed and extensive damage when belligerent states conducting offensive military operations In WWI, aircraft were initially used for reconnaissance; later their combat and bombing role became important in the war (Chang, 1998). Especially in WW II, in order to control the air supremacy, squadrons of fighters of belligerent states frequently fought each other or dropped bombs on the trenches when they could not find enemy fighters to shoot at. Consequently, the aircraft manufacturers were motivated to develop more advanced fighters to achieve military need, such as B-17, B-24, etc. During the last few years of the war, pure jets were developed in the end (Kuang Fu publishing, 1988).

Although in WW II, jet engines did not contribute greatly toward overall success on either side, in the aftermath of World War II, the use and evolution of jet engines not only accelerated aircraft speed, but also stimulated a boom in civil aviation. The increased reliability of aircraft stimulated a rapid rise in passenger travel from the 1940s, while cargo transportation grew significantly owing to the development of the large freighter Boeing 747 in the 1960s (Doganis, 2002). Flying thus became a convenient and rapid means of mass transportation, which simultaneously created a global village. In 1976, an even more advanced technology, supersonic aircraft in the form of Concorde, entered the service market (Kuang Fu publishing, 1988), marking a new chapter of aviation. With the growing air traffic in recent years, aircraft manufacturers are competing to develop new aircraft to satisfy more and more air travel demand, including A380, supersonic transport aircraft (SSTs), Boeing 7e7 etc. In particular, the idea of SSTs is to fly as fast as Concorde, but be able to carry more passengers and consume less fuel and moreover, satisfy strict environmental requirements (Muir and Thomas, 2003).

Doganis (2002) expressed that: "In the last fifty years technological innovation in air transport has far outstripped that in any other transport mode." Particularly in civil aviation, compared to the era of the piston engine, turbo-prop aircraft have significantly improved productivity, while the arrival of turbo-jets has dramatically increased speed and reliability. Statistics from 1960 to the early 1980s show that the introduction of jet engines helped to reduce the rate of fatal accidents per 1 million landings from around 50 to 2. In 2000, a new safety figure revealed that big-jet hull loss accident figures from 1991 to 2000 showed a reduction in the loss rate from 1.5 to 1 per million flights; a 33.3 percent drop in the hull loss accident in a decade, which is quite impressive (Learmount, 2001).

2.1.2 The Growing Traffic and Airline Safety

Although the technological developments in aviation were beneficial in aircraft safety improvement, the increasing size and capacity of aircraft and the speed with which new, larger aircraft were introduced, created two main problems for airlines, according to the analysis of Doganis (2002). One is the strong downward trend on load factor, and the other is the problem of financing the new capital investment. However, paradoxically, for the last fifty years, the airline industry has been characterised by continued and rapid growth in demand for its services, given the problems.

The rate of growth of air traffic seems to follow closely developments in the world's gross domestic product (GDP), and there would be no slowing down according to the air traffic forecasters[3] (Doganis, 2001). Although air travel growth varied in different regions, strong growth was evident in the worldwide demand for air travel in the last decade (IATA, 2001). In this new decade, Doganis (2001a) and Boeing (2001) also predict that world air traffic measured in Revenue Passenger Kilometres (RPKs) will grow around 5 percent annually within the next 10 and 20 years respectively. Before September 11th, over the 20-year forecast period, 2001 to 2020, the market is predicted to be worth $3.1 trillion (Boeing, 2001).

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[3] For example, in the 1990s both short-term, like IATA (1998), and long-term forecasts, such as Airbus (1995), agree with the fact that international traffic would increase steadily world-wide at around 5.5 percent per annum until the year 2000, and remain at 5 percent per annum well into the twenty first century. This should culminate in the world international scheduled passenger traffic rising to a forecasted 789 million by the year 2010 (Watkins, 1997).

With the growing traffic of air travel in the long-term, the demand for safety services is simultaneously rising. It is because speed and safety are the airline industry's coin of value, each a mutually dependent value that is worthless without the other. Becker (1992) revealed, "Public awareness of airline safety issues is likely to increase in the 1990s. The growth will in part be simply a function of an increased number of passengers and frequency of travel." In addition, it is found at least 30 percent of air travellers use perceptions of an airline's safety record as a basis for deciding which airline to choose; at least 85 percent of respondents would pay more for increased airline safety procedures. Fifty-five percent of respondents have a clear idea of what safety information is important and what details they want before choosing an airline (Becker, 1992). The perception towards airline safety remains an important issue for the public and the media over these years (Taylor and Hsu, 2001b). In particular, when passengers consider air travel is unsafe, they will choose other modes of transportation or rather stop travelling. Taking September 11th, the terrorist attack in the US in 2001 for example, although not the fault of the airlines involved[4], the strong impact on the airline industry caused a decline in air traffic flow to a large degree and consequently shook the air transport business to the core[5]. Also the Gulf war in 1991 had a similar effect but to a lesser degree.

After September 11th, the forecast of future demand had to be reproduced as a result. IATA (2002) is forecasting in its new interim five-year forecast that the global airline industry will recover in 2003 led by traffic on Europe-Middle East, transatlantic and transpacific routes. Traffic demand might return as predicted in the long-term according to the relationship with GDP. Given the homogeneous nature of the airline product (Doganis, 2002), no matter what the result will be, the demand for safety and obligation of providing safety services to ensure passenger safety is still a prerequisite of airline business.

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[4] Although the argument between security and safety remains controversial, the measure of the former is for safety purposes without a doubt, which makes it necessary to include in the context of safety services.

[5] Global international passenger traffic in October 2001, the month after the September 11th attacks, fell 23.5% (IATA statistics, 2003). In addition, airlines, like Sabena, Swissair, and Canada 3000 were closed down; some others were caved by capital injections from their government, such as Air New Zealand, LOT, etc. By the end of 2001, the airline industry was in turmoil (Doganis, 2002)

2.1.3 The Regulatory Environment

The roots of today's aviation safety programmes extend back to the early days of commercial aviation following World War I (Wells, 1991). In 1919 Paris convention accepted that states have sovereign rights in the air space above their territory, and directed the government intervention in air transport. Since then, the airline industry subsequently expanded and the regulatory environment was required for improvement. Accordingly, a framework of international regulation has gradually evolved in response to the technical, economic and political developments in air transport in the period 1919-1949 (Doganis, 2002).

Prior to World War II, international aviation issues were mainly agreed by bilateral agreements between governments. The "Chicago Convention", signed in 1944, formed the basis for international standards and recommended practices, and aimed to improve all aspects of civil aviation world-wide through the providing the framework for the orderly and safety development of international air transport (Berendsen, 2000; Doganis, 2002). In 1944, International Aviation Transport Association (IATA) evolved as a result of the Chicago Convention. The IATA's members are airlines, the parties working with the results of agreements on a day-to-day basis (Berendsen, 2000). In 1947, the International Civil Aviation Organisation (ICAO), based in Montreal, Canada, became the world authority. ICAO's standards are incorporated into the programmes of the authorities, like UK Civil Aviation Authority (CAA), etc. The members of ICAO are governments who signed the Chicago Convention (The function of ICAO will be introduced in next section).

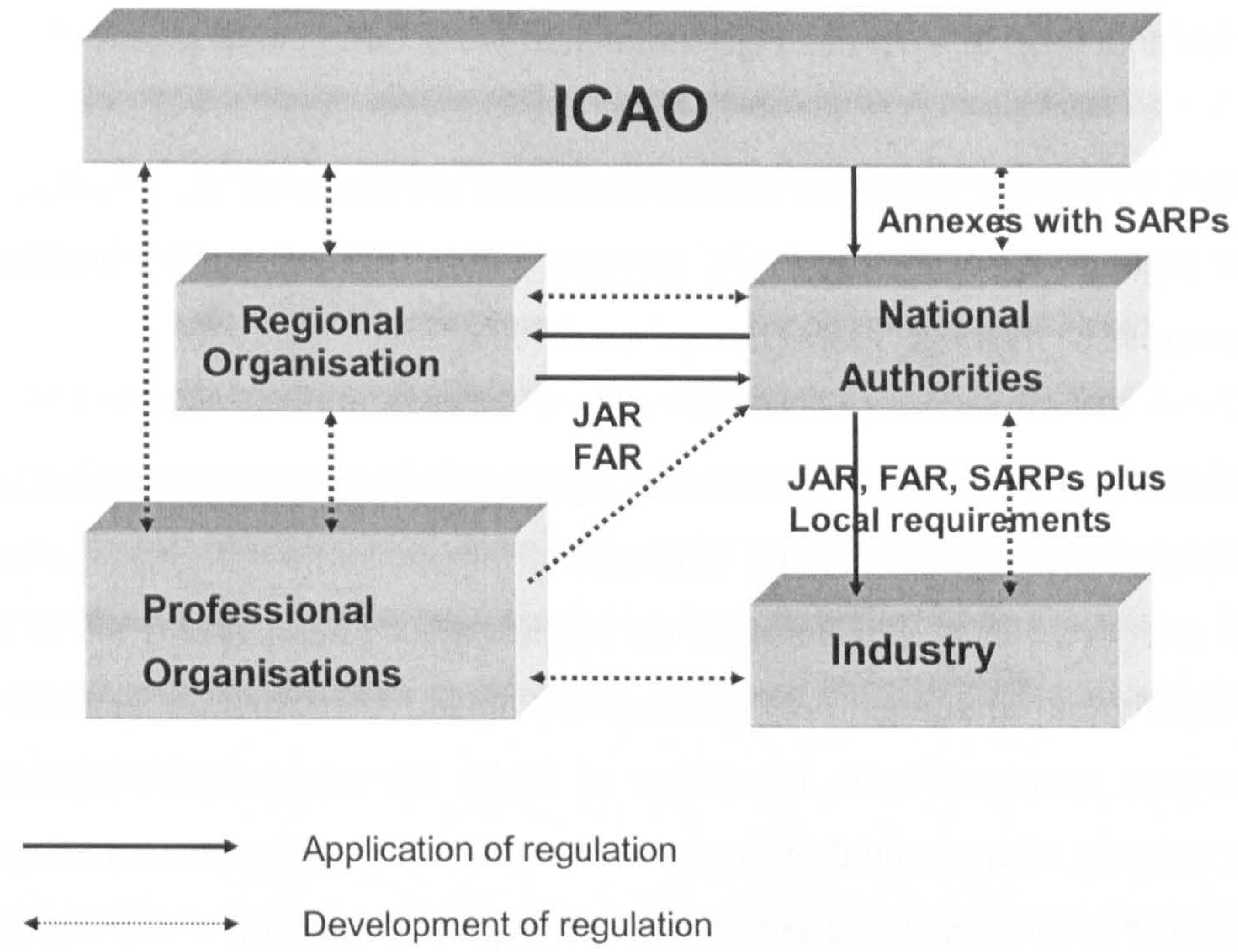
The sanction of IATA and ICAO together with bilateral agreements and inter-airline pooling agreement created a highly regulated operating environment till the 1970s. Broadly speaking, the *regulatory environment* contains two kinds of regulations. One is those which are economic in nature and concerned with regulating the business and commercial aspects of air transport; the other is regarding technical standards and regulations, which cover every aspect of airline activity and aim to achieve very high levels of safety in airline operations (Doganis, 2002). Yet in 1979 and the following two decades, the gradual liberalisation of the economic regulations consequently affects international air services. In the next sections, the non-economic regulation environment will be outlined as well as the repercussions of the economic regulations on airline safety.

2.1.3.1 The current regulatory environment of non-economic regulation

There have been many other international aviation organisations formed to provide effective solutions for airline safety since World War II. In Figure 2-2, Berendsen (2000) portrayed the structure of current regulatory environment in safety. It can be circumscribed by Doganis' (2002) non-economic regulations which deal with airlines, such as flight operations (aircraft airworthiness, performance, etc), engineering and maintenance, personnel training and qualification, as well as the third parties, such as airport and air traffic.

As shown in Figure 2-2, ICAO is situated at the top. The underpinning philosophy of ICAO is to have aviation safety directly supervised by **national civil aviation authorities**, who adapt the ICAO framework within their countries and assist the development of practical aspects of the implementation of the Standards and Recommended Practices (SARPs) issued by ICAO. For example, CAA in the UK has powers to cover aviation in the United Kingdom, while the Federal Aviation Administration (FAA) acts in a similar role in the US. Besides, although FAA is a national civil aviation organisation, it can span much of the aviation transport chain. For example, FAA had launched its own "safety oversight" procedures to inspect and monitor if safety regulations are adequately implemented in certain countries. If the airworthiness standards are deemed as inadequate, aircraft from such countries will not be allowed to fly into the US.

Figure 2-2 Current Regulatory Environment



Source: Berendsen, 2000

In addition to national regulators, Berendsen (2000) explained that the need for harmonisation has resulted in the formation of several supra-national organisations. One of the most successful examples within Europe is the Joint Aviation Authorities (JAA). JAA produces Joint Airworthiness Requirements (JARs). The aim of JAA is to foster the harmonisation of aviation safety across its member States, by implementing these common regulations and their joint application. Recently, the JAA has worked closely with the FAA in an attempt to achieve some degree of standardisation between JARs and Federal Aviation Regulations (FARs), with the intention of harmonising regulations globally.

It is worth noting that it is up to each state to decide whether it wishes to adopt each JAR by incorporating it into its own legislation, i.e. JARs are not mandatory, which arguably result in the shortfall of JAA. As such, the need for the European Aviation

Safety Agency (EASA) seems to be apparent and has been considered to establish since 2002. From 28 September 2003, EASA, with mandatory power, has become operational for certification of aircraft, engines, parts and appliances. It aims to help to maintain a high level of safety and environmental protection in civil aviation[6].

In addition, EUROCONTROL is another successful supranational organisation which provides regional upper airspace ATC services within Europe, and harmonises ATC services across its member States (Berendsen, 2000).

There are other groups called Professional Organisations in Figure 2-2. Normally they are independent, non-profit making international organisations offering international aviation safety resources. For instance, the Flight Safety Foundation (FSF) is known internationally for providing timely, practical and objective information to its members and everyone concerned with the safety of flight. Its independence provides the aviation industry with a neutral forum to meet and identify safety concerns, determine solutions and implement ideas and actions to improve safety on a non-competitive basis[7].

2.1.3.2 The impact of economic regulation on airline safety

The consequence of globalisation, privatisation & deregulation

Traditionally, governments are concerned with many aviation issues. These include ownership of airlines, regulation of domestic routes and fares, limits to foreign ownership, etc. and most notably with the safety of air transport.

With the increasing demand and expansion of networks, globalisation and privatisation encourages nations to adjust to the regulatory environment. Since liberalisation has been adopted by the US in 1978, followed by key European countries and European

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[6] Reference from EASA website: http://www.easa.eu.int

[7] Reference from FSF website: http://www.flightsafety.org

Union after the mid-80s (Doganis, 2002; Chang, 2002), deregulation is becoming a worldwide trend and frees airlines to pursue strategies that offer air travellers greater value. Many countries have removed restraints within their national boundaries and revised rules of allowable foreign investment, like the US (Chang, 2002). As a result, airlines are free to choose where to fly, what services to provide and how much to charge. Passengers benefit from the offers regarding lower prices and more convenient flight times (Boeing, 2001).

While airlines now have flexibility to pursue strategies that meet the needs of the next century's global community, it also comes with the responsibility of ensuring that each operation is safe. A series of questions such as: Have the risks increased as a consequence of economic deregulation? Has the deregulated market raised financial pressures on existing companies causing a reduction in their safety standards? Both need to be answered.

Research has been carried out to find the relationship between deregulation and safety performance after deregulation occurred in 1978 in the US. The conclusion reached after a 1987 conference at Northwestern University was that "subject to conditions, safety performance does not appear overall to have been impaired by deregulation" (Moses and Savage, 1990; Dannatt, 2000). Morrison and Winston (1988) support the conclusion that the secular improvement in safety has not been interrupted by deregulation because they found a reduction in insurance expense association with deregulation. Wells (1991) also states "Deregulation is not directly related to aviation safety, however some industry observers are concerned about its unintended negative impact." Some studies generally conclude that while air transport safety has become safer after economic deregulation in 1978, it might have been safer still in the absence of deregulation (Barnett and Higgins, 1989; Barnett and Wang, 1998; Savage, 1999).

Although most research results reveal the non-negative aspects stemming from deregulation, there are still some concerns. Rose (1992) argued that improvements in airline safety do not appear to have slowed appreciably since deregulation.... Nevertheless, the possibility that regulatory effects may operate with long lags, through such mechanisms as reduced maintenance or increased aircraft age, suggests that scrutiny of aggregate safety performance over the next few years is essential. So Dannatt (2000) pointed out that an important variable likely to have influenced the safety outcome was the effect of the safety regulator, and regulation's effect on safety is likely to be the outcome of chosen policies, changes taking place in the industry and the segments of the industry to which they are applied.

However, in terms of safety issues, regulatory authorities have been criticised for being untimely and unresponsive, and existing frameworks, with local and regional structures, do not have the flexibility to adapt to a dynamic, changing market place and environment (Berendsen, 2000). From a 1985 safety review, a task force reported that the area in most need of improvement was that of timeliness in identifying and responding to safety issues (FAA, 1997a). In addition, the cost-cutting strategies, profit concerns, the effect of mergers and alliance between airlines, etc., resulting from the competitive environment might also cause airline mission and structure to change. As a result, some regulators have taken action to ensure that appropriate skill levels are maintained, like UK CAA. Aside from that, regulations and safety action should not be perceived as a burden by the airlines. It is also of importance to harmonise the regulation throughout the industry while maintaining adequate scope for competition.

2.2 Airline Safety Management System

2.2.1 Flight Safety Risk

The airline business is a high risk business (Smith, 1996; Doganis, 2002). The airline industry's risk encompasses factors such as operation efficiency, industry fundamentals, competitive position, evaluation of management, financial flexibility, etc. Table 2-1 lists the business risk profile in the airline business. Due to the geographical range and complexity of "real-time" operations, the nature of the risk profile in the airline industry is far wider than most other businesses.

Table 2-1 Airline Industry Business Risk Profile

Type	Risks
Technical	Accidents Increasing system sophistication
Economic	Financial exposure (currency, interest, insurance) Loss of vital systems or information
Commercial	Impact on value of brand Destructive competition Loss of key markets Denial of access to key markets
Political	Impact of legislation or regulation Terrorism or hijack Requirement to operate uneconomic services
Human	Strikes Loss of key personnel Error or incompetence Personal injuries (health and safety risk)
Operational	Inadequate monitoring of control systems Lack of control over suppliers
Environmental	Noise Pollution Congestion Natural disasters

Source: Compiled from Smith (1996) and Sadgrove (1996)

Within the business risk listed above, risks regarding flight safety, whether technical or operational types, often attract lots of attention by the public, because these are most commonly associated with threat to life and limb. The consequences are accidents or incidents (see appendix A for the ICAO definitions of accident and incident).

Figure 2-3 presents the yearly number of accidents and fatality accident rate from 1950s to 2003, which reveals two trends since 1990: one is the decreasing number of accidents and the other is the flat accident fatality rate[8] in fatal aviation accidents[9] according to aircraft accident statistics (Aviation Safety Network, 2003). The former is decreasing owing to the industry having invested heavily in developing advanced technology to increase aircraft reliability and productivity. However, it's almost impossible to

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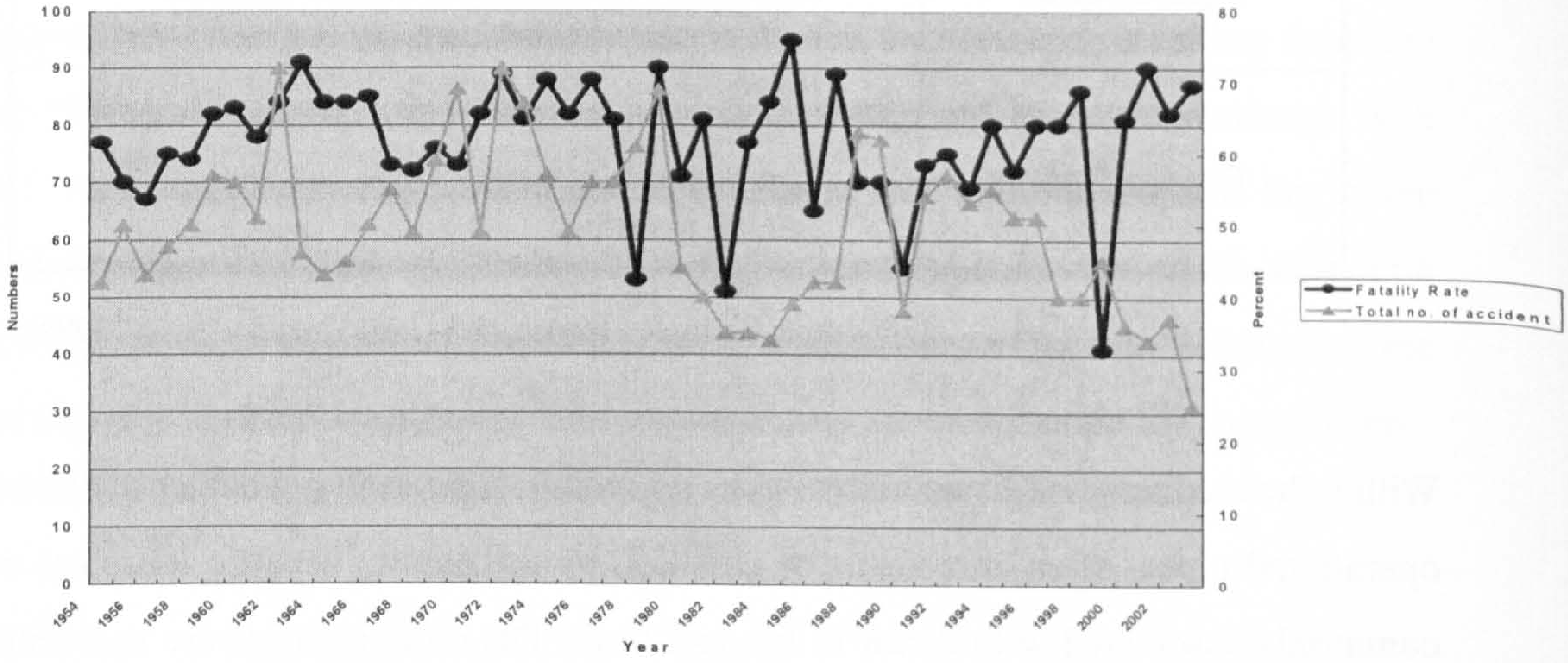
[8] Accident Fatality Rate: average percentage of occupants involved in fatal airliner accidents that did not survive the accidents.

achieve zero accident rate even with the advanced technology because other factors, like human factors[10] and environmental factors, can still cause incidents and fatal accidents. If taking a closer look at the fatality rate in fatal accidents, it shows that in average 70 percent occupants didn't survive in the fatal accidents, and the trend seems to grow upward since 2000. The observation demonstrates that the consequences of fatal accidents may become more and more massive given the advanced aircraft capability and productivity. The dramatic nature of aircraft accident not only always attracts the media and grabs the headlines, frequently resulting in enormous media coverage[11], but also has become a matter of great public interest and concern, sometimes resulting in more serious business risk.

Figure 2-3 Annual No. of Accidents vs. Fatality Rate



Source: Aviation Safety Network website http://aviation-safety.net/statistics

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[9] Accidents are classified into fatal event and non-fatal event. For fatal event, any circumstance where one or more passengers die during the flight from causes that are directly related to a civilian airline flight. The fatal event may be due to an accident or due to a deliberate act by another passenger, a crew member, or by one or more persons not on the aircraft. These events include sabotage, hijacking, or military action and exclude cases where the only passenger deaths were to hijackers, saboteurs, or stowaways.

[10] Muir and Thomas (2003) state that when discussing passenger safety in very large transport aircraft (VLTA), also pointed out that VLTA will increase passenger capacity and flight duration, but emergency evacuation in the event of a survivable crash poses a challenge for aircraft manufacturers and authorities.

[11] For example, data reveal that from 1978 to 1994, the New York Times disproportionately reported fatal events involving jet aircraft and fatal events in the U.S. or involving US carriers (Curtis, 1997).

The impact of aircraft crashes with the associated loss of life is important for the public, who have the power of veto for a particular airline. Not only do crashes cause loss of human life, they also damage the viability of an airline. The aviation industry tends to measure the accident rate according to the rate of fatal accidents per 1 million landings. However, the perceived accident rate of the public, the media and the investment parties is the number of accidents per month or per year. Consequently, an increase in the perceived accident rate may result in many airlines suffering financially as the public refuse to patronise airlines perceived as less safe. These risks can have a serious commercial impact on the business of certain airlines, and at worst can cause their demise (Taylor and Hsu, 2001b).

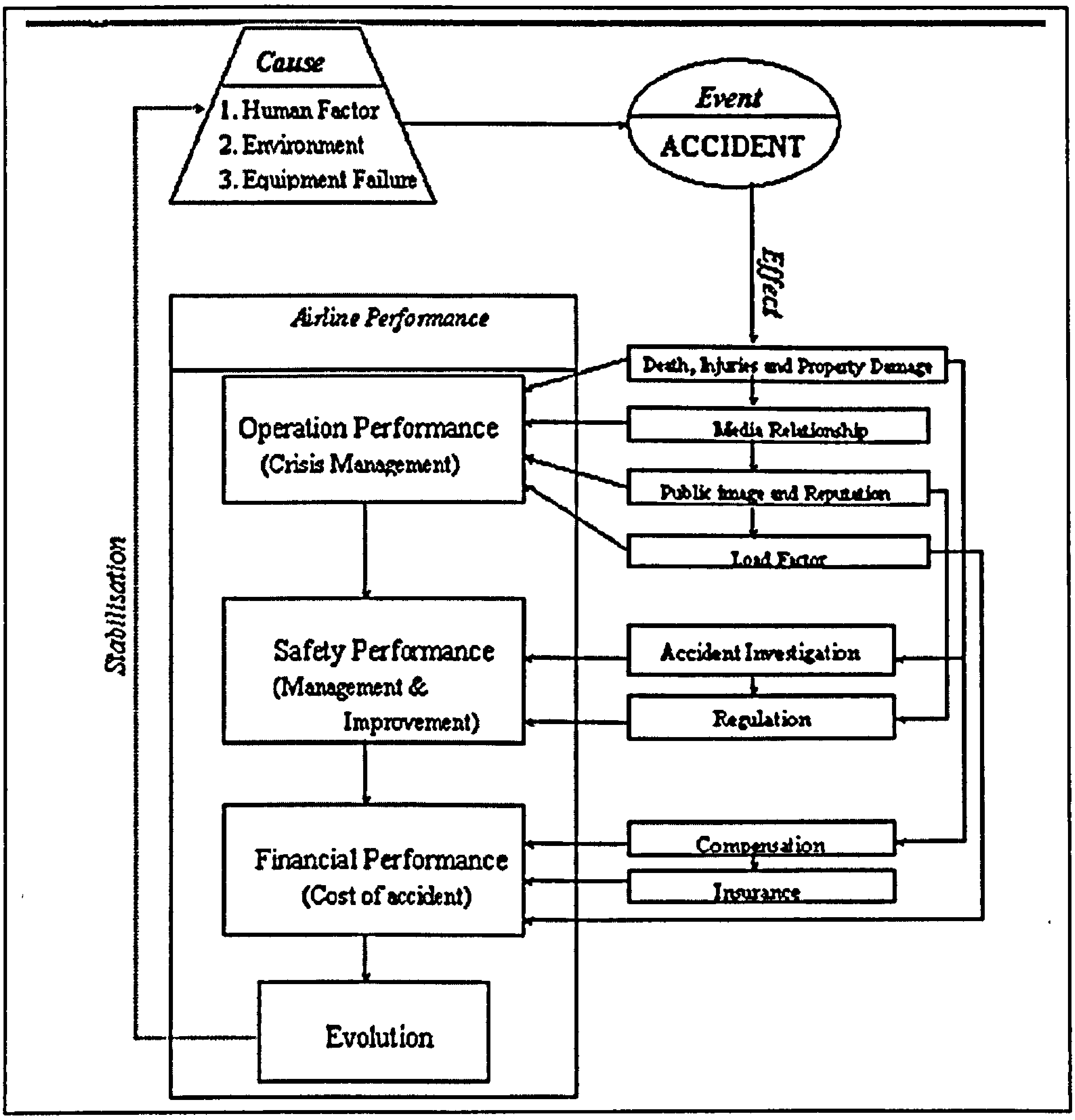
Accidents like the ValuJet crash in Florida Everglades and loss of the TWA B747 off Long Island (NTSB, 1997) represent the most tragic risk faced by the airline business. The airlines managed to remain in business but paid a very high price. In other cases, airlines such as that of Air Florida, which failed to emerge from bankruptcy in late 1980s in the aftermath of a B737 crash in 1982 (NTSB, 1983), were not fortunate enough to survive (Smith, 1996; ATI). This is the most serious business risk resulting from flight safety risk.

2.2.2 The Impact of Accidents on Airline Safety Performance

No matter how severe an accident is, the airline performance in terms of company reputation, airline operation, fiscal problems, safety commitment, etc. will be affected to some degree. Figure 2-4 was developed in order to identify the influence of accident on airline performance by demonstrating the sequence of causes, event, effects, and influenced performance following an accident.

Broadly speaking, three main aspects are identified which contains the operation performance- crisis management, safety performance, and the financial performance-costs of accidents. The scale of the impact stems from the effects of an accident. The result of Hsu and Taylor's work (1999, 2001b) shows that with the growth of globalisation and integration, airlines face new problems in the matter of accident; most importantly, lack of planning, training, and preparation will contribute towards greater financial loss. It leads to the conclusions that the most important influence of accidents on airline performance is the safety performance, and the suggestions for airline operation and safety improvements.

Figure 2-4 The Impact of Accident of Airline Performance



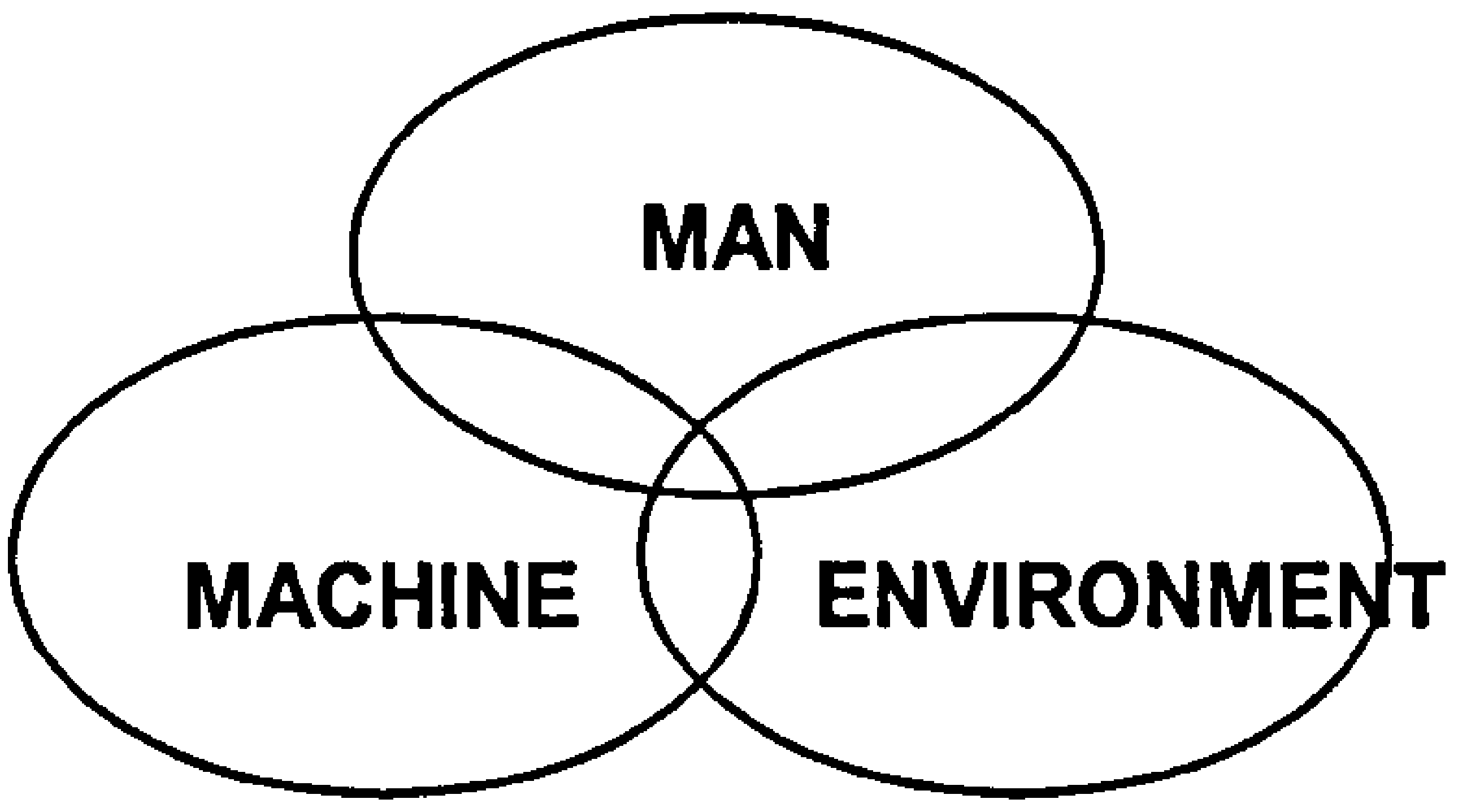
Source: Hsu, 1999; Taylor and Hsu, 2001b

2.2.2.1 Safety improvement and management

One of the problems in the aftermath of accidents is the failure of safety commitment. What are these safety deficiencies and how to improve them in order to prevent accidents from recurring are issues that airlines are eager to know. Meanwhile, following an accident, the public and the media are always desperate to know who should be blamed, who should take the responsibility and who should make the improvements.

Figure 2-5 shows "The Safety Trinity", demonstrated in the ICAO Accident Prevention Manual. These are the bases of all activities in aviation safety and also the main causes of an aircraft accident.

Figure 2-5 The Safety Trinity

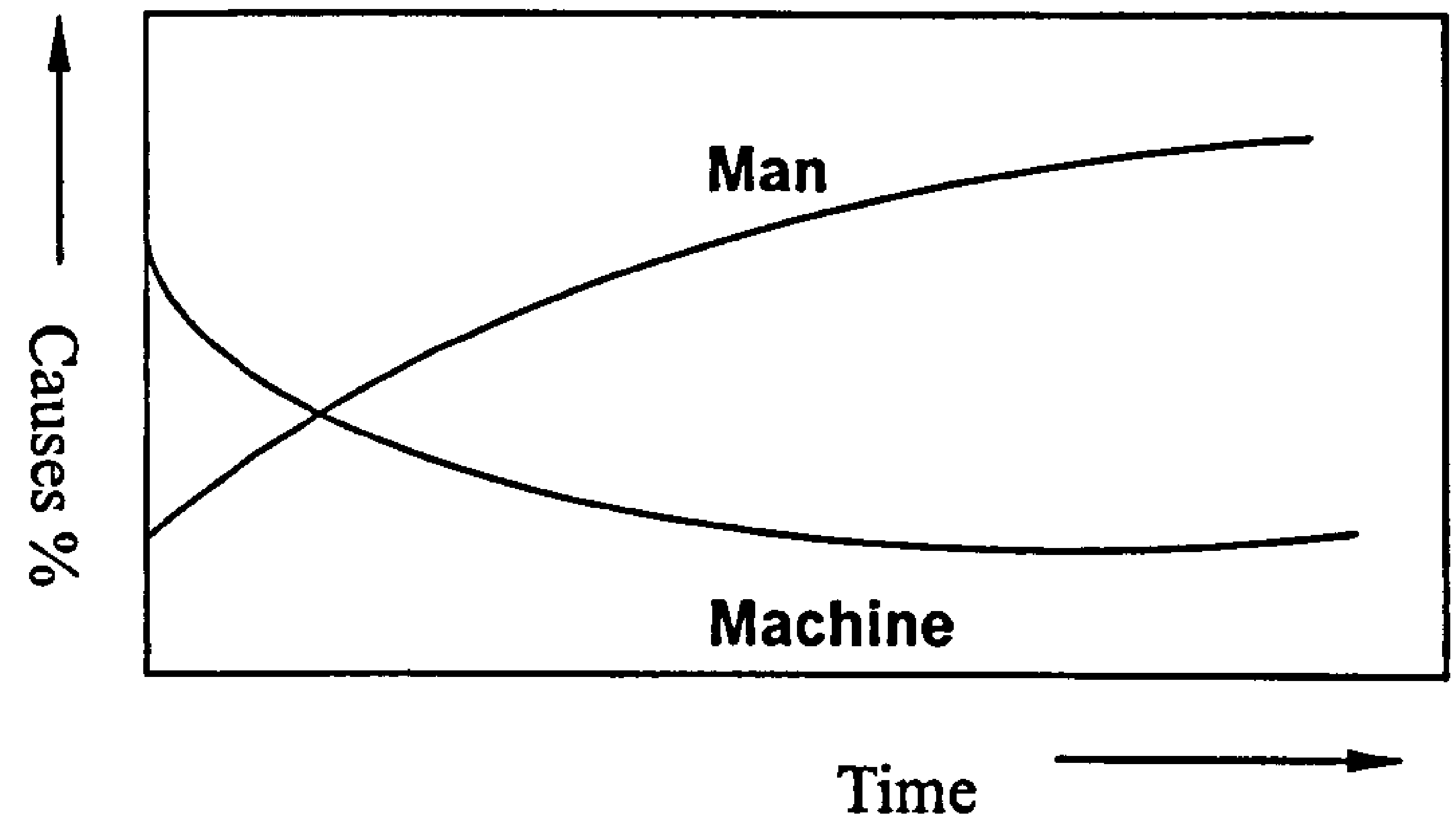


Source: ICAO Accident Prevention Manual

Tracing back the causes of accidents in the early years of aviation, the causes of accidents were mostly associated with catastrophic structural failures (Machine) or adverse weather conditions (Environment). Investigators tended to focus on the technical aspects of the mishap under investigation because the reliability of aircraft systems was not always guaranteed. There were, therefore, very good reasons for investigators choosing that approach at the time. Consequently airlines were led to focus on the technical approach to safety (Taylor and Hsu, 2001a).

When commercial jets became common transport in the seventies, technology reached a level of maturity. Accidents caused by hardware failures appeared to steadily decline as a result. The attention then moved to the role of human crew (Man) as a result of a number of high-profile accidents (see Figure 2-6). It became apparent that accidents were occurring where the primary cause of the accident could not be associated with a mechanical failure. It was not until then that the science of "Human Factors in Aviation" was truly born (Taylor and Hsu, 2001a). Safety responsibilities are therefore allocated to those at the operational end: flight crews, air traffic controllers, technicians and others. Nevertheless, this view should be changed when the whole aviation system is concerned.

Figure 2-6 Man Causes and Machine Causes



Source: ICAO Accident Prevention Manual

As Robert W. Sweginnis, a specialist in accident investigation and system safety, said, "Mishaps normally have both technical and management causes. Technical causes identify deficiencies in the operational system. Management causes identify deficiencies in the management system which allowed the operational deficiencies to exist." (quoted from Aarons, 1998).

Management has great leverage in affecting operational safety within a company. Through its attitudes and actions, management influences the attitudes and actions of all others in an airline. No one would deny that senior management commitment ranks among the top requirements, and that good communication, employee empowerment and a high value placed on safety are also considered to be very important.

In addition, outside the company, regulators and countries are increasingly recognising the role of management in air safety by holding the management accountable for a serious incident or accident (like corporate killing). Therefore, management must put safety into perspective, and must make rational decisions about where safety can help to meet the objectives of the organisation in the light of the impact of accident on safety performance. As such, the following sections are served to explore the safety management concept extracted from accident/incident and how these measures act in a loss control system.

2.2.3 Definition of Safety Management

Safety improvement and management are part of the countermeasures of a loss control system (accidents/incidents), which result from changed public awareness and expectation, regulatory changes, and the development of both civil and criminal liability.

Since safety is a judgment of acceptability of risk, safety management should be the technique or practice of managing safety or controlling risk. Overall (1999) points out that a common definition for Safety Management is "A systematic management of activities to secure high standards of safety performance". Akhurst and Vivian (1997) also put it "Safety Management is a mechanism that could be employed to address the lessons by providing for effective monitoring and auditing of safety and the allocation of responsibility and accountability in safety critical organisations." In other words, safety management simply involves giving safety the highest priority possible in a safety significant business.

In the airline industry, the exact definition of safety management may vary a little in different airlines according to their business plans or safety aims. For instance, Bisson (1997) pointed out that Britannia Airways defines Safety Management as "all those activities which underpin the safety and worthiness of the aircraft" in accordance with the strategic safety aim of Britannia - to continue to be safe and reliable airline.

Nevertheless, in the aviation industry, regulatory authorities around the world have defined safety management in greater detail. The United Kingdom's Civil Aviation Publication (CAP) 712 defines safety management as "the systemic management of the risks associated with flight operations, related ground operations, and aircraft engineering or maintenance activities to achieve high levels of safety performance." (UK CAA, 2001).

The definition provided by UK CAA is a complex and complete explanation of safety management in the current aviation industry. It focuses on the risks associated with business, not focusing on safety but a lack of unsafe incidents/accidents. Moreover, it emphasises that management is systematically in association with all risks stemming from aircraft-related activities. Meanwhile, it contains the concept of systems for the management of safety.

2.2.4 System Safety and Safety Management System

A study of systems for the management of safety (System Safety) or Safety Management System (SMS) raised consideration of the three constituent parts - management, safety and systems. Edwards (1999) puts it "A company's Safety Management Systems define how the company intends to manage air safety as an integral part of its business management activities. A Safety Management System is defined as a systematic and explicit approach to managing risk, and is largely a loss control management system."

In the US, the System Safety discipline emerged on the engineering and management scene in 1962 with the dawning of the space transportation era. System safety principles emphasise the rigorous development of effective safety risk mitigation strategies based on comprehensive and thorough risk assessment and its management is a long-term, comprehensive approach that assures that systems and techniques have safety designed in from the outset (McIntyre, 2002).

Canadian's civil aviation authority, Transport Canada (2001b), says it: "A safety management system is a businesslike approach to safety. It is a systematic, explicit and comprehensive process for managing safety risks. As with all management systems, a safety management system provides for goal setting, planning, and measuring performance."

The United Kingdom National Air Traffic Services (NATS) began the introduction of formal safety management system (SMS) in 1991 (Profit, 1995), largely because of the increasing attention on safety matters and airspace capacity from outside groups, including the public, the media and Parliament. Profit (1995) states, "A safety management system is no more than a systematic and explicit approach to managing safety - just as a quality management system is a systematic and explicit approach to improving the quality of a product to meet the customer's requirement."

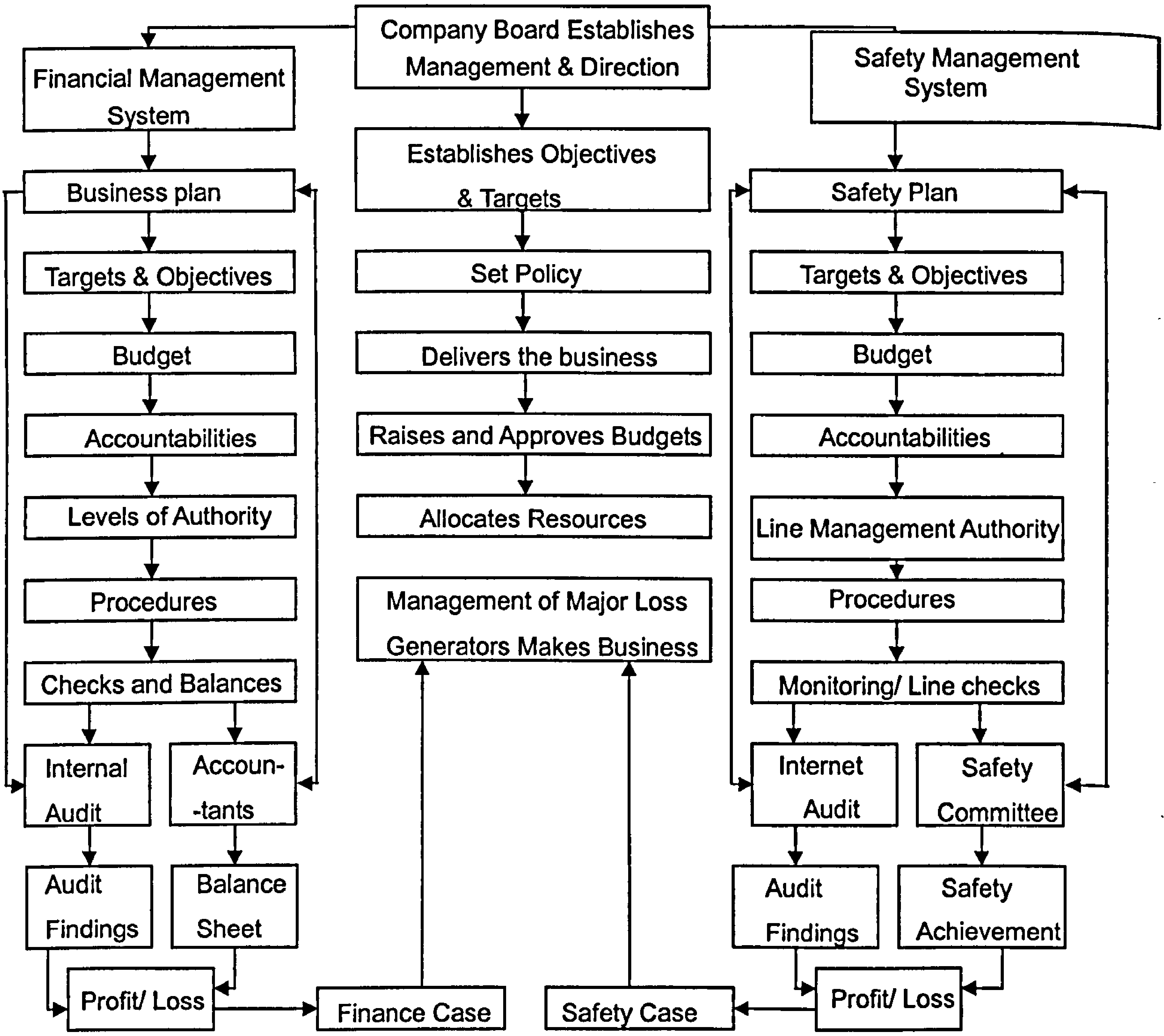
In CAP 712, a safety management system is defined as "an explicit element of the corporate management responsibility which sets out the company's safety policy and defines how it intends to manage safety as an integral part of its overall business." (UK CAA, 2001).

UK CAA also provides an analogy between SMS and **financial management system** of a company.

"*The features of a financial management system are well recognised. Financial targets are set, budgets are prepared, levels of authority are established and so on. The formalities associated with a financial management system include checks and balances. The whole system includes a monitoring element so that corrections can be made if performance falls short of set targets. The outputs from a financial management system are usually felt across the company. Risks are still taken but the finance procedures should ensure that there are no business surprises.*"

Edwards (1999) also provides a comparison of the financial management system and safety management system (see Figure 2-7). The management of safety should fill a similar place in the organisation's management, in the same way that a financial system deals with the control and use of money, providing a framework for managing one of the potential loss generators. In other word, the objectives of SMS are to act as a loss control system and to be focused on actively managing the key risks to an aircraft operator.

Figure 2-7 The Comparison of Finance and Safety Management System

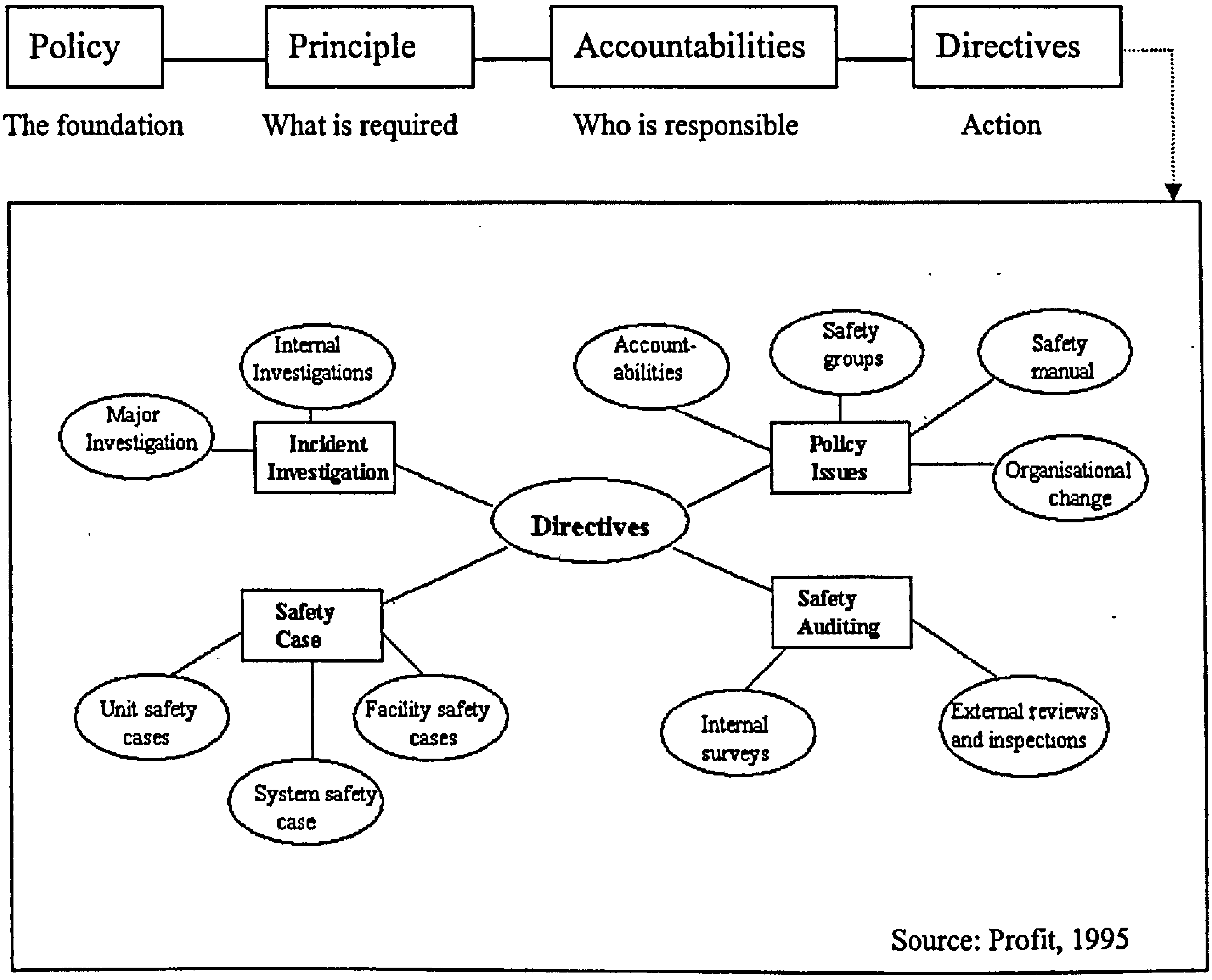


Source: Edwards, 1999

2.2.4.1 The Components of a safety management system

The commitment, organisation and assurance of continuing safe operations are achieved through a SMS. As such, a Safety Management System must be top management led and is a systematic approach to managing all aspects of safety in the business using a **structured approach.** Profit (1995) describes that in an organisation, the policies, principles, accountabilities, directives and procedures constitute SMS (see Figure 2-8). The safety management actions required by the policies and principles are implemented by directives, as shown by the bubble diagram within the figure. Directives and their associated procedures can be grouped under the broad headings of policy issues, incident investigation, safety cases and safety auditing as shown. The total picture in Figure 2-9 illustrates and rationalises the components of a typical safety management system in the aviation industry.

Figure 2-8 The Components of a SMS



Source: Profit, 1995

2.2.4.2 The characteristics of a safety management system

Researchers and organisations (Edwards 1999; Overall 1999; GAIN 2000; and CAP 712) have provided definitions of the basic characteristics (prerequisites) of SMS. Common characteristics are:

1. Comprehensive corporate approach to managing safety
2. Effective organisation for delivering safety
3. Robust systems for assuring safety

The top management of the organisation is responsible for establishing the comprehensive corporate approach to safety, but it will fall to the Chief Executive to ensure that there is an effective organisational structure below Board level to deliver safety. Meanwhile it is the management's responsibility to make sure that the system is robust enough to provide safety assurance.

In reality, these features cannot be presented without the practice of the components of a SMS. As mentioned in the previous section, the main components of a SMS are Policy, Principles, Accountabilities and Directives, which appear sequentially but work interactively. Policy and Principles define the corporate approach and the Board has the corporate approach shown in the statements. This approach is embedded in the structure of an organisation and everyone is assigned his or her accountabilities. Eventually, the structured approach is implemented by Directives, and aims to create a robust system to ensure safety.

In other words, the characteristics of a SMS are the prospects of how the components work and demonstrate. Therefore, a model is constructed by combining the main components and characteristics of a SMS (see Figure 2-9). This model presents a more explicit interaction between these three sequential characteristics of a SMS and other elements in the proceeding periods.

Figure 2-9 The Interaction of Characteristics and Components of a SMS

Source: compiled from various authors

1. Policy and principles: corporate approach to safety

Corporate approach to safety is about the involvement of Board/Top management to show leadership and commitment to safety by clear policy objectives and safety improvement targets. The "Place" allowing the Board to show leadership and commitment to safety is "safety policy statements".

In other words, the Board defines and details safety objectives and intentions for safety standards. These generic ideas are reflected in safety policy statements, which enable management to demonstrate the fundamental approach to managing safety that is to be adopted in the organisation. As such, the policy statement is a vital starting point.

Safety management principles contemplate the policy statements

In the policy statements, safety management principles, decided by the Board to be applied within the organisation, are fundamental requirements that define the scope of the SMS. "What is required and what is achievable" are key questions of the safety objectives in order to provide a framework for processes to identify safety shortcomings so that remedial action can be taken (Profit, 1995).

In addition, a safety improvement programme, approved by the Board is an important and powerful way of keeping the Board's attention on safety. It forces the Board to review the safety standards and the development of a SMS with regulatory minima. As such, a company's safety statement should include the following:

- ✓ Safety objectives
- ✓ Arrangements for the achievement of safety objectives
- ✓ Flight safety principles
- ✓ Health principles
- ✓ Quality principles
- ✓ Corporate and safety standards

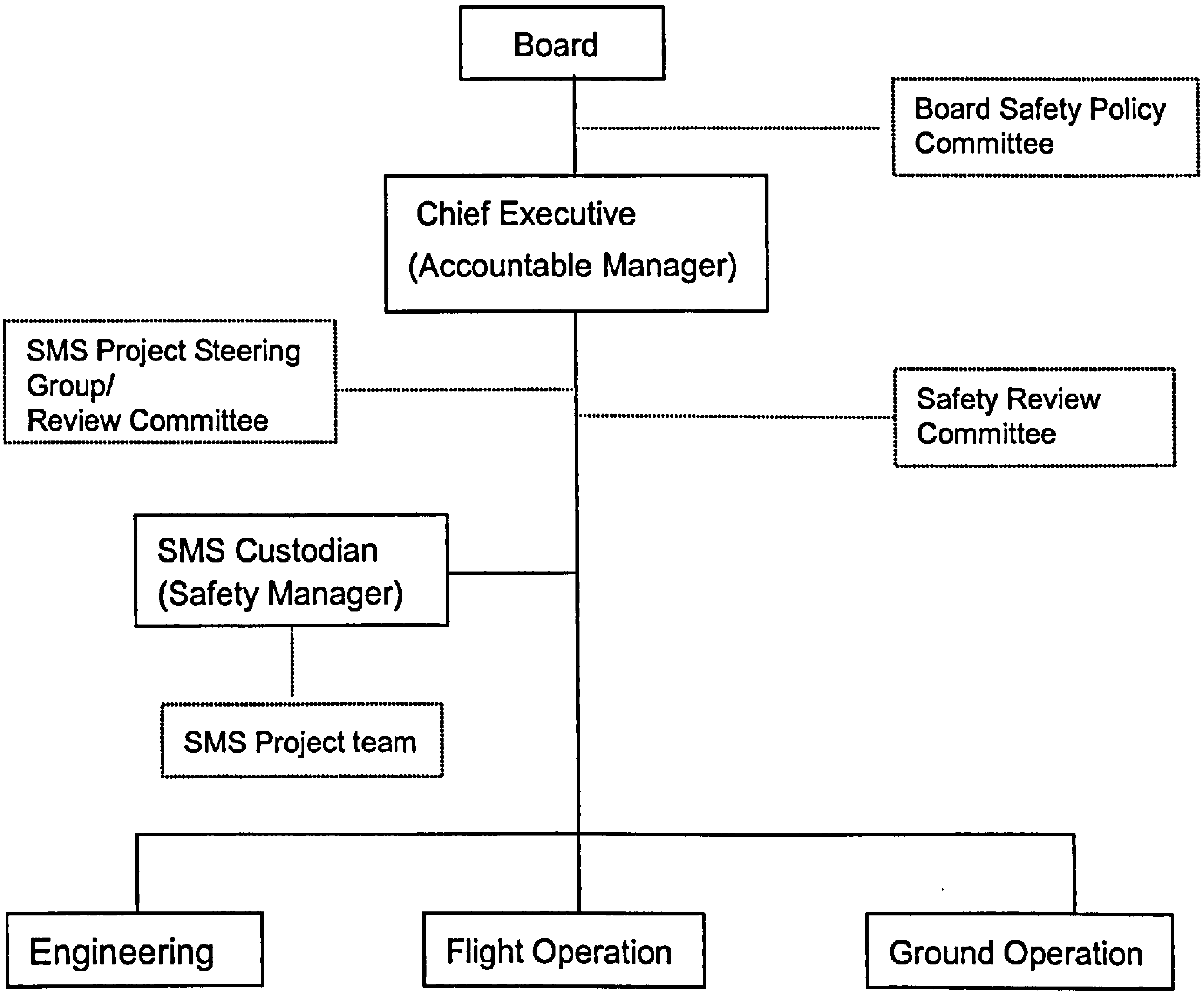
2 Effective organisation for delivering safety versus accountabilities

Edwards (1999) pointed out seven key areas for effective aviation organisations to deliver safety.

- Committee/structure for overseeing safety management
- Management review mechanism
- Clarity of line management responsibilities
- Coherent cascade of accountabilities for safety
- Role of Accountable Manager (CEO) and a SMS custodian
- Change management process in place
- Effective company and training requirements

In accordance with these key points, Overall (1999) presented a relative organisational structure (see Figure 2-10). The consideration of safety is systematically designed into the management structure, the committee and business of planning, and operation for an effective organisation. The objective is to ensure that everyone involved in a safety-significant role is left with no doubt as to his or her individual accountabilities for safety. The committee is, in the meantime, allowed to oversee safety management and the management can review mechanisms.

Figure 2-10 The Suggested Organisational Structure



Source: Overall, 1999

The coherent cascade of accountabilities for safety is from Board level down through the management structure. Each safety accountability, within a job specification, requires certain knowledge, skills and experience. The organisation needs to ensure that everyone understands his or her individual and collective responsibilities and accountabilities.

The Board safety policy committee should have inputs from all the senior fleet managers and other senior managers of the departments. However, the executive responsibility for safety management rests with the Chief Executive Officer (CEO). The CEO is the Accountable Manager and is the link between the Board and the executive. GAIN (2000) defines the Accountable Manager as the person acceptable to the country's regulatory authority who has corporate authority for ensuring that all operations and maintenance activities can be financed and carried out to the standard required by the Authority, and any additional requirements defined by the operator.

An airline's resources are controlled by its headquarter and how the resources are allocated has a direct impact on the company's safety management programme. Some regulators have mandated the appointment of an independent safety expert directly reporting to the CEO/Accountable Manager of the airline. There are two reasons for this. One is to enable the organisation's head to allocate necessary resources on safety and the other is to provide a Custodian of the SMS when any safety project is planned. In FAR part 121 (1996), the expert is named the Director of Safety while in JAR-OPS 1 (1998), it is called Accident Prevention Advisor who could be the Quality Manager of the organisation. The exact placement of the safety manager function can vary from airline to airline, but the critical elements of access to top management should be maintained because safety reports can then be assured of the proper levels of assessment and implementation.

To ensure the safety manager retains a clear and objective view of the safety of the operation, ideally he/she should have no operational responsibilities, but the incumbent should certainly have considerable operational management experience and the technical background necessary to understand the engineered systems that support the operation (Profit, 1995). The role of a safety manager is responsibility for the development and maintenance of an effective SMS, promotion safety management, reporting shortcomings and monitoring remedial actions.

Generally speaking, operational effectiveness will not be obtained without the adoption of a rigorous approach to identifying accountability for safety, which is exercised through an organisation's hierarchical structure of management committees and meetings, and its consultative arrangements with its workforce.

3. Robust systems for assuring safety by practising directives

The previous corporate approach and organisational structure have helped to build a basic framework in which to deliver safety. In addition, safety directives, shown in Figure 2-8, offer the practices to complete the objectives mentioned and assure safety for a robust system.

Safety directives are *instructions* or *procedures* for implementing the SMS after developing the policies, principles and accountabilities suitable for the organisations. According to his experiences, Profit (1995) indicates Directives which include:

1. Incident investigation: internal investigation and major investigation.
2. Safety auditing: internal surveys and external review and inspection.
3. Safety cases: unit safety case, system safety case and facility safety case.
4. Policy issues: accountabilities, safety groups, safety manual and organisational change.

No sequence exists for these four directives as long as they are kept to the minimum essential to implement the SMS. Before the important managerial issue in SMS-*risk management* is introduced, there is a need to see the link between quality and safety management.

2.2.5 Linking Quality with Safety[12]

Understanding and recognising quality in the spectrum of civil aviation is important. From the customer point of view, quality has influence on travel demand and market share. For both regulators and carriers, the performance of carriers is of concern. Knowing the information and position can help to enhance the quality of carriers, especially when the outcomes of a specific aspect of quality, such as air safety, are engaging people's curiosity.

In 1987, after carrying out a study for more than 5 years, Dumas discovered that quality programmes and safety programmes have the same components, i.e. successful safety programmes and successful quality programmes are based on the same solid foundations (Dumas, 1987). This accounted for the first contribution relating to the integration of quality with safety (Herrero et al., 2002). Using this idea, Manzella (1997) affirmed that SMS and quality management system are in need of integrating together. Figure 2-11 shows that quality and safety principles are essentially the same.

Accordingly, based on the ICAO recommended practice (Annex 6 part1), JAR-OPS states that an operator shall establish an accident prevention and flight safety programme, which may be integrated with the quality system, including programmes to achieve and maintain risk awareness by all persons involved in operations. They instruct the operator to design and run a "quality system" with its "quality assurance programme" to demonstrate regulatory compliance. In addition, the ISO 9000 international standards also help to implement quality systems. It offers some useful advice that procedures should be documented only where a lack of documentation may detract from quality. Yet it is worth noting that the decision as to whether or not it does detract from quality (or safety) is a crucial one and thus one that should only be taken by a person or committee fully competent to make such a decision.

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[12] Please refer to Appendix C for the academic background of quality and safety.

Figure 2- 11 The Principles and Relationship of Quality and Safety

SAFETY	vs.	QUALITY
Goal: Zero accidents		Goal: Zero defects
Incident analysis		Event analysis
Written policies, procedures and guidelines		Documented policies, procedures and work instructions
Safety committees		Quality circles, employee involvement team
Employee participation		Empowerment
Statistical analysis		Control charts, statistical process control
All accidents are preventable		All non-conformances are preventable

Source: Manzella, 1997

In terms of organisational structure, FAA (GAIN, 2000) suggested that the Flight Safety Officer has a similar position to Quality Manager. When the management functions of safety and quality are the same, these two positions can be combined in one, as some airlines do. Also CAP 712 (UKCAA, 2001) indicated that in most small and medium sized companies it is expected that the Flight Safety and Quality tasks will have many common points and there can be no objection to the combination of the roles in one staff member.

2.3 Risk Management

2.3.1 Definition of Risk and Risk Management

There are various definitions of "Risk" (Profits, 1995; Janic, 2000; Transport Canada, 2001a) and they are all worded in slightly different ways. Yet the underlying concept remains the same: a chance causing injury or loss. This concept implies that risk may involve objectively or subjectively known or assumed exposure probabilities in relation to space, people and time-dependency. And the degree of risk will be based on the likelihood that damage or harm will result from the hazard[13] together with the severity of the consequences. As Paries (1996) states "A risk is the product of a given probability and a given amount of damage".

Civil aviation is an activity where four types of risks are present (Janic, 2000). Identified by Sage and White (1980), these four risks are as follows:

- **Real risk** to an individual, which may be determined on the basis of future circumstances as they develop;
- **Statistical risk**, which may be determined by the available data on the incidents and accidents in question;
- **Predicted risk**, which may be predicted analytically from the models structured and relevant historical studies;
- **Perceived risk**, which may intuitively be felt and thus perceived by individuals.

To the airline industry, the occurrence of an incident/accident constitutes a known statistical risk when flying has its inherent real risk. To manage risk involves the prediction of risk by anticipating and making changes in equipment when the risk is perceived. As such, risk management is a technique to manage all these four risks in this industry.

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[13] A hazard can become a risk because of people, procedures, aircraft and equipment, and acts of nature (GAIN, 2000). It is an event that has the potential to result in damage or injury.

Organisational risk management

Risk management relies upon the premise that the likelihood of an event happening can be reduced. In the aviation industry, risk management is defined by aviation authorities and organisations as:

- The identification, analysis and economic elimination, and/or control to an acceptable level, of those risks that can threaten the assets or earning capacity of a commercial airline (GAIN, 2000).

- The process of identifying risks, assessing their implications, deciding on a course of action and evaluation the results. In civil aviation, the term is frequently used in the context of decision-making about how to handle situations which affect aviation safety (Transport Canada, 2001a).

Modern airlines face a formidable range of risks, ranging from strategic changes in the commercial environment, through to the adverse commercial impact of accidents and public relations disasters. Management of risk is, therefore, the essence of safety management. Knowing the risks enables resources to be more efficiently allocated to the concerns, and assessed on the basis of severity and frequency so that effort can be put into the areas of greatest risk and of significant safety concerns.

Risk management activities and the failure to manage risk involve the expenditure of resources (FSF, 1999a), whether for the airlines or society. In terms of the former, Taylor and Hsu (1999, 2001a) have identified the impact of accident on airlines' financial performance and safety improvement activities. It is a truism that effective organisations actively attempt to manage those risks which potentially impact upon organisational survivability. That is why Janic (2000) points out that a practical problem in air transport is how to manage risk and safety. However, the difficult task for management is to determine which risks carry the most potent dangers (Fischoff, 1994; Hood et al, 1992).

Therefore, a thorough and systematic risk management process should be made associated with resources targeted accordingly, in order to make the best risk allocation.

2.3.2 Risk Management Process in Safety Management System

As risk is manageable, it is termed risk management. Global Aviation Information Network (GAIN)(2000) depicts the system approach to risk management is known as system safety, implying that the process of risk management, which is used throughout industry and commerce, involving identifying work activities and hazards and estimating, evaluating and controlling the associated risk, is the just tool used to achieve a SMS. International Federation of Airworthiness (IFA)(1998) used to suggest a safety loop, which is a cycle of activities including hazard identification, risk assessment, risk control and recovery, and feedback in order to implement SMS (see Figure 2-12).

Figure 2-12 Safety Loop

Source: IFA, 1998

In aviation operations, not all of risks can be eliminated; some risks can be accepted and some can be reduced to an acceptable level. Figure 2-12 demonstrates the sequential procedures to a robust SMS are the processes by which risk can be identified, measured, evaluated and controlled so that the highest standards of safety can be achieved. The whole process follows a logical pattern. The first step is to identify the hazards. The second step is to assess the risk stemming from hazardous activities and determine whether the organisations are prepared to accept the risk. The third step is to find and identify the defences that can control the risk. The fourth step is to examine whether risks are appropriately managed and use the feedback information to evaluate organisational changes.

In other words, risk management is SMS in the making. It is effective risk management that contribute to the robust SMS. Profit's (1995) model, previously presented in Figure 2-8 (page 29) which shows a robust SMS can be achieved by maintaining safety levels (eliminating risks) through the *directives* and *procedures* (practices), provides a discussion base for the following sections, which will explore these four steps describing in Figure 2-12 in detail and investigate current risk measures used in the airline industry.

2.3.2.1 Hazard identification

Hazard identification is a systematic examination of potentially hazardous activities to establish safe, effective procedures and practices. There are many ways to identify hazards, which might be obvious or latent in operations. The most important thing is that hazard identification should be undertaken on a frequent basis depending on the complexity of operations and associated risks. The following are some useful methods of identifying hazards:

1. Incident/accident investigation

Incident/accident investigations help to find out the causes of mishaps or serious occurrences. This is also classified as one of the most important identification processes for hazards. As such, this section aims to firstly introduce how accidents are analysed in order to identify the accident causes and then illustrate the role of incident investigation on hazard identification.

Analytical methods for accident investigation

An accident is always deemed as a failure of risk management and is a brutal eruption into damage management (Paries, 1996). As such, accident investigation has a clear role within the safety process. Accident investigation is the appropriate tool to uncover unanticipated failures in technology or rare, bizarre events. A proper accident investigation can reveal how specific behaviours, including errors and error management, can generate an unstable or catastrophic state of affairs (Ho, 1996; Hsu, 1999).

Ferry (1988) distinguishes over 20 types of accident analysis approaches, including:

- Events sequencing
- Known precedent
- All cause/multiple cause
- Codes, standards, and regulations (CSR's)
- The four M's of man, machine, media, management
- Re-enactment
- Reconstruction
- Simulation
- Epidemiological
- Hazard analysis documentation
- Inferential conclusions
- Programme evaluation review technique (PERT)
- Critical path method (CPM)
- Failure mode and effect analysis (FEMA)
- Technique for human error rate prediction (THERP)
- Fault tree analysis (FTA)
- Change analysis
- Management oversight review (TOR)
- Scenario modelling
- Preliminary hazard analysis

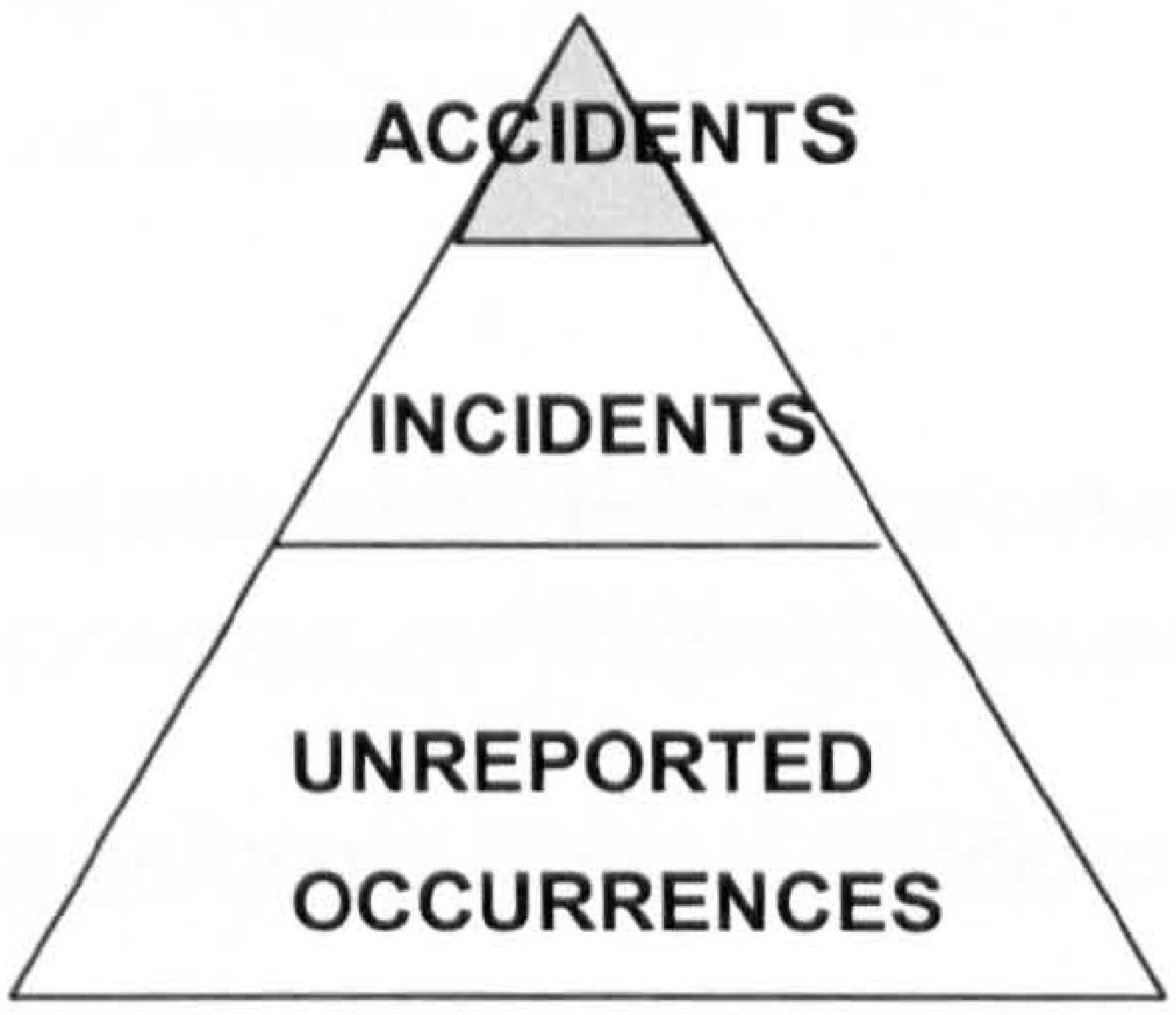
Two most common accident analytical approaches are "Event Sequencing" and "All cause/multiple cause". The former is to select the cause initiating the sequence of events that lead to an accident. The latter is to identify the primary cause which is most responsible for the accident.

Importance of incidents

Although the analytical tools of an accident are many, and experts can use them successfully to trace the causation, accidents are too rare to provide enough data for research. Therefore, an incident investigation is called. According to the Heinrich

Pyramid (see Figure 2-13), for every major accident in a given endeavour, there will be 3-5 less significant accidents and 7-10 incidents but there will be at least several hundred unreported occurrences (the exact numbers may vary in different airlines).

Figure 2-13 The Heinrich Pyramid



Source: Adapted from Hart, 1999

Apart from the reason that incidents outnumber accidents, so they provide more data for analysis and investigation, there are another two reasons to investigate and study incidents. Firstly, incidents reveal similar hazards as accidents, but they are not as severe as accidents and they will not result in serious adverse legal or financial consequences. Secondly, more information is available from the people involved (Ho, 1996).

Safety investigation seeks to identify causes of the incident and recommend the necessary remedial action to reduce the risk of recurrence. For a complex system like the airline industry, it needs to conduct a more formal and detailed investigation using an investigation team from a higher formation in the organisation with specific investigation or technical experience.

2 Incident reporting systems

In 1947, the pioneering work of Fitts and Jones in developing the "Critical Incident Technique" helped to establish the value of the investigation of incidents. Interviews and written surveys were used to examine errors made by crewmembers in utilising cockpit instruments (Nagel, 1988). Their research systematically showed the significance of poor human engineering in incident generation and accident causation. Lauber also stated the importance of incident and an incident databases which he described "...is a veritable gold mine of information waiting to be tapped" (quoted from Ho, 1996). Clearly, this shows that the incident investigation is important but the source of incident database - incident reporting systems are even more important to develop.

National reporting systems

ICAO Annex 13 recommends to its member States the provisions about the incidents reporting system:

1. The requirement to establish incident reporting systems
2. A requirement for the investigation of serious incident.

Some countries have set up their own national reporting systems, for example, ASRS (Aviation Safety Reporting System) (U.S.), MORs (Mandatory Occurrence Reports)(U.K.), EUCARE (European Confidential Aviation Safety Reporting System) (Germany), CAIR (Confidential Aviation Incident Reporting Network) (Australia), and SECURITAS (The Confidential Transportation Safety Reporting System Program) (Canada), etc. The quality of their databases is attributed to the cooperation and provision of airlines, and the information provided by airlines is attributed to the established reporting system in their companies.

Reporting systems of airlines

The existence and health of a reporting system in a company can create access to top management and ensure that safety deficiencies are recorded. Reporting systems, such as BASIS (British Airways Safety Information System) and ASAP (Aviation Safety Action Partnership) [14], are created for airline operation with two major goals: to identify safety concern and to provide methods of corrective action.

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[14] **BASIS**: Created by British Airways. Gather, categorise and analyse safety information including incident reports and digital data using modular system.

ASAP: A joint project between the Allied Pilots Association, the FAA and the American Airlines.

Take **BASIS** [15] for example. It is used by over 100 organisations for safety management. BASIS was developed by safety professionals to answer such questions as "How safe are we?", "Where should we put our limited resources to become even safer?" The modules used contain:

1. *Air Safety System*
   This module is used to process flight crew generated reports of any safety-related incident. This was the original BASIS module and provides analysis in an exceptionally easy-to-use format.

2. *Auditing System*
   The BASIS Audit module has been designed to store and analyse details of JAR Ops (Flight Operations, Engineering, and Ground Operations) and Health and Safety audits.

3. *Cabin Safety Reporting*
   Safety incidents in the cabin are now starting to receive the attention they deserve. Violent, abusive and/or unsafe behaviour by passengers are among the issues that the aviation industry is trying to better understand and ultimately address.

4. *Ground Found Occurrence Reporting*
   Aircraft maintenance plays a vital role in ensuring if aircraft are airworthy for services. It is therefore essential that reports raised by ground mechanics related to aircraft safety are taken seriously then stored and analysed in a similar way to air safety reports (ASRs) generated by flight crew. This module was developed to collect and analyse such maintenance reports.

5. *Ground Handling Reporting*
   There is an increased awareness of Ground Handling events within the aviation industry and this, together with the financial cost of damage and the operational disruption caused by delays, has made Ground Handling Reporting a key element of an organisation's safety management programme.

6. *Human Factors Reporting*
   In safety management the ultimate tool would enable the Flight Safety Managers to know all the causal factors behind their next incident before the investigator has a reason to write a report.

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[15] Sources are from GAIN (2000) & BASIS website: http://www.winbasis.com/

7. *Maintenance Error Investigation*

Before an organisation can hope to tackle maintenance error it must first identify what maintenance errors are occurring and more importantly why; i.e. what were the contributory factors? This module uses information derived from an interview process known as MEDA (Maintenance Error Decision Aid) which was jointly developed by Boeing and a number of airlines including British Airways.

8. *Safety Information Exchange*

Users extract and send their data quarterly to the BASIS team. The data is de-identified at source and merged into one global database which is then distributed to those users who have contributed data. The merged database is sent out every quarter and contains incidents occurring during the preceding 12 months.

Factors affecting implementation

To obtain a high degree of incoming reports, the most important characteristics for a good reporting system should contain three characteristics including Confidentiality, Anonymity and Feedback (Ho, 1996; Bacchi et al, 1997). Confidentiality is the number one guideline that must be strictly obeyed in any working place. Confidentiality means the reporter's name will only be known by those authorised by the system. Keeping the reporter's identity from being disclosed or discussed by the third party should also receive higher priority than the reported case itself.

It is also important to inform the reporter as each stage proceeds and assure the reporter that his/her work is highly appreciated. Trust in the system must be encouraged by direct and indirect feedback to the aviation community. Reporters must be allowed to see the value in their programme participation through feedback, which can foster their willingness to continue reporting their experiences, i.e. feedback must demonstrate results and value of contributing.

Meanwhile, during the implementation of a voluntary reporting system, a reporter's trust is the main key to the success of any reporting systems. Bacchi et al (1997) point to some issues such as programme publicity and the availability of the reporting forms, saying that cannot be underestimated although publishing the reports is a good way to enhance the exchange of information. For example, the forms should be designed as postage-paid and should be available to all potential users. Additionally, the provision of a structured guide would enhance the quality of the reports' information and prevent returned reports being incomplete.

To sum up, if everyone in the company is able to discuss the incidents frankly without fear of punishment, and have access to the reporting system with confidence, similar incidents might not occur and future accidents can be avoided. Anonymity should be the last resort. Freedom from job loss is the key. This is the major aim in developing incident reporting systems.

3. Safety audit

During the 1950s and 60s, safety professionals created a different measure to assess safety effectiveness - the audit, when problems with accident measures became obvious (Petersen, 1998). The theory behind the audit is: Accidents are either unforeseeable (the true accident) or unforeseen (oversight). If firms can dictate what actions to take in order to prevent accidents in advance, it can then measure how well these predetermined actions are executed. As such, the prime objectives of any safety auditing are to determine safety standards and enhance safety, according to Hamilton (1998).

There are various types of audit, such as checklist; yes-no type audit; quantified audits; and audits that end with scores or points awarded, etc., just like quality management systems eliminate risks as a matter of routine by objectively examining all aspects of a unit's activities that impinge on quality. Auditing means the checking of compliance with working practices against procedures and standards. It is one of the tools used to check the quality of safety programmes and identify any hazardous situations.

Safety auditing can be also fulfilled by internal safety surveys, and external review and inspection because an honest and critical self-audit is one of the most powerful tools that management can employ to measure flight safety margins (FSF, 1999b). The methodology of self-audit is used by senior airline management to identify administrative, operational and maintenance processes and related training that might present safety problems. The results are used to focus management attention on areas that require remedying to prevent incidents and accidents. Most of important of all, Arbon et al, (1990) argue that audits have confirmed that organisations which have deliberately fostered an attitude of mutual respect between various categories of employees enjoy a higher level of morale, and operational reliability and maintenance standards.

2.3.2.2 Risk assessment

After identifying the hazards, the next step in the process is to critically assess and rank risks. Since a general conception of risk is the chance, in quantitative terms, of a defined hazard occurring, it therefore combines a probabilistic measure of the occurrence of the primary events with a measure of the consequence of those events (Warner, 1992), i.e. two considerations are in need: the likelihood of the hazard and the severity of the consequences. These are reflected in the hazard analysis techniques introduced below.

Hazard (risk) analysis

Hazard analysis is the application of methods to identify hazards and associated risk (UKCAA, 2001). It is based on prediction, and the accuracy of the results is dependent on the correct identification of all significant potential hazards, and on the accuracy of the data analysed (Profit, 1995). This enables defences (risk control) to be developed and contingency plans to be produced and implemented. There are various techniques to perform risk analysis. The following are some tools frequently used in the airline industry (See Appendix D for the details):

1. *Probabilistic Risk Assessment (PRA)*
2. *Hazard Mode and Effect Analysis (HMEA)*
3. *Fault Tree Analysis (FTA)*
4. *Event Tree Analysis*
5. *Flight Operation Risk Assessment (FORAS)*
6. *Risk Analysis Matrix (RAM)*
7. *Risk specific safety index products - performance indicators*

2.3.2.3 *Risk control / recovery*

The essence of this stage is to develop and implement appropriate measures to prevent occurrence (risk control) or to recover if things go wrong (risk recovery). As long as defences can be identified, risks are under control.

Identify the defences

The objective of the hazard identification is to provide the organisation with a technique for early identification of the risks to which it is exposed. Risk management requires that once hazards are identified and their risks are ranked, the defences, which may exist as suitable physical or procedural controls to prevent an unplanned release of the hazards should be identified. Therefore, introducing the identification of control is to reduce the severity and likelihood of a hazard, to levels of "as low as reasonably practical" (ALARP). This is obtained by using methodologies for the removal, reduction, or control of the hazards or the threats that could release them.

Table 2-2 demonstrates some risk control programmes existing in airline operations to prevent the top two accident causes: **CFIT** (Controlled Flight into Terrain), **ALA** (Approaching and Landing Accident). These programmes are diagnostic tools designed for remedial actions.

Take CFIT for example. It is described by the Flight Safety Foundation as "When an airworthy aircraft, under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew." It can happen at anytime during the flight but most often occurs when an aircraft is preparing to land. CFIT has been a large focus for several years but still remains a large killer in aviation.

Studies have shown that the industry could prevent more than 80 percent of total aviation fatalities by eliminating CFIT and approach/landing accidents (Cooper, 1996). Several recommendations have been made to ICAO to help control this problem. Among the suggestions is that of implementing Ground Position Warning System (GPWS). First developed in the early 1970s, the GPWS concept was one aspect helping to slim down the number of CFIT accidents and it began appearing in large aeroplanes by 1973. ICAO mandated GPWS in the 1970s and today more than 95 percent of the world's airline fleet have them installed. Furthermore, the NTSB has encouraged the use of Enhanced Ground Proximity Warning System (EGPWS) which some of the major US carriers have begun using on a voluntary basis (Air Safety Week, 2001).

Meanwhile, the use of Flight Data is of significant importance. It not only increases safety by looking for and addressing weakness in operation, but also helps management to make sound decisions and monitors the effectiveness of those decisions. Flight Operation Quality Assurance (FOQA) data provides a precise record of flight parameters and crew actions. It is a routine downloading and systematic analysis of aircraft parameters that were recorded during flight either by the crash-protected recorder or the Quick Access Recorder (QAR).

Table 2-2 Risk Control Tools for Top Accident Causes

Top accident cause	Analytical programme (risk programme)	Note
1. CFIT (Controlled Flight Into Terrain)	**FOQA** (Flight Operation Quality Assurance)	Similar to DFDR (Digital Flight Data Recorder)
	TAWS (Terrain Avoidance Warning Systems) **EGPWS** (Enhanced Ground Proximity Warning Systems) **GPWS** (Ground Position Warning System)	FAA said, by the end of March 2005, the total US fleet will be retrofitted with TAWS (EGPWS). Some airlines in the US implement it on a voluntary basis already
	MSAW (Minimum Safety Altitude Warning)	
2. ALA (Approaching and Landing Accident)	**ALAR** (Approaching and Landing Accident Reduction)	
3. Others	**TCAS** (Traffic Collision Avoidance System)	
	QAR (Quick Access Recorder)	Valuable diagnostic tools Providing information from normal flights
	Precision-like approaches	
	Services difficulty report	

Source: compiled from AIR SAFETY WEEK, 2001 and various journals

Holtom (1999) stated from a Flight Operation perspective, a FOQA programme could identify the following:

- Non-compliance and divergence from Standard Operating Procedures (SOPs)
- Inadequate SOPs and inadequate published procedures
- Ineffective training and briefing, and inadequate handling or command skills
- Fuel inefficiencies and environmental unfriendliness

The ultimate aim of FOQA is to identify these operational shortfalls so that risk prevention strategies can be conducted and safety significance events can be avoided in the future.

2.3.2.4 Feedback & organisational learning

Effective feedback is an important construct if organisations decide to prevent incidents and accidents. There are two main tasks in this stage according to Figure 2-8 (page 29) and Figure 2-12 (page 40):

- ☞ Thoroughly document the process and its results (Safety case)
- ☞ Feedback information on performance to enable organisational learning

1. Safety case development

The concept of Safety Cases has been adopted in several industries, such as nuclear, chemical, rail, air transport and so on as a means to demonstrate safe operation. More specifically, the safety case is a systematic and structured demonstration by an organisation to provide assurance, through comprehensive evidence and argument, that the aircraft operator has an adequately safe operation. It aims to identify the hazards faced by a company and how to establish the potential for harm from those hazards through risk assessment. In practice, the safety case is a documented description of the major hazards that the aircraft operator faces and the means employed to control those hazards (Profit, 1995; Edwards, 1999). The organisation will have identified and assessed the major hazards and safety risk and be able to demonstrate that they can manage them to levels which are as low as reasonably practicable (Edwards,1999a). The essential feature is that safety case should identify potential weaknesses in the process and then identify the measures in place to mitigate or control the risks and explain how the risks are managed. Only when the procedures are documented can it help to prevent accidents/incidents from occurring. For example, Standard Operating Procedures (SOPs) are a set of procedures that provide operators with step by step guidance for their task. Standardisation ensures the best method of operation and makes sure employees behave in a consistent and predictable way (See Appendix E for detailed explanation of documentation).

2. Organisational learning and change

After having identified the hazards, assessed and controlled the risks, and documented the safety case, the next step is to manage the learning through feedback information. Effective feedback is important within the context of inter-organisational learning (Smith, 1999). Stacey (1993) also claims that the whole issue of feedback is central to the systems approach to learning. It therefore shows the need to discuss organisational learning.

Marquardt and Reynolds (1993) state: "Learning organisations teach their employees the critical thinking process for understanding what it does and why does it. These individuals help the organisation itself to learn from mistakes as well as success." This notion clearly explains that organisational learning is affected by a group rather than individuals working alone.

"Learning" means the adjustment of coping mechanisms based on a new understanding of the world. According to Shrivastava (1983), learning is a framework of knowledge development, utilisation of knowledge in understanding the cause and effective relationships, and perspective on knowledge and expertise. Organisational learning also includes working and dealing with practical and experiential learning, and innovation diffusion as well as the transfer of that experiential learning. To be effective, organisational learning should involve a change in the core beliefs, knowledge and assumptions held by both management and operators, which also leads to effective and systematic changes to the operation of the organisation.

Changes might be trivial, minor or major. All of them have to be managed in order to maintain control of their activities. The range of organisational change is from the whole business, down to local departmental changes. Any major organisational change should be accompanied by a formal analysis and evaluation of its safety management implications. The value of safety should be learned and viewed as a core function value of the organisation and as such, as a value that will accrue to the benefit of the airline, its employees and its customer base.

Nevertheless, Choularton (2001) points out that achieving a level of learning which addresses the root causes of disasters, is difficult. Recent research shows us that while effective learning about hazards is a common assumption of such attempts, organisations can be very resistant to learning the full lessons from the past accidents/incidents and mistakes (Pidgeon and O'Leary, 2000). Smith (1999) has suggested a number of barriers to learning, as summarised in Figure 2-14. Many barriers listed are consequent on the fundamental problems associated with communication and core belief. It is because organisations may ignore the **human aspects** of causality which are central to crisis incubation and the learning process.

Figure 2-14 Barriers to Organisational Learning

Barriers to Organisational Learning
Rigidity of core beliefs, values and assumptions
Lack of corporate responsibility
Incrementalist approach (failure to deal with emergency)
Reconstruction and projection
Focus on a single-loop learning
Peripheral inquiry and decoy phenomenon
Centrality of expertise, denial & the disregard of outsiders
Ineffective communication & information difficulties
Cognitive narrowing and fixation (reductionist)
Maladaption, threat minimization and environmental shits

Source: Smith, 1999

Human reliability

Hammer (1972) states "A popular misconception is that by eliminating failure a product will be safe. A product may be made safer by eliminating or minimising failure, but there are other causes of accident... mishaps often occur where there is no failure." The importance of Hammer's work lies in the fact that he recognised there are other causes of accidents: dangerous characteristics of the product, human action, extraordinary environmental factors, or combinations of these (McIntyre, 2000). To err is human. Human errors now account for 80 percent of aircraft accidents (IATA, 1975; IFA, 1998). Yet many of these accidents could have been avoided if the basic concept of human factors had been observed. As such, the main aviation safety authorities around the world (such as FAA, Transport Canada, JAA) have undertaken a series of initiatives, including the consideration of Human Factors in Operations, Certification and Maintenance. Some may focus on research, publication of guidance material and the promotion of Human Factors Programmes without changing the regulatory framework, while others decided to enhance their regulations by embedding human factors concepts within them. It is suggested that the cooperation and efforts of regulation systems should certainly provide more effective controls for the human element and reliability of airline safety services (JAA). As such, there is a need to have an in-depth investigation to probe into the relationship between human aspect and SMS.

2.4 Human Contribution

2.4.1 Human Factors versus Risk

A Greek myth that has been adapted to tell of the first man-made aviation disaster is the story of Icarus flying. It is said that in order to escape from Crete, Dædalus, who was imprisoned by King Minos, built wings of feathers and wax for himself and his son, Icarus. Warning Icarus not to fly too close to the sun, the two took to flight. Nevertheless, Icarus did not listen to what his father said and flew towards the sun. As a result, the wax *melted*[16] and Icarus plummeted to his death.

This story told about the cause of an accident- human factor- failure to follow SOPs or principles, which not only made the journey at risk but also resulted in the horrible consequence (causal factors). From the modern investigation point of view, in addition to causal factors, what are the "contributing factors" to the accidents? i.e. why Icarus failed to follow SOPs? Maybe he knew "the higher you fly, the colder it is", so he decided to ignore what his father told him- the wax would melt; or maybe he just simply did not trust his father and disregarded his teaching. As such, the study of human factors starts from investigating causal factors of accident/incidents towards exploring the contributing factors of dangerous activities for improvement.

No human activities can be carried out without risk, particularly in a high-risk industry such as the aviation business, which "people" design, build, operate, maintain, and manage. The failures of people involved in the daily routine of operations are often the symptoms of deeper deficiencies at the foundations of the system. Grose (1987) states that from a risk management point of view, an inability to absorb the consequences of unsafe acts and omissions is ultimately considered to be a symptomatic failure of the overall risk management system.

Therefore, understanding human factors in aviation has become the subject of increasing attention ever since it was highlighted at the IATA's 1975 Operation Symposium in Istanbul, Turkey. Later, ICAO acknowledged human error research as the most relevant opportunity to increase safety. In 1989, in order to reflect the results of research as to the human factors in flight operations of that time, ICAO stated that:

> *"The expansion of Human Factors awareness presents the international aviation community with the single most significant opportunity to make aviation both safer and more efficient."*

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16 As a matter of fact, the higher you fly, the colder it is. Therefore, the ending of this story should be corrected and replacing "the wax melted" to "the wax cracked and fell apart because of the low temperature". Another possible cause, provided by the aircraft accident investigator - Frank Taylor, was that Icarus got high enough to reach "coffin corner" and consequently lost control without having suffered any structural failure at all. After all there had been no opportunity to do any flight testing!

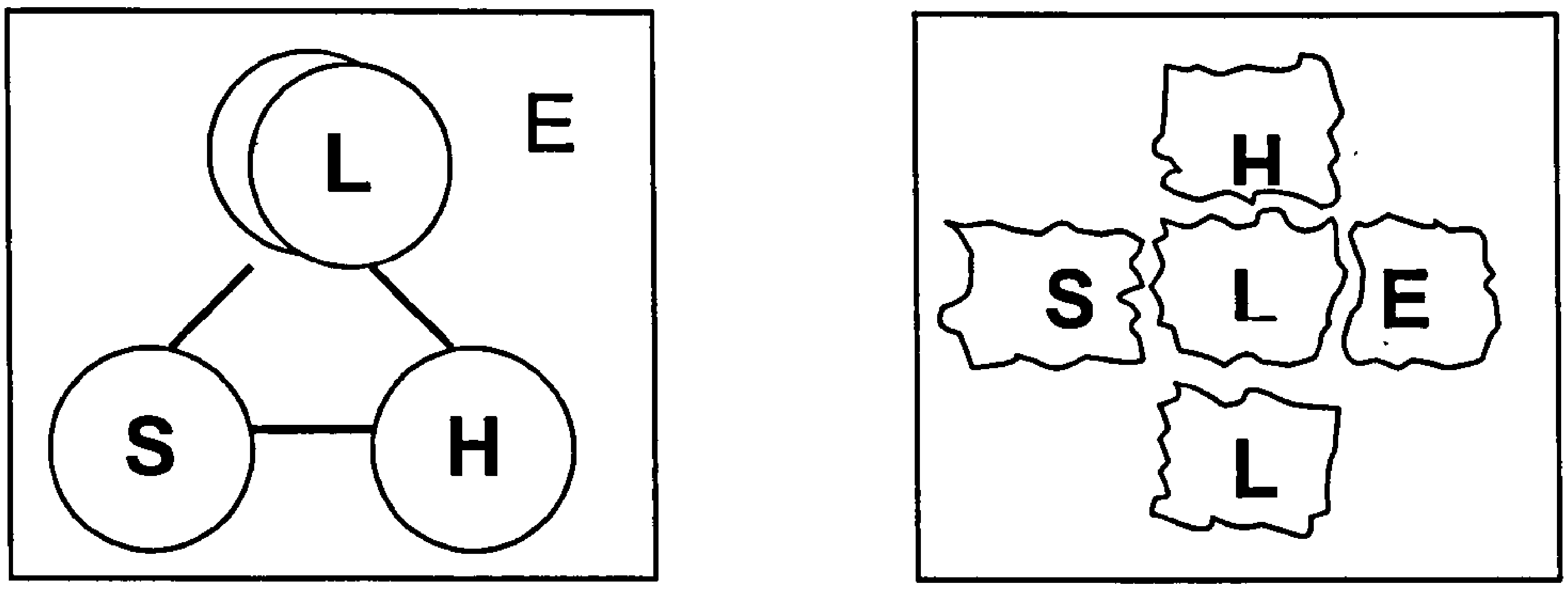
An accident can ultimately be deemed to derive from a system which is inadequately specified or designed, or which has insufficient defences-in-depth (ICAO, 1994). This notion means human factors not only play an important role in causing incidents/accidents (insufficient system or design), but also in preventing them (as long as defences are identified).

'Human factors' is a strange and possible ungrammatical name for a discipline or study. Nevertheless, it has come to be used to encompass all of those considerations that affect man at work (Green et al, 1996). Thus, human factors involve gathering information about human abilities, limitations, and other characteristics and applying it to tools, machines, systems, and environments. In aviation, human factors is studied for a better understanding of how humans can be integrated with the technology and working environment with most safely and efficiently approach. In the Human Factors Guide for Aviation Maintenance published by FAA (1995), Human Factors is defined as:

> *"Human Factors refers to the study of human capabilities and limitations in the workplace. Human Factors include, but are not limited to, such attributes as human physiology, psychology, work place design, environmental conditions, human-machine interface, and interaction of humans, the equipment they use, the written and verbal procedures and rules they follow, and the environmental conditions of any system."*

To best illustrate the concept of human factors, a SHELL model (shown in Figure 2-15 a, b) is adopted. The SHELL model was first developed by Professor Elwyn Edwards in 1970s. Since then, this model has been widely applied to the field of aviation human factors and has become a valuable tool in aviation safety. Hawkins (1993) modified this model by summarising the main concerns of human factors, subsequently adopted by ICAO.

Figure 2-15 The SHELL Model



(a) Source: Taylor, 1999

(b) Source: Hawkins, 1993

These two figures in fact have slightly different focal point although they have the same elements. There are four main components in the SHELL model: Software, Hardware, Environment and Liveware. Each element symbolises different feature as followings:

S= **Software** (the non-physical aspects of the workplace, such as documentation and computer)
H= **Hardware** (equipment and machinery, such as the layout of the aeroplane)
E= **Environment** (the workplace and general surroundings, such as weather)
L= **Liveware** (human element, i.e. other people working as team members)

The SHELL concept recognises the importance of people, equipments and environment, software and their interactions with each other. The difference between the Hawkins and Edwards models is the interfaces produced between each element; the former shows four interfaces while the latter presents three more interactions between these elements. The following are the interfaces demonstrated in both models.

Liveware- Liveware:

This interface concerns the interaction of human beings. It emphasises that human work needs to be recognised as a team-based activity; otherwise this work will not function well. As such, communication, leadership, shared situational awareness and so on are emphasised to avoid the misunderstanding. Crew Resource Management (CRM) is designed to accomplish this goal.

Liveware- Hardware:

This interface concerns about the man-machine system. It is mostly dealt with by the science of Ergonomics. For example, different socket in the aircraft design to prevent from any mismatch and potential hazards. This interface has been the focus of most Human Factor attention in the past.

Liveware- Software:

This interface encompasses the non-physical aspects of the system, such as procedures, manuals, quick reference handbook, computer programmes, etc. Aircraft engineering has now attracted lots of concerns because of its heavy reliance on manuals, computers and paperwork. Procedures are ambiguous or badly written or translation causes misunderstanding and even cost incident or accidents at the worst.

Liveware- Environment:

This interface represents a very important interface, because of the ways in which tasks and situations can combine with human limitations to create unsafe acts and quality lapses.

The following three interfaces were showed in the Edwards model in addition to the previous four.

Software- Hardware

This interface is concerned when considering the non-physical aspects-machine of the working place. For example, procedures are designed that are not compatible with the instrument or electronic database (manual) on board requires too complicated computer operation to obtain the information.

Software- Environment

This interface concerns with the non-physical aspects of the working place -environment system. For instance, the ground handling procedures or loading procedures cannot be carried out in the rain and darkness.

Hardware- Environment

This interface deals with the machine-environment system, as aviation is developed based on adapting the environment to match human requirements. For example, instruments or lights cannot be seen in bright sunlight from some angles or similar background. To solve this problem, Cranfield University is now conducting a research regarding this interface. Dr. Tony Head from Human Factor Group was leading a project studying glider conspicuity trails (Head, 2003).

Taylor (1999) indicates that Edwards' model can best illustrate all the interactions between these elements when viewing the whole aviation system, while Hawkins' model failed to draw the attention to all of the interfaces. This is because an essential part of Hawkins' model is on the interfaces between the Liveware and other components, i.e. his concept recognised the importance of human elements, which have important interactions with the people, equipments and environment. In other words, Liveware is the heart of the model. The SHELL model revealed a very important tool for air safety, as "Human Factors" has been developed progressively to enhance aviation safety, by promoting the understanding of predictable human limitations and its applications in an attempt to manage human error.

2.4.2 Human Error

Hollnagel (1993) reveals that the estimated involvement of human error in the breakdown of hazardous technologies increased fourfold between the 1960s and the 1990s, from minima of around 20 percent to maxima of more than 80 percent. Statistics present an estimate of human error in different industries (see Table 2-3), showing that human performance (problems) dominates the risks in hazardous industries; the variability of percentage of failures may come from the type and access of reporting system. However, especially in the aviation industry, it is now widely recognised that 80 percent of all aviation accidents are the result of human error (IATA, 1975). Therefore, the obvious danger is, as Professor James Reason says, "Challenge is either you manage human error or human error will manage you!" (IFA, 1998) This notion implies the involvement of greater cost and greater danger.

Table 2-3 Estimates of Human Error in Different Industries

Industry	Percentage of all failures
Jet transport	65-85
Air traffic control	90
Maritime vessels	80-85
Chemical industry	80-90
Nuclear power plants (US)	70
Road transportation	85

Source: IFA, 1998

2.4.2.1 Cost of human error

In a significant part of accidents, maintenance error is one of the main causes, which is accountable for up to 25 percent of all aviation accidents resulting from human error (JAA, IFA, 1998). Maintenance is a highly error-provoking activity, regardless of who is doing the job. Statistically, there are 600,000 removable parts in an aircraft so there are many chances for error. The commonest error type is leaving out necessary steps during installation. Incorrect installation accounts for 60 percent of maintenance error. Goglia (2000) even announced the fact that "the actual experience in the US was: in the last 5 years FAR operators had suffered 14 hull losses, 7 of which were attributable to maintenance or engineering failures. That is 50 percent of the total." According to GE's (General Electric) estimation, maintenance error is around 20-30 percent of in-flight shutdown (IFSD) and costs $500,000 each time (IFA, 1998). Other data presented by Boeing indicates that it costs around $10-20,000 or more per hour of maintenance related delay, and $50,000 or more for each flight cancellation (Boeing, 2001). For airlines this figure is greatly exceeded. Between 1988 and 1991, a US airline with a fleet of more than 300, encountered 203 recorded maintenance mishaps, which resulted in 13,299 out-of-services hours, and cost $16.5m in repairs, excluding lost revenue, which is likely to amount to many more millions of dollars (IFA, 1998).

Perrow (1984) mentions that we are facing the growing complexity of the system in our technological environment. In the aviation industry, accidents have many causes of failures arising from different levels of causes. As such, a basic knowledge of Human Factors is a crucial part in aircraft maintenance, operation and other department expertise. to improve safety through understanding of human error, it may be useful to address errors as *symptoms* (contributing factors) rather than causes of accidents (causal factors). In addition, there is a need to predict where errors might occur and to prevent them from happening and causing any financial costs. Error can be managed systematically and cost-effectively. This is central to error management.

2.4.2.2 Error Management (EM)

Major accidents inquiries (e.g. Three Miles Island, Challenger, King's Cross, Herald of Free Enterprise, Piper Alpha, Clapham, Exxon Valdez, Kegworth, etc.) indicate that the human causes of major accidents are distributed very widely, both within the system as a whole and often over years prior to the actual event (Reason, 1995b). The ICAO Human Factors Manual states:

> *"Although human failure is the predominant factor contributing to aviation accidents and incidents, it has never been clear what aspects of human capabilities and limitations should - or could - be addressed by training. On the other hand, it has been Equally clear for some years that Human Factors education and training within the aviation system could be improved."*

Indeed, as human error is frequently a precursor to failures of risk management systems, a thorough understanding of error management is required in order for such measures to be improved and made effective.

Wiener (1995) points out that error management (EM) can be viewed as involving the tasks of Error avoidance, Error detection and Error recovery. In addition, there are three essential facts of EM: (1) Human fallibility unchangeable, (2) Everything we do is vulnerable and (3) Key activities are interconnected. It reflects the spirit of EM- you cannot change the human condition, but you can change the conditions under which people work. Moreover, in an operational context, errors are caught in time and do not produce damaging consequences. Counter-measures to error should not just look at avoiding errors, but to make them visible and trap them before they produce hazardous consequences. This is the essence of error management.

Over the last 20 years, behavioural scientists have learned a great deal more about the varieties of human error, their mental origins and the factors likely to promote them. It is increasingly clear that "bottom-up" analyses, starting with the investigation of human error (Rasmussen, 1985; Reason, 1990), ultimately reach the same conclusions as the "top-down" approach adopted in recent disaster investigations - namely that human error must be viewed in context and that risk-reducing defences will necessarily be multi-faceted if they are to match the complexity of the operational context and tasks (Johnston, 1996).

Previous research has been focused on finding human factors that link to pilot-error accidents through accident investigation. The traditional aspects of human factors (errors) address communication, stress, and ergonomics, such as:

- Improvements in engine, aircraft system, flight deck design and passenger cabin design are made to reduce the accident rate and increase efficiency (manufacturer side).

- Analyses of aircraft accidents reveal that only 30 percent of crew related accidents resulted from technical skill failures on the part of individual. Instead, they show that between 60-70 percent of crew related accidents are caused by team management breakdown. This has led to Crew Resource Management techniques being developed and applied on the flight-deck. Thus, CRM is intended to facilitate teamwork and communication between crew members to reduce the incidence of errors (Helmreich, 1997; Sales et al., 1999).

- Human Reliability analysis
  Much of the effort of human reliability analysis is dedicated to reducing the uncertainty about human performance by producing or obtaining a more precise estimate of numbers used, i.e. refines the probabilities for the defined events (Hollnagel, 1993).

Gradually it became clear that erroneous actions during maintenance shared the same importance as erroneous actions of design and system operation. The rationale and basic principles of comprehensive error management in terms of engineering and maintenance is developed and named HERO (Human Error Reduction Operation). It is an "operation" because it can take many forms. There is no infallible way. Different mixes of techniques and practices suit different organisations. The important thing is that HERO should be based on sound error management principles. Comprehension and the judged relevance of this kind of training material has been trailed successfully in a number of aircraft maintenance organisations (British Airways Engineering, Singapore Airlines Engineering Company, Cathay Pacific, etc) (IFA, 1998).

The following are some measures that are effective to achieve HERO.

✈ *The Qantas Human Error & Accident Reduction (HEAR) Programme*

One of the most successful HF programmes is HEAR, developed by Qantas in 1995 for maintenance engineers following a series of repeated incidents. The programme was organised and delivered by a group of frontline engineers with strong management support: a "shop floor" approach. Error-Reducing Conditions (ERCs) are focused on to achieve the aim.

✈ *Team Resource Management - Maintenance Resource Management (MRM)*

The term MRM was originally used as a parallel to CRM (Crew Resource Management) but has evolved somewhat over the years as it has been appreciated that CRM concepts could not all be related directly to the maintenance engineering context. An example is Continental Airlines, who has established a CRM-type of course for their engineers. They are claiming marked declines in ground-damage incidents and dispatch delays as a result.

✈ *Maintenance Error Decision Aid (MEDA)*

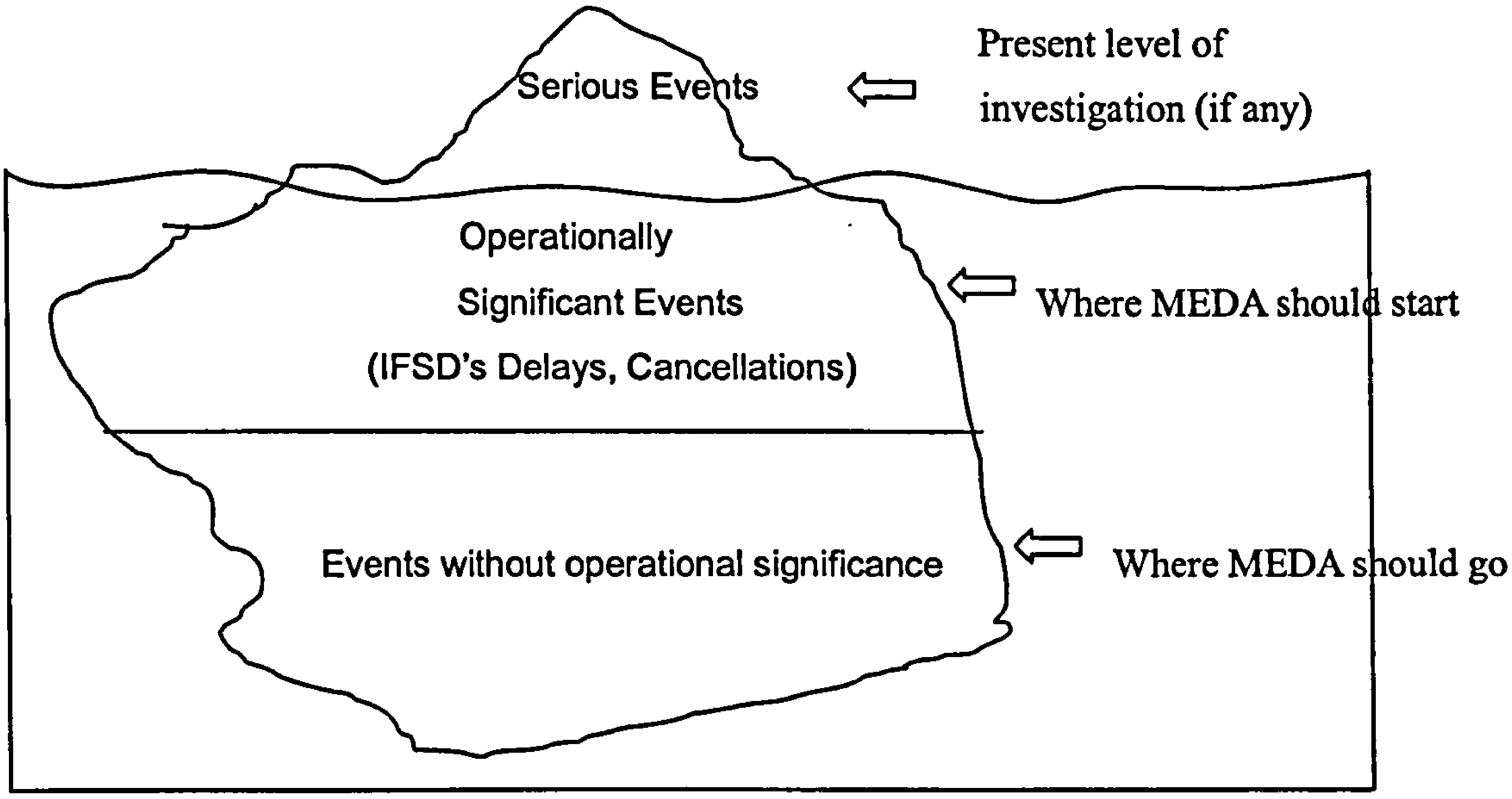
Developed by Boeing, MEDA is a maintenance error investigation tool, for investigating maintenance lapses. It has been developed as a project to provide maintenance organisations with a standardised process for analysing contributing factors or errors and developing possible corrective action.

"The Error Iceberg" is used to explain where MEDA should be applied (see Figure 2-16). The basic idea behind MEDA is "Errors are seldom random". Errors originate in a workplace or system. As such, the investigation occurs at two levels.

1. Line investigation: MEDA begins with a paper-based investigation that gives line engineers a standardised way of identifying the causes of lapses and of preventing their recurrence.
2. Organisational trend analysis: MEDA then provides the means for examining past lapses using a computer-based trend analysis. MEDA is designed to provide a common language to increase communication between maintainers, regulators and manufacturers.

MEDA is a tool that provides front-line engineers with a principled means of detecting and removing error-provoking factors. It is a complete and wide-ranging process with a paper-based investigation at its core. By 2000, 104 carriers globally have received MEDA training from Boeing. It is the most widely used Human Factors based maintenance error investigation tool in aircraft maintenance today (Chapman, 2000). In the USA, about 33 percent of airlines use MEDA, about 33 percent are thinking about it, and about 33 percent have decided not to use it due to concerns about vulnerability to regulatory action and litigation, particularly in the US. Many Canadian airlines are using the MEDA process, as are several UK airlines (UKCAA, 2000). (See Appendix F for other MEDA-like approaches)

Figure 2-16 The Error Iceberg



Source: Chapman, 2000

To sum up, although all organisations operating hazardous technologies use various forms of EM, the main purpose of error management is rather pragmatically to enable specific system changes to be made in response to specific unwanted occurrences as well as an effort to improve the system design. With human factors awareness training, everyone in the organisation is given the tools to make the organisation an improved working environment.

2.5 A Retroactive Approach to Safety

Accident investigation and incident reporting system

Human imperfection remains a fact of life. Learning the relevant lessons for prevention is the primary reasons why aviation accidents are formally investigated and in such painstaking detail. Accident investigation, therefore, has an apparent role within the safety process. It is the appropriate tool to uncover unanticipated failures in technology or rare, bizarre events. Hollnagel (1993) indicated that in order to prevent accidents from happening it is necessary to take a closer look at the accidents that have happened, to see if something can be learned from them. Maurino (2001) also points out that the most widely used tool to document operational human performance and define remedial strategies is the investigation of accidents.

A proper accident investigation can reveal how specific behaviours, including errors and error management, can generate an unstable or catastrophic state of affairs. Serious or fatal accidents often serve as the catalyst for improving the safety system. Such events can make either a temporary or a permanent change for a company to manage its safety.

However, there are limits to the lessons available through this process because investigation always serves purposes other than accident prevention. To identify the type and frequency of errors, or discover any training deficiencies, is possible but this is only the tip of the iceberg. Reason (1995) argues that most accident investigations tend to stop when answers are found to the proximal cause, responsibility and prevention questions. Consequently it usually takes a long and expensive public inquiry to identify the underlying organisational failure types. Should accident investigation restrict itself to mere retroactive analysis, its only contribution in terms of human error would be increased industry database, the usefulness of which remains dubious. (Maurino, 2001)

Incident reporting systems are better than accident investigation for understanding system and operational human performance. Incidents are more significant markers than accidents because they identify and signal weaknesses within the overall system before it breaks down. Their value lies in pinpointing the concern. Nevertheless, there are limits to the value of this information. The main limitations are: Incidents are self-reported so the process and mechanism underlying an error may not reflect reality and it therefore captures the external manifestations of errors only. Helmreich and Merritt[17] describe incident reporting thus: the incident is like a broken bone that sends to the doctor. The doctor sets the bone, but rarely considers the root causes- weak

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[17] From http://www.psyutexas.edu/psy/helmreich/localsol.htm (09/08/01)
"*Local Solutions for Global Problems: The need for Specificity in Addressing Human Factors Issues*." By Helmreich R., and Merritt A., Aerospace Crew Research Project, The University of Texas at Austin.

bones, poor diet, victim of abuse, high-risk lifestyle? Therefore, setting the bone is no guarantee that the patient will not present again next month with another symptom of the same root cause.

Risk management tools and human factors

Analysis of the behaviour of operational personnel in accidents and incidents has been the method adapted to assess the impact of human performance on safety traditionally. Because of the recorded negative outcomes, investigators are engaged in discovering the bad behaviours of operational personnel. While they examine human performance in safety occurrences, they enjoy the benefit of hindsight. Risks can be identified and managed so that they are reduced to tolerable levels.

In the past, many improvements in safety have been reactive i.e. response to errors. Risk management tools are developed in order to collect the safety information and prevent the identified errors, such as DFDR, QAR, GPWS and CRM training. However, Maurino (2001) argues that DFDR and QAR providing information from normal flights are valuable tools but these can not yield information on the human behaviours leading to provide the context in which to diagnose the problems. Also, the limitation of FOQA data is that no information is recorded about why particular actions were taken (Helmreich, 2001).

Error management developed after human factors issues were recognised and errors were found to be managed. Like the observation of training behaviours (e.g. flight crew simulator training), EM is another tool which is of help in understanding operational human performance. Nonetheless, training behaviours are sometimes biased towards safety due to only an approximation of behaviour during line operation if everything is done by the book.

A retroactive approach

Maurino (2001) stated "Looking only at data after the fact is a bit like trying to design a good celebration by focusing on sweeping up after the parade", which is a retroactive approach to safety. Accident causes serve as contributing and primary factors to this approach while risk management, human factor and error management are the diagnostic tools. These after-fact measures are as it should be, but the difficulty now is that there are so few accidents that it is difficult to analyse trend and patterns. Savage (1999) indicated that we need another way to prevent the next accident. In order to uncover the mechanisms underlying the human contribution to failures and successes in aviation safety, we need to look beyond the visible manifestations of errors when remedial strategies are designed.

It is increasingly recognised that effective organisational risk management requires the active support of managers at all organisational levels. Effective prevention strategies must focus upon the identification, removal or amelioration of systematic risk factors. It is suggested that the control of operational risk in the aviation system will require greater proactive intervention by airline management in the future. Johnston (1996) further proposes that proactive and systemic risk management approaches will be more effective in preventing accidents than *ad hoc* reactions to individual acts of failures, or reactive interventions directed to individual workers. Therefore, a proactive approach is in need of investigation.

2.6 Proactive Safety

2.6.1 What is Proactive Safety?

The concept of proactive safety was not officially acknowledged in the aviation industry until the mid 1990s, when a new and effective safety approach was actively being sought. In contrast to a reactive approach, researchers have emphasised the importance of a proactive approach to safety in aviation (Maurino, 1996; Johnston, 1996; Merritt and Helmreich, 1996; Savage, 1999; McFadden and Towell, 1999). Merritt and Helmreich (1996) concur that "With regard to safety, it is important to be proactive, rather than waiting for incidents and then reacting in a band-aid fashion. To this end, periodic safety audits can identify weaknesses in the system." The "band-aid" application progresses safety through human factors knowledge in the aftermath of damage. It has fought a consistent battle against latent systemic failures and has progressed towards improving system safety, but in a limited way. Therefore, identifying and eliminating latent system failures to achieve safety is not a new problem, but is a crucial one, and one in need of a solution (Merritt and Helmreich, 1996).

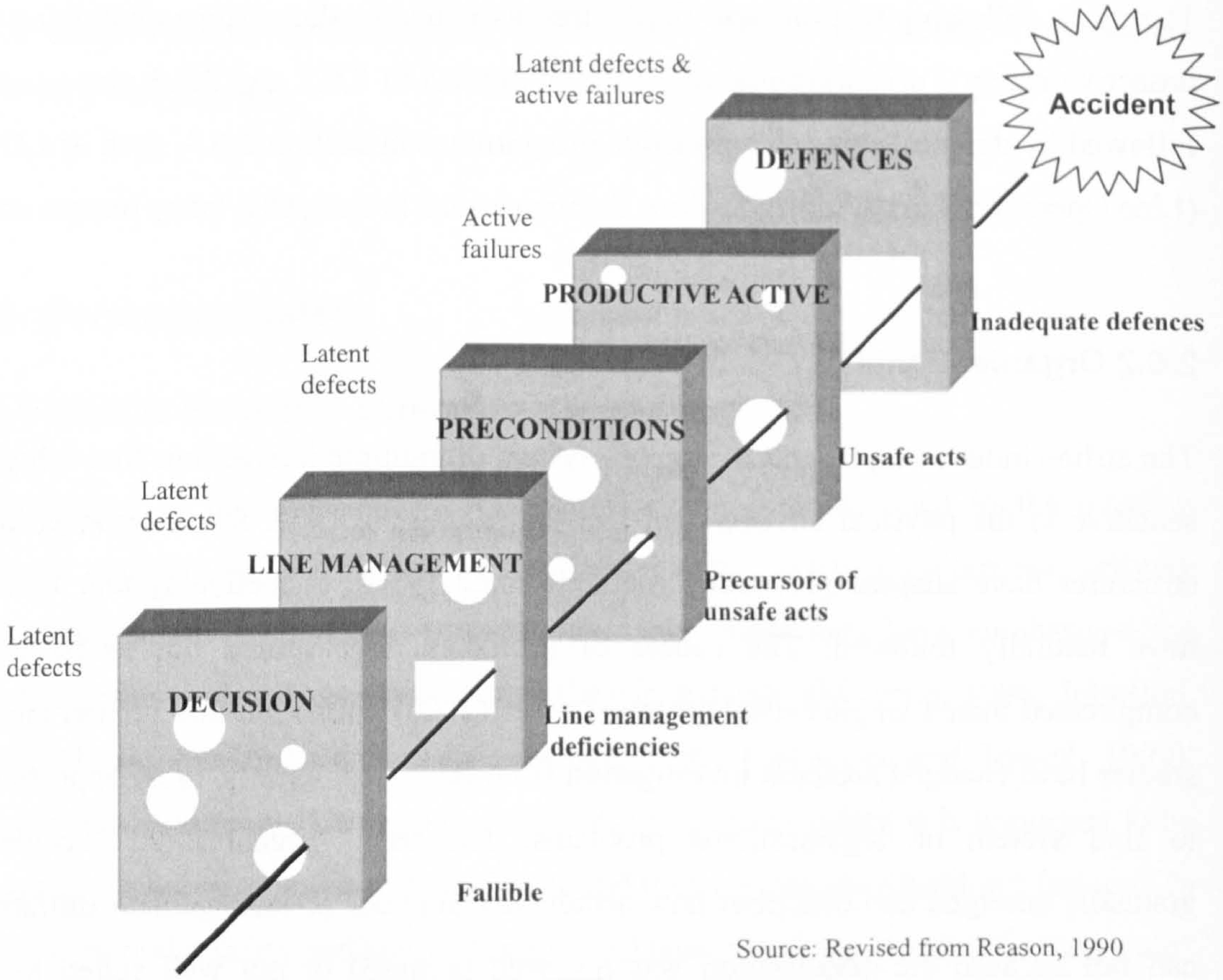
Aviation is an industry where people need to interact closely with technology to achieve the production goals. In particular, the introduction of advanced technology has added the challenge to the air transport industry because technology is widely used as a means to improve safety, but it is used without cultural consideration. The cultural transformation of these two airlines- British Airways (BA) and Scandinavian Airlines System (SAS)(See Appendix G) have presented a new dimension for aviation professional to investigate, which is that the prospective changes in the company are the way to bring about organisational change (Ho, 1996) and a proactive approach to safety. The only way of proactive management being present in every working place is through the organisational and cultural level of company. Cultural transformation can decrease the latent failure and active errors and prevent incidents and accidents from occurring. Therefore, following sections will firstly introduce the two dimensions underlying the proactive safety - organisational and cultural aspects in 2.6.2 and 2.6.3 respectively, followed by demonstrating the proactive programmes in section 2.6.4, such as LOSA (Line Operation Safety Audit), to show the importance to detect the latent human error.

2.6.2 Organisational Accident

The airline industry represents a complex system of multiple interactions that is highly sensitive to the physical environment and the passage of time. Since organisational structures have adapted procedural methods since 1970s, collective system failures have naturally followed. The causes of accidents have turned out to be more complicated than a single causal reason. Lauber (1996) points out that human factors studies have changed accident investigation from fault finding only, to an opportunity to find system or organisational problems. The term "organisational accident" gradually emerged and describes how accidents can occur or management initiatives can fail because the organisation was not well prepared or not well suited to the initiative. Reason's model (1990) provides a theoretical framework of accident causation to illustrate a more profound understanding of organisational accident.

The Swiss Cheese Diagram (see Figure 2-17) shows how accidents are the consequence of a series of failures in a system, which, as shown in the figure, include fallible decisions, line management deficiencies, precursors of unsafe acts, unsafe acts and inadequate defences. Each slice of cheese symbolises a condition of a company, and the holes on the slides of cheese are the breaches of each condition. Whenever these features happen to combine, there is the possibility of the occurrence of an accident. Reason (1990) also notes "In considering the human contribution to system disasters, it is important to distinguish two types of error: Active errors, whose effects are felt almost immediately, and latent errors[18] whose adverse consequences may lie dormant within the system for a long time, only becoming evident when they combine with others to breach the system's defences."

Figure 2-17 Reason's Organisational Accident Model



Source: Revised from Reason, 1990

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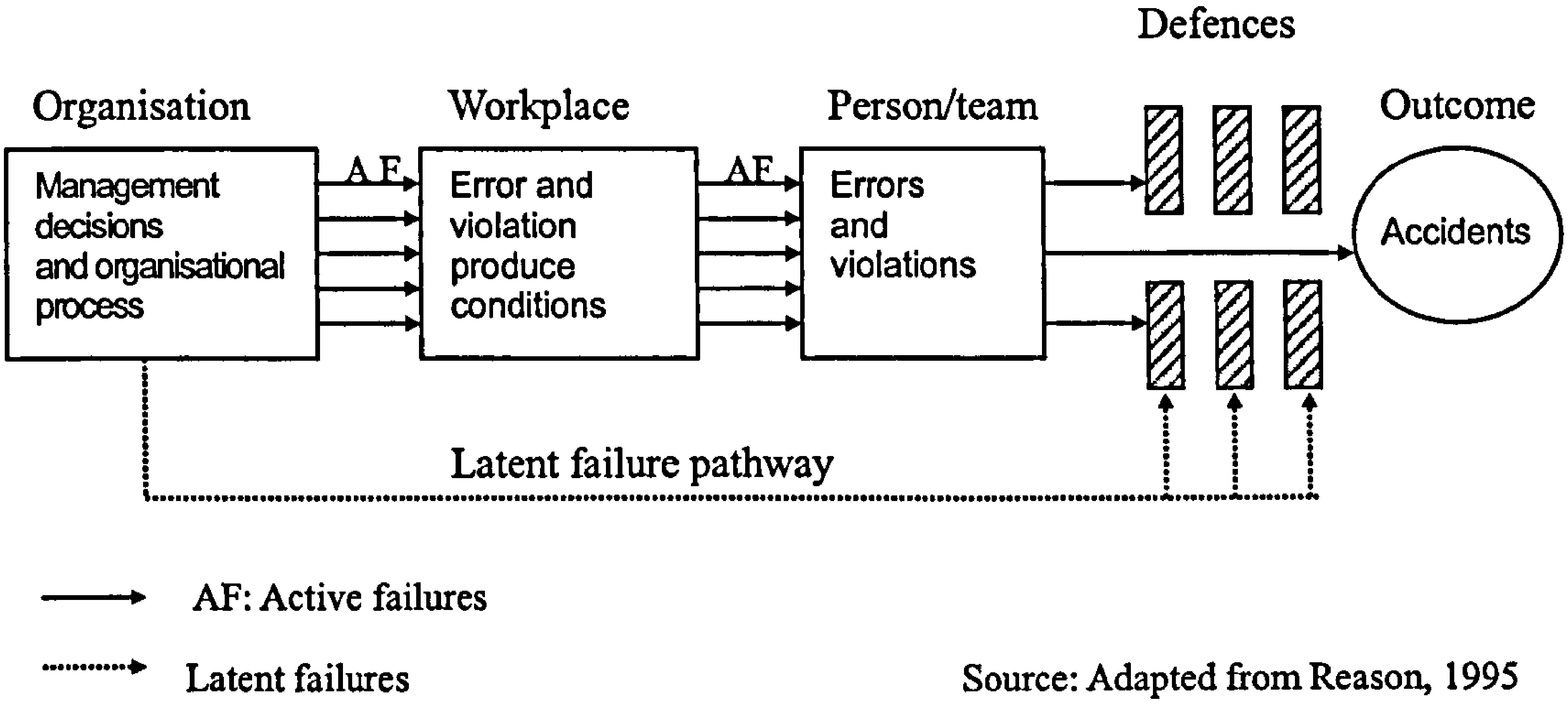
[18] Reason replaced the term "latent errors" gradually as "latent conditions" in his subsequent study.

This well-known cheese model is redrawn as Figure 2-18 to better illustrate where and how active errors and latent failures occur. It shows the various levels of a system and their possible involvement in contributing to an accident or incident. By using systemic analysis, the relative importance of each level in preventing a major accident can be manifested. Traditionally, acts (a person's behaviour) and conditions (the physical work environment) represent immediate accident causes. These have been viewed as unsafe acts and conditions. As Figure 2-18 shows, all accidents result from a combination of specific situations that consist of individual actions and workplace conditions. Two causal pathways are identified in this model: an active failure pathway running from the organisation via the workplace conditions to the actions of an individual or team, and a latent failure pathway that runs directly from the organisation processes to the defences.

Figure 2-18 A Model of Organisational Accident Causation



Source: Adapted from Reason, 1995

As mentioned previously, with the advance of technology and the reliability of aircraft, modern aircraft accidents are generally not the result of mechanical failures, but are mainly due to human factors. However, traditionally in the airline industry human performance has been considered as separate from the context or system within which it takes place, such as "pilot-error", "controller-error", or "maintenance-error". It is not adequate to describe the complex ways in which accidents happen because this ignores the component of the decision-making process (the management) i.e. the airline industry's multi-level human involvement. Beaty (1995) puts it, "Modern aircraft accidents result from collective mistakes rather than individual errors". Moreover, Edkins (1998) points out that "Aircraft accidents have a positive correlation with latent failures, arising from the broad management functions of an organisation". Latent failures are decisions or actions originating within management that have damaging consequences but may lie dormant for a period of time. They combine with local workplace factors, and errors or violations usually committed by operational personnel. If system defences are breached, the result may be an accident.

The latent condition has changed the trend in favour of finding systemic or organisational problems. It also illustrates the effects that management's efforts can have on instilling a culture where safety is an operational value. Given the unique role of management in culture, many cultural strategies originate with and/or require the full enthusiasm of management. But Merritt and Helmreich (1996) argue that before any action can be taken, in order to strengthen or alter the culture, there must be a clear perception of the existing culture.

By definition, the commonly accepted definition of safety is "risks being minimised to an acceptable level". Acceptable risks are, however, reached at either an individual or group level. Each individual's decision will be governed to a large degree by his or her personality. At group level, the combination of personalities simultaneously creates a culture (Braithwaite and Caves, 1997). This implies the coherent relationship between safety and culture. Meanwhile, Maurino (1996) suggests a need to re-visit the conventional views on human errors. Not only must human and organisational behaviour be considered as inseparable from the contexts within which they take place, but also prevention endeavours must build upon proaction rather than reaction. As such, following sections aim to explore the cultural dimension and its importance in airline safety together with the proactive approaches to safety and its correlation with culture dimension within the airline industry.

2.6.3 Culture and Safety

2.6.3.1 The concept of culture

Culture is defined as the ideas, customs, and art of a society (Collins, 1995). Gradually the concept of "culture" has become widely used in the field of social science, in which multiple meanings of the term are available. Among them, two main models can be found. According to Rohner (1984),

> "*There are those who view culture as being behaviour; the regularly occurring, organised modes of behaviour in technological, economic, religious, political, familial and other institutional domains within a population. In contrast to the various "behavioural" models of culture are a group of theorists who hold that culture is a symbol system, an ideational system, a rule system, a cognitive system, or in short, a system of meanings in the heads of multiple individuals within a population.*"

Whether culture is seen as being behaviour, or a shared meaning system with certain observable behavioural consequences, a more exact understanding is required for the present study.

Consistent with the view of Hofstede (1980), who defines culture as "the software of the mind", Merritt and Helmreich (1996) provide the following definition of culture:

> "*Culture can be defined as the values, beliefs, rituals, symbols and behaviours that we share with others that help define us a group, especially in relation to other groups. Culture gives us cues and clues on how to behave in normal and novel situations, thereby making the world less uncertain and more predictable for us.*"

They also postulate that culture encompasses two components: Surface structure and Deep structure. The former is constructed with observable behaviours, while the latter provides the logic guiding the behaviours.

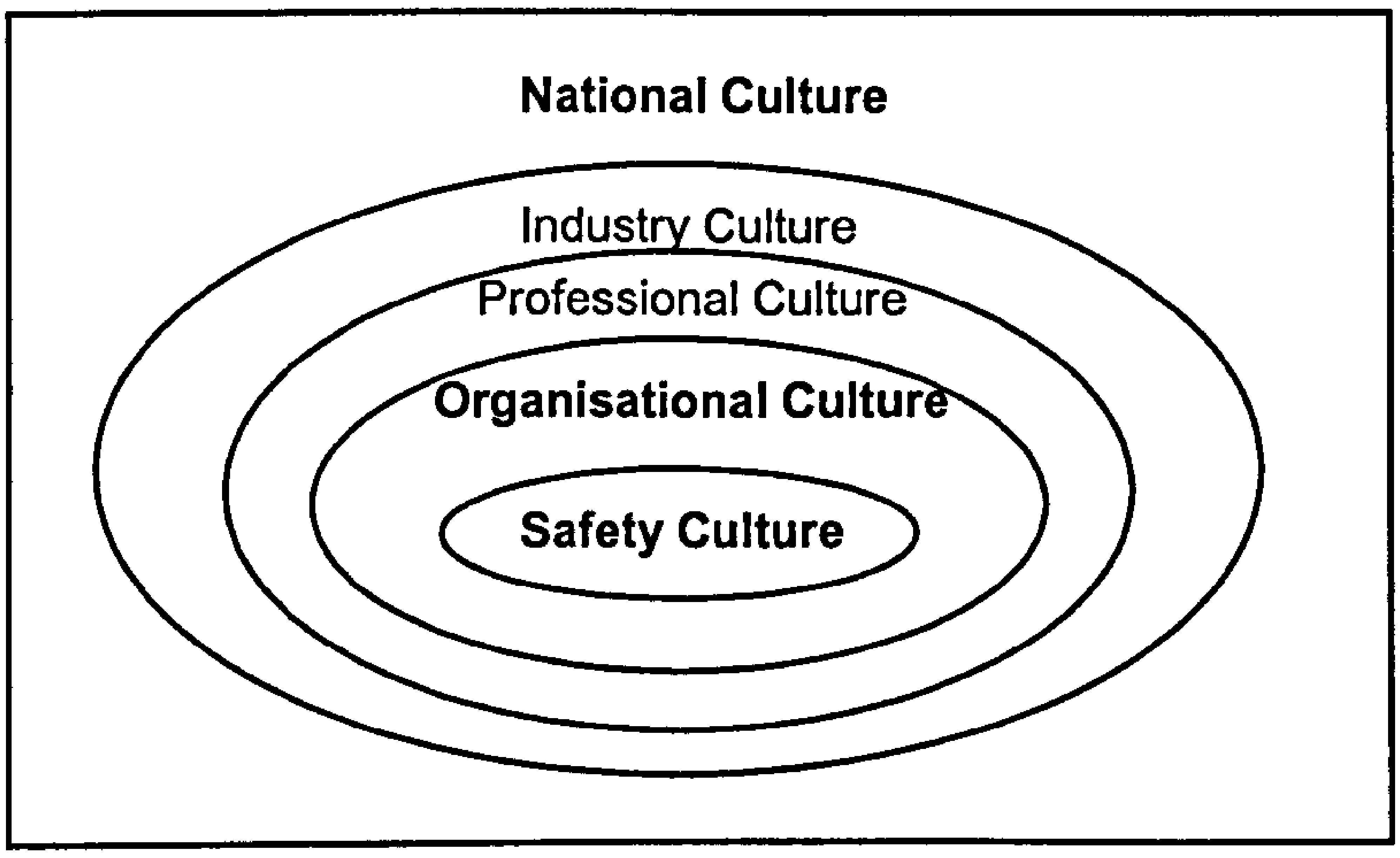
The definitions of culture reveal the fact that cultures are specific to a defined group of people. Therefore, Hofstede (1994) argues that culture should include layers of national culture, regional/linguistic/religious culture, gender culture, generation culture, social class culture and organisational culture, since people are usually part of a number of groups.

In keeping with this theme, Helmreich and Wilhelm (1997) identify and discuss three intersecting cultures that surround every flight crew; national, professional and organisational cultures. Helmreich (1999) points out that many professions such as aviation have strong cultures and develop their own norms and values along with recognisable physical characteristics such as uniforms or badges. His research reveals that professional culture can contribute to aviation's splendid safety record, but the "macho" attitude of invulnerability can lead to risk-taking, failure to rely on fellow crew members, and error.

Morley (1999) also identifies a similar stratification of culture which includes layers of national culture, industry culture, organisational culture and organisational safety culture. Industry culture is included to reflect the norms, attitudes and values in association with an industry and to illustrate the fact that different industries may have their own set of systems of meaning to distinguish them from others.

Summarising from these researchers' work, three main and distinct levels of culture are found: *national, organisational* and *safety culture.* These are presented in Figure 2-19 and will be discussed in the following sections.

Figure 2-19 Layers of Culture



Source: compiled from Helmreich and Wilhelm 1997; Morley, 1999

2.6.3.2 National culture

National culture is undoubtedly an important influence in aviation (Johnston, 1993; Maurino, 1994; Merritt and Helmreich, 1996). One of the most influential individuals in this field of culture variation is Geert Hofstede (1980), who conducted a questionnaire study across IBM, a large multi-national corporation. The questionnaire data was collected from 80,000 IBM employees in 66 countries across seven occupations. Four dimensions of national culture were identified:

Dimension 1: ***Power Distance***

This is the extent to which differences in power among people are expected and desired, i.e. the unequal distribution and exercise of power which is expected and accepted in a culture. Countries high on power distance (e.g. China) demonstrate dependence of subordinates on their superiors. Leaders are expected to be autocratic and decisive, and subordinates are unlikely to approach their superiors. In countries low on power distance (e.g. Australia), superiors are likely to consult with their subordinates.

Dimension 2: ***Uncertainty Avoidance***

This is the degree to which members of a culture feel uncomfortable with risk or unknown situations. Members in a high uncertainty-avoidance culture (e.g. Japan) tend to be intolerant of unstructured or unpredictable situations. On the other hand, cultures that have low uncertainty avoidance (e.g. Denmark) are likely to value stability and rules in their daily lives, and accept and encourage dissenting views.

Dimension 3: ***Individualism-Collectivism***

This relates to the extent to which members of society value individual achievement over group membership and goals. In a highly individual culture (e.g. the US), people are expected to act according to their own interests, while a collective culture values loyalty to and harmony with the group, so that people tend to act according to the interest of the group (e.g. Singapore, Taiwan).

Dimension 4: ***Masculinity-Femininity***

This is the extent to which differences in gender roles are valued. In a high masculine culture, members place a high value on assertiveness and toughness in males and tenderness in females (e.g. Japan). In a high feminine culture, members value a welfare society and both genders are allowed to display feminine traits (e.g. Sweden).

However, Merritt (1997) found all four dimensions, apart from Masculinity-Femininity, when replicating Hofstede's survey by using commercial pilots as respondents. As a result, Merritt suggests that this dimension can be absent because aviation is already a financially rewarding profession and has, therefore, little concern for masculine traits such as "the opportunity for high earning".

Helmreich (1999) notes that Individualism-Collectivism and Power Distance are two related dimensions of national culture having particular relevance for aviation. He also suggested a third dimension, labelled Rules and Order, which is similar to Hofstede's concept of Uncertainty Avoidance. Members in a high Rule and Order culture believe rules should not be broken and written procedures are needed for all situations (e.g. most Asian countries). Those low on this attitude show lower concern for rules and written procedures (the US, European countries).

2.6.3.3 Organisational culture

The concept and essence of culture has been linked increasingly with the study of organisations. With the recognition of the symbolic aspects of organised settings have come calls for a cultural perspective on organisations (Turner, 1971; Whorton and Worthley, 1981; Smircich, 1983). Similar to national culture, organisational culture provides a behavioural referent for members of an organisation by defining what the organisation does, and does not, represent. An organisation's culture reflects its attitude and policies about human error, and the openness and trust between employees and management.

The characteristics of organisational culture

Although organisational culture is a complex concept (Guldenmund, 2000), a number of researchers have tried to define and describe the characteristics of organisational culture (e.g. Schein, 1992; Robbins, 1992; Hampden-Turner, 1994). For example, Hampden-Turner argues that corporate culture is describable, measurable if necessary and, within limits, alterable. He describes the characteristics of corporate culture as follows:

1. ***Individuals make up a culture:*** Culture comes from within people. They use the culture to reinforce ideas, feelings and information which are consistent with their beliefs.

2. ***Cultures can be rewarders of excellence:*** Culture is a source of motivation. It creates an environment for bringing out the potential of all its members and a system for rewarding defined tasks.

3. ***Culture is a set of affirmations:*** No group, corporation, tribe or nation can start from nothing. Culture proves that.

4. ***Culture affirmations tend to fulfil themselves:*** Cultures create results and consequences, no matter whether for good or for bad.

5. ***Cultures make sense and has coherent points of view:*** One cannot understand a corporate culture without seeing that its actions logically follow from its beliefs. Culture can be studied.

6. ***Cultures provide members with continuity and identity:*** Only if beliefs are shared, affirmed, fulfil themselves and retain distinctive meanings over time, despite changing environments, can a corporation retain its sense of identity and continuity.

7. ***Cultures are patterns:*** A culture is no particular thing or object, but a pattern which appears both through time and across the organisation. So cultures are structured from repeating events.

8. ***Cultures are about communications:*** Culture can produce solidarity. It is most important to grasp that many cultures facilitate communication, sharing of experience and information. They can make their members strongly supportive of each other.

Guldenmund (2000) summarises and lists the organisational characteristics from previous researchers and literature review as follows:

1. ***It is a construct:*** When operationalising a construct, it is generally assumed that there are several variables that co-vary or fit together to form a unified whole.

2. ***It is relatively stable:*** Researchers have found a period of stability of at least five years for organisational culture.

3. ***It has multiple dimensionality:*** Dimensions are always composites, comprised of several variables.

4. ***It is something shared by (groups of) people:*** Culture is something that is mutual and reciprocal. It is a synergistic aggregate composed of several parts. The characteristics are the base for assuming multiple cultures within a large organisation, in that such an organisation can be divided into divisions, departments, units, etc, that will have developed their own culture.

5. ***It consists of various aspects:*** This means that several different cultures can be distinguished within an organisation (e.g. safety culture, service culture, etc).

6. ***It constitutes practices:*** Culture is perceived as having multiple layers. At each level, culture has particular manifestations which can be studied separately.

7. ***It is functional:*** Culture is functional in the sense that it supplies a frame of reference for behaviour.

Although there is some disagreement with numbers 1 and 3 between researchers, overall, organisational culture is a relatively stable, multi-dimensional, holistic construct shared by (groups of) organisational members, which supplies a frame of reference and which gives meaning to and/or is typically revealed in certain practices (Guldenmund, 2000). It is not suggested that a single organisational culture is needed universally. Successful airlines can be characterised by different cultures and operational styles, just as many different personality types can make good airline pilots, cabin crew, ground staff and so on.

Organisational culture and safety

Organisations are complex entities and safety is just one aspect of their function. Naturally, different organisations demonstrate different abilities to manage risk and to realise the long-term benefits of the effective management of safety. The difference in the ability of organisations to manage their affairs with respect to safety has led to a wide-ranging treatment within the literature of the characteristics of organisations.

The relevance of organisational characteristics to safety is obvious in the previous section when discussing the characteristics of organisational culture. Since organisational culture is a multi-dimensional construct and consists of various aspects, the link between organisational culture and safety is therefore clear; Korean Air is a good example[15]. As Hayward (1997) indicates, organisational culture has the potential to have a very significant direct impact on the safety performance of organisations. Merritt and Helmreich (1996) also note that it is organisational culture which ultimately shapes workers' perceptions of safety, the relative importance placed on safety, and members' activities regarding safety.

Figure 2-20 portrays schematically the concept of the organisation-culture relationship. Culture is imported into the organisation through its membership. Its presence is believed to be revealed in the patterns of attitudes and actions of individual organisation members (Smircich, 1983). This figure also embodies the concepts of Merritt and Helmreich (1996):

> "*An integrated organisational culture can be characterised by sub-group cooperation, a strong corporate identity ...high employee morale, all of which create a positive impact on service and safety.*"

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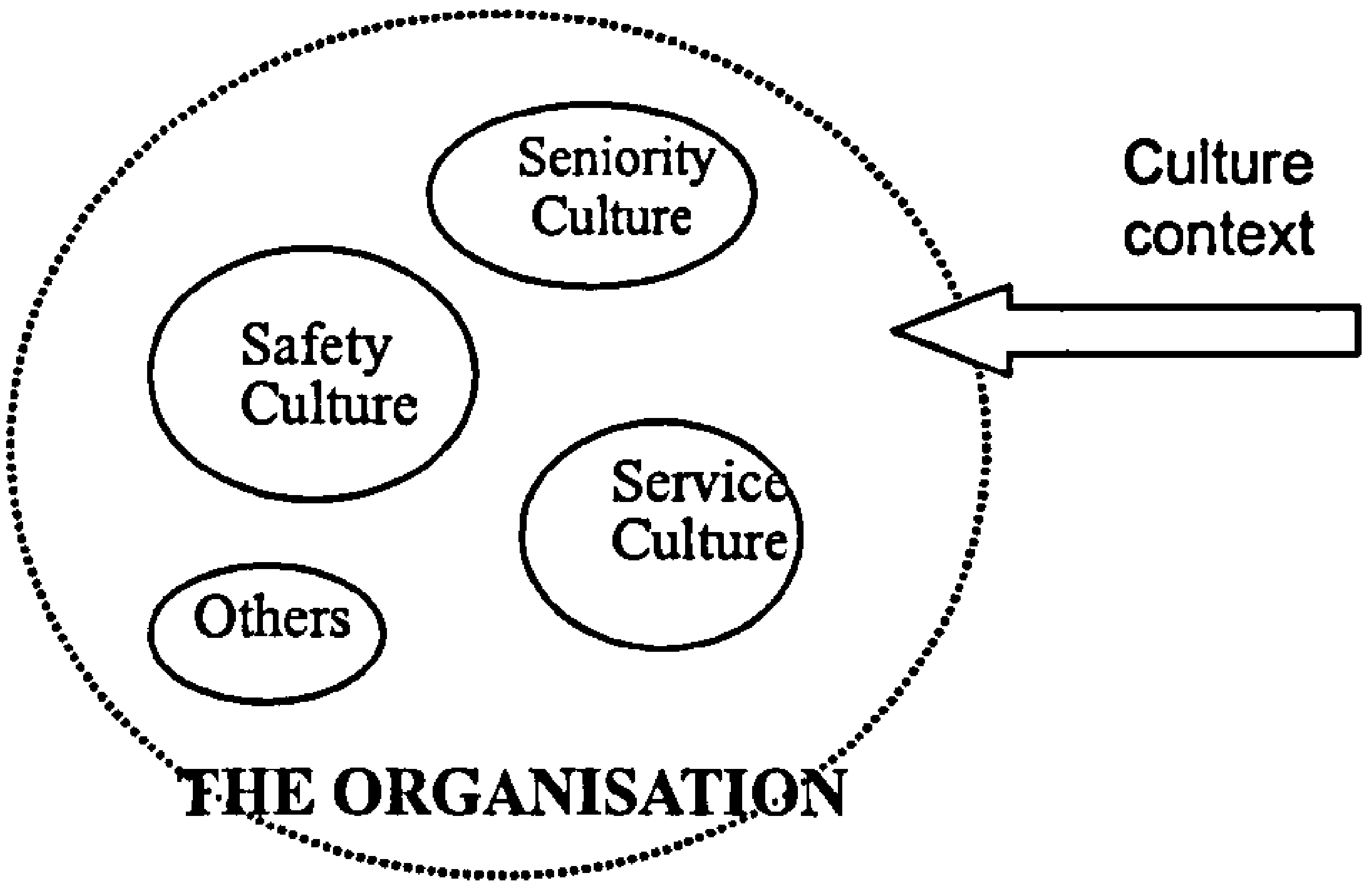
[15] Take Korean Airlines (KAL) for example. Since 1995 and 1993, Delta Air Lines and Air Canada had code-share agreements with KAL respectively. Unfortunately, KAL had suffered 10 serious accidents from 1990 to 1998. By anyone's standard, those numbers represent the symptoms of a system in trouble. Following the crash of a Boeing MD-11 freighter in China in April, 1999, Delta Air Lines and Air Canada immediately suspended its code-share on KAL flights pending a thorough review of the Korean carrier's operations. Because both of them would not like to take the risk of being perceived as in the same image as KAL. In November 1999 the Korean government imposed a ban on KAL launching new international flights following a spate of serious accidents that led to the suspension of a number of airline alliance agreements. It raises the question: When KAL's code-share partner Delta Air Lines completed its independent safety audit, would KAL really ignore things that clash with traditional ways? In 1999, KAL underwent a safety audit, but KAL's reluctant acknowledgment of a leaked internal safety report in 1999 revealed its fundamental safety culture had not been changed at all following the series of accidents (Hsu, 1999; Lee, 2000).

Figure 2-20 Organisation and Subcultures



Source: Adapted from Smircich, 1983

Various types of organisation

Westrum (1993, 1995) provides a view regarding the basic organisation communication styles so that an aviation organisation can learn from the styles of management of its employees. He examines three patterns of information used by aviation organisations: pathological, bureaucratic, and generative (see Table 2-4). This concept has been adapted widely in the aviation world.

These categories reflect the communication patterns between employees and upper management and support employees after problems are reported. The "pathological" style is a highly conflicted organisation. "bureaucratic" organisations process information as a routine job and fail to handle changes. A "generative" style can help to create a highly reliable organisation.

Different types of organisation will foster different corporate cultures. Ideally, the generative types of organisation are favoured and encouraged because the generative culture can help and support employees in learning from mistakes, rather than apportioning blame and taking punitive action.

Table 2-4 Basic Organisation Communication Styles

Pathological	Bureaucratic	Generative
Information is personal power	Information is routine	Information is seen as a key source
Responsibility is shirked	Responsibility is compartmented	Responsibility is shared
Messengers are shot	Messengers are listened to if they arrive	Messengers are trained
Bridging is discouraged	Bridging is tolerated	Bridging is rewarded
Failure is punished or covered up	Organisation is just and fair	Failure leads to inquiry or learning
New ideas are actively crushed	New ideas present problems	New ideas are welcome

Source: Westrum, 1995

2.6.3.4 Safety culture

As presented previously, the characteristics of organisational culture can affect the way in which an organisation manages risk. Adams and Ingersoll (1989) comment that at the organisational level of analysis it may often be more appropriate to discuss culture in terms of subcultures. Hence, combined with the fact that different types of organisations demonstrate different safety records, the concept of organisational culture to the management of risk has led to a significant amount of discussion within the management and literature of the safety culture concept.

In particular, safety culture was discussed to a large degree following the Chernobyl nuclear accident (1986). The Chernobyl accident was identified as being caused by the organisations responsible for the Chernobyl Nuclear Power Plant, which lacked a "safety culture" and resulted in an inability to remedy design weaknesses despite these being known about before the accident. The human errors and violations of procedures were interpreted as evidence of a poor safety culture.

In the airline industry however, it is not easy to measure how good a good safety culture is or how bad is a bad safety culture. If examining the definition of safety culture, there are various kinds of interpretation and explanations. Table 2-5 lists some definitions of safety culture. Although there is much discussion around the concept, there is little common understanding of what constitutes an exact definition of safety culture (McDonald and Ryan, 1992). Nonetheless, it is generally agreed that they contain similar underlying elements of a safety culture: beliefs, attitudes, norms, and values. Some definitions also encompass the tangible manifestations of culture: priorities, behaviours and practices. Yet the most important of all, as indicated by Hayward (1997), is that the establishment of an appropriate safety culture is the recognition that human error is unavoidable and that it is the responsibility of a mature organisation to effectively manage that error.

Table 2-5 Definitions of Safety Culture

Researchers	Definition
Cox and Cox (1991)	Safety cultures reflect the attitudes, beliefs, perceptions, and values that employees share related to safety.
Pidgeon (1991)	The set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimising the exposure of employees, managers, customs and members of the public to conditions considered dangerous or injurious.
Geller (1994)	Everyone feels responsible for safety and pursues it on a daily basis in a total safety culture.
Lee (1996)	The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to and the style and proficiency of an organisation's health and safety management.
Merritt and Helmreich (1996)	A safety culture is more than a group of individuals enacting a set of safety guidelines. It is a group of people guided in their behaviour by their joint belief in the importance of safety, and their shared understanding that every member willingly upholds the group's safety norms and will support other members to that common end.

2.6.4 Contemporary Safety Programmes with Proactive Concepts in the Airline Industry

Abeyratne (1998) points out that regulation of a high tech industry such as aviation must move towards a proactive rather than a reactive approach to safety. Now there is a consensus among the international aviation community that human factors must progress beyond the "knob and dials" approach of ergonomics, beyond training and beyond the post-mortem application of human factors knowledge in accident investigation. A good safety programme would most likely have identified safety hazards within the training and checking systems, and resolved deficient aviation safety defences in order to evaluate and improve the integrity of safety defences, as well as the safety measures before an accident or incident. Efforts have already been made in this field recently and some programmes were developed as a result. Within the modern airline industry, there are five programmes with proactive concepts to help to assess the airline's safety. They are: (1) British Airways MESH Programme (Reason, 1994), (2) Boeing's Safety Programme Model (Boeing), (3) BASI-INDICATE Programme (Edkins, 1998), (4) PERS (FAA, 1997b), and (5) LOSA (Line Operation Audit). In particular, MESH and PERS are applied in engineering maintenance aspects (see Appendix H for the introduction of these programmes in details).

2.6.4.1 Managing Engineering Safety Health (MESH)

Objectives

Managing Engineering Safety Health (MESH) is a programme created for British Airways Engineering Company in 1992 by a team lead by Professor James Reason from the University of Manchester. It is a set of diagnostic instruments for making visible, within a particular engineering location, the situational and organisational factors most likely to contribute to human factors problems (Reason, 1994; Maurino et al, 1995).

Designed to assess the safety climate of an organisation, the measures of MESH give an indication of the system's state of safety (and quality), both at the *local workplace level* and *in general.* It is a system of measuring a number of local and organisational factors and the interplay between them. The local factor assessments are made at weekly intervals by a randomly selected proportion of the workplace in each of a variety of workplaces (i.e. operational hangars, majors overhaul hangars, workshops, etc.). The organisational factors are assessed at three-monthly intervals by technical management in each location because these are the people best placed to judge the impact of "upstream" organisational factors upon the reliability of their various workplaces (Reason, 1995a).

Advantages

Reason (1995a) suggests that by identifying factors in need of improvement and tracking the changes over time, MESH enables the maintenance of adequate safety health, comparable to a long-term fitness programme, in which the focus of remedial efforts switches from dimension to dimension as previously salient factors improve and new ones come into prominence. The advantages of MESH can be thus summarised as follows:

- Staffs are all involved in safety.
- Managers can prioritise remedial actions and check upon their impact.
- Direct safety resources where they are most needed.
- Encourage better communications between management and staff.

Limitations

Although the first impression of MESH appears to be that it is easy, the implementation of this tool may lead to some difficulties. Caution must be expressed when interpreting the implied meaning of results when employing a single rating scale method of investigation. Due to personal tendencies, some people tend to use only the extreme of the scale, while others tend to use only the middle area. In addition, the MESH users have no access to any overview of the global structure and the items to be rated are displayed on separate rating pages.

Meanwhile, the factors rated in MESH have very general meanings and can be interpreted and rated according to different interpretations. Consequently, the results obtained by MESH are not sufficiently detailed for suggesting proper corrective actions.

MESH has never been applied by low capacity operators, and would be beyond the resources of smaller operators. Although it has also been implemented by Singapore Airlines Engineering Company, this programme is not adopted widely by other airlines and has not achieved the significant improvements in safety performance that were originally expected. A number of improvements and modifications are currently being made as a result.

2.6.4.2 The Boeing Safety Programme

Quoted from CASA (1998), the Boeing Safety Programme is a comprehensive programme designed not only to introduce the reason for having effective safety programmes, but also to introduce the tools for running them. The programme is presented by Boeing as a two-day training course and is useful for ramp, maintenance and flight operations.

Approaching from an organisational standpoint, it covers management's involvement and support for the programme through the development of integrated mission and policy statements. The model describes how safety functions can be linked within an operation in different ways.

The safety process begins with some of the traditional safety programme elements including information gathering, investigation, evaluation, and change. The programme also includes sections on the products of a safety programme, including newsletters, bulletins and other forms of communication within the organisation, and resources available to the Safety Officer/Manager. The section on resources identifies some organisations that are dedicated to safety, various training institutions that offer safety related training.

The Boeing manual provides many useful checklists. It also gives anecdotal coverage of incidents to show how pre-emptive actions could have prevented the occurrences. However, it was developed for larger airline operations and much of it would probably be superfluous to the smaller passenger-carrying operator (CASA, 1998).

2.6.4.3 Identifying Needed Defences in the Civil Aviation Transport Environment (INDICATE)

Objectives

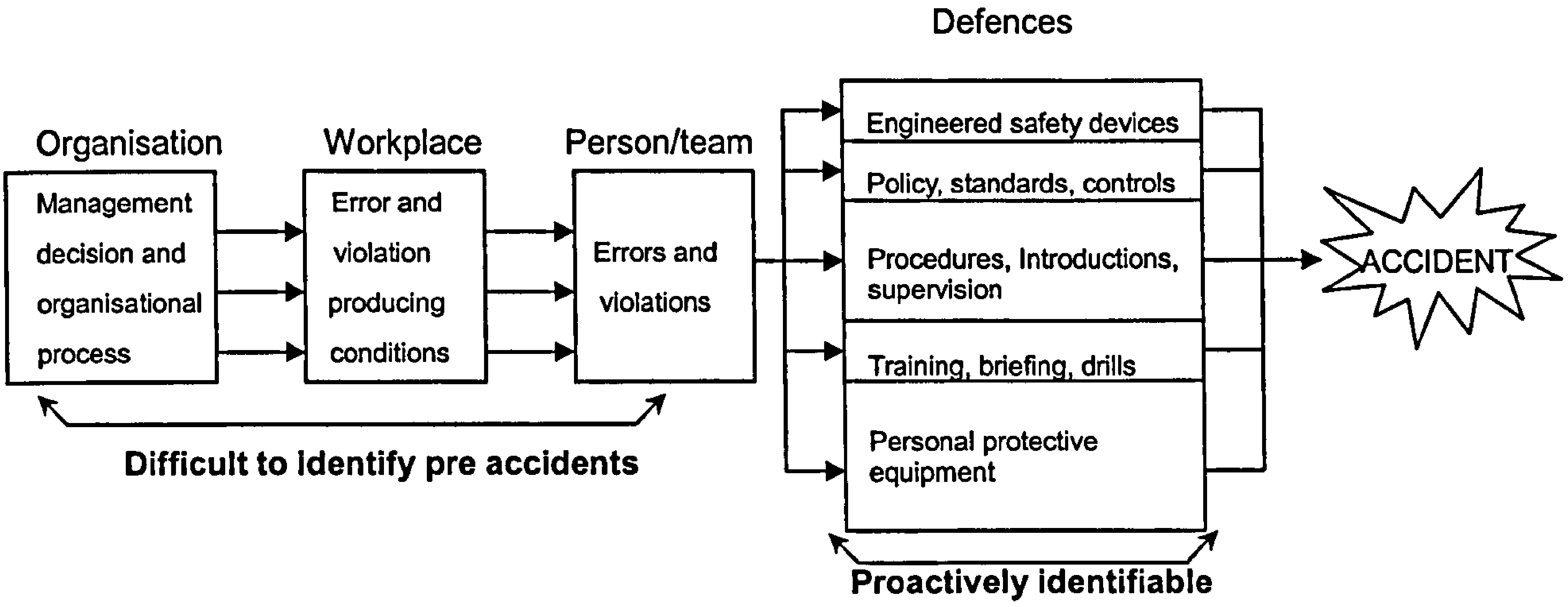
INDICATE is a safety programme that has been developed in consultation with the Australian regional airline industry for proactive purposes. The name is based on the underlying purpose of the programme which is to identify and resolve deficient aviation safety defences (Edkins, 1998). It provides a formal communication channel for aircraft operators to regulations, policies and standards to the Bureau of Air Safety Investigation (BASI) in Australia. It is also known as BASI-INDICATE.

According to Edkins (1998), safety defences are barriers or safeguards put in place to protect a system from both human and technical failure. He presents a modified version (Figure 2-21) of Reason's model of organisational accident causation (see Figure 2-18, page 71). Edkins argues that each of the organisation, workplace and person/team components of Reason's model is difficult to identify *before* an accident because latent failures are usually unforeseeable, workplace factors are dynamic, and errors or violations are unpredictable. This model implies that the integrity of safety defences can be more accurately determined as they are more tangible and thus more measurable components within a system. The INDICATE programme has therefore been designed to regularly evaluate airline safety defences so that the potential risk of an accident can be minimised.

Evaluation criteria

There are many potential measures of airline safety performance, including the absolute number of fatal and non-fatal accidents; fatal and total accidents per million departures; passenger fatalities per million passengers or per million miles, etc. Regardless of which measure is used, it is important that it is examined regularly if a safety management programme is to be effective in improving safety performance. Nevertheless, accidents are so rare in airline operations that they cannot be used as a statistically reliable index of safety performance.

Figure 2-21 Proactive Defence Evaluation Model



Source: Edkins, 1998

As such, the INDICATE programme was evaluated based upon the following five safety performance criteria (Edkins, 1998; BASI, 1998). These criteria were:

1. Airline safety culture
2. Airline staff risk perception of aviation safety hazards
3. Staff willingness to report safety hazards
4. Action taken on identified safety hazards
5. Staff comments about safety management

A trail with an Australian regional airline revealed that there was a clear difference between two experimental groups, and the programme had had a positive influence on the airline's safety performance.

Benefits

In Australia, it is a legal requirement to report air safety incidents via an Aviation Safety Incident Report (ASIR). However, there is a recognised problem of under-reporting, which in part stems from a lack of awareness about what should be reported despite this mandatory requirement.

The programme provides a simple and structured process to encourage staff to report safety hazards and deficiencies within their work area. The safety information database and software allows management to address all safety-related concerns. Furthermore, senior management regularly meet with safety staff to determine what to do about identified hazards. It is clear that consistent communication of safety-related information within an organisation is crucial for improving staff attitudes towards safety.

Edkins (1998) explains that the results of the INDICATE trial suggest that measuring safety culture provides a useful method for monitoring changes in company safety performance and may assist in identifying elements of a safety management programme that require improvement, such as a hazard reporting system.

Most importantly of all, the evaluation of the INDICATE programme illustrates that the greatest source of variance is not necessarily aircraft equipment or the category of operation, but the real cost from the safety culture of organisations within the aviation system. The benefits from implementing such initiatives will ultimately help to improve operational safety and, in some cases, reduce operating costs.

2.6.4.4 Proactive Error Reduction System (PERS)

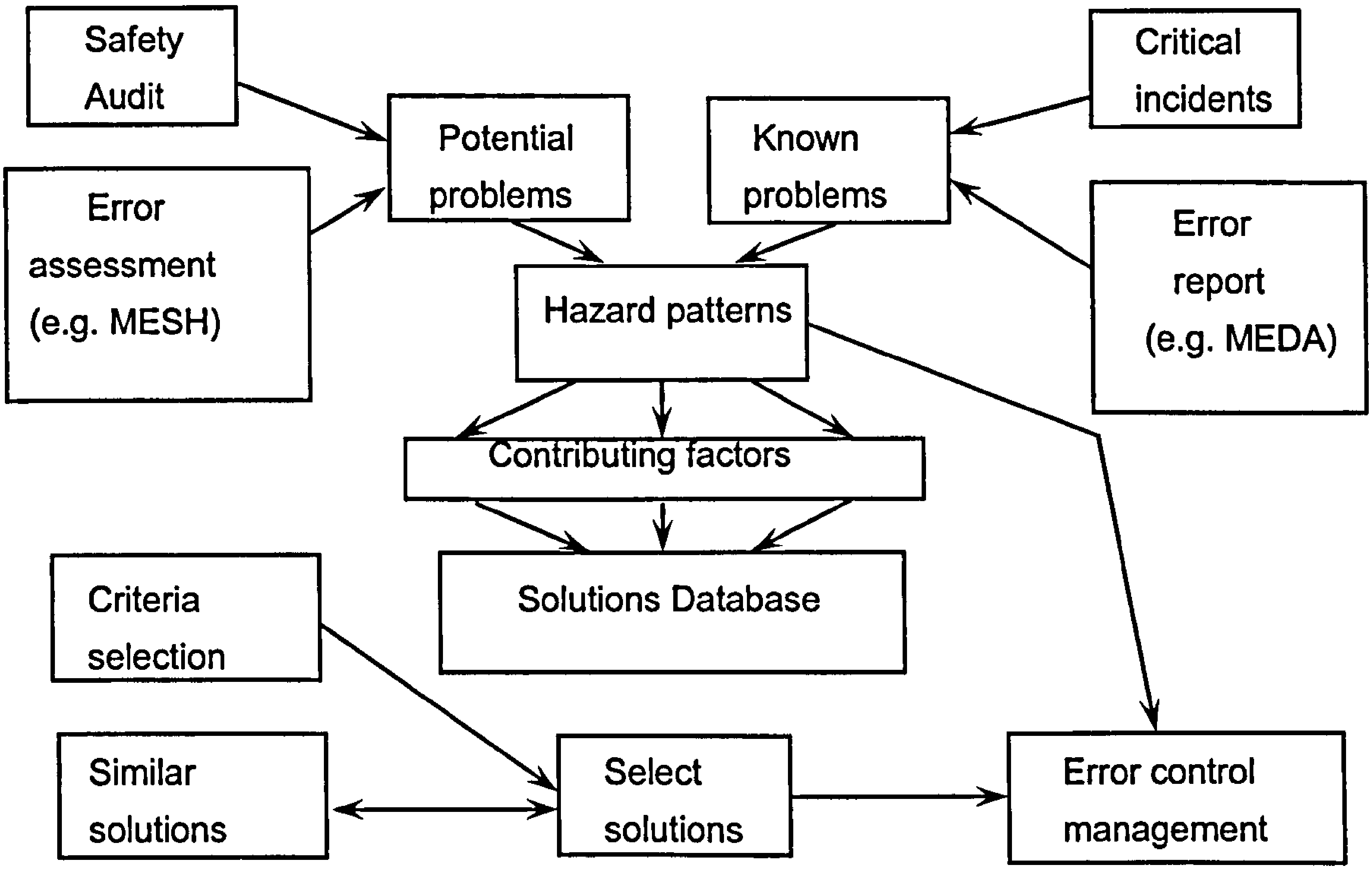
Objectives

The PERS programme is funded by the Federal Aviation Administration's Office of Aviation Medicine and devised by Dr. Colin Drury at the University at Buffalo (UB), the State University of New York (IFA, 1998). The FAA-funded project began in 1989 following a Congressional hearing prompted by an incident in which 18 feet of roof pulled away from an Aloha Airline jet as it was flying over the Pacific Ocean. A flight attendant was sucked from the plane and 61 passengers were injured.

For years, Drury and his co-workers have analysed errors by airline workers in detail.

They are using this knowledge to build practical tools that allow users to arrive quickly at solutions to errors made by airline workers. PERS is an error management system which can be used by non-experts in human factors because it is based on a human-factors approach to solving errors. The idea behind this is that one should not just determine the immediate cause of the error, but examine all the things that lead up to it. As such, this programme, as shown in Figure 2-22, is structured to use the repeating patterns found in incident data in order to help airlines move from the recognition of human factors as an issue to practical human factors solutions.

Figure 2-22 The PERS Structure



Source: FAA, 1997 b

Advantages

There are four distinct functions within the programme:

1. A comprehensive error management system which can combine many existing data collection and analysis systems (e.g. MESH, MEDA). In other words, it facilitates the importing of data from other systems such as other audits and MESH, and links databases of maintenance errors with databases of known solutions.

2. PERS facilitates the identification of error-prone situations by using
   - error audit of specific tasks
   - error assessment like MESH.
3. PERS supports error management strategies, identifying situations for design/procedure changes.
4. PERS facilitates error reporting by employing
   - error reporting modules like MEDA (an error-reporting system with interfaces to MEDA)
   - critical incident reporting modules.

PERS provides a way for airline personnel to analyse an error or potential error, to discover why it occurred, and then to see how they might go about changing systems, equipment or work patterns to prevent future errors. PERS not only tells airline workers what to do if an error occurs, but it also tells them what to do even if what have occurred are not actual errors, but error-prone situations.

2.6.4.5 Line Operation Safety Audit (LOSA)

Objectives

LOSA was developed by the team of Professor R. Helmreich at the University of Texas, USA. Under LOSA, flaws in human performance and prevalence of error are taken for granted and the objective becomes improving the context within which human perform. LOSA ultimately aims to introduce a buffer zone or time delay between an error and the point at which its consequences become a threat to safety. The better the buffer or the longer the time delay, the stronger the tolerance of the operational context to the negative consequences of human error (Maurino, 2001).

LOSA are programmes that use expert observers to collect data about crew behaviours and situational factors on normal flights. Observations generate a narrative of the flight classified by phase, and these are conducted under strict no-jeopardy conditions, which mean that no crew are at risk for observed actions. Observers code observed threats to safety and how they are addressed, errors and their management, and specific behaviours that have been associated with accidents and incidents. If explained by using Figure 2-21 in INDICATE programme, it is the errors of **person/team** that LOSA would like to collect.

The critical difference between a LOSA flight and a line check is LOSA's guarantee of anonymity for the crew. Data are entered into a de-identified database and no crew actions are reported to management or the regulatory agency. In LOSA, error is classified as deviation from organisational or crew exceptions or intentions. Errors committed by the flight crew are described and coded along with actions taken to deal with the consequences of the errors. Table 2-6 lists the various errors and remedial strategies employed in LOSA.

Advantages of LOSA

Data from LOSA provides a picture of system operations that can guide organisational strategy in safety, operations, and training. Helmreich (2001) points out that a particular strength of LOSA is that it captures exemplary as well as deficient performance, which provides airlines with the areas in which they excel as well as those in need of improvement and used as models for training. As such, data collected in LOSA are proactive and can be used immediately to prevent adverse events.

The other strength is that a database is being developed that allows organisations to compare their results with other airlines. Such comparisons help in interpreting the significance of the number of procedural and decision errors observed and the effectiveness of threat and error counter-measures. The data allow management to prioritise safety initiatives and training departments can use the information to develop targeted training.

Meanwhile, the informative aspect of LOSA data is the ability to link threat recognition and error management with the specific behavioural markers that from the core of CRM. Using LOSA, a model incorporating the Swiss Cheese model has been developed (Helmreich, 1999). It recognises both overt and latent threats, and how they fit into the management of error and undesired states.

Table 2- 6 Various Error Types and Remedial Strategies

	Varieties of error	Remedial strategies
Procedural errors	Crew intending to follow a procedure but doing it incorrectly. Include the usual classification of slips, lapses and mistakes such as incorrect data entries or flying the wrong headings. Intention is correct but the execution flawed.	Suggests poor workload management or may be a reflection of inadequate procedures.
Communication errors	These involved failures in the transfer of information, including mis-statements, misunderstandings and omissions. Examples include incorrect read back to ATC or communicating wrong course to the other pilot.	Communications errors may reflect a need for more focus on CRM, especially interpersonal communication issues.
Decision errors	When crews choose to follow a course of action that unnecessarily increases risk to the flight in a situation not governed by formal procedures, this action is classified as a decision error. E.g., crews may choose not to deviate around bad weather on their flight path, resulting in an encounter with turbulence.	It suggests a need for further CRM concentration on expert decision-making and risk assessment.
Proficiency errors	This classification is applied to situations where a crew member lacks the knowledge or stick-and-rudder skill necessary to perform a task. E.g., like extreme manoeuvres on approach, choosing to fly into adverse weather. A number of observed proficiency errors involve lack of knowledge of flight deck automation.	Suggests a need to tighten standards for qualification and evaluation.
Intentional non-compliance	When crews obviously and intentionally violate company or regulatory requirements. Failing to abort an unstable approach as required by company procedures would fit into this classification. E.g., omitting required briefing or checklist	

Source: Adapted from Helmreich, 1999

These markers emerge very clearly in observer ratings of the actions taken by effective crews. Those who deal proactively with threat and error exhibit the following behaviours:

- active captain leadership
- briefing known threats
- asking questions, speaking up
- decisions making and reviewed
- operational plans clearly communicated
- preparing/planning for threats
- distributing workload and tasks
- vigilance through monitoring and challenging

Although the challenge for the implementation of analysis of normal operations is to overcome the obstacles presented by a blame-oriented industry, LOSA has been appreciated by various airlines which are willing to make the investment in conducting the necessary observations and analyses. In addition, the value of LOSA has also been recognised by ICAO and has gained support to conduct a "LOSA Week" to promote this programme to interested countries.

2.7 The Proactive vs. Retroactive Approaches to Safety

In the twentieth century, the value of accident investigations in identifying causes and initiating corrective action to prevent future errors has been greatly appreciated because the knowledge acquired through accident investigations has paved the way for improvements in air travel. However, the use of after-the-fact measures as a trigger to initiate safety efforts has been a very reactive approach to airline safety.

Studies have shown that most safety systems are reactive (Johnson 1994; Earnest, 1997). Johnson (1994) reveals the result of a survey, in which 83 percent of respondents indicated that "safety programmes are reactive, isolated within organisations and preoccupied with quick fixes and putting out fires." Earnest (1997) listed nine select criteria that can help to determine whether a safety culture is primarily proactive or reactive. Although these comparisons are focused in the areas of safety and health, some of them can be adopted and expanded the view on the airline industry. These characteristics are therefore detailed in the following paragraphs and listed in Table 2-7.

1. Incident/Accidents investigation:

In a retroactive system, the process of incident investigation tends to follow the "Domino theory" (Heinrich, Petersen & Roos, 1980), which typically focuses on a concept: identify the unsafe act, remove the hazard and prevent the recurrence (See Appendix I). As such, incident/accident investigators focus solely on accident symptoms rather than root causes in the organisation, which may become the source of future accidents.

In a proactive system, the occurrence of incidents/accidents has been recognised to be a system problem, as with Reason's model, which traces the causes of accidents back to the management system, and contains active failures and latent failures. To detect the latent condition and put in place defence against it is beyond the single-cause concept to take proactive steps to change the system.

2. Safety performance evaluation and measures

In a retroactive system, Earnest (1997) stated that safety evaluation is based on the absence of injury, so the management tends to rely on after-fact-measures to provide guidance and assume that safety is achieved. With a system that judges safety performance based solely on the absence of incidents/accidents, it may be wrongly assumed that the company is doing the right things as long as there is no occurrence of injuries.

With a proactive safety system, evaluation is based on the improvement of safety systems, and includes the function of management. Safety is evaluated and monitored in the long term in order to enable strategic planning.

3. Safety practice and performance

Within a retroactive safety system, safety practices are developed in response to accidents/incidents, just like a band-aid applications (Merritt A. and Helmreich, 1996). For example, GPWS or EGPWS are designed to prevent CFIT, because CFIT has been the major cause of aircraft accidents in the last decade. There are also other risk management tools which are designed for different causes.

By contrast, there are clear written safety practices in a proactive safety system, which have been developed based on a thorough evaluation of hazards in order to implement safety defences before incidents/accidents occur. Not only risk management tools are used to prevent identified risks (hazards), but also the latent conditions and safeguards that can be identified by using tools like MESH or INDICATE.

4. Safety goal and vision

One of the obvious differences between retroactive and proactive approaches to safety is the goal for safety. In the former, safety goals are based only on the reduction of injury or incident/accident at an organisational level. In the latter, attention is placed on the strategies for achieving these goals at both departmental and organisational levels, or even at group level. There are also periodic reviews and different milestone expectations from the management in order to ensure that the goals are achieved, and to reward employees. Safety goals are aligned with management plans to prevent recurrence, which results in substantial changes.

5. Safety programme and training

In a retroactive safety system, programmes and training go little beyond the mandated regulation (Earnest, 1997) due to cost consideration. Take EGPWS for example; although it is a fact that this equipment can effectively prevent CFIT from occurring, not all airlines are willing to install EGPWS unless it is a regulatory requirement. Training is another example, which is in some airlines, cabin crew training takes two months and in others it takes three months.

Conversely, in order to ensure the best programmes and performance, a proactive safety system needs to go beyond a purely mandatory level. Safety should have a higher priority than cost. The quality of safety programmes reflects how important the management think it is, and the willingness for the management to allocate resources.

6. Employee recognition and attitudes

To improve the safety system, employees must understand the structure, content and goals of the system, as well as how it functions. They should also understand how performance is evaluated in the system. This concept is not fostered in a retroactive system, so employees just adopt the attitude that "good safety performance is zero accidents." Since safety culture is weak, safety improvement just ends up with related personnel being re-trained in the aftermath of incidents or accidents.

Recognition in a proactive safety system is based on improving system safety, which helps to ensure the continuous improvement in the long-term. A strong safety culture is fostered in both the company and its safety system. As such, safety health is consequently achieved.

Table 2-7 Comparison of Different Characteristics in the Proactive and Retroactive systems

	Retroactive	Proactive
Incidents/accidents investigation	Focused on causal factors and unsafe acts, active failures (e.g. Domino theory)	Focused on root causes and latent mistakes in management (e.g. Reason's model)
Safety performance measure and evaluation	After-the-fact performance measure, evaluation based on the absence of injuries, and mistakes in the short-term	Evaluation based on the improvement of safety system and long-term strategies
Safety practice and performance	Tends to respond to incident/accident and injury avoidance, a band-aid solution	Identifies safety defences before any latent conditions are formed
Safety goal and vision	Based solely on eliminate errors and accident reduction	Aligned with company goal and have no conflict with production goals
Safety programme and training	Only meets regulatory minimal requirement	Beyond regulatory requirements on a voluntary basis
Safety recognition and attitudes	Good safety performance is zero accidents - short term	Emphasised on continuous improvement in the long term

Source: Adapted from Earnest (1997)

CHAPTER 3

Research Methodologies

> *"Science came into existence through the opposite belief.*
> *It is the same with mathematics, which would certainly not*
> *have come into existence if one had known from the beginning that*
> *there was in nature no exactly straight line,*
> *no real circle, no absolute magnitude."*
>
> *~ Friedrich Nietzsche*

3.0 Introduction

In Chapter 2, the concept of an airline safety management system (SMS) has been investigated (Research objective 1). The literature and practical industry programmes demonstrate that both retroactive and proactive approaches to safety are used within airline SMS. The difference between retroactive and proactive safety management is in the treatment of the contributing causes of accidents and their underlying factors to prevent accidents from occurring again. In particular, the cultural and organisational dimensions have been illustrated as two main components in the proactive approach to safety (Research objective 2).

However, it is evident from the preceding chapter that the components of a proactive approach to safety are an important but as yet, relatively undefined task in the airline industry. Therefore, the industry needs a model to conceptualise the 'safety mechanism' in proactive safety management (Research objective 3), which contains the cultural and organisational consideration, identified in Chapter 2, and organisationally influential factors (Research objective 4). Chapter 2 has completed the study to meet the research objective One & Two. According to the findings, Chapter 3 follows to present the research methods to solve the found problem in order to achieve research objective Three, Four and Five ultimately. As such, the investigation requires a fully explored method.

This chapter introduces the methodologies used in this thesis, which are exploratory in focus and qualitative and quantitative in nature. It aims to establish a framework for the study of proactive approach to safety and for the evolution of airline safety management system by the development of a 'safety mechanism model'. *Interviews* were firstly undertaken to gain the empirical knowledge and experiences necessary to develop a safety mechanism for proactive safety management with the combined findings from the literature review. The *safety mechanism model*, as well as the influential factors, is subsequently developed. Meanwhile, the use of a *retrospective case study* and the *safety survey* aim to provide the reader with an appreciation of the safety mechanism model in relation to how the safety mechanism has been tested, and how the organisational factors affect the airline safety management system.

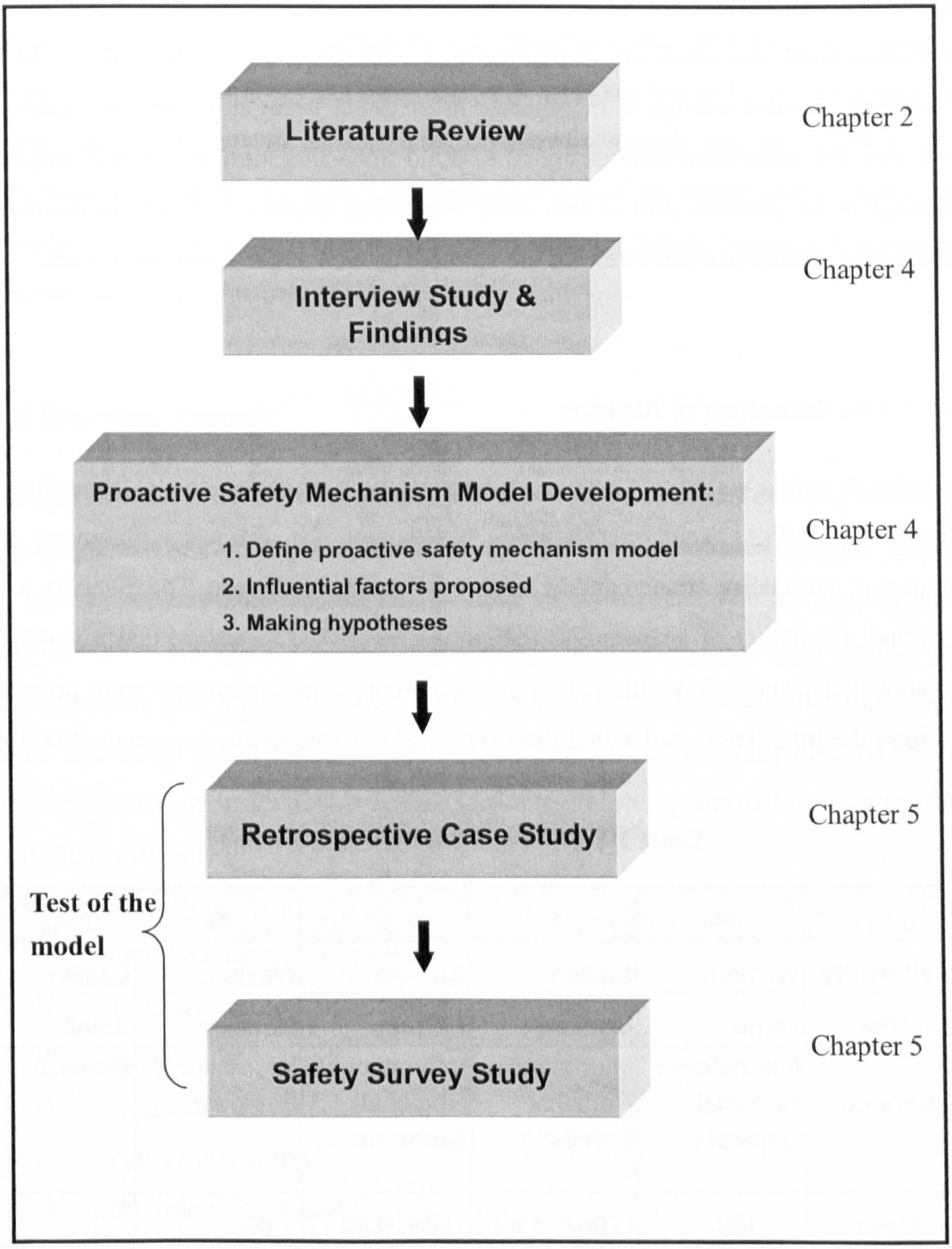
For the purpose of better illustrating the methodologies mentioned in this chapter, Figure 3-1 demonstrates the structure of methodologies adopted in the thesis.

Chapter 3 follows to present the research methods to solve the found problem in order to achieve research objective Three, Four and Five ultimately. As such, the investigation requires a fully explored method.

This chapter introduces the methodologies used in this thesis, which are exploratory in focus and qualitative and quantitative in nature. It aims to establish a framework for the study of proactive approach to safety and for the evolution of airline safety management system by the development of a 'safety mechanism model'. *Interviews* were firstly undertaken to gain the empirical knowledge and experiences necessary to develop a safety mechanism for proactive safety management with the combined findings from the literature review. The *safety mechanism model*, as well as the influential factors, is subsequently developed. Meanwhile, the use of a *retrospective case study* and the *safety survey* aim to provide the reader with an appreciation of the safety mechanism model in relation to how the safety mechanism has been tested, and how the organisational factors affect the airline safety management system.

For the purpose of better illustrating the methodologies mentioned in this chapter, Figure 3-1 demonstrates the structure of methodologies adopted in the thesis.

Figure 3-1 The Structure of Used Research Methods



3.1 Interviews

The method chosen for this part of the study is a series of semi-structured qualitative interviews conducted to include various airline safety people. The use of semi-structured interviews meant that the topics discussed were grounded on Chapter 2 but were flexible enough to incorporate other issues brought by the participants. In this way, the interviews were designed to build upon literature review and empirical findings in the previous part of this study. Following sections will present the details of how the airlines and interviewees are selected as well as the interview format.

3.1.1 The Selection of Airlines

In order to gain a varied perspective on how safety is managed, five safety managers in different airlines were interviewed[19], based upon the airline's willingness, size, scope and nationality, and the author's time plan and convenience. The diversity in the size and nationality of airlines was thought to be critical to ensure that a variety of organisational and safety cultures, and safety management practices were presented through the interviews. A detailed description of the companies is presented in Table 3-1.

Table 3-1 The Profile of Selected Airlines

	A	B	C	D	E
Nationality	Western	Eastern	Eastern	Western	Eastern
Size	Large	Medium	Medium	Medium	Small
Service	International Regional Domestic	International Regional Domestic	International Regional Domestic	International Regional	Domestic
Fleet	>100	100>, < 50	100>, < 50	50>	20>

Note: All of them run passenger, charter, and cargo services.

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[19] Two civil aviation authorities were interviewed as well (one western, one eastern). The CAA provided a view from the regulatory angle. Although these opinions were not included in their entirety in the interview results, they played an important part as a reference when completing the interviews with airlines, and when summarising the final results of this research.

3.1.2 The Selection of Interviewees

As the set of interviews was intended to provide a broad view of the safety activities within the airline industries, interviewees were approached on primary criteria. People were sought who were felt to have sufficient experience and knowledge to be able to provide an overview of his or her airline, as well as the airline industry as a whole. In this way, the opportunity sample therefore consisted of people who are in charge of a safety department or mostly related to safety activities of the organisation. Their titles are varied according to the different companies, such as Safety Manager, Director of Safety or Safety, and Security VP.

3.1.3 Interview Format

A number of topic areas were identified from the previous analyses as being critical to the management of safety system and these formed the basis of the interview format. The topics were not only focused on proactive safety management or organisational safety culture as more practical discussions were sought (semi-structured). As reactive safety practices and proactive safety culture are inextricably linked, the topics that formed the basis for the discussions ranged from the more tangible and easily describable safety management practices to the less easily quantified issues of safety culture. They included:

- Safety management system
- Risk management programme
- Safety audit
- Organisational structure
- Culture and safety
- The role of regulator
- Improvement
- Others

Interview followed a semi-structured format. The detailed questions can be found in Appendix J. Each interview lasted from one to one and half hours approximately. The majority of the interviews were conducted in the interviewee's place of business. Where this was not possible, the interview was conducted by telephone. Given the requirement from the participants, the names of airlines are omitted for reasons of confidentiality.

The findings from these interviews, combined with the results of literature review, were then used to develop a safety mechanism model of how a proactive safety approach develops and evolves within the airline industry. The interview findings are discussed in Chapter 4.

It should also be kept in mind that the interviews were semi-structured in format and therefore these formed only the basis of the interviews. In addition, although interviewees were willing to take part in the interviews, there might be some inherent difficulties in obtaining complete information from the interviewees due to the policies of individual companies.

3.2 Model Development

3.2.1 Purpose of the Model

As discussed in previous chapter, a proactive approach to safety is called for to improve airline safety management system. This calls stem largely from the shortcomings in existing retroactive safety programmes, which focus on the identification of the accident causes and the human factors which are thought to constitute effective safety management. Some programmes have been designed to help to maintain safety proactively as introduced previously but few of them have had significant success. Therefore, apart from the method of interview which provides the existing knowledge of what is thought to contribute to an effective proactive safety (a safety mechanism), what is further required is a model which builds upon the safety mechanism by adding an increased knowledge of the organisational factors which serve to influence a proactive safety mechanism, and which will serve to be the predictors[20] of the performance of airline safety management system.

The model focuses on the hypothesised organisational factors which impact upon the development of a safety mechanism. Many such factors have been identified from the analyses in the chapter of literature review and will be identified in the interview. Building upon the results of this work, a hypothesised model of the development of a proactive safety mechanism will be presented.

In short, the purpose of the model is to provide a greater understanding of the complex and potentially important concept of a proactive safety mechanism and its influential factors for the airline industry. In addition to this, this model intends to:

- ✓ Identify the layers which contribute to the development of a proactive safety mechanism
- ✓ Identify the factors which exert an influence on the safety mechanism
- ✓ Identify the organisational factors which are the predictors of the safety mechanism and safety performance

In this way, the relationship between airline safety management system and safety mechanism and safety performance should become clear.

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[20] In statistical term, 'Predictor' means a possible factor (input) to forecast the consequence of something (output). For example, in Multiple Regression procedures, it will estimate a linear equation of the form:

$$Y = a + b_1*X_1 + b_2*X_2 + ... + b_p*X_p$$

In this equation, the regression coefficients (or B coefficients) represent the contributions of each independent variable (Xs) to the prediction of the dependent variable (Y). Therefore, Xs are the predictors of Y.

To this end, *four general hypotheses* will be explored and tested. The term hypothesis as used here should be understood in the broad sense of the word as these are intended to outline the aims and objectives of this part of study. These statements should be considered to be propositions, made from known facts, which form the basis for this investigation, rather than hypotheses in the statistical sense, which will be tested and either accepted or rejected. The outcomes of the investigations with respect to these hypotheses will be discussed in order to summarise the results of the investigations which formed the substances of this thesis.

3.3 How to Test the Model

Two methods have been used to test the model. One is a retrospective case study and the other is the use of a safety survey.

3.3.1 A Retroactive Case Study

The use of an "organisational accident" to demonstrate the failure of socio-technical systems is a technique employed extensively by Reason in developing and making a case for the Resident Pathogen Model. Working backwards from the accident site provides what Reason (1995b) calls a pathogen trail. This case study approach is based on Reason's concept, but it will focus mainly on the commercial airline industry. The use of the after-the-fact approach is not gifted with the spirit of "proactive" concept. However, at this stage, by dissecting the pathogen trail, the bottom-up metaphor helps to illustrate how the model explains the safety mechanism, which develops under the various factors identified in next chapter.

Selection Criteria

This case, the crash of Air Ontario Flight 1363, was selected in accordance with the following criteria:

Firstly the case must be informative, i.e. sufficient and available information is required. In the case of accident, formal accident investigation reports can help to provide a sufficiently lengthy pathogen trail to facilitate the analysis. Usually the more severe cases are the accidents/incidents, as the better known they are, the more they are subject to intense scrutiny. The case of Air Ontario is well qualified to serve as a subject for informative discussion in this section. However, it is worth noting that this does not mean that only serious or severe accidents/incidents are suitable to illustrate the model.

By using the case study, it aims to provide a useful illustration of the myriad forces, which conspire to define a system's safety mechanism. Given the complexity of the case, it is hoped that the case study will serve to provide the reader with a greater appreciation of the explanatory power of the model in relation to the way in which the safety mechanism developed, and how the safety management system has evolved.

3.3.2 Safety Survey

What is required next is an in-depth examination of the structure underlying the model. As such, the following methodology will use quantitative studies aimed at looking more closely at the relationships between the forces hypothesised to be at work under the domains of the model.

The study was conducted using a three-stage process of: questionnaire development, questionnaire piloting and questionnaire distribution. In other words, the survey was developed based on the safety mechanism model. The pilot questionnaire allowed the instrument to be tested and modified to suit the target audience for the final distribution.

3.3.2.1 Stage 1: Questionnaire development

1. The concept of a safety survey

The term "survey" means to make a detailed investigation of the behaviour, opinions, etc, of a group of people (Collins, 1995). There are three types of survey, based on the degree of their structure or formality (Hague, 1993). These are structured, semi-structured and unstructured surveys.

In structured surveys, the wording and sequence of most of the questions are fixed and are identical for each respondent, with each question having predefined answers. This ensures that any differences between responses are attributable to individual differences and not to variations in the survey.

The semi-structured survey has a mixture of questions with predefined answers, as well as those where the respondents are free to answer anything that he/she wishes. The advantages of this type of survey are the greater flexibility that they offer, and the opportunity of finding out more in-depth reasons for certain answers.

With unstructured surveys there are no pre-specified questions. Usually a checklist of questions is used to assist the respondents in describing their experiences, opinions and attitudes.

A perception survey, or called a culture or climate survey, is used to measure/assess the respondents' concept or behaviour. Bailey and Petersen (1989) suggest that *a perception survey is a better measure of safety performance and a much better predictor of safety result*, as it can identify the strengths and weaknesses of elements of a safety system. In other words, a *safety survey* is essentially used to review the extent of satisfaction with aviation operations, and to diagnose any problems that may be apparent or suspected. By assessing safety attitudes, the real safety level of an organisation can be determined.

Interviews and questionnaires are usually used in safety surveys to determine whether a particular facility or operation presents the risk of hazards. The former includes telephone or face-to-face interviews, while the latter are self-reported questionnaires, which may contain "positive and negative measurement" or "attitude scaling" types of questions, also called Safety Climate Questionnaire (SCQ).

Formation and use of the safety survey - Safety Climate Questionnaire (SCQ)

The safety survey has gradually increased in use since the 1980s. Some researchers (see examples in the next paragraph) claim that measuring safety climate can indicate the changes in organisational safety behaviour and would therefore be useful for evaluating safety programmes. They also argue that any effort to improve safety should be perceived as such by employees, and that the only way to measure this is by using a safety climate questionnaire (SCQ). SCQ is a structured survey, in which most of the questions have predefined answers and there is little latitude for a respondent to stray beyond them. However, it does have the advantages of a structured survey mentioned in previous section.

For example, Zohar (1980), who was the first to develop a safety climate survey, used it to establish the high agreement in employees' perceptions regarding the safety climate in their company. The level of this climate is correlated with safety programme effectiveness, as judged by safety inspectors. Zohar found eight safety climate dimensions in the resulting responses, they are *(1) Importance of safety training, (2) Management attitudes toward safety, (3) Effects of safe conduct on promotion, (4) Level of risk at work place, (5) Effects of work place on safety, (6) Status of safety officer, (7) Effects of safe conduct on social status, and (8) Status of safety committee.* Brown and Holmes (1986) found three dimensions by having Zohar's model validated on American sample. These three retaining factors were: *(1) Employee perception of how concerned management is with their well-being, (2) Employee perception of how active management is in responding to this concern, (3) Employee physical risk perception.* Dedobbeleer et al. (1990) studied the relationships between safety climate and organisational factors prevalent in most safety programmes. They also attempted to validate Brown and Holmes's three factors, but only found two factors, one of which measured *Management's commitment to safety in terms of management's safety attitudes and practices*; the other factor labelled *Workers' involvement in safety.*

In 1990s, increased efforts were made in the discussion of the measurement of safety climate and its subsequent applications. Safety climate scales have been developed primarily on the basis of attitude items (e.g. Niskanen, 1994), or based exclusively upon safety-related perceptions, with both attitudinal and perception items (e.g. Williamson et al., 1997).

Meanwhile, several questionnaires have been developed in an attempt to determine the key factors that comprise safety climate. Flin et al. (2000) and Guldenmund (2000) identified twenty-seven such studies. By 2000, over thirty studies using safety climate questionnaires have been published (Guldenmund, 2000). It is worth noting that there is no explicit distinction or discussion between safety culture and safety climate within these studies, and safety climate is generally taken to comprise a summary of employee perceptions of a range of safety issues. As such, whether safety culture and safety climate are the same or they have not been sufficiently defined to identify the deficiencies will be further investigated in the model.

2. Design of the questionnaire

Budworth (1996) refers to measuring safety climate as taking the "safety temperature" of an organisation. As such, potential uses for a safety climate questionnaire include: measuring employee perceptions of management commitment to safety, detecting areas for safety that require improvement, identifying trends in an organisation's safety performance and establishing benchmarks for safety climate, emerging from research on organisations.

According to the characteristics of the safety mechanism model, the concept of the safety climate survey will be adapted for questionnaire development in this research as a reference point. In order to obtain an individual's self-assessment of the conditions hypothesised in the model, a questionnaire was developed to reflect concerns at each layer identified in safety mechanism. The main objectives of this safety mechanism survey are to provide an assessment of the concerns affecting the safety mechanism; to verify its influential factors, and to validate the hypothesised factor structure in the safety mechanism.

In accordance with the hypothesised organisational factors, this questionnaire is designed to consist of two parts - internal factors and external factors. These items deal with the concerns of individuals both in the internal and external environment. They were intended to examine the degree to which the individual felt part of their organisations or considered organisational concerns when making choices at work.

A statement was constructed for each item (potential concern) so that participants could be asked to rate the extent to which these aspects of their working environment were considered when making choices at work. The response format consisted of a six point scale which ranged from "Strongly disagree" (1) to "Strongly agree" (6), plus "N/A" (7).

Therefore, these two sections of the questionnaire sought to verify the salience of various concerns which were identified as being relevant to the development of a safety mechanism by assessing the frequency with which each was considered in making day-to-day choices at work.

3. Method of interpreting the questionnaire

In order to determine the underlying dimensions of the organisational safety mechanism, a principal component of factor analysis, followed by a varimax rotation was performed on the questionnaire to interpreting the results.

Factor Analysis

Many statistical methods are used to study the relationship between independent and dependent variables. Factor analysis is different. It is used to discover the patterns of relationship between many dependent variables, with the goal of discovering something about the nature of the independent variables that affect them, even though those independent variables are not measured directly. The inferred independent variables are called *factors*.

In other words, factor analysis is a form of multivariate analysis which is based on the assumption that human behaviour is rarely attributable simply to one cause or influence, and that underlying factors, components or elements can be identified and used to explain complex human behaviour. As such, the purpose of this technique is to identify these underlying factors in terms of their common underlying dimensions.

Principal Components Factors Analysis

As factor analysis is a technique which is able to reduce a system of many scaled measurements (or variables) down to a small number of factors, it is accordingly a method of data reduction. By analysing a set of attitude data using this technique, it may be possible to gain a more coherent comprehension of the human behaviour being examined. In factor analysis, the factors are not directly observed; rather, they are defined by a group of variables or items that are components of the abstract factors.

As mentioned above, factor analysis is often applied to many attitudinal items in a survey, so it is commonly used on Likert scales with at least five categories. A typical factor analysis suggests answers to four major questions (Darlington, 2002)[21]:

1. How many different factors are needed to explain the pattern of relationships among these variables?
2. What is the nature of those factors?
3. How well do the hypothesised factors explain the observed data?
4. How much purely random or unique variance does each observed variable include?

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[21] Darlington, R. B., Factor Analysis. http://comp9.psych.cornell.edu/Darlington/factor.htm, 2002.

Steps in conducting a factor analysis

There are four basic steps in factor analysis:

1. Data collection and generation of the correlation matrix
2. Extraction of initial factor solution
3. Rotation and interpretation
4. Construction of scales or factor scores to use in further analyses

This questionnaire study is going to follow these main steps to conduct the analysis. The results are detailed in Chapter 4.

4. Target sample for study

The target sample selected for the present study is airline safety managers world-wide, including Africa, Asia and Pacific, Middle East, Latin America and the Caribbean, Europe, and North America. The rationale behind this decision included several factors to do with the nature of the required data.

Firstly, a cross-airline approach was taken in order to ensure diversity in the sample; a general population survey provided a means of this diversity without having to approach multiple airlines. Secondly, the information which was sought from the survey was general in nature. The present study dealt with the factors which influenced an individual's actions, which may affect safety on a daily basis, necessitating a relatively in-depth knowledge of the industry. Therefore, the general population, i.e. airline safety managers world-wide, was deemed to be the most readily available target audience which could provide the diversity and knowledge required for the study. The method and means of acquiring this sample will be discussed.

There are around 2000 commercial airlines in the world, including scheduled, charter, cargo, and helicopter airlines (ATI, 2001)[22]. However, 80 percent of the revenue of the total airline industry was generated by only 20 percent of these in the year 2000. As such, the initial idea was to find out the most profitable top 400 (2000×20 percent) airlines in the world. Steps taken were as follows:

1. *Airline Business* (September, 2001), listed the top 200 passenger airlines, ranked in terms of RPK (Revenue Passenger Kilometre) in 2000.

2. *Air Transport World* (July, 2001), showed the most powerful airlines by region.

Table 3-2 Samples and Regions of Questionnaire Administration

Region / Source	**Africa**	**Asia & Pacific**	**Latin America & Caribbean**	**Europe**	**Middle East**	**North America**	**Total**
Airline Business Sept 2001 (Top 200 in terms of RPK)	13	48	22	65	13	39	200
Air Transport World July 2001 (World traffic Statistic 2000)	7	39	1	42	3	33	125
Total	**20**	**87**	**23**	**107**	**16**	**72**	**325**

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[22] Air Transport Intelligence (ATI), Online Database. http://www.rati.com

Table 3-2 shows the results of these findings. By putting the results of these two databases, these are the top 325 airlines in terms of RPKs and traffic in 2000 (a full list in alphabetical order is shown in Appendix K), and the breakdown result for each region. As there was no available database to search for the remaining 75 airlines to make the sample total 400, it was decided to use these 325 airlines as the distribution sample.

Addresses and contact details for the safety managers of the targeted airlines were obtained from the ATI database. In cases where the names of safety people were unavailable, the name of the recipient of the survey package was replaced by a generic title of "Safety Manager".

3.3.2.2 Stage 2: Questionnaire piloting

A pilot study was conducted in order to identify any specific problems with the questionnaire in terms of understanding the questionnaire items, understanding of the questionnaire instructions, or other problems with the data obtained (such as possibility of restriction of range or response bias).

Due to the restraints of geography and time, plus the fact that the factor analysis requires a large sample to conduct the analysis, it was decided that the pilot survey would not entail the standard procedure of carrying out a mailshot to members of the target population. Instead the nearest and most convenient persons were chosen as respondents for the pilot test. The questionnaire was completed and criticised by eight individuals who possessed skills and experiences in aviation, by personal hand-in or by email. These respondents worked at a management level in different airlines, which is one of the limitations of the targeted sample.

3.3.2.3 Stage 3: Distribution procedure

The questionnaire, printed in the style of an A4 booklet, was sent by post in a sealed envelope to the representative (Safety Manager) at each participating company. Each survey package was contained in an envelope which bore the name of the University and a label which identified the package as the Safety Research Study. Included within the survey package was a questionnaire, along with a covering letter from the author and a freepost envelope. The covering letter was printed on the School of Engineering letterhead, and was hand addressed and signed by the researcher. It explained the purpose of this research and ensured the confidentiality and anonymity of all responses. The pre-addressed freepost envelope enabled the direct return of the completed information to the author. Both the questionnaire and covering letter are available at Appendix L.

3.4 Summary

With respect to fulfilling the main objectives of this research, an interview study will be conducted followed the findings of literature review in order to develop the safety mechanism model. The case study and questionnaire study are followed to plan and implement with the aim of testing the hypotheses of the safety mechanism model. With respect to the hypothesis, the results of the factor analytic study will be presented, which will serve to group the myriad variables identified within the model into a number of factors. As such, the hypothesised factor structure in the safety mechanism can be identified as well as a framework for understanding the factors which underlie the development of a safety mechanism across regions. The following chapter will present the result of these studies.

CHAPTER 4

Interview Findings and Model Development

> *"Many of the ills of organisations stem from imposing an inappropriate structure on a particular culture, or from expecting a particular culture to thrive in an appropriate climate. Vines don't grow where the sunshine doesn't fall in the right proportions with the rain."*
>
> *~ C. B Handy, 1985*

4.1 Interview Findings

Aligning with the interview format described in Chapter 3, the findings of the interviews are discussed as follows. For the purpose of this discussion, these findings have been collapsed across airlines and organised according to the topics discussed during the interview.

4.1.1 Safety Management System

The purpose of this section of the interviews was to obtain an idea of how safety is managed within different airlines and how the safety management system is conducted. All of the airlines interviewed use the term "Safety Management System" (SMS) to describe their system of safety management.

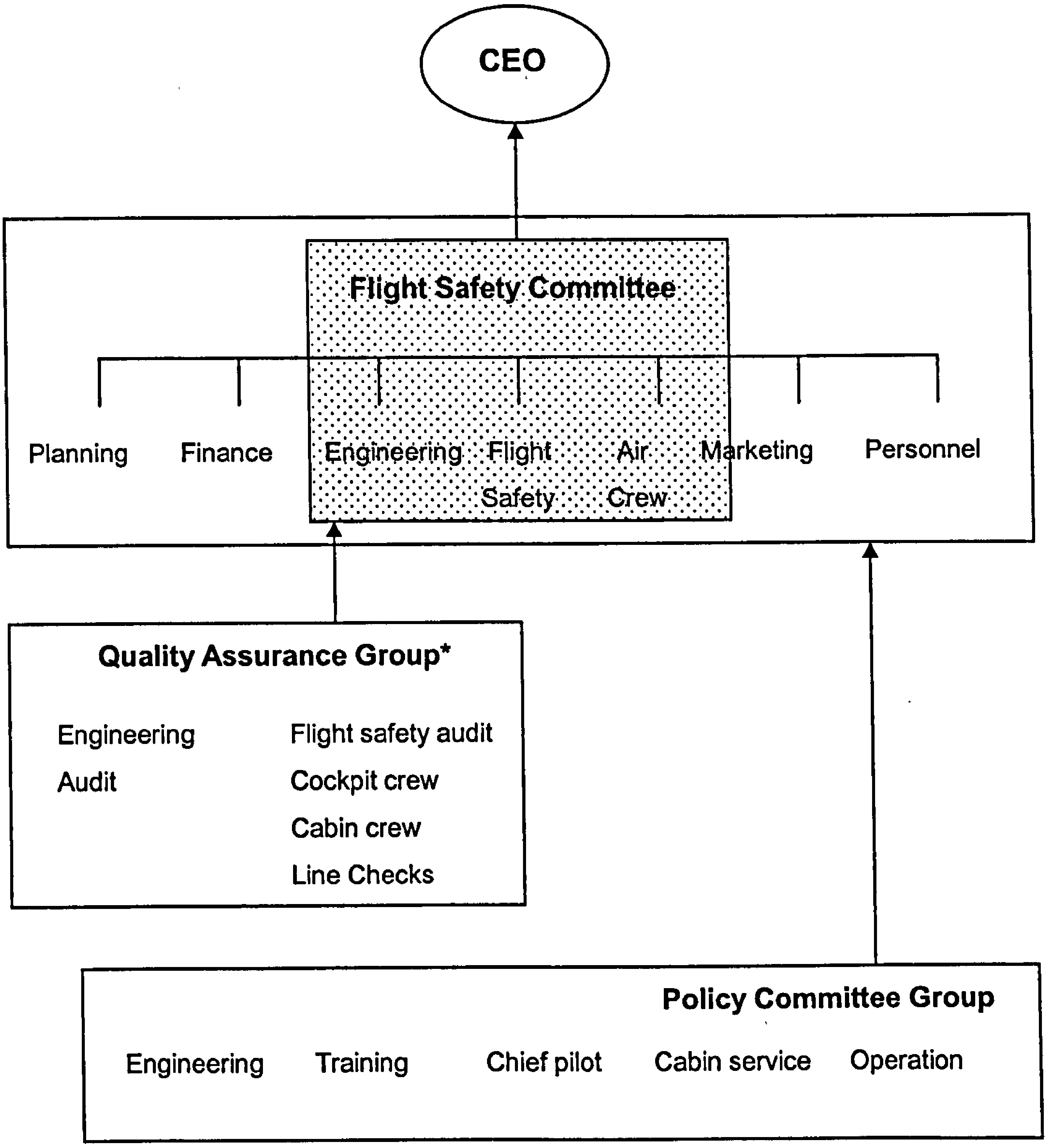
Although the structure of a SMS might not be the same in every airline, all interviewees agreed that SMS should be an integrated system, including risk management tools, associated support, training and communication systems, which involves all the departments in the company. According to the interviewees, the components of a SMS should cover the following:

- ✓ Clear policy and objectives
- ✓ Top management commitment
- ✓ Identification of safety risks
- ✓ Safety performance evaluation: performance indicators of safety to result in enhanced operational and maintenance performance
- ✓ A well established safety culture
- ✓ Feedback to ensure continuous improvement

One airline employee interviewed portrayed the airline's concept of a safety management system, which is similar to the diagram presented by Britannia Airways (see Figure 4-1). Members from Policy Committee and Quality Assurance (different names are used in different airlines) involved with advising on flight safety. The managers of these groups freely discuss and communicate inter-departmental safety concerns. The flight safety committee directly report to the president (CEO). The direct access to the top president was also emphasised by other airline interviewees (see next section 4.1.2).

Meanwhile, both interviewees from western airlines emphasised that a SMS should be built as a proactive system, which can anticipate potential safety problems, ensuring they are addressed before an incident or accident occurs.

Figure 4-1 Airline Safety Management System



Source: Adapted from Sharples, 1996

* Note: Within Quality Assurance Group, **training audits** should be included and applied to cockpit and cabin crew on a regular basis.

4.1.2 Organisational Structure

Some attention needs to be paid to the issue of the safety manager's position within the organisational structure. With traditional organisational safety approaches, the safety officer, who is independent of the operational departments, reports on the company's safety performance to the chief executive in order to make the final decisions about safety improvement and investment. All the safety managers in the interviewed airlines have direct access to the top managers and relative independence compared with other departments in their airlines.

4.1.3 Risk Management and Risk Programmes

The purpose of this section is to explore one of the values of a SMS - risk assessment and evaluation, in the airline industry.

All the five airlines involved in the interviews were using some form of risk assessment procedures and tools. Some were highly formalised (large and medium size), some were less so (small size). The management of the risk assessment process is often termed "risk management"[23]. One interviewee put the aim of risk management well: "Our aim is to find a technique that helps us to manage risk, without having conflicts with our financial goals and fitting in the decision-making processes. More importantly we want to find a technique that enables us to spot a hazard before it had manifested itself."

One interviewee called the process "hazard management" and provided the following definition of hazard management: "Hazard Management is kind of the risk based management approach basically. The techniques used in hazard management are identifying hazards by risk-control measures to prevent the occurrence of hazards."

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[23] The concept of risk management has been discussed in Chapter 2 from the academic point of view, which shows that a robust SMS can be achieved by practising safety directives and initiatives. These processes constitute quality and risk management.

The value of risk management or hazard management is the processes/ procedures to spot the hazards and then reduce/ eliminate them. The success of this system largely depends on the quality of safety information gathering process that fit in the system. As such, in some airlines in the industry, the quality manager replaces the safety manager in charge of the safety function. Yet this view is not totally agreed by interviewees. One interviewee noted: "Safety has always been considered implicit in the quality management; accordingly, many companies regard their quality policy as their safety policy too. It is really a misunderstanding." For example, ISO 9000 will provide a process that assures *consistent* application, however, standards may be good or bad!

The following are the detailed results of discussions with interviewees regarding risk management. Under the safety management system, a common technique is to use varying techniques to identify risk and then to apply controls to manage the hazard. This process is assisted by determining a level of severity based on the product of the seriousness of an event against the frequency of such an event happening. Hazard can then be managed to the level of "As low as reasonably practical" (ALARP). Figure 4-2 outlines the common risk assessment framework and concepts[24] in the interviewed airlines.

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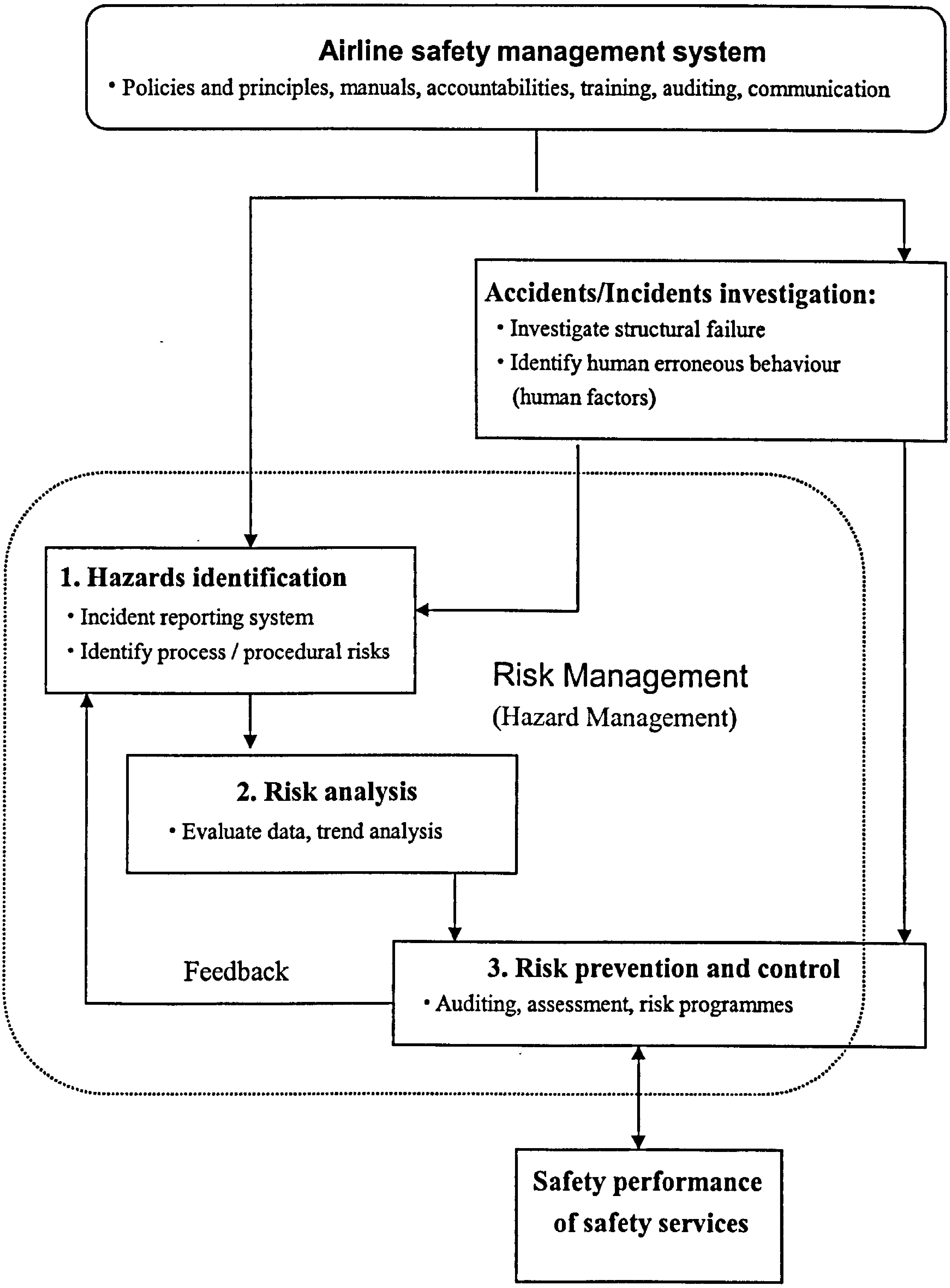
[24] Please refer to Chapter 2 for the description of various risk programmes and analyses.

Figure 4-2 The Common Framework of Risk Assessment in the Interviewed Airlines



1. Hazard identification:

- ✈ Identify all undesirable events or circumstances associated with each hazard which could result in harm (from accidents/incidents investigation, and incident reporting systems)
- ✈ Identify and categorise potential sources of harm, whether process or procedural risks

Apart from identifying and categorising source of harm, the major aim is also to feed the database with data and parameters. Not only can the database be used for risk analysis, but also safety cases can be developed in the following stages. It is worth noting that in terms of flight safety data, two western airlines use BASIS to input, analyse and manage flight crew-related errors for their safety information database, from which safety cases are developed. Two eastern airlines develop their own safety databases similar to BASIS, due to the fact that their safety case technique is still at the research stage, and the software interface is unable to meet their requirements, although they acknowledged the value of BASIS. The other just has a simple safety database and no plans to develop safety cases so far.

In terms of maintenance aspects, two airlines use MEDA for the input data; one is under consideration. One western airline has developed a database similar to MEDA. The small eastern airline uses a simple input database.

2. Risk analysis:

- ✈ Systematically evaluate all potentially harmful events and circumstances to identify the degree of risk exposure

The aim of risk analysis is to evaluate the input data and undertake a trend analysis (even human reliability analysis). Within the interviewed airlines, one of them uses Risk Analysis Matrix and FORAS. Two use FORAS and one has developed a similar technique but with a different name. It was found that larger airlines tend to use multiple risk analyses to analyse risks due to the scope and complexity of their fleet.

3. Risk prevention and control

- ✈ Develop/implement appropriate measures to prevent occurrence of accidents
- ✈ Evaluate possible harmful effects of undesirable events/circumstances actually occurring and define those measures necessary to limit/contain them and re-establish a safe operating situation

The aim of risk control is to minimise or mitigate the risk exposure by using defences (process/technology). Safety policy should mandate equipment fit. There are a few techniques employed by the interview airlines, and some equipment is installed on a voluntary basis, such as EGPWS.

Two points are noticeable here. One is that larger airlines are willing to invest in expensive equipment for safety, and are more willing to spend time in auditing[25] (e.g. an internal survey). The other is that the interview airlines tend to focus on the risk control tools for flight safety (for instance, CRM and FOQA have been paid a great deal of attention and have been developed for a long time); however, western airlines show a greater awareness of maintenance audits than do eastern airlines.

To sum up, the following risk programmes have been adopted by the interview airlines, and are also regarded as the basic requirement for current airline safety management operations.

- ✓ Air Safety Reports /Incident report system
- ✓ BASIS (or other safety information database), and confidential data exchange (only for BASIS users)
- ✓ GPWS

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[25] Another view on this is, Western airlines comply with a regulatory requirement, while others may have no regulatory requirements imposed for that. However, without the leverage will hesitate to commit to investment.

- ✓ Traffic Collision Avoidance System (TCAS, not for the smaller airlines)
- ✓ FOQA, or Quick Access Recorders (QAR)
- ✓ FORAS or Risk Matrix
- ✓ CRM
- ✓ Human Factors (HF) and Error Reduction (particularly in maintenance)

4.1.4 Safety Audit

A safety audit is an important component of the safety management system. It is also part of the safety assessment process and risk management. As accidents are either unforeseeable or unforeseen, the objective of safety auditing activities is to avoid the latter type of accident or incident. As such, some attention needs to be paid to the issue of safety monitoring and audit.

The interviewees thought that it was possible to eliminate risks as a matter of routine by objectively examining all aspects of a department's activities that impinge on air safety. This can be achieved by carrying out a safety audit and taking remedial action as soon as shortcomings (potential hazards) are identified.

Safety auditing includes both an internal and external review, and inspection[26]. The purpose of the routine self-inspection is to confirm that minimum safety requirements are met for the purpose of the company's safety goals. The result of the safety audit can also be used as indicators of safety performance[27]. Some safety managers mentioned specific auditing programmes (e.g. the large western airline has several audits respectively for flight operation, ground operation and engineering. There is also a cross-department audit. The complexity of the programmes is higher than for the medium and small airlines). Besides, with the growth of alliance and network

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[26] The external examination and inspection from the regulators will be discussed more in the section about the regulator's role.

[27] There are other safety performance indicators such as accident/incident rates, aircraft proximity hazard reports and equipment failures to show the level of risk, and the shortcomings in need of improvement.

sharing, an increased risk of cross-cultural issues also impact operation. Most of the safety manager mentioned that the new joint relationship aims to increase the competitive advantages and market share by cooperation and standardisation, which, nonetheless, inevitably results in significant changes and difficulties in airline operation, in particular with safety services. Differences in company culture and safety system result in problems. KAL and Delta are good examples (Please refer to section 2.6.2.3, footnote 15 for the case of Delta's safety review on KAL).

One interviewee especially mentioned the value of auditing the cultural aspects of safety[28]. However, its current state of progress is to promote the non-blame and reporting culture (as is the case with the other four interview airlines) and evaluate the safety culture by distributing a safety culture survey (only one interview airline). There is no practical programme to support cultural auditing so far.

4.1.5 Culture versus Safety

The relationship between culture and safety management was one of the major focuses of the interviews, and Chapter 2 has showed its importance to proactive safety management. The culture approach was recognised by the interviewees, but as mentioned in the previous section, the culture approach is making slow progress, due to the difficulties of measuring so called "culture".

As discussed in Chapter 2, layers of culture can be understood as overlapping elements. Therefore, a safety culture exists as a subset of organisational culture. Since the interviewees for the research were selected for their ability to manage safety, organisational culture was not mentioned explicitly by all interviewees, compared with safety culture. Below are the resulting discussions of organisational and safety culture respectively.

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[28] Glennon (1982) reveals that organisations with poor safety culture scores had higher accident rates than those organisations with better safety culture scores. However, there is no further academic evidence to support this statement.

4.1.5.1 Organisational culture as a source of reliability

Although organisational culture attracted less attention by the interviewees, the interview findings reveal that organisational culture is likely to be seen as a source of reliability to sustain the airlines and their safety culture. Reliability is conventionally embodied in structure and training, but seems to be up against some limits. Here however, it means the support that organisations can commit and the resources that they can allocate. That is to say, if the organisational culture places safety as a higher priority than production, the resource allocation within the airline will favour the concerns of safety over those of cost.

It was also found that the concept of organisational culture, to the interviewees, was very abstract. One of the interviewees used the term "organisational climate" to express a concept similar to that of organisational culture. Other interviewees did not distinguish between organisational culture and organisational climate. Generally speaking, interviewees regarded organisational culture/climate as the culture which reflects the belief of employees towards mission, activities, etc that have worked well in the past, have been assumed to translate into behaviours and norms.

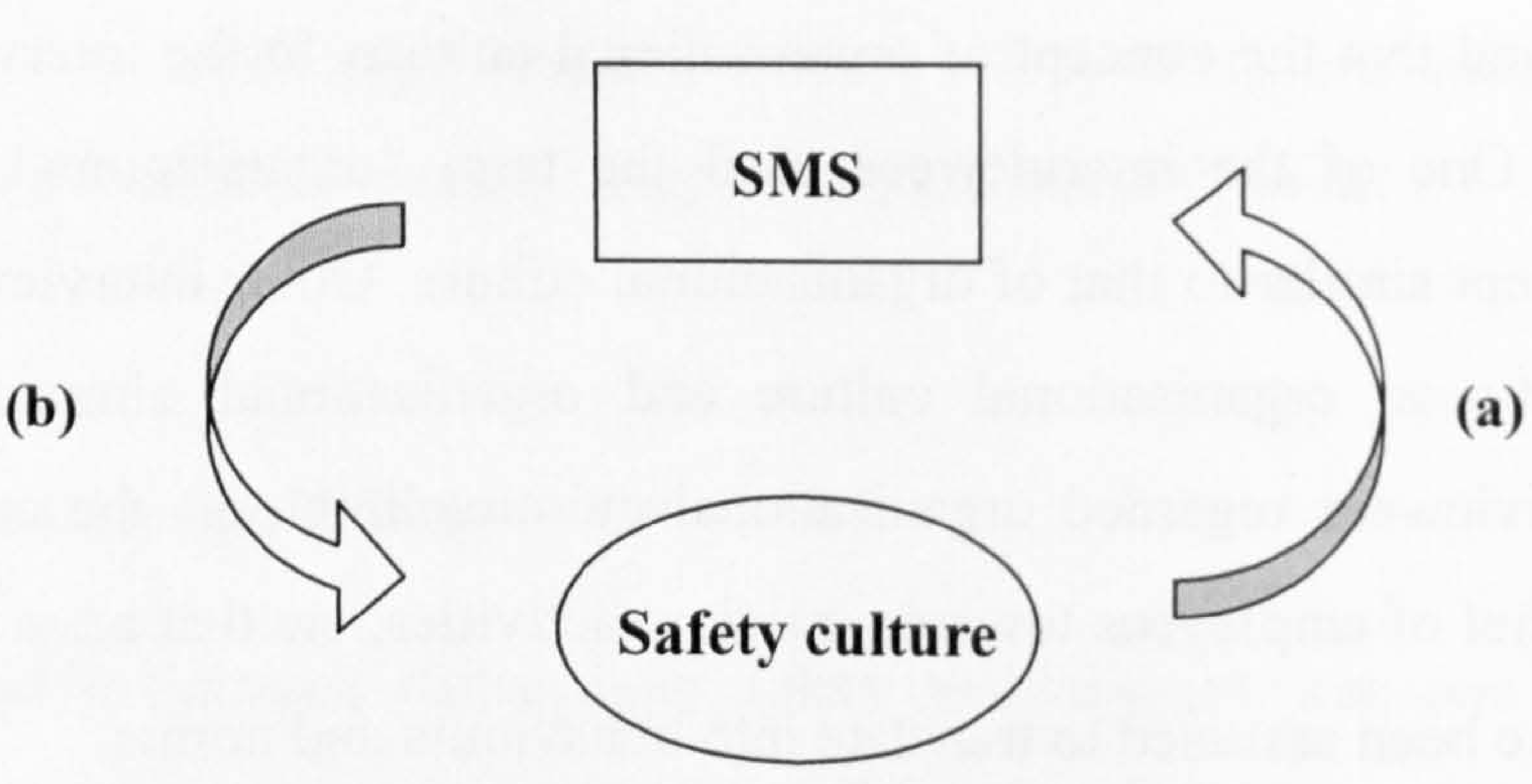
4.1.5.2 Safety culture/climate

Aspects of safety culture were more remarked upon by the interview airlines than were those of organisational culture. The premise put forth was the observations of interviewees, which is that a safety culture consists of a combination of safety practices (from SMS) and the interaction of the organisation with various aspects of its environment.

The phrase "safety culture" is used very commonly in the airline industry, so no interviewee chose to use "safety climate". However, when asked the difference between safety culture and safety climate, four interviewees reckoned that there was a slight difference between these two.

Moreover, all interviewees believed that how a firm responds to safety depends largely on its safety culture. To build a good safety culture is thus the goal of the interview airlines because an organisation with an appropriate safety culture would be more likely to implement an appropriate safety management system, and safety management programmes would not be effectively used if they were not supported by an appropriate safety culture. It therefore shows the relationship between safety culture and safety management system (See Figure 4-3).

Figure 4-3 The Relationship between Safety Culture and SMS



(a) Interviewees show how a good safety culture can implement a robust SMS and safety initiatives (e.g. a no-blame culture can encourage line workers to report errors, which can help to identify hazards)

(b) Premise: Safety culture consists of safety practices and initiatives in the SMS.

4.1.6 The Role of Regulator and the Relationship with Airlines

The final area of interest is the role of regulator and its relationship with the airlines, because the civil aviation authority is closely involved in the development of the airlines. The impact of regulatory environment on airline safety has been discussed in Chapter 2. Below is a summary of the interviews in terms of the interviewees' thoughts on regulators, which also contain some opinions from the interview on regulators:

View from Interviewees-

There are many functions provided by aviation regulators. Especially in recent years, the increasingly intense competition, privatisation, strategic alliances and new type of operation like low cost operators are taking place with the developments in the world's airline industry, which reflects a continuing growth in demand for air transport. This complexity places more stress on the regulators than ever before.

For airlines, regulators, such as Civil Aviation Authorities, act as monitors and inspectors in terms of the safety function. The purpose of the routine inspection by the external regulators is to confirm that minimum safety requirements are met for approval purposes, both for airlines' and passengers' own good. Given the commercial competition between airlines, monitoring and inspecting airline safety is becoming more and more important, in particular with other issues resulting from the alliance and network sharing, such as the exchange of cockpit and cabin crew, the requirement for safety standards, the use of risk programmes and so on. The standardisation and improvement of global alliances' joint safety performance are therefore in need of regulators' close attention and inspection.

View form regulators -

In addition to this inspection function, regulators also act as assisters. Their guidance and principles are needed to help to maintain civil aviation operational safety risks at the level of ALARP (mentioned by the interviewees as well). By gathering and sharing safety information, the regulatory environment aims to provide airlines with the industry's latest principles, information and programmes. For instance, the concept of human factors has been recognised as important in the drive to improve aviation safety.

Human Factors encompasses psychology, physiology and engineering. In the broad array of civil aviation, Human Factors include design and operation of aircraft, maintenance of aircraft, provision of air traffic services, etc. As such, given CRM, accident investigation, design of flight instruments, human limitations, maintenance errors, etc being traditionally attracted a great deal of attention, regulators must pay and have paid much more attention to human factors than before although remedy of HF is getting more about influencing organisational culture and value as to the individual. Some areas are in need of more exploration, such as organisational issues, safety management concepts, integrated design and learning from incident data.

So far in this industry, with the help of various methods, techniques and tools, Human Factors advice has been developed to help to apply human factors in many areas by the trained specialists. For example, the western CAA interviewed has four HF specialists under its regulation group. The main areas of their work are:

1. Supplying human factors input to specific tasks/projects within the technical divisions of regulation group;

2. Raising awareness of human factors and initiating human factors training across the division appropriate to divisional needs;

3. Fostering relationships with and/or participating in relevant groups outside CAA, such as JAA, and ICAO;

4. Keeping abreast of developments within human factors and applying this knowledge as appropriate.

These functions not only feature in the jobs of regulators, but also imply the interaction between airlines and regulators and the assistance offered by the regulators.

4.1.7 Improvement and Other Comments

The following is a summary of the interviewees' observations regarding safety improvements in the air transport industry and in their airlines so far:

- ✓ Safer aircraft designs
- ✓ Developing and improving national and international regulations
- ✓ Enhanced staff training
- ✓ Integrated and intelligent systems to support first line crews
- ✓ Human factors issues

One airline interviewee particularly mentioned total safety management, which was a contribution from the study of human factors and the development of a no-blame culture.

In addition, one interviewee stressed that the importance of safety control lay in a multi-channel feedback system, and the ability to respond effectively to events or hazards.

One interviewee stated that "In the current airline industry, the misunderstanding still exists quite common in some airlines, such as, 'More (extra) safety is costly', 'quality assurance system is there to ensure all work is done in accordance with procedure and process', etc. These complacent thoughts will only lead to nowhere in safety improvement, particularly when there is a conflict between cost and safety."

Another interviewee said that "Risk management must be effective because through this process, risk can be identified, measured, reviewed and controlled. Nevertheless, it is more important that all employees truly understand what's the value of safety in all operations for the purpose to create a sustainable operating environment."

The results of interview will be used to strengthen the underpinned knowledge of the safety mechanism and the development of organisational factors.

4.2 The Safety Mechanism Model

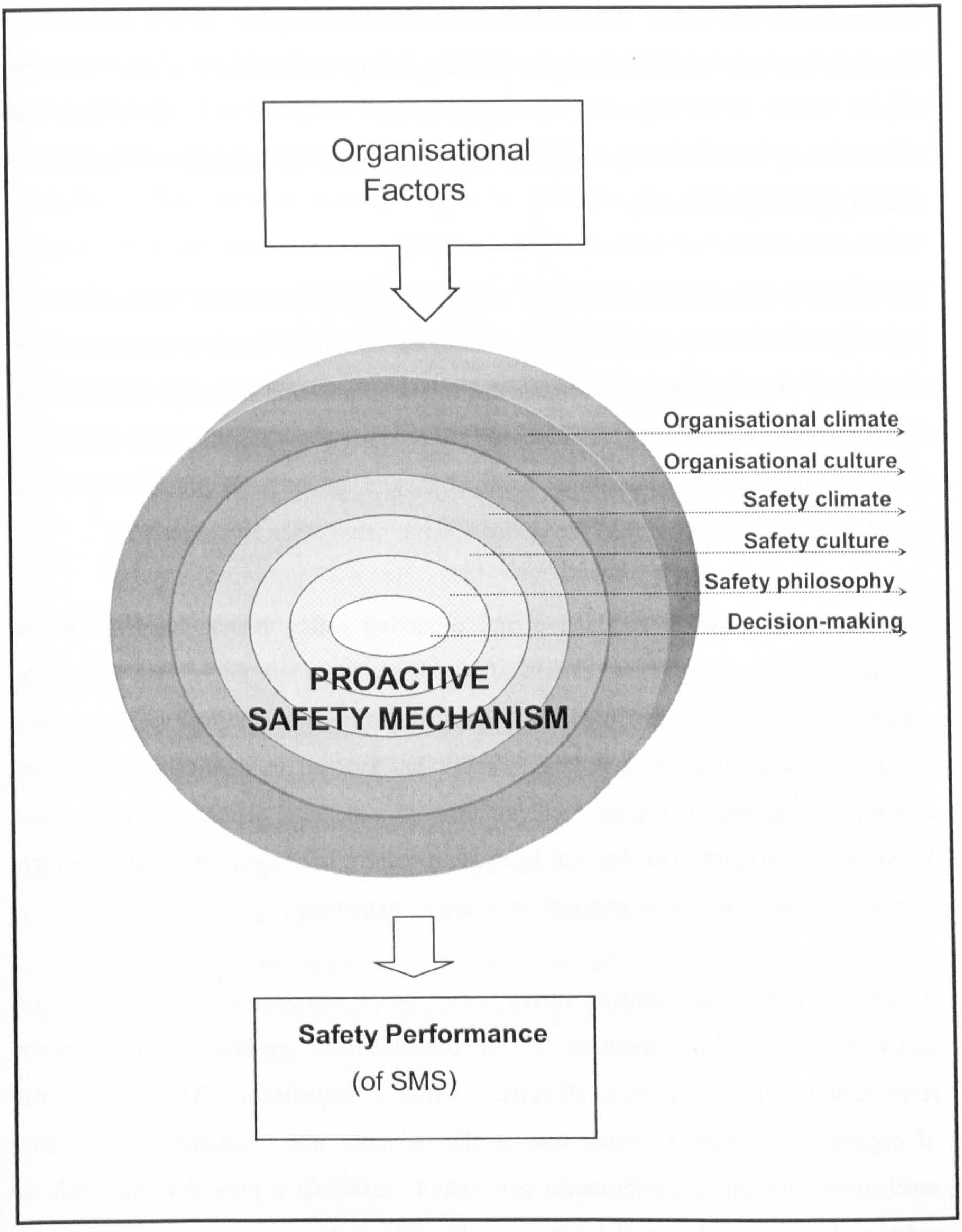
As previously discussed in Chapter 3, what is required at this point after conducting the interview is to develop the safety mechanism model, building upon the existing knowledge of what is thought to contribute to an effective proactive safety by increasing the knowledge of the factors which affect a proactive safety mechanism, and the SMS performance, to improve the shortcomings of existing retroactive safety programmes. The followings will illustrate the development of the model.

4.2.1 Overview and Hypotheses of the Model

The framework of this model is designed at Figure 4-4. The safety mechanism is organised as a series of concentric circles which are intended to represent the relationship of each layer, which combines with organisational factors to form a safety mechanism model. It has both bottom-up and top-down metaphors characterising the safety mechanism. The former is that of throwing pebbles into a pond. If one stone is thrown in, ripples emanate from the point of entry and continue unchecked. Thus, carrying the metaphor over to the issue of a safety mechanism, with the stone thrown into the pond, each level of the system is relatively affected, from each individual's understanding of the concept, which translates to knowledge, and subsequently to behaviour, which eventually shapes the organisational climate.

Taking this one step further, the organisational climate exerts an influence on organisational culture, which in turn affects safety climate and safety culture. Safety culture influences safety philosophy, and safety philosophy shapes managerial decision-making, which results in good or bad consequences for safety performance.

Figure 4-4 The Structure of Proactive Safety Mechanism Model



With having each layer of the composite defined (see Hypothesis 1), this model will focus on the top-down metaphor of the safety mechanism, which illustrates the way in which climate/culture presents both opportunities and threats for safety management, because the climate/culture of an airline is often held as being of critical importance to corporate strategic decision making. Namely, safety is ultimately a state of mind (Sayce, 2001). It is supported by organisational structure and regulations, but fundamentally it is the matter of concept and behaviours, which influence the outcome of safety (see Hypothesis 2).

The safety mechanism model is not a model of proactive safety management or organisational climate/culture. It is a model of the evolution of safety performance in the context of proactive safety management. The implication of using this model to assess proactive airline safety is to identify the organisational factors which will affect the safety mechanism. Meanwhile, external factors are there to present the forces outside the airline which reflect the environmental factors (see Hypothesis 2).

The difference between retroactive and proactive safety management is in the treatment of the contributing causes of accidents and their underlying factors to prevent accidents from recurring. The traditional approach to studying aviation safety has involved analysing accident data. Research has focused on identifying factors that link to, for example, pilot-error accidents through systematic accident investigations. However, the accident rate has not been significantly improved for decades, which points to the need for a new approach in safety management.

Proactive safety management moves away from pilot-error as the focus of understanding accident causation, to the organisational approach, which assigns responsibility for an accident to all systems within an organisation. The investigation of organisational factors, which acts as the mediator and predictor of the safety mechanism and safety performance can help to establish a proactive approach to safety and improve safety performance (see Hypothesis 3).

The systematic approach is designed to ensure continuous improvement by analysing whether the values of an airline's climate/culture are consistent with good safety practices. For this purpose, management need to establish a support system so that all employees can use operational definitions to analyse the resulting data and to identify barriers to continuous improvement.

Most important of all, chapter 2 stated that the current proactive concept and approaches aim to uncover the latent organisational conditions, and avoid the company surrounding errors or inadequate recognition, which degrade safety in the workplace. This research therefore aims to establish the organisational factors affecting the safety mechanism in order to establish the proactive approach to safety. Certainly it requires an understanding of the traditional aspects of human factors-communication, stress, and ergonomics, as well as accident investigation, incident investigation data. etc, which have been identified in Chapter 2. An airline's safety health and performance need the co-ordination of both reactive and proactive safety management (see Hypothesis 4).

Hypotheses

In keeping within the aim of this part of the research, to develop the safety mechanism within the proactive management, four general hypotheses will be explored and tested. The term hypothesis, as used here, should be understood in the broad sense of the word as these hypotheses are intended to outline the aims and objectives of the remainder of this thesis. These statements should be considered as propositions, developed from known facts, which formed the basis for this investigation. This is quite different from the hypotheses in the statistical sense that implies specific inferences and will be tested and either accepted or rejected.

Hypothesis 1:

The safety mechanism is the composite of organisational climate/culture, safety climate/culture, safety philosophy, and decision-making. The definition of each layer will be redefined (except decision making) to suit the airline industry.

☞ This hypothesis will be tested by a literature review.

Hypothesis 2:

The safety mechanism model will be demonstrated as a multidimensional construct, which will be influenced by a complex factor-structure. Meanwhile, this factor structure will also reflect the current environmental factors in the airline industry.

☞ This hypothesis will be tested by the use of case study and questionnaire.

Hypothesis 3:

The organisational factors mediate the relationship between the safety mechanism and safety performance, and act as predictors of safety performance.

☞ This hypothesis aims to be tested by the literature and questionnaire, which includes a self-rated safety performance measure.

Hypothesis 4:

The safety mechanism model is seen as being critical to the development of proactive safety management and evolution of safety performance; however, the airline safety health and performance need the coordination of proactive and reactive safety management.

☞ This hypothesis will be tested by the combined findings, including the literature review, case study and questionnaire.

4.2.2 Layers and Their Definitions

For the purposes of the model, six system layers have been specified. The six layers of the safety mechanism are: (1) organisational climate, (2) organisational culture, (3) safety climate, (4) safety culture, (5) safety philosophy and (6) decision-making. These layers will be defined in the following sections to suit the application to the airline industry.

4.2.2.1 (1) Organisational climate & (2) Organisational culture

The characteristics of organisational culture and their relationship with safety have been discussed in Chapter 2. However, when conducting interviews with airline safety managers, the term "climate" was found to be used by one interviewee, although the term "culture" tended to be more commonly used. According to the *Collins Dictionary* (1995), "climate" is defined as: a) typical weather conditions of area; b) a prevailing trend. This would seem to have a different meaning as compared with culture. Yet sometimes the two are used interchangeably when they are applied to organisational research. Identification of organisational climate and organisational culture is needed however because these two concepts are so global and so abstract that they can run the risk of becoming virtually meaningless.

What is organisational climate and the distinction between the two

In the 1970s and 1980s, organisational culture and climate attracted a great deal of attention because they provided views for managers to overlook their business. Much research was undertaken under the heading of organisational climate in the 1970s. Gradually, during the 1980s, the term "culture" replaced the term "climate" in this type of research (Guldenmund, 2000). Organisational culture is seen as a kind of reliability to sustain a business, as proved in the interview. Nowadays, this concept is referred to by the term "organisational culture", whereas the term "organisational climate" has come to mean more and more the overt manifestation of culture within the organisation.

Nonetheless, debates on distinguishing organisational climate from organisational culture always exist. For example, De Cock et al. (1986) argue that organisations are characterised by a coherence of numerous processes. Organisational climate then is the perception of this coherence by all the members. On the other hand, organisational culture is the underlying meaning given to this coherence, which forms a pattern of significance and values (quoted from Guldenmund, 2000).

Conversely, Schein (1992) conceives climate as preceding culture, i.e. climate is culture in the making. So climate is replaced by culture and culture then conveys a broader, and more profound and comprehensive meaning. Furnham and Gunter (1993) regard organisational climate as being an index of organisational health, but not a causative factor of it. What organisational climate measures may access are some dimensions of organisational culture within a limited range.

Culture is part of organisational climate

In order to have a clear construction of the safety mechanism, this research intends to follow the themes of De Cock et al. (1986) and Schneider (1975). In particular, the latter brought the distinction between descriptive attributes (perception of organisational practices) and affective attributes (reaction to same practices and procedures) for organisational climate and organisational culture respectively, given the difficulties of distinguishing organisational climate from culture. Therefore, organisational culture is seen as part of organisational climate.

This concept is also supported by Handy (1985). He provided an analogy to explain why an appropriate organisational climate is important if a management initiative (efforts to manage safety or some other aspects of performance) is to thrive within the organisation:

> *"...many of the ills of organisations stem from imposing an inappropriate structure on a particular culture, or from expecting a particular culture to thrive in an appropriate climate. Vines don't grow where the sunshine doesn't fall in the right proportions with the rain - nor has anyone yet found a more effective technology for tending the vines than the human hand."*

Using the analogy of the garden, organisational climate is just like the environment, which needs to be full of sunshine and rain to cultivate the flowers and plants. Organisational culture is like the ways of coping with the influence of the environment. For instance, nationally-owned airlines are literally more politically-orientated than privately-owned airlines in terms of organisational climate, i.e. nationally-owned airlines value their nations' benefits higher than the airlines themselves. Thus, this type of airline's organisational culture tends to be bureaucratic and inflexible[29].

The detailed definitions and differences between organisational climate and organisational culture are listed in Table 4-1.

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[29] Refer to Table 2-4 (page 81) for Bureaucratic organisational culture

Table 4-1 Definitions of Organisational Climate and Culture

Organisational climate	Organisational culture
▪ Describing aspects of the airline's state, (political, economic, brand-value,..), tend to be affected by external factors.	▪ A complex phenomenon of social grouping, serving as the prime medium for all members of an airline to interpret their collective identity, beliefs and behaviours.
▪ Perceptions of organisational practices, a more superficial concept than culture.	▪ Reactions to those same practices and procedures, created by all organisation members (internal factors), not owned by any group.
▪ An index of airline's health, but not a causative factor of it.	▪ Used to be taught to the new member as the framework for cognitions and behaviours (reaction) to the problems.
▪ Multi- dimensional (a number of different climates exist within an airline).	▪ Multi- dimensional (one of the important and direct impact is safety).

4.2.2.2 (3) Safety climate & (4) Safety culture

What is safety climate?

Contemporaneous with the derivation of safety culture from organisational culture is the associated term "safety climate". The concept of safety climate emerged from the research on organisational culture and climate. Schneider (1975) argues that a number of different climates exist within an organisation. Researchers began to measure one specific type of organisational climate - safety climate. Since then, a few researchers have defined safety climate (see Table 4-2). As we can see, most researchers aim at the same concept but differ on what this concept might encompass. In other words, safety climate tends to be thought of as regarding an employee's perception of safety, but its operation of the concept varies according to different companies.

Table 4-2 Definitions of Safety Climate

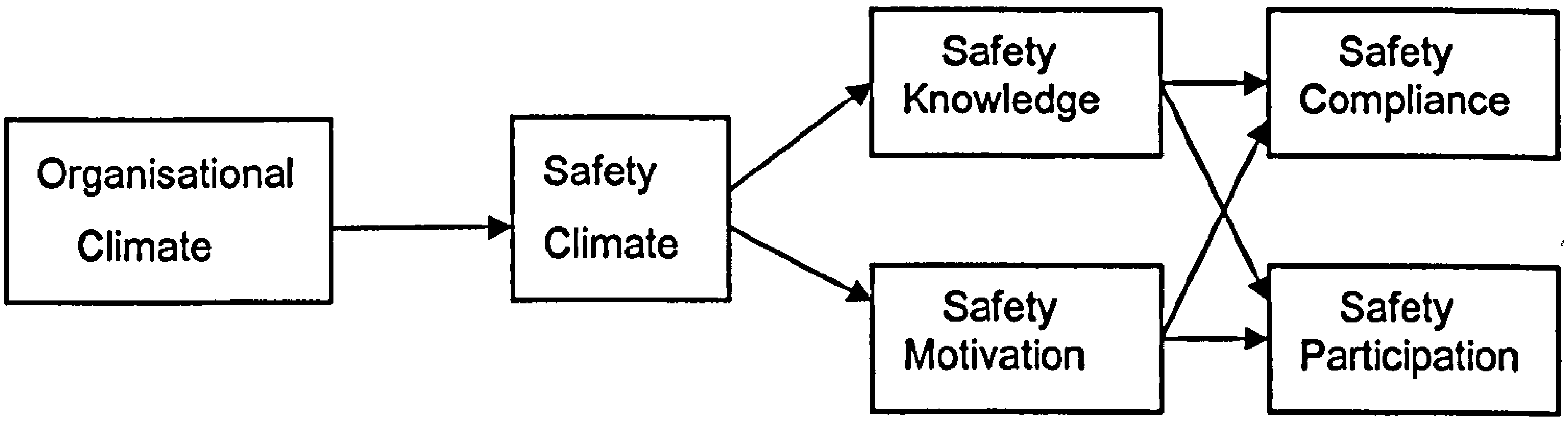
Researcher	Definition
Zohar (1980)	A summary of perceptions that employees share about their work environments
Glennon (1982)	A special kind of organisational climate making employees' perceptions of the characteristics of their organisation and have a direct impact upon their behaviours to reduce or eliminate danger
Cooper and Philips (1994)	Safety climate is concerned with the shared perceptions and beliefs that workers hold regarding safety in their work place
Cabrera et al (1997)	Shared perceptions of organisational members about their working environment and about their organisational safety policies
Williamson et al (1997)	A summary concept describing the safety ethic in an organisation which is reflected in employees' belief about safety

The influence of safety climate

Recently in safety literature, the emphasis has shifted from the individual human who might be responsible for incidents/accidents (single human error) towards a systemic or organisational approach. Defined in the previous section, organisational climate derives from aggregate employee perceptions and consequently, it is multi-dimensional and can potentially influence safety-related behaviours. Safety climate is then thought of as the mediating factor between organisational climate and safety performance by some researchers.

Neal et al. (2000) examine the impact of organisational climate on safety climate, and the impact of safety climate on safety knowledge, motivation and performance of individuals in organisations. They found that safety climate operated as a mediating variable between organisational climate and safety performance, as measured by self-reports of compliance with safety regulations and procedures, as well as participating in safety activities, which were also mediated by employees' safety knowledge and motivation (see Figure 4-5).

Figure 4-5 The Impact of Safety Climate



Source: Neal et al., 2000

The relationship between safety climate and safety culture

While perceptions are more associated with climate, attitudes are considered to be a part of safety culture[30]. The safety culture of an organisation is the product of individual and group values, attitudes, competencies and patterns of behaviour. These characteristics determine the commitment, the proficiency and effectiveness of an organisation and in particular, its safety management. The safety culture within any organisation is an indicator of the state of respect for safety consciousness, the willingness and determination to comply with the company's policies and procedures, and compliance with regulatory requirements. To individual, safety culture is the accountability that an individual has to himself or herself; the accountability goes up to the line supervision and finally to the employer.

Certain attributes are critical to a strong culture. Understanding performance requirements, respect for training, respect for peers and supervisors and professional pride are examples of positive attributes that contribute to a healthy culture.

As such, it is found that the model provided by Neal et al. (2000) contains the components of safety culture[31] although Neal et al. did not specify it as such. In order to have a clear understanding of safety climate and safety culture within the airline industry, this study redefines these two concepts (see Table 4-3) and follows these definitions when developing the safety mechanism model. It is worth noting that one of the main differences between safety climate and safety culture in the airline industry is that the former is formed according to mandatory regulations.[32] As it is governed by a minimum requirement, safety climate is supposed to pervade the whole airline and tends to be regulation-orientated.

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[30] The definition of safety culture is listed in Table 2-5.

[31] According to the Collins Dictionary (1995):
Attitude: the way a person thinks and behaves, opinion, frame of mind
Behaviour: manner of behaving
Belief: trust of confidence, faith, feeling
Motivation: desire, incentive, drive

[32] Please refer to Chapter 2, Section 2.1.3 for the regulatory environment.

Table 4-3 The Definitions of Safety Climate and Safety Culture

Safety Climate	Safety Culture
▪ derived from the aggregate employee perceptions of safety ▪ governed by the minimum requirement from regulators (regulation-oriented) or other aviation authorities ▪ pervading the whole airline ▪ potentially influencing safety-related behaviours	▪ a series of attitudes, behaviours, and social and technical practices ▪ established to minimise the exposure of employees, managers, passengers, and third parties to hazardous conditions ▪ frequently identified as being fundamental to an airline's ability to manage safety-related aspects of operations ▪ particularly technical departments are involved (flight operations, engineering, maintenance)

A strong safety climate does not guarantee a strong safety culture; but a strong safety culture must mean a strong safety climate being achieved since safety culture is fostered by safety climate. For example, CAL suffered two serious accidents in the four years from 1994-1998. The whole external and internal environment, including regulation, equipment, safety programmes, training, etc. have been changed in order to improve its safety climate. However, the accident in 2002 proved that CAL's safety culture is still in need of improvement, although the general environment and the perceptions of employees towards safety have been substantially changed.

Safety culture is defined as a series of attitudes, behaviours, and social and technical practices, which are established to minimise the exposure of employees, managers, passengers and third parties to hazardous conditions. It is frequently identified as being fundamental to an airline's ability to manage the safety-related aspects of its operations (particularly in technical departments, such as flight operations, maintenance, etc.)

Organisations or authorities have provided a number of instructions regarding how to achieve a "good"[33] or "strong" safety culture. ICAO (1994), for example, provided the following indications of a good safety culture:

- Senior management placing a strong emphasis on safety;
- Staff having an understanding of hazards within the workplace;
- Senior management's willingness to accept criticism and an openness to opposing views;
- Senior management fostering a climate to encourage feedback;
- Emphasising the important of communicating relevant safety information;
- Promoting realistic and workable safety rules; and
- Ensuring that staffs are well-educated and trained so that they understand the consequences of unsafe acts.

Some safety programmes try to develop a Safety Culture Index as an indicator of safety performance, for example the BASI-INDICATE Safety Programme, discussed in Chapter 2. When there is a measurement system in place, the operational deficiency and the room for improvement are easier to spot. As such, now culture presents both an opportunity and a threat to the aviation industry.

4.2.2.3 (5) Safety philosophy and (6) Decision-making & action

The culture of an organisation is often held to be of critical importance to corporate strategic decision-making (Johnson and Scholes, 1988). Nevertheless, there should exist a philosophy before management make decisions and employees take action. The term "philosophy" signifies the airline management's overall view of how they are going to "shape" the company and conduct the business. For employees, philosophy means the priorities and plans that they follow.

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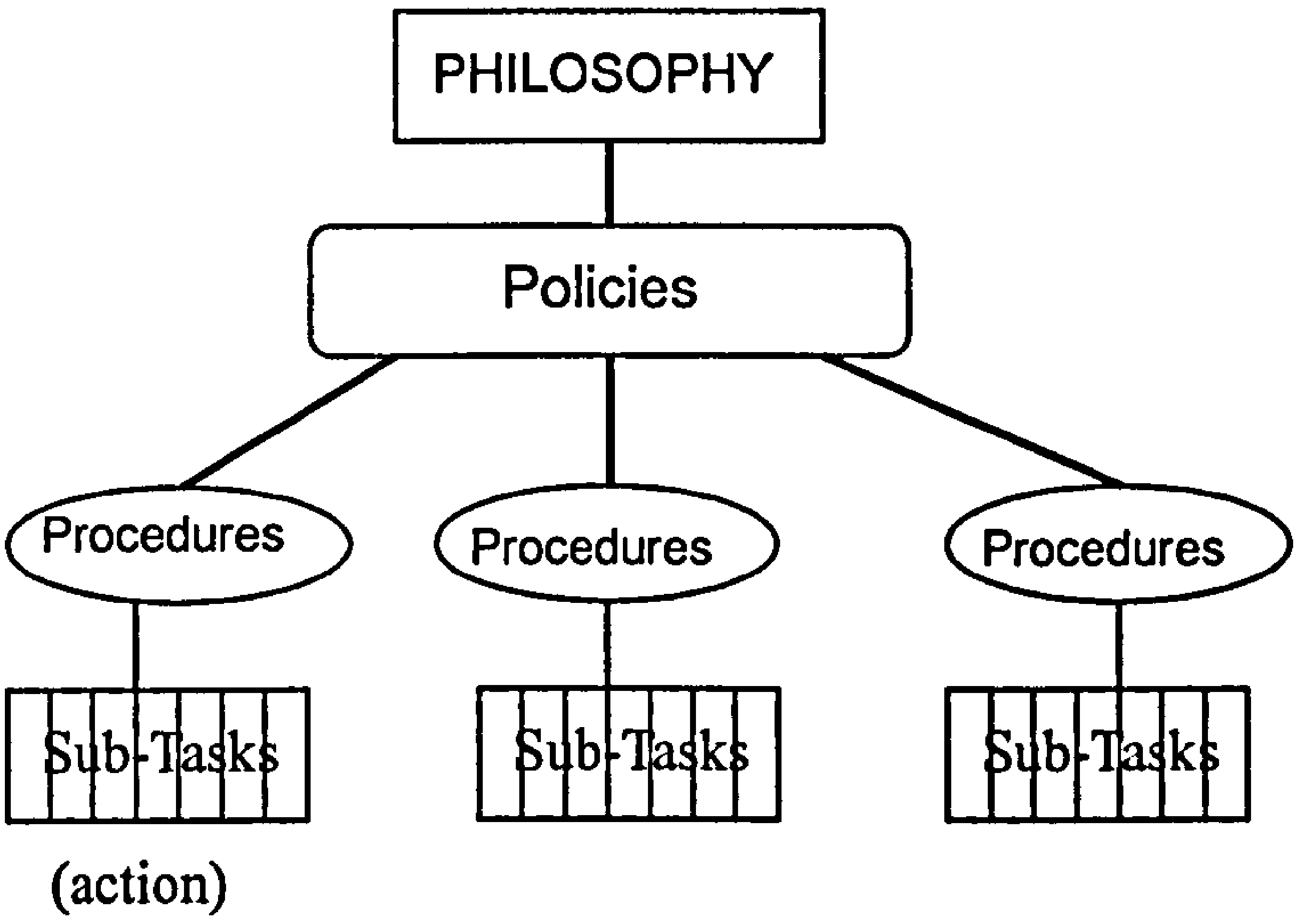
[33] The meaning of "good" or "bad" safety culture is sometimes very subjective because there appears to be no worldwide benchmarking tool or measurement to evaluate safety culture yet. As such, this study chooses to use "strong" or "weak" culture, instead of "good" or "bad".

Degani and Wiener (1994) argue that a company's philosophy is largely influenced by the individual philosophies of the top decision makers and company culture. Although most airline managers (in this study, the safety managers interviewed) cannot clearly state their philosophy, such a philosophy of operation does exist within airlines. They can be in combination with economic factors, political factors, major organisational change, etc. to generate policies, and can be inferred from policies and procedures to exercise training, punitive actions, etc. Figure 4-6 shows the three 'P' (philosophy, policies, procedures) framework.

Figure 4-6 The Three 'P' Framework in the Airline Industry



Source: Degani and Wiener, 1994

Safety philosophy is the foundation of safety culture. In other words, safety philosophy defines the organisation's goals. Safety climate may exist in part as a result of the regulation's rules, requirements, and the company's procedures and standards to meet them; however, if a philosophy is not extracted at CEO level, safety culture cannot exist. It constitutes the logic, rationale, plans and priorities towards safety. It is safety philosophy that drives safety culture in practice and carries out a continuous self-assessment. Without such a philosophy, an airline cannot ensure that its safety standards and performances are improving. For example, quoted from Wiener et al. (1991), Delta Air Lines used to produce a statement of flight deck automation philosophy, which acknowledged that *"the purpose of automation is to aid the pilot in doing his or her job"* and that the *"pilot must be proficient in* *operating their airplanes in all levels of automation...must be knowledgeable in the selection of the appropriate degree of automation*." Furthermore:

"Automation should be used at the level most appropriate to enhance the priorities of Safety, Passenger Comfort, Public Relations, Schedule, and Economy, as stated in the Flight Operation Policy Manual.

In order to achieve the above priorities, all Delta Air Lines training programmes, training devices, procedures, checklists, manuals, ...and the day-to-day operations of Delta aircraft shall be in accordance with this statement of philosophy."

There are two issues about the automation here. The first arises from the ability of the pilot to properly use the automation in all needs. Different technology requires different operating methodology. Accidents have occurred where the transitional issues were not fully understood. The second is that any operational definition to automation is understood and SOPs amended to account for this. This requires supports at the training level. By this statement, Delta clearly shows its safety philosophy on flight deck automation, given the emergent operational problem generated in the philosophy of operations. With the priority and referents made in the statement, pilots as well as other employees are provided with a better understanding of the safety achievement.

The definitions of safety philosophy and decision-making, which are applied to the development of the safety mechanism, are described in Table 4-4.

Table 4-4 The Definitions of Safety Philosophy and Decision Making

Layer	Definition
Safety Philosophy	▪ Logic + plan+ priority towards safety ▪ Inferred from policies and procedures to exercise training, punitive actions
Decision-making	Action

4.2.3 Organisational Factors

4.2.3.1 Individuals influenced by the safety mechanism model

Before listing the factors influential in the safety mechanism model, it is necessary to distinguish the different roles of individuals in an airline. These roles serve to define the individuals influenced by the safety mechanism. The impacts of these specific individuals on the safety mechanism are likely to be complex and at each level, a number of contradictory goals are also likely to compete for resources. As such, three categories of people have been identified as being important to understanding the factors which contribute to the development of a safety mechanism.

1. **Line worker**

   Individuals at this level perform the essential work of an airline. They are the resource used by management to achieve its objectives. Frequently they are described as working at the "sharp end", and include pilots, cabin crew, ramp personnel, ground staff, etc.

2. **Middle management**

   Individuals at this level are responsible for implementing policy through the management of operational resources (e.g. line personnel and equipment). They do not set the strategic directions for the company. In the airline industry, they include management pilots, supervisors of ground staff, maintenance line managers, etc.

3. **Senior Management**

   At this level, individuals are responsible for setting the strategic direction of the organisation by establishing policy. They do not directly manage line workers, who are required to report to middle management. Senior management includes heads of department, the vice president and board members.

4.2.3.2 Concerns and needs for different groups

This section aims to identify the needs and concerns which need to be addressed, and which consequently influence the acts of individuals in each group, and thus influence the safety mechanism.

<u>Line workers</u>

Concerns and needs of line workers are thought to include:

1. **Individual safety and health**
   Employees are motivated to participate in safety initiatives safely because no one would wish to be ill or injured at work. This should have a positive influence on the safety mechanism.

2. **Role of line worker towards sense of safety and security**
   The main role of line worker is in delivering the standard of operation through adherence to procedures or SOPs. As such, line personnel are in the best position to spot hazards in the workplace. Vigilance of individual members is critical to safety in an organisation. Besides, many safety initiatives depend on a "no blame" culture for their success. A perceived threat to job security for speaking up on safety issues would erode the safety mechanism.

3. **Safety concepts, skills, knowledge and attitudes**
   Donald and Cantor (1993) point to that individuals' attitudes and behaviour are related to the level of safety in operations. Thus, individual and collective attitudes might influence the development of safety mechanism positively or negatively.

4. **Decision-making style**
   Employees require the training to make contribution to safety. For example, incident reporting systems are used to identify the potential significance of events, and these not only require the knowledge, but also the co-operation of line workers. The process of decision-making will exert an important influence on the result.

5. **Communication channel**

   In order to fully understand the corporate policy, management style, awareness of safety, etc., line workers need to communicate to others; to their colleagues and to the management, in the organisation.

Middle management

Concerns and needs of middle management are thought to include:

1. **Management ability**

   Middle managers must be aware of all aspects potential hazards in order to manage safety effectively. Also, these managers are expected to encourage line workers to participate in safety initiatives and express the safety concerns.

2. **Role of middle management on decision-making style and process**

   Senior management usually use performance indicators to judge the performance of middle managers so that top managers can determine how to allocate the resources on production and safety. When the financial success of a department is decided by such process, middle mangers' responsibility is to decide and provide safety needs while completing the job function under budget limitation. In other words, middle management is the level at which the organisation can be changed. If his/her line workers repeat deficiencies, it needs management support to fix it. Financial pressures can be perceived to limit management freedom to change and improve.

3. **Communication bridge**

   Middle managers are like the bridge between line workers and top management. Thus they should act as the primary channel downwards to the line and upwards to senior management in order to deliver the correct information.

4. **Manager's leadership**

   Being emphasised for long by researchers, management's leadership is important to the organisation. Budworth (1996) is one of them. He identified the critical essence to the effectiveness of safety professional is leadership and communication skills. As such, managers' leadership is important to the development of a safety mechanism.

Senior management

The concerns of senior management, based upon the findings of these interviews and factors noted in previous chapters, are thought to be:

1. **Senior management's commitment**

   Grimaldi and Simonds (1984) are some of the researchers to stress that the attitudes and behaviour of management have a profound effect on safety practice. In other words, the management's commitment to safety operations may influence safety mechanism and consequently safety performance would be affected in an airline.

2. **Maintain the stability in the aftermath of accidents/incidents**

   Discussed in Chapter 2, risk in the aviation industry is most commonly associated with threats to life and limb. Air transport accidents could risk airline business and at worst, might result in an airline's demise. The impact of accidents thus has a significant impact on an airline's long-term survival if it is not well managed. Therefore, it is the responsibility for senior management to maintain the stability of the airline.

3. **Leadership and communication capability**

   Similar to the middle management, senior management needs the interpersonal skills and leadership to communicate with their subordinates. Meanwhile, they must be able to listen to the safety concerns of middle management and line workers and act upon the input of their subordinates.

4. **The way to monitor safety performance**

   Discussed in previous chapters, the use of accidents as indicators of safety provides an insufficient indication of the actual safety health of the system. As such, senior managers are expected to explore more meaningful indicators of safety and concentrate on organisational process and organisational goals not only outcomes.

5. **Financial health of the organisation**

   As mentioned previously, the goals of safety and production are competing for resources in airlines and sometimes conflicts are caused as a result, especially in the era of cost cutting. It is senior management's biggest task to maintain the airline's financial health because a highly competitive commercial environment might cause lack of profit, which will reduce the incentives to invest in safety as a result.

6. **Decision-making style - to meet safety and production goals and shareholder demands**

   Generating maximum profitability has always been airlines' primary goal, but risk is very expensive to eliminate completely. Thus, airlines' managers make decisions (allocate limited resources) on the basis of cost-effective comprehension, which results in a trade-off situation between two strategic goals, i.e. safety and investment costs. Senior management focus on what safety investment for how long may have a negative or positive impact on the airline's safety mechanism by showing management support.

7. **Relationship with the regulator**

   How to directly develop a relationship of trust with the regulatory authority and compliance with regulatory practices within the industry is not the biggest task of senior management. However, the behaviours of senior management are so indicative to the employees and the public, which will consequently affect the safety mechanism. According to one CAA regulator, many of senior management underestimate the extent to which the regulators "trust" the senior management of the airlines to deliver a safe system.

8. **Relationship with the public**

   Similar to the above relationship with the regulators. Meanwhile, some interviewees identified that to establish a good relationship with the public has a positive impact on airline safety.

Table 4-5 lists the results of the concerns and influences of line workers, middle management and senior management. For simplicity of further analysis, Table 4-5 also summarises these concerns according to their similarities, and this forms the construct of the organisational factors of the safety mechanism.

Table 4-5 Various Groups' Concerns & Implied Factors

Group	Concerns	Implied Factors
Line worker	Individual safe and health	- Perceived safety
	Sense of safety and security	- Perceived safety
	Safety concept, skill, knowledge and attitudes	- Perceived safety
	Decision-making style	- Decision-making style
	Communication channel	- Communication
Middle management	Management ability	- Management control
	Decision-making style and process	- Decision-making style
	Communication bridge	- Communication
	Manager's leadership	- Management control
Senior management	Senior management's commitment	- Management control
	Maintain the stability in the aftermath of incidents/accidents	- Post-incident/accident
	Leadership and communication capability	- Communication
	The way to monitor safety performance	- Operation & maintenance
	Financial health of the organisation	- Commercial pressures
	Decision making style- to meet organisational goals and shareholder demands	- Decision making style + The investment community
	Relationship with the regulator	- Industry regulation
	Relationship with the public	- Public relationship

4.2.3.3 Summary of organisational factors

Given that organisational factors are the macro forces that affect safety in an aviation organisation (Westrum, 1996), these influential factors are divided into internal factors and external factors. The former are those forces from within the company, while the latter express the forces coming from outside the company. These hypothesised organisational factors are listed in Table 4-6. In addition to the factors summarised in Table 4-5, are additional factors found in the interviews and the literature, which include safety information, organisational structure, documentation, country influence and region influence.

Table 4-6 Breakdown of the Factors

External Factors	Internal Factors
1. Industry regulations 2. Public relationships 3. The investment community (shareholeders) 4. Country influences 5. Regional influences	1. Perceived safety 2. Operation and maintenance 3. Risk management (control) 4. Management control (quality control) 5. Commercial pressures 6. Safety information (info technology) 7. Organisational structure 8. Personnel communication and relationships 9. Post-incident/accident (impact of incident/accident) 10. Decision-making style and process 11. Corporate safety policy 12. Documentation

In terms of **external factors**, country and regional influences are hypothesised to have influence on the safety mechanism in accordance with Hofstede's (1994) layers of culture, discussed in Chapter 2, which should take account of national culture, regional culture, gender culture, etc. Since organisational cultures are the subset of national cultures, the latter will provide the context in which organisational culture will develop. Moreover, people are usually part of a number of groups, and they are potentially influenced by the culture of these groups. Researchers have studied and confirmed the influence of national and regional cultures on cockpit crew performance (Westrum, 1996; Ho, 1996; Helmreich, 1999) and also on maintenance workers (Al-Harabi, 2001). Their analyses have led to the cultural assumption arising from the other groups of people, which has simultaneously affected the safety mechanism.

Internal factors are summarised from the previous literature review, the interview findings and the concerns of different groups. Among these factors, "*Commercial Pressures*" is the one not acknowledged (or less so) by the airline interviewees, but one which obviously has a significant influence on safety. Reason (1990) describes how in a company, production and safety goals compete for a finite amount of investment in terms of capital, personnel, time, equipment, etc., and Westrum (1996) notes that safety is often one of the targets for cost-cutting[34]. As such, the following paragraphs will try to demonstrate the impact of commercial pressures on the safety mechanism from an economic point of view.

The economic consequences of safety translate into accident costs and safety investment costs. The costs and benefits of safety cannot be measured only in economic terms; however, the concept of safety costs can be illustrated in the environment as follows:

According to Pasman (2000), safety costs are the sum of safety investment, maintenance, insurance and residual costs, which can be expressed by this equation:

$$\begin{aligned}\textbf{Safety Costs} = \textbf{Safety investments} + \textbf{Maintenance cost}\\ + \textbf{Insurance cost} + \textbf{Residual risk costs}\end{aligned}$$

---

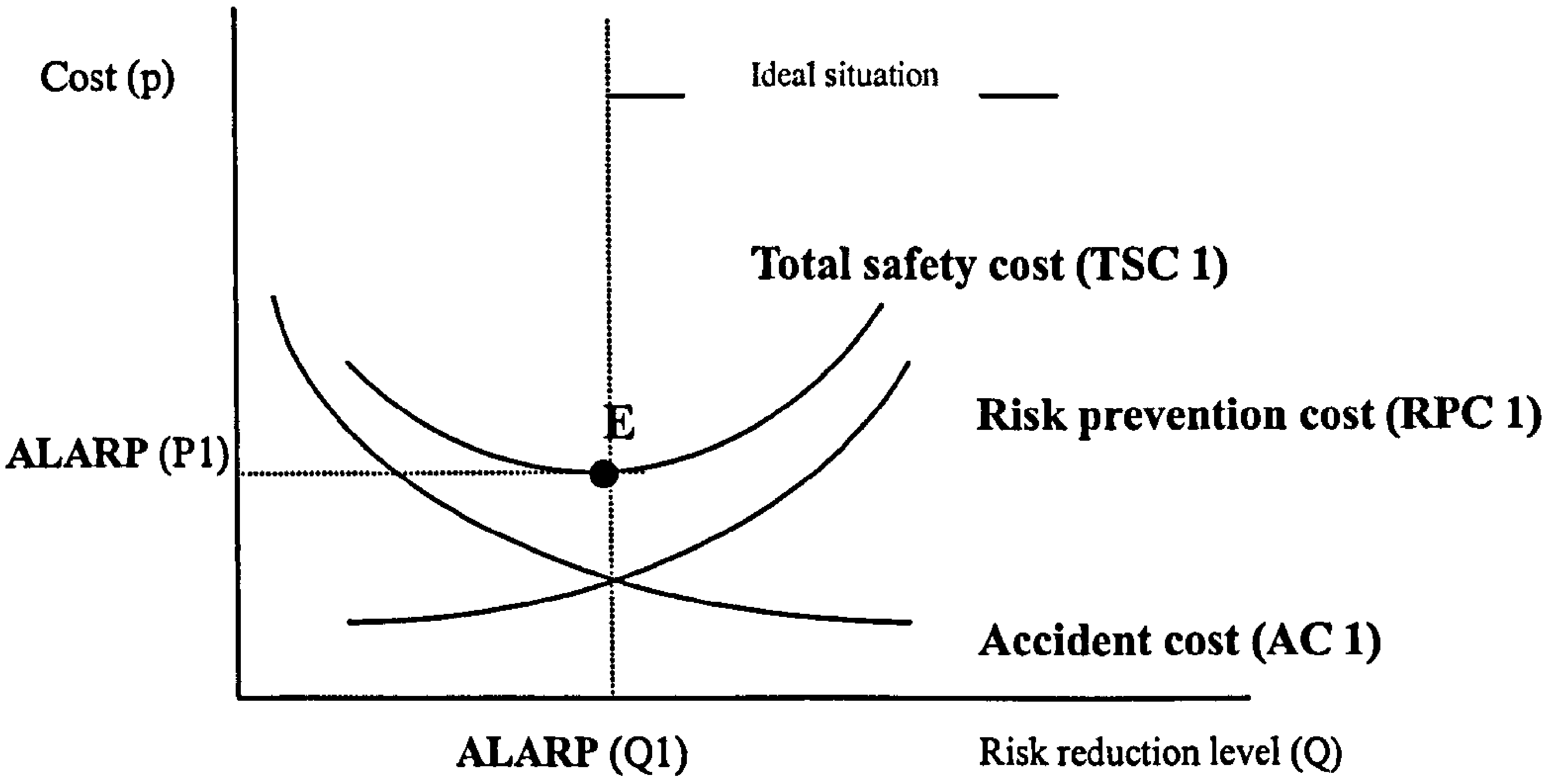
[34] Actually to "target" safety means it may manifest itself by deferring equipment fit, defer/minimise maintenance, training, etc. That does not mean safety is literally affected but does require the approach to managing safety to be revised.

This equation can be simplified as follows:

Total Safety Costs (TSC 1) = (Safety investments + Maintenance cost) +
(Insurance cost + Residual risk costs)
= Risks prevention costs (RPC 1) + Accident costs (AC 1)

Prevention costs are the costs invested by airlines in order to improve flight safety and prevent accidents from occurring. As illustrated in Figure 4-7, the more prevention costs are invested, the larger is the risk reduction achieved. For example, a well-trained crew will have more awareness of abnormal situations which will affect safety. Accident costs will then be reduced with the increase of the risk reduction and prevention costs.

Figure 4-7 The Concept of Safety Cost



E: the optimal safety cost
ALARP: As low as reasonably practicable

Source: Adapted from Pasman, 2000; Hsu, 1999

Ideally safety can be obtained by maximising risk reduction, which means that the right side of the diagram is a closer fit. Nevertheless, this comes with a higher safety cost. From the point of view of an airline's management, they may see the ideal point as being to the left of point E on the total safety cost line, in spite of the higher accident cost. An increased effort just to stay even or to attain modest reductions will not appear unless they are extremely farsighted. Within this area, it means that management is willing to risk more accidents so that they can pay less for prevention and place the resources elsewhere.

To this end, Figure 4-8 portrays the hypothesised safety mechanism model: both internal and external factors exert influence on safety mechanism, which will manifest itself on the airline safety services, i.e. the performance of safety management system.

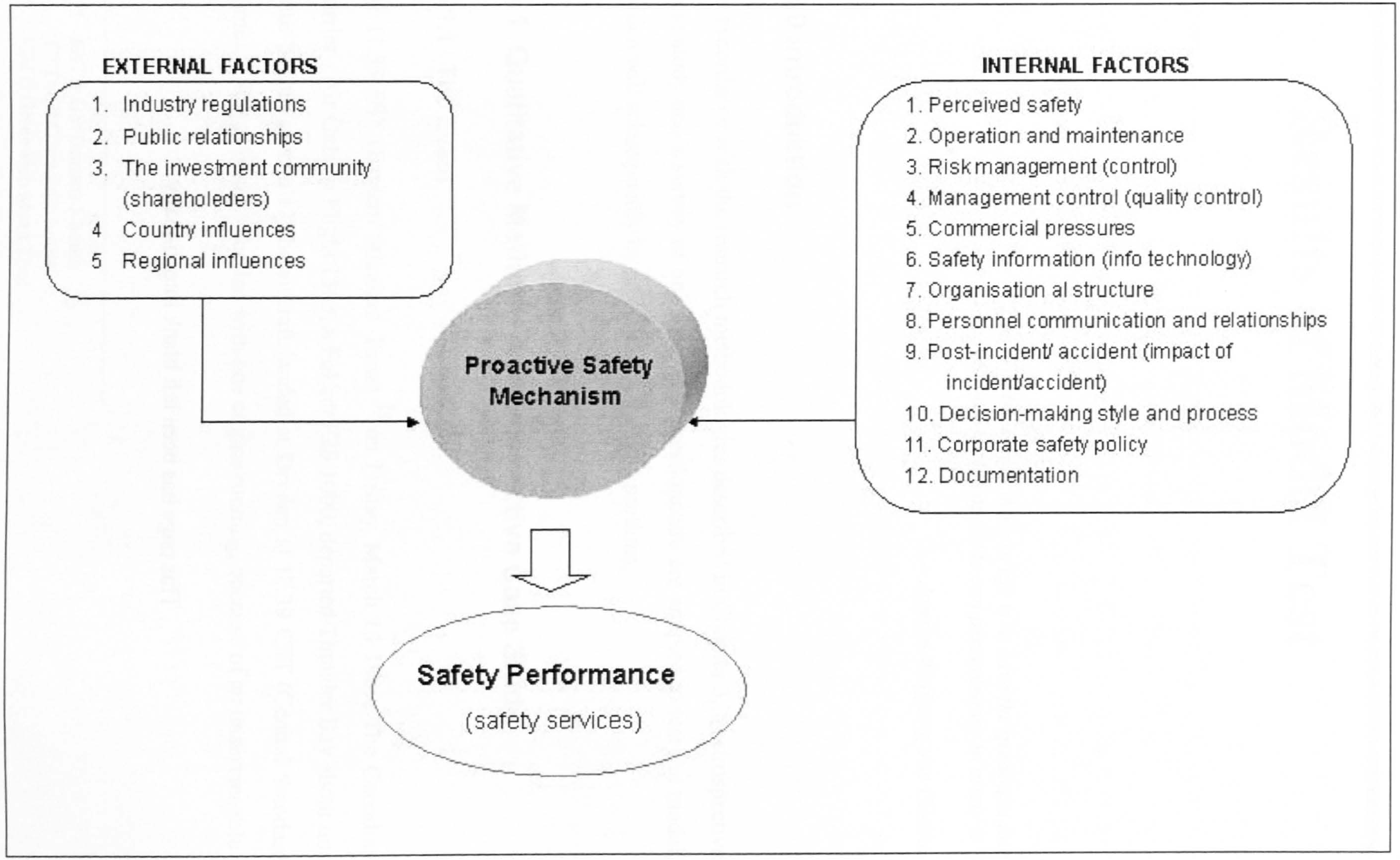


Figure 4-8 The Hypothesised Safety Mechanism Model

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CHAPTER 5

Results of Model Test

"The most important thing in life is to have the great aim and to possess the aptitude and perseverance to attain it."

~ Johann Wolfgang von Goethe

5.0 Introduction

In accordance with the research methodologies described in Chapter 3, a retrospective case study and a survey of opinions with questionnaire are adapted to test the model, which will subsequently be presented in the next sections.

5.1 Qualitative Method - A Retrospective Case Study

5.1.1 The Event

At 11.55 EST (Eastern Standard Time) [35] on Friday, March 10 1989, The Canadian carrier - Air Ontario Flight 1363, a Fokker F28 1000, departed Thunder Bay about one hour behind schedule. The aircraft landed at Dryden at 11.39 CST (Central Standard Time) [35]. It was being refuelled with one engine running, because of an unserviceable

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[35] EST = GMT minus 5 hours
CST= GMT minus 6 hours,
GMT: Greenwich Mean Time

Auxiliary Power Unit (APU). Although a layer of 1/8-1/4 inch of snow had accumulated on the wings, no de-icing was done because de-icing with either engine running was prohibited by both Fokker and Air Ontario.

Since no external power unit was available at Dryden, the engines could not be restarted in case of engine shutdown on the ground. At 12.09 CST the aircraft started its take-off roll using the slush-covered Runway 29. The Fokker settled back after the first rotation and lifted off for the second time at the 5700ft point of the 6000ft runway. No altitude was gained and the aircraft rushed in a nose-high attitude, striking trees. Less than one kilometre from the end of runway, Flight 1363 became a mound of smouldering metal and the death trap of 21 passenger and three crew members.

After a 20-month investigation of the probable cause of the accident, the inquiry's report concluded that "*Captain Morwood, as the pilot-in-command, must bear responsibility for the decision to land and take off in Dryden on the day in question. However, it is equally clear that the air transportation system failed him by allowing him to be placed in a situation where he did not have all the necessary tools that should have supported him in making the proper decision.*" To the benefit of the Canadian Aviation System, the accident became the subject of the most pervasive and intense inquiry in the history of aviation.

In the introduction to the inquiry's lengthy report, Mr. Justice Moshansky outlined the systems perspective adopted by the commission. The Inquiry set out to identify the elements of the aviation system and examine each in turn. It is shown that this accident was the result of a failure in air transportation system.

The failure to which Moshansky refers are those events and conditions which led to the Captain of Flight 1363 finding himself in Dryden, behind schedule in poor weather conditions, without the possibility of de-icing the aircraft and without stranding the passengers on board in Dryden at the start of a holiday weekend. It is these conditions which defined the operational environment encountered by the individual, and to a large extent predetermines their response to that environment. In essence, these conditions combine to form the "safety mechanism" in Air Ontario.

5.1.2 The Pathogen Trails by Appling the Safety Mechanism Model

The following are the pathogen trails dissected by applying the safety mechanism model with a bottom-up metaphor:

Result (Failure)

The crash happened because of a loss of lift caused by a build-up of ice on the wing and the aircraft crashed shortly after take-off from Dryden.

Decision- Making

Layer / Individuals	**Decision- making**
Line personnel	1. Captain took off without de-icing in snowy condition. 2. Maintenance left APU un-serviced[36] when the aircraft left Winnipeg that morning.
Middle management	The dispatch team sent the disabled aircraft to an airport lacking ground start facilities in bad weather; furthermore, APU was left inoperative.
Senior management	Managers intended to maximise the utilisation of aircraft and profit so the aircraft had to fly anyway.

---

[36] APU is MEL (Minimum Equipment List) item, Captain has to determine the effects.

Safety Philosophy

Layer / Individuals	**Safety Philosophy**
Line personnel	1. Line personnel were highly motivated to keep the aircraft flying and took necessary steps to do this. 2. Ground handlers were reticent.
Middle management	1. Managers appeared to regard the on time performance and aircraft dispatch rate as prime performance criteria. 2. Staff put the aircraft into service before an adequate supply of spare parts had been obtained, and did what was necessary to keep the aircraft flying.
Senior management	1. Managers saw the flight was behind schedule in poor weather conditions 2. Managers required the aircraft had to fly, even without the possibility of de-icing, because passengers could not be stranded in Dryden at the start of a holiday weekend

Safety Culture

Layer / Individuals	**Safety Culture**
Line personnel	1. Cockpit crew behaviour: did not walk around to have the aircraft inspected, so the development of ice was left unchecked. 2. Cabin crew attitude: did not communicate well. (instruction was given to flight attendants, discouraged them from informing the air crew of the ice building up on the wings) 3. Maintenance: deferred maintenance had become normal practice for maintenance and flight crew working on the F-28. 4. Ground handling personnel: it was okay to refuel while the engine was running. (the aircraft left Winnipeg that morning with an unserviceable APU. Dryden Airport possessed no ground-start equipment, so at least one engine had to kept running during the stop over)
Middle management	1. Management failed to deliver and communicate safety information to the line personnel. 2. Management ineffectively observed and coached safe behaviour. (Flight crew and maintenance staff used different information to determine what constituted "essential equipment").
Senior management	Management lacked communication with key persons, and safety managers had no direct access to CEO.

Safety Climate

Layer / Individuals	**Safety Climate**
Line personnel	1. Maintenance: there was no harm in running the risks of maintenance deferment. 2. Crew: a number of mandatory occurrences were never reported to Transport Canada. Crew were obliged to keep the aircraft flying. (The involvement of line personnel in any safety initiatives was probably minimal because there was a significant degree of labour unrest in the months preceding the accident.)
Middle management	1. Had no approved MEL for F-28, which served to outline which systems were of a degree of importance that the aircraft could not be operated without them. 2. Had no operation manual for F-28, so pilots referred to various other manuals for information, including a Fokker manual which had not been updated for four years. 3. Failed to provide training in jet operations and performance to dispatchers.
Senior management	1. Failed to develop a safety organisation (committee). 2. Appointed a management pilot as CP who had a significant number of duties in the turbulent period while. (The check pilot (CP) and first flight safety officer (FSO) resigned after one month in the position due to lack of management support, the position of FSO remained vacant until the accident) 3. Forbad de-icing with the engine running. (and aircraft manufacturer of F-28)

Organisational Culture

Layer / Individuals	**Organisational Culture**
Line personnel	The airline was new (merger of two small airlines with different operating cultures). It was experiencing considerable organisational change, including a lengthy pilot strike, introduction of two aircraft types, reduction of the workforce, etc.
Middle management	1. Either accepted or were unaware of the improper safety practices throughout the company. 2. Over taxed, inexperienced with jet operations. 3. Lacked the support of senior management.
Senior management	1. Need to deal with different company culture, labour unrest, replace aging fleet with newer equipment, etc., and were faced with a merger. 2. Lack of the communication of an organisational mission including safety, organising work to achieve the mission and striving for the continuous improvement in terms of safety.

Organisational Climate

Layer Individuals	**Organisational Climate**
Line personnel	Given the company environment being turbulent (merger, pilot strike, etc.) and the recession in the 1980s where aviation jobs were difficult to find, were likely to do what was necessary to ensure their own job security.
Middle management	1. As above. 2. The developed working environment was "a new airline which is responsible for the emphasis placed upon operational goals by senior management".
Senior management	1. To maintain viability in the competitive airline industry, commercial imperatives were seemed to be felt by senior management to a greater degree than the requirement to increase safety, partly in the absence of regulatory pressure from Transport Canada. 2. The developed working environment was "a new airline which is responsible for the emphasis placed upon operational goals by senior management".

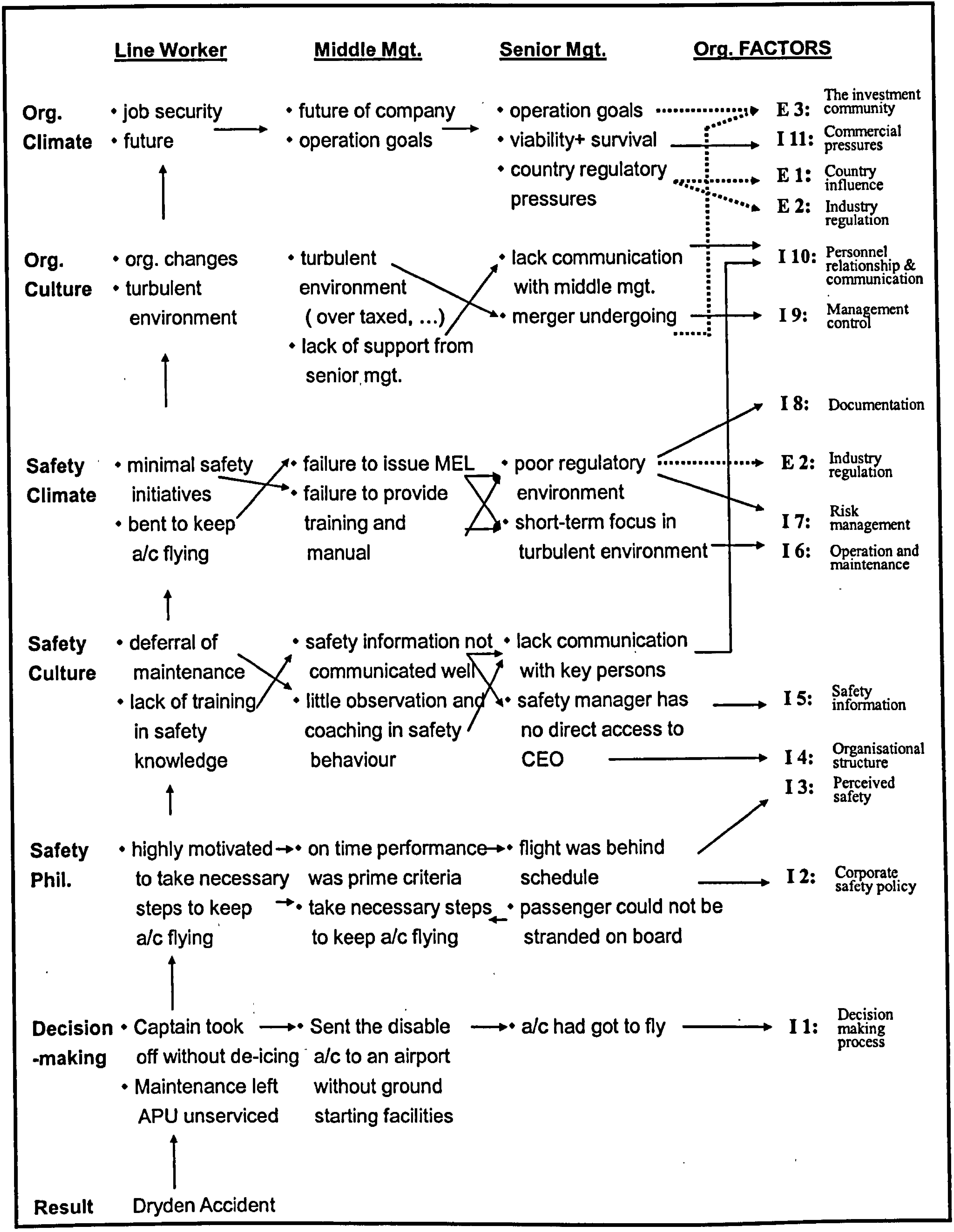
5.1.3 Conclusions of the Organisational Factors Which Influence the Safety Mechanism

After analysing the safety mechanism of Air Ontario, the underlying (influential) factors of the safety mechanism can be illustrated with a backward approach as follows (see Figure 5-1):

Figure 5-1 Findings and Conclusions of the Safety Mechanism Model Applied to Air Ontario Accident

Note: 1. Org. = Organisation, Mgt.= Management, Phil. = Philosophy, a/c = Aircraft

2. Please refer to section 5.1.3.1 & 5.1.3.2 for the description of the organisational factors.



5.1.3.1 Conclusions of internal factors

I 1. Decision Making Process

This factor featured the action and decision-making process of the individuals in Air Ontario. It clearly showed that the decisions of line workers were influenced by senior management.

I 2. Corporate Safety Policy

Safety policy was motivated by on-time performance and aircraft utilisation.

I 3. Perceived Safety

The F-28 aeroplane was new to Air Ontario and it was the first jet aircraft to enter service with the airline. As such, inexperience could be attributed to a failure on the part of the maintenance crews, dispatchers and pilots to realise the potential implications of an unserviceable APU where no ground start facilities were available.

I 4. Organisational Structure

The structure of Air Ontario was not clear or healthy enough to fulfil its safety responsibilities.

I 5. Safety Information

Safety information was not communicated well throughout the company.

I 6. Operation and Maintenance

Deficient scheduling (over-commitment of F-28). There was no standardised manual which caused ambiguous operative, dispatch, and maintenance procedures. Deferred maintenance resulted from inadequate spares purchasing and inexperience on the part of maintenance (lack of skills and knowledge).

I 7. Risk Management

The reporting of hazards was insufficiently practiced and the regulatory environment was not complete within the company.

I 8. Documentation

Maintenance personnel regularly defer repairs while awaiting spare parts, and pilots would delay recording technical problems in the aircraft log until the end of day if they thought the report would serve to ground the aircraft pending repairs. The practice of passing notes from one crew to the next so the last crew of the day could record all of the technical problems was commonplace.

I 9. Management Control

The merger of two airlines caused some management changes and pressures because of the different cultures of the two companies. The fact that managers could not have full support from the top manager resulted in the management control problem.

I 10. Personnel Relationships and Communication

Low morale caused inefficient communication between line personnel and management.

I 11. Commercial Pressures

To ensure that the organisation continued to exist, the primary concern facing senior management was the viability and survival of the airline. Increasing competition and commercial imperatives increased commercial pressures and the danger of decreased safety investment.

5.1.3.2 Conclusions of external factors

E 1. Country Influences

Deregulation failed to produce an effective regulatory environment.

Government failed to respond to warnings from the industry and the regulator.

E 2. Industry Regulations

Transport Canada failed to provide clear minimum operating standards for operators. It also failed to be aware of the operational failings.

E 3. The Investment Community

The merger had caused the investment community to focus on operating revenue.

The case study does not reveal the hypothesised internal organisational factors - post accident/incident (because of no previous accidents), and external organisational factors - public relationships and regional influence (because of no supportive information). It shows that any single occurrence will be unlikely to demonstrate all the factors of the model, and as such the model should not be rigidly applied to particular cases. Nevertheless, it is hoped the readers will have a better understanding of how the safety mechanism is useful in terms of identifying the number and complexity of interactions involved in the formation of a safety mechanism as set out in the hypothesis of this model.

5.2 Quantitative Study - Safety Questionnaire

Followed the case study, safety questionnaire is the next method used to validate the model. As described in Section 3.3.2, this questionnaire is designed to consist of two parts - internal factors and external factors in accordance with the hypothesised organisational factors. As such, fifty-seven items were included in the first part of the questionnaire, dealing with the concerns of individuals in the internal environment. These items were intended to examine the degree to which the individual felt part of their organisations or considered organisational concerns when making choices at work. Included in this section were the questions related to the internal factors: "*The concept of perceived safety*", "*Concerns in the aftermath of incident and accident*", "*Personnel relationships and communication within the company*", "*The recognition of organisational structure*", "*The development of information system technology*", "*Internal pressures from the commercial activities*", "*The ability of management control*", "*Risk management programmes*", "*Operation and maintenance related activities*", "*Decision-making style and process*", "*Corporate safety policy*", and "*Concerns of written documentation*".

In this section, questions related to the "*Perceived safety*", "*Personnel relationships and communication*", and "*Operations and maintenance*" are referred to in the SCQ developed by Glendon and Litherland (2001), and Glendon et al. (1994), whose research investigated the structure of factors within a safety climate and the relationship between safety climate and safety performance. Six factors, including "Communication and support", "Adequacy of procedures", "Work pressure", "Personal protective equipment", "Relationships" and "Safety rules", were identified by these two research groups led by Glendon. Due to the similarity of the intended questions, four items loaded on the factor "Communication and support", three items loaded on "Relationships", two loaded on "Work pressures" and two loaded on "Adequacy of procedures", one loaded on "Safety rules", and these were selected for use in the internal environment part of the safety mechanism questionnaire.

In the second section regarding the external factors, eighteen items were included, to examine whether the external environment can exert an influence on airline safety, and in particular, on safety culture. Included in this category were the external factors: "*The influence of industry regulation*", "*Public relationship*", "*Investment community* (such as investors, etc)", "*Country influence*" and "*Regional influence*", "*Terrorism*", and "*Political issues*".

5.2.1 Finding from Pilot Study

Section 3.3.2.2 has outlined the method and participants of pilot study. The result of pilot questionnaire was encouraging in a number of respects. Although these participants generally accepted the questionnaire, some issues were raised which needed to be addressed in the questionnaire itself. These problems are reviewed below and actions taken to rectify there are outlined.

1. **Re-editing some questions (issues) in the survey:**

   For example, over 80 percent of people suggest that the question about the satisfaction of "organisational learning" was too conceptual to be included in the survey; terrorism and political issues should not be included, etc.

2. **Enable respondents to select a category of "don't know":**

   In the pilot questionnaire, there is no category for "don't know" because the respondents (the management) were expected to know the answers. However, in an attempt to enhance the accuracy of the questionnaire, steps were taken to expand the scale of response. In addition, "don't know" responses may be indicative of safety system failure.

3. **Increase one self-rated question to assess the safety performance of the organisation:**

   This will be analysed separately and compared with the results of questionnaire. The question: How would you rate the safety performance of your company with respect to the rest of airline industry? This variable was measured on a six point Likert scale ranging from "Below Average for Industry" through to "Average for Industry" and "Above Average for Industry".

In summary, the substantive changes made to the questionnaire between the pilot study and the final study were:

- ✓ The exclusion of three issues (one safety concept, terrorism, world-wide political issues).
- ✓ The addition of a response scale and self-rated question item.
- ✓ The addition of an expanded definition of the purpose of the questionnaire.
- ✓ For the questionnaire distributed to Taiwan and Mainland China, a Chinese translation copy was added for the convenience of the respondents.

No changes were made to other parts (other items) of the questionnaire.

5.2.2 Results of the Safety Survey

This section presents the results of questionnaire study.

A total of 325 questionnaires were sent out (see Appendix K for the distribution list). Nine were returned and marked "cannot deliver" or "addressee has gone away". Therefore 316 were assumed to have reached the intended recipient. Of these, two people returned questionnaires which were only partially completed and they were deleted from the analysis. 104 questionnaires were returned completed. This constitutes a total response rate of 33.54 percent (106 out of 316) and a completed response rate of 32.91 percent[37] (104 out of 316).

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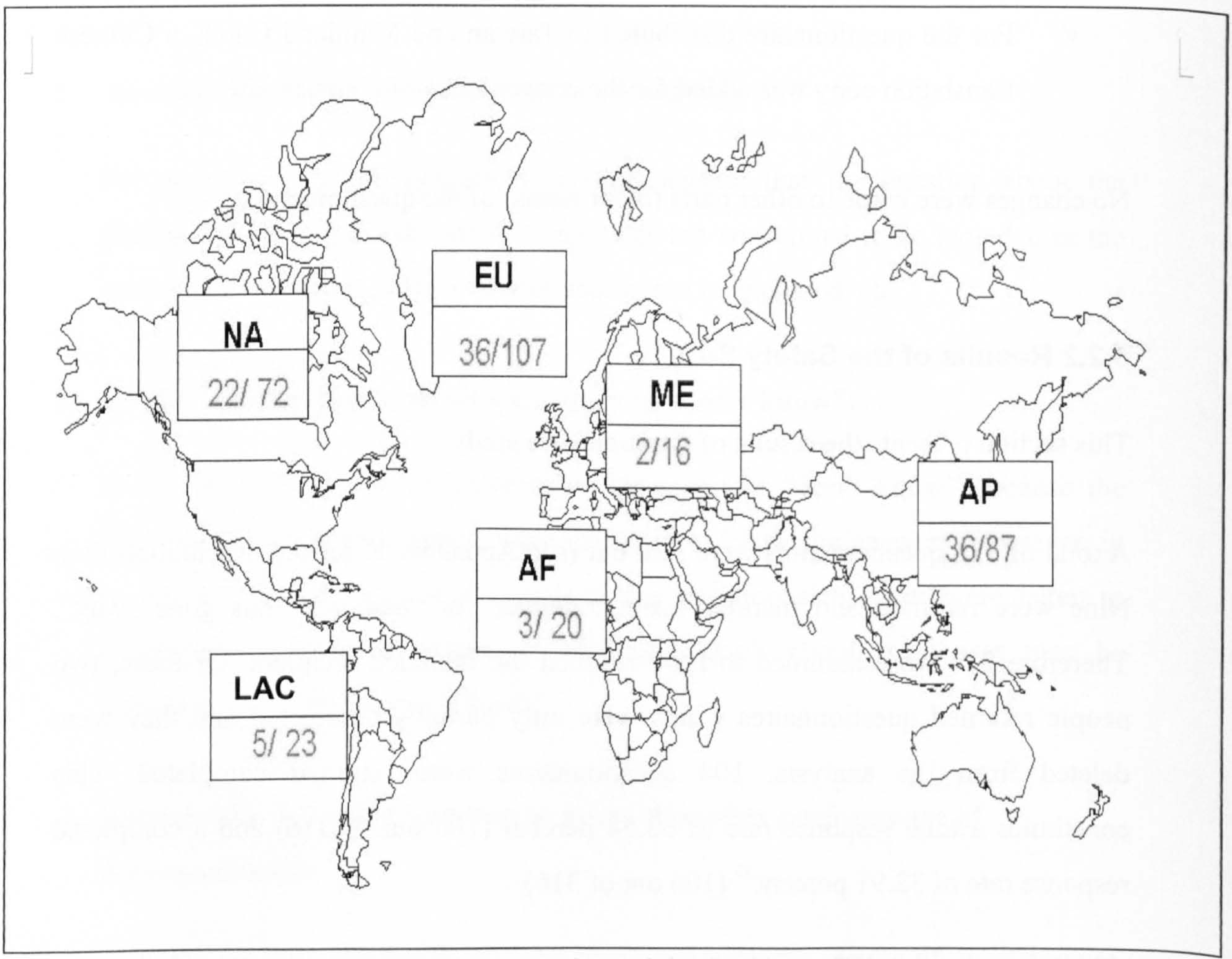
[37] The response rate for a market research survey is 25 percent in average.

5.2.2.1 Respondent demographics

Figure 5-2 shows the distribution of questionnaires and the sample obtained around the world. As can be seen, 72 questionnaires were sent to North America, of which 22 were returned. In Europe, 107 were sent out and 36 were returned. In the Middle East, 16 were distributed and 2 were returned. 20 questionnaires were sent to Africa and 3 were returned. In Latin America and the Caribbean, 23 were sent out and 5 were returned. 87 were distributed to the Asia and Pacific region and 36 were returned. Appendix M lists the comments and suggestions of the participants.

Figure 5-2 Distribution of Final Sample by Region



Note: **NA**- North America, **LAC**- Latin America and the Caribbean, **EU**- Europe, **AF**- Africa, **ME**- Middle East, **AP**- Asia and Pacific

The distribution of respondents from around the world was not equivalent to the target sample. The proportion of returned questionnaires from Africa and the Middle East were much lower than the intended sample rates; both of them were lower than 3 percent[38]. In addition, the proportion of completed questionnaires from North America and Europe were only one or two percent different from the percentage of actual sample rate. The proportion of returned questionnaires from Asia and the Pacific region was higher then expected. Apart from the personal preference, the reason affecting the willingness to response the questionnaire may have a lot to do with the company 'culture' and policy, some of which clearly state that response to external questionnaire is prohibited. The proportions of returned questionnaire are as indicated in Table 5-1.

Table 5-1 Distribution Percentage of Final Sample by Region

Region	**Intended sample** (% of total 316)	**Actual sample** (% of total 104)
Africa	6.32	2.97
Asia and Pacific	27.5	35.6
Latin America and the Caribbean	7.27	4.95
Europe	33.86	35.6
Middle East	5.06	1.98
North America	22.7	21.7

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[38] The potential impact of an uneven sample on the survey result will be discussed in next chapter when interpreting the results of survey.

5.2.2.2 Survey Results

Table 5-2 shows the factor structure extracting from the survey responses, slightly different from the hypothesised model (Figure 4-8 in page157), which, however, confirm the existence of organisational factors within the safety mechanism, and provide a greater understanding of the forces at work within the internal and external working environment of the airline industry. The following chapter will further interpret the results by applying the statistical analyses and discuss their implication. The hypothesised model in Figure 4-8 and the result of this safety survey are compared in Chapter 6, section 6.6 (page 211).

Table 5-2 The Factor Structure of a Proactive Safety Mechanism from Survey Result

Internal factors	External factors
1. Employee safety attitude& behaviour 2. Employee safety concept 3. Level of operational safety in operation and maintenance 4. Corporate safety policy 5. Personnel- quality of working life 6. Employment of risk programmes 7. Impact of accident/incidents 8. Financial concern 9. Procedures and documentation 10. Commercial cost pressures 11.Organisational structure and management commitment 12. Communication system 13. Necessity of safety reports	1.Influences of region and country 2.Public and the media influence 3.Impact of regulatory environment 4.Involvement of investment community

CHAPTER 6

Analyses and Discussions

> *"There is unlikely to be a single universal set of indicators for all types of hazardous operations, one way of communicating how safety health can be assessed is by listing the organisational factors that are currently measured."*
>
> *~Prof. J. Reason, 1995*

6.0 Introduction

This chapter aims to analyse the survey results, explore and discuss the inter-relationships between variables (question items) in the questionnaire. Since the questions are classified into internal environment and external environment, the analysis of the organisational factor structure of the safety mechanism will be divided into two categories, i.e. internal and external factors. The results for internal factors and external factors are presented first to analyse their relationship with the items in the questionnaire. Then these factors are discussed respectively in section 6.5 (page 195) as well as compared to the hypothesised model in section 6.6 (page 211) in order to further investigate their implication and how these factors can make their contribution to the industry.

6.1 Organisational Factors in Internal Environment

In keeping with the aim of this chapter, Principal Component Analysis, followed by a varimax rotation, was performed on the 56-item (internal environment) questionnaire data from 104 respondents in order to examine the organisational factor structure.

The data were deemed to be suitable for the analysis (data reduction procedures), as indicated by the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value of 0.74 (Hair et al., 1995). The Bartlett Test of Sphericity was significant [$\chi^2 = 4527.621$, $P< 0.05$], indicating that correlations exist among some of the response categories (see Table 6-1).

Table 6-1 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.740
Bartlett's Test of Sphericity	Approx. Chi-Square	4527.621
	df	1326
	Significance	.000

This method of factor extraction was preferred since it uses the maximum amount of variance available in the data, and the varimax rotation was selected since orthogonal factors would simplify both factor interpretation and later analyses by providing uncorrelated factors.

The first analysis yielded a sixteen-factor solution, which accounted for of 76 percent of the variance. However, this interpretation was rendered problematic because of four complex items, each of them loaded on two factors. As a result, these items were removed from further analysis (Question 14, 36, 37 and 44). A subsequent analysis of the remaining variables yielded a new fifteen-factor solution. Several components had high factor loading (>.70) and some variables had low loading numbers, such as variable 20, 32, etc. These items were treated as suspect and may later be considered for removal from the analysis (Hair et al., 1995). Appendix N shows the reproduced Rotated Factor Loading Matrix.

Factor loading (or loading number) means the correlation coefficients between the variables (questionnaire items) and factors. It shows the extent to which the questionnaire items are correlated to the factor. The subsequent section therefore aims to illustrate the underlying nature of each factor, which is characterised by the grouped questionnaire items.

6.1.1 Loading Factors from Principal Components Analysis (PCA)

The Principal Components Analysis produced some interesting results. The primary groupings of concern are shown together with the loading factors in the following paragraphs. The items loading primarily onto each factor were examined to see if the factors made theoretical sense and each factor is labelled in terms of its common underlying dimension nature. This result not only shows the current situations, but also demonstrates what representatives thought to be important.

1) Factor 1: Employee safety attitude and behaviour

All of the items which loaded onto this factor were concerned about the safety behaviour and attitude demonstrated by airline employees. Therefore, factor 1 is labelled as "*Employee safety attitude and behaviour*". The questionnaire items which correlated/loaded against "*Employee safety attitude and behaviour*" are listed in Table 6-2.

Table 6-2 The Underlying Nature of Factor 1 "Employee safety attitude and behaviour"

V	Loading	Item
03	.815	Employees use correct safety procedures to carrying out the job.
04	.774	Employees ensure the highest levels of safety when carrying out the job.
07	.640	Employees voluntarily carry out the tasks or activities that help to improve safety.
02	.608	Employees know how to perform their job in a safe manner.
1	.462	There is an organisational awareness towards safety in the airline.

Note- V: Questionnaire item number, Loading: Correlation to the factor

2) Factor 2: Employee safety concept

This factor dealt with the safety concepts of airline employees, and the degree to which that safety perception was shared. Thus, factor 2 is labelled as "*Employee safety concept*". The questionnaire items which correlated/loaded against "*Employee safety concept*" are listed in Table 6-3.

Table 6-3 The Underlying Nature of Factor 2 "Employee safety concept"

V	Loading	Item
09	.834	Safety rules can be followed without conflicting with work practices.
05	.830	Employees believe flight safety is an important issue.
06	.609	Employees feel that it is important to maintain safety at all times.
08	.537	Employees are encouraged to submit ideas to improve safety in the airline.
35	.434	Safety management aims are sufficiently supported within the airline.

Note: V- Questionnaire item number, Loading: Correlation to the factor

3) Factor 3: Level of operational safety in operation and maintenance

This factor "*Level of operational safety in operation and maintenance*" was concerned with the level of operational safety in association with front line, i.e. operation and maintenance issues, especially regarding training. Therefore, it is named "*Level of operational safety in operation and maintenance*". The questionnaire items which correlated/loaded against "*Level of operational safety in operation and maintenance*" are listed in Table 6-4.

Table 6-4 The Underlying Nature of Factor 3 "Level of operational safety in operation & maintenance"

V	Loading	Item
46	.940	There are adequate opportunities to express views about operational problems.
43	.930	Training is carried out by the individuals with relevant operational experience.
48	.885	There is an effective mechanism by which the safety manager or the safety committee can report to the CEO and can make recommendations for a change or action
42	.420	Potential errors, consequences and recovery point are identified in training

Note: V- Questionnaire item number, Loading: Correlation to the factor

4) Factor 4: Corporate safety policy

This factor groups variables concerning about the safety goal and policy issues within airlines. Therefore, it is labelled as "*Corporate safety policy*". The questionnaire items which correlated/loaded against "*Corporate safety policy*" are listed in Table 6-5.

Table 6-5 The Underlying Nature of Factor 4 "Corporate safety Policy"

V	Loading	Item
53	.821	The airline has a clearly stated set of goals and objectives.
52	.763	The policy statements define the airline's fundamental approach towards safety.
55	.568	An effective documentation management system ensures the availability of procedures.
51	.517	Safety statements and policies of an airline define the management's intention in safety matters and company's commitment to safety.

Note: V- Questionnaire item number, Loading: Correlation to the factor

5) Factor 5: Personnel – quality of working life

This factor dealt with the personnel working quality and relationships within the airlines. The low variable loading onto this factor of item 20 (0.345< 0.4) would be deleted in the further analysis. Therefore, it is labelled as "*Personnel - quality of working life*". The questionnaire items which correlated/loaded against "*Personnel - quality of working life*" are listed in Table 6-6.

Table 6-6 The Underlying Nature of Factor 5 "Personnel - quality of working life"

V	Loading	Item
17	.825	Personnel are confident about their future within the airline.
18	.821	Morale is good.
45	.619	Frustrations that arise from factors outside staff control can be accommodated without adversely affecting work.
19	.599	Good working relationships exist in the airline.
20	.345	Employees' jobs are well-defined.

Note- V: Questionnaire item number, Loading: Correlation to the factor

6) Factor 6: Employment of risk programme

This factor consisted of three items and represented the use of risk programme and the degree to which the risk programmes have influence on airlines' safety. Therefore, factor 6 is labelled as "*Employment of risk programme*". The questionnaire items which correlated/loaded against "*Employment of risk programme*" are listed in Table 6-7.

Table 6-7 The Underlying Nature of Factor 6 "Employment of risk programme"

V	Loading	Item
26	.718	Data collection, analysis and presentation have an influence on safety performance.
38	.685	An effective ongoing hazard identification programme has an influence on organisational safety culture.
24	.515	An adequate system exists for transmitting critical information regarding safety within the airline.

Note- V: Questionnaire item number, Loading: Correlation to the factor

7) Factor 7: Impact of accident/incidents

This factor was concerned with how to deal with the aftermath of accidents/incidents and how airline safety performance is influenced by accidents and incidents. Thus, it is named "*Impact of accident/ incidents*". The questionnaire items which correlated/loaded against "*Impact of accident/ incidents*" are listed in Table 6-8.

Table 6-8 The Underlying Nature of Factor 7 "Impact of accident/ incidents"

V	Loading	Item
11	.849	After an accident has occurred, appropriate actions are usually taken to reduce the chance of reoccurrence.
12	.777	After an incident has occurred, appropriate actions are usually taken to reduce the chance of reoccurrence.
13	.738	There is a documented business continuity plan in the event of accidents.
10	.700	There is an appropriate Emergency Response Plan.

Note- V: Questionnaire item number, Loading: Correlation to the factor

8) Factor 8: Financial Concern

This factor only consisted of two items and was somewhat difficult to define. Both of them seemed to identify airlines' financial concerns, but it was of interest that they were not grouped with Factor 10, which presented the commercial pressures of airlines.

In the case of financial goals, this represents the degree to which a conflict exists between safety and financial goals. In the case of shareholders' welfare, it represents whether the welfare of shareholders and organisational safety culture are correlated, i.e. the company's profitability and safety are correlated. According to both of their similar essence, this factor was resolved by the level of "*Financial concern*". The questionnaire items which correlated/loaded against "*Financial concern*" are listed in Table 6-9. Meanwhile, as the relatively high proportion of variance was explained by this factor (93 percent, refer to Appendix O), it was decided to keep this factor in for further analysis.

Table 6-9 The Underlying Nature of Factor 8 "Financial concern"

V	Loading	Item
30	.876	There is no conflict between safety and financial goals.
31	.854	Shareholder's welfare and airline's organisational safety culture are correlated.

Note- V: Questionnaire item number, Loading: Correlation to the factor

9) Factor 9: Procedures and documentation

This factor derived from the analysis which focused on the importance of written documentation and procedures regarding safety within the company. Therefore, factor 9 is labelled as "*Procedures and documentation*". The questionnaire items which correlated/loaded against "*Procedures and documentation*" are listed in Table 6-10.

Table 6-10 The Underlying Nature of Factor 9 "Procedures and documentation"

V	Loading	Item
54	.669	The roles and responsibilities for the personnel in the safety management system are clearly defined and documented.
56	.576	Written work procedures match the way tasks are done in practice
49	.536	In the event of CEO making an unfavourable response to a safety recommendation, there is a procedure whereby the matter is monitored by the safety manager or the safety committee until it is resolved.

Note- V: Questionnaire item number, Loading: Correlation to the factor

10) Factor 10: Commercial cost pressures

This factor dealt with the degree to which commercial pressures influenced airline safety. Interestingly, item 27 and item 28 rendered minus loading numbers, because the statements of these two items used negative expression to emphasise the problems. As predicted, they were grouped together within the factor concerning commercial pressures. Hence, even though the numbers concerning internal consistency[39] were affected by their low proportion, this factor "*Commercial cost pressures*" remained valid. The questionnaire items which correlated/loaded against "*Commercial cost pressures*" are listed in Table 6-11.

Table 6-11 The Underlying Nature of Factor 10 "Commercial cost pressures"

V	Loading	Item
27	-.818	Management is concerned for cost more than safety.
28	-.675	Safety budget is the first item to be reduced when commercial pressures emerge.
34	.534	The values of management are identified as being safety orientated.
29	.517	Safety rules are adhered to even under cost pressures.

Note: V- Questionnaire item number, Loading: Correlation to the factor

11) Factor 11: Organisational structure and management commitment

This factor consisted of four items, which mainly dealt with the degree to which airline safety is affected by organisational structure and management commitment. Therefore, it is labelled "*Organisational structure and management commitment*". The questionnaire items which correlated/loaded against *Organisational structure and management commitment* are listed in Table 6-12.

Table 6-12 The Underlying Nature of Factor 11 "Organisational structure& management commitment"

V	Loading	Item
21	.695	The size of the airline has an influence on organisational safety culture.
22	.665	The airline's history has an influence on organisational safety culture.
33	.437	Senior management commitment plays an important role in determining the safety performance.
23	.403	Airline ownership has an influence on organisational safety culture.

Note: V- Questionnaire item number, Loading: Correlation to the factor

12) Factor 12: Communication system

This factor derived from the analysis focused on the importance of a safety communication system. It was of interest that the internal consistency of this factor (refer to footnote 39), consisting of items 25, 16, 15 and 50, increased from 54 percent to 66 percent if item 50 was excluded. As such, in the further analysis, item 50 is

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[39] Please refer to section 6.1.2 for the calculation of internal consistency.

is excluded from the factor. As such, this factor is labelled as "*Communication system*". The questionnaire items which correlated/loaded against "*Communication system*" are listed in Table 6-13.

Table 6-13 The Underlying Nature of Factor 12 "Communication system"

v	Loading	Item
25	.605	An adequate system exists for exchanging critical information regarding safety problems with other airlines.
50	-.502	Personnel's decision-making is affected by the organisational safety culture.
15	.441	There is good communication between different groups in the airline.
16	.328	Changes in working procedures and their effect on safety are effectively communicated to employees.

Note- V: Questionnaire item number, Loading: Correlation to the factor

13) Factor 13: Necessity of safety reports

This factor consisted of only two items and represented the degree to which the safety reports were concerned. The limited number of items loading onto this factor indicated that further study in this area might be warranted. Thus, this factor is named "*Necessity of safety reports*". The questionnaire items which correlated/loaded against "*Necessity of safety reports*" are listed in Table 6-14.

Table 6-14 The Underlying Nature of Factor 13 "Necessity of safety reports"

v	Loading	Item
39	.817	Confidential reports should be properly de-identified in order to foster organisational safety culture.
40	.528	There should be a procedure established for acknowledging safety-related reports.

Note- V: Questionnaire item number, Loading: Correlation to the factor

14) Factor 14: Requires further definition

This factor derived from the analysis focused upon to which degree the risk programmes have the influence on organisational safety culture, i.e. how safety programmes affect safety. It is of interest to note that this item was not grouped with factor 6 "*Employment of risk programme*" or factor 13 "*Necessity of safety report*". More work is required in this area. Given the low number of variables loading onto this factor, and the difficulty associated with its interpretation, this factor was not included for further analyses.

Table 6-15 The Underlying Nature of Factor 14

v	Loading	Item
41	.701	Risk audit, risk assessment, and risk evaluation have an influence on organisational safety culture.

Note- V: Questionnaire item number, Loading: Correlation to the factor

15) Factor 15: Requires further definition

This factor was somewhat difficult to define as it contained only two different items. In the case of variable 47, it represented the decision-making process regarding safety. For the case of variable 32, it represented the degree to which the role of the safety committee was played in determining the safety performance, providing the low number of variables loading onto this factor. This factor requires further definition and investigation to provide a precise interpretation. As such, this factor was deleted from further analysis.

Table 6-16 The Underlying Nature of Factor 15

v	Loading	Item
47	.820	Final decisions about safety investment are made by the Chief Executive Officer (CEO).
32	.392	Safety committee has an influence on organisational safety culture.

Note- V: Questionnaire item number, Loading: Correlation to the factor

6.1.2 Statistical Analyses for Internal Factors

✈ *Reliability and consistency*

To judge the internal reliability of factors, Cronbach's Alpha statistics were calculated for the factors (See Appendix O). For example, factor 1, with all items loaded onto it demonstrated an internal consistency of .85. Similarly the other factors all demonstrated acceptable levels of internal consistency, except for factors 10, 12, 13 and 15 (factor 2= .846, factor 3= .89, factor 4= .83, factor 5= .82, factor 6= .74, factor 7= .759, factor 8= .93, factor 9= .72, factor 10= .04, factor 11= .61, factor 12= .66, factor 13= .54, factor 15= .33).

As mentioned in the previous sections, the low reliability generated by factor 10 was because of the expression of the variables of 27 and 28, while the reliability of factor

12 rose to 0.66 when variable 50 was excluded.

In addition, factor 15, which remained undefined, demonstrated predictably low internal consistency. Meanwhile, a reliability score could not be calculated for factor 14 as it only contained one variable. These three factors were excluded from further analyses, leaving thirteen factors: *Employee safety attitude & behaviour, Employee safety concept, Level of operational safety in operation and maintenance, Corporate safety policy, Personnel- quality of working life, Employment of risk programme, Impact of accident/incidents, Financial concern, Procedures and documentation, Commercial cost pressures, Organisational structure & management commitment, Communication system, Necessity of safety reports.*

✈ Mean, Standard deviation & Scale scores

For the purpose of subsequent analyses, mean and factor scores (Appendix P) /scales scores (Appendix Q) were calculated for each of the scales identified in the Principal Component Analysis in order to further investigate what respondents thought to be important and what they felt satisfied with, and in which regions.

Factor scores are coefficients of cases on the factors, while scale scores are the sum of the responses for all items loading onto the factor, which was calculated and divided by the number of items loading onto that factor, which is named the scale score. In order to indicate the highest and the lowest scores rated by the representatives, mean of scale scores were applied within this section. Mean and standard deviation of scale scores can be found in Appendix P.

✈ Oneway Analysis of Variance (ANOVA) across regions

In order to see whether these underlying factors differed across the regions, oneway Analyses of Variance (ANOVA) were conducted for each factor across regions. Respondents were asked to reveal which regions they came from when completing the survey. There were six regions in the world; namely Africa, Asia and Pacific, Latin America and the Caribbean, Europe, Middle East and North America, as shown in Figure 5-2 (page 174) and Table 5-1 (page 175). The complete tables of ANOVA plus Mean and Standard Deviation for all 13 internal factors can be found in Appendix Q.

The observation from these various analyses will be discussed and compared to the empirical experiences in section 6.5.1 (page 196), when interpreting the internal factors respectively.

6.2 Organisational Factors in External Environment

As mentioned previously, this questionnaire consisted of two parts: internal environment and external environment. The following sections are the analyses of external factors exerting influences on the structure of safety mechanism.

The purpose of this section is to explore the inter-relationships between external variables on the questionnaire, and to develop factors which could be used in subsequent analysis. Similar to section 6.1, PCA followed by a varimax rotation was performed on the 16-item questionnaire data from 104 respondents in order to examine the underlying structure.

The data were deemed to be suitable for the analysis (data reduction procedures), as indicated by the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value of 0.724 (Hair et al., 1995). The Bartlett Test of Sphericity was significant [$\chi^2 = 633.276$, $P < 0.05$], indicating that correlations exist among some of the response categories (see Table 6-17).

Table 6-17 KMO and Bartlett's Test: External factors

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.724
Bartlett's Test of Sphericity	Approx. Chi-Square	633.276
	df	120
	Sig.	.000

The first analysis yielded four factors with eigenvalues greater than one, which together accounted for 68.51 percent of the explained variance. A varimax rotation was performed to enhance factor interpretability. Appendix N displays factor loadings from the varimax rotation.

The Principal Components Analysis produced some interesting results. Each factor will be discussed in turn. Before that, the individual items loading onto each factor are outlined in the tables (from Table 6-18 to Table 6-21), which accompany the result of analyses.

6.2.1 Loading Factors from Principal Components Analysis (PCA)

1) Factor E1: Influences of Region and Country

Factor E1 "*Influences of region and country*" dealt with the degree to which the impact of region and country was perceived to have on organisational safety culture. Included within this factor were regional economic, regional geography, regional culture, regional religion and country economics. Interestingly, regional and country influences were originally designed as two separated factors. This finding revealed that they were seen as one concern (factor) from managers' point of view, and regional economic influence attracted more concerns than country economic influence. The questionnaire items which correlated/loaded against "*Influences of region and country*" are listed in Table 6-18.

Table 6-18 The Underlying Nature of Factor E1 "Influence of region and country"

v	Loading	Item
70	.879	Regional economic influence and organisational safety are correlated.
69	.857	Regional geographical influence and organisational safety culture are correlated
72	.804	Regional cultural influence and organisational safety are correlated.
68	.715	The country economic influence and organisational safety culture are correlated
71	.685	Regional religion influence and organisational safety culture are correlated.

Note- V: Questionnaire item number, Loading: Correlation to the factor

2) Factor E2: Public and the Media Influence

Factor E2 "*Public and the media influence*" focused on the company's relationship with the public and the media, and to what extent organisational safety culture was influenced. The items loaded onto this factor and were all indicative of the media and public influences; customers' and consumers' perspectives were included. The questionnaire items, which correlated/loaded against "*Public and the media influence*" are listed in Table 6-19.

Table 6-19 The Underlying Nature of Factor E2 "Public and the media Influence"

V	Loading	Item
61	.881	The customer's reaction has influences on organisational safety culture.
63	.777	The perceived corporate image has influences on organisational safety culture.
62	.757	Consumer habits have influences on organisational safety culture.
60	.546	The relationship with the media has influences on organisational safety culture.

Note- V: Questionnaire item number, Loading: Correlation to the factor

3) Factor E 3: Impact of the Regulatory Environment

This factor dealt with the degree to which organisational safety culture was influenced by industry regulation/regulators. Included within this factor were the adherence to, and influence of, safety authorities. As such, this factor is labelled as "*Impact of the regulatory environment*" which shows that safety authority has been regarded as one of the most influential and important factors of the safety mechanism. The questionnaire items, which correlated/loaded against "*Impact of the regulatory environment*", are listed in Table 6-20.

Table 6-20 The Underlying Nature of Factor E3 "Impact of the regulatory environment"

V	Loading	Item
58	.809	Safety information from aviation safety authorities is highly valued.
59	.756	The regulations from the aviation safety authority have an influence on organisational safety culture.
57	.750	The recommendations and suggestions from the industry safety committee are adhered to all the time.

Note- V: Questionnaire item number, Loading: Correlation to the factor

4) Factor E 4: Involvement of Investment Community

Factor E4 "*Involvement of investment community*" was concerned with the degree to which organisational safety culture was influenced by the investment community. It is unclear why the last item was included in this factor. Yet since the number of loading is so low, this item is deleted in the further analysis. The questionnaire items, which correlated/loaded against "*Involvement of investment community*", are listed in Table 6-21.

Table 6-21 The Underlying Nature of Factor E4 "Involvement of investment community"

v	Loading	Item
65	.797	The investors' perspective has influences on organisational safety culture.
66	.788	The stock market's reaction has influences on organisational safety culture.
64	.555	The organisation's investments in other businesses are correlated with the organisational safety.
67	.219	The country culture and organisational culture are correlated.

Note- V: Questionnaire item number, Loading: Correlation to the factor

6.2.2 Statistical Analyses for External Factors

✈ *Reliability and consistency*

Cronbach's Alpha statistics were calculated to assess the internal consistency of these factors. All of the factors were shown to be reliable (Factor E1= .8575; Factor E2= .7854; Factor E3= .686; Factor E4= .636), as shown in Appendix O. As such, these four external factors are: *Influences of region and country*, *Public and the media influence*, *Impact of regulatory environment*, and *Involvement of investment community.*

✈ *Mean, Standard deviation & Scale scores*

For the purposes of subsequent analyses, factor scores (Appendix P) /scale scores (Appendix Q) were calculated for each factor identified in the Principal Component Analyses (PCA) in order to further investigate what respondents thought to be important and what they felt satisfied with, and in which regions. The same method was used as in the internal factor structure. In order to arrive at the best interpretation, both scale scores and factors scores were calculated. However, mean of scale scores were applied within this section because they indicated the highest and the lowest scores rated by the representatives. Mean and standard deviation of scale scores can be found in Appendix Q.

✈ *Oneway Analysis of Variance (ANOVA) across regions*

In order to see whether these underlying dimensions differed across the regions, oneway Analyses of Variance (ANOVA) were conducted for each questionnaire scale across six regions: Africa, Asia and Pacific, Central/South America, Europe, Middle East, North America. Appendix Q lists the table of ANOVA for all 4 external factors.

The observations from these various analyses will be discussed and compared to the empirical experiences in section 6.5.2 (page 206), when interpreting the external factors respectively.

6.3 Relationship between Organisational Factors and Safety Performance

Looking back to the hypothesised model illustrated in Figure 4-8 (page 157), both internal and external factors (input) exert influence on safety mechanism, which will manifest on the safety performance (output). Therefore, this analysis aimed to explore the relationship between the organisational factors (both internal and external) identified in this chapter and safety performance through the survey. As it is not possible to identify the safety performance from the anonymous survey, self-rated safety performance is therefore adopted. It was thought that an examination of the factors identified in the study were the biggest predictors of self-rated (perceived) safety performance, i.e. what organisational factors contributed to the explanation of the perceived safety performance, and to what degree, would provide some interesting insights into the development of a proactive safety mechanism. Hence, a stepwise multiple regression procedure was used. This part of the research was intended only as a guide to indicate which factors were the best predictors of perceived safety performance.

By applying the standard multiple regression analysis, the dependent variable was the self-rated safety performance, and the independent variables were the organisational factors - the influential dimensions of the safety mechanism; the latter were assessed in order to forecast the former. Appendix R shows that the result of the multiple regression and variance accounted for by the factor scores in the regression equation was significant ($F_{4,99} = 28.822$, $P<0.05$). It indicates that **there is a relationship between self-rated safety performance and organisational factors.** And without the existence of external factors, internal factor 2 "*Employee safety concept*", factor 12 "*Communication system*", factor 7 "*Impact of accidents/incidents*" and factor 3 "*Level of operational safety in operation and maintenance*" are the best predictors of self-rated safety performance among these organisational factors. If expressed by a linear equation, they have the form, according to Appendix R:

$$Y_1 = .486 + .403 * (factor\ 2) + .244 * (factor\ 3) + .113 * (factor\ 7) + .133 * (factor\ 12)$$

Where

Y_1 is self-rated safety performance
Factor 2 is Employee safety concept
Factor 3 is Level of organisational safety in operation and maintenance
Factor 7 is Impact of accidents/incidents
Factor 12 is Communication system

It is worth noting that in the equation, the regression coefficients (or *B* coefficients) represent the independent contributions of each independent variable (factors) to the prediction of the dependent variable (self-rated performance), i.e. for example, factor 2 "*Employee safety concept*" is correlated with the Y_1 (self-rated safety performance) after controlling for all other factors (factor3, factor 7 and factor 12). The direction of the correlation coefficients in the equation also indicates that higher factor scores are associated with better rated perceived safety performance.

6.4 Relationship between Internal and External Factors

One of the four hypotheses of this thesis is that the safety mechanism is a multiple and complex construct. This has been demonstrated through the case study included in Chapter 5 and will be further explored here in order to shed some additional light on this hypothesis.

As such, the following analysis was carried out to explore the relationship between the internal and external factors that were identified to have influence on a proactive safety mechanism in the previous sections, given that in Table 6-1, the Bartlett Test of Sphericity, indicates that correlations exist between some factors. For this purpose, correlations were calculated for each internal factor against each external factor. Appendix S shows the correlation and significant relationship between internal and external factors, including:

- **Correlation between E1 "Influences of region and country" and internal factors:**

  As shown in Appendix S, external factor E1 "*Influences of region and country*" demonstrated quite low correlations with all thirteen of the internal factors. The highest correlation (r=.216) was observed between this factor and internal factor 11 "*Organisational structure and management commitment*". A moderate and significant correlation (r=.198) was also observed between this factor and internal factor 10 "*Commercial cost pressures*".

- **Correlation between E2 "Public and the media influence" and internal factors:**

  Factor E2 "*Public and the media influence*" is found to be most correlated with internal factor 1 "*Employee safety attitude and behaviour*", factor 2 "*Employee safety concept*", factor 9 "*Procedures and documentation*", and factor 11 "*Organisational structure and management commitment*", shown in Appendix S. The highest correlations were observed between this factor and internal factors relating to "*Organisational structure and management commitment*" (r=.367) and "*Employee safety concepts*" (r=.272). Further significant correlations were observed between this factor and internal factors relating to "*Procedures and documentation*" (r=.244), and "*Employee safety attitude and behaviours*" (r=.216).

✈ **Correlation between E3 "Impact of regulatory environment" and internal factors:**

This factor E3 "*Impact of regulatory environment*" was significantly correlated with **all** internal factors. Among the internal factors, the highest correlation was observed between this factor and internal factor 3 "*Level of operational safety in operation and maintenance*" (r=.455).

✈ **Correlation between E4 "Involvement of investment community" and internal factors:**

Factor E4 "*Involvement of investment community*" demonstrates low correlations with all thirteen of the internal factors. However, this factor was found to be highly correlated with "*Commercial cost pressures*" (r=.226), and "*Financial concern*" (r=.198). Meanwhile, significant correlations were observed between this factor and those factors relating to "*Corporate safety policy*" (r=.235), and "*Impact of Accident/incidents*" (r=.219).

The implication of the results will be interpreted together with the discussion of each factor respectively in the following section.

6.5 Interpretation of Individual Factors

With the confirmation of the existence of organisational factors in the safety mechanism, a greater understanding of the forces (input) is provided at work within the internal and external working environment of the airline industry as well as the relationship to safety performance (output). Table 6-22 lists the summaries of statistical analyses from the preceding analyses. The following sections will carry out the in-depth discussion of the result findings.

6.5.1 Discussion of Internal Factors

✈ Factor 1: Employee safety attitudes and behaviour

The first factor derived within the internal environment is "*Employee safety attitude and behaviour*". Thus, the importance of employee competence regarding safety is emphasised. Among the skills and abilities (loading items) included within these factors are: employees' ability to comply with safety procedures, safety knowledge, safety participation, and safety motivation, which echoes the existing literature on safety culture explored in Chapters 2 and 4.

Furthermore, it is interesting to note that this factor did not predict perceived safety performance, i.e. individuals who rated the "*Employee safety attitude and behaviour*" highly on the questionnaire did not rate the *Perceived safety performance* more highly.

Additionally, the table of means indicated that means of factor 1 "*Employee safety attitude and behaviour*" scores were in the range of 4.2- 4.9. Safety managers in Africa reported the perceived factor 1 "*Employee safety attitude and behaviour*" more frequently than other regions within the airline industry, which also demonstrated an awareness of such concerns has more effect in this region compared to others.

A significant difference was observed on this factor across different regions ($F_{5,98} = 2.997$, $P<0.05$). When the effects are significant, the means must then be examined in order to determine the nature of the effects. There are procedures called "post hoc tests" to assist to perform this task. One of the post hoc multiple comparisons used was Least-Significant Difference (LSD). It indicated that this was attributable to a significance between respondents in North America compared to Europe as well as Asia and Pacific ($p<.05$), i.e. the mean difference was significant at the .05 level, which meant that there was variability of the opinions (rating scores of questions in

Table 6-22 Summaries of the Survey Results

Statistical Result / Organisational Factors	Safety performance predictor	ANOVA Significant across region (attribute to)		Factor mean score rating		Significant correlation			
				Highest	Lowest	E1	E2	E3	E4
1. Employee safety attitude and behaviour		✓	NA-EU-AP	AF	ME		✓	✓	
2. Employee safety concept	✓			AF	ME		✓	✓	
3. Level of operational safety in operation and maintenance	✓			AF	ME			✓	
4. Corporate safety policy		✓	NA-EU-AP	AF	ME			✓	✓
5. Personnel- quality of working life				AP	ME			✓	
6. Employment of risk programmes				AP	ME			✓	
7. Impact of accident/incidents	✓			LAC	ME			✓	✓
8. Financial concern				NA	ME			✓	✓
9. Procedures and documentation				AF	LAC		✓	✓	
10. Commercial cost pressures				AP	ME	✓		✓	✓
11. Organisational structure and management commitment				AF	ME, LAC	✓	✓	✓	
12. Communication system	✓			AF	LAC			✓	
13. Necessity of safety reports				NA	AP			✓	
E1. Influences of region and country				AF	NA	Internal Factor 10, 11.			
E2. Public and the media influences				ME	NA	Internal Factor 1, 2, 9, 11.			
E3. Impact of regulatory environment		✓	NA-AF-AP	AF	NA	Internal Factor 1~ 13,			
E4. Involvement of investment community				LAC	AF	Internal Factor 4,7,8,10.			

Note:

1. AF- Africa, AP- Asia and Pacific, EU-Europe, LAC-Latin America and the Caribbean, ME-Middle East, NA-North America.

the survey) towards employee safety attitudes and behaviour within these three regions. Generally speaking, the higher the rating scores, the more satisfaction there was towards employee safety attitudes and behaviour, and the more importance and attentions of safety culture were placed in the company. Further referring to the table of mean (Appendix P), the mean scores of this factor in six regions showed that the lowest ratings on this factor originated from the Middle East while the highest ratings came from Africa. This seems to contradict industry indicates: Middle East airlines have better airline publicity and aircraft performance than Africa airlines which tend to have poor publicity, poor accident record and lack of regulatory framework. The contradiction will be further explained when discussing the bias of the questionnaire responses.

A significant correlation was also observed between factor 1 "*Employee safety attitude and behaviour*" and external factor E2 "*Public and media influence*" and external factor E3 "*Impact of regulatory environment*", in particular E3. As to E2, since public and media influence involve company reputation management, it is therefore more related to employee safety knowledge and safety motivation, which constitute this factor. Thus, a higher level of understanding and activity on the part of the regulatory environment and the public and media are associated with employee safety attitudes and behaviour which favours the development of a proactive safety mechanism.

✈ Factor 2: Employee safety concept

The safety concept factor included employees' beliefs, shared perceptions and organisational atmosphere. The presence of this factor is consistent with the literature which described the contribution of a safety climate to the organisation, in Chapter 4.

No significant differences were observed for this factor ($F_{5,98} = 2.123$, $P>0.05$). It showed the degree of perceived employees' safety concepts rated by respondents at all regions were similar to each other. Furthermore, an examination of the mean scores for each group on this factor revealed that higher scores tended to be rated (except for Latin America and the Caribbean, and the Middle East), which showed the highest satisfaction of the perceived safety concept, and the importance of a safety climate was felt by the respondents. Across the regions, scale scores reveal the highest ratings (higher satisfaction) were observed in Africa, while the lowest were in the Middle East (lower satisfaction).

Factor scores from the multiple regression analysis (Appendix R) show this factor to be a significant predictor of perceived safety performance. It meant that those who rated the employee safety concept highly on the questionnaire rated the perceived safety performance more highly. Meanwhile, the direction of the correlation coefficients indicates that higher factor scores are associated with better rated perceived safety performance.

A significant correlation was observed between factor 2 "*Employee safety concept*" and external factor E2 "*Public and media influence*", and external factor E3 "*Impact of regulatory environment*", shown in Appendix S. In other words, employee safety concept is likely to be more influential on a proactive safety mechanism when the media and public and the regulatory environment become more active and involved.

✈ Factor 3: Level of operational safety in operation and maintenance

Operation and maintenance issues were highlighted since this factor is concerned with the degree to which individuals are empowered to deal with operations and maintenance issues, especially regarding training. In Chapters 2 and 4, the importance of these items was identified as being critical to the continual improvement of safety.

The oneway ANOVA for this factor approached, but failed to reach statistical significance ($F_{5,98} = .647$, $P>0.05$). Therefore, it could be concluded that managers working in all regions displayed a similar degree of concern for operation and maintenance aspects.

Factor scores from the multiple regression analysis show that this factor is a significant predictor of perceived safety performance (Appendix R) within the airline industry, i.e. individuals who rated this factor highly on the questionnaire rated the

Perceived safety performance more highly. It also indicates that higher factor scores are associated with better rated perceived safety performance.

A significant correlation was observed between factor 3 "*Level of operational safety in operation and maintenance*" and external factor E3 "*Impact of regulatory environment*", shown in Appendix S. This finding reveals that the influence of regulators and regulations for safety is associated with the level of operational safety in operation and maintenance to a significant degree. With African region reveals the highest mean score of this factor, it seems to conflict with the conclusion in previous paragraph and industry findings since African regulatory regimes are largely regarded as ineffective. Again, similar to factor 1 "*Employee safety attitude and behaviour*", the bias will be explained in section 6.7 and 6.8.

✈ Factor 4: Corporate safety policy

The safety policy within airlines was represented by a factor of its own which includes items relating to clear stated policy towards goals, objectives and approaches to safety. A significant difference ($F_{5,98} = 2.363$, $P<0.05$) was observed on this factor between groups of respondents representing different regions, which described the degree to which the airline focused on and practiced its safety policy. In a similar manner to factor 1"*Employee safety attitude and behaviour*", the post hoc multiple comparison - Least-Significant Difference (LSD) indicated that region of North America differed from the regions of Europe and Asia and Pacific ($P<.05$), indicating the variability which exists within these regions. Meanwhile an examination of means revealed that Africa perceived this aspect to be more satisfactory in their working environment, and regarded this factor to be more important than those who were in other regions. The lowest ratings on this factor originated from the Middle East (refer to previous factors for the African issue).

A significant correlation was observed between factor 4 and external factor E4 "*Involvement of investment community*", and external factor E3 "*Impact of regulatory environment*", presented in Appendix S. It indicates that the investment community is likely to be more associated with the organisations which value safety policy and/or post event impact in order to develop a proactive safety mechanism.

✈ Factor 5: Personnel – quality of working life

Factor 5 "*Personnel – quality of working life*" included items relating to personnel attitudes, morale, working relationships, and frustration accommodation. No significant differences were observed between the responses from various regions on this factor ($F_{5, 98}$ =.111, P>0.05). Thus, there is no need to conduct the post hoc multiple comparisons because groups of respondents representing all regions reported similar attention to their companies' personnel working life quality.

Given the similar degree across regions, two points were observed from the Mean/Standard Deviation Table for factor 5 "*Personnel – quality of working life*". One was that the scores rated by all representatives were relatively low compared with other factors, which showed less satisfaction with the quality of employee working life, because no significant difference was observed on this factor across different regions[40] and the observation of lower ratings is shown in the table of mean. The other was that the highest rating on this factor originates from Asia and Pacific, while the lowest one is from the Middle East. As such, Asia Pacific representatives had a better acknowledgement of this factor, given the low tendency of mean scores of other regimes.

A significant correlation was observed between factor 5 "*Personnel – quality of working life*" and external factor E3 "*Impact of regulatory environment*", shown in Appendix S. As such, regulators are likely to take greater steps towards encouraging proactive safety in the organisations in which employees' working quality support such action.

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[40] Notwithstanding the lack of regional variations, there is likely to be variations between the different workforce group, e.g. pilots, engineers, cabin crew, etc.

✈ Factor 6: Employment of risk programmes

This factor was represented by three variables relating to the importance of data analysis systems, safety information and hazard identification systems to safety culture, identified in Chapter 2. Respondents were thought to have a similar degree of feeling towards the employment and benefit of risk programmes because no significant differences were observed ($F_{5,98} = .693$, $P>0.05$) between regions on this factor across different regions. As such, representatives from various regions have a similar degree of view regarding airline risk programmes.

A significant correlation was observed between factor 6 "*Employment of risk programmes*" and external factor E3 "*Impact of regulatory environment.* It indicated that regulators are likely to encourage proactive safety in the organisations in which the employment of risk programme helps to support such action.

✈ Factor 7: Impact of accidents/incidents

This factor includes the existence of emergency plans, actions taken in the aftermath of accidents and incidents, and business continuity plans. In Chapter 2, the importance of these items was identified as being critical to safety improvement.

The oneway ANOVA across regions on factor 7 "*Impact of accident/incidents*", dealing with the management's view of the influence of incidents/accidents, did not demonstrate any statistical significance ($F_{5,98} = .598$, $P>0.05$). Therefore respondents across different regions did not vary appreciably in their views of the actions that the company took to deal with the aftermath of incidents/accidents.

However, Mean/Standard Deviation Table of factor 7 showed standard deviations of five regions were over one, showing that there was variability within all regions except Latin America and the Caribbean. This interesting observation might be caused by that not all the airlines were used to have accidents, which had the responses deviated within regions.

Multiple Regression analysis shows that this factor is a significant predictor of perceived safety performance (Appendix R) within the airline industry. It indicates that there exists a positive relationship between "*Impact of accident/incident*" and *Perceived safety performance*, i.e. individuals who had high rating scores of the former was likely to rate the latter with high scores.

A significant correlation was also observed between factor 7 "*Impact of accident/incident*" and external factor E3 "*Impact of regulatory environment*" and external factor E4 "*Involvement of investment community*", demonstrated in Appendix S.

✈ Factor 8: Financial concern

Factor 8 "*Financial concern*" is the one split from commercial pressures. It is represented by two variables relating to conflict between safety and financial goals and shareholders' welfare. ANOVA of factor 8 "*Financial concern*" did not reveal any significant difference across regions ($F_{5,98} = .675$, $P>0.05$). Given this fact plus the mean scores were lower, it implies that representatives rated this factor -*Financial concern*, to a similar degree, which indicates that financial concerns did influence safety goals, but not by much, compared to other factors.

Five standard deviations within regions were observed to be higher than one (Appendix Q), showing the potential differences of concerns towards factor 8 within individual regions. Secondly, the managers in North America demonstrated the highest concern in this regard compared with managers in other regions.

✈ Factor 9: Procedures and documentation

Factor 9 "*Procedures and documentation*" included items relating to documented responsibilities, written work procedures and written monitor procedures. Respondents across the regions had a similar degree of opinions towards procedures and documentation in their airlines since no significant difference was observed on this factor across the different regions ($F_{5,98} = .384$, $P>0.05$). As such, respondents across different regions displayed a similar degree of concern regarding factor 9 "*Procedures and documentation*" with their airlines. An examination of the mean scores for each group on this factor (Appendix Q) revealed that managers in all regions had their companies' documentation process rated with a similar frequency of 4.3. The highest rating on this factor originates from Africa, while the lowest one is from Latin America and the Caribbean. The contrary to the empirical experiences will be explained in later sections.

✈ Factor 10: Commercial cost pressures

This factor derived from items relating to management concerns, safety budget, value of management, and trade-off between cost and safety, demonstrated in Chapter 4. Similar to factor 8 "*Financial concerns*", oneway ANOVA for regions approached, but failed to reach statistical significance ($F_{5,\ 98} = .415$, $P>0.05$). Therefore, respondents across different regions did not vary appreciably in their views of commercial cost pressures on safety performance.

An examination of the table of means (Appendix Q) revealed the highest rating on this factor originated from Asia and Pacific, while the lowest one was from the Middle East. The lower mean scores suggest that respondents across the regions had low appreciation of the influence of this factor upon safety. It reflected the fact that commercial cost pressures were not significantly perceived by safety mangers across regions, especially Middle East.

"*Commercial cost pressures*" was significantly correlated to E1 "*Influence of region and country*", E3 "*Impact of regulatory environment*" and E4 "*Involvement of investment community*" (Appendix S). This shows that commercial cost pressures exert a significant impact on promoting proactive safety with the influence of region and country, regulatory environment and investment community. The smaller correlations indicated the decreasing impact actions.

✈ Factor 11: Organisational structure and management commitment

This factor represented by five items relating to the size and history of airline, leadership, senior management commitment and airline ownership. Although no significant difference ($F_{5,98}$ = .981, P>0.05) was observed on this factor across the different regions, the table of mean (Appendix Q) shows the high rating tendency of respondents, which means that the importance of organisational structure and management commitment was highly appreciated by representatives across regions to a similar degree, as factor 11 "*Organisational structure and management commitment*" indicated the importance of understanding and involvement of organisational structure and management commitment in the company. The highest rating on this factor originated from Africa, while the lowest one was from the Middle East and Central/ South America.

✈ Factor 12: Communication system

This factor included the exchanging safety information system, personnel's decision-making, group communication, and employee communication. No significant difference was observed on this factor across different regions ($F_{5,98}$ = 1.313, P>0.05). By this result, respondents across different regions did not vary appreciably in their views of the communication system. Moreover representatives tended to have a low rating across regions on this factor, showing that similar degree of view of airline representatives was less satisfaction towards the individual airlines and *Communication system* is seen as less effective.

In addition, factor 12 "*Communication system*" is a significant predictor of perceived safety performance within the airline industry (Appendix R). This relationship not only indicates the positive correlation between these two factors, but also the contribution of the communication system to perceived safety performance. Across the regions, the highest ratings were observed in Africa, while the lowest were in Latin America and the Caribbean. A significant correlation was also observed between factor 12 "*Communication system*" and external factor E3 "*Impact of regulatory environment*", indicating the positive relationship between these two factors.

✈ Factor 13: Necessity of safety reports

Factor 13 "*Necessity of safety reports*" included two items relating to confidential report identification, and procedures for safety reports, described in Chapter 2. The oneway ANOVA across regions on this factor approached, but failed to reach statistical significance ($F_{5,98} = .565$, $P>0.05$), i.e. respondents across the regions were deemed to have a similar degree of concern, which tended to be high on this factor. Thus, respondents across different regions did not vary dramatically in view of the safety reports, and the representative across regions all placed importance on the necessity of safety reports. This can be explained, for example, although various European JAR requirements for mandatory operating on maintenance and operational issues, the necessity and importance of safety reports are never been neglected and still been highly concerned.

The highest rating on this factor originated from North America, while the lowest one was from Asia and Pacific. A significant correlation was observed between factor 13 "*Necessity of safety reports*" and external factor E3 "*Impact of regulatory environment*", shown in Appendix S. Again, it showed that the necessity of safety reports and the impact of regulatory environment were positively correlated.

Within the interpretation of internal factors, it showed some findings are contrary to the industry experiences. The contradiction will be further interpreted in section 6.7 (page 214).

6.5.2 Discussion of External Factors

✈ Factor E1: Influences of region and country

Factor E1 "*Influence of region and country*" included items relating to economic, geographic, cultural and religious influence of region and country. No significant difference was observed on this factor across the different regions ($F_{5,98} = .669$, $P>0.05$), so respondents were seen to regard the impact of region and country to a similar degree and they had a common feeling of less impact of this factor, shown by the lower mean scores.

Factor E1 "*Influence of region and country*" demonstrated quite low correlations with all thirteen of the internal factors as shown in Appendix S. As such, one can conclude that the influence of region and country does exert an influence on the safety mechanism but it was seen to play a relatively minor role in the development of a proactive mechanism. However, a number of moderate correlations were observed which warrant some further discussion at this point.

The highest correlation was observed between this factor and internal factor 11 "*Organisational structure and management commitment*". This finding indicates that a higher level of influence of region and country is associated with organisational structure and management commitment towards developing proactive safety mechanism to a significant degree. It also suggests that regions and countries are likely to exert an influence on encouraging proactive safety in the organisations in which structure and commitment support such action.

A moderate and significant correlation was also observed between E1 "*Influence of region and country*" and internal factor 10 "*Commercial cost pressures*", which demonstrates the impact of commercial pressures. It shows that the degree to which region and country exert an influence to establish a proactive safety mechanism is associated to a significant degree with commercial cost pressures.

✈ Factor E2: Relationship with the public and the media

Factor E2 "*Relationship with the public and the media*" was represented by four variables relating to customer relations, perceived corporate image, customer habits and media relationships. Representatives across the regions were thought to have no different degree of concerns regarding this factor because no significant difference was observed on this factor across different regions ($F_{5,98} = .909$, $P>0.05$). Therefore, respondents across different regions did not vary appreciably in their views of how the public and the media influence organisational safety. Compared to E1 "*Influence of region and country*", the mean score of E2 "*Relationship with the public and the* *media*" in various regions was much higher, indicating that the public and media were deemed as an importantly influential factor.

A significant correlation was observed between E2 "*Relationship with the public and the media*" and internal factor 11 "*Organisational structure and management commitment*", factor 2 "*Employee safety concept*", factor 9 "*Procedures and documentation*" and factor 1 "*Employee safety attitude and behaviour*", shown in Appendix S. The highest correlations were observed between this factor and internal factors relating to "*Organisational structure and management commitment*" and "*Employee safety concept*". As such, a higher level of understanding and activity on the part of the public and media is associated with an organisational structure and management commitment and employee safety concept which favours the development of a proactive safety mechanism.

Further significant correlations were observed between E2 "*Relationship with the public and the media*" and internal factors relating to "*Procedures and documentation*", and "*Employee safety behaviours*". Accordingly, a better appreciation of procedures and documentation with respect to safety and well-behaved employee safety behaviours is likely to involve more positive relation to influence media and public or receive its influence, which in turn affect a proactive safety mechanism.

✈ Factor E3: Impact of regulatory environment

This factor was represented a factor of its own, which included items relating to: value of safety authority information, the influence of regulations and the adherence of industry safety committee suggestions. The oneway ANOVA for region on Factor E3 "*Impact of regulatory environment*", dealing with safety authority's influence on organisational safety demonstrated statistical significance ($F_{5,98} = 2.435$, $P<0.05$). Post hoc multiple comparisons - Least-Significant Difference (LSD) indicated that this was attributable to a significance between respondents in North America compared to Africa as well as Asia and Pacific ($p<.05$), i.e. the mean difference is significant at the .05 level.

The examination of table of means revealed the highest rating on this factor originated from Africa, while the lowest one was from North America. However, the empirical experiences show North America is heavily regulated, perhaps too much, while Africa less so with safety information promulgated by regulators. The Africa result may indicate a dependence upon regulatory impact due to inadequacies in the company management structure. Yet there is still a need to further investigate the impact of bias of questionnaire in subsequent sections.

Additionally, a significant correlation was observed between E3 "*Impact of regulatory environment*", and all internal factors (Appendix S), showing the close relationship between airlines and regulatory environment. This finding is of importance, and it indicates that a higher level of understanding and activity on the part of the regulatory environment is associated with all internal factors which favour the development of a proactive safety mechanism. It demonstrates that the role of the regulator and regulation were deemed to be important to the internal organisational factors for promoting proactive safety.

Among the internal factors, the highest correlation was observed between this factor and internal factor 3 "*Level of operational safety in operation and maintenance*". This finding reveals that the influence of regulators and regulations for safety is associated with the level of operational safety in operation and maintenance to a significant degree[41]. Regulators are likely to take greater steps towards encouraging proactive safety in the organisations in which operation and maintenance support such action.

✈ Factor E 4: The influence of investment community

Factor E4 "*The influence of investment community*" included items relating to investors' prospective, stock market's reaction, and business investment. No significant difference was observed on this factor across different regions ($F_{5,98} = .910$, $P>0.05$). Thus, respondents across different regions did not vary appreciably in their view of how investment influenced organisational safety.

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[41] It is interesting to note that despite the regulatory environment and the findings here it is non-compliance with regulatory requirements that after leads to incidents/accidents.

Also, table of mean/standard deviation showed relatively lower mean scores, compared to other factors. Most of the standard deviations were greater than one or close to one, indicating the variance within the individual regions. The highest rating on this factor originated from Latin America and the Caribbean, while the lowest one was from Africa.

According to Appendix S, factor E4 shows low correlations with all thirteen of the internal factors. A significant correlation was observed between E4 "*The influence of investment community*" and "*Commercial cost pressures*", and "*Financial concern*". As such, the degree to which the investment community's influence on establishing proactive safety mechanism is associated with organisations' financial issues to a significant degree.

Meanwhile, significant correlations were observed between E4 "*The influence of investment community*" and those factors relating to "*Corporate safety policy*", and "*Impact of Accident/incidents*". It indicates that the investment community is likely to be more associated with the organisations which value safety policy and/or post event impact in order to develop a proactive safety mechanism. It reflects a tendency of investors to continue investing if an airline does not have an accident or bad press imperative of its safety policy.

In summary, the evidence from these findings support the second hypothesis of this thesis which states that the safety mechanism will be demonstrated as a complex and multidimensional construct, which will be influenced by a set of factor-structure. Hypothesis three, stating that the organisational factors mediate the relationship between the safety mechanism and safety performance, and act as predictors of safety performance, is also supported by the findings.

6.6 Comparison with the Hypothesised Factor Structure

The results of survey reveal a slightly different factor structure in comparison to that of the hypothesised model (see Table 6-23). In terms of internal underlying factors, the factors derived from the internal environment confirm the general structure of the safety mechanism model with few changes, when compared with the hypothesised internal factor structure. These changes are listed below:

- Factor 1- "Perceived safety" in the hypothesised model was separated into two internal factors: "*Employee safety attitude and behaviour*" and "*Employee safety concept*" in the survey results and the latter is the predictor of perceived safety performance. This finding is of interest because, as mentioned in the previous section, safety behaviour is related to safety culture, while safety concept is more related to safety climate. It therefore indirectly proves the construct of the safety mechanism and would be able to provide the airlines with exact influential factors to promote proactive safety.

- Factor 8- "Personnel communication and relationship" was split into two factors in the survey results- "*Personnel-quality of working life*" and "*Communication system*". It shows that to employees, good working relationship in the company manifest itself on the quality of work life, including morale, well defined job function, and accommodation of frustration. These are what personnel deem to be as important in the working environment and have influence on proactive safety. Meanwhile, the appearance of "*Communication system*" indicates the importance of the organisational communication system, especially when the issue is related to proactive safety and examined as one of the predictors of perceived safety performance.

- Factor 6- "Safety information" was reconstructed to create a new factor- "*Necessity of safety report*". This result reveals that within airline safety information systems, safety reports attract higher attention and are thought of as one of the influential factors on a safety mechanism, and as one of the predictors of perceived safety performance.

✈ Items in Factor 4- "Management control (or quality control)" were not grouped together; instead most of them were included in "*Organisational structure and management commitment*". As such, "Management control" was dismissed and replaced by "*Organisational structure and management commitment*" to cover the managerial issues, which echoes to Chapter 2 when describing the important of these managerial issues on airline safety.

✈ Factor 10- "Decision-making style and process" was out of the factor structure because the results did not reveal the characteristic of this factor. Similarly, a new factor emerged and grouped the financial issue items together. This new factor was therefore named "*Financial concern*". Again, it showed the degree to which the survey respondents regarded these concerns important to the development of a safety mechanism.

In terms of external factors, in total the results of the survey identified four factors in the external environment. Compared with the original ones proposed (five in total), country influence and regional influence were combined into one factor. This finding, together with the fact that the scores rating of this factor was lower than that of others pointed to the fact that influences of region and country were not exerting as powerful an influence on proactive safety mechanisms as was initially proposed. As to the other three factors, the survey results revealed the same factor structure. However, the factor names were changed slightly in order to describe their characteristics more accurately.

Table 6-23 Comparison of the Factor Structure

	Hypothesised model	Survey result
Internal	1. Perceived safety 2. Operation and maintenance 3. Risk management (control) 4. Management control (quality control) 5. Commercial pressures 6. Safety information (info technology) 7. Organisational structure 8. Personnel communication and relationships 9. Post-incident/ accident (impact of incident/accident) 10. Decision making style and process 11. Corporate safety policy 12. Documentation	1. Employee safety attitude& behaviour 2. Employee safety concept 3. Level of operational safety in operation and maintenance 4. Corporate safety policy 5. Personnel- quality of working life 6. Employment of risk programmes 7. Impact of accident/incidents 8. Financial concern 9. Procedures and documentation 10. Commercial cost pressures 11. Organisational structure and management commitment 12. Communication system 13. Necessity of safety reports
External	1. Industry regulations 2. Public relationships 3. The investment community 4. Country influences 5. Regional influences	1. Influences of region and country 2. Public and the media influence 3. Impact of regulatory environment 4. Involvement of investment community

6.7 Discussion of the Bias in the Result

The conclusions outlined in the previous section support the perspectives which underline the safety mechanism in Chapter 4. This section aims to identify the ways in which the conclusions regarding organisational factors expand the understanding of the development of a proactive safety mechanism. As such, some consideration of the interpretation of the data and some discussion of where the results fit within the existing literature are in order.

There are two points worth noting as the bias the results when applying results from this study.

1. The uneven representation of respondents across different regions:

The respondents from different regions include twenty-two from North America, three from Africa, thirty-six from Europe, thirty-six from Asia and Pacific, five from Latin America and the Caribbean and two from the Middle East (Figure 5-2, page 174).

Two points need to be addressed here. Firstly, according to Figure 5-2, the proportion of returned questionnaires from Africa and the Middle East were much lower than the intended sample rate. Secondly, the low number of representatives from Africa and the Middle East in the current sample revealed that higher scores were rated by African representatives, while lower scores were rated by representatives from the Middle East on most of the factors, which may limit the power of the analyses, especially when discussing these three factors with significant differences across regions. As such, there is a need to review the results of factors 1 "*Employee safety attitude and behaviour*", factor 4 "*Corporate safety policy*" and factor E3 "*Impact of regulatory environment*", which will be discussed in next section - Implication for the proactive safety mechanism model.

2. Two undefined factors: internal factor 14 and 15:

These two factors remained undefined and were not subjected to further analyses.

Both factors contained items which, although only moderately related to other items within the questionnaire, still point to elements which were thought to be important to the development of a proactive safety mechanism. The fact that they were not included in the other thirteen internal factors would demonstrate that they account for some degree of variance which was not accounted for by other factors. Therefore, some thought is required before they should be dismissed as unimportant, and it may be advisable to expand upon these factors in future research.

Factor 14 contained one item which dealt with the degree to which the individuals felt the influence of risk audit, risk assessment and risk evaluation on organisational safety culture (Table 6-15, page 186). The fact that this item was not included in factor 6, which represents the "*Employment of a risk programme*", would indicate that the individual's assessment of the level of risk posed by the organisation is not indicative of the correlation between risk management and organisational safety. This is curious when interpreted in the context of the finding described in Chapter 2, which indicated that the system approach to risk management is known as system safety, implying that the process of risk management, which is used throughout industry and commerce, involves identifying work activities and hazards and estimating, evaluating and controlling the associated risk, is the just tool used to achieve SMS (GAIN, 2000).

Factor 15 associates two items which indicate the Chief Executive Officer's (CEO) decisions about safety investment, and the influence of the safety committee on organisational safety culture (Table 6-16, page 186). There is no similarity between these two items, making this factor difficult to define, although both items were deemed to be variables influential on organisational safety culture. The former item focuses on the decision making style in the organisation, which the interview suggested may not be symbolic enough to promoting a proactive safety mechanism, and needs more work. The latter considers the influence of the safety committee on safety, which is supposed to be included in internal factor 11 "*Organisational structure and management commitment*". Chapter 2 highlighted Edward's (1999) and Overall's (1999) comments regarding the importance of an effective organisational structure for airline safety culture. This result may imply that a safety committee has a review role to play in determining what are the safety issues; however, the setting and planning of the safety committee depends on the characteristics and operations of different airlines, which in turn influence organisational safety and the proactive safety mechanism.

6.8 Implications of the Survey Results

Described in Chapter 4, the top-down method was selected for the safety mechanism model since it provided a useful description of the complex interactions which take place between the myriad factors critical to the development of proactive safety. As discussed previously, this analogy represents a way of thinking and the actions of organisation. The aim of this model is to provide a greater understanding of such organisational factors as influence an airline's proactive safety mechanism, and the evolution of safety management system and safety performance (services). The current result is useful in this regard.

Looking back on the results:

1. Predictors of perceived safety performance

It is worth noting that the significant predictors of perceived organisational safety performance were: "*Employee safety concept*", "*Communication system*", "*Impact of accident/ incidents*" and "*Level of operational safety in operation and maintenance*". Although a causal relationship could not be established from correlational analyses, these findings do provide some insight into the critical factors of perceived airline safety performance.

Firstly, this finding demonstrates a relationship does exist between organisational factors and safety performance. In particular, it was discovered that these four factors - the importance of employee safety concepts, organisational communication, post-event adjustment, and the requirement for management to create an atmosphere where personnel's contribution to safety in operation and maintenance, predict and contribute to airline safety performance to a significant degree. The regression equation also shows that "*Employee safety concept*" makes the largest contribution to the prediction of perceived safety performance, while the "*impact of accidents/incidents*" makes the least contribution to the prediction. It reflects the literature in chapter 2: safety concept defines safety policies and principles, which assign safety accountability, practice safety directives and consequently influence the outcome of SMS.

Meanwhile, the highest rating of perceived safety performance was from the European region. Interestingly, it was found that regardless of the low number of African representatives, **European** representatives rated the highest scores for factor 1 "*Employee safety attitude and behaviour*", factor 2 "*Employee safety concept*" and factor 3 "*Level of operational safety in operation and maintenance*". This implies that European airlines acknowledge more readily employees' safety concepts, attitudes, behaviour and performance on operation and maintenance within their airlines, and are reported to demonstrate these concerns more frequently and more satisfactorily than other regions within the airline industry. This result is expected also because European Authorities influence on SMS and related issues. As such, it may be concluded that airlines in which these issues are thought to be important and are acknowledged by the management may have the appropriate motivation and attitudes to participate in safety initiates.

2. Implication of mean scores and standard deviation of factors

As described previously, the scores rated by the respondents not only showed the current situation of individual airlines, but also revealed what people thought to be important, the degree to which they felt satisfied with them, and the regions they came from. Across different regions, the results of ANOVA indicated that no significant differences on each organisational factor were observed, except for internal factor 1 "*Employee safety attitude and behaviour*" and factor 4 "*Corporate safety policy*", plus external factor E3 "*Impact of regulatory environment*". This finding pointed to the fact that safety managers from different regions viewed each organisational factor influencing the proactive safety mechanism to a similar degree, with the exception of these three factors. This is useful especially for the regulatory authorities such UKCAA, FAA, Transport Canada, etc. when they promote the concept of SMS. As such, followings will be divided into three parts to discuss:

✈ ***With significant difference across regions:***

In terms of factor 1 "*Employee safety attitude and behaviour*", a significant difference was observed for factor scores across regions. Post hoc multiple comparisons - Least-Significant Difference (LSD) - indicated that this was attributable to a significance between respondents in North America compared with Europe, as well as Asia and Pacific. Moreover, regardless of the responses from Africa and the Middle East, the table of means shows that safety managers in **Europe** reported to voice this concern more frequently than other regions within the airline industry. As such, one may conclude that European representatives (safety managers) are more satisfied with their employees' competence on safety attitudes and behaviour and are more aware of the influence of employee safety attitudes and behaviour on the proactive safety mechanism.

In terms of factor 4 "*Corporate safety policy*", post hoc multiple comparisons – LSD - indicated that this was attributable to a significant difference between respondents in North America compared with Europe and Asia and Pacific. Taking Africa and the Middle East out of consideration, the table of means shows that safety managers in **North America** observed this aspect more frequently in their working environment and deemed the influence of corporate safety policy on the proactive safety mechanism to be more significant than did those from other regions. The occurrence may result from the heavily regulated environment and regulatory compliance in the region of North America.

In terms of external factor E3 "*Impact of regulatory environment*", post hoc multiple comparisons – LSD - indicated that this was attributable to a significant difference between respondents in North America compared with Africa as well as Asia and Pacific. Without taking into account those respondents from Africa and the Middle

East, the table of means shows that safety managers in **Asia and Pacific** regarded the impact of the regulatory environment, including regulators and regulations, on proactive safety mechanisms as being more important than did those from other regions. Apart from the effect of European influence, such as in Malaysia, HK, Brunei, and Singapore, the influence of Power Distance in National culture dimension, identified in Chapter 2 may be the main effect.

✈ ***With no significant difference across regions:***

In terms of **internal factors** that were found to have no significant differences across regions, the following factors were rated with lower mean scores on average when compared with the mean scores of other factors: "*Personnel - quality of working life*", "*Financial concern*", "*Commercial cost pressures*" and "*Communication system*". Tested by ANOVA, safety managers from various regions had similar degree of concerns regarding these factors. This indicated that in addition to regarding these factors as being influential upon the safety mechanism, safety managers from various regions had common feelings of their employees being less satisfied with the quality of their working life, less effective communication systems, and fewer perceived financial pressures compared with other internal factors.

Some factors were rated with higher scores including: "*Employee safety concept*", "*Organisational structure and commitment*", and "*Necessity of safety report*". This demonstrated that the safety representatives had common feelings of higher satisfaction of employee safety concepts, the importance of organisational structure and management commitment, and the necessity of safety reports.

In terms of **external factors,** the two following factors were rated with lower scores, and across the different regions respondents viewed these factors to a similar degree: "*Influences of region and country*", and "*Involvement of investment community*". The findings demonstrated that firstly, these factors are regarded as being the influential factors within the safety mechanism in the external environment; and secondly, respondents from various regions had common feelings of relatively less influence of region and country on organisational safety (the analysis of the relationship of internal and external factors in section 6.4 also found that the influence of region and country was seen to play a relatively minor role in the development of proactive safety mechanism), and less influence of the investment community than other external factors.

✈ ***With a difference within regions:***

Meanwhile, the two factors: "*Impact of accidents/incidents*" and "*Financial concern*" were tabled to have a standard deviation value greater than one within most of the regions, except Latin America and the Caribbean on the factor "*Impact of accident*", and Africa on the factor "*Financial concern*". This meant that there was some variability in responses to the factors within the individual regions, and future study may be needed.

3. Factor 2 "*Employee safety concepts*" vs. Factor 1 "*Employee safety attitudes and behaviour*"

As mentioned in section 6.6, these two factors were split off from one factor in the original proposed model. In accordance with the definitions of safety climate and safety culture within the airline industry, given in Chapter 4, safety concept is related to safety climate, while safety attitude and behaviour is more closely related to safety culture. Further investigation of the factor scores revealed that the mean scores for safety concept tend to be higher than for safety attitude and behaviour. As such, one may conclude that the former is deemed to be more important and satisfactory than the latter.

4. Factor E3 "*Impact of regulatory environment*" is correlated to all internal factors

Factor E3 emerged as one of the most influential factors of the safety mechanism, although the result of ANOVA showed that there was a significant difference between respondents in North America compared with Africa, as well as Asia and

Pacific, on this factor. The most noticeable point is that it is correlated to all the internal factors by the correlation test. This finding revealed that the airline industry is a highly regulated business and with the rising competitive airline industry (e.g. Alliance, network sharing), the role of regulator will become more crucial.

5. Factor 10 "*Commercial cost pressures*" and Factor 8 "*Financial concern*":

The appearance of factor 10 "*Commercial cost pressures*" proved that commercial cost pressures do exert an influence on airline safety mechanism, although, as mentioned in Chapter 4, those airline safety managers interviewed did not admit any cost pressure on safety. More interestingly, factor 8 "Financial concern" emerged as a newly formed factor, which was identified to be one of the influential factors on the safety mechanism in the survey results. It further showed that financial issues also attracted the attention of the respondents to a critical degree, although the mean scores of it and factor 10 "Commercial cost pressures" were not as high as other factors.

6. Implication of organisational learning:

One point worth noting here is the survey results reveal the implication of organisational learning within the model. Choularton (2001) and Sagan (1993) present four constraints on organisational learning. These are:

1. **Feedback** from the real world is often ambiguous. This allows pre-conceived and convenient positions to be supported through different interpretations of the available information.
2. **Post-event adjustment** often takes place in a highly charged or political environment in which apportion of blame is sought.
3. **Fault reporting** from those individuals with vested interests in obscuring the truth prevents objective analysis of the situation.
4. Secrecy, or the failure of internal **organisational communication** due to restrictions on information flow, prevents learning from taking place.

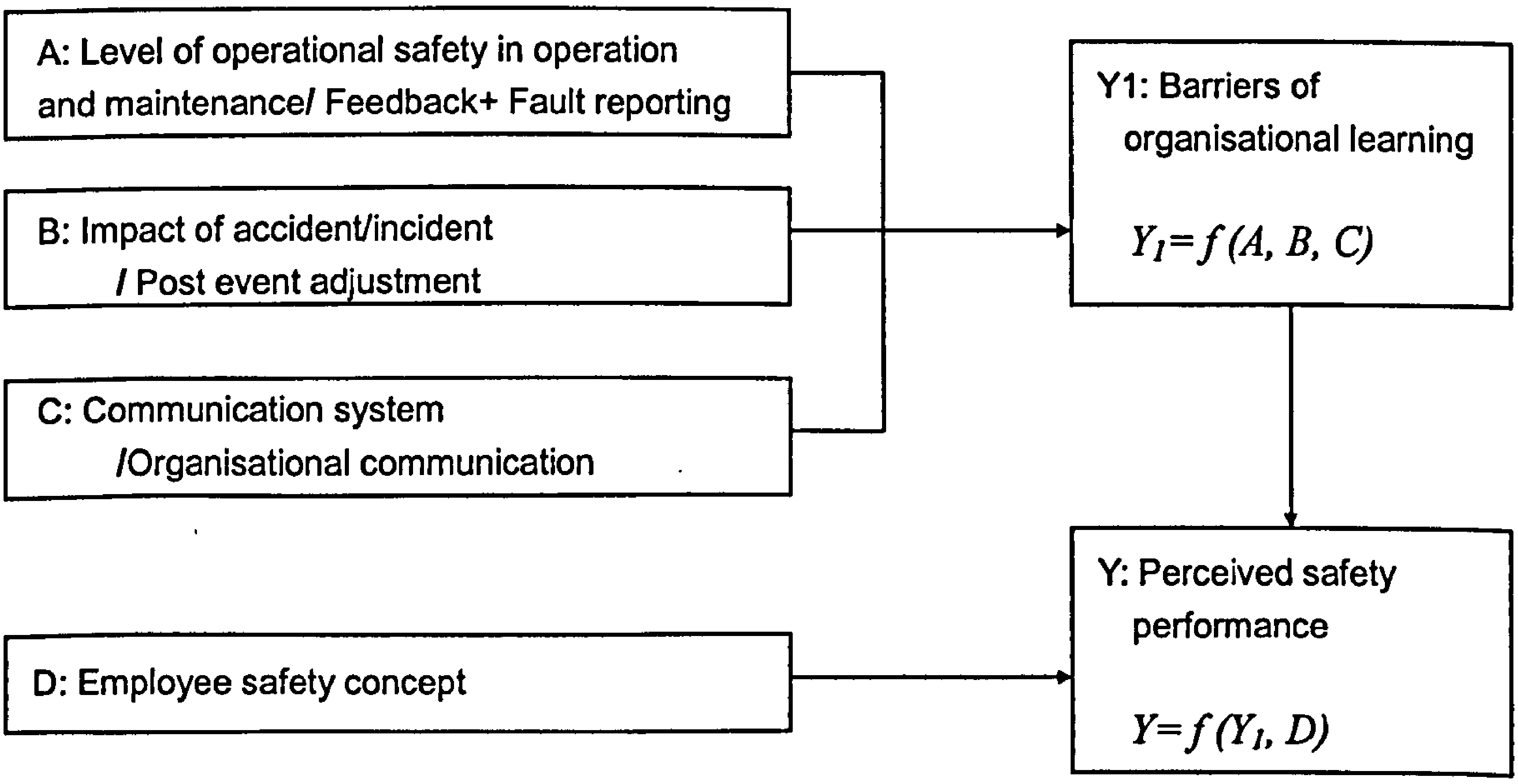
These four points correspond to the three predictors of perceived safety performance: "*Level of operational safety in operation and maintenance*", "*Impact of accidents/incidents*" and "*Communication systems*". Assume that the barriers of organisational learning (Y1) is the function of these three organisational factors (A, B, C). This could transform the relationship into a new equation, which is that perceived safety performance (Y) is the function of Y_1 and D (see Figure 6-1). As such, organisational learning barriers can be concluded to be one of the predictors (factors to predict and influence) of perceived safety performance. This equation indicates the contribution that organisational learning barriers can have on self-rated safety performance, although it does not prove the degree of this contribution.

Interestingly, this safety survey initially included the concern of organisational learning, but the results of the pilot study suggested that this concern should be dismissed, as stated in Chapter 5. Hence, the validation of organisational learning-related issues in the organisational factors might need further investigation in the future.

Figure 6-1 Organisational Learning Barriers vs. Perceived Safety Performance

Perceived Safety Performance Predictors from the survey result

/ Barrier of organisational learning identified by Choularton and Sagan



6.9 Examination of the Findings for the Primary Hypotheses

Previous sections have identified the factors which influence proactive safety mechanism and discussed some relationships between these factors and their implications. The next will integrate the findings from the study and the rest of the investigations reported in this thesis.

Four general hypotheses were explored and tested in order to develop the safety mechanism within a proactive management. As mentioned in Chapter 4, the term hypothesis as used here should be understood in the broad sense of the word as these are intended to outline the aims and objectives of the model. These statements should be considered to be propositions, made from known facts, which form the basis for this investigation, rather than hypotheses in the statistical sense, which will be tested and either accepted or rejected.

To this end, four hypotheses were set to be explored and tested in this thesis. The outcomes of the investigation with respect to these hypotheses will be discussed in the following sections in order to summarise the results of the investigation which formed the substances of this thesis.

6.9.1 Hypothesis 1

Hypothesis 1:
The safety mechanism is the composite of organisational climate/culture, safety climate/culture, safety philosophy, and decision-making. The definition of each layer will be redefined (except decision-making) to suit the airline industry.

The first hypothesis, the redefinition of organisational climate, organisational culture, safety climate, safety culture and safety philosophy, is critical to the application of a safety mechanism for the airline industry. As the current existing definitions of organisational climate, organisational culture, safety climate, and safety culture are the generalisation for an open system, there is a need to distinguish the differences between airlines and other industries in order to develop an airline safety mechanism.

Building upon the knowledge of existing definitions of organisational climate/ culture, and safety climate/ culture stated in Chapter 2 and Chapter 4, the primary evidence for this hypothesis was presented in Chapter 4, where organisational climate, organisational culture, safety climate, safety culture and safety philosophy were redefined to illustrate and suit the needs of the airline industry. As such, through the literature and empirical findings, the first hypothesis is supported.

6.9.2 Hypothesis 2

Hypothesis 2:
The safety mechanism model will be demonstrated as a multi-dimensional construct, which will be influenced by a complex factor-structure. Meanwhile, this factor structure will also reflect the current environmental factors in the airline industry.

The hypothesis that each layer of this safety mechanism would have a unique definition (Hypothesis 1) is critical to the justification of a complex and multi-dimensional construct underlying the safety mechanism model. Having defined the components in the model, this model illustrates a top-down metaphor, which shows that the organisational climate exerts an influence on organisational culture, which affects safety climate and culture; safety culture influences safety philosophy, and safety philosophy informs decision-making, which results in good or bad consequences in safety services. The multi-dimensional relationships are explained and supported by the literature described in Chapter 4 regarding the development of the model.

Meanwhile, the assertion that this construct would be found to be influenced by a set of identifiable factors is important. The identification of a limited number of factors serves to reduce the myriads of issue relating to the development of a safety mechanism to a reasonable number of items, and to acknowledge there are real effects imposed by theses factors. The results of principal component analyses were successful in identifying the internal (thirteen) and external (four) factors for the safety mechanism; for example external factor E1 "*Influence of region and country*" shows the effect of culture and value of the country and region in which the organisation exists, although no efficient evidence proves whether the influence of country or region can override any organisational attempts at developing itself. If expressed by an equation, it has the form:

$$Y = F(X_1, X_2 \ldots X_{13})$$
$$Y = F(E_1 \ldots E_4)$$

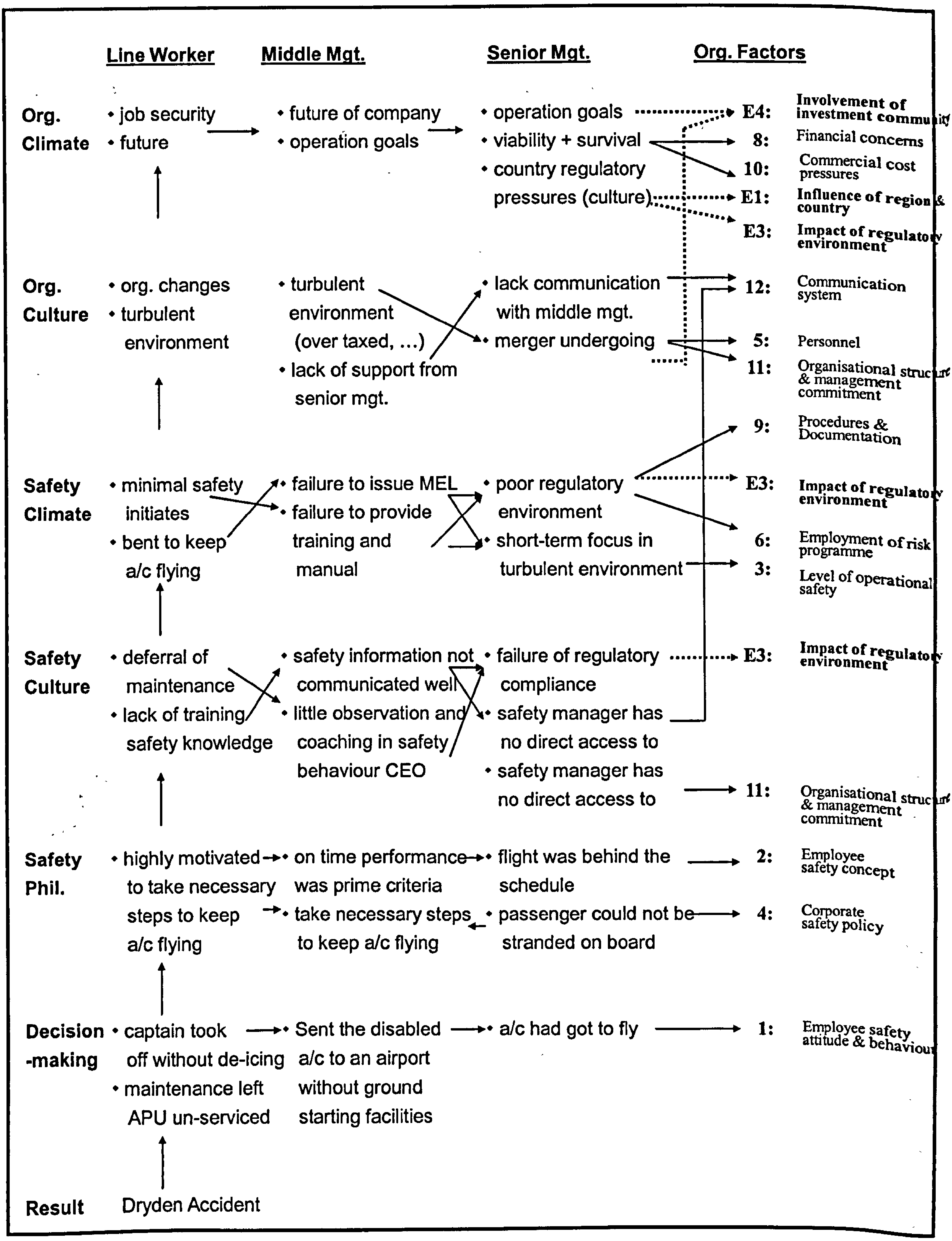
Where

Y is the safety mechanism, (the composite of Y is defined in Hypothesis 1)
Xs are internal organisational factors,
Es are external organisational factors.

Various ANOVA in this chapter further reveal the complexity of the factor-structure by identifying the fact that not all respondents regard these factors to be important to the same degree, and identifying which factors are placed as high concerns in which regions.

Moreover, the case study in Chapter 5 provides sufficient evidence to test the model and conclude this hypothesis. However, one point to note here is that there are slight differences regarding the factor-structure compared with the one originally proposed, discussed in section 6.6. As such, there is a need to redraw the case study by using the new factor-structure of the safety mechanism (Figure 6-2).

Figure 6-2 The Safety Mechanism Model Applied to the Air Ontario Accident



Note: 1. Org. = Organisation, Mgt. = Management, Phil. = Philosophy, a/c = Aircraft

Moreover, the evidence of a complex factor-structure is also supported by some analyses conducted in this chapter, where the factor scores between internal factors and external factors were correlated to a significant degree. In particular, all the internal factors were found to be significantly correlated to *"the impact of the regulatory environment"*, which was evidence that the airline industry is a highly regulated business, and that regulators strongly desire airlines' co-operation. It also implies that with the different regulatory structures across regions, a more harmonised regulatory environment is necessary.

The safety mechanism model is not a model of proactive safety management or organisational climate/culture. It is a model of the evolution of safety services within a proactive safety management system. The importance of this model is to assess airline proactive safety by identifying the organisational factors which will affect organisational climate and analogously influence the safety mechanism. These findings generally support the second hypothesis that the safety mechanism model is a multi-dimensional construct, which is influenced by a factor-structure: internal factors exert influence within the airline, while external factors reflect the environmental influential forces.

6.9.3 Hypothesis 3

Hypothesis 3:

The organisational factors mediate the relationship between the safety mechanism and safety performance, and act as predictors of safety performance.

The third hypothesis, that the organisational factors mediate the relationship between the safety mechanism and safety performance, and act as predictors of safety performance, is important in fully understanding the implications of the safety mechanism. There are two reasons. Firstly, it highlights the relationship between the safety performance and organisational factors, i.e. the particular factors at a particular time, which affect airline safety performance to a significant degree. Secondly, the identified predictors serve to identify the areas recommended for improvement and for future study of this research topic (see section 6.11).

The evidence of influence of safety mechanism on self-rated safety performance is presented in Chapter 4 when discussing the model demonstrated by Neal et al (2000). The primary evidence with regard to this hypothesis was presented in this chapter. The result of the multiple regression analysis indicates that there is a relationship between safety performance factor and organisational factors, i.e. four factors are the best predictors of self-rated safety performance among these organisational factors. If expressed by a conceptual equation, it has the form (refer to section 6.3):

$$Y_1 = .486 + .403 * X_2 + .244 * X_3 + .113 * X_7 + .133 * X_{12}$$

Where Y_1 is the perceived safety performance (output or effect),
Xs are organisational factors (inputs or causes):
X_2: Employee safety behaviour
X_3: Level of operational safety in operation and maintenance
X_7: Impact of accidents/incidents
X_{12}: Communication system

Although one may argue that the essence of organisational factors in a company's organisation deliberations will almost certainty affect safety performance as it leaves the way open to error and failure, it is worth noting that the questionnaire respondents rated the "safety performance" here because there exists the difficulties to define/ rate airline safety performance in reality plus the questionnaire is anonymous. Therefore, Hypothesis 3 should be the hypothesis regarding the organisational factors as the predictors of *perceived* safety performance. The findings of these four internal factors show internal environment will have more influence on the perceived safety performance than external environment, and the attention should be paid more than other factors when proactive safety management system is developed.

6.9.4 Hypothesis 4

Hypothesis 4:
The safety mechanism model is seen as being critical to the development of proactive safety management; however, the airline safety health and performance still needs the coordination of proactive and reactive safety management.

The last hypothesis stated that the safety mechanism model is critical to the development of proactive safety management and airline safety health; however, airline safety performance still needs the co-ordination of proactive and reactive safety management. The logic underlying this hypothesis is that in the light of empirical study and literature review, current proactive concepts and approaches aim to uncover the latent organisational conditions and avoid the surrounding errors or inadequate recognition, which cause safety to be degraded in the workplace. Building on this knowledge, this research aims to identify the importance of the safety mechanism, and the organisational factors which affect it in order to establish a proactive approach to safety.

As mentioned in Chapter 2, and in keeping with the aim of maintaining a well-functioning safety services, continual adjustments, and sometimes the introduction of new methods, are required. Nevertheless, when undertaking such changes, one must be also careful that those aspects of safety services that function well are not destroyed. From the result of literature review, retroactive approaches to safety have been identified as important existing tools to improve airline safety management system. This fact is also supported by the results of survey, which reveal the factor-structure containing these factors "*the employment of risk programmes*", "*impact of accidents/incidents*", and "*the necessity of safety reports*", which were identified as retroactive approaches to safety in Chapter 2. Moreover, this factor – "***impact of accidents/incidents***" is found to be one of the predictors of perceived safety performance. These findings indicate that the safety mechanism is built on a proactive concept; however, retroactive and proactive vehicles both exert influences on this mechanism model in order to achieve safety performance and safety health. As such, it can be concluded that that the airline's safety health and performance do need the co-ordination of both retroactive and proactive safety management and the fourth hypothesis is accepted.

From these results, the safety mechanism model provides an indication as to what drives the development of a safety mechanism, what the influential factors of the safety mechanism are, and what organisational factors are the predictors of perceived safety performance. Figure 6-3 portrays the safety mechanism model resulting from the survey. By the acceptance of the four hypotheses, these results are the main contributions that have been made from the thesis.

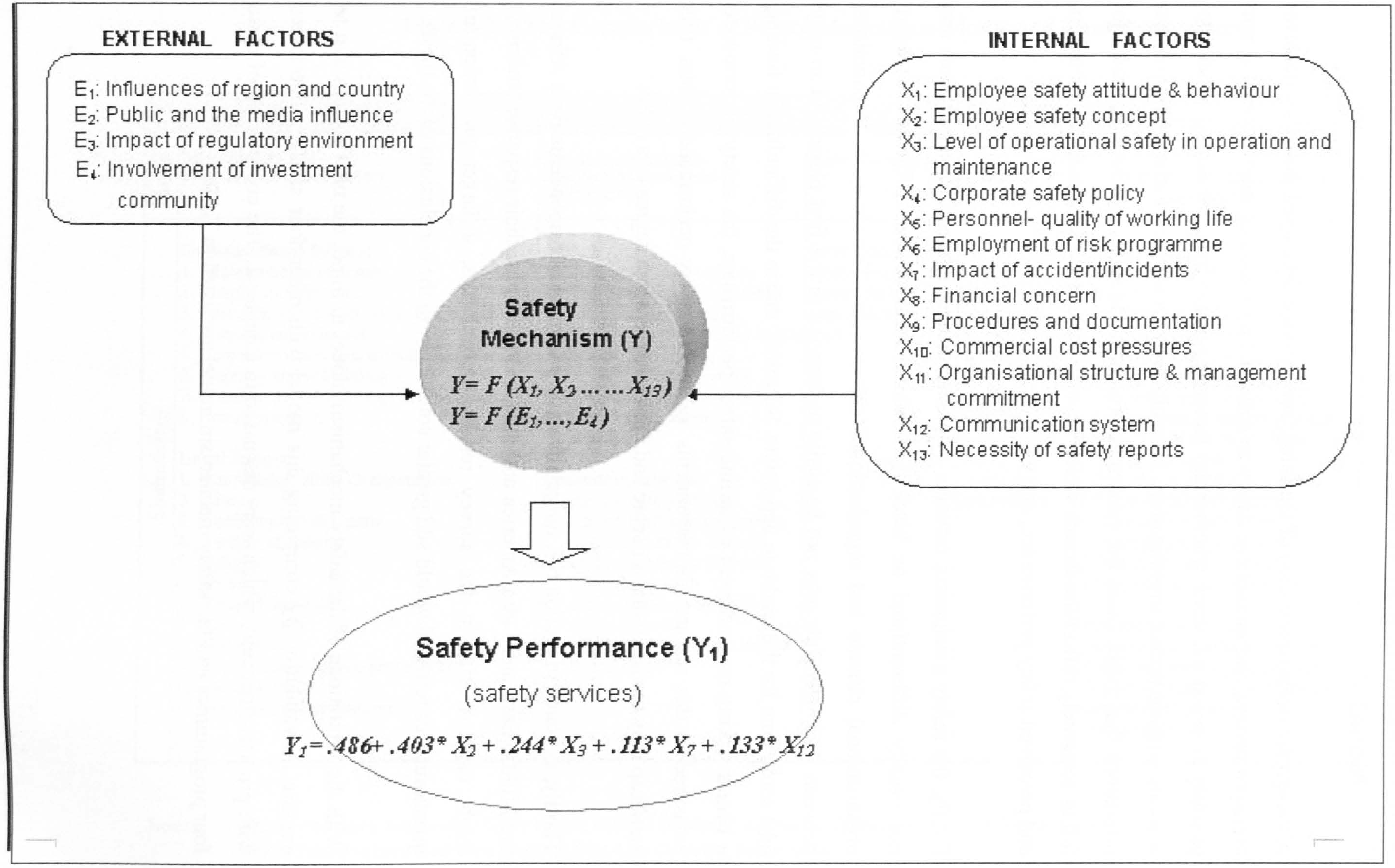


Figure 6-3 The Safety Mechanism Model (survey result)

6.10 Limitations and Validation of the Safety Mechanism Model

Although the items (questions) of the safety survey were developed from an extensive literature review, and qualitative data was collected by means of interviews, it is not possible to say at this time whether the factors analysed from the survey would be accurate without further investigation. As such, the next sections focus mainly on the limitations that might cause the factors identified in the safety mechanism model to fail to accurately reflect the factors which have an influence on the safety mechanism and perceived safety performance, and why.

Firstly, the safety mechanism contains a number of inter-related elements, which are not usually differentiated as black and white, such as the difference between organisational climate and organisational culture, etc. Therefore, the distinctions between these elements may not be easily understood in the first place, and so may take some time for the reader to appreciate. Secondly, due to the difficulties in finding a benchmarking measurement of airline safety performance, the safety performance measured in this research is respondents' perceived safety performance. Thus, this handicap may deviate its factor score and regression to some degree as a result.

Thirdly, as stated in section 6.7, the relatively low number of respondents from Africa, the Middle East, and Latin America and the Caribbean, plus their response tendency, might cause a bias in the survey results; nevertheless, a larger proportion of questionnaires returned would add greater confidence to the conclusions of the thesis.

With the limitations of the safety mechanism model in mind, the next section aim to explore its validation by comparing this model with other four safety programmes with proactive concept, which were discussed in Chapter 2. The comparison of these four programmes and the safety mechanism model are listed in Table 6-24.

Table 6-24 The Comparisons of Safety Mechanism Model and Four Programmes

	MESH	INDICATE	PERS	LOSA	Safety Mechanism Model
Target	Maintenance side- Periodically assess factors	Divide company into intervention group and control group	Airline workers	Line personnel observation	Airline workers- Deliver factors into the airline by cross functional project and support
Methodology	**Organisational factors:** 1. Organisational structure 2. People Management 3. Provision and quality of tools& equipment 4. Training and selection 5. Commercial and operational pressures 6. Planning and scheduling 7. Maintenance of buildings and equipment 8. Communication **Local factors:** 1. Knowledge, skills & experience 2. Morale 3. Tools, equipment, parts 4. Quality of support 5. Fatigue 6. Pressure 7. Time of day/night 8. Environment 9. Computers 10. Paperwork, manuals, procedures 11. Inconvenience 12. Personnel safety features	**Action:** 1. Appoint a safety officer 2. Regular meeting to identify hazardous situations 3. Establish a confidential safety reporting system 4. Regular safety meeting 5. Safety information database 6. Safety information distribution **Evaluation criteria:** 1. Airline safety culture 2. Airline staff risk perception of aviation safety hazards 3. Staff willingness to report safety hazards 4. Action taken on identified safety hazards 5. Staff comments about safety management	Error management system, based on human factors approach to solve errors.	Collect crew behaviours and situational factors on normal flight. The result of analysis can provide strategies in safety, operations and training.	**Internal factors:** 1. Employee safety attitude & behaviour 2. Employee safety concept 3. Level of operational safety in operation and maintenance 4. Corporate safety policy 5. Personnel- quality of working life 6. Employment of risk programme 7. Impact of accident/incidents 8. Financial concern 9. Procedures and documentation 10. Commercial cost pressures 11. Organisational structure & management commitment 12. Communication system 13. Necessity of safety reports **External factors:** 1. Influences of region and country 2. Public and the media influence 3. Impact of regulatory environment 4. Involvement of investment community

Note:
1. MESH-Managing Engineering Safety Health, INDICATE-Identifying Needed Defences In the Civil Transport Environment, PERS- Proactive Error Reduction System, LOSA-Line Operation Safety Audit
2. Boeing safety programme is not included in this chart
3. Please refer to chapter 2 and Appendix H for the benefits and limitations of MESH, INDICATE, PERS, and LOSA.

Reason (1995b) points out that effective safety management requires both reactive and proactive information in order to guide an organisation to that region of the "safety space" associated with the greatest resilience to operational hazards. In both cases, though, it is necessary to identify the organisational and situational factors contributing to unsafe acts. As such, MESH employed Reason's philosophy and his model for programme development. Referring to Table 6-24, in MESH, front line personnel assess the local factors, and technical management assess organisational factors at periodic intervals. The aim is to identify factors in need of improvement and track the changes over time, with the help of computer software package. However, there is no literature which describes exactly how these factors were chosen.

As to INDICATE, Reason's model was applied to develop the programme as well, but with a difference in focal point. The INDICATE programme focuses on the aims of identifying and resolving deficient aviation safety defences before the occurrence of mishaps. By dividing the experiment company into two groups and observing their operation, it provides a means of evaluating the effects of the programme. It is more suitable to small and medium sized airlines with budgetary limits.

PERS is an error management system which can be used by non-experts in human factors because it is based on a human-factors approach to solving errors. PERS provides a way for airline personnel to analyse an error or potential error, to discover why it occurred, and then to see how they might go about changing systems, equipment or work patterns to prevent future errors. The solutions presented by PERS tend to be limited to exploring potentially hazardous situations by analysing the ongoing problems.

LOSA highlights exemplary, as well as deficient performance, which shows airlines the areas in which they excel as well as those in need of improvement. A database is being developed that allows organisations to compare their results with those of other airlines. The focus of LOSA is mainly on flight crew and flight operations division. However, the expense of LOSA is too high to be afforded by airlines with budgetary limits.

Comparing the safety mechanism model with other programmes, it is found that aside from the contribution of organisational factors exploration and identification within the academic literature, this model also provides the airline industry with a "benchmark" of organisational factors which are an aggregation of the viewpoints of various representatives across all regions. The rating of each question (response) presents the tendency of each organisational factor, i.e. how important it is and to what degree it is to be satisfactory across regions. These organisational factors are also assessed by ANOVA to investigate whether significant differences exist across regions. It is important to understand the regional difference, especially when applying this model in the real world. Meanwhile, this model offers a "prototype" of the contributing organisational factors to the perceived safety performance.

It is not the intention of this part of the thesis to suggest that the safety mechanism model is the best among these programmes, although the flexibility of this model's application exceeds that of other programmes. Its benefits include its relatively low cost, the fact that there is no limitation to specific divisions, it provides a platform for the integration of organisational factors and change management, etc. (see the application of the safety mechanism model in the following section). The purpose of the comparison is to show the differences between different programmes, and to hopefully validate the model by pinpointing its advantages, and the contribution that it makes to the literature and to the real world. This point should be emphasised.

6.11 The Application of the Safety Mechanism Model

The case study of Air Ontario has demonstrated the retrospective application of the safety mechanism model, which is quite useful in retroactive safety management, e.g. accident/incident investigation. This portion of the study will add value to the application of the safety mechanism model in reality. The application of this model is its implementation in a practical situation, providing a vehicle for identifying organisational factors within airlines. In other words, there needs to be a change, but how can change be brought about in the existing organisation? A process of change management must be adopted in order to effectively embed the organisational factors that have been identified in the safety mechanism model. As mentioned previously, the factors identified serve as a benchmark and a prototype on a world-wide basis. Therefore, the airline can identify its own factor set (by replicating the questionnaire in its own organisation, or department, i.e. local factor-set), compare the results with the safety mechanism model, and decide which factors are in need of change.

There are several well-known corporate change management tools. Six Sigma[42] is one of them. Six Sigma provides a means to identify the major areas (project) for improvement, form the team, and apply the Define (D) Measure (M) Analyse (A) Improve (I) and Control (C) methodology[43] to complete the project. By data collection and analysis, root causes of problems can be found, and direction for improvements are able to be identified.

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[42] **Six Sigma** – A vision of quality which equates with only 3.4 defects per million opportunities for each product or service transaction. This concept has been used in corporate management to improve deficient processes. In other words, Six Sigma is a highly disciplined process that helps to focus on developing and delivering near-perfect products and services. The essence behind Six Sigma is that defects are unknown and need to be identified. If you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them and get as close to "zero defects" as possible. General Electric (GE) is a role model famous as a Six Sigma organisation.

[43] **DMAIC** – (Define, Measure, Analyse, Improve and Control) is a process for continual improvement purposes. It is systemic and fact based. This closed-loop process eliminates unproductive steps, explores new measurements, and applies controls for improvement (see *Appendix T)*.

The following shows the application of the model by using the prototype factor set as a demonstration. As such, thirteen internal and four external factors were identified as influential factors of the safety mechanism. According to Figure 6-3 (page 231), they have the form:

$$Y= F(X_1, X_2 ... X_{13})$$

$$Y= F(E_1 ... E_4)$$

$$Y_1= .486+ .403*X_2 + .244*X_3 + .113*X_7 + .133*X_{12}$$

Where Y is the safety mechanism

Y_1 is perceived safety performance

Xs are internal factors, Es are external factors

- X_2 is Employee safety behaviour
- X_3 is Level of operational safety in operation and maintenance
- X_7 is Impact of accidents/incidents
- X_{12} is Communication system

As the survey result reveals, there are four influential factors for perceived safety performance, and it is suggested that these should be applied as the starting point for improvement. One point worth noting is that although "*Employee safety concept*" is identified as the biggest predictor of safety performance, it is however found that the "*Employee safety concept*" has the highest level of satisfaction, while the "*Communication system*" is less satisfactory. Therefore, "*Communication system*" is the factor in greatest need of improvement, if budget or resources allocation in a company is not enough to support all improvement plans at one time.

By applying the Six Sigma approach, factors can be broken down to several manageable projects, collecting the improved results and achieving a better perceived safety performance. The details of the application of organisational factors using the Six Sigma approach are described as follows:

Referring to the denotation in previous page, break Y_1 down to a number of Xs of a manageable size for improvement. As such,

$$Y_1 = F\,(X_2, X_3, X_7, X_{12})$$

X_2, X_3, X_7, X_{12} are the focus or results of the process to be improved. Each X contains a Six Sigma project, which aims to explore possibilities for improvement.

Take communication system (X_{12}) for example:

$$X_{12} = F\,(Z_1, Z_2, Z_3, Z_4 \ldots .)$$

where X_{12} is the communication system
Zs are the actions needed to improve X_{12}

Each Six Sigma project encompasses three aspects, as follows:

1. Who: cross-function team members (the major players)
2. What: objectives, measurements
3. How: analysis, improvement, control tools

$$\left.\begin{array}{l}\text{2. What: objectives, measurements}\\ \text{3. How: analysis, improvement, control tools}\end{array}\right\} \longrightarrow \text{DMAIC process}$$

The DMAIC processes of X_{12} could be detailed in Table 6-25.

$X_{12} = F(Z_1, Z_2, Z_3, Z_4 \ldots)$, Zs will be identified in the "Analyse" phase.

Table 6-25 The DMAIC Process of X_{12} "*Communication system*"

Phase	Action	Goal
Define (D)	What is important to the communication system (critical factors)?	Define "X_{12}"
Measure (M)	What and how is the process of communication system performing? How reliable is the obtained data?	Measure "X_{12}"
Analyse (A)	What are the critical defects causing variation? To what degree? *For instance:* *Z_1= Knowledge management system* *Z_2 = Performance evaluation system* *Z_3 = Existing resources (bulletin, company mail, etc) and communication channels incorporation* *Z_4= Rewarding system*	Find & Measure the "Z_s"
Improve (I)	How to fix the critical defect (Zs)? What variation in critical Xs can be removed? *For instance:* *How much percentage of employee satisfaction/ benefit and communication channels can be increased by building a KM website?*	Improve the "Z_s"
Control (C)	How can the improvement be maintained? *For instance:* *Maintain the website and free flow of channels*	Control "Z_s" so that there is no variation in the "X_{12}"

It is worth noting that, Six Sigma is not panacea that can cure all the problems. Having demonstrated the Six Sigma methodology, there are also other change management tools that can assist practitioners in identifying these actions (sub-factors) which warrant the greatest amount of attention in improving the organisational factors.

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CHAPTER 7

Conclusions and Recommendations

"But People who are freed from the confines of their box on the organization chart, whose status rests on real world achievement ... those are the people who develop the self-confidence to be simple, to share every bit of information available to them, to listen to those above, below and around them and then move boldly."

~ Jack Welch, 1989

7.1 Conclusions - Thesis Aims Revisited

Looking back to Chapter 1, five objectives have been set out. By summarising the findings which are aligned with the objectives for the reader, this chapter aims to bring together the knowledge gained throughout the investigations that formed the substance of this study. The achievement of this thesis and the findings, as well as its recommendations, will be discussed in the following sections.

7.1.1 Objective One

✓ **To evaluate current airline safety management systems and become a reference text which can be used by academics and industry.**

Starting from Chapter 2, this thesis opens by defining safety as "risks are minimised to an acceptable level" and introducing the safety interactions in the air transport system, given that the safety of air travel and its inherent challenges have been with us since the first passenger flight. By identifying the interaction of safety significant activities and external influence within the system, which are involved in conducting a safe flight, it was found that the external impacts are mainly from three aspects: technical innovation, growing traffic, and the regulatory environment. The innovation of technology increases the reliability and productivity of aircraft, which in turn stimulate the growth of air traffic. Nonetheless, it is the airline's responsibility to provide transportation as well as safety, each is mutually dependent on, and worthless without the other. Especially with the increasing competition in the airline industry, the safety records of airline not only are used as a basis for passengers for deciding which airline to choose, but also directly associates with the airline's reputation within the media and public. Meanwhile, given the complexity of aviation environment, the regulators play an important role in airline operation. These all exert influence on the airline safety management system (SMS).

The subsequent literature review probes the evaluation of airline safety management system and clearly compares the empirical situations systematically, which identifies and rationalises the areas for improvement in the airline industry. It is concluded that safety is supported by organisational structure and regulations; fundamentally it is the concept and behaviours that define safety policy and principles, which influence the outcome of SMS. In addition, SMS must represent a pure closed loop. It must have facility for setting process and standards and subsequent reviews, and then adjustment is revised process or new process. The judge needs to consider what is acceptable and when there is a threat requiring change. The coverage of literature review and extent of evaluation is sufficient depth and quality to be used as a reference by academics and the industry. Therefore, the objective one - *to evaluate current airline safety management systems and become a reference text which can be used by academics and industry*, is achieved.

7.1.2 Objective Two

- ✓ **To investigate retroactive and proactive approaches to safety and their application within the airline industry.**

The evaluation of current airline safety management system leads to two main approaches to enhance and improve airline safety services in the present circumstances. One approach is that of *retroactive measures*; the other is the *proactive measures.*

Traditionally retroactive approach to safety

The main tasks of the second objective are to firstly review current after-fact measures to safety, including accident investigation, human factors, and risk management - evaluating the existing risk control tools to maintain safety quality. Within a complex system like the airline industry, it is necessary - and usually taken for granted - to trace back the causal factors leading to the accident. By identifying the strategies that would enable us to cope with the deficiencies, the control system of airline safety services can be improved. The value of accident investigation lies in learning the relevant lessons for future prevention. As such, accident investigation is an appropriate tool to find out unanticipated failures in technology, and serves the purpose of contributing to the human error database. Recent incident reporting systems are also emphasised. Their value lies mainly in understanding system and operational human performance, pointing out causes for concern and signal weaknesses before the system breaks down.

Other impacts of accidents include the improvement of safety management and risk management. The concept of the safety management system is now extended to integrate existing knowledge of safety management and provide a systematic view of "know-how", to which this industry has woken. Risk management tools are also developed in order to collect safety information and prevent the identified errors, which were discovered in the human factor study. As human imperfection remains a fact of life, error management is developed to observe training (analyse workplace) behaviours in an attempt to help to understand operational human performance.

Causes of accidents serve as contributing and primary factors to this approach, while risk management, human factors and error management are the diagnostic tools. However, the low number of accidents makes it difficult for these after-fact measures to determine patterns and to establish what to do next. Although incident investigation can have both reactive and proactive concept, a few researchers have proposed that adopting a proactive approach would be more effective than simply reacting to accidents. As such, contemporary proactive approaches to safety are investigated.

Proactive Approaches to Safety

The main tasks in this part are to evaluate current proactive concept and measures, to develop a proactive approach to safety from a cultural and organisational dimension, and investigate the differences between retroactive and proactive approaches. The difference between retroactive and proactive safety management is in the treatment of the contributing causes of accidents and their underlying factors to prevent accidents from occurring again. The traditional approach to studying aviation safety has involved the analysis of accident data. Research has focused on finding factors that link to, for example, pilot-error accidents through systematic accident investigations. However, accidents still happen and the accident rate has not been significantly improved for several decades, which points to the need for a new approach in safety management.

Proactive safety management moves away from individual error as the focus of understanding accident causation, to the organisational approach. This method assigns the responsibility from one person at the sharp end to all systems within an organisation. As such, the current contemporary approaches investigated in this thesis are designed to aim at a systematic approach to the identification and prevention of accidents. The concept is also designed to ensure continuous improvement by analysing whether the values of an airline's culture are consistent with good safety practices. Most important of all, the proactive approach aims to change the organisational culture surrounding errors or inadequate recognition, which degrade safety, and uncover the latent organisational conditions stemming from organisational culture.

Chapter 2 presents the results of an exploration of empirical and theoretical findings regarding the approaches to safety within the airline industry. The results also show the importance of and need for proactive approaches. To this end, the second objective- *to investigate retroactive and proactive approaches to safety and their application within the airline industry* is achieved.

7.1.3 Objective Three

✓ **To develop a model for a 'safety mechanism' in the context of proactive safety management**

It is evident from the research findings that proactive safety is an important but still relatively undefined task in the airline industry. What it lacks is a model to conceptualise the safety mechanism in proactive safety management, which encompasses the culture and climate considerations and organisationally influential factors. Therefore, the aim to establish a framework for the study of a proactive approach and for the evolution of airline safety management system by the development of a safety mechanism model, has been targeted and developed after investigating both approaches to safety.

Chapter 3 therefore describes these methodologies applied in the study. These methods provide a framework which allows airline safety management system to be analysed in a systematic manner, especially as the main emphasis was on the fundamental objectives of the evaluation, i.e. to obtain a critique of some of the main problems relating to airlines' safety management system, and justify the best solutions for overcoming them.

This proactive safety mechanism model is built upon the existing knowledge of what is thought to contribute to an effective proactive safety by adding an increased knowledge of the organisational factors, which serve to influence the proactive safety mechanism, and which will serve to be the predictors of the safety mechanism and performance of airline safety services. As such, this part of study is exploratory in focus and qualitative in nature.

In Chapter 4, it introduces that interviews were firstly undertaken to gain the empirical knowledge and experiences necessary to develop a safety mechanism for proactive safety management. Combined with the academic studies in previous chapters, it is found that management systems and programmes must provide an effective safety framework because it is the importance of safety to the organisation, and the workers' perception of the value of safety, that "manipulate" safety performance.

A safety mechanism model consisting of organisational climate, organisational culture, safety climate, safety culture, safety philosophy and decision-making has been developed. This model is neither a model of proactive safety management nor an organisational safety culture/climate model. It is a model of the evolution of the airline safety services (performance) with proactive safety management in SMS. By means of defining the criteria and interaction between each layer, the discussion provides an appreciation of how the safety mechanism should fit within in the airline industry, and build upon the concepts which have been prominent within the literature to this point in time. Therefore, the third objective - *to develop a model for a 'safety mechanism' in the context of proactive safety management* is achieved.

7.1.4 Objective Four

- ✓ **To verify organisational factors that affect the safety mechanism and investigate the relationship between the factors.**

The model also focuses on the influential factors which impact upon the development of a safety mechanism. Given the need for an examination of the structure underlying the model, Chapter 5 therefore presents the result of model test, including a case study and safety survey, Chapter 6 analyses and discusses the results in order to verify the fourth objective.

Case study

The case study presented in Chapter 5 provides a useful illustration of the myriad forces which conspire to define a system's safety mechanism. Given the complexity of the case, the case study provides the reader with a greater appreciation of the explanatory power of the model in relation to how the safety mechanism has developed and how the safety management system and services have evolved.

Survey Results

The main objective of this safety mechanism survey is to take a closer look at the relationships between the forces hypothesised to be at work, provide an assessment of these forces, verify the influential factors and validate the hypothesised factor structure in the safety mechanism. In short, it aimed to provide a framework for understanding the factors which underlie the development of a safety mechanism across regions. By the survey results, the primary contribution which this model makes to the literature is to expand the concept of proactive safety from a conceptualisation of what an effective organisational culture or safety culture should be to a comprehensive model which recognises the fact that the safety mechanism is a complex, multi-dimensional construct, which evolves with time according to a wide variety of organisational factors within the internal and external working environment of the airline industry. By doing so, possible remedial action for the evolution of airline safety management system and services can be recommended.

To this end, four hypotheses were set to be explored and tested in this thesis. They are discussed in Chapter 6:

Hypothesis 1: *The safety mechanism is the composite of organisational climate/culture, safety climate/culture, safety philosophy, and decision-making. The definition of each layer will be redefined (except decision-making) to suit the airline industry.*

The first hypothesis is supported by the literature review and empirical findings.

Hypothesis 2: *The safety mechanism model will be demonstrated as a multi-dimensional construct, which will be influenced by a complex factor-structure. Meanwhile, this factor structure will also reflect the current environmental factors in the airline industry.*

The second hypothesis is supported by the case study and survey results, although a slight difference between the hypothesised factor structure and survey results was found out.

Hypothesis 3: *The organisational factors mediate the relationship between the safety mechanism and safety performance, and act as predictors of safety performance.*

The third hypothesis is supported by the literature and survey results.

Hypothesis 4: *The safety mechanism model is seen as being critical to the development of proactive safety management; however, the airline safety health and performance still needs the coordination of proactive and reactive safety management.*

The forth hypothesis is supported by the combined finding from the results of interview, case study and safety survey.

As such, the fourth objective - *to verify organisational factors that affect the safety mechanism and investigate the relationship between the factors* is achieved after these four hypotheses are supported by the research findings.

7.1.5 Objective Five

- ✓ **To make recommendations concerning how airlines can fit the proposed safety mechanism model to the industry for the evolution of a safety management system.**

In Chapter 6, the limitations and application of the safety mechanism model are also discussed to validate the model. Moreover, section 7.2 provides the final recommendations in order to fit in the airline industry and make contribution for the evolution of an airline safety management system. The objective five is then achieved.

7.2 Recommendations

The following are the recommendations in view of:

1. Future research areas:

Firstly, consistent monitoring of safety performance measurement is necessary to justify the model, because the essence of proactive safety management is to measure safety performance in operation on a regular basis, instead of measuring errors or the occurrences of incidents or accidents, which are used as measurement in retroactive safety management.

Secondly, it would be interesting to conduct other factor-structures on a regional or country –wide scale. As Reason (1995a) has stated, "there is unlikely to be a single universal set of indicators for all types of hazardous operations, one way of communicating how safety health can be assessed is by listing the organisational factors that are currently measured." Therefore, a listing of various organisational factor sets, plus ANOVA analysis of factors, can provide a clear and complex view from different angles and concerns.

Thirdly, as mentioned previously, there are several change management tools in current use in industry, and documented in the literature. It is worth exploring tools other than Six Sigma to integrate the identified organisational factors into airline operations, to identify the actions (sub-factors) required for the improvement in daily operations (or on a regular basis), and to suit the different needs of different companies in different regions.

Lastly, although a proactive safety concept is emphasised in this thesis, there is still a need to develop the retroactive approaches to safety, the concepts and methodologies of which are described in Chapter 2. Because retroactive safety management has proved fruitful for the entire airline industry, its value is without doubt. For example, perhaps accident investigation must improve in its global consistency. Organisations must however learn form the misfortune even if the accident report is not aimed at them.

2. The airline safety management system:

Due to the variability of the airline industry, individual airlines should focus on conducting safety surveys and their analysis to decide which of the factors are most critical to them. It is worthy noting that although English is an international language, it is recommended to use their native languages to design the questions in order to ensure the respondents fully understand the meaning and implication, when conducting the safety survey. By doing so, the most critical (important) areas in the airline can be identified (it is even better to conduct deep dialogue interviews to augment the survey analysis).

One particular factor was also identified as critical to perceived safety performance, namely the *barrier of organisational learning*. This fact has two implications: (1) if the barriers confronted by the company are not removed, safety performance is unable to improve. So barriers of organisational learning are critical to airline safety performance. (2) to remove the barriers of organisational learning relies on change management, as discussed in Section 2.3.2.4.

The latter implication echoes and justifies the tools adopted by the research to translate the factors into the company change management tools. Yet it is worth noting that in Section 2.3.2.4, change management is stated as the result of organisational learning, which is attributed to feedback in risk management, or broadly speaking, the safety management system. In other words, it is "mistakes" that drives the learning and change. This approach matches up with the retroactive concept. Compared with the change management tools adopted in the safety mechanism model, the latter help to identify the defects proactively and correct them in advance before they become "mistakes". Both of them, however, are equally important to airline operations. As such, airline managers need to evaluate and distinguish them carefully in order to choose suitable change management tools for airline operation.

Moreover, the suggested change management tools require the cross function co-operation between different departments, similar to BA's example regarding culture change (Appendix G). The thesis has also discussed the need for a complex interaction across all departments when addressing flight safety risks and business risks within the airline industry, and the interdepartmental training programmes associated with proactive training for employees in responding to assaults or potential assaults in Chapter 2. To this end, the systemic approach requires that organisational change is brought about by an improvement in organisational factors. Once this is done, the proactive safety mechanism will become stronger and stronger.

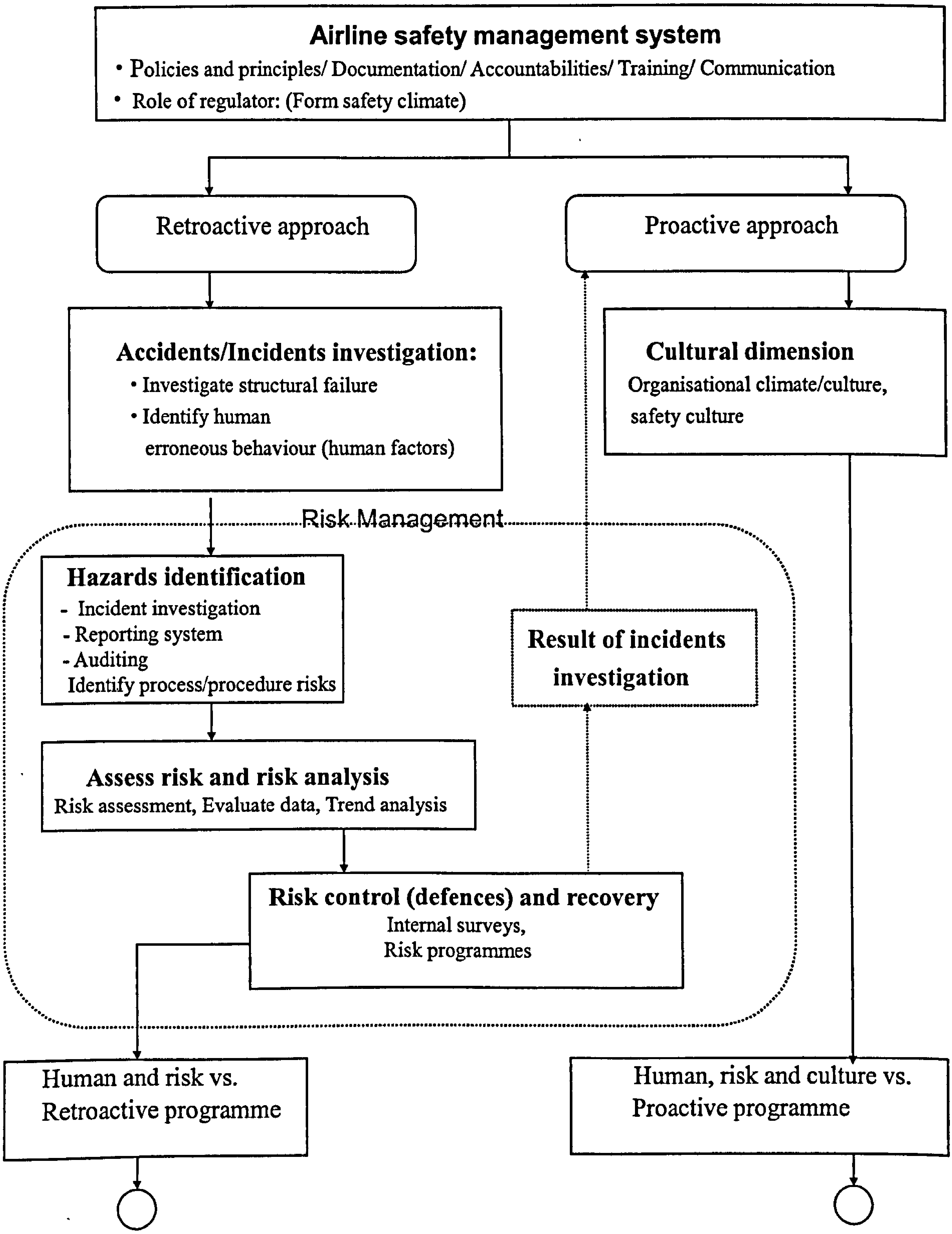
Furthermore, one point worth emphasising is the fact that the identified internal organisational factors are all found to be significantly correlated with the impact of the regulatory environment. The role of the regulator and its relationship with airlines are described in Chapter 2 and Chapter 4 (the results of the interviews), where also identifies that airline safety climate is governed by the regulatory environment and regulators. It is obvious that the recent deregulation, globalisation and privatisation of airlines have strengthened the role and responsibilities of regulators, who provide many functions to the airline, especially in terms of safety monitoring and safety inspection. With their help, management's role is to develop a supportive system to identify barriers proactively and retrospectively so that all employees can strive for continuous improvement. The aim of evolution within airline safety management system can then be achieved.

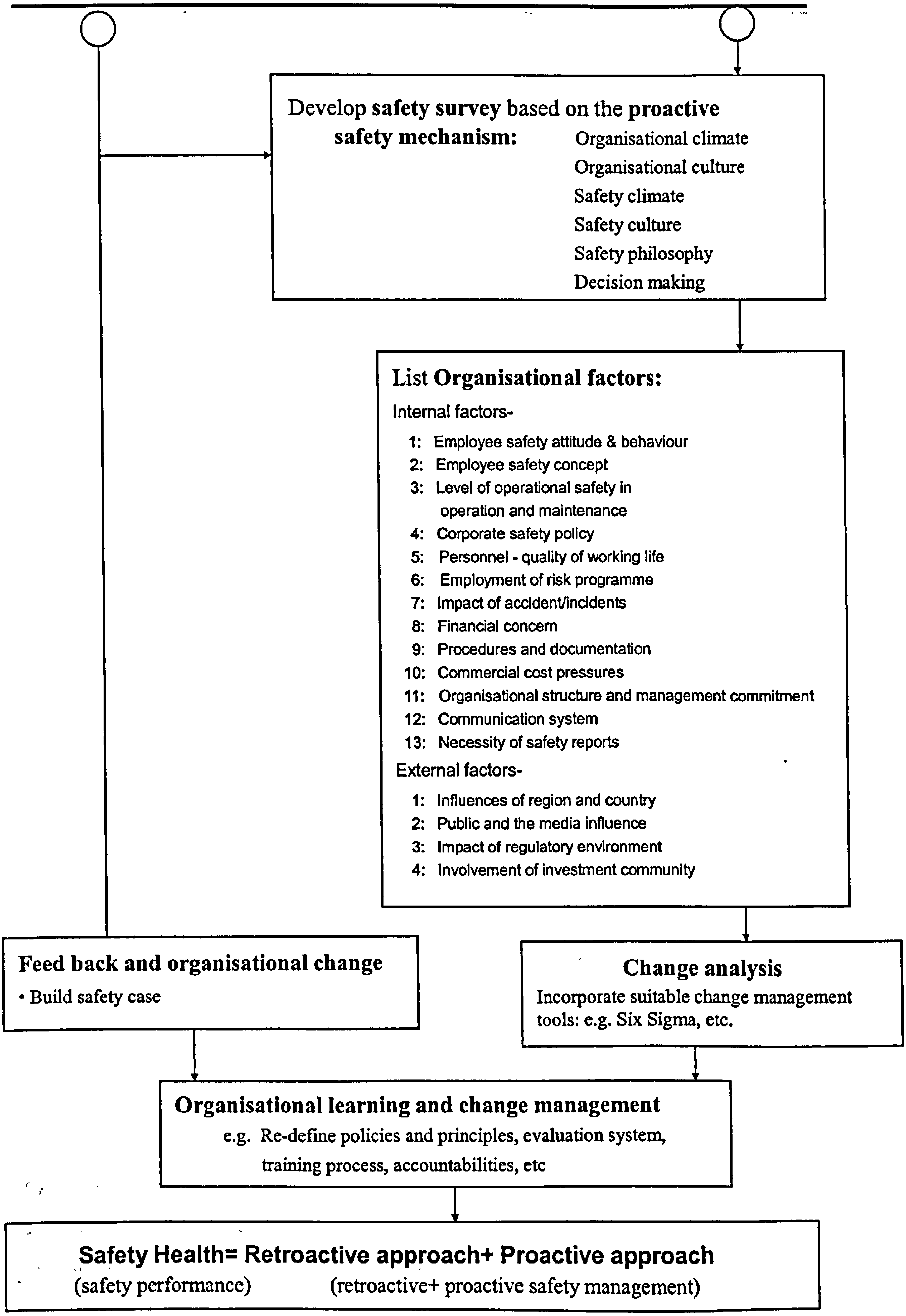
Lastly, in order to fulfil the recommendations to the airline industry and particularly to safety managers, a framework is developed to recommend how an airline safety management system may be benchmarked and improved by incorporating the research results from the thesis.

In Chapter 4, the results of the interviews summarised a common framework of risk assessment in the airline industry, as presented in Figure 4-2 (page 120). Based on this finding, Figure 7-1 adds the main results of this research containing the extent of previous chapters as well as the application and recommendations mentioned in this chapter. The establishment of this figure provides the industry with a quick and clear picture of the structure regarding retroactive and proactive management in airline safety management system, which also allows various airlines to assess themselves by comparing themselves with other airlines.

To the end, by further providing this framework, it is hoped that the airline industry and particularly safety managers will become more aware of their positions and the competitive advantages of improving safety when conducting airline safety management system and safety performance.

Figure 7-1 A Generic Framework for Retroactive and Proactive Approach to Safety within Airline SMS





Develop **safety survey** based on the **proactive safety mechanism:**
Organisational climate
Organisational culture
Safety climate
Safety culture
Safety philosophy
Decision making

List **Organisational factors:**

Internal factors-
1: Employee safety attitude & behaviour
2: Employee safety concept
3: Level of operational safety in operation and maintenance
4: Corporate safety policy
5: Personnel - quality of working life
6: Employment of risk programme
7: Impact of accident/incidents
8: Financial concern
9: Procedures and documentation
10: Commercial cost pressures
11: Organisational structure and management commitment
12: Communication system
13: Necessity of safety reports

External factors-
1: Influences of region and country
2: Public and the media influence
3: Impact of regulatory environment
4: Involvement of investment community

Feed back and organisational change
- Build safety case

Change analysis
Incorporate suitable change management tools: e.g. Six Sigma, etc.

Organisational learning and change management
e.g. Re-define policies and principles, evaluation system, training process, accountabilities, etc

Safety Health= Retroactive approach+ Proactive approach
(safety performance) (retroactive+ proactive safety management)

Finale

In an attempt to provide transport and safety services, the airline industry involve an array of equipment, high technology and supporting services, etc. The complexity of this structure provides many opportunities for errors, some of which even result in serious incidents or accidents. Though aircraft accidents occur very infrequently, they undoubtedly have a high impact and pose a severe threat to airline viability. To prevent them from recurring, the industry throughout the world has invested substantial amounts of time and money in discovering the causes of accidents and incidents. In recent years, the airline industry has begun to analyse hazardous situations and to correct them before they result in accidents or incidents. However, even with this effort and the advance of technology, accidents still occur, and with each accident, public fears about air safety are fuelled.

Accidents/incidents bring risk and fear into our lives, so people are motivated to satisfy these safety needs and search the reasons why they went wrong, which is the sprit of retroactive safety management. If this need is not met (e.g. to improve the reliability of aircraft), people will be stuck at this level, and will feel that something is lacking. Yet, the cause of dissatisfaction is easy to identify (e.g. causes of accidents/ incidents, human factors, etc.).

On the other hand, proactive safety management is like reaching the top level of self-actualisation. At this level, people start to pursue the self-actualisation needs, which are "the desire to become more and more what one is, to become everything that one is capable of becoming." As though built into the human gene, everyone in the airline has the necessary concepts, attitudes, behaviours, knowledge, decision-making, etc. orientated towards safety.

One metaphor is that retroactive approaches to safety are like plastic surgery. One can actually become more beautiful after the surgery but the fundamental genetic makeup is never changed. The way one thinks and behaves still remains the same as before. Offspring will inherit this genetic makeup, which may become a family trait.

Conversely, proactive approaches to safety are more like genetic engineering before a baby is even born, in order to create the right personality. This is the essence of proactive safety management. Therefore in summary, the ultimate contribution of this research is to provide airlines with reliable data, applicable references and practicable methodology to enable their safety management system to evolve at a fundamental, “genetic” level.

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APPENDIX A Definitions of Accident/ Incident

In the aviation industry, the most widely used definition is the one developed by the International Civil Aviation Organisation (ICAO, Annex 13, 1994). In order to effectively prevent accidents and promote aviation safety, ICAO revised the content of annex 13 in March of 1994. It suggests its state members to define "serious incident" and to thoroughly investigate them. The current version revised in 2001 has clearly defined the serious injuries.

AIRCRAFT ACCIDENT:

An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which:

(a) a **person** is fatally or seriously injured as a result of:

- being in the aircraft, or
- direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
- direct exposure to jet blast;

EXCEPT when the injuries are from natural causes, self inflicted or inflicted by other persons, or when the injures are to stowaways hiding outside the areas normally available to the passengers and crew; or

(b) **the aircraft** sustains damage or structural failure which:

- adversely affects the structural strength, performance or flight characteristics of the aircraft and
- would normally require major or replacement of the affected component.

EXCEPT for engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wing tips, antenna, tires, brakes, fairings, small dents or puncture holes in the aircraft skin; or

(c) the aircraft is missing or is completely inaccessible.

Note 1. For statistical uniformity only, an injury resulting in death within **thirty** days of the date of the accident is classified as a fatal injury by ICAO.

Note 2. An aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located.

INCIDENT:

An occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.

SERIOUS INCIDENT:

An incident involving circumstances indicating that an accident nearly occurred.

Note 1. The difference between an accident and a serious incident lies only in the result.

Note 2. Examples of serious incidents can be found in Attachment D of Annex 13 and in the ICAO Accident/Incident Reporting Manual (Dot 9156)

SERIOUS INJURIES:

An injury which is sustained by a person in an accident and which:

a) requires hospitalisation for more than 48 hours, commencing within seven days from the date the injury was received; or

b) results in a fracture of any bone (expect simple fractures of fingers, toes, or nose); or

c) involves lacerations which cause sever haemorrhage, nerve, muscle or tendon damage; or

d) involves injury to any internal organ; or

e) involves second or third degree burns, or any burns affecting more than 5 percent of the body surface; or

involves verified exposure to infectious substances or injurious radiation.

APPENDIX B Impact of Accident on Airline Operation & Finance Performance

B.1 The Immediate Impact on Operation Performance – Crisis Management

Crisis management is the "first aid" of the breach in the airline's safety services relationship, because following an accident the airline must deal effectively and courteously with its passengers and crew, with the victims, both alive and dead and also with their friends and relatives. At the same time it will have to deal with the media and with business, political and other pressures resulting from the accident (Taylor, 1997). These are the immediate effects resulting from an accident. They not only instantly affect the airline's operation but also may have a significant influence in the following undertaking.

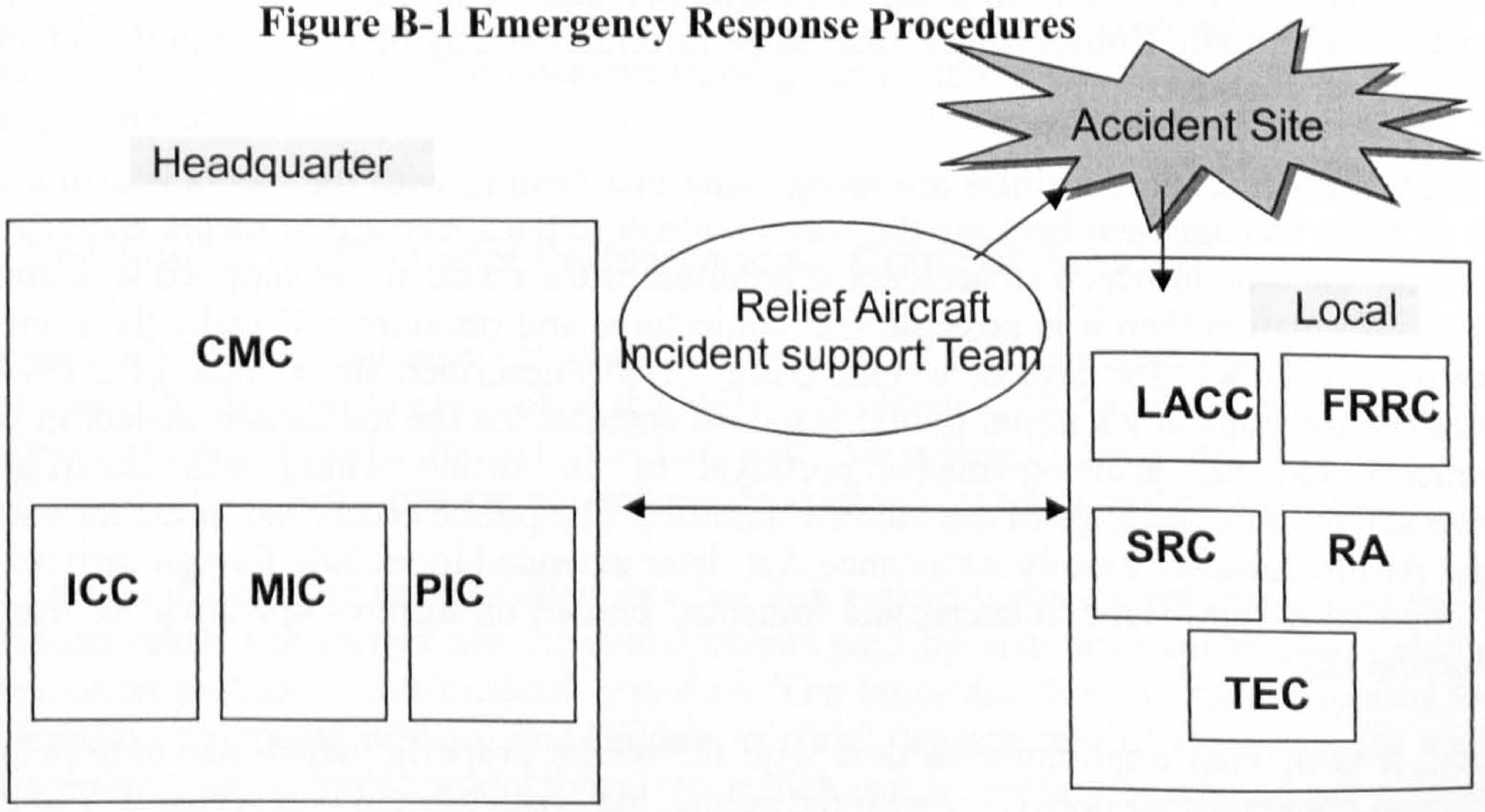
The effects resulting from an accident i.e. death, injuries and property damage, the relationship with media, public image and load factor will be discussed in the following sections.

B.1.1 Death, injuries, and property damage

When an airline is created, it is obligated to take on the responsibilities of transportation and safety, which are worthless without each other, just like the industry's coins of value. As such, once there is a failing on each side, the airline must be responsible for the outcome and dealing with the following details: the death, injuries, and damaged property, which are the immediate effects, resulting from the accident and the most threatening crisis for any airline.

Once an accident has occurred, the airline duty Operation Control Manager receives information that something has gone wrong. According to the call-out list and designated process, key personnel are informed with great urgency. Upon the notification of an accident, various departments are involved and emergency facilities are activated in accordance with Emergency Response Procedures (ERPs). Emergency Response Manuals vary with different airlines and countries. However, in order to achieve an effective management, emergency response procedures should at least cover the following: (see Figure B-1)

Figure B-1 Emergency Response Procedures



Source: Adapted from Taylor, 1997

(1) The Headquarters Response - Crisis Management Centre (CMC) includes
  a. Media Information Centre (MIC)
  b. Passenger Information Centre (PIC)
  c. Incident Control Centre (ICC)

(2) The Local Response
  a. The local Accident Control Centre (LACC)
  b. The Survivors Reception Centre (SRC)
  c. The Friends and Relatives Reception Centre (FRRC)
  d. The Reputation Area (RA)
  e. Liaison with local hospitals and hotels
(3) The mobile response is involved in the activation of
  a. the Relief Aircraft
  b. the Incident Support Team (IST)

In order to assist with local response, airlines have plans to dispatch an aircraft to carry personnel and specialists to the scene of the accident. Most of the IST members are trained volunteers who provide support to the airline local staff, and with the handling of the incident and those involved.

The Emergency Response Procedures will inevitably affect the normal aircraft and aircrew scheduling with dramatic changes. Due to the damage or the loss of the accident aircraft, the airline has to reschedule the timetable. For example, an aircraft may need to be taken out of normal service as a relief aircraft; or the airline may need to lease another aircraft from elsewhere as a replacement. Ground staff may also be asked to perform additional work to handle trivial tasks during the critical period. These are classified into the uninsured costs of the accident. As to the public, they need to be informed about the changed time-tables as soon as possible in order to reschedule their own plans.

B.1.2 The relationship with the media

Few news events have such a powerful draw as aviation disasters. It is the dramatic nature of aircraft accidents that attracts the media and grabs the headlines. Data reveals that from 1978 to 1994, the New York Times disproportionately reported fatal events involving jet aircraft and fatal events in the U.S. or involving US carriers (Curtis,1997).

Once an accident has occurred, the first task for the newsroom is to despatch reporters to the scene so that they can collect all possible information and pictures describing the event and its immediate aftermath. Consequently, inaccurate information may be reported to the public due to lack of verification.

As such, more and more airlines are recognising that dealing with the media is also a major part of crisis management because the way in which airlines respond to media enquiries will determine the tone in which an accident is reported. If the media is not supplied with constant factual information then it is possible that conjectures and rumours will make the front page of many newspapers for days or weeks. Bailey (1999) described an example of a TWA 800 explosion: the company's initial public response antagonised the media and maladroit public comments fed the growing media portrayal of an airline which was uncaring and unresponsive to the feelings of the victims' families. The public outcry led to the introduction of the Airline Disaster Family Assistance Act, later extended to include foreign carriers. This has imposed a significant financial and logistical burden on airlines operating to, from and within the US.

Hence, it is of vital importance to deal with the media properly, which not only helps the airlines to communicate positively with the public, but creates a win-win scenario. The power of media can never be underestimated.

B.1.3 Reputation, public image and load factor

While the accident airline is likely to suffer the most, rebuilding confidence quickly is crucial. Because the load factor is always in direct proportion to its public image and reputation.For example, following the A300 crash at Nagoya in April 1994, China Airlines experienced a 20 percent decline in the number of passengers during May and did not notice an increase until December.

Another example is that of British Midland. In the aftermath of the Boeing 737 accident in 1989 near the UK's East Midlands airport, the chairman of British Midland, Sir Michael Bishop, went to the scene quickly and spoke to the media as well as expressing concern and sympathy for victims' families. According to the observation of Guild (1995), British Midland suffered no subsequent loss of traffic on the route from London Heathrow airport to Belfast. Five years later, British Midland claimed to be the market leader on that route.

Dealing with its clients, the passengers, and the crew, as well as their relatives, friends and the media is never easy. Besides that, an airline must continue to be fully operational for months and years to come and ensure that, despite any accidents. This, of course, makes the recovery from accident harder.

A Boeing spokesman once said: "*Ours is a business that is based almost entirely on public confidence.*" Indeed, in today's competitive market, a carrier perceived as being not as safe as others is less favourable to the travelling public. As the airline business is highly dependent on public confidence, so the question is: How to recover the airline's public image should an accident occur? There are various answers to this question.

Take US Air for example. Following an accident in 1994, and in order to rebuild the public's image, a full page advertisement revealed the fact that the company planned to hire outside organisations to scrutinise safety and in addition appoint a new vice president for safety. This resulted in controversial discussions. Some aviation consultants thought the more quickly the airline returned to normal operation the better, without the need to draw public attention to the event. Nevertheless, some people argued that USAir did the right thing to inform the public of their plans and were searching for a solution to remedy the situation.

There can be no right or wrong regarding the strategies of coping because different reactions and strategies vary with different types of airline and their nationality. One implication worth noting is that few managers have had the opportunity of acquiring the necessary knowledge to deal with such a crisis since an aircraft accident is a rare occurrence. Therefore, Taylor (1997) suggests that it is not sufficient to know that there is a chapter on accidents somewhere in a manual. There is a clear need for intensive training, and without this a crisis could very easily become a catastrophe.

B.2 The Impact on Financial Performance— Costs of Accident

It seems fairly simple that accident costs are the sum of all reportable damage, injury, and illness costs. People tend to just look at the costs of accident in terms of monetary costs which will affect airlines directly. In fact, accident costs vary largely from airline to airline and country to country. Their sums are not entirely determined by economic consideration.

Costs of aircraft accident are classified into two categories: Insured Cost and Uninsured Cost (or Hidden cost). The former are the actual claims paid by insurance companies, commonly compensation payments and medical expenses. The latter are those costs not related to the compensation payments directly and hidden in some departments of the company such as damaged reputations, lower productivity, etc. which can be neither quantified nor estimated. Therefore, the monetary value is not always the most critical factor.

From the above, there are two fundamental points that should be noted in relation to the cost of accidents: firstly, there are economic consequences of aviation safety; secondly, the costs and benefits of safety cannot be measured only in economic terms.

Although the economic consideration of accident costs is not the first priority for every airline, accident costs could have an influence on the airlines' financial performance. These costs can individually and collectively drain the company's financial reserves. Those which are tangible and able to be measured by monetary value, such as loss of business, the expenditure of a crisis management centre, costs of accident investigation, etc. will affect the airline's cash flow and profitability directly.

Meanwhile, those costs that stem from the intangible uninsured costs also have a significant impact. A damaged reputation, lower brand loyalty, decreasing company morale, and so on, would shake the confidence of stockholders and employees, and lower the company's stock price. These intangible costs can even acquire greater importance than direct financial effects measured by accounting methods. In some cases they have caused the collapse of a company.

Therefore, given insured costs are covered by proceeds from insurance for the crashed aircraft, the accident company cannot expect to recover all the uninsured costs as the premiums are too high to be afforded, particularly when safety costs, like the safety improvement and safety prevention cost (investment), are included.

APPENDIX C Quality Management versus Safety Management

C.1 The Concept of Quality

One of the most influential individuals in the quality revolution has been Dr. Edwards Deming. It was in 1950 when Japan had a weak economy and a reputation for manufacturing cheap and low-quality goods, that a group of visionary scientists, engineers, and businessmen brought to Japan an American management consultant, Dr. Deming. He not only taught the Japanese industry how to use a tool called statistical process control to achieve continuous improvement in quality but he also brought a philosophy for the total management of a company.

Thirty years later Japan had become one of the world's greatest industrial powers, having has achieved a reputation for quality that was unsurpassed. Witnessed by business and industries in other countries, in 1980s "Quality" grew in popularity for companies to focus on. Quality awards, such as the Malcolm Baldrige National Quality Award (MBNQA) in the US, were consequently being established to provide quality criteria in several industrialised countries.

Particularly over the last 10 years, industry's commitment to quality has significantly affected the activities and tasks performed to create products and provide services (Manzella, 1997). Almost any production company has a quality control or quality assurance department, which has allowed companies to increase quality and productivity with less supervision.

In the early stages of development, the concepts of quality and excellence have focused primarily on external customers - providing "quality" products, improving customer satisfaction and building better customer relationships. Gradually, the management system exists not to ensure the management's orders are executed but to help employees and remove barriers that prevent them from doing the job (Smith, 1996).

Understanding and recognising quality in civil aviation is important. There are several reasons. Firstly, quality influences travel demand and market share from a customer's point of view. Secondly, the performance of carriers is of interest to the regulators, carriers themselves and the public. Knowing the information and position can help to enhance quality of carriers. Lastly, the outcomes of a specific aspect of quality, such as air safety, are engaging people's curiosity,

C.2 Linking Quality with Safety

A remarkable evolution in quality assurance specifications has taken place during the last 35 years (Hughes, 2000). This evolution has taken the form of various quality-improvement initiatives, which have produced several forms of specifications, each an improvement on the previous one:

- Statistically orientated end-result specifications (1960s);
- Statistical quality assurance (1970s);
- Total quality management (1980s)

In other words, the evolution of quality management shows three stages: quality control, quality assurance and total quality. Similar stages can be found in SMS, including safety control, safety assurance and total safety (Herrero et al., 2002). The objective of quality is to improve the quality of the product through the detection and elimination of defects. It is similar to the objective of safety which is the reduction of injuries through the elimination of unsafe acts and work conditions.

One of the first contribution, relating to the integration of quality with safety was by Dumas

(Herrero et al., 2002). In 1987, after carrying out a study for more than 5 years, Dumas discovered that quality programmes and safety programmes have the same components, i.e. successful safety programmes and successful quality programmes are based on the same solid foundations (Dumas, 1987).

Manzella (1997) affirms that in order to obtain excellent safety results, one needs to integrate the safety system into the quality management system. Table C-1 illustrates the similar elements of quality and safety. He comments that quality and safety principles are essentially the same. As Crosby (1989) states, "Safety is a great analog for understanding quality. Everything in safety is about relating to the absolute of quality management."

Table C-1 The Principles and Relationship of Quality and Safety

SAFETY	vs.	QUALITY
Goal: Zero accidents		Goal: Zero defects
Incident analysis		Event analysis
Written policies, procedures and guidelines		Documented policies, procedures and work instructions
Safety committees		Quality circles, employee involvement team
Employee participation		Empowerment
Statistical analysis		Control charts, statistical process control
All accidents are preventable		All non-conformances are preventable

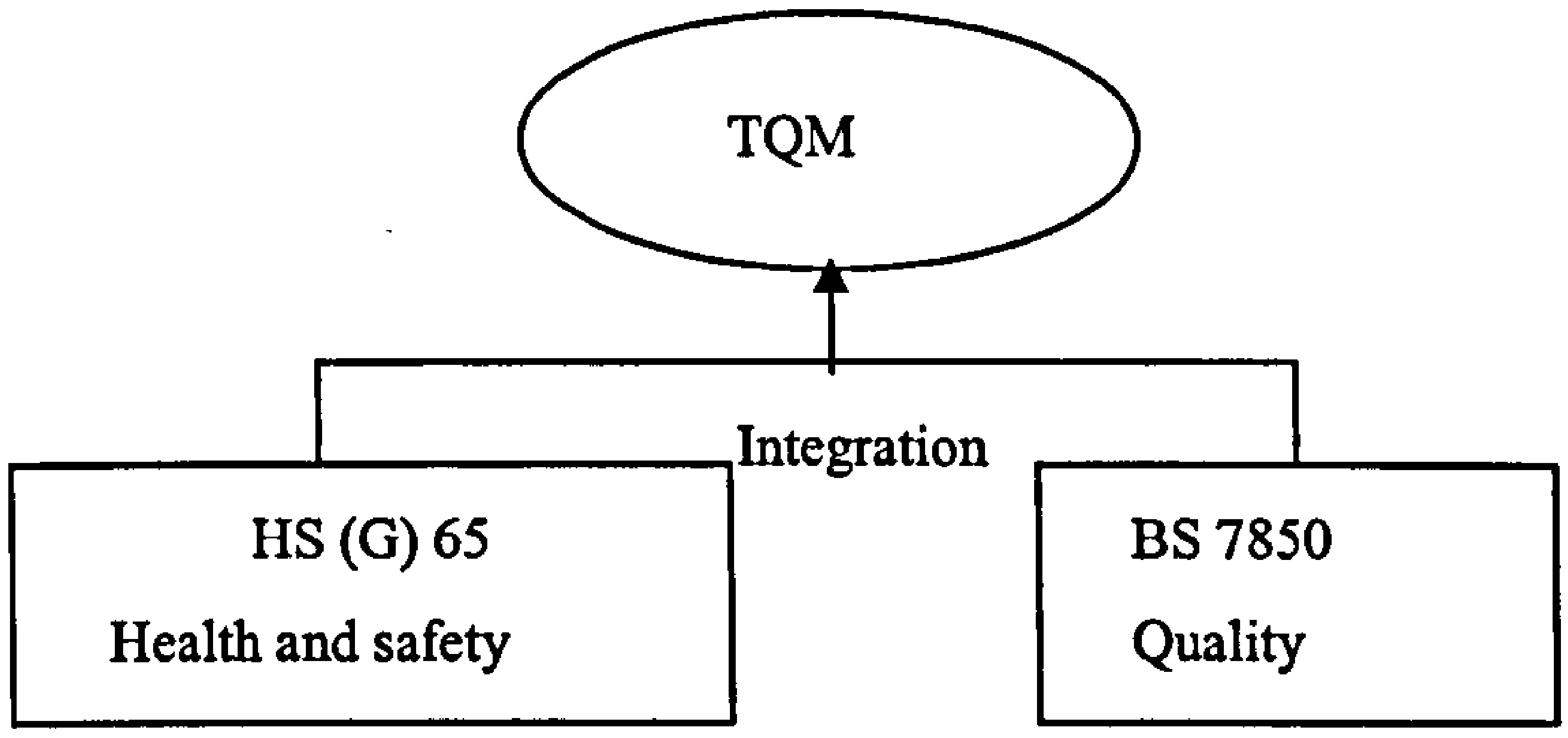
Source: Manzella, 1997

C.3 From TQM to Safety

Following the evolution of quality management, TQM has been a popular intervention all around the world, especially in industrialised countries (Garvin, 1991; Evans and Lindsay, 1995; Samson and Terziovski, 1999). It is a management framework set up to deliver self-regulatory compliance.

Since 1992, the UK's occupational health and safety has been viewed as an integral part of TOM, which is based upon two respects: the model, HS (G) 65, and the norm, BS (British Standards) 7850 (Deacon, 1994) (see Figure C-1). HS (G) 65 is used for safety and health management, while BS 7850, the quality regulation added to the traditional concept of TQM that satisfaction of the client, the safety, the health, the environment and the managerial objectives are checks to each other.

Figure C-1 Model of Integrated Quality Safety



BS: British Standards are developed and maintained by BSI British Standards, which is the UK's National Standards Body.

HS (G) 65: Published by HSE (Health & Safety Executive, British agency) as practical guide for directors, managers, health and safety professionals and employee

Source: Deacon, 1994

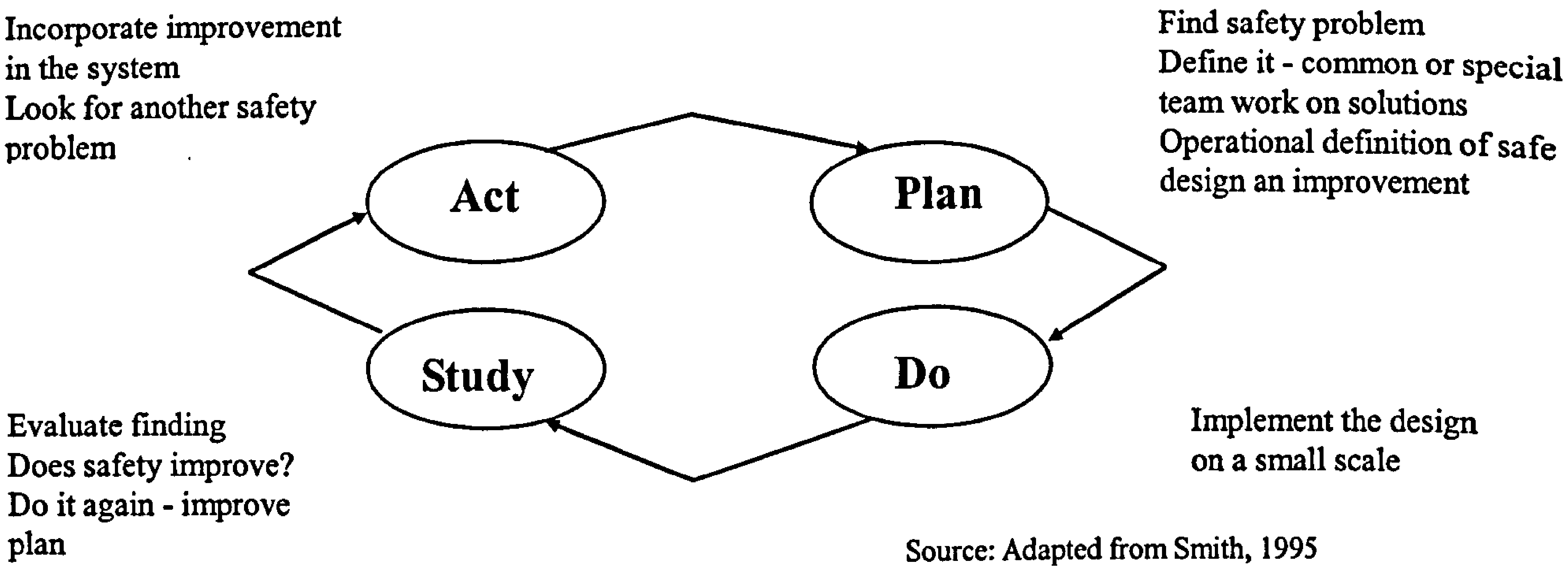
Although there are always going to be debates about how to categorise elements of TQM (Samson and Terziovski, 1999) or there is less agreement as to what the key elements of TQM are and what the critical factors are that influence the TQM implement process (Porter and Parker, 1993), there is a widespread consensus that TQM is a way of managing organisations to improve their overall effectiveness (Porter and Parker, 1993) and TQM has demonstrated that it is an effective way of maximising the long-term competitiveness of a company and can improve the effectiveness of the programmes of safety and health (Goetsch, 1999).

To this end, JAR - OPS 1 (aeroplanes) and 3 (helicopters) demand the delivery of safety and airworthiness. Based on the ICAO recommended practice (Annex 6 part 1), JAR- OPS states that an operator shall establish an accident prevention and flight safety programme, which may be integrated with the quality system, including programmes to achieve and maintain risk awareness by all persons involved in operations. They instruct the operator to design and run a "quality system" with its "quality assurance programme" to demonstrate regulatory compliance. In addition, the ISO 9000 international standards can also help to implement a quality system. It offers some useful advice that procedures should be documented only where a lack of documentation may detract from quality.

With the well-defined management structure, TQM is actually no more than a formalised method of communication to ensure the right measures are taken at the right time to satisfy JAR-OPS 1 & 3 requirements and the company's intentions for compliance, as well as the various construct requirements for Health & Safety, the Environment and so on.

The famous PDSA (Plan, Do, Study and Act) quality cycle, also called Deming Wheel (see Figure C-2), provides the tools needed to accomplish continuous improvement in quality, productivity and safety.

Figure C-2 Using PDSA for Safety



Source: Adapted from Smith, 1995

Scherkenbach (1991) provides a useful outline of how to operationally define PDSA in eight steps:

I. Plan: Develop a plan to improve
Step 1: Identify the opportunity for improvement
Step 2: Document the present process
Step 3: Create a vision of the improved process
Step 4: Define the scope of the improvement effort

II. Do: Execute the plan
Step 5: Over a period, pilot the proposed changes on a small scale with customers

III Study: Study the result
Step 6 : Observe what you learned about the process improvement

IV. Act: Adjust the process, based on new knowledge
Step 7: Operationalise the new mix of resources
Step 8: Repeat the cycle

These steps are, in fact, the processes of TQM. They describes how this cycle works in a particular company, bringing into its scope all existing documentation and management practices and making improvements. Most important of all, the implication from this cycle is what the tools of the Quality Assurance Programme are and how to use them to achieve (measure) quality.

Salazar (1989) points out two tools exist that can be used to measure the quality of a safety programme:

1. Safety inspections that identify the practices, behaviours, and unsafe conditions; and
2. Safety audits that identify the actions carried out by top management of the company that affect positively the system of safety.

C.4 Total Safety Management (TSM) versus TQM

TSM is safety management written and practiced using the principle of TQM (Herrero et al., 2002). The similarities and differences between TQM and TSM are listed in Table C-2. According to Goetsch (1999), TQM makes everybody involved in the progress of quality, and TQM also makes the Director of Quality act as both coordinator and assistant. TSM makes sure everybody is involved in the topics of safety, and the functions of the Safety Directors would be those of coordinating the processes and facilitating the necessary resources.

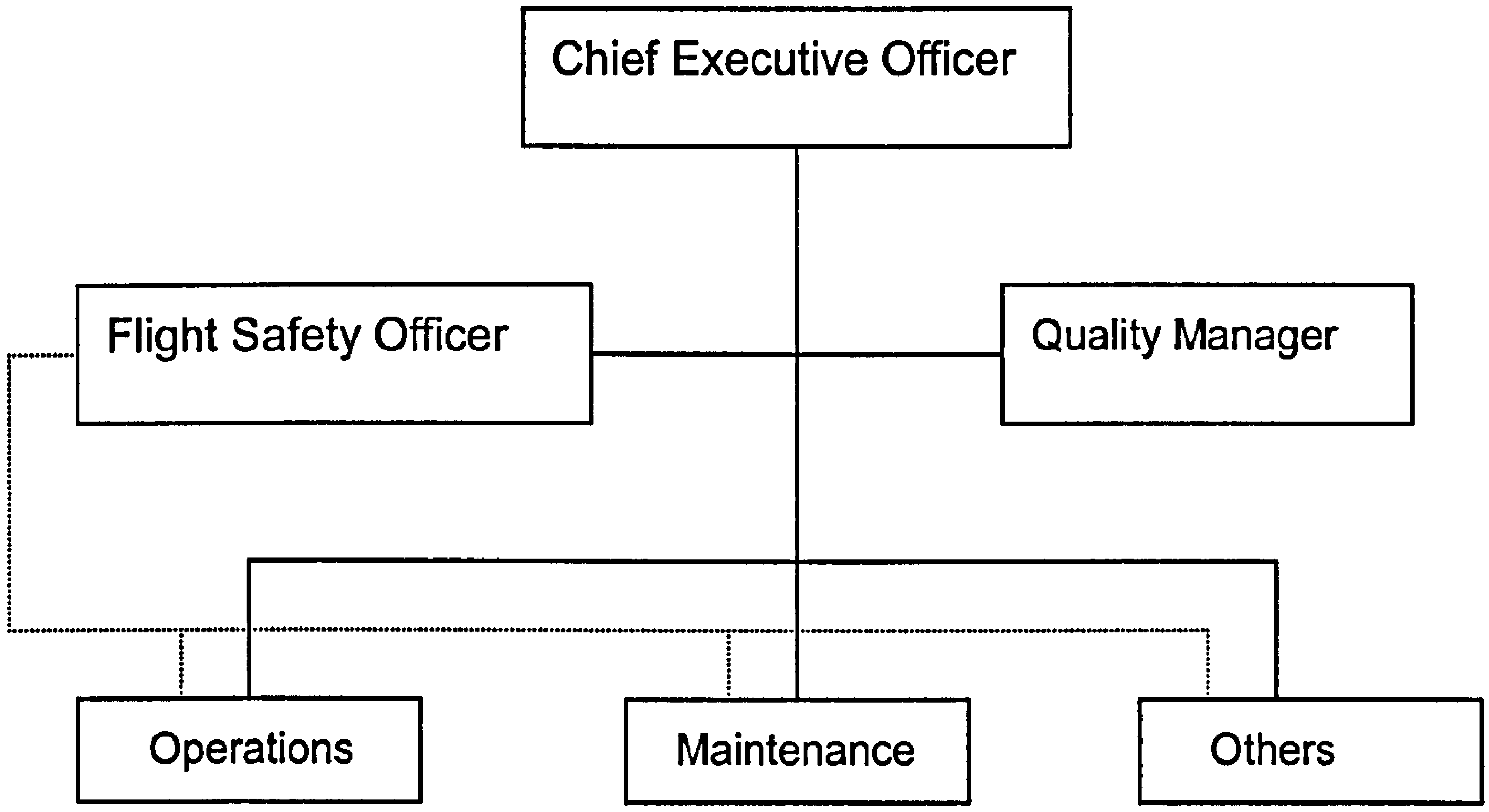
Table C-2 Differences and Similarities between TQM and TSM

TQM	TSM
Know the processes	Know the sources of risks
Minimise the errors	Minimise the risks
Center on prevention	Center on prevention
Reduce variations	Reduce the uncertainty
Deepen in the satisfaction of the client	Deepen in the safety of the workers the organisation and the clients
The problems are caused more by the system than by the individuals	The accidents and injuries are caused more by faulty planning than by the people

Source: Saunders, 1995

Manzanedo (1994) advancs the concept of TSM, indicating that many concepts, principles, rules, technical and objectives of the TQM could move the TSM with a single change of quality for safety (quoted from Herrero et al, 2002). This is reflected in the organisational structure (see Figure C-3) suggested by FAA (GAIN, 2000), where the Flight Safety Officer has a similar position to the Quality Manager. When the management functions of safety and quality are the same, these two positions can be combined in one, as some airlines do. Also CAP 712 (UKCAA, 2001) indicates that in most small and medium sized companies it is expected that the flight safety and quality tasks will have many common points and there could, therefore, be no objection to the combination of the roles in one staff member.

Figure C-3 An Example of Organisational Structure



Note:

Safety & Quality functions may be combined under the same management function.

Formal Reporting ————

Formal Communication ……………

Source: GAIN, 2000

APPENDIX D Risk Analysis Techniques

There are various techniques to perform risk analysis. The following are some tools frequently used in the airline industry:

1. **Probabilistic Risk Assessment (PRA)**
   PRA quantifies the probabilities and consequences associated with accidents and malfunctions by applying probability and statistical techniques as well as various consequence evaluation methods.

2. **Hazard Mode and Effect Analysis (HMEA)**
   This in-depth risk analysis has also been called Reliability Analysis for Preliminary Design (RAPD), Failure Mode and Effect Analysis (FMEA), Failure Mode, Effect, and Criticality Analysis (FMECA), and Fault Hazard Analysis (FHA). Basically it is a tabular analysis used to analyse the effects of system and sub-system failures on a system's operation. This bottom up analysis is a simple method and useful for complex systems.

3. **Fault Tree Analysis (FTA)**
   FTA is a graphical method commonly used in engineering and systems safety engineering. It is used to assess a system by identifying an end event and examining the range of potential contributory events. FTA documents qualitatively the potential causal chains leading to the head event, and accommodate quantitative analysis of the probability of the head event.

4. **Event Tree Analysis**
   The purpose of Event Tree Analysis is to organise, characterise, and quantify potential accidents in a methodical manner by modelling the sequence of events that result from a single initiating event. This analysis is used when time sequence is important and is a useful tool for analysing emergency response to system failures.

5. **Flight Operation Risk Assessment (FORAS)**
   FORAS is a tool that will assess the accident/incident risk associated with a flight operation. FORAS is designed to give safety managers and other users a quantitative assessment of specific risk for an operation, broken down into a variety of subgroups, by fleet, region, route or individual flight. This assessment is performed using a mathematical model which synthesises a variety of inputs, including information on crew, weather, management policy and procedures, airports, traffic flow, aircraft and dispatch operations. The system will identify those elements that contribute most significantly to the calculated risk, and will be able, in some cases, to suggest possible interventions. Two risk categories were identified in the first stage of FORAS: Controlled Flight into Terrain (CFIT) and in-flight injuries due to atmosphere turbulence.

6. **Risk Analysis Matrix (RAM)**
   Using RAM, it is possible to standardise the qualitative risk assessments and categorise the hazard using the criteria the airlines consider important. Although there might be different formats of RAM, the essence is the same. In RAM, risk is calculated as a function of both the likelihood of occurrence and the severity of the likely outcome. The Risk Matrix shown in Figure D-1 is based upon the one regularly used by British Airways Safety Services in their monthly safety bulletin 'Flywise'.

Five categories of risk are identified:

A: Severe - an incident requiring the highest priority for resources and action.
B: High- incidents of significant concern which take priority over most other incidents.
C: Medium- incidents requiring the attention and action of a line department.
D: Low- an incident of low concern which normally requires no further action.
E: Minimal- incidents that are of statistical interest only.

Figure D-1 The Risk Matrix

Likelihood of occurrence

		LOW	MEDIUM	HIGH
Severity	HIGH	**C**	**B**	**A**
	MEDIUM	**D**	**C**	**B**
	LOW	**E**	**D**	**C**

Source: Flywise

7. **Risk specific safety index products - performance indicators**
A safety rating system that assesses the declining or substandard operational performance can provide airlines with risk indicators and an early warning signal thus allowing an early remedial action. For example, Schwartz (1998) suggests a Risk Index Performance Indicator for FSF. The risk indexing products include:

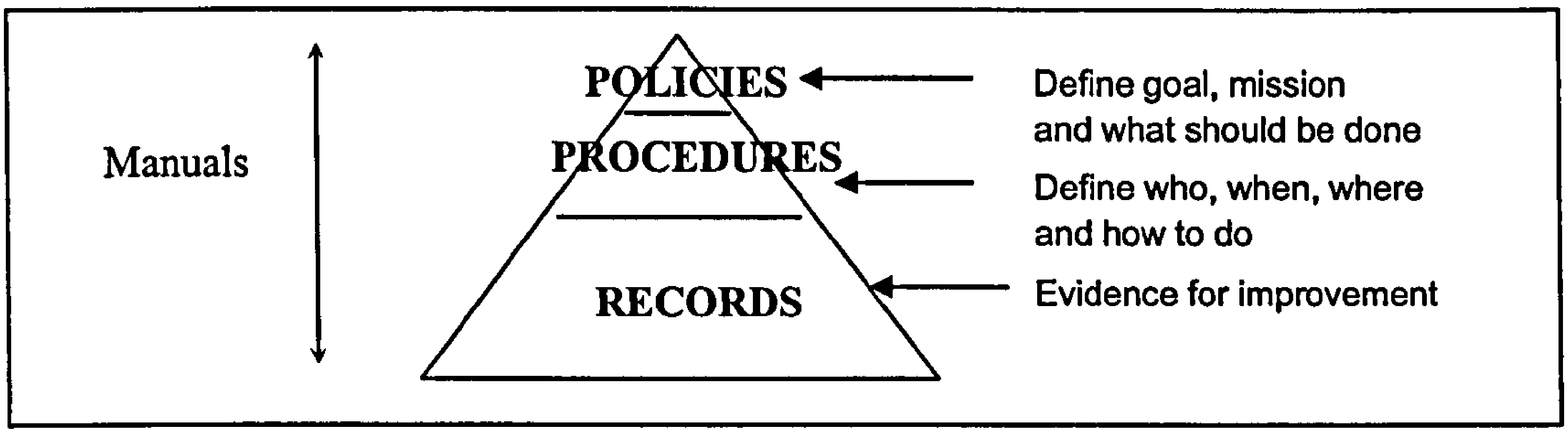
1. Primary product
   - a set of risk-specific safety indices
2. Secondary products
   - associated trend measure
   - global (organisational trend indicator)

And the potential uses of risk index are:
- Performance analysis
- Benchmarking
- Relational database
- Performance predictor
- Safety management

APPENDIX E Documentation Pyramid

To achieve the efficiency and safety of an organisation, the operation concepts and documentation it is very important to maintain consistency and logic. An airline's safety documentation, can be viewed as a hierarchy containing three tiers: policies, procedures and records (Ho, 1996), as shown in Figure E-1.

Figure E-1 The Documentation Pyramid



Source: Adapted from Ho, 1996

Policies

The policy statement is a document stating the company's missions and goals, and defines what will be done and what should be done. It should be clearly written and easy to understand.

Procedures

With the stated policies, procedures are made by the users to operate the equipment efficiently, as such procedures are not inherent in the equipment. Degani and Wiener (1994) argued that procedures are a form of quality assurance by management and regulating agencies over the operators; they exist to specify unambiguously six things:

1. What the task is
2. When the task is conducted (time and sequence)
3. By whom it is conducted
4. How the task is done (activities)
5. The sequence of actions
6. What type of feedback is given (callout, actions etc.)

Since procedures are working instructions, it is noted that they should be designed to be consistent with the policies. For example, Standard Operating Procedures (SOPs) are a set of procedures that provide operators with step by step guidance for their task. Standardisation ensures the best method of operation and makes sure employees behave in a consistent and predictable way. Following SOPs can maintain the services quality and can achieve a certain level of safety. It is a part of the assurance system.

Records

Records are the evidences for improvement, also serving as one means to check if policies and procedures have been followed. Ideally, all departments should review their practices and procedures periodically to ensure compliance. Although records also show problems un-reviewed, they do provide valuable and traceable information and data for management, who can check the need for initiating corrective action.

Manuals

Manuals are the documents recording SOPs. They specify the priorities and goals of work and procedures for different departments. Manuals should be revised periodically in order to meet the company's needs for safety improvement.

APPENDIX F Other MEDA-like Approaches

The Aircraft Dispatch and Maintenance Safety (ADAMS) consortium has also produced a paper-based tool, similar to the MEDA form but much expanded (UKCAA, 2000). Other tools (shown in Table F-1) are computerised versions of the MEDA form, some with data analysis capabilities.

Table F-1 Other MEDA-like Approaches

Tool	Description
TEAM (Tool for Error Analysis in Maintenance)	Developed by Galaxy Scientific[F1], customised for each airline.
AMMS (Aurora Mishap Management System)	Developed by ex-MEDA and ex-US Air Force personnel. It is a commercially available system, designed for use in the transport industries. PC based but adds the costing element.
BASIS MEI (BASIS maintenance Error Investigation)	Developed by BA.
MEDA/SEDA	This software package is the BF Goodrich adaptation of the Boeing MEDA software.
UKCAA MEMS FMS (Maintenance Error Management System Free MEDA Software)	A customised generic version of the BF Goodrich software.

Source: UK CAA, 2000

[F1] Galaxy Scientific, a software company in the USA were the software supplier to Boeing during the development of MEDA so TEAM naturally utilises the MEDA tool but provides a personalised front end for the user (Chapman, 2000).

APPENDIX G Cases of Organisational Change - Culture Transformation

The establishment of major culture changes appears to be rare but is feasible (Ho, 1996). Management can direct cultural shift by articulating the desired values, and reinforcing the proper norms; however, management must be sincere in their efforts in this direction. Two of the most well known examples are Scandinavian Airlines System (SAS) and British Airways (BA). Not only were the culture of their companies changed, but also their fortunes.

G.1 The Case of SAS

In the early 1980s, SAS went through a spectacular turnaround process. The new president, Jan Carlzon, had discovered that the reputation of SAS rested upon the millions of "moments of truth", i.e. verbal encounters between airline staff and passengers, instead of the products provided, the safety of the aeroplanes, the convenience of schedules and so on. Yet the "moments of truth" usually last at most less than thirty seconds. So he led the company to switch from a *product-and-technology* orientation to a *market-and-service* orientation in the four years from 1980 to 1983. The background and circumstances of SAS before and after this cultural change are listed in Table G-1.

Table G-1 The Cultural Change Case: SAS

Company feature	SAS
Size	Medium
Length of major cultural change effort	From 1980-1983
Loss reported before change effort (after)	Small loss reported in 1980 (2 percent of revenues)
Leader background	Unconventional insider
Career path	Grew up in SAS, but not in the core business

Source : Kotter and Heskett, 1992

G.2 The Case of British Airways

Similarly, BA's cultural change was under the new leadership of Colin Marshall in 1983. After witnessing the success of SAS, the new CEO began to put the culture transformation into practice. Hampden-Turner (1990) notes the following actions and considerations that occurred in BA:

1. **Sending out clear signals. Five cultural signals were sent by Marshall:**

- Making decisions: making mistakes is more forgivable than not deciding in the first place.
- Face the customers: need to start to face outward, toward customers.
- Names, not titles: no one should hide behind titles or job descriptions.
- Cross-functional groups: large committees are replaced by small groups in parallel, charging them with responsibilities.
- Less hierarchy: reduce the number of levels of hierarchy.

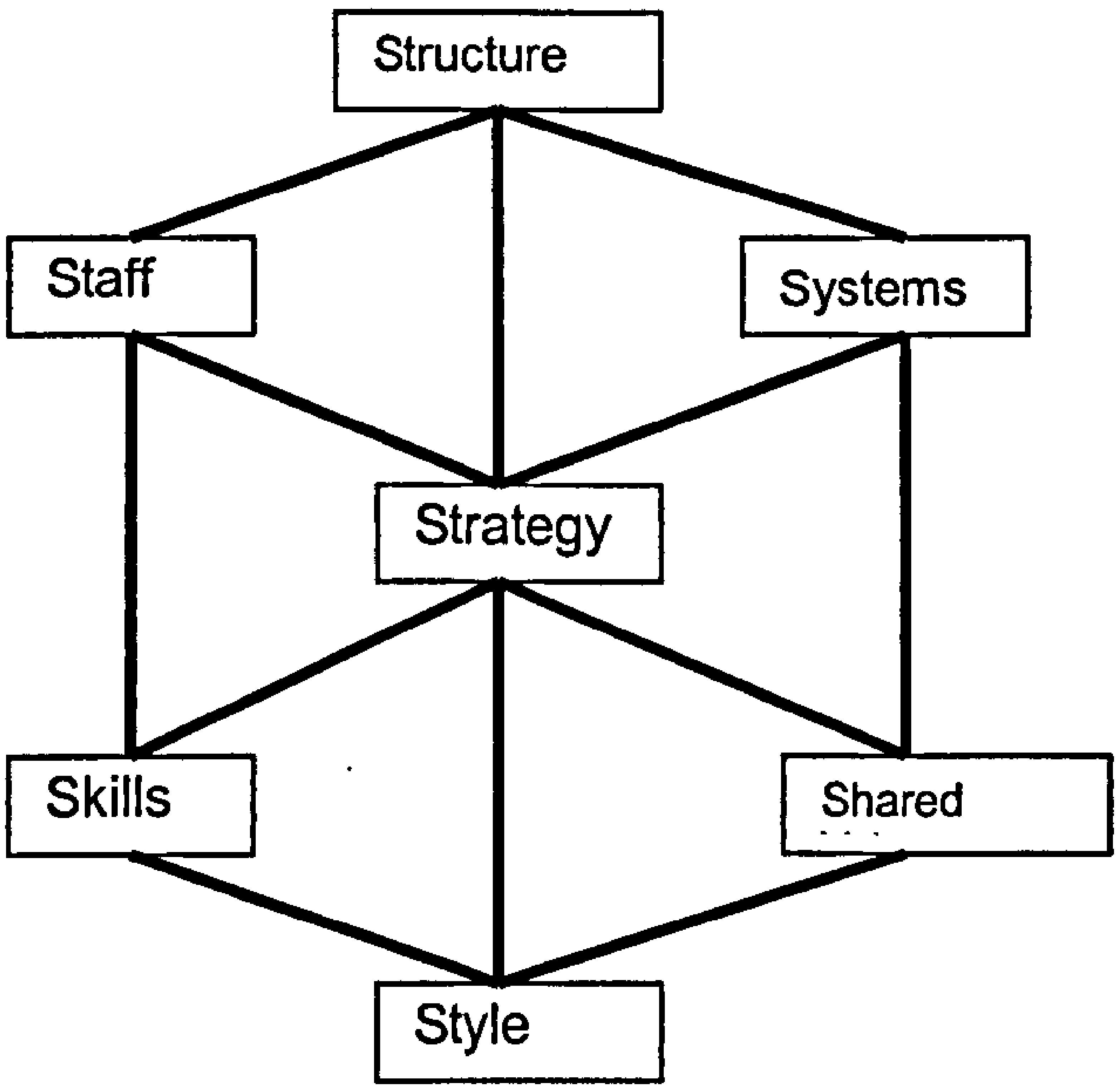
2. **Cultural research**
   A major research into customer attitudes towards BA was conducted. The findings showed that BA was "cold, aloof, uncaring and bureaucratic" to its customers. This was due to military and technology in its cultural orientation until the early 1980s. In fact, BA also found that culture is really what customers buy. Production innovation can be rapidly imitated and copied from other airlines, but culture can not be copied. It has to be learned.

3. **Changing the culture through training programmes**
   The human resources department started to organise and initiate several training programmes, which pushed human dynamics into more positive patterns. Meanwhile, the empowerment message from Marshall was clearly given by showing that grass roots staff were the only people who could help the organisation.

4. **Extending change throughout the organisation**
   It was not enough to galvanise the ground staff and the cabin crews alone. Cultural changes in one section of an organisation must pervade the whole organisation in order to last and be successful. Managers were trained to create a *vision* for the whole organisation so that they could identify with their top management group, followed by a vision for the group they managed. Subordinates had to be shown how their job contributed to the larger objective.

5. **Management theory can be applied to real management**
   BA's version of the seven Ss diagram is shown in Figure G-2. The seven Ss, mobilised by an overall Strategy, include hiring the right Staff, training them with the right Skills, managing them in the Style required, Sharing values with them, installing the right Systems and improving the Structure. By using such a model, culture and strategy can be united as a whole.

Figure G-2 BA's Version of Seven Ss Diagram



Source: Hampden-Turner, 1990

BA had, eventually, turned itself round and made a great improvement (see Table G-3). The successful story of BA has now become a touchstone of the cultural change issue. BA revealed the essence of its success, which is "what we have got to build are the kind of groups that nurture individuality and the kind of individuals that can sustain and develop groups." That clearly showed the organisational culture BA would like to build (for all groups) and the importance of subcultures (as groups consisting of individuals).

Table G-3 The Cultural Change Case: BA

Company feature	BA
Size	Large
Length of major cultural change effort	From 1982-1988
Loss reported before change effort (after)	Significant loss reported in 1981 (7 percent of revenues)
Leader background	Outsider
Career path	Become CEO at BA in 1983. Came from Sears Holdings

Source : Kotter and Heskett, 1992

The other key to cultural and organisational changes is to maintain the changes, which was also achieved by BA, although it did face some dilemmas. While cultural transformation is taking place, in order to sustain competitive advantage, maintaining changes, providing feedback and adjusting the changes are necessary. This concept and its associated processes are now commonly termed the *learning organisation.* Senge (1994) notes that "Learning organisations are the places where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free and where people are continually learning how to learn together." As such, the best consequence of cultural changes can result in organisational learning, and a learning organisation can cultivate a better culture. Organisational change is then achieved.

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APPENDIX H Four Proactive Safety Programmes

H.1 Managing Engineering Safety Health (MESH)

1. Origin and objectives

Managing Engineering Safety Health (MESH) is a programme created for British Airways Engineering Company in 1992 by a team lead by Professor James Reason from the University of Manchester. It is a set of diagnostic instruments for making visible, within a particular engineering location, the situational and organisational factors most likely to contribute to human factors problems (Reason, 1994; Maurino et al, 1995).

Designed to assess the safety climate of an organisation, the measures of MESH give an indication of the system's state of safety (and quality), both at the local workplace level and in general. It is a system of measuring a number of local and organisational factors and the interplay between them.

2. Philosophy

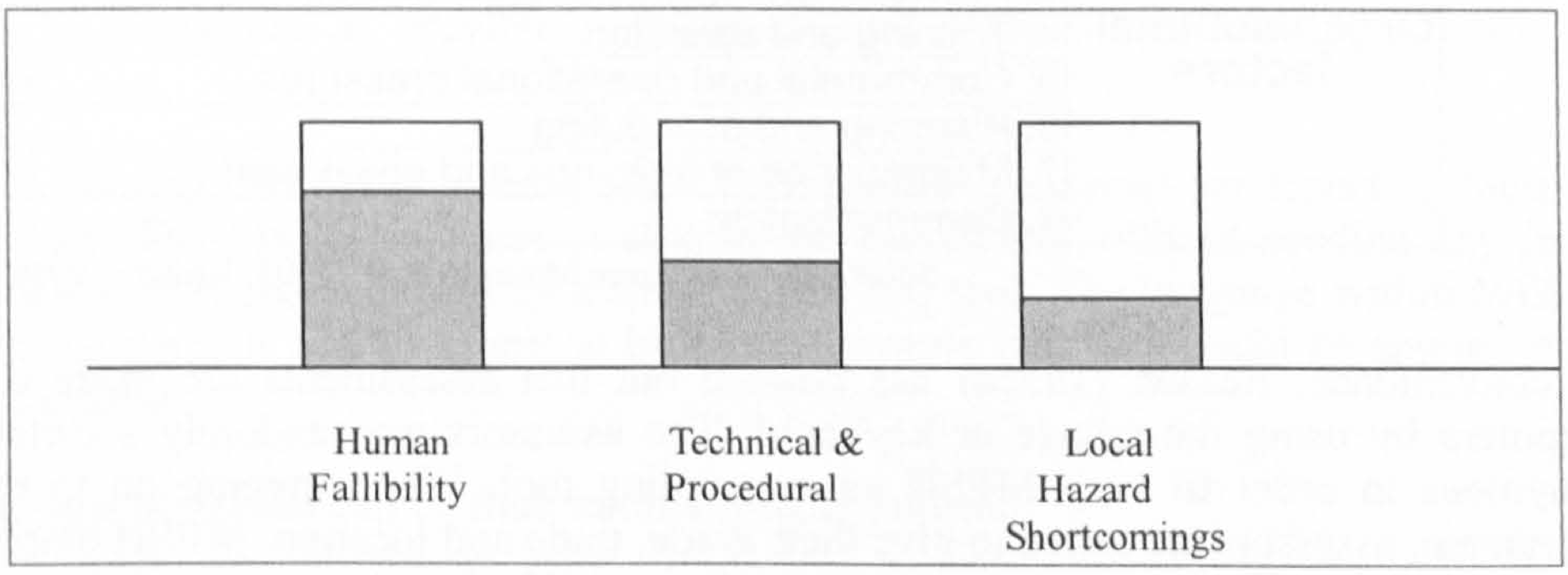
According to Maurino et al (1995), the underlying philosophy of MESH is:

- High standards of safety, quality and productivity are all dependent on organisational 'health'.
- 'Health' is assessed and controlled through regular measurements of 'vital signs' at both local and system levels.
- MESH identifies those 2-3 factors most in need of correction and measures remedial efforts so that a system's state of health can be assessed and controlled.
- MESH is designed to provide the measurement necessary to sustain long-term system fitness.

The programme identifies three basic groups into which accident-producing factors fall (Maurino et al, 1995; CASA, 1998). These are shown in Figure H-1:

- Human fallibility (at the organisational and workplace levels)
- Technical and procedural shortcomings
- Local hazards.

Figure H-1 Accident-producing Factors in the Workplace



Note: Grey area is for demonstration

Source: Maurino et al, 1995

The content of each of these buckets (the grey area in Figure H-1) will never be empty completely although they can change from time to time. Imagine that each bucket gives off particles. The fuller the bucket, the more it gives off. MESH is designed to give up-to-date indication of the fullness of the buckets, if we assume accidents and incidents arise when these particles combine by chance in the presence of some weak or absent defence. It does this by sampling selected ingredients in each bucket (Maurino et al., 1995).

3. Process of assessment

As such, a system's safety health can be assessed by first listing the "ingredient factors", which are divided into organisational factors and local factors. Exactly what local factors are assessed depends on the workplace. Different factors can be developed for different workplaces. They are intended to give a short-term indication of the accident-producing factors present within a particular workplace.

Table H-1 shows the 12 local factors, which were derived from a survey of the problems encountered by maintainers in a line 'casualty' hangar. Ideally around 25 percent of the workforce are required to rate each local factor for the extent to which it causes problems in a limited number of recent jobs. Ratings are made on a weekly basis.

MESH also assesses the impact of upstream organisational factors upon a particular workplace, as shown in Table H-2. Those who are in charge of the department or hangar, i.e. line managers, rate how much each organisational factor has caused problems in that site. These ratings are made quarterly.

Table H-1 Local Factors Measured in an Operational Hangar

Local factors	1. Knowledge, skills and experience
	2. Morale
	3. Tools, equipment, parts
	4. Quality of support
	5. Fatigue
	6. Pressure
	7. Time of day/night
	8. Environment
	9. Computers
	10. Paperwork, manuals, procedures
	11. Inconvenience
	12. Personnel safety features

Source: Adapted from Maurino et al., 1995; Reason 1995a

Table H-2 Organisational Factors Measured in Each Workplace

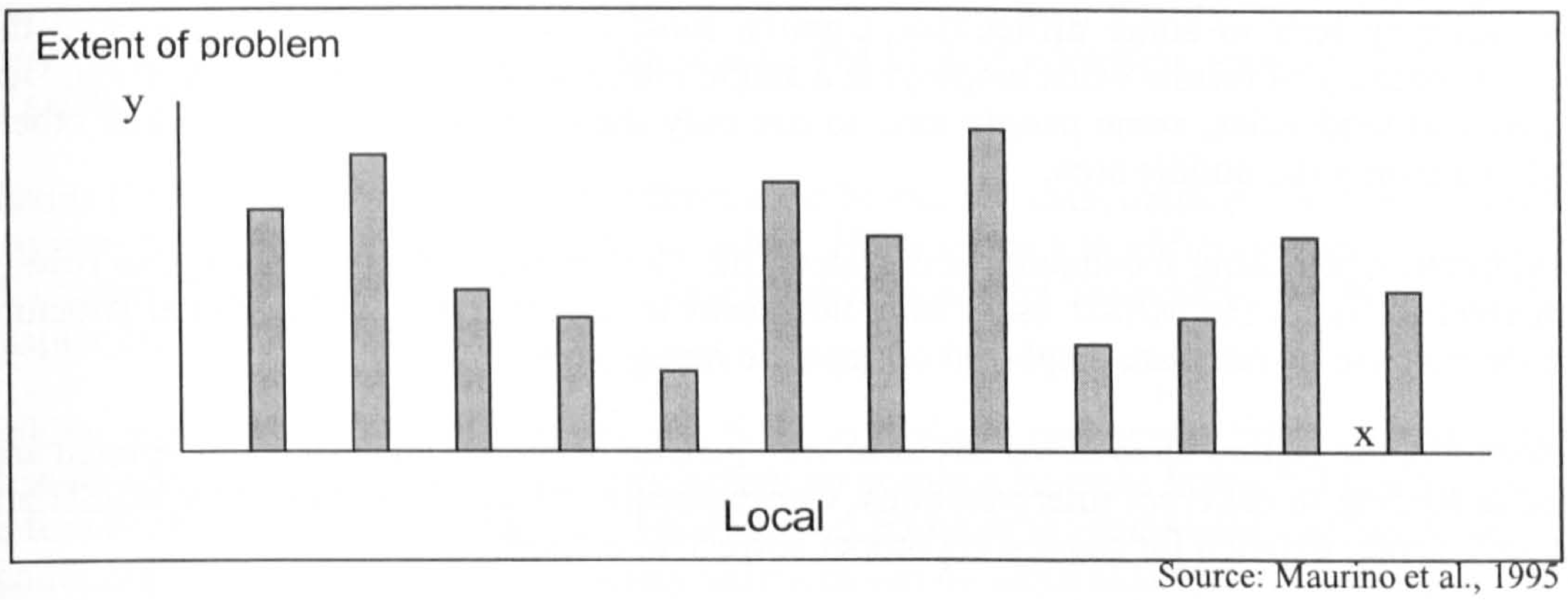
Organisational factors	1. Organisational structure
	2. People management
	3. Provision and quality of tools and equipment
	4. Training and selection
	5. Commercial and operational pressures
	6. Planning and scheduling
	7. Maintenance of buildings and equipment
	8. Communication

Source: Adapted from Maurino et al., 1995; Reason 1995a

For convenience, Reason (1995a) has pointed out that assessments are made directly on computers by using the mouse or keyboard. The assessors are randomly selected and are anonymous in order to keep MESH as a sampling tool. When logging on to the MESH programme, assessors are asked to give their grade, trade and location. MESH employs direct a 5-point rating of the dimensions with regard to specific locations and tasks. For example, the questions are phrased as follows: "To what extent has this factor (either local or organisational factor) been a problem in carrying out these jobs (a previously specified list of 3-5 recently performed tasks)?"

The results of both local and organisational measurements are converted into bar diagram profiles, graphically on an x and y-axis, with the x-axis being the factors and the y-axis being the extent of the problem. Figure H-2 shows a schematic local factor profile.

Figure H-2 A Local Factor Profile



Source: Maurino et al., 1995

When completing their rating, assessors are provided with a profiled summary of their own input together with a cumulated profile for all ratings made over the past four weeks (Maurino et al., 1995). The whole diagnostic package is implemented within a linked suite of computer programmes into which all the gathered information and sample results are fed and then tracked. Their purpose is to identify the two or three factors most in need of remediation. As mentioned previously, MESH is a sampling tool. It samples jobs and tasks to identify those factors most likely to come together to cause future incidents. It also tracks the progress of subsequent remedial actions.

In MESH, the local factor assessments are made at weekly intervals by a randomly selected proportion of the workplace in each of a variety of workplaces (i.e. operational hangars, majors overhaul hangars, workshops, etc.). The organisational factors are assessed at three-monthly intervals by technical management in each location because these are the people best placed to judge the impact of "upstream" organisational factors upon the reliability of their various workplaces (Reason, 1995a).

4. Advantages

Reason (1995a) also suggests that by identifying factors in need of improvement and tracking the changes over time, MESH enables the maintenance of adequate safety health, comparable to a long-term fitness programme, in which the focus of remedial efforts switches from dimension to dimension as previously salient factors improve and new ones come into prominence.

In terms of training, MESH is directly used by front-line personnel for reporting their own points of view. The MESH end user is able to use the system without needing any further training because it is characterised by a single phase and tool. The language within MESH is simple and the items it addresses are so broad and generic that they could be applied in any other environment.

The advantages of MESH can be thus summarised as follows:

- Staff are all involved in safety.
- Managers can prioritise remedial actions and check upon their impact.
- Direct safety resources where they are most needed.
- Encourage better communications between management and staff.

5. Limitations

Although the first impression of MESH appears to be that it is easy, the implementation of this tool may lead to some difficulties. Caution must be expressed when interpreting the implied meaning of results when employing a single rating scale method of investigation. Due to personal tendencies, some people tend to use only the extreme of the scale, while others tend to use only the middle area.

In addition, when using a computerised system, the "bigger picture" is not always so readily available. As such, the MESH users have no access to any overview of the global structure and the items to be rated are displayed on separate rating pages.

Meanwhile, the factors rated in MESH have very general meanings and can be interpreted and rated according to different interpretations. Consequently, the results obtained by MESH are not sufficiently detailed for suggesting proper corrective actions.

MESH has never been applied by low capacity operators, and would be beyond the resources of smaller operators. Although it has also been implemented by Singapore Airlines Engineering Company, this programme is not adopted widely by other airlines and has not achieved the significant improvements in safety performance that were originally expected. A number of improvements and modifications are currently being made as a result.

6. Other MESH-Like applications

MESH employs a systemic approach to safety management and is readily adapted to a range of industries and disciplines. Prior versions of MESH-like instruments have been developed for the oil and railway industries. Later versions are now being evaluated by the US nuclear power generation industry (IFA, 1998). Meanwhile, Shell International uses a similar method in its tanker and exploration operations in the form of Tripod-DELTA. Likewise, British Rail currently employs a proactive instrument called REVIEW, which has also been used at West Australian Railways. (In the case of REVIEW and Tripod-DELTA, only organisational factors are assessed. The judgments are made regularly by supervisors in differing activities and locations, via a computer programme. Tripod assessments are made quarterly; those for REVIEW are made at approximately monthly intervals.)

H.2 Identifying Needed Defences In the Civil Aviation Transport Environment (INDICATE)

1. Origin and objectives

INDICATE is a safety programme that has been developed in consultation with the Australian regional airline industry for proactive purposes. The name is based on the underlying purpose of the programme which is to identify and resolve deficient aviation safety defences (Edkins, 1998). It provides a formal communication channel for aircraft operators to regulations, policies and standards to the Bureau of Air Safety Investigation (BASI) in Australia. It is also known as BASI-INDICATE.

2. Underlying philosophy

The basic premise underlying the INDICATE programme is that generally people working within the aviation industry will report safety hazards if given sufficient opportunity and the right work environment. However, some individuals are reluctant to report safety hazards for fear of blame or retribution, especially if the problem reflects negatively on company management. Alternatively, safety hazards report may be reported but with little feedback given to the reporter; and some smaller airlines do not have formally appointed operational safety officers, to whom staff can access directly and can confidentially report safety hazards.

Consequently potential safety problems remain undetected.

INDICATE was designed to minimise this type of communication problem by providing a simple but structured process to ensure that consistent and high-quality safety information is disseminated to all company staff. This is achieved by first educating staff about the concept of safety defences (BASI, 1998).

Edkins (1998) points out that safety defences are barriers or safeguards put in place to protect a system from both human and technical failure. He presents a modified version (Figure 2-22 in chapter 2) of Reason's model of organisational accident causation (see Figure 2-20 in chapter 2).

Edkins argues that each of the organisation, workplace and person/team components of Reason's model are difficult to identify before an accident because latent failures are usually unforeseeable, workplace factors are dynamic, and errors or violations are unpredictable. This model implies that the integrity of safety defences can be more accurately determined as they are more tangible and thus more measurable components within a system. Regularly evaluating defences provides a tangible means by which latent organisational failures can be identified. The INDICATE programme has therefore been designed to regularly evaluate airline safety defences so that the potential risk of an accident can be minimised.

3. Basic elements of the INDICATE programme

The INDICATE programme involves establishing and maintaining the following six core safety activities (CASA, 1998; Edkins 1998, 1999; BASI, 1998):

i. Appointing an operational Safety Manager or Safety Officer who is available to staff as a confidante for safety related issues
ii. Conducting a regular series of staff meetings to identify safety hazards within the operation
iii. Establishing a confidential safety hazard reporting system
iv. Conducting regular safety meetings with management
v. Maintaining a safety information database
vi. Ensuring safety information is regularly distributed to all staff

4. Methodology

Co-operation was agreed with Kendell Airlines, an Australian regional airline, to trail the INDICATE programme. Commencing in July 1996, it took eight months to complete the trial and determine whether or not the programme had had a positive influence on the airline's safety performance.

Since Kendell operates out of two major regional centres, the INDICATE programme was implemented in one regional centre as an intervention group (INDICATE base - 81 staff) while the other served as a control group (non-INDICATE base - 72 staff). This enabled a comparison at the end of the trial period to objectively evaluate any changes in safety performance across the two bases. Table H-3 summarises the six core elements of the INDICATE programme as well as showing differences in application across the intervention and control groups.

Table H-3 Differences in Application of the INDICATE Programme Across Both Experimental Groups

Six core safety activities of the INDICATE programme	A	B
i. Appointing an operational Safety Manager or Safety Officer who is available to staff as a confidante for safety related issues	Yes	No
ii. Conducting a regular series of staff meetings to identify safety hazards within the operation	Yes	No
iii. Establishing a confidential safety hazard reporting system	Yes	No
iv. Conducting regular safety meetings with management	Yes	No
v. Maintaining a safety information database	Yes	No
vi. Ensuring safety information is regularly distributed to all staff	Yes	No

A: Intervention group (INDICATE base)
B: Control group (non-INDICATE base)

Source: Adapted from Edkins, 1998

5. Evaluation criteria

There are many potential measures of airline safety performance, including the absolute number of fatal and non-fatal accidents; fatal and total accidents per million departures; passenger fatalities per million passengers or per million miles, etc. Regardless of which measure is used, it is important that it is examined regularly if a safety management programme is to be effective in improving safety performance. Nevertheless, accidents are so rare in airline operations that they cannot be used as a statistically reliable index of safety performance.

As such, the INDICATE programme was evaluated based upon the following five safety performance criteria (Edkins, 1998; BASI, 1998). The criteria were used in both intervention and control groups to determine whether the programme would achieve an improvement in airline safety performance over the eight month period. These criteria were:

1. Airline safety culture
2. Airline staff risk perception of aviation safety hazards
3. Staff willingness to report safety hazards
4. Action taken on identified safety hazards
5. Staff comments about safety management

These criteria were chosen because safety culture and hazards risk perception have been well researched within various industries and show a strong relationship to workplace accidents. However, they are essentially attitudinal measures which should not be relied upon in isolation. In addition, the remainder of the criteria were included because they are more tangible indicators of the programme's success and were considered complementary to the attitudinal criteria. All the criteria should provide a comprehensive evaluation of the validity of the INDICATE programme (BASI, 1998).

6. Brief description of each criterion

1. Airline Safety Culture

In order to measure changes in safety culture during the eight month trial, the Airline Safety Culture Index (ASCI) was developed. A questionnaire consisting of 25 positively worded statements was constructed and each statement requires a response on a five point Likert scale, ranging from strongly agree to strongly disagree. Based on Brown and Holmes (1986), Cooper (1995) and ICAO (1994), a number of items were developed regarding the following core dimensions: management commitment (2 items), management action (6 items), employee commitment (4 items), level of perceived risk (1 item), beliefs about accident causation (2 items), emergency procedures (1 item), the provision of safety training (2 items), and safety communication (7 items).

The questionnaire was administered on three occasions to both groups; prior to the implementation of INDICATE, at the mid term of the trial, and at the end of the trial period. By comparing the difference in both groups at different periods, it is expected that the intervention group would demonstrate a better safety culture score when compared with the control group.

1. Staff Risk Perception of Aviation Safety Hazards

ICAO's Accident/ Incident Reporting System was used to compile a list of the most frequently occurring safety hazards in commuter/regional airlines from 1979-1996. The list of aviation safety hazards was presented to staff both in the intervention group and control group at the beginning and the end of trial. It required respondents to rate each of the hazards according to their potential to affect the safety of airline passengers. Each hazard was rated in accordance with its hazardousness and the likelihood of it occurring within the airline environment. The questionnaire produced an individual risk perception score for both hazardousness and likelihood.

It was expected that there would be little difference in risk perception between groups at the commencement of the trial. Nevertheless, a significant reduction in the mean hazardousness and likelihood scores of staff in the intervention group was expected.

2. Staff Willingness to Report Safety Hazards

During the eight month period, both intervention and control groups had chances to access a confidential safety reporting system to inform management about safety hazards that they felt had potentially serious safety implication. Identical information on how to use the reporting system was given to both groups. It was expected that the intervention group would have submitted more reporting hazard report forms, compared with the control group.

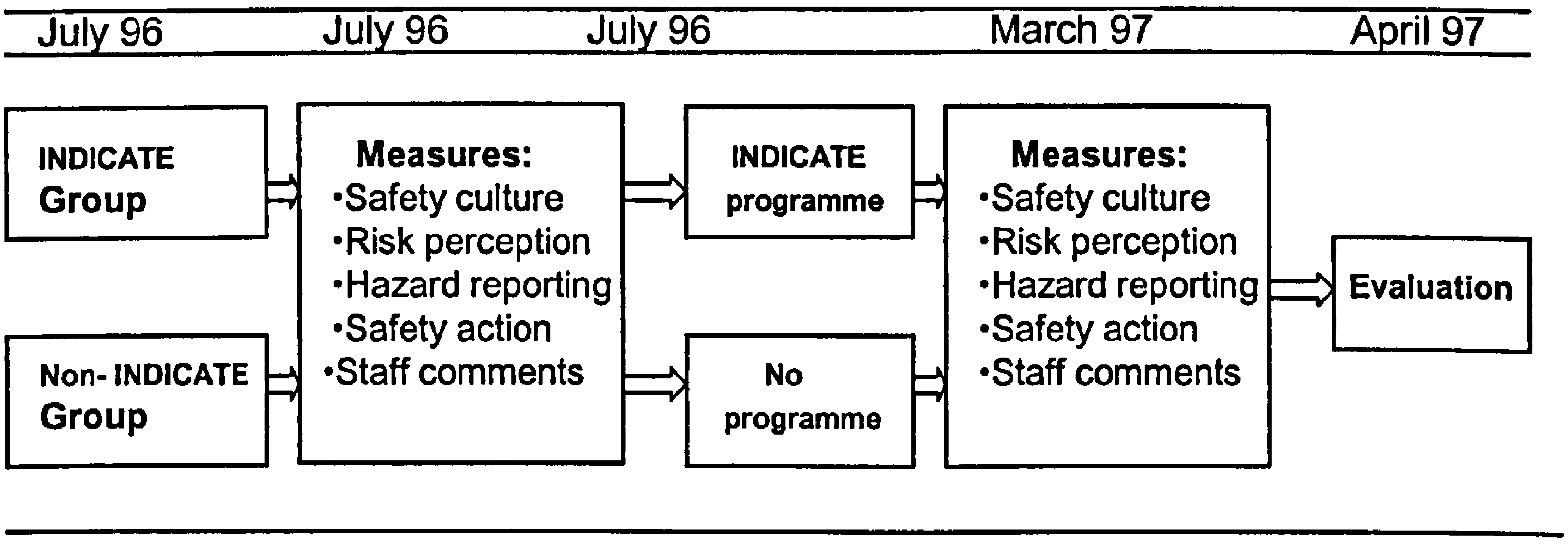
3. Action Taken on Identified Safety Hazards

It was also expected that the intervention group would have achieved more action on safety hazards compared with the control group because the implementation of the INDICATE programme within the airline provides a structured framework to address safety hazards.

5. Staff Comments About Safety Management

Staff were given the opportunity to complete a free response section in the safety culture questionnaire before and at the conclusion of the trail. It was expected that staff in the intervention group would have more positive comments about safety management compared with the control group, at the end of trial. Figure H-5 contains the summary of the methodological design in the eight month trial.

Figure H-5 The Methodological Design in the Eight Month Trail



7. Implementing INDICATE

Within the company there is a Co-ordinator or Safety Officer who is responsible for running the programme. Depending on the size of the operation, this function may be part of someone's existing duties, or be the responsibility of a dedicated position.

Approximately every month a safety meeting was conducted with the managers from each section (technical crew, cabin crew, maintenance crew, ground crew, operations and union/association groups). At these meetings safety issues raised by staff or management, at any level, were discussed.

8. Results

The evaluation results reveal that there is a clear difference between the intervention and control groups. According to Edkins (1998) and BASI (1998), staff in the Intervention group:

- are more positive about safety management
- are more willing to report safety hazards
- have more confidence in management's ability to address safety issues
- feel there is a better quality of safety communication between management and staff and between different operational departments

9. Benefits

In Australia, it is a legal requirement to report air safety incidents via an Aviation Safety Incident Report (ASIR). However, there is a recognised problem of under-reporting, which in part stems from a lack of awareness about what should be reported despite this mandatory requirement.

The programme provides a simple and structured process to encourage staff to report safety hazards and deficiencies within their work area. The safety information database and software allows management to address all safety-related concerns. Furthermore, senior management regularly meet with safety staff to determine what to do about identified hazards. It is clear that consistent communication of safety-related information within an organisation is crucial for improving staff attitudes towards safety.

In addition, INDICATE provides a computer programme to assist the company in detailing all reported concerns. The software programme:

- records the nature of each safety hazard
- records any action (or lack of action) taken on each hazard

- maintains the confidentiality of the reporter
- generates a recommendation for either:
  - – a departmental manager
  - – senior management
  - – appropriate aviation authorities

Where the information on the hazard is sent depends on the nature of the hazard and who is best equipped to assist in rectifying an identified problem (CASA, 1998).

As such, a number of benefits of INDICATE are concluded:

1. Encourages better communication between management and employees about safety.
2. Reveals critical areas for development of procedures or training and for priority inspections.
3. Provides a framework for feedback as to the efficacy of assumptions made about hardware or operational procedures.
4. Provided a baseline for management decisions regarding safety issues.
5. Provided a cost-effective safety management tool.

Edkins (1998) explains that the results of the INDICATE trial suggest that measuring safety culture provides a useful method for monitoring changes in company safety performance and may assist in identifying elements of a safety management programme that require improvement, such as a hazard reporting system.

Most importantly of all, the evaluation of the INDICATE programme illustrates that the greatest source of variance is not necessarily aircraft equipment or the category of operation, but the real cost from the safety culture of organisations within the aviation system. A small to medium size airline, operating within a limited budget, does not have to spend large amounts of money to improve its own safety culture. The benefits from implementing such initiatives will ultimately help to improve operational safety and, in some cases, reduce operating costs.

Currently there are over twenty passenger carrying operators of varying sizes both Australia and overseas which have implemented the INDICATE programme, which is easily tailored to the varying requirements of different sizes of operation.

H.3 Proactive Error Reduction System (PERS)

1. Origins

The PERS programme is funded by the Federal Aviation Administration's Office of Aviation Medicine and devised by Dr. Colin Drury at the University at Buffalo (UB), the State University of New York (IFA, 1998). The FAA-funded project began in 1989 following a Congressional hearing prompted by an incident in which 18 feet of roof pulled away from an Aloha Airline jet as it was flying over the Pacific Ocean. A flight attendant was sucked from the plane and 61 passengers were injured.

2. Underlying philosophy

For years, Drury and his co-workers have analysed errors by airline workers in detail. They are using this knowledge to build practical tools that allow users to arrive quickly at solutions to errors made by airline workers.

PERS is an error management system which can be used by non-experts in human factors because it is based on a human-factors approach to solving errors. The idea behind this is that one should not just determine the immediate cause of the error, but examine all the things that lead up to it. As such, this programme, as shown in Figure 2-23, is structured to use the repeating patterns found in incident data in order to help airlines move from the recognition of human factors as an issue to practical human factors solutions.

3. Advantages

There are four distinct functions within the programme:

1. A comprehensive error management system which can combine many existing data collection and analysis systems (eg. MESH, MEDA). In other words, it facilitates the importing of data from other systems such as other audits and MESH, and links databases of maintenance errors with databases of known solutions.
2. PERS facilitates the identification of error-prone situations by using
   - error audit of specific tasks
   - error assessment like MESH.
3. PERS supports error management strategies, identifying situations for design/procedure changes.
4. PERS facilitates error reporting by employing
   - error reporting modules like MEDA (an error-reporting system with interfaces to MEDA)
   - critical incident reporting modules.

PERS provides a way for airline personnel to analyse an error or potential error, to discover why it occurred, and then to see how they might go about changing systems, equipment or work patterns to prevent future errors. PERS not only tells airline workers what to do if an error occurs, but it also tells them what to do even if what has occurred are not actual errors, but error-prone situations.

4. Scenario

For example, suppose that an aircraft was hit by a ground vehicle driven by a mechanic. The programme will ask: Why was the mechanic there? What was the mechanic doing? Why was he in a hurry?

In one instance, it was found that drivers of ground vehicles often put the vehicles into neutral, but did not turn them off when they got out of the vehicles for the simple reason that the engines got so cold that they would be difficult to restart (Goldbaum, 1996). Therefore, by providing such detailed information about an incident, the airline should be able to pinpoint and address the chain of events that lead up to the error.

H.4 Line Operation Safety Audit (LOSA)

1. Origins and objectives

LOSA was developed by the team of Professor R. Helmreich at the University of Texas, USA. Under LOSA, flaws in human performance and prevalence of error are taken for granted and the objective becomes improving the context within which human perform. LOSA ultimately aims to introduce a buffer zone or time delay between an error and the point at which its consequences become a threat to safety. The better the buffer or the longer the time delay, the stronger the tolerance of the operational context to the negative consequences of human error (Maurino, 2001).

2. Underlying philosophy

LOSA are programmes that use expert observers to collect data about crew behaviours and situational factors on normal flights. Observations generate a narrative of the flight classified by phase, and these are conducted under strict no-jeopardy conditions, which means that no crew are at risk for observed actions. Observers code observed threats to safety and how they are addressed, errors and their management, and specific behaviours that have been associated with accidents and incidents.

Data from LOSA provides a picture of system operations that can guide organisational strategy in safety, operations, and training. Helmreich (2001) points out that a particular strength of LOSA is that the process identifies examples of superior performance that can be reinforced and used as models for training. Data collected in LOSA are proactive and can be used immediately to prevent adverse events.

3. Methodology of LOSA

The critical difference between a LOSA flight and a line check is LOSA's guarantee of anonymity for the crew. Data are entered into a de-identified database and no crew actions are reported to management or the regulatory agency.

In LOSA, error is classified as deviation from organisational or crew exceptions or intentions. Errors committed by the flight crew are described and coded along with actions taken to deal with the consequences of the errors. Table 2-6 in chapter 2 lists the various errors and remedial strategies employed in LOSA.

4. Advantages of LOSA

One of the important aspects of LOSA is the fact that it captures exemplary as well as deficient performance, which provides airlines with the areas in which they excel as well as those in need of improvement.

The other strength is that a database is being developed that allows organisations to compare their results with other airlines. Such comparisons help in interpreting the significance of the number of procedural and decision errors observed and the effectiveness of threat and error counter-measures. The data allow management to prioritise safety initiatives and training departments can use the information to develop targeted training.

Meanwhile, the informative aspect of LOSA data is the ability to link threat recognition and error management with the specific behavioural markers that from the core of CRM. Using LOSA, a model incorporating the Swiss Cheese model has been developed (Helmreich, 1999). It recognises both overt and latent threats, and how they fit into the management of error and undesired states.

These markers emerge very clearly in observer ratings of the actions taken by effective crews. Those who deal proactively with threat and error exhibit the following behaviours:

- active captain leadership
- briefing known threats
- asking questions, speaking up
- decisions making and reviewed
- operational plans clearly communicated
- preparing/planning for threats
- distributing workload and tasks
- vigilance through monitoring and challenging

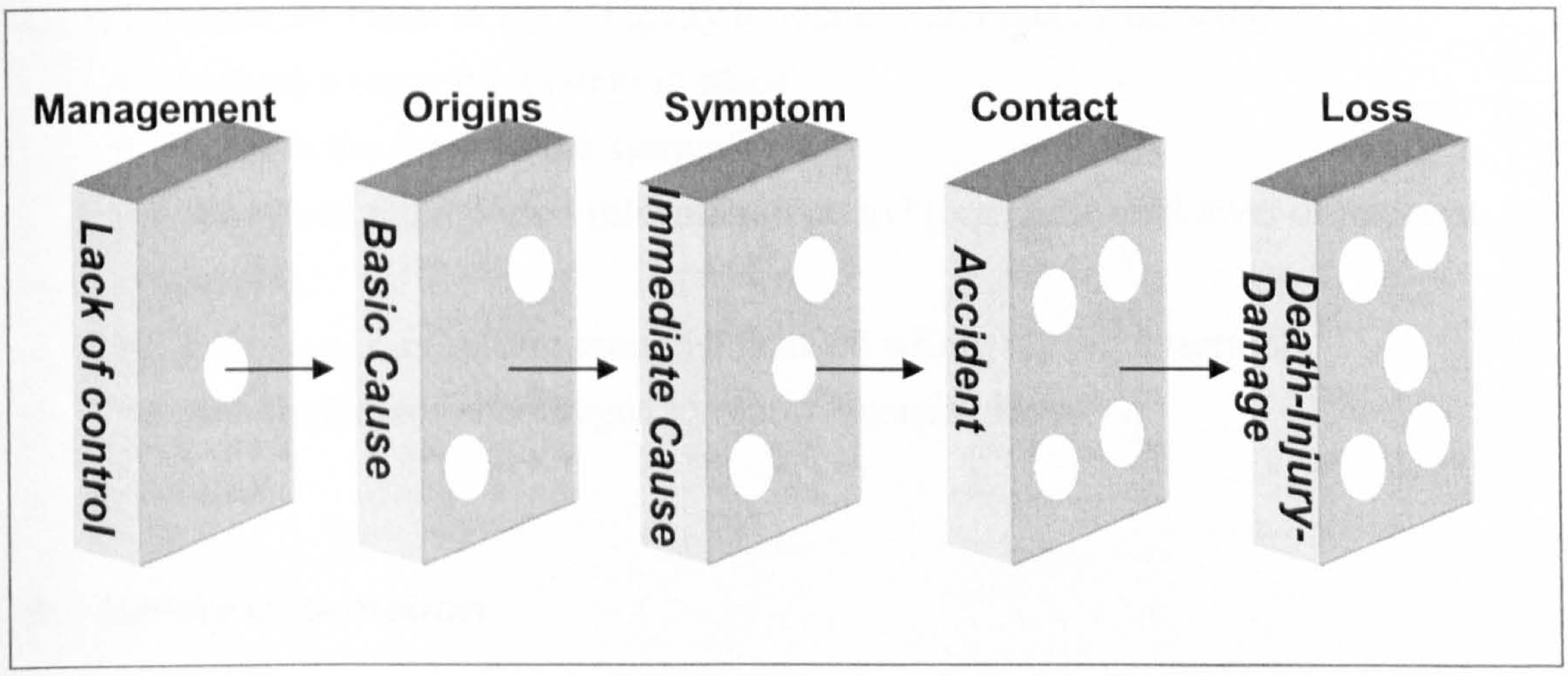
Although the challenge for the implementation of analysis of normal operations is to overcome the obstacles presented by a blame-oriented industry, LOSA has been appreciated by various airlines which are willing to make the investment in conducting the necessary observations and analyses. In addition, the value of LOSA has also been recognised by ICAO and has gained support to conduct a "LOSA Week" to promote this programme to interested countries.

APPENDIX I Domino Theory

An accident is the undesired event (unwanted consequence) due to loss of control. Consequently, it may result in damage to the elements of a system. A domino sequence originally presented by Frank Bird, Jr. and now updated by Heinrich, Petersen & Roos (1980) clearly states the accident sequence in a loss of control system by explaining the five key loss control factors in order of dominoes (see Figure I-1).

Within this system, control as a function of professional "Management" is optimised through five established steps that systematically produce desired results. Origin, like etiology, refers to the sources and its appropriated identification with the basic or underlying cause serves to reinforce the desire to achieve a more effective control.

Figure I-1 An Accident Sequence Domino



Source: Revised from Heinrich, Petersen & Roos, 1980

The immediate cause is usually a "Symptom" of a deeper underlying problem. Safety managers and quality control managers frequently refer to these causes as unsafe acts/conditions or substandard acts/conditions. Historically they are regarded as the most important factors to attack.

An accident is described as an undesired event that results in death, injury, or property damage. When considering the broader implications of accidents with "Contact", we can see some more important relationships between the safety, environment, and exposure factors, and the importance of interface between related human elements in a coordinated loss control system.

"Injury" has been frequently used to mean bodily damage or harm through traumatic accident. Damage, as used in this injury factor, is intended to cover broadly all types of tangible and intangible property damage. To optimise loss reduction, the safety manager will also direct substantial attention to control countermeasures at this last factor in the sequence. It is also referred to as the post-contact stage.

APPENDIX J Interview Questions

✈ Safety performance and management

1) What is the organisational structure to manage safety?
2) How safety performance is monitored, measured and audited?
3) Key indicators? Any statistics are used to indicate the changes in performance?
4) How to decide the safety level?
5) What is the safety management system in your company?
6) What are the components of a SMS?

✈ Hazard discovery and reporting (risk management)

1) The use of risk assessment methods or tools?
   By whom? How often? Who approves?
2) What steps are taken in the company to identify and rectify hazards?
   - Is there a reporting system in place?
   - What is the focus of the system?
   - Who does the reported information go to? (organisational level or national level?)
   - Is the reported information visible used within the organisation?
   - Are employees encouraged to report hazards? How?

✈ Safety information

1) Who manages the safety information?
2) Any safety publication within the company to reveal the safety information?
3) What is the relationship between safety information and discipline procedures?
   Any feedback to employees?
4) Safety manual? Scope?
5) Any regular safety meeting with other companies?
6) Barriers?

✈ Safety culture

1) Any cultural approach in safety management?
2) Focus on long term or short term?
3) Any conflicts between safety and production goals?
4) Safety goal? Included in company mission statement?
5) Leadership
6) Communication

✈ Industry

1) What is the role of organisation within industry (e.g. regulator, operator, service provider)?
2) What are the main hazards faced within the industry?
3) What is the degree of risk?

✈ Regulator

1) Do regulators provide sufficient information?
2) What's the role of regulator?

APPENDIX K Airline Distribution List

ACES Colombia
Aegean Aviation
Aer Lingus
Aero Lloyd
Aeroflot
Aerolineas Argentinas
Aerolitoral
Aeromexico
Aeropelican
Air 2000
Air Afrique
Air Algerie
Air Berlin
Air Botnia
Air Caledonie
Air Canada
Air Canada Regional
Air China
Air Dolomiti
Air Europa
Air France
Air Guinee
Air Hong Kong
Air Jamaica
Air Kazakhstan
Air Liberte
Air Littoral
Air Macau
Air Madagascar
Air Malawi
Air Malta
Air Mauritius
Air MidWest
Air Moldova
Air Namibia
Air New Zealand
Air Nippon
Air Nostrum/Iberia Reg
Air One
Air Pacific
Air Tahiti
Air Transat
Air Vegas
Air Wisconcin
Air Zambique
Air-India
Airline of South Australia
Airlink Pty Ltd
Airours Internaional
AirTran Airways
Alaska Airlines
Alitalia
All Nippon Airways
Allegheny
Alliance
Aloha Airlines
Alpine
America West Airlines
American
American Eagle Airlines
American Trans Air
Amtran
Arkia Israeli Airlines
Asiana Airlines
Atlantic Coast Airlines
Atlantic Southeast Airlines
Atlas
Augsburg Airways
Austral Lines Aereas
Australian Air Express
Austran Airlines
Aviacsa
Avianca
AZZURRAir
Bankok Airways
Bering
Biman Bangladesh Airlines
Binter Canarias
bmi british midland
Bouraq
Britannia Airways
British Airway
British European
British International Helicopter
British Med. Airways
British Regional Airlines
British World
Brymon Airways
BWIA West Indies Airways
Canada 3000 Airlines
Canada 3000 Cargo
Canadian Regional
Cape Air
Cargolux
Cathay Pacific
CCAir
CCM Airlines
Cebu Pacific Air
Chautauqua Airlines
China Airlines
China Eastern Airliens
China Hainan Airlines
China Northern Airlines
China Northwest Airlines
China Southern Airlines
China Xinjiang Airlines
CityFlyer Express
CityJet
Climber
Comair
Comair Limited
CommutAir
Condor
Continental
Continental Express
Continental Micronesia
Copa Airlines
Corporate
Corseair
Croatia

Air Philippines
Air Seychelles
CSA Czech Airlines
Cyprus Airways
Delta
Delta Air Transport
Deutsche BA
DHL Airways
Dniproavia
Domodedovo
Dragonair
Eagle Airways
Eastern Australia
easyJet
Egyptair
El Al
Emirates
Era
Ethiopian Airlines
EuroLOT
Eurowings
EVA Air
Evergreen International Airlines
Express Airlines I
Far East Air Transport
FedEx Express
Fine
Finnair
First Air
Flight West
Flying Colours
Frontier Airlines
Fujairah Air
Garuda Indonesia
Gemini
Ghana Airways
Go
Grand Aire Inc

Great Lakes
Gujarat Airways
Gulf Air
Gulfstream International Airliens

Braathens
Brit Air
Hawailian Airlines
HeavyLift Cargo
Horizon Air
Iberia Airlines
Icelandair
Impluse
Indian Airlines
Indonesia Air Transport - IAT
Iran Air
JAL
JALways
Japan Air System
Jet Airways
JetBlue Airways
JMC Airlines
Kendell
Kenmore Harbor
Kenya Airways
KLM
KLM cityhopper
KLM uk
Korean Air
KrasAir
Kuban
Kuwait Airways
LAB Flying Service
LAM Mozambique
LanChile
LAPA
Lauda Air
Lauda Air Spa
Lietuva
Lineas Aereas Allegro
Lithuanian
Lloyd Aereo Boliviano
LOT Polish Airlines

Love Air
LTU International Airways
Lufthansa
Lufthansa Cargo India

Crosair
Crossair
Luthansa CityLine
Luxair
Maersk Air
Maersk Air UK
Malaysia Airlines
Macair
MalEv
Mandala
Mandarian
Martinair
Meridiana
Merlin Express
Mesa Airlines
Mesaba Airlines
Mexicana
MIAT- Mongolian Airlines
Middle East Airlines
Midwest Express
Monarch
National Airlines
National Jet
Negeria
Nepal Airways
Nippon Cargo
Nordeste LA Regionals
Northwest
Olympic Airways
Oman Air
Pacific Airlines
Pakistan
Pakistan International Airlines
Palmair Flightline
Pearl Aviation
Pelangi Air
PGA- Portugalia
Philippine Airlines

Polar
Premiair
Pulkovo Airlines
Qantas

Hapag-Lloyd
Regionair
Regional Compagnie Aerienne Europeene
Rio-Sul
Royal Air Maroc
Royal Airlines
Royal Brunei Airlines
Royal Jordanian Airlines
Royal Nepal Airlines
Royal Phnom Penh Airways
Ryan International Airlines
Ryanair
SA Airlink
Sabena
Sahara
SAS
SAS Commuter
Saudi Arabian Airlines
Shandon
Shanghai Airlines
SIA
Sibir Airlines
SilkAir
Skyway
Skyways Express
SkyWest Airlines
South African Airways
Southern Winds
Southwest
Spanair
Spirit Airlines
Spirit Airlines
SriLankan Airlines
Sun Country Airlines
Sunshine Express
Sunstate
Swissair
Syrianair
TACA International Airlines
TAM Linhas Aereas
TAP Air Portugal
Taquan
Lumbini Airways
TAROM
Thai Airways International
THY Turkish Airlines
Trans States Airlines
TransAsia Airways
Transavia Airlines
Transbrasil
Transaero
Transeast
Transtate
Tunisair
Turkmenistan Airlines
TWA
Tyrolean Airways
UNI Airways Corps
United
UPS
US Airways
Vanguard Airlines
Varig
VASP Brazilian Airlines
Vietnam Airlines
Virgin Atlantic Airways
Virgin Blue Airlines
Virgin Express
VLM Airlines NV
Volare Airlines Spa
WestJet Airlines
Wideroe's Flyveselskap
World Airways
Wuhan
Xiamen Airlines
Yemenia
Yunnan Airlines
Qatar Airways

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APPENDIX L Covering Letter & Questionnaire

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Direct Dial + 44 (0) 1234 754236/7

Dear Sir/Madam,

I am a PhD student, in the Department of Human Factors and Air Transport (School of Engineering, Cranfield University, UK), conducting research into the airline safety management. The purpose of my research is to evaluate current airline safety management, investigate organizational factors affecting flight safety and justify the best practice for safety improvements within the airline industry.

It would be greatly appreciated if you could spend a few minutes completing the attached questionnaire. This research is not sponsored by any outside organization. The information you provide will be used strictly for the purpose of this study and all replies will be treated as highly confidential. A summary of the results can be provided if required.

If you are not the appropriate person to fill in this questionnaire, may I ask you to pass it on to the appropriate person since it is an important part of my dissertation. Completed questionnaires may be returned in the FREEPOST envelope provided. No postage is required. Alternatively, the fax and email addresses, as indicated below, may be used to return the questionnaires.

Fax: +44 (0)1234 752 207
Email: y.l.hsu.1999@cranfield.ac.uk

Should you have any questions or require any further information regarding the survey, please do not hesitate to contact me. It is hoped that you will find time to make a contribution to this research, which hopefully, will benefit the aviation industry. Thank you very much indeed!

Yours faithfully

Iris HSU
Department of Human Factors and Air Transport
Cranfield University
15 November 2001

Ref. No.: ______

Airline Safety Management Questionnaire

Please provide your point of view on these questions. All information given will be treated as strictly confidential. <u>Results of this survey will be calculated in aggregate form so that neither airlines nor individuals can be recognized.</u>

Region: ☐ Africa ☐ Asia & Pacific ☐ Latin America & Caribbean
☐ Europe ☐ Middle East ☐ North America

Position in your airline:

Airline (optional):
Name (optional):
Contact address (optional)
Tel:
Fax:
E.mail:

This survey examines the factors which might influence the way your organization deals with safety issues. Please respond with reference to your own organization.

For each question, please circle the number which corresponds to the extent to which you agree or disagree with the statement.

		strongly disagree		**⟷**			**strongly agree**	**N /A**
1.	There is an organizational awareness towards safety in the airline.	1	2	3	4	5	6	7
2.	Employees know how to perform their job in a safe manner.	1	2	3	4	5	6	7
3.	Employees use correct safety procedures to carrying out the jobs.	1	2	3	4	5	6	7
4.	Employees ensure the highest levels of safety when they carry out the jobs.	1	2	3	4	5	6	7
5.	Employees believe flight safety is an important issue.	1	2	3	4	5	6	7
6.	Employees feel that it is important to maintain safety at all times.	1	2	3	4	5	6	7
7.	Employees voluntarily carry out the tasks or activities that help to improve safety.	1	2	3	4	5	6	7
8.	Employees are encouraged to submit ideas to improve safety in the airline.	1	2	3	4	5	6	7
9.	Safety rules can be followed without conflicting with work practices.	1	2	3	4	5	6	7
10.	Safety problems are openly discussed between employees.	1	2	3	4	5	6	7
11.	There is good communication between different groups in the airline.	1	2	3	4	5	6	7
12.	There is an appropriate Emergency Response Plan.	1	2	3	4	5	6	7
13.	After an accident has occurred, appropriate actions are usually taken to reduce the chance of reoccurrence.	1	2	3	4	5	6	7
14.	After an incident has occurred, appropriate actions are usually taken to reduce the chance of reoccurrence.	1	2	3	4	5	6	7
15.	There is a documented business continuity plan in the event of accidents.	1	2	3	4	5	6	7

	strongly disagree		↔		strongly agree		N /A
16. Changes in working procedures and their effect on safety are effectively communicated to employees.	1	2	3	4	5	6	7
17. Personnel are confident about their future with the airline.	1	2	3	4	5	6	7
18. Morale is good.	1	2	3	4	5	6	7
19. Good working relationships exist in the airline.	1	2	3	4	5	6	7
20. Employees' jobs are well defined.	1	2	3	4	5	6	7
21. The size of the airline has an influence on organizational safety culture.	1	2	3	4	5	6	7
22. The airline's history has an influence on organizational safety culture.	1	2	3	4	5	6	7
23. Airline ownership has an influence on organizational safety culture.	1	2	3	4	5	6	7
24. An adequate system exists for transmitting critical information regarding safety within the airline.	1	2	3	4	5	6	7
25. An adequate system exists for exchanging critical information regarding safety problem with other airlines.	1	2	3	4	5	6	7
26. Data* collection, analysis and presentation has an influence on safety performance. *(*Data obtained from the operation, risk assessment, maintenance, and aircraft manufactures)*	1	2	3	4	5	6	7
27. Management is concerned for the cost more than safety.	1	2	3	4	5	6	7
28. Safety budget is the first item to be reduced when commercial pressures emerge.	1	2	3	4	5	6	7
29. Safety rules are adhered to even under cost pressures.	1	2	3	4	5	6	7
30. There is no conflict between safety and financial goal.	1	2	3	4	5	6	7
31. Shareholder's welfare and airline's organizational safety culture are correlated.	1	2	3	4	5	6	7
32. Safety committee has an influence on organizational safety culture.	1	2	3	4	5	6	7
33. Senior management commitment plays an important role in determining the safety performance.	1	2	3	4	5	6	7

	strongly disagree		⟷			strongly agree	N /A
34. The values of management are identified as being safety orientated.	1	2	3	4	5	6	7
35. Safety management aims are sufficiently supported within the airline.	1	2	3	4	5	6	7
36. Leadership has an influence on organizational safety culture.	1	2	3	4	5	6	7
37. There is correlation between the quality assurance system and organizational safety culture.	1	2	3	4	5	6	7
38. An effective ongoing hazard identification program has an influence on organizational safety culture.	1	2	3	4	5	6	7
39. Confidential reports should be properly de-identified in order to foster organizational safety culture.	1	2	3	4	5	6	7
40. There should be a procedure established for acknowledging safety-related reports.	1	2	3	4	5	6	7
41. Risk audit, risk assessment, and risk evaluation have an influence on organizational safety culture.	1	2	3	4	5	6	7
42. Potential errors, consequences and recovery points are identified in training.	1	2	3	4	5	6	7
43. Training is carried out by individuals with relevant operational experience.	1	2	3	4	5	6	7
44. Workload is reasonably balanced.	1	2	3	4	5	6	7
45. Frustrations that arise from factors outside staff control can be accommodated without adversely affecting work.	1	2	3	4	5	6	7
46. There are adequate opportunities to express the views about operational problems.	1	2	3	4	5	6	7
47. Final decisions about safety investment are made by Chief Executive Officer (CEO).	1	2	3	4	5	6	7
48. There is an effective mechanism by which the safety manager or the safety committee can report to the CEO and make recommendations for a change or action.	1	2	3	4	5	6	7

	strongly disagree	↔				strongly agree	N /A
49. In the event of CEO making an unfavorable response to a safety recommendation, there is a procedure whereby the matter is monitored by the safety manager or the safety committee until resolved.	1	2	3	4	5	6	7
50. Personnel's decision-making is affected by the organizational safety culture	1	2	3	4	5	6	7
51. Safety statements and policies of an airline define the management's intention in safety matters and airline's commitment to safety.	1	2	3	4	5	6	7
52. The policy statements define the airline's fundamental approach towards safety.	1	2	3	4	5	6	7
53. The airline has a clearly stated set of goals and objectives.	1	2	3	4	5	6	7
54. The roles and responsibilities for personnel in the safety management system are clearly defined and documented.	1	2	3	4	5	6	7
55. An effective documentation management system ensures the availability of procedures.	1	2	3	4	5	6	7
56. Written work procedures match the way tasks are done in practice.	1	2	3	4	5	6	7
57. The recommendations and suggestions from the industry safety committee are adhered to all the time.	1	2	3	4	5	6	7
58. Safety information from aviation safety authorities is highly valued.	1	2	3	4	5	6	7
59. The regulations from the aviation safety authority have an influence on organizational safety culture.	1	2	3	4	5	6	7
60. The relationship with the Media has an influence on organizational safety culture.	1	2	3	4	5	6	7
61. The customer's reaction has an influence on the organizational safety culture.	1	2	3	4	5	6	7
62. Consumer habits have an influence on organizational safety culture.	1	2	3	4	5	6	7

	strongly disagree ←→ **strongly agree N /A**
63. The perceived corporate image has an influence on organizational safety culture	**1 2 3 4 5 6 7**
64. The organization's investments on other business are correlated with the organizational safety.	**1 2 3 4 5 6 7**
65. The investors' prospective has an influence on organizational culture.	**1 2 3 4 5 6 7**
66. The stock market's reaction has an influence on organizational culture.	**1 2 3 4 5 6 7**
67. The country culture and organizational culture are correlated.	**1 2 3 4 5 6 7**
68. The country economic influence and organizational culture are correlated.	**1 2 3 4 5 6 7**
69. Regional geographical influence and organizational safety culture are correlated.	**1 2 3 4 5 6 7**
70. Regional economical influence and organizational safety are correlated.	**1 2 3 4 5 6 7**
71. Regional religion influence and organizational culture are correlated.	**1 2 3 4 5 6 7**
72. Regional cultural influence and organizational safety are correlated.	**1 2 3 4 5 6 7**
73. How would you rate the safety performance of your company with respect to the rest of your industry? (1: below Average for Industry 6: Above Average for Industry)	**1 2 3 4 5 6 7** Below Average → Above Average

Please offer any suggestions or comments if any:

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Thank you very much for your time. Your help has been highly appreciated!!

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APPENDIX M Participants Comments

1. The answers above incorporate both flight safety and ground safety. The level of safety awareness among flight crews is higher than the level among ground crew staffs and management. A lot of progress has been made in that domains since the establishment of Corporate Safety a year ago. Still, a lot of effort is required to achieve a fully comprehensive Safety Management System.

2. Previous poor management is very hard to overcome. The employees become very untrusting and unwilling to accept that new management cares about safety.

3. Our company is a young one and is the flight safety department. The present answers are from similar audits we made internally, a couple months ago.

4. Bottom Line - if CEO is highly safety conscious then so is organization. If he is not- the culture is not established.

5. We are committed to the safest flight operation possible. Therefore, it is imperative that we have uninhibited reporting of all incidents and occurrences that in any way affect the safety of our operations. We urge to every single employee to help us in providing our outcomes and our employees with the highest level of flight safety achievable within our working environment.

6. Q'67-72 is my case. I think in some region of the world, the answer would be very different.

7. We are a regional airlines serving a domestic/international parent airlines. Group integrates do sometimes affect/influence issues relating to customer focus, your survey doesn't address that issue.

8. Our CEO is also the accountable management person agreed with our local regulatory authority. This also has a big influence in out airlines safety culture.

9. The safety department is only five months old and the above reflects the existing situation which I hope to improve on safety (health).

10. To question 31, I am sure shareholders think differently - they don't see the correlation.

11. Question 47 investment decision doesn't have to go to CEO that far.

12. In the last 4 questions I was not sure whether regional reflects to a region within the world, i.e. middle east, sub-Saharan Africa, etc. or if it means region within a country. My responses were based on regions within a country.

13. The concept that safety should come from the "Top" is completely true. Another point is that many times and at many organisations. The upper management does not know well about safety; they are at the kindergarten level while safety people are at "PhD". Lack of understanding and communication.

APPENDIX N Rotated Component Matrix for Internal & External Loading Factors

1) Internal Factors –

Variables	Loading Factors														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
V03	**0.815**	0.170	0.126	0.026	0.146	0.212	0.112	0.074	0.117	-0.027	0.083	0.023	-0.012	0.016	0.041
V04	**0.774**	0.034	0.103	0.088	0.159	0.069	0.172	-0.059	0.248	0.100	0.061	0.020	-0.050	0.084	-0.014
V07	**0.640**	0.384	0.080	0.242	0.160	-0.013	0.054	-0.047	-0.085	-0.154	0.172	0.052	0.002	0.064	0.056
V02	**0.608**	0.170	0.224	-0.010	0.049	0.409	0.078	0.103	0.196	0.096	-0.119	-0.030	0.100	-0.026	0.004
V01	**0.462**	0.156	0.158	0.221	0.197	0.198	0.175	0.242	0.361	0.109	0.052	-0.021	-0.057	0.091	-0.051
V09	0.161	**0.834**	0.170	0.121	0.058	0.043	0.054	0.163	0.241	0.064	0.002	-0.027	-0.002	0.076	-0.016
V05	0.166	**0.830**	0.187	0.125	0.065	0.057	0.073	0.158	0.228	0.064	0.015	-0.026	0.007	0.084	-0.020
V06	0.550	**0.609**	0.196	0.148	0.089	-0.005	-0.056	0.099	-0.076	0.050	0.170	0.048	-0.025	0.127	0.180
V08	0.296	**0.537**	-0.076	0.049	0.236	0.321	0.030	0.204	-0.081	-0.022	-0.113	0.229	0.138	-0.103	-0.026
V35	0.076	**0.434**	-0.060	0.317	0.158	0.387	0.130	0.055	0.228	0.279	0.429	-0.030	-0.138	0.026	0.017
V46	0.097	0.106	**0.940**	0.054	0.118	0.073	0.054	0.041	0.092	0.025	0.042	0.045	0.011	0.017	0.031
V43	0.101	0.082	**0.930**	0.069	0.116	0.098	0.045	0.035	0.095	-0.011	0.064	0.038	-0.008	-0.019	-0.005
V48	0.138	0.127	**0.885**	0.051	0.143	0.057	0.035	0.048	0.064	-0.002	0.027	-0.013	0.045	0.096	0.047
V42	0.343	0.086	**0.420**	0.409	0.206	0.200	0.090	-0.060	-0.031	0.097	-0.039	0.140	0.056	-0.176	0.000
V53	0.049	0.194	0.085	**0.821**	0.016	0.055	0.178	0.152	0.092	0.088	0.008	0.050	0.094	-0.087	-0.046
V52	0.068	0.019	0.077	**0.763**	0.034	0.118	0.235	0.208	0.164	0.154	0.043	-0.017	0.166	0.119	-0.088
V55	0.274	0.260	0.069	**0.568**	0.063	0.152	-0.013	0.081	0.294	-0.018	0.136	0.099	0.022	-0.239	0.106
V51	0.189	0.033	0.133	**0.517**	-0.114	0.032	0.300	0.345	0.166	0.122	-0.151	-0.023	0.117	0.242	-0.254
V17	0.107	0.036	0.058	0.018	**0.825**	0.032	0.176	-0.003	0.075	0.170	-0.001	0.212	0.037	0.117	-0.102
V18	0.230	0.051	0.173	-0.013	**0.821**	0.066	-0.001	0.067	0.104	0.049	0.169	-0.080	-0.154	0.007	-0.058
V45	0.080	0.286	0.229	0.175	**0.619**	0.014	0.072	0.068	-0.016	-0.070	-0.060	-0.006	0.010	-0.293	0.139
V19	0.282	0.086	0.222	-0.008	**0.599**	0.085	0.122	0.253	0.279	0.044	-0.022	-0.057	-0.142	0.176	-0.029
V20	0.299	0.091	0.163	0.314	**0.345**	0.032	0.176	-0.003	0.075	0.170	-0.001	0.212	0.037	0.117	-0.102
V26	0.199	0.035	0.196	0.100	0.106	**0.718**	0.106	0.138	0.060	-0.040	0.060	0.124	-0.172	0.050	0.033
V38	0.191	0.096	0.034	0.043	0.285	**0.685**	0.285	-0.067	0.166	-0.012	-0.026	-0.052	0.188	0.240	0.020
V24	0.180	-0.046	0.415	0.237	-0.100	**0.515**	-0.100	0.163	-0.071	0.132	0.087	0.189	0.199	0.078	0.021
V11	0.181	0.047	0.064	0.197	0.136	0.155	**0.849**	0.063	0.041	0.049	0.093	0.039	0.052	0.015	0.141
V12	0.160	0.043	0.061	0.237	0.145	0.172	**0.777**	0.088	0.052	0.038	0.122	0.012	0.057	0.003	0.109
V13	0.160	0.189	0.224	-0.033	0.277	0.151	**0.738**	0.115	0.176	0.324	-0.030	0.328	0.151	-0.091	0.160
V10	0.001	0.324	0.124	-0.026	0.113	0.144	**0.700**	0.166	0.415	0.162	-0.087	0.094	0.185	-0.155	-0.014
V30	0.084	0.152	0.016	0.204	0.102	0.079	0.059	**0.876**	0.085	0.107	0.061	-0.002	0.033	-0.076	0.034
V31	0.232	0.228	0.105	0.179	0.104	0.081	0.093	**0.854**	0.078	0.136	-0.051	0.000	0.018	-0.037	-0.012
V54	0.399	0.047	0.064	0.197	0.117	-0.056	-0.117	0.064	**0.669**	0.107	0.108	0.035	0.014	-0.033	0.132
V56	-0.051	0.043	0.061	0.123	0.129	0.070	0.082	0.126	**0.576**	0.086	0.270	0.121	0.160	-0.045	0.097
V49	0.165	0.216	0.160	0.325	0.151	0.247	0.190	0.008	**0.536**	0.087	0.023	0.169	-0.143	0.137	-0.103
V27	-0.006	0.231	0.035	-0.092	0.057	-0.170	-0.234	-0.098	-0.156	**-0.818**	-0.023	-0.005	-0.031	0.027	-0.109
V28	0.278	0.047	0.089	0.229	0.197	-0.123	0.261	-0.108	-0.044	**-0.675**	0.161	0.197	-0.104	0.157	0.203
V34	0.301	-0.160	-0.084	0.193	0.188	-0.096	0.241	0.185	0.026	**0.534**	0.132	0.381	-0.220	0.173	0.056
V29	-0.006	0.250	0.160	0.048	0.296	-0.155	0.153	0.176	-0.014	**0.517**	0.157	0.413	-0.230	0.175	0.121
V21	0.226	0.189	0.214	-0.025	-0.214	0.300	0.047	-0.144	0.141	-0.142	**0.695**	0.122	0.070	-0.119	0.002
V22	0.052	-0.082	0.045	0.323	0.189	0.391	0.130	0.098	-0.020	0.046	**0.665**	-0.047	0.075	0.151	-0.097
V33	0.139	0.067	0.162	-0.168	-0.114	0.011	0.311	0.077	0.236	0.278	**0.437**	-0.049	-0.100	0.047	-0.003

V23	0.325	0.277	0.033	0.260	0.129	0.149	0.214	0.299	0.240	0.008	**0.403**	0.144	0.072	-0.178	0.002
V25	0.430	-0.006	0.094	0.067	0.298	0.172	0.244	-0.103	0.296	-0.053	-0.026	**0.605**	0.147	0.179	0.042
V50	0.276	0.046	-0.013	-0.033	0.277	0.151	0.091	0.037	-0.022	0.071	-0.125	**-0.502**	0.101	0.180	0.184
V15	-0.035	0.135	0.045	0.177	-0.136	0.065	0.111	0.261	0.223	0.033	-0.069	**0.441**	-0.023	-0.123	-0.097
V16	0.073	0.189	0.224	0.240	0.012	0.014	0.043	0.115	0.176	0.324	-0.030	**0.328**	0.151	-0.091	0.160
V39	0.124	-0.029	0.011	-0.064	0.037	0.352	0.036	0.018	0.052	0.084	0.095	0.036	**0.817**	0.079	-0.141
V40	0.035	0.266	0.288	-0.119	-0.094	0.037	0.223	0.156	0.054	-0.281	-0.026	-0.107	**0.528**	0.345	0.256
V41	0.294	0.169	0.090	0.051	0.049	0.184	-0.041	-0.128	-0.037	-0.095	0.031	0.037	0.181	**0.701**	0.037
V47	0.161	-0.017	0.060	0.123	0.117	-0.057	-3.557	-0.031	0.094	0.009	-0.103	-0.031	-0.100	0.001	**0.820**
V32	0.166	0.285	0.040	0.325	0.129	0.080	0.071	0.292	-0.062	0.243	0.182	0.074	0.087	0.268	**0.392**

2) External Factors –

Variables	Factors			
	1	2	3	4
70	**0.879**	0.127	0.004	0.113
69	**0.857**	0.123	0.000	-0.020
72	**0.804**	0.154	0.076	0.027
68	**0.715**	-0.230	0.164	0.096
71	**0.685**	0.168	-0.150	0.296
61	0.034	**0.881**	0.003	0.053
63	0.103	**0.777**	0.035	0.054
62	0.083	**0.757**	-0.029	0.210
60	0.181	**0.546**	0.435	0.283
58	-0.038	-0.005	**0.809**	-0.072
59	-0.019	0.165	**0.756**	0.273
57	0.097	-0.051	**0.750**	-0.017
65	0.038	0.226	0.011	**0.797**
66	0.242	-0.079	0.024	**0.788**
64	0.049	0.331	0.131	**0.555**
67	0.180	0.027	0.187	**0.219**

APPENDIX O Alpha Values for Internal & External Factors

1) Internal Factors –

	Factor												
	1	2	3	4	5	6	7	8	9	10	11	12	13
V03	.815												
V04	.774												
V07	.640												
V02	.608												
V01	.462												
V09		.834											
V05		.830											
V06		.609											
V08		.537											
V35		.434											
V46			.940										
V43			.930										
V48			.885										
V42			.420										
V53				.821									
V52				.763									
V55				.568									
V51				.517									
V17					.825								
V18					.821								
V45					.619								
V19					.599								
V26						.718							
V38						.685							
V24						.515							
V11							.849						
V12							.777						
V13							.738						
V10							.700						
V30								.876					
V31								.854					
V54									.669				
V56									.576				
V49									.536				
V27										-.818			
V28										-.675			
V34										.534			
V29										.517			
V21											.695		
V22											.665		
V33											.437		
V23											.403		
V25												.605	
V15												.441	
V16												.328	
V39													.817
V40													.528
Alpha	.85	.846	.89	.83	.82	.74	.759	.93	.72	.04	.61	.66	.54

2) External Factors –

Variables	Factors			
	Factor1	Factor 2	Factor 3	Factor 4
70	.879			
69	.857			
72	.804			
68	.715			
71	.685			
61		.881		
63		.777		
62		.757		
60		.546		
58			.809	
59			.756	
57			.750	
65				.797
66				.788
64				.555
Reliability (Alpha)	0.8575	0.7854	0.686	0.636

APPENDIX P Mean and Standard Deviation of Internal and External Factor Scores

1) Internal factors -

Factor 1

Region	#Cases available	Mean	Std. Deviation
North America	22	-0.63922	.8892058
Africa	3	0.35631	1.1738282
Europe	36	0.31140	.9568387
Asia and Pacific	36	0.07855	1.0234124
Latin America and the Caribbean	5	-0.30452	.4907790
Middle East	2	0.02391	.5595636

Factor 2

Region	#Cases available	Mean	Std. Deviation
North America	22	0.05703	.9077366
Africa	3	0.29888	.2097007
Europe	36	0.02356	1.0386296
Asia and Pacific	36	0.13639	.8940901
Latin America and the Caribbean	5	-1.20469	1.1258093
Middle East	2	-0.94312	2.1768678

Factor 3

Region	#Cases available	Mean	Std. Deviation
North America	22	-.1167249	1.2608643
Africa	3	.4161720	.5230922
Europe	36	.1434193	.8517345
Asia and Pacific	36	-.1018476	1.0343227
Latin America and the Caribbean	5	.2528859	.7532800
Middle East	2	-.7207907	.8191174

Factor 4

Region	#Cases available	Mean	Std. Deviation
North America	22	0.27234	.8722531
Africa	3	0.20191	.6216546
Europe	36	-0.44308	1.2119959
Asia and Pacific	36	0.24465	.8027764
Latin America and the Caribbean	5	0.13786	.4579773
Middle East	2	-0.07165	.6006844

Factor 5

Region	#Cases available	Mean	Std. Deviation
North America	22	0.05100	.9153141
Africa	3	0.01032	.5199314
Europe	36	-0.05361	1.1199545
Asia and Pacific	36	0.02347	.9439098
Latin America and the Caribbean	5	0.14110	.8994528
Middle East	2	-0.38663	2.4425141

Factor 6

Region	#Cases available	Mean	Std. Deviation
North America	22	0.16137	.7284979
Africa	3	-0.43425	1.1351994
Europe	36	-0.08888	1.1968939
Asia and Pacific	36	0.09050	.9292668
Latin America and the Caribbean	5	-0.09189	1.1633706
Middle East	2	-0.92322	.1899493

Factor 7

Region	#Cases available	Mean	Std. Deviation
North America	22	0.06720	1.1130961
Africa	3	0.55952	.3892361
Europe	36	0.07701	.8364943
Asia and Pacific	36	-0.07538	1.1201511
Latin America and the Caribbean	5	-0.54081	.7475811
Middle East	2	-0.25566	1.7282853

Factor 8

Region	#Cases available	Mean	Std. Deviation
North America	22	0.32917	.9702956
Africa	3	0.12134	.6369803
Europe	36	-0.15066	1.1318192
Asia and Pacific	36	-0.01434	.9148090
Latin America and the Caribbean	5	-0.05188	1.1005971
Middle East	2	-0.15911	.1319623

Factor 9

Region	#Cases available	Mean	Std. Deviation
North America	22	0.17659	.9438688
Africa	3	0.37270	1.1803107
Europe	36	-0.08588	1.0087299
Asia and Pacific	36	-0.02776	.9871342
Latin America and the Caribbean	5	0.03291	1.4968176
Middle East	2	-0.53837	.9182260

Factor 10

Region	#Cases available	Mean	Std. Deviation
North America	22	0.05404	1.1028550
Africa	3	-0.25663	.4709795
Europe	36	0.10972	1.0229031
Asia and Pacific	36	0.42071	.9438381
Latin America and the Caribbean	5	-0.12281	1.1838685
Middle East	2	-0.29334	1.2140648

Factor 11

Region	#Cases available	Mean	Std. Deviation
North America	22	-0.05329	1.0395035
Africa	3	0.81012	.5241767
Europe	36	-0.07998	1.1712296
Asia and Pacific	36	-0.05820	.7823002
Latin America and the Caribbean	5	0.35314	1.1636854
Middle East	2	0.97525	2.382782E-02

Factor 12

Region	#Cases available	Mean	Std. Deviation
North America	22	0.31854	1.0178718
Africa	3	0.34801	.6752834
Europe	36	0.02561	.9357360
Asia and Pacific	36	-0.30011	1.0211141
Latin America and the Caribbean	5	0.17671	1.2877234
Middle East	2	0.47327	.3039628

Factor 13

Region	#Cases available	Mean	Std. Deviation
North America	22	0.02816	.8662379
Africa	3	0.11566	.4541094
Europe	36	0.16807	1.0695120
Asia and Pacific	36	-0.21146	1.1172311
Latin America and the Caribbean	5	-0.00735	.2146302
Middle East	2	0.31609	.1977127

2) External factors -

Factor E1

Region	#Cases available	Mean	Std. Deviation
North America	22	-0.09102	.9365840
Africa	3	0.93939	.1280186
Europe	36	-0.00948	.9958194
Asia and Pacific	36	-0.05993	1.1070402
Latin America and the Caribbean	5	0.28506	.9391227
Middle East	2	0.12890	.1224544

Factor E2

Region	#Cases available	Mean	Std. Deviation
North America	22	-0.03430	1.0597765
Africa	3	0.67918	.3656843
Europe	36	-0.14582	1.1735208
Asia and Pacific	36	0.05530	.7391132
Latin America and the Caribbean	5	-0.03162	1.2493247
Middle East	2	1.06694	1.0080965

Factor E3

Region	#Cases available	Mean	Std. Deviation
North America	22	-0.51725	1.1415366
Africa	3	0.78367	.5608238
Europe	36	-0.04268	.9389754
Asia and Pacific	36	0.30931	.9178501
Latin America and the Caribbean	5	-0.15646	.6343100
Middle East	2	0.10613	1.2918311

Factor E4

Region	#Cases available	Mean	Std. Deviation
North America	22	-.1713927	1.1113964
Africa	3	-.4350394	.7676257
Europe	36	-.1214183	1.0891926
Asia and Pacific	36	.1732103	.8271913
Latin America and the Caribbean	5	.5836195	1.1682217
Middle East	2	.1465730	.6180094

APPENDIX Q Table of ANOVA and Mean/Standard Deviation for Internal & External Factors

1) Internal factors –

Factor 1

Analysis of Variance (ANOVA)					
Source	Sum of Squares	DF	Mean Squares	F	Sig.
Between Groups	13.661	5	2.732	2.997	.015
Within Groups	89.339	98	.912		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.4182	.8093
Africa	3	4.9333	.8327
Europe	36	4.8722	.6764
Asia and Pacific	36	4.7833	.7788
Latin America and the Caribbean	5	4.3600	.6693
Middle East	2	4.2000	1.697

Factor 2

Analysis of Variance (ANOVA)					
Source	Sum of Squares	DF	Mean Squares	F	Sig.
Between Groups	10.065	5	2.013	2.123	.069
Within Groups	92.935	98	.948		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	5.0818	.6780
Africa	3	5.5333	.2309
Europe	36	5.1667	.6616
Asia Pacific	36	5.1500	.6868
Latin America and the Caribbean	5	4.3200	.0640
Middle East	2	4.2000	.2627

Factor 3

Analysis of Variance (ANOVA)					
Source	Sum of Squares	DF	Mean Squares	F	Sig.
Between Groups	3.292	5	.658	.647	.664
Within Groups	99.708	98	1.017		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.7273	.1545
Africa	3	5.4167	.5774
Europe	36	4.9861	.7652
Asia Pacific	36	4.8542	.9662
Latin America and the Caribbean	5	4.8000	.5420
Middle East	2	4.1250	.2374

Factor 4

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	11.082	5	2.216	2.363	.045
Within Groups	91.918	98	.938		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	5.0341	.8739
Africa	3	5.5000	.8660
Europe	36	4.5000	.9524
Asia Pacific	36	4.8958	.8585
Latin America and the Caribbean	5	4.9000	.7202
Middle East	2	4.1250	.1768

Factor 5

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	.579	5	.116	.111	.990
Within Groups	102.421	98	1.045		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	3.8523	.9019
Africa	3	3.8333	.0408
Europe	36	3.8194	.9975
Asia Pacific	36	3.9653	.9931
Latin America and the Caribbean	5	3.8000	.5969
Middle East	2	2.7500	.0607

Factor 6

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	3.465	5	.693	.682	.638
Within Groups	99.535	98	1.016		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.9773	.7192
Africa	3	5.1667	.5204
Europe	36	4.9028	.8091
Asia Pacific	36	4.9306	.8527
Latin America and the Caribbean	5	5.0140	.8023
Middle East	2	4.2500	1.4749

Factor 7

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	3.050	5	.610	.598	.701
Within Groups	99.950	98	1.020		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.6818	1.0065
Africa	3	5.0000	1.0000
Europe	36	5.0833	1.1307
Asia Pacific	36	4.8056	1.1166
Latin America and the Caribbean	5	5.4000	.8944
Middle East	2	4.0000	2.8284

Factor 8

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	3.429	5	.686	.675	.643
Within Groups	99.571	98	1.016		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.4318	1.1051
Africa	3	4.3333	.5774
Europe	36	3.8472	1.2468
Asia and Pacific	36	4.0556	1.1388
Latin America and the Caribbean	5	3.9000	1.5969
Middle East	2	3.7500	1.0607

Factor 9

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	1.981	5	.396	.384	.858
Within Groups	101.019	98	1.031		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.3182	.9825
Africa	3	5.2500	.4330
Europe	36	4.3125	.8668
Asia Pacific	36	4.4653	.8518
Latin America and the Caribbean	5	4.3000	1.2796
Middle East	2	4.6250	.8839

Factor 10

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	2.134	5	.427	.415	.838
Within Groups	100.866	98	1.029		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	3.7273	.5871
Africa	3	3.5833	.6292
Europe	36	3.7847	.6385
Asia and Pacific	36	3.9653	.6712
Latin America and the Caribbean	5	3.6000	.5184
Middle East	2	2.6250	.5303

Factor 11

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	4.909	5	.982	.981	.433
Within Groups	98.091	98	1.001		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.8977	.8579
Africa	3	5.5000	.4330
Europe	36	4.9444	.6947
Asia Pacific	36	4.7917	.6982
Latin America and the Caribbean	5	4.5000	1.1319
Middle East	2	4.5000	.7678

Factor 12

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	6.466	5	1.293	1.313	.265
Within Groups	96.534	98	.985		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	3.9432	.7438
Africa	3	4.6667	.3819
Europe	36	4.2292	.6824
Asia Pacific	36	4.1458	.8093
Latin America and the Caribbean	5	3.8500	.5755
Middle East	2	4.0000	1.4142

Factor 13

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	2.884	5	.577	.565	.727
Within Groups	100.116	98	1.022		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	5.4773	.6633
Africa	3	5.5000	.8660
Europe	36	5.2361	.7120
Asia Pacific	36	5.2083	.6254
Latin America and the Caribbean	5	5.5000	.8660
Middle East	2	5.2500	.3536

2) External factors –

Factor E1

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	3.402	5	.680	.669	.648
Within Groups	99.598	98	1.016		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	3.536	.906
Africa	3	4.667	.306
Europe	36	3.628	1.028
Asia and Pacific	36	3.639	1.113
Latin America and the Caribbean	5	4.040	.740
Middle East	2	4.000	.283

Factor E2

Analysis of Variance (ANOVA)					
Source	**Sum of Squares**	**DF**	**Mean Squares**	**F**	**Sig.**
Between Groups	4.567	5	.913	.909	.478
Within Groups	98.433	98	1.004		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.1136	1.0738
Africa	3	5.0000	.2500
Europe	36	4.1111	1.1235
Asia Pacific	36	4.3472	.7399
Latin America and the Caribbean	5	4.3000	.1911
Middle East	2	5.3750	.8839

Factor E3

Analysis of Variance (ANOVA)					
Source	Sum of Squares	DF	Mean Squares	F	Sig.
Between Groups	11.383	5	2.277	2.435	.040
Within Groups	91.617	98	.935		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	4.2273	1.0047
Africa	3	5.5556	.5092
Europe	36	4.6481	.8124
Asia Pacific	36	4.8981	.7425
Latin America and the Caribbean	5	4.5333	.5055
Middle East	2	4.6667	1.4142

Factor E4

Analysis of Variance (ANOVA)					
Source	Sum of Squares	DF	Mean Squares	F	Sig.
Between Groups	4.571	5	.914	.910	.478
Within Groups	98.429	98	1.004		
Total	103.000	103			

Region	#Cases available	Mean	Std. Deviation
North America	22	3.6364	1.1311
Africa	3	3.7778	1.0715
Europe	36	3.6759	.9904
Asia Pacific	36	4.0278	.9771
Latin America and the Caribbean	5	4.4667	1.2824
Middle East	2	4.1667	.2357

APPENDIX R Multiple Regression Result

Self-rated Safety Performance vs. Organisational Factors

Multiple R	.733
R^2	.538
R^2 Adjusted	.619
Standard Error	.535

Analysis of Variance

	DF	*Sum of Squares*	*Mean Squares*	*F*	*P*
Regression	4	33.007	8.252	28.822	.000
Residual	99	28.343	.286		

Variables in Equation

Variable	*B*	*SEB*	*Beta*
Factor 2	.403	.083	.388
Factor 12	.244	.073	.275
Factor 7	.113	.051	.164
Factor 3	.133	.064	.158
(Constant)		.486	.413

APPENDIX S Correlation of Internal and External Factors

	E1	E2	E3	E4
Factor 1	.008	.216*	.421**	.146
Factor 2	-.021	.272**	.314**	.141
Factor 3	-.059	.055	.455**	.165
Factor 4	.020	.163	.352**	.235*
Factor 5	-.127	.107	.394**	.150
Factor 6	.014	.155	.327**	.155
Factor 7	-.012	.164	.355**	.219*
Factor 8	-.050	.047	.224*	.198*
Factor 9	-.069	.244*	.419**	.121
Factor 10	.198*	.131	.207*	.226*
Factor 11	.216*	.367**	.339**	.109
Factor 12	-.105	.118	.371**	.079
Factor13	.087	.017	.25*	.142

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Internal Factors	External Factors
1: Employee safety attitude & behaviour	E1: Influences of region and country
2: Employee safety concept	E2: Public and the media influence
3: Level of operational safety in operation and maintenance	E3: Impact of regulatory environment
4: Corporate safety policy	E4: Involvement of investment community
5: Personnel- quality of working life	
6: Employment of risk programme	
7: Impact of accident/incidents	
8: Financial concern	
9: Procedures and documentation	
10: Commercial cost pressures	
11: Organisational structure & management commitment	
12: Communication system	
13: Necessity of safety reports	

APPENDIX T DMAIC Process in Six Sigma

$Y=F(X_1,..X_n)$

Where Y is the output (business focus)

Xs are the input (processes)

Phase	Action	Goal
Define **(D)**	What are the critical factors to the business focus (from internal and/or external customer point of view)?	Define "Y"
Measure **(M)**	What and how is the process (The Y) performing? How reliable is the obtained data?	Measure the "Y"
Analyse **(A)**	What are the critical defects (Xs) causing deficiency? To what degree of the variation? (Xs: room for improvement)	Find and Measure the "Xs"
Improve **(I)**	How to fix the critical defect (Xs)? What variation in critical Xs can be removed?	Improve the "Xs"
Control **(C)**	How to maintain the improvement?	Control "Xs" so no variation in " Y"

Source: combined from various authors