



UNIVERSITY OF  
NORDLAND

BODØ GRADUATE SCHOOL OF BUSINESS

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# MASTER THESIS

**BUSINESS FIRST – SAFETY ALWAYS**

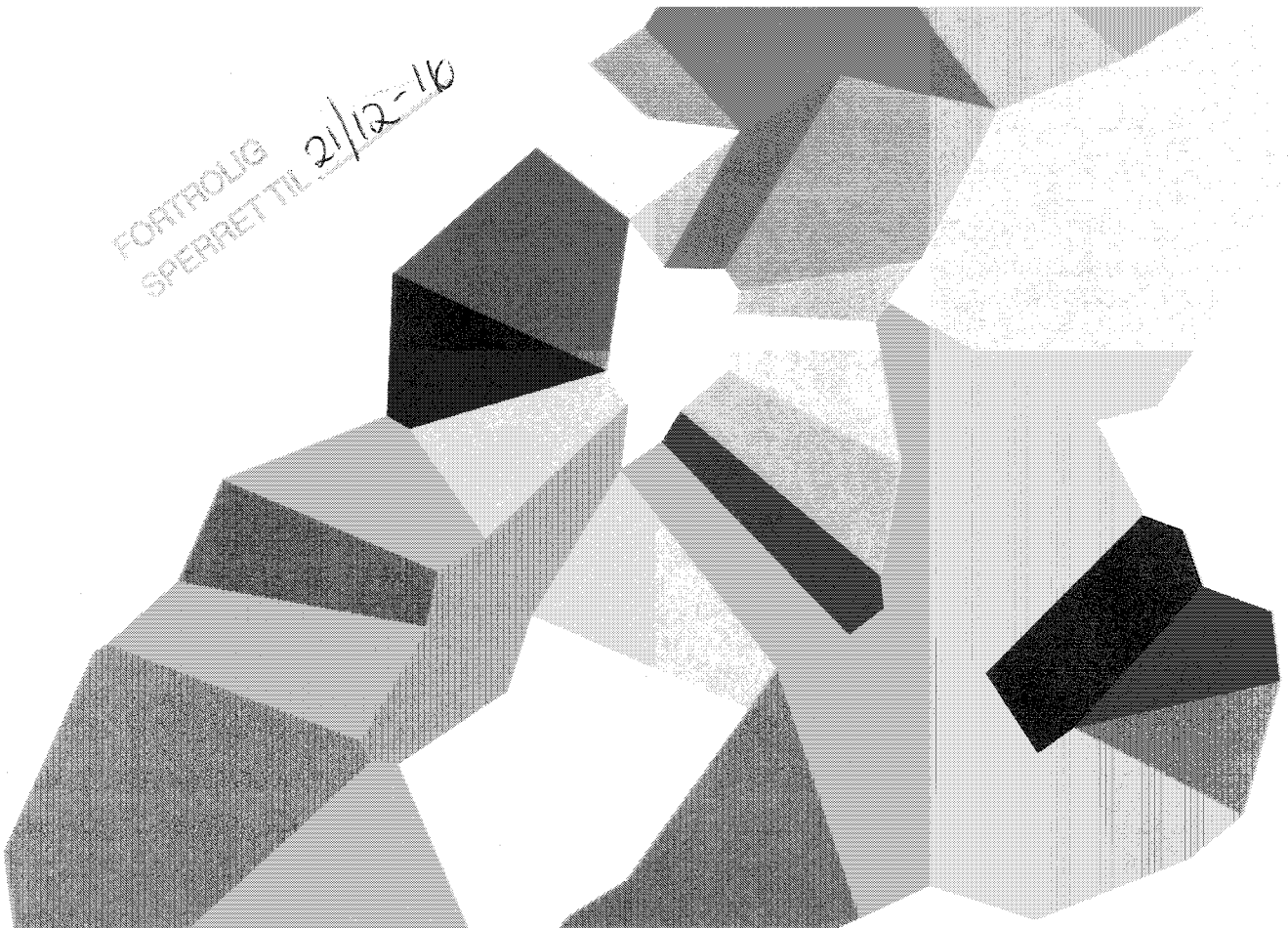
**(WHAT INHIBITS AND PROMOTES THE  
IMPLEMENTATION OF SAFETY MANAGEMENT  
SYSTEMS (SMS) IN AVIATION)**

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## **Abstract**

The purpose for this dissertation is to study factors that inhibit and promote the implementation of Safety Management System (SMS) in aviation. To gain insight into the subject, an extensive literature review has been made. Using the literature review, I have identified a set of factors that inhibit and promote SMS implementation. A model for analysis and questionnaire was constructed based on these factors.

The question posed for the study is; what inhibits and promotes the implementation of System Management Systems (SMS) in aviation? The approach applied in the study is Complexity System Theory.

The findings show that 'Safety Leadership' and 'Safety Culture' are regarded as the most important promoters for SMS implementation. From a scale from 1-5, the average score for 'Safety Leadership' is 4,8 and 4,7 for 'Safety Culture'. Interesting is that Software management with the average score of 3. This indicates that either the respondents were uncertain about the question or the importance of Software management as a promoting factor in SMS implementation. Among the inhibiting factors, the average score for both 'Quality Data and Information' and 'Human Factors' was 4,2. The interesting result is that among the ranking of inhibiting factors, 'Resources' was not rated as the most important inhibitor. The average score for 'Resources' was 4,1. However, the difference is very small. 'Software Knowledge' had the lowest average score of 3, among the restraining factors. This indicates that either the respondents were uncertain about the question or the importance of 'Software Knowledge' as a inhibiting factor in SMS implementation.

The dissertation recommends that the inhibiting factors should be reasonable targeted. These factors have to be attended to since they can seriously affect the implementation of Safety Management System. However, the important enablers such as 'Safety leadership' and 'Safety Culture' must be taken seriously. Furthermore, a continuous development and monitoring of the strategic enabling factors are essential. This is important, since the promoting factors also by time need to adapt to the changes in the system, and they can easily become inhibitors.

**Keywords:** Safety Management System (SMS), safety, system, complexity and systems, risk management, safety-centric

## **Preface**

This dissertation is written as part of MBA in Aviation studies at University of Nordland.

“A good heart can make the blind see and the deaf hear” Mark Twain.

A many good hearts have contributed to my dissertation. They have not only opened my eyes and ears too.

There are many people I would like to thank for their patience while I have been working on this paper. Special thanks to Leena and family members for all your moral support.

I am ever thankful for my employer, the Norwegian Civil Aviation Authority for giving me this opportunity.

Finally, I wish to thank my supervisor for the dissertation, Associate Professor, Abbas Strømmen-Bakhtiar.

## Summary

The study is on Safety Management System implementation (SMS). The background to the study is that in 2006, the International Civil Aviation Organization (ICAO), signed out the international standard for Safety Management Systems in aviation. The organization also mandated that its entire member states to implement Safety Management System programs in their aviation industries by 2009. Currently, only a few countries can flag that they have implemented at a national level.

The question posed for the study is; what inhibits and promotes the implementation of System Management Systems (SMS) in aviation?

Based on the literature review, enabling and inhibiting factors were selected for the study. I constructed a model for analysis related to the question, theory and the literature review. The model is holistic, and I believe my contribution to existing research is a holistic approach to safety system studies. The approach applied in the study is Complexity System Theory.

The findings show that 'Safety Leadership' and 'Safety Culture' are regarded as the most important promoters for SMS implementation. From a scale from 1-5, the average score for 'Safety Leadership' is 4,8 and 4,7 for 'Safety Culture'. Interesting is that Software management with the average score of 3. This indicates that either the respondents were uncertain about the question or the importance of Software management as a promoting factor in SMS implementation. Among the inhibiting factors, the average score for both 'Quality Data and Information' and 'Human Factors' was 4,2. The interesting result is that among the ranking of inhibiting factors, 'Resources' was not rated as the most important inhibitor. The average score for 'Resources' was 4,1. However, the difference is very small. 'Software Knowlegde' had the lowest average score of 3, among the restraining factors. This indicates that either the respondents were uncertain about the question or the importance of 'Software Knowlegde' as a inhibiting factor in SMS implementation.

The dissertation recommends that the inhibiting factors should be reasonable targeted. These factors have to be attended to since they can seriously affect the implementation of Safety Management System. However, the important enablers such as 'Safety leadership' and 'Safety Culture' must be taken seriously. Furthermore, a continuous development and monitoring of

the strategic enabling factors are essential. This is important, since the promoting factors also by time need to adapt to the changes in the system, and they can easily become inhibitors.

Future studies may include:

- Performing such a survey on a larger population or among organization is recommended.
- Longitudinal studies for countries and organizations that have not yet implemented SMS can be fruitful in the long run. It will then be a better performance indicator.
- Content analysis on the websites such as LinkedIn could present some interesting results



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## **Acronyms and Abbreviation**

(LIST OF ACRONYM AND ABBREVIATION)

ALARP - As low as reasonably practicable  
ALoS A - cceptable level of safety  
AOC Air operator certificate  
ATC - Air traffic control  
ATM - Air traffic management  
CAA - Civil aviation authority  
CM – Compliance Monitoring  
CRM - Crew resource management  
EASA – European Aviation Safety Agency  
EU – European Union  
ICAO – International Civil Aviation Organisation  
ISO- International Organization for Standardization  
LOSA -Line operations safety audit  
QA Quality assurance  
QS - Quality system  
QMS - Quality management system  
ROI – Return on investment  
SA - Safety assurance  
SHEL - Software/Hardware/Environment/Liveware  
SMM - Safety management manual  
SMS - Safety management system(s)  
SMSM - Safety management systems manual  
SOPs - Standard operating procedures  
SRM - Safety risk management  
SSP - State safety programme

## Chapter 1 Introduction

"Business first – safety always," is on how to go about business in aviation industry in the 21st century, through safety management systems. The statement and motto may sound controversial, especially in the aviation industry where safety is paramount. However, it is no secret that the main purpose for a commercial airline operation is to make money. Thus, safety comes along in the process. But this is not always the case. Safety is often considered separate from the company process and regarded as an added cost.

Safety is often spoken of as the first priority. An example is like in the European Commission press release on blacklisted operators, a statement made by Commission Vice-President Siim Kallas, responsible for transport, that stated:

"The Commission is ready to spare no effort to assist its neighbors in building their technical and administrative capacity to overcome any difficulties in the area of safety as quickly and as efficiently as possible. In the meantime, **safety comes first**. We cannot afford any compromise in this area. Where we have evidence inside or outside the European Union that air carriers are not performing safe operations we must act to exclude any risks to safety " (Europa, 2011).

In 2006, the International Civil Aviation Organization (ICAO), signed out the international standard for Safety Management Systems in aviation. The organization also mandated that its entire member states to implement Safety Management System programs in their aviation industries by 2009 (ICAO, 2009).

Currently, only a few countries can flag that they have implemented according to ICAO standards and guide lines. These are countries like Australia, Canada, and New Zealand that have engaged in SMS in aviation for a few years now. According to Stolzer et al, it's just now emerging in the United States, and is non-existent in most other countries (Stolzer et al 2010). It has only recently been implemented in the United Kingdom (UK), and Norway is among the countries that have not implemented SMS yet.

There is so far some confusion concerning Safety Management Systems in aviation. And there are already several interpretations of what SMS is and who it is intended for.

Furthermore, how it should be implemented or even organized. As William R. Voss, President and CEO at Flight Safety Foundation, argues on why SMS needs to be reconsidered:

“We also knew that all these consultants couldn’t possibly know much about the subject and would be forced to regurgitate the ICAO guidance material that was being put out. It was obvious that the process people dealing with ISO and QMS would embrace the concept of SMS and treat it as another process exercise. It was clear that the regulators were going to have a very hard time evaluating an SMS and would reduce the concept to a series of checklists. All of those predictions have come true, so it is time to take a honest look at where we are and where we are going from here. The ICAO guideline was built around “four pillars” so now everybody has an SMS with four pillars. And of course, now every regulator has a checklist that counts the pillars. We have policies, posters, forms, processes and meetings. This is all really very comforting to people who have never grasped the concept of risk management” (Areospace World p. 1, 2012)

The airline industry is very complex and global business has never been more challenging and unpredictable. Therefore; knowledge and understanding of risk management are essential to get a better grip of what SMS is all about and working with it effectively. Hubbard (2009), however, argues about how uncritical use of risk analysis and management is a risky business itself. He is concerned about the different approaches to risk management and how risk analyses are performed.

## **1.2 Background**

There has been a growing interest for SMS since ICAO mandated that its entire member states to implement SMS programs. The situation is that the implementation status varies a lot among different countries and among continents. However, there is evidence that there is great interest on the subject, based on the ongoing activities on the Internet. The specialized websites such as LinkedIn contain much of the contemporary debate on the subject. There are also a few blogs covering the development in the subject and issue. Many of the contents on these internet sites, however, need to be carefully scrutinized for their sources and validity, before accepting these comments and opinions as actually correct. That said; these websites are valuable sources indeed for monitoring the current issues and state of the debate. Since they provide:

- individual experiences relevant for the subject
- personal interpretations and questions on issues in the subject
- expert comments and answers
- personal convictions

However, like in many debate forums and channels. There is a tendency of a few who tend to dominate the discussion. This is also the case here. The advantage is while they on the one hand keep the debate alive. The disadvantage is that they tend to limit the depth of the debate.

The contemporary debates on the websites and the official documents have been use to analyzed what inhibit and promote SMS in aviation, in my attempt, to fill the gap in the existing research.

Safety management in aviation has a long history. The same applies to different method of risk assessments and methods. It is important that SMS should be conceptualized as a change in safety risk management. Without understanding what the changes imply, one would be missing the whole point.

Contributions from this research effort should support efforts in organizations on how they implement and developed their SMS and the authorities on information and communications.

### **1.3 Purpose of the dissertation**

The purpose for this dissertation is to study factors that inhibit and promote the implementation of Safety Management System (SMS) in aviation. To gain insight into the subject, an extensive literature review has been made.

## 1.4 Problem formulation

Several issues brought my interest to try to understand what Safety Management System (SMS) in aviation was all about.

1) As mentioned earlier, in 2006, the International Civil Aviation Organization (ICAO), signed out the international standard for Safety Management Systems in aviation. The organization also mandated that its entire member states to implement Safety Management System programs in their aviation industries by 2009 (ICAO, 2009). The second version of the Safety Management Manual (SMM), was published in 2009 and yet by 2012, many countries, including Norway had not a State Safety Program (SSP). The SSP is the national safety document that each civil aviation authority is to develop for implementing and monitoring of SMS. Questions that came to my mind were. Why is it taking so long, what is in the way, why is it difficult to implement, why is it that only a few countries have to manage to implement it?

2) The second issue that came to my mind was. Why is SMS a new concept in aviation? Commercial airline at least in the western countries, is known for its records and as the safest means of transportation. As Stolzer et al (2010) writes, SMS is already found in a wide variety of industries, such as chemical, oil, construction, occupational, food, highway, electrical, and others. The question is then, why has SMS not been implemented earlier in aviation? Hasn't there been a need? I should point out that, what exists and is applied today, is what is referred to as safety programs.

So why is the situation as it is today? Is it possible to identify factors that restrain or enable the implementation of SMS in aviation?

The main question in the dissertation is, therefore, what inhibits and promotes the implementation of System Management Systems (SMS) in aviation?



## **1.5 Limitation and scope**

The dissertation is limited to issues related to implementation of SMS.

## **1.6 Structure of the dissertation**

Chapter 1: Introduction, background and purpose of the research topic.

Chapter 2: Theory, Definitions and concepts

Chapter 3: The literature review

Chapter 4: Promoting and inhibiting factors in system safety programs

Chapter 5: Methodology

Chapter 6: Data and analysis

Chapter 7: Phased approached strategy for implementing SMS

Chapter 8: Discussion

Chapter 9: Summary and further studies

## **Chapter 2 Theory, Definitions and Concepts**

In this chapter I intend to present the theory chosen for my dissertation. I will also present some definitions that relate to the topic I have chosen. These are concepts and terminologies that I believe will give the reader a good introduction and perspective on the subject.

Personally, I have used this chapter as a guideline for writing this dissertation. Furthermore, it has improved and has broadens my knowledge in Complexity systems and system safety research.

### **2.1 Theory**

The approach I am taking in the dissertation is based on complex systems theory. According to Lichtenstein, it originates from Prigogine's research on "dissipative structures," which "explains how regimes of order come into being and retain their form amidst a constant dissipation of energy and resources" (Prigogine, 1955, in Lichtenstein 2007, p. 288). The idea became popularized in the 1960s and 1970s by von Bertalanffy's formulation of General Systems Theory (von Bertalany, 1968, in Lichtenstein, 2007). Today, it is known as complexity and systems theory (Dekker, 2011).

According Lichtenstein, at its essence, complexity researchers are providing new ways to understand *how and why order emerges*. Lichtenstein explains that formally, emergence has been defined in terms of "qualitative novelty", and the focus was on the creation of coherent structures in a dynamic system. He continues that, "when these emergent structures are different "in kind" from the elements that compose them - when a new "level" of order has come into being, or a pattern of activity can be discerned that in some way transcends but includes the elements of the system, emergence can be said to have occurred" (Lichtenstein 2007, p. 288). Thus, emergence is a process by which "...patterns or global-level structures arise from interactive local-level processes... [The] combination of elements with one another brings with it something that was not there before" (Mead, 1932, in Lichtenstein, 2007 p. 289).

Schwandt and Szabla (2007) have categorized systems discourse into three periods:

1900-1940 Work Systems to Cooperative Systems

1940- 1970 Functionally Driven Systems to Interactive Systems

## 1970-2000 Learning Systems to Complex Systems

The period from 1900-1940,

The concept of systems began its movement away from the mechanical and formalized reductionary application of systems theory to a functional analysis of the social system. The discourse is characterized by the control of production of materials and products and the need to structure a workforce in an industrial age that could provide the labor requirements for a growing population and economy. The shift in the social systems discourse acknowledge the need for a more complex treatment of the system's influence on people, and the people's influence on the system. Toward the end of this time period, the focus began to be placed on the nature of the relationships between the elements of the system in order to maintain the system's stability or equilibrium. "The elements of the system were no longer just the workers and the work; they became the roles of the worker and management in hierarchical structures (Weber, 1930, in Schwandt and Szabla 2007 p. 43),

Schwandt and Szabla (2007), describe that the early discourse on social systems indicate the beginning of a shift away from purely objective and reductionary ideology that accompanied the migration of systems theory from the hard sciences to the social sciences. In their view, this was the beginning of an understanding that efficiency was dependent, not only on the rational control processes imposed on elements (people), but also on the mutual action of the elements under social conditions (role definitions) and a set of societal standards that guided the choice of the individuals (norms).

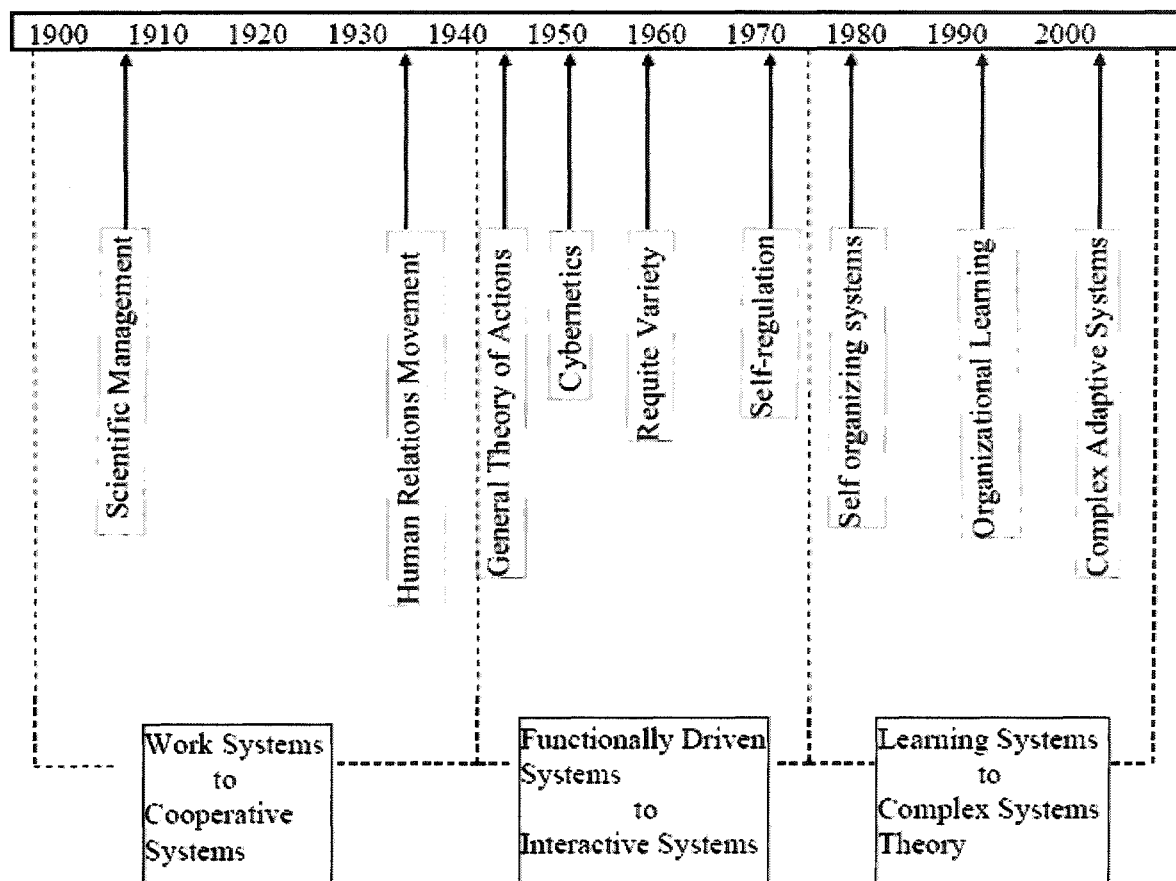
The period from 1940-1970

Two streams of the system discourse provide for the evolution of thinking along different courses. The first stream assumed that it is the internal system's actions that maintain a balance with the system's environment. These action would provide the system with the capacity to adapt to any disturbance in the environment (import needed energy), achieve system's goals, integrate itself (coordinate and control the actions to achieve goals), and maintain a set of cultural patterns to support the value and norms of the collective (Parsons and Shills, 1952, in Schwandt and Szabla 2007 p. 48).

The second stream of influence on the discourse resulted from the introduction of computational sciences to the understanding of social communications (Wiener, 1948, in *ibid*, 43). Schwandt and Szabla, meant this emphasized the need for information in the form of

feedback so that the system could maintain a homeostasis state. The introduction of “cybernetics” as a conceptual analytical frame focused on the responsiveness of the system to forces in the environment that were responsible for the deviations from intended outcomes (as opposed to equilibrium (Buckley, 1967, in *ibid* p. 48). According to Schwandt and Szaba, the role of system’s structure was to provide for control of information flow and distribution, the scanning of the environment for required information, the selection of sources of information, and the importation of information as a source of energy to combat entropy (the disordering and eventual death of the system).

The introduction of the concept of complexity and the loss of the perceived ability to control and predict social dynamics provided a critical turning point in the discourse concerning social systems. The emphasis became increased variety as opposed to suppression, or control, of variety (*ibid*)



**Figure 2.1** System Discourse Summary.

Adapted and modified from Schwandt and Szabla (2007 p. 56)

The period from 1970-2000

Schwandt and Szabla (2007) explains that this time period did not see an end of functionalism, rather it saw its argumentation with concepts of information control, knowledge utilization (rational contingent decision-making, strategic thinking, and eventually organizational learning), and a reemphasis of the individual's interpretative influence on social systems structures. Social systems discourse incorporated three major concepts that again moved away from psychological security of reductionism: self generation, learning and complexity.

Buckley (1968) described that self-generation reflected the realization that social structures was emergent and regenerative stemming from reciprocal and ongoing social interactions (in Schwandt and Szabla, 2007). Giddens's (1984) theory of the structuration described the dual nature of the agents altering the social structure – guiding the actions of the agents, and the actions of the agents altering the structure (in *ibid*). This is just a short presentation of two main contributors to the first stream of the social system discourse during this period. Harbermas, Luhmann are among others who have contributed during the period, but their theories won't be presented here. Although, I can mention that their theories have also contributed greatly to development in Communication and Language studies.

Schwandt and Szabla (2007) describes that the second stream of social discourse emanated from the conceptualization of social systems as, not only having goals of production, but also being driven by goals of knowledge creation through learning. In this discourse, "in which neg-entropy (or energy) is critical to the system's survival" (Baliley, 1994, in Schwandt and Szabla, 2007 p. 52)

According to Schwandt and Szaba (2007), the third stream of social system discourse reflects a merger of cybernetics, organizational learning, complexity science and the dynamics of social interaction. Emergence and tension have become major concepts in understanding structure and leadership. "Emergence can be thought of as the evolution and recombination of interations into new actions"(Anderson, 1999, in Schwandt and Szaba p. 53). This is a reflection of Giddens's structuration theory in that it assumes that structure is multifaceted and is ever changing itself.

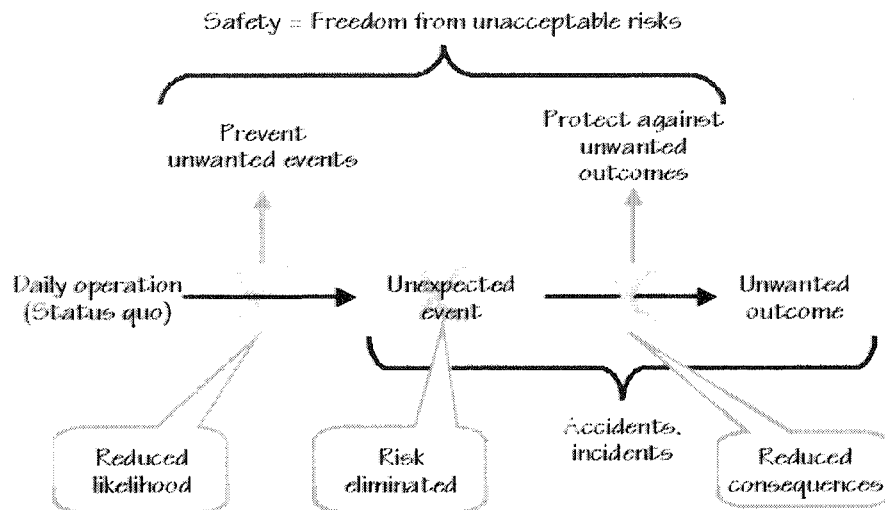
Presented above is the development in discourses or theories that have led to what complex systems theory is today. One can see that it embodies many different disciplines.

Dekker (2011) has summarized complexity and systems theory as follows.

- Complex systems are open systems – open to influences from the environment in which they operate and influencing that environment in return. Such openness means that it is difficult to frame the boundaries around a system of interest.
- In a complex system, each component is ignorant of the behavior of the system as a whole, and doesn't know the full effects of its actions either. Components respond locally to information presented by them there and then. Complexity arises from the huge, multiplied webs of relationships and interactions that result from these local actions.
- Complexity is a feature of the system, not of the components inside it. The knowledge of each component is limited and local, and there is no component that possesses enough capacity to represent the complexity of the entire system in that itself. This is why the behavior of the system cannot be reduced to the behavior of the constituent components, but only characterized on the basis of the multitude of ever-changing relationships between them.
- Complex systems operate under conditions far from the equilibrium. Inputs need to be made the whole time by its components in order to keep it functioning. Without that constant flow of actions, of inputs, it cannot survive in a changing environment. The performance of complex systems is typically optimized at the edge of chaos, just before system behavior will become unrecognizably turbulent.
- Complex systems have a history, a path-dependence. Their past is co-responsible for their present behavior, and descriptions of complexity have to take history into account.
- Interactions in the complex systems are non-linear. That means that there is an asymmetry between for example, input and output, and that small events can produce large results. The existence of feedback loops means that complex systems can contain multipliers (where more of the one means more of the other, in turn leading to more of one, and so forth) and butterfly effects.

## 2.2 Safety

Safety means different things to different people (Stolzer et al, 2002). Despite the universal agreement that safety is important, there is no unequivocal definition of what safety is. Most people, practitioners and researchers alike, may nevertheless accept a definition of safety as ‘the freedom from unacceptable risks’ as a good starting point (Hollnagel, 2009).



**Figure 2.2:** Definition of safety

Source: (Hollnagel, 2009 p. 9).

This definition can be operationalised by representing an accident as the combination of an unexpected event and the lack of protection or defence as depicted in the figure above (figure 2.1). According to Hollnagel, this rendering suggests that safety can be achieved in three different ways: by eliminating the risk, by preventing unexpected events from taking place, and by protecting against unexpected outcomes when they happen anyway. Hollnagel argues that, although the definition of safety given in Figure 2.1 looks simple, it raises a number of significant questions for any safety effort. The three main questions are:

- 1) What the risks are and how they can be found, i.e., about what can go wrong?
- 2) How the freedom from risk can be achieved, i.e, what means are available to prevent unexpected events or to protect against unwanted outcomes?
- 3) The third question has two parts, namely how much risk is acceptable and how much risk is affordable.

Hollnagel points out that answering these questions is rarely easy and emphasizes that without having at least tried to answer them, efforts to bring about safety are unlikely to be successful (Hollnagel, 2009).

Hollnagel's description of 'risk elimination' needs further elaboration since it does not clearly explain how the process of risk management functions in practice. We take risks (into account) according to the probability and magnitude of injury or loss. Risk managers look at all sources and scenarios of risks and calculate their likelihood of occurrence and the costs that they may incur. Once this task has been accomplished, the organization is presented with a set of options:

- Risk Avoidance (eliminate the source of risk or avoid actions that may result in such risk)
- Risk Reduction (put in resources or take actions that reduces the amount of risk involved)
- Risk Transfer (share the risk with others, insure against it or outsource it)
- Risk Tolerance (accept the consequences and budget/prepare for it) (Supervision notes: Strømmen-Bakhtiar)

Safety is defined by ICAO as "the state in which the possibility of harm to persons or property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management" (ICAO 2009, p 2-2).

A term that is included in the ICAO's definition of safety that needs further explanation is hazard identification. ICAO define hazard as " a condition or an object with the potential to cause injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform a prescribed function" (ICAO 2009, p 4-1). Behind this view is that, systems in which people must actively and closely interact with technology to achieve production goals through delivery of services are known as socio-technical systems. All aviation organizations are thus socio-technical systems. Hazards are normal components or elements of socio-technical systems. They are integral to the contexts where delivery of services by socio-technical production systems takes place. In and by themselves, hazards are not "bad things". Hazards are not necessarily damaging or negative components of a system. It is only when hazards interface with the operations of the system aimed at service delivery that their damaging potential may become a safety concern.



What does hazard identification mean then in this context? Hazards are part of the fabric of any socio-technical production system implies that the scope of hazards in aviation is wide. Hazard identification then involves the scope of factors and processes that should be looked into (ICAO, 2009, p. 4-4).

ICAO's safety definition is based on the concept that "safety is viewed as the outcome of the management of certain organizational processes, which have the objective to keeping safety risk of the consequences of hazards in operational contexts under organizational control" (ICAO, 2009, p. 2-2). According to Stolzer et al, the ICAO definition relates to safety management since it recognizes that the risk in activity is not reduced to zero, but rather to an acceptable level. Furthermore, it explains that safety is maintained by a process and that process involves identifying the hazards that impede safety, and managing risks (Stolzer et al, 2010).

### **2.3 Management**

A generally accepted definition is that management is the process of getting activities completed efficiently and effectively with and through other people. The functions normally associated with management are planning, organizing, staffing, directing, controlling and budgeting. Management is leading and directing an organization or an activity through the deployment and manipulation of resources, whether the resources are human, financial, intellectual, material or other (Stolzer et al, 2010)

There is already extensive literature on management. Therefore, the definition does not need further explanation here. However, more discussion on management will be done, when discussing challenges related to safety leadership later.

### **2.4 System**

In the section on system discourse and its development, I did not present the definitions of a system or was it discussed. In this section I will present several definitions of a system, since there are very many of them. Furthermore, the term varies a lot depending on subject or research area. Since "the definition of what a system is can be a touchy issue" (Hollnagel (2009 p. 20).

Before I present the different definitions of a system, here is an illustration:

For example, is a mechanical wrist watch a system of integrated mechanical parts or not? If it is, where are the people? The illustration presented indicates that a system does not necessarily have to include people. However, in many of the definitions that is presented below includes people and much more.

However, first here is an introduction to system thinking that may help in explaining some of the interpretations.

System thinking is an epistemology, when applied to human activity is based upon four basic ideas: *emergence*, *hierarchy*, *communication*, and *control* as characteristics of systems. When applied to natural or designed systems the crucial characteristic is the *emergent properties* of the whole. *Emergence* or *emergent properties*; is the principle that the whole entities exhibit properties which are meaningful only when attributed to the whole, not to its parts - e.g. the smell of ammonia. Every model of a human activity system exhibits properties as a whole entity which derive from its component activities and their structure, but cannot be reduced to them. *Hierarchy*; the principle that according to entities meaningfully treated as wholes are built up of smaller entities which are themselves wholes ... and so on. In a hierarchy, *emergent properties* denote the level. *Communication* is the transfer of information. *Control*; is the process by means of which a whole entity retains its identity and/or performance under changing circumstances. In the formal system model the decision-taking process ensures that the control action is taken in the light of the system's purpose or mission and the observed level of the measure of performance (Checkland, 2009 p. 312-318)

The systems concept originated in the realm of the physical or natural sciences (e.g., physics and biology). Its migration to the social sciences entailed the acceptance of a rational and objective worldview that became the basis for social formalism and mechanical applications of systems theory to social research and practice. The concept was formalized by Bertalanffy (1956) in his discussion of General Systems Theory as "a set of elements standing in interaction" (Schwant and Szabla, 2007).

According to Hollnagel, a system can broadly be defined as the intentional organisation or arrangement of parts (components, people, functions, subsystems) that makes it possible to achieve specified and required goals. Stolzer et al (2010, describe that a useful way to think

about the concept of systems, is that it is an amalgam of people, procedures and processes, and equipment that are integrated to perform a specific function or activity within a particular environment. Or as define by Stephans (2004), a system is a composite of people, procedures, and plant and hardware working within a given environment to perform a given task.

The first definition relates to a system as a means to achieve goals, the second definition sees a system as a method to function in a specific environment, while the third definition describes a system as a tool for a concrete task.

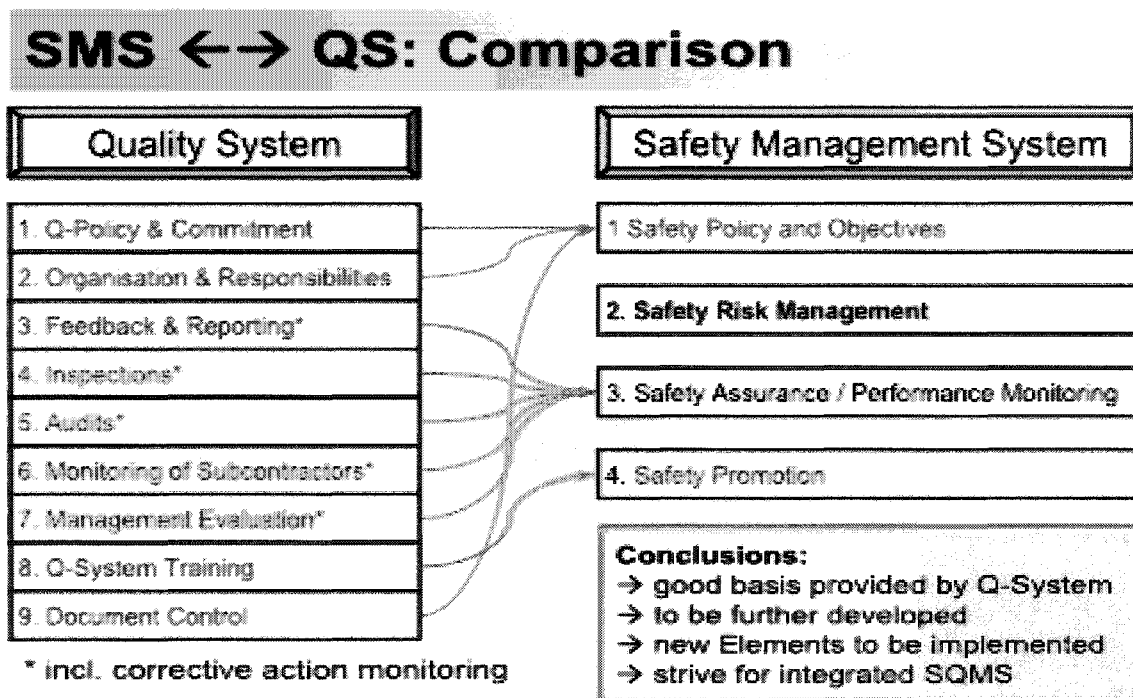
Scwandt and Szabla (2007), emphasizes that in general, the core components of the definition of a system have not significantly varied of the 100 years they have examined in their study, based on studies from 1911 to 2007. According to them, each theorist seems to have accepted a general and simplistic definition of a system that included some set of defined elements and a number of relationships between and among the elements. However, what have varied are the nature of the elements and the complexity of their relationships. The above cited definitions support this observation.

System can be open or closed or isolated. An *open system* exchanges matter and energy with its surroundings. Most systems are open systems; like a car, coffeemaker, or computer. A *closed system* exchanges energy, but not matter, with its environment; like Earth or the project Biosphere2 or 3. An *isolated system* exchanges neither matter nor energy with its environment. A theoretical example of such system is the Universe (Wikipedia, 2012)

## **2.5 Safety Management Systems (in aviation)**

I have gone through the definitions of the three main words in the dissertation; safety management systems. What is SMS then and how can it best be described and understood? According to Flouris, and Yilmaz (2011:157), the safety management systems (SMS); is deeply rooted in organizational behavior theory. ICAO states that SMS is based on the principles of quality management systems (QMS). Stolzer et al (2010) define SMS as: a dynamic risk management system based on quality management (QMS) principles in a structure scaled appropriately to the operational risk, applied in a safety culture environment (Stolzer et al, 2010). It is however important to know the distinctions between quality and safety. Quality according to International Standards Organization (ISO) 9000:2005, defined as

“the degree to which a set of inherent characteristics fulfils requirements” (Mario Periobon in Aerosafetyworld june 2012 p. 46). The definition of safety has always been presented earlier. According to Mario Periobon, the two principles are nevertheless related but not the same. While quality refers to meeting requirements, safety refers to keeping people and property from harm (Mario Periobon in Aerosafetyworld june 2012 p. 46-47). The relationship between Safety Management System and Quality Management can better be understood when presented as in the figure 2.2 below.



**Figure 2.3** Relation between Quality System and Safety Management System. Source: Swiss CAA

Both systems strive to achieve a high level of safety. However, the approaches are partially different. Quality system (QS) is to ensure safe operations, and the approach is Safety Assurance / Compliance Monitoring. Safety management System is to reduce or maintain risk of harm to persons or property damage at or below an acceptable level, and the approach is risk-management & Safety Assurance / Compliance Monitoring (ICAO, 2009). Reason (2009), explains that a safety management system provides the administrative structures necessary to drive good safety practices. It focuses upon the technical and managerial factors associated with hazards. It is top-down and management-led. It is prescriptive – this is, it states how things *ought* to be. It is comprehensive, embracing all hazards and their requirement.

### Chapter 3 Literature review

This chapter is on the literature review. The literature review serves many different purposes and entails a wide variety of activities. Hence, literature review has been defined in a number of ways. But one of its main functions is to identify theories and the previous research which have influence the research topic, methodology being applied and the identifications of the problem to research.

#### 3.1 Current issues

The number of airline departures has risen dramatically in the past few years; therefore, there is a need to employ new methods and programs that can drive down accident rates (Stolzer et al 2010). It is also vital to develop methods that not only maintain the current safety records but also cost-effective. Furthermore, there are airline operations and still many countries that are struggling with bad safety records that now have the option of adopting a more integrated system. The increase of airline departures naturally means an increased in volume and capacity for the other sectors of the airline industry. It is also important service providers are involved, and they meet the business demands and safety standards that the airliners are operating.

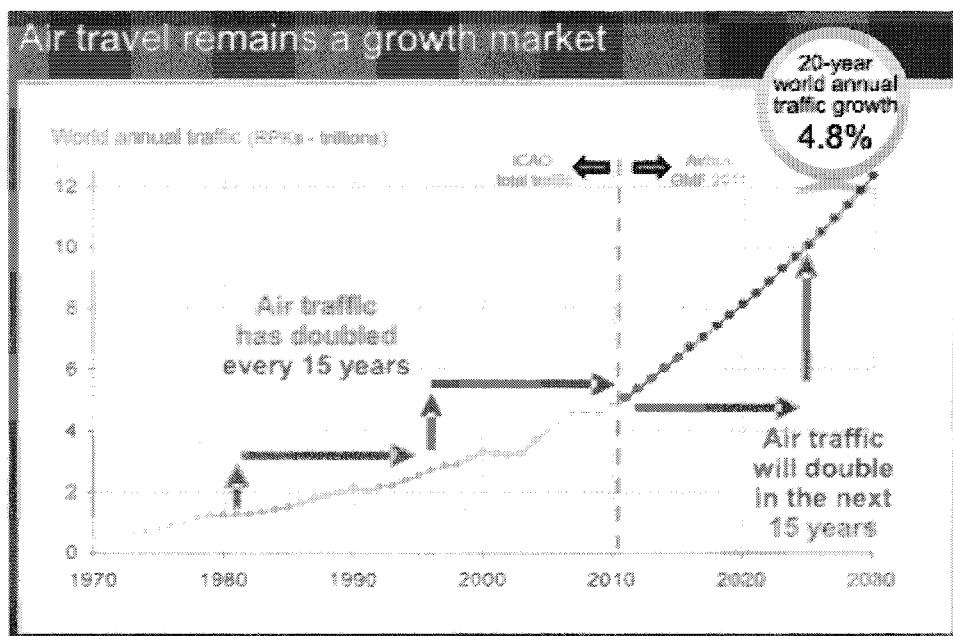


Figure 3.1 Air travel remains a growth market. Source: ICAO & Airbus

There is much that speaks for a further increase in capacity in many parts of the world and to be able to meet this demand. It is important the industry is best suited for the future development. For the regulators, it is an important step and opportunity to develop modern oversight methods and the development of performance based safety oversight, also known as risk-based oversight.

### **3. 2 Current context**

The ICAO Safety Management Manual (SMM) is the foundation for my Master of Business Administration (MBA) dissertation. It is also the essential document for the regulatory framework for the implementation of safety management systems (SMS). The first edition was already published 2006 with the time frame that the 190 members countries should have implemented by 2009. Today, only a few countries have implemented SMS according to ICAO. Some countries have implemented with certain modifications, and other countries are waiting for how their states will adopt it. There are also cases where the service providers have implemented it without the involvement of their Civil Aviation Authority (CAA). In Europe, it has recently been mandated by the European Aviation Safety Agency (EASA) through the implementing rules.

### **3. 3 Evolution of system safety approach in aviation**

In aviation three main research areas have influence the development in system safety. It can be divided as studies in technical, human and organizational factors. The development in research areas can be divided into three time periods:

1940s -1970s the focus was on technical factors.

1970s- 1990s, the focus was on Human Factors.

From the early 1990s the focus was on Organizational factors. Today, it is a combination of the three factors.

#### **3. 3.1 Technical factors**

The early days of aviation, those before and immediately following the Second World War until the 1970s, can be characterized as the “technical era” where safety concerns were mostly related to technical factors. Aviation was emerging as a mass transportation industry, yet the technology supporting its operations was not fully developed, and technological failures were

the recurring factor in safety breakdowns. The focus of safety endeavours was rightly placed on the investigation and improvement of technical factors (ICAO 2009).

### **3. 3.2 Human factors**

The early 1970s saw major technological advances in many areas such as, radar (both airborne and ground-based), autopilots, flight directors, improved navigation and communications capabilities and similar performance-enhancing technologies, both in the air and on the ground. This heralded the beginning of the “human era”, and the focus of safety endeavours shifted to human performance and Human Factors, with the emergence of crew resource management (CRM), line-oriented flight training (LOFT), human-centred automation and other human performance interventions. The mid-1970s to the mid-1990s has been dubbed the “golden era” of aviation Human Factors, in reference to the huge investment by aviation to bring under control the elusive and ubiquitous human error. Nevertheless, in spite of the massive investment of resources in error mitigation, by the mid-1990s human performance continued to be singled out as a recurring factor in safety breakdowns. The downside of Human Factors endeavors during a significant portion of the “golden era” was that they tended to focus on the individual, with scant attention to the operational context in which individuals accomplished their missions (ICAO 2009).

It was not until the early 1990s that it was first acknowledged that individuals do not operate in a vacuum, but within defined operational contexts. Although scientific literature was available regarding how features of an operational context can influence human performance and shape events and outcomes, it was not until the 1990s that the people in aviation industry acknowledged that fact. This signaled the beginning of the “organizational era” when safety began to be viewed from a systemic perspective, to encompass organizational, human and technical factors. It was also at that time that the notion of the organizational accident was embraced by aviation (ibid)

Criticism on the single dimensional focus in human error principles and what human factors could not explain led to the concerns to understand the organizational factors

### 3. 3.3 Organizational factors

Industry-wide acceptance of the concept of the organizational accident was made possible by a simple, yet graphically powerful, model developed by Professor James Reason, which provided a means for understanding how aviation (or any other production system) operates successfully or drifts into failure. According to this model, accidents require the coming together of a number of enabling factors — each one necessary, but in itself not sufficient to breach system defences. Because complex systems such as aviation are extremely well-defended by layers of defences in depth, single-point failures are rarely consequential in the aviation system. Equipment failures or operational errors are never the cause of breaches in safety defences, but rather the triggers. Breaches in safety defences are a delayed consequence of decisions made at the highest levels of the system, which remain dormant until their effects or damaging potential are activated by specific sets of operational circumstances. Under such specific circumstances, human failures or active failures at the operational level act as triggers of latent conditions conducive to facilitating a breach of the system's inherent safety defences. In the concept advanced by the Reason model, all accidents include a combination of both active and latent conditions (ICAO 2009). See section the latent condition model for their definition.

The Reason model has influence much of the studies in system safety and is presented below

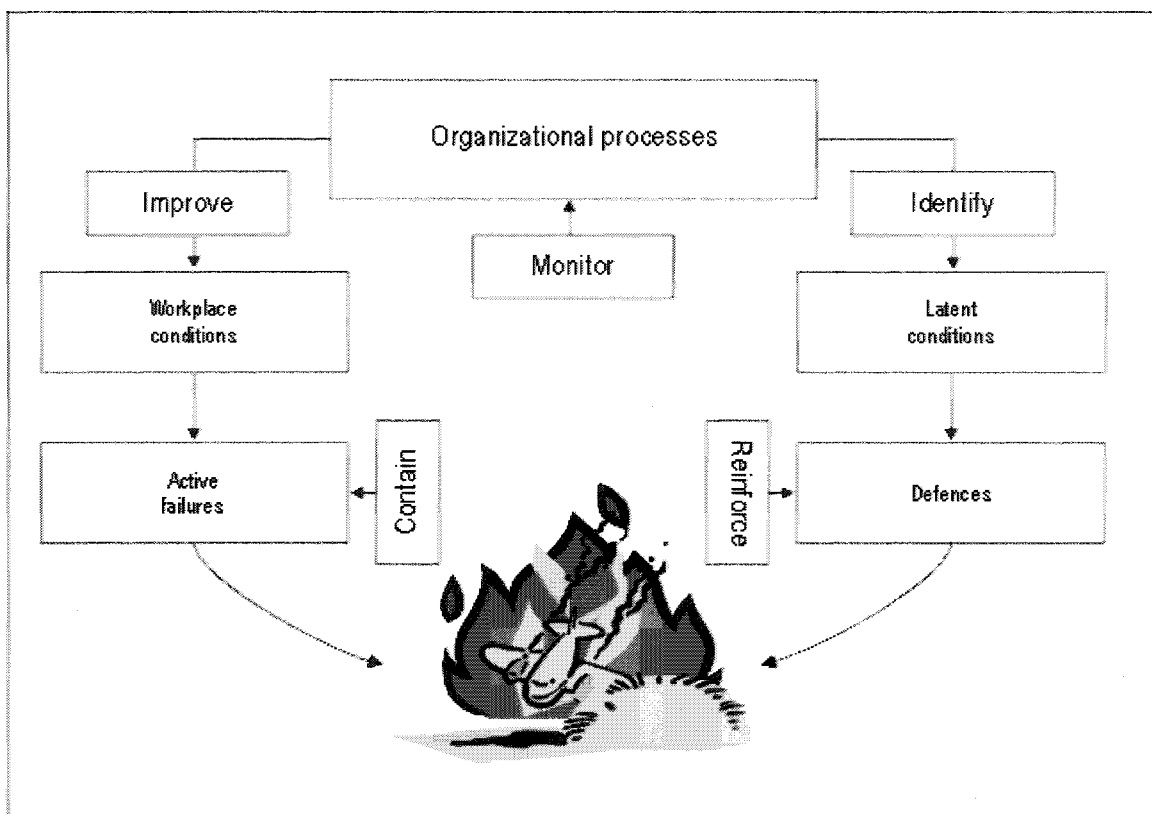
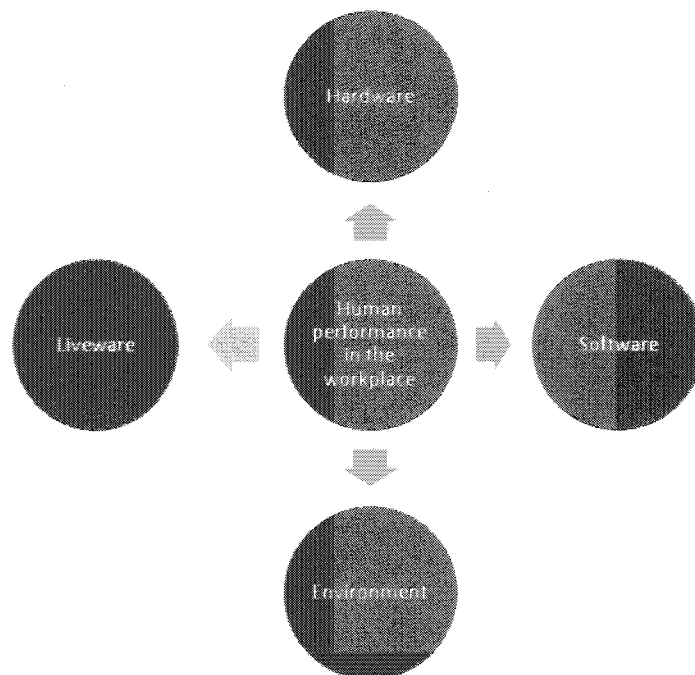


Figure 3.2. The perspective of the organizational accident (Source: ICAO, 2009)



### 3.3.4 Operational context

A simple, yet visually powerful, conceptual tool for the analysis of the components and features of operational contexts and their possible interactions with people is the SHEL model. The SHEL model (sometimes referred to as the SHEL(L) model) can be used to help visualize the interrelationships among the various components and features of the aviation system. This model places emphasis on the individual and the human's interfaces with the other components and features of the aviation system. The SHEL model's name is derived from the initial letters of its four components: a) Software (S) (procedures, training, support, etc.); b) Hardware (H) (machines and equipment); c) Environment (E) (the operating circumstances in which the rest of the L-H-S system must function); and d) Liveware (L) (humans in the workplace) (ICAO 2009).



**Figure 3.3.** The interface between various components in the operational context. Adapted from the SHELL model.

Figure 2 depicts a modified version of the SHEL model. The figure is intended to provide a better understanding of the relationship of individuals to components and features in the workplace.

**Liveware.** In the centre of the model are the humans at the front line of operations. Although humans are remarkably adaptable, they are subject to considerable variations in performance. Humans are not standardized to the same degree as hardware, so the edges of this block are not simple and straight. Humans do not interface perfectly with the various components of the world in which they work. To avoid tensions that may compromise human performance, the effects of irregularities at the interfaces between the various SHEL blocks and the central Liveware block must be understood. The other components of the system must be carefully matched to humans if stresses in the system are to be avoided. Some of the more important factors affecting individual performance are: **Physical factors:** These include the human's physical capabilities to perform the required tasks, e.g. strength, height, reach, vision and hearing. **Physiological factors:** These include those factors which affect the human's internal physical processes, which can compromise physical and cognitive performance, e.g. oxygen availability, general health and fitness, disease or illness, tobacco, drug or alcohol use, personal stress, fatigue and pregnancy. **Psychological factors:** These include those factors affecting the psychological preparedness of the human to meet all the circumstances that might occur, e.g. adequacy of training, knowledge and experience, and workload. **Psycho-social factors:** These include all those external factors in the social system of humans that bring pressure to bear on them in their work and non-work environments, e.g. an argument with a supervisor, labour-management disputes, a death in the family, personal financial problems or other domestic tension (ibid).

The interface between the human and technology or **Liveware-Hardware (L-H)** is the one most commonly considered when speaking of human performance. It determines how the human interfaces with the physical work environment, e.g. the design of seats to fit the sitting characteristics of the human body, displays to match the sensory and information processing characteristics of the user, and proper movement, coding and location of controls for the user. However, there is a natural human tendency to adapt to L-H mismatches. This tendency may mask serious deficiencies, which may only become evident after an occurrence.

The L-S interface *Liveware-Software (L-S)*; is the relationship between the human and the supporting systems found in the workplace, e.g. regulations, manuals, checklists, publications, standard operating procedures (SOPs) and computer software. It includes such “user-friendliness” issues as currency, accuracy, format and presentation, vocabulary, clarity and symbology.

c) *Liveware-Liveware (L-L)*. The L-L interface is the relationship between the human and other persons in the workplace. Flight crews, air traffic controllers, aircraft maintenance engineers and other operational personnel function as groups, and group influences play a role in determining human performance. The advent of crew resource management (CRM) has resulted in considerable focus on this interface. CRM training and its extension to air traffic services (ATS) (team resource management (TRM)) and maintenance (maintenance resource management (MRM)) focus on the management of operational errors. Staff/management relationships are also within the scope of this interface, as are corporate culture, corporate climate and company operating pressures, which can all significantly affect human performance.

The interface between the human and both the internal and external environments (*Liveware-Environment (L-E)*). The internal workplace environment includes such physical considerations as temperature, ambient light, noise, vibration and air quality. The external environment includes such things as visibility, turbulence and terrain. The twenty-four hour a day, seven days a week, aviation work environment includes disturbances to normal biological rhythms, e.g. sleep patterns. In addition, the aviation system operates within a context of broad political and economic constraints, which in turn affect the overall corporate environment. Included here are such factors as the adequacy of physical facilities and supporting infrastructure, the local financial situation, and regulatory effectiveness. Just as the immediate work environment may create pressures to take short cuts, inadequate infrastructure support may also compromise the quality of decision-making. Care needs to be taken in order that operational errors do not “filter through the cracks” at the interfaces.

For the most part, the rough edges of these interfaces can be managed, for example: a) The designer can ensure the performance reliability of the equipment under specified operating conditions. b) During the certification process, the regulatory authority can define realistic conditions under which the equipment may be used. c) The organization’s management can develop standard operations procedures (SOPs) and provide initial and recurrent training for

the safe use of the equipment. d) Individual equipment operators can ensure their familiarity and confidence in using the equipment safely under all required operating conditions.

### **3. 5 Approaches to Safety Management**

Safety management can be categorized into three main approaches. They are the person, engineering, and organizational model.

The person model is exemplified by the traditional occupational safety approach. The emphases are upon individual unsafe acts and personal injury accidents. It views people as free agents capable of choosing between safe and unsafe behavior. This means that errors are perceived as being shaped predominantly by psychological factors such as inattention, forgetfulness, poor motivation, carelessness, lack of knowledge skills and experience, negligence and –on occasions- culpable recklessness. Its principal applications are those domains involving close encounters with hazards (Reason, 1997).

The most widely used countermeasures are ‘fear appeal’ poster campaigns, rewards and punishments, unsafe act auditing, writing another procedure, training and selection. Progress is measured by personal injury statistics, such as fatalities, lost-time injuries, medical treatment cases, first aid cases and the like. It is frequently underspinned by the ‘iceberg’ and ‘pyramid’ views of accident (Reason, 1997).

The engineering model has its origins in reliability engineering, traditional ergonomics (and its modern variant – cognitive engineering) risk management and human reliability assessment. Typically the model focuses on how the performance of the front-line operators (for example, control room operators and pilots) is influenced by the characteristics of the workplace or specifically, by the informational properties of the human-machine interface. Research in this area was originally supported by the nuclear power industry, the military, the space agencies, the chemical process industries, oil and gas industries and aviation – domains in which the safety of a system hinges critically on the reliability of a small number of human controllers. The practical applications of this approach include: hazard operability studies (HAZOPS), hazard analysis studies (HAZANS), probabilistic risk assessment (PRA), technical safety audits, reliability and maintainability studies (RAMS), human reliability

assessment (HRA), cognitive task analyses, ergonomic guidelines, databases, and the application of decision support systems (Reason, 1997).

The organizational model disciplinary link is with crisis management. According to Reason, this is not always apparent to its practitioners. The intellectual origins are based on two main works. The first was '*Man-Made Disaster (1978)*' by Barry Turner and the second major influence was *Normal Accidents (1984)* by Charles Perrow. The model emphasises the necessity for proactive measures of 'safety health' and the needs for continual reforms of the system's basic processes. As such, it has much in common with Total Quality Management. Indeed, the organizational model deliberately blurs the distinction between safety-related and quality-determining factors. Both are viewed as important for increasing the system's intrinsic resistance to its operational hazards. Both are seen as being implicated in organizational accidents (Reason, 1997).

### **3. 5.1 Main differences in the three approaches to Safety Management**

According to Reason, the Person model is the most adopted of the three approaches and has the longest history, stretching back to the beginnings of industrialization. It is usually policed by safety departments and safety professionals, though – more recently – the accent has been upon personal responsibility. The engineering model in contrast to the person model, human errors are not regarded simply as the product of what goes on between an individual's ears. Rather, they emerge from human-machine mismatches, or poor human engineering – that is, the failure on the part of the system designers to tailor the system appropriately to the cognitive strengths and weaknesses of its human controllers. The organizational model views human error more as a consequence than as a cause. Errors are the symptoms that reveal the presence of latent conditions in the system at large. They are important only in so far as they adversely affect the integrity of the defences. In many respects, the organizational model is simply an extension of the engineering model and is in no way incompatible with it. Human-machine mismatches are seen as being the result of prior decisions in the upper echelons of the system. And these, in turns, are shaped by wider regulatory and societal factors.

The engineering and organizational models are both necessary for understanding the aetiology of organizational accidents and for limiting their occurrence. Where there is a conflict is between both of these models and largely person-directed approach of the traditional

occupation safety professionals. However, these differences are often more a matter of circumstance than of substance (Reason, 1997).

### **3. 6 Safety science - explaining accidents and creating safety**

The literature review shows that there are several models that have been adopted to explain how we can understand safety. Important to bear in mind is that, while on the one hand there are models/theories that try to treat accident as ‘the outcome of a series of events along a linear pathway and see risk as the uncontrolled release of energy’ on the other hand models and theory that treat ‘how accidents emerge from the interaction of multitude of events, processes and relationship in a complex system, and that take a more interactive, sociological perspective on risk’ (Woods et al 2010. p. 36).

#### **3. 6.1 Linear and latent conditions models**

The three main models that fall under the linear and latent failure models are:

- The sequence-of events model.
- Man-made disaster theory.
- The latent conditions model.

#### **3. 6.2 The sequence-of events model or the domino model.**

The linear way of conceptualizing how events interact to produce a mishap was first articulated by Heinrich in 1931 and is still a common place today. According to this model, events preceding the accident happen linearly, in a fixed order, and the accident itself is the last event in the sequence (Woods et al, 2010). It has been known too, as the domino model, for its depiction of an accident as the endpoint in a string of falling dominoes. Consistent with the idea of a linear chain of events is the notion of a root cause – a trigger at the beginning of the chain that sets everything in motion ( the first domino that falls and then, one by one, the rest. The sequence-of-events idea is pervasive, even if multiple parallel or converging sequences are sometimes depicted to try to capture some of the greater complexity of the precursors to an accident. The idea forms the basic premise of many risk analysis methods and tools such as fault-tree analysis, probabilistic risk assessment, critical path models and more.

Also consistent with the chain of events is the notion of barriers – a separation between the source of hazard and the object or activity that needs protection. Barriers can be seen as blockages between dominoes that prevent the fall of one affecting the next, thereby stopping the chain of reaction. From the 1960s to the early 1980s, the barrier perspective gained new ground as a basis for accident prevention. Accidents were typically seen as a problem of uncontrolled transfer of harmful energy, and safety interventions were based on putting barriers between the energy source and the object to be protected.

Wood et al (2010) indicates that complications in the sequence-of events is that people can assume a cause-consequence equivalence, where each effect is a cause, and each cause is an effect, but also a symmetry between cause and effect. Thus, they argue that, this has become an assumption that we often take for granted in our considerations of accidents. In the sense that, people may take for granted a symmetry between cause and effects, for example, that a very big effect (e.g., in the numbers of fatalities) must have been due to a very big cause (e.g., egregious errors).

Wood et al (2010) emphasis that the sequence-of-events is blind to patterns about cognitive systems and organizational dynamics. In their view, people only appear as another step that determined a branch or continuation of the sequence underway. Such that human performance becomes a discrete, binary event – the human did or did not do something – which failed to block the sequence or continued the sequence. Thus, these errors constitute a cause in the chain of cause/effects that led to the eventual outcome. Furthermore, outsiders can easily construct alternative sequence, “the accident would only have been avoided if only those people had seen or done this or that”. Versions of such thinking show up in accident reports and remarks by stakeholders after accidents.

### **3. 6.3 Man-made disaster theory**

In 1978, Barry turner offered one of the first accounts of accidents as a result of normal everyday organizational decision making. Accidents, Turner concluded, are neither chance events, nor acts of God, nor triggered by a few events and unsafe human acts. Nor is it useful to describe accidents in terms of the technology itself (Pigeon and O’Leary, 2000 cited in Woods et al 2010). According to Wood et al (2010), Turner’s idea was that “man-made disasters” often start small, with seemingly insignificant operational and managerial

decisions. From then, there is an *incubation period*. Over a long period of time, problems accumulate and the organization's view of itself and how it manages its risks grows increasingly at odds with the actual state of affairs (miscalibration), until this mismatch actually explodes into the open in the form of an accident (Turner, 1978 cited in Woods et al 2010).

Man-made disaster theory preserved important notions of the sequence-of events model (e.g, problems at the root that served to trigger others over time) even if the sequence spread further into the organization and deeper into history than in any previous models of accidents. Yet the Turner's insight added new focus and language to the arsenal of safety thinking (Woods et al, 2010).

An important post-accident discovery highlighted by man-made disaster theory is that seemingly innocuous organizational decisions turned out to interact, over time, with other preconditions in complex and unintended ways. None of those contributors alone is likely to trigger the revelatory accident, but the way they interact and add up falls outside the predictive scope of people's model of their organization and its hazard control up to that moment.

Wood et al (2010) point out that Turner's account was innovative because he did not define accidents in terms of their physical impact (e.g, uncontrolled energy release) or as a linear sequence of events. Rather, he saw accidents as organizational and sociological phenomena. Thus, accidents represent a disruption in how people believe their system operates; a collapse of their own norms about hazard and how to manage them. An accident, in other words, comes as a shock to the image that the organization has of itself, of its risks and how to contain them. The developing vulnerability is hidden by the organization's belief that it has risk under control.

Lanir (1986) used the term "fundamental surprise," to capture this sudden revelation that one's perception of the world is entirely incompatible with reality (cited in Woods et al, 2010). Woods et al (2010) point out that, interestingly, the surprise in man-made disaster theory is not that a system that is normally successful suddenly suffers a catastrophic breakdown. Rather, the surprise is that a successful system produces failure as a systematic by-product of how it normally works.



### 3. 6.4 The latent conditions model (aka “swiss cheese”)

The latent failure model is an evolution and combination of the ideas from preceding theories and models on accident causation, particularly the sequence-of-events model and Man-made disaster theory (Wood et al (2010)). The model was introduced by James Reason in 1990. However, during the years it has there have been several modifications to the name of the model. When the term first appeared it was as “latent errors”, then it changed to “latent failures”. Now the term “latent conditions” is preferred, since it does not necessarily involve either error or failure (Reason, 1997 p. 20). Despite this, many researchers still today use the term “latent failure” when referring to this model.

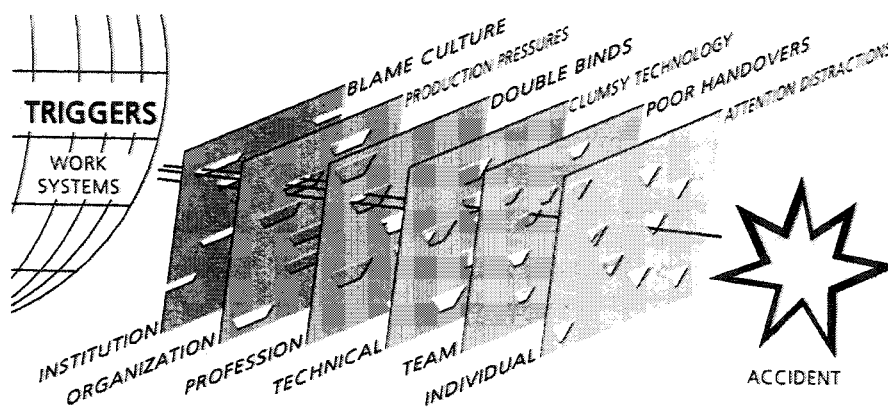
According to the “latent conditions” model, disasters are characterized by a concatenation of several small failures and contributing factors — each one necessary, but in itself not sufficient to breach system defenses (Reason, 1997; woods et al, 2010, ICAO, 2009). An example, because complex systems such as aviation are extremely well-defended by layers of defences in depth, single-point failures are rarely consequential in the aviation system. Equipment failures or operational errors are never the cause of breaches in safety defences, but rather the triggers. Breaches in safety defenses are a delayed consequence of decisions made at the highest levels of the system, which remain dormant until their effects or damaging potential are activated by specific sets of operational circumstances. Under such specific circumstances, human failures or active failures at the operational level act as triggers of latent conditions conducive to facilitating a breach of the system’s inherent safety defences. In the concept advanced by the Reason model, all accidents include a combination of both active and latent conditions (ICAO 2009)

The latent condition thus distinguishes between active failures and latent conditions:

***Active failures*** are actions or inactions, including errors and violations, which have an immediate adverse effect. They are generally viewed, with the benefit of hindsight, as unsafe acts. Active failures are generally associated with front-line personnel (pilots, air traffic controllers, aircraft mechanical engineers, etc.) and may result in a damaging outcome. They hold the potential to penetrate the defences put in place by the organization, regulatory authorities, etc. to protect the aviation system. Active failures may be the result of normal errors, or they may result from deviations from prescribed procedures and practices.

**Latent conditions** are conditions present in the system well before a damaging outcome is experienced, and made evident by local triggering factors. The consequences of latent conditions may remain dormant for a long time. Individually, these latent conditions are usually not perceived as harmful, since they are not perceived as being failures in the first place. Latent conditions become evident once the system’s defences have been breached. These conditions are associated with managers, designers, maintainers, or regulators – people who are generally far removed in time and space from the event (Reason 1997, Wood et al, 2010, ICAO, 2009).

Active failure and latent conditions model be described as such:



**Figure 3.4** Active failure and latent conditions. Source: Woods et al, 2010.

Complex system failure according to the latent conditions model. Failures in these systems require a combination of multiple factors. The system is defended against failure but these defences have defects or “holes” that allow accidents to occur.

Woods et al (2010) states that a very important contribution of the latent conditions model is that it brought about making many more stakeholders think more critically about the rich context that surrounds and helps produce accidents.

Critic or limitation of the latent conditions model:

- The depiction of complex system as a static set of layers present problems. This is because, it does not explain how such latent conditions come into being, nor how they actually combine with active failures.
- Also, the model does not tell how layers of defence are gradually eroded, for example under the pressures of production and resource limitations and over-confidence based on successful past outcomes (Wood et al, 2010).

### **3.7. Complexity, control and sociological models**

The main theories that examine how accidents emerge from the interaction of a multitude of events, processes and relationships in a complex system and that take a more interactive, sociological perspective on risk are:

- Normal-accident theory
- Control theory
- High-reliability theory

#### **3.7.1 Normal-accident theory**

Perrow (1984) promoted the idea of *system accidents*. Rather being the result of a few or a number of component failures, accidents involve the unanticipated interaction of a multitude of events in a complex system – events and interactions whose combinatorial explosion can quickly outwit people’s best efforts at predicting and mitigating disaster. The scale and coupling of these systems creates a different pattern for disaster where incidents develop or evolve through a conjunction of several small failures. Yet to Normal Accident Theory, analytically speaking, such accidents need not be surprising at all (not even in a fundamental sense). The central thesis of what has become known as normal accident theory (Perrow, 1984) is that accidents are the structural and virtually inevitable product of systems that are both interactively complex and tightly coupled (Wood et al, 2010)

According to Wood et al (2010), interactive complexity and coupling are two presumably different dimensions along which Perrow plotted a number of systems (from manufacturing to military operations to nuclear power plants). The separation into two dimensions has spawned a lot of thinking and discussion (including whether they are separable at all). And has offered new ways of looking at how to manage and control complex dynamic technologies, as well as

suggesting what may lie behind the label “human error” if things go wrong in a tightly coupled interactively complex system. Normal accident theory predicts that the more tightly coupled and complex a system is, the more prone it is suffering a “normal” accident.

Interactive complexity refers to component interactions that are non-linear, unfamiliar, unexpected or unplanned, and either not visible or not immediately comprehensible for people running the system. Linear interactions are those in expected and familiar production or maintenance sequences, and those that are quite visible and understandable, even if unplanned. Complex interactions are those of unfamiliar sequences, or unplanned and unexpected sequences and either not visible or not immediately comprehensible (Perrow, 1984)

Wood et al (2010), argue that humans can hardly be recipient victims of complexity and coupling alone. According to them, the very definition of Perrowian complexity actually involves both human and system, to the point where it becomes hard to see where one ends and the other begins. Furthermore, they argue that the categories of complexity and coupling are not as independent as normal accident theory suggests. They also indicate that another problem arises when complexity and coupling are treated as stable properties of a system, because it misses the dynamic nature of much safety-critical work and the ebb and flow of cognitive and coordinative activity to manage it.

### **3.7.2 Control theory**

Accident models based on control theory explicitly look at accidents as emerging from interactions among system components. They usually do not identify single causal factors, but rather look at what may have gone wrong with the system’s operation or organization of the hazardous technology that allowed an accident to take place (Wood et al, 2010). According to Rasmussen, (1997) safety or risk management is therefore viewed as a control problem (cited in Wood et al, 2010), and accidents happen when components are not adequately handled; when safety constraints that should have applied to the design and operation of the technology have loosened, or become badly monitored, managed, controlled (Wood et al, 2010).

Other main distinctive characteristic of control theory are:

- Control theory tries to capture imperfect processes, which involve people, societal and organizational structures, engineering activities, and physical parts.
- Control theory sees the operation of hazardous technology as a matter of keeping many interrelated components in a state of dynamic equilibrium (which means that control inputs, even if small, are continually necessary for the system to stay safe: it cannot be left on its own as could a statically stable system). Keeping a dynamically stable system in equilibrium happens through the use of feedback loops of information and control. Thus, accidents are not the result of initiating (root cause) event that triggers a series of events, which eventually leads to a loss. Instead, accidents result from interactions among components that violate the safety constraints on system design and operation, by which feedback and control inputs can grow increasingly at odds with the real problem or processes to be controlled.
- Control theory embraces a much more complex idea of causation, taken from complexity theory. Small changes somewhere in the system, or small variations in the initial state of a process, can lead to huge consequences elsewhere. The Newtonian symmetry between cause and effects no longer applies.
- Control theory sees accidents as the result of normal system behavior, as organizations try to adapt to multiple, normal pressures that operate on it every day (Woods et al, 2010).

### **3.7.3 High-reliability theory**

High reliability theory describes the extent and nature of the effort that people, at all levels in an organization, have to engage in to ensure consistently safe operations despite its inherent complexity and risk (Woods et al, 2010).

Critique of the model is that:

- Wrong assumptions, since the operational people, those who work at the sharp end of an organization hardly defined safety in terms of risk management or error avoidance.
- The model also sustains decomposition assumptions that are not really applicable to complex systems (Leveson, 2002 cited in Woods et al, 2010). For example, it suggests that

each component or sub-system (layer of defence) operates reasonably independently, so that the results of a safety analysis (e.g., inspection or certification of people or components or sub-systems) are not distorted when we start putting the pieces back together again. It also assumes that the principles that govern the assembly of the entire system from its constituent sub-systems or components are straightforward. And that the interactions, if any, between the sub-systems will be linear: not subject to anticipated feedback loops or non-linear interactions.

What is interesting and also important here are that not all the models/theories can be without care, adapted to creating and understanding safety in complex systems. This is because, understanding and knowing their limitations and areas of adaptation is important in creating safety and working in a demanding environment such as complex systems. Furthermore, there are important in understanding the concept of system.

### **3. 8 Summary**

In this chapter, I have through the literature review tried to relate earlier studies on system safety or safety system to the theoretical approach. These include historical background on where the research in civil aviation focused on through different time periods. In the process I have presented different safety and accidents models. I have also shown how the trend will be in the future on the number of airline departures. In this context, it is important to have systems that can tackle this development. In the process, I have argued for why there is a need for to have better systems for those who have not implemented such systems today. Furthermore, the opportunity such system can help the civil aviation authorities in performance-based safety oversight.

## **Chapter 4 Promoting and inhibiting factors in system safety programs**

In this chapter I will present how I have come about to elaborate the factors that are important for implementing Safety Management System. To try to answer the question on factors that are important for promoting Safety Management System, I have adopted the McKinsey 7-s model on strategy implementation. The model is explained below. To try to answer the questions on what inhibits or restrains the implementation of Safety Management system, I have looked for the key problem areas in safety system or system Safety. 8-key problem areas were identified.

### **4.1. What promotes implementation of Safety management system in aviation?**

In order to answer this question, I have looked for factors that are important for implementation. Through the literature review, I discovered that I could adopt the McKinsey 7-s model for the purpose in the study. Today it is better known or referred to as the 7-s model. According to Kaplan (2005), the model was introduced by McKinsey partners Tom Peters and Robert Waterman in the book “In Search of Excellence”. In brief, the model, describes the seven factors critical for effective strategy execution. The McKinsey 7-s comprise of: style, skills, staff, schemes, structure, shared values and systems.

#### **4.1.1 Definition of variables and categories as enablers**

References to this section are based on Kaplan (2005) and Osarenkhoe (2006).

Factors that promotes the implementation

Safety leadership or Leadership of safety (*style*):

The leadership style of managers – how they spend their time, what they focus attention on, what questions they ask of employees, how they make decisions; also the organizational culture (the dominant values and beliefs, the norms, the conscious and unconscious symbolic acts taken by leaders (job titles, dress codes, executive dining rooms, corporate jets, informal meetings with employees).

Procedures and Policy (*skills*):

The distinctive competencies of the organization; what it does best along dimensions such as people, management practices, processes, systems, technology, and customer relationships.

Training and Recurrency training (*Staff*):

The people, their backgrounds and competencies; how the organization recruits, selects, trains, socializes, manages the careers, and promotes employees.

Business Objectives (*Strategy /Schemes*): The positioning and actions taken by an enterprise, in response to or anticipation of changes in the external environment, intended to achieve competitive advantage.

Organizational Structure (*Structure*):

The way in which tasks and people are specialized and divided, and authority is distributed; how activities and reporting relationships are grouped; the mechanisms by which activities in the organization are coordinated.

Safety Culture (*Shared values*):

The core or fundamental set of values that are widely shared in the organization and serve as guiding principles of what is important; vision, mission, and values statements that provide a broad sense of purpose for all employees.

Software Management (*Systems*):

The formal and informal procedures used to manage the organization, including management control systems, performance measurement and reward systems, planning, budgeting and resource allocation systems, and management information systems.

## **4.2 General problems in system safety**

Stephans (2004), mention eight general problem areas related to system safety that are vital for safety services. These problem areas are interrelated; however, they can be summarized as follows:

- Standardization
- Risk assessment codes
- Data
- Communications
- Life Cycle
- Education and training



- Human factors
- Software

For my questionnaire and research design, I have reduced the number to 7. The reason for this is that data and communications factors are very similar. Instead of treating them as two separate or different issues, they are reduced to one factor and renamed as “Quality Data and information”

#### **4.2.1 Definition of variables and categories as inhibitors**

Below are factors that inhibit implementation of Safety Management System in aviation.

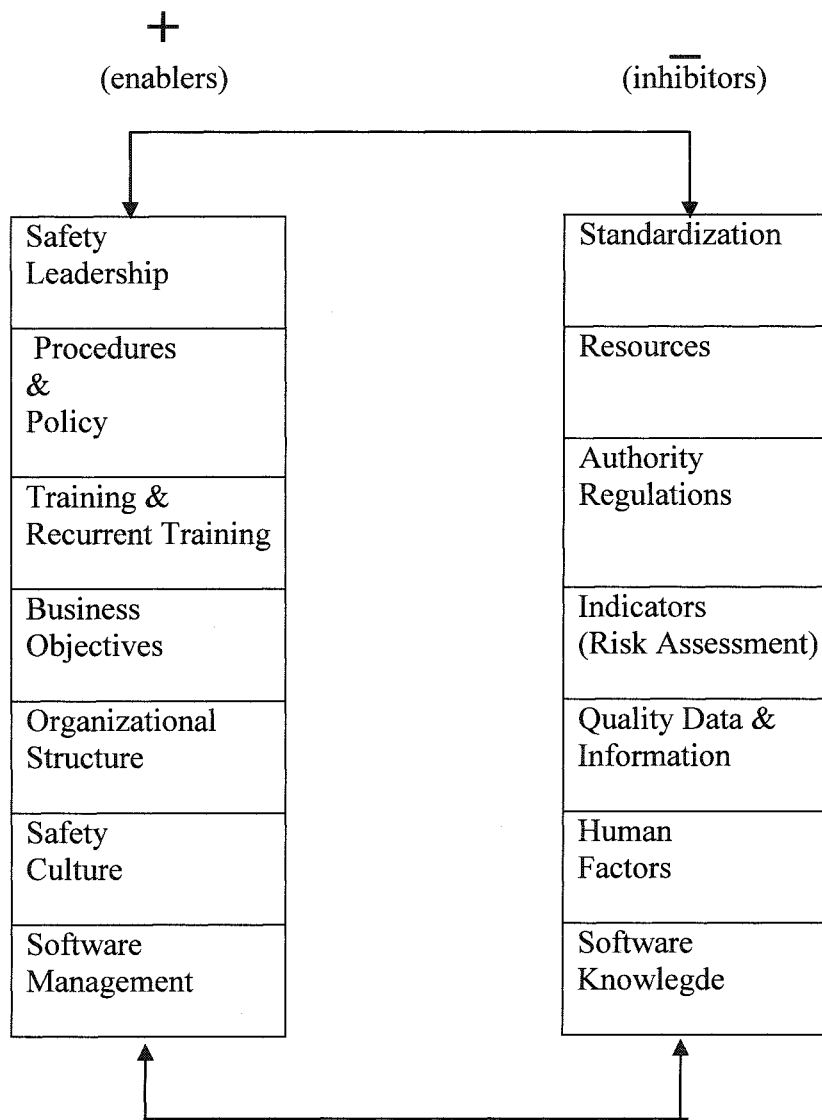
These are regarded as general problem areas in safety system.

- **Standardization**  
Standardization as an inhibiting factor implies lack of standard terms, basic tools and techniques
- **Resources**  
Resources can be divided into at least three categories; human, technical and financial.  
Example: Budgetary factors such as lack of resources to fund activities
- **Authority Regulations**  
How authority information is interpreted, different practices of the same regulation among different national authorities. Furthermore, communication and partnership with the market.
- **Indicators (risk assessment)**  
There is no standard risk assessment code (RAC). Thus, the process is too subjective and furthermore, creates difficulties in establishing and comparing indicators.
- **Quality data and information**  
The lack of systematic cataloging and uniform methods of data analysis; this includes reporting routines.
- **Human factors**  
There is considerably less reliable data available on human performance than on hardware.

Software knowledge

Software is applied and functions independently of the total effort

### 4.3 Model for analysis



**Figure 4.1** Model for analysis of promoting and inhibiting factors in Safety Management System implementation.

The model for analysis is constructed based of the main question in the study, and from the different sources from the literature review. It is a holistic approach and in line with the theoretical approach I have chosen. On the right hand side are the enablers or promoters and on the left side are the inhibitors. The enabling factors can also be seen as the factors for strategic implementation. The inhibiting factors are general problems areas in system safety.

The arrows indicate that the elements in the model are not constant. Both enablers and inhibitors influence each other. The dotted line illustrates that within each side the dimension or balance changes. For example, too much focus on the business objectives can reduce the attention on the other elements.

#### **4.4 Summary**

I have described in this chapter how I have through the literature review come to separate between the promoting (enablers/facilitators) factors and the inhibiting (barriers/inhibitors/restraining) factors. Based on these factors, I have presented the model for analysis that I intend to apply in the research. The model for analysis is related to the question I have earlier posed. Further, it can be used a theoretical model in the analysis of Complex systems. The model is holistic, and neither should it be conceptualized as static. In Chapter 9, this model will be presented in a wider context.

#### **Remarks**

It is always difficult to divide between what is a promoter or an inhibitor, since there are always many other elements can be involved or included in the concept. This can be very challenging, especially when undertaking a survey. Thus, the answer may vary according to the followings:

- The knowledge of those who answer
- It depends very much on the situation or their experiences
- Cultural aspect
- The concept is interpreted as two sides of the same thing

The last point is very interesting from a complexity system theory point of view. It is interesting in the sense that it try's to study why the changes come about. Furthermore, it does not see structure as "static". It is therefore important to bear in mind that these factors are not constant (static).

According to Anantamula and Kanungo; 'it may be not useful to normatively classify elements as facilitators or inhibitors'. However, from the standpoint of enablers and barriers, this approach allows us to understand how each of these elements can behave as an enabler as well as an inhibitor (Anantatmula & Kanungo 2007, p. 7).

I also believe that the 7-s model can be applied as a holistic approach to safety organizations, since it covers many factors that are often left out.

## Chapter 5 Methodology

This chapter is on methodological issues concerning research and research methods in management. It includes also the research and questionnaire design for the study.

### 5.1. What is methodology?

Methodology is a combination of techniques used to inquire into a specific situation (Easterby-Smith et al., 2012). It raises all sorts of philosophical questions about what is possible for researchers to know and how valid their claims to knowledge might be. (Fischer 2004). The philosophical questions can be summarized to four areas of assumptions, which are of ontological, epistemological, human nature and methodological nature.

Ontology or assumptions of ontological nature according Burrell and Morgan (1979), concerns the very essence of the phenomena under investigation. The basic ontological question a social scientist faces is whether the ‘reality’ to be investigated is external to the individual – imposing itself on the individual consciousness from without – or the product of individual consciousness; whether ‘reality’ is of an ‘objective’ nature, or the product of individual cognition; whether ‘reality’ is a given ‘out there in the world, or product of one’s mind.

There are four different types of ontological views; realism, internal realism, relativism and nominalism.

**Table 5.1** Four different types of ontologies

Ontology	Realism	Internal realism	Relativism	Nominalism
Truth	Single truth	Truth exists, but is obscure	There are many ‘truths’	There is no truth
Facts	Facts exist and can be revealed	Facts are concrete, but cannot be accessed directly	Facts depend on the viewpoint of the observer	Facts are all human creations

Source: Easterby-Smith et al. ( 2012 p. 19)

Epistemology or assumptions of epistemological nature are assumptions about the grounds of knowledge – about how one might begin to understand the world and communicate this knowledge to fellow human beings. These assumptions entail ideas, for example about what forms of knowledge can be obtained, and how one can sort out what is regarded as ‘true’ from what is to be regarded as ‘false’. The epistemological assumptions in these instances determine extreme positions on the issue of whether knowledge is something which can be acquired on one hand, or is something that has to be personally experienced on the other (Burrell and Morgan, 1979). The other views are presented below:

*Positivism*; is that the social world exists externally, and that its properties should be measured through objective methods, rather than being inferred subjectively through sensation, reflection and intuition. *Social constructionism*, focuses on the ways that people make sense of the world, especially through sharing their experiences with others via the medium of language. In other words, ‘reality’ is determined by people rather than by objective and external factors (Easterby-Smith et al., 2012).

The human nature assumptions entail a view of human beings responding in a mechanistic or deterministic fashion to the situations encountered in their external world. This view tends to be one in which human beings and their experiences are regarded as products of their environment; one in which humans are conditioned by their external circumstances. This perspective can be contrasted with one which attributes to human beings a much more creative role: with a perspective where ‘free will’ occupies the centre of the stage; where man is regarded as the creator of his environment, the controller as opposed to the controlled, the master rather than the marionette. In these two extreme views of the relationship between humans beings and their environment, one finds great philosophical debates between the advocates of determinism on the one hand and the voluntarism on the other (Burrell and Morgan 1979).

Assumptions of methodological nature are influenced by the way one attempts to investigate and obtain ‘knowledge’ about the social world. Since different ontologies, epistemologies and models of human nature are likely to incline social scientists towards different methodologies. The methodological issues of importance that treat the social world as if it were a hard, external, objective reality are thus the concepts themselves, their measurement and identification of underlying themes. However, the methodological issues of importance

that view social reality that stresses the importance of the subjective experience of individuals in the creation of the social world. The principal concern is with understanding the way in which individuals creates, modifies and interprets the world in which he or she finds herself. In extreme cases, the emphasis is placed upon the explanation and understanding of what is unique and particular to the individual rather than what is general or universal. In short, the approach questions whether there exists an external reality worthy of study (Burrell and Morgan, 1979).

Thus, understanding the philosophical issues has bearing on interpreting research, performing research and the production of knowledge.

The approach I have chosen is relativism. According to Easterby-Smith et al. (2012), the ontological view in relativism, is that phenomena depend on the perspective from which we observe them. The epistemological position is that observation will be more accurate or credible, if made from several different perspectives. I am aware that how the questions have been constructed have some bearing on the results in my study. I also believe that if resources were available (more time), qualitative study would be needed to get more answers.

## **5.2 Realist research**

It is common that most of the research in management take a realist approach (Fisher, 2004), many textbooks treat realism and positivism as the same. However, they “should be treated as separate approaches” according to (Johnson and Duberley, 2004 in Fisher 2004, p. 35). I believe that claiming that realism and positivism are the same, has methodological implications that might result in applying wrong methods. However, it is correct to say that both realism and positivism are associated to functionalist perspectives and objectivist views. However, it would be wrong to claim that realism and positivism are the same, when defining what ‘knowledge’ and reality they attempt to explain.

Furthermore, this issue is very important when attempting methodological pluralism. Meaning when one try’s to adopt approaches from two different philosophical dimensions in a research. Fisher (2004), the big question is whether it is possible to combine realist research and an interpretative approach? Gill and Johnson (1997), “argue that if you take a realist

stance, then aspects of an interpretivist approach could be brought in a useful adjunct to the research. But they also claim that the reverse is not true” (in Fisher 2004: 49).

There are at least two ways in which interpretivism may be called in to aid realist research:

1. A research may start off with a piece of realist research that identifies an association between two variables, then use an interpretative approach to understand causal connection, mechanism, which shows in all complexity how different aspects interact.
2. The other possibility uses the ease with which interpretivist research generates hypotheses about the associations between variables. In this case interpretivist research is ground-clearing operation that precedes a piece of realist research (Fisher 2004).

### **5.3 Research design**

Based on the literature review, I have been able to identify and summarize what I mean are important factors that are vital in promoting or inhibiting Safety Management System implementation. These are factors that are highlighted and of concern in system safety studies. The terminology or wording in many of the literature is different, but in general, they describe and to relate to the same issues.

#### **5.3.1 Questionnaire design**

Since I wanted to study the attitude towards the promoting and inhibiting factors, the Likert scale was chosen for the purpose. I chose the original Likert scale Scale of 1-5; and the reason is that it is easily identifiable and commonly use.

According to Riley et al., “the Likert scale assumes the groupness of attitudes so that dimensions are said to be related and therefore only total sample scores can be interpreted. To put it simple, the objective of an attitude survey is to find this positive-negative tendency towards the object. This is done by developing an equal number of positive and negative statements about the object then invite the subject to say to what extent they agree or disagree with the statement. If we are measuring a tendency then there must be some dividing line between positive and negative. The mid-point in the scale fulfills this function. The measuring principle is to find a total score and see if the subjects are above or below the mid-point score: above means positive, and below negative” (Riley et al. 2000, p. 121)



In the study, the scale Very Import =5, Important = 4, Uncertain =3, Little important = 2, and Not Important = 1, was used for finding out the importance of the enablers and inhibitors for the respondents. The scale Strongly Agree =5, Agree = 4, Uncertain =3, Disagree = 2, and Strongly Disagree = 1, was used to find out the opinion on the relevance of SMS.

Preparing or finding a question that cannot be easily misunderstood is not an easy task. Especially when defining a questionnaire. There is always the possibility of creating leading question but also confusing question. Leading question can be questions design to give more the view of the researcher than the issue under study. Confusing questions can be how the question is posed but also the sentences or terms are contradicting.

Two main questions were posed. In the first question, it was to rank promoting factors according to the Likert scale. These factors are regarded as important strategic elements. As earlier mentioned, I see my contribution to system safety studies is a holistic approach to the organizational factors. Important here is that the focus in most studies have been mainly on management. The other factors existing in an organization is not clearly stated. Furthermore, the debates end in most cases by packaging the organizational issues as production demands. I have chosen to adapt the 7-s strategic items, since these are not only important for any business success but indeed essential a successful strategic implementation.

In the second question, it was to rank inhibiting factors that restrain SMS implementation. These factors are also identified through the literature review as problem areas in system safety.

The questions were kept simple because SMS applies to different sectors in the aviation industry. In other word, the question was not only intended or directed to a specific sector or area. The questionnaire consisted of two parts. In the first part, respondents were asked to rank the importance of 7 enablers and 7 inhibitors of SMS implementation. The second part was to get background information of the respondents. This part was intended to be used as control questions. It included work titles, main country of operation, and knowledge of SMS.

The research was first intended to be operators in Norway. Two companies were contacted to conduct/distribute the questionnaire internally. When I saw that I was not getting response. I

decided to publish the questionnaire on LinkedIn. The questionnaire survey was conducted from 16 April 2012 to 14 May 2012 on an internet website targeting aviation professionals with interest in Safety Management, and only a total of 31 effective samples were obtained. Unfortunately, the response was not overwhelming. But the answers were no doubt interesting despite the low response rate.

However, I have decided to present the results here and for that matter the dissertation takes a more theoretical approach. The lessons from the response despite the low response rate should not be underrated. Since it gives knowledge of the follow:

- how questionnaire on Safety Management System should be conducted and developed
- issues that need to be followed up, say through qualitative studies.

When publishing a questionnaire on the internet, one cannot say much about the population.

#### **5.4.1 Reliability and validity**

Reliability is about replication (being) able to repeat or reproduce results. Example in an attitude research; a scale is reliable to the extent to which repeated applications of the scale produce the same results given that the attitudes under investigation remains the same.

Validity, on the other hand, is about whether your measuring instrument actually measures the specific attitudes you set out to find not some alternative attitudes however closely they may be related (Riley et al., 2000)

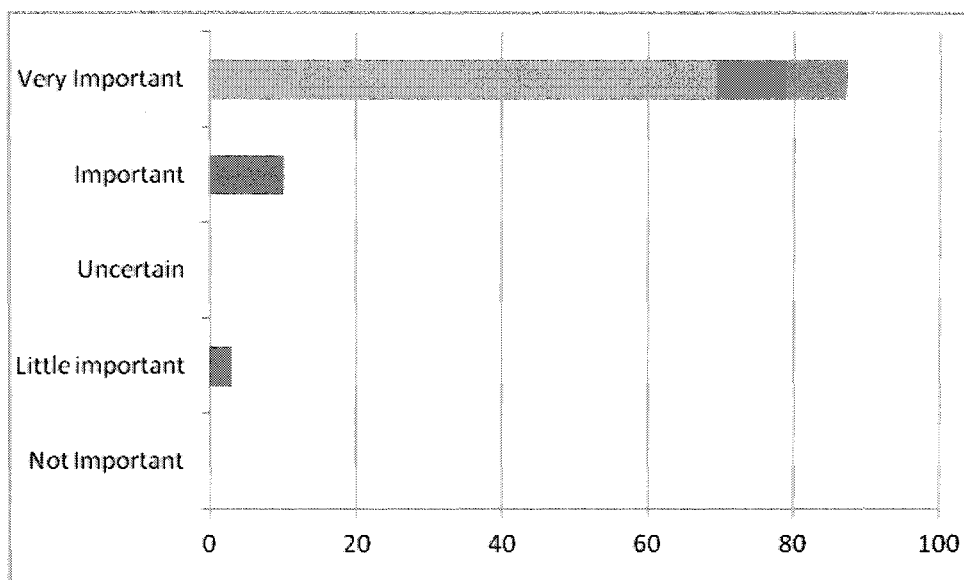
The reliability in my study would therefore, if I performed the same investigation and got the same answer. The reliability would even be better if another researcher had come up with the same results.

The validity of the study can be discussed, since the study was intended for different areas in aviation. The meaning and definitions of some of the 'factors' will therefore have different interpretations, depending on how it is used in that sector. Another issue is the cultural aspect. Although the definitions may be the same, the meanings would be different depending on the cultural setting and how things are done. The responses in this study came from 16 different countries.

## Chapter 6 Data analysis

In this chapter I will present the results from the survey.

### 6.1. Safety leadership as a factor in promoting Safety Management System



**Figure 6.1** Safety Leadership as a promoting factor in SMS. (Percent) N=31

Figure 6.1 indicates that Safety leadership is clearly recognized as an important enabler for SMS. The figure shows that 97 percent of the respondents regard safety leadership as an important or very important factor for implementing SMS. The average score for all the answers is 4,8 on a scale from 1-5. It is also the highest score for factors regarded as important for promoting SMS implementation. The indication is that safety leadership is a very important enabler and the result is not surprising.

Safety leadership is the key word in the management of safety. The purpose of a SMS, is a management system for ensuring safe and efficient operations. In the ICAO context, this falls under what is defined as safety accountabilities. This implies that;

“The [organization] shall identify the Accountable Executive who, irrespective of other functions, shall have ultimate responsibility and accountability, on behalf of the [organization], for the implementation and maintenance of the SMS. The [organization] shall also identify the accountabilities of all members of management, irrespective of other functions, as well as of employees, with respect to the safety performance of the SMS. Safety responsibilities, accountabilities and authorities shall be documented and communicated throughout the organization, and shall include a

definition of the levels of management with authority to make decisions regarding safety risk tolerability” (ICAO, 2009, 8-APP 1-2).

According to Reid et al (2008), management systems have been demonstrated as important in the management of safety performance in the same way that general management systems are important in the management of productivity. Leadership, and particularly that of senior managers within an organisation, is regularly put forward as a fundamental aspect in the success of management systems.

However, Reid and company, argues that very few studies have been undertaken concerning leadership of safety in organizations. They question among other things, whether safety needs to be managed in a different way to other aspects of the business, such as productivity? And if there is there a particular leadership style for senior managers (e.g. transformational) that influences the level of safety in their organizations? (Reid et al (2008).

There are, however, on going research on leadership of safety in organizations. It does not implicit go by that name. This field of studies falls under what is named complex system leadership theory. More on the complex system leadership theory will be discussed later.

Back to the issue of if ‘safety needs to be managed in a different way to other aspects of business’? There are certainly many ways of answering this question. Briefly, safety doesn’t have to be managed differently, but one can say that traditional managerial leadership has limitations, as regards to safety.

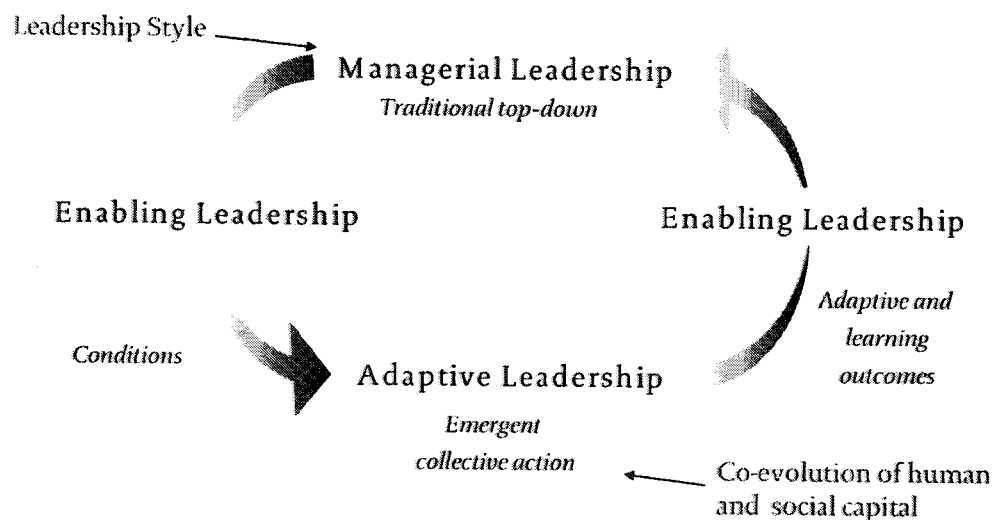
Schreiber and Carley (2007) argue that traditional leadership has limited applicability to postmodern organizations as it is mainly focused on efficiency and control. Whereas, the postmodern organizations has a design paradox in which leaders are concerned with efficiency and control, as well as complex functioning.

What is known as the organizational design paradox, is that the recognition that while organizations need to stimulate emergent collective action, they also have bureaucratic nature and a need to efficiently control organizational outcomes for exploitation. Complex functioning is the coevolution of human and social capital that results from the interdependent interactions among autonomous agents with diverse knowledge. Complex functioning

produces learning and adaption, both of which are needed for effective response in highly volatile environments.

The relationship between managerial leadership and complexity leadership can best be described by the figure depicted below. These include the three entangled leadership roles of complexity theory, managerial leadership, adaptive leadership and enabling leadership.

*Managerial leadership* is the traditional notion of formal leadership roles with top-down control and strategic planning. Leadership style is a behaviour that is associated with formal leadership roles. *Adaptive leadership* is leadership that occurs within the interdependent interactions of emergent collective action and that helps produce emergent outcomes such as learning and adaption. Adaptive leadership is important to the complex functioning of the network. *Enabling leadership* has two roles. First, it creates conditions that stimulate emergent collective action and adaptive leadership. Second, it channels productive emergent outcomes originating in the collective action response back up to the managerial leadership for strategic planning and exploitation (Schreiber and Carley, (2007).



**Figure 6.2** The three entangled leadership roles of complexity leadership theory.

Source: Uhl-Bien et al. (2002) in Schreiber and Carley, (2007 p. 233).

The bottom line is , “leadership style may be important to complex functioning because differences in how decisions are made within the organization could affect the coevolution of human and social capital” (Schreiber and Carley (2007), p. 229). Naturally, this has

consequences for employee's dedication, commitment and participation to the organization's strategic intent.

Safety leadership (in aviation) should therefore, also, entail elements of enabling leadership and adaptive leadership. Thus, in order to tackle the challenges in globalization, aviation sector as a turbulent market, and stimulate change and commitment for safety efforts.

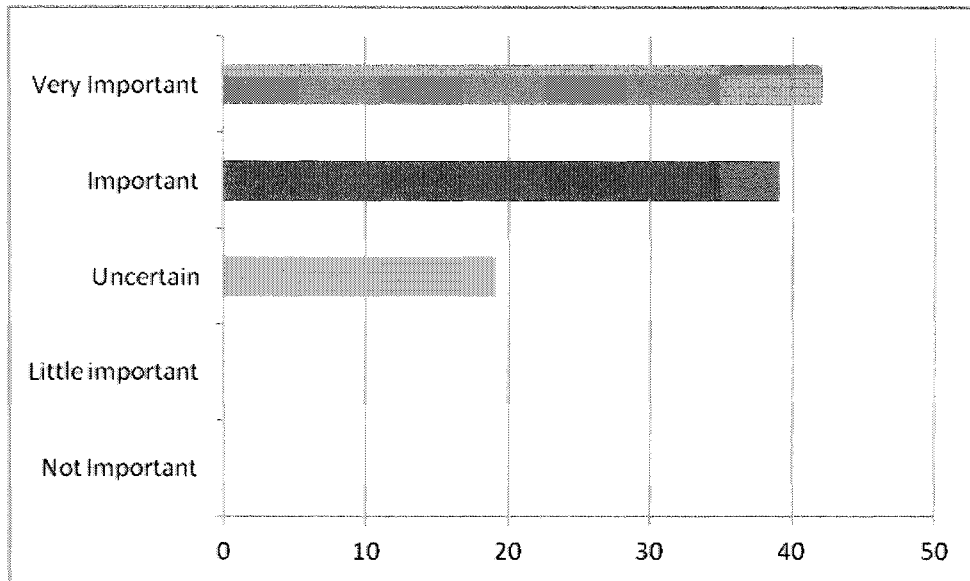
## **6.2. Procedures and policy as a factor in promoting Safety Management System**

Aviation sector is highly respected and reckoned for its routines concerning procedures. An illustration is the book "Why Hospitals Should Fly – The Ultimate Flight Plan to Patient Safety and Quality Care". The book is about how the health care system can learn from aviation safety. However, it is interesting that other sectors such as railway, hospitals, nuclear plants have implemented SMS, but in the aviation sector, this is a new thing. This is not to say that safety programs have been missing in aviation.

Safety policy is one of the four pillars of SMS. The others pillars are safety risk management, safety assurance, safety assurance and safety promotions. According to the ICAO SMS framework, safety policy and objectives is composed of five elements:

- management commitment and responsibility
- safety accountabilities
- appointment of key safety personnel
- coordination of emergency response planning
- SMS documentation

One of the main purpose of the safety policy, is that it should actively encourage effective safety reporting and, by defining the line between acceptable performance (often unintended errors) and unacceptable performance (such as negligence, recklessness, violations or sabotage), provide fair protection to reporters. The SMS documentation is the Safety Management System Manual (SMSM), is meant as a key instrument for communicating the organization's approach to safety to the whole organization. It documents all aspects of the SMS, including the safety policy, objectives, procedures and individual safety accountabilities (ICAO, 2009).

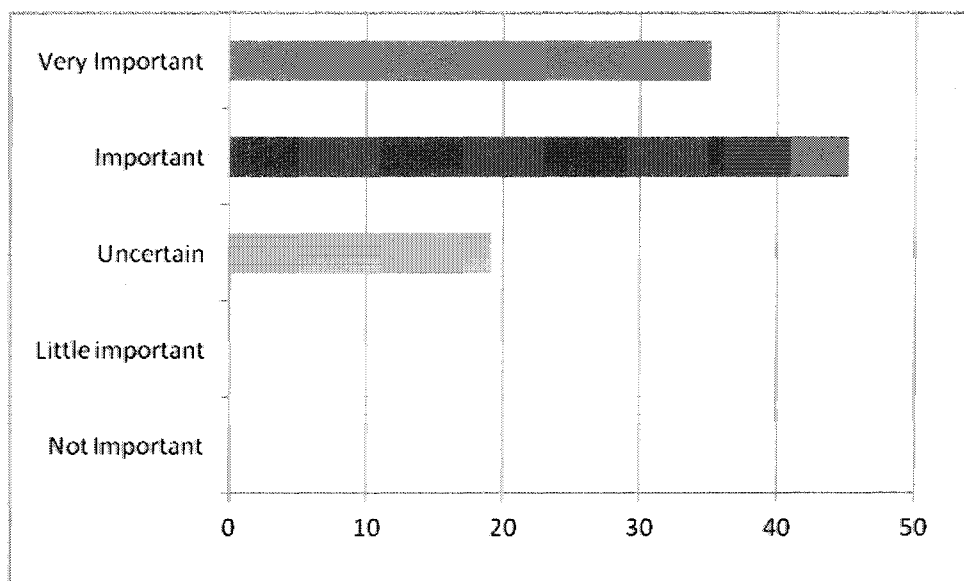


**Figure 6.3** Procedures and policy as a promoting factor for SMS. (Percent) N=31

The results from the respondents show that 42 percent regard procedures and policy as very important, 39 percent as important. However, 19 percent are uncertain. The average score for all the answers is 4,2 on a scale from 1-5. It is the third highest score for factors regarded as important for promoting SMS implementation.

### **6.3. Training and recurrent training as a factor in promoting Safety Management System**

Training and recurrent training is a requirement that is regulated in aviation. However, training comes with a cost.



**Figure 6.4** Training and recurrent training as a promoting factor for SMS. (Percent) N=31

35 percent regard training and recurrent training as very important, while 45 say this is important. 19 percent are uncertain. The average score for all the answers is 4,1. This is the fourth highest score for factors regarded as important for promoting SMS implementation.

Safety promotion, as presented earlier, is one of the four pillars of SMS. According to the ICAO SMS framework, safety promotion is composed of two elements:

- Training and education
- Safety Communication

Concerning Training and education, “The [organization] shall develop and maintain a safety training programme that ensures that personnel are trained and competent to perform the SMS duties. The scope of the safety training shall be appropriate to each individual’s involvement in the SMS”. As regards to Safety communication, “the [organization] shall develop and maintain formal means for safety communication that ensures that all personnel are fully aware of the SMS, conveys safety-critical information, and explains why particular safety actions are taken and why safety procedures are introduced or changed” (ICAO,2009 p. 8-APP-1-3).

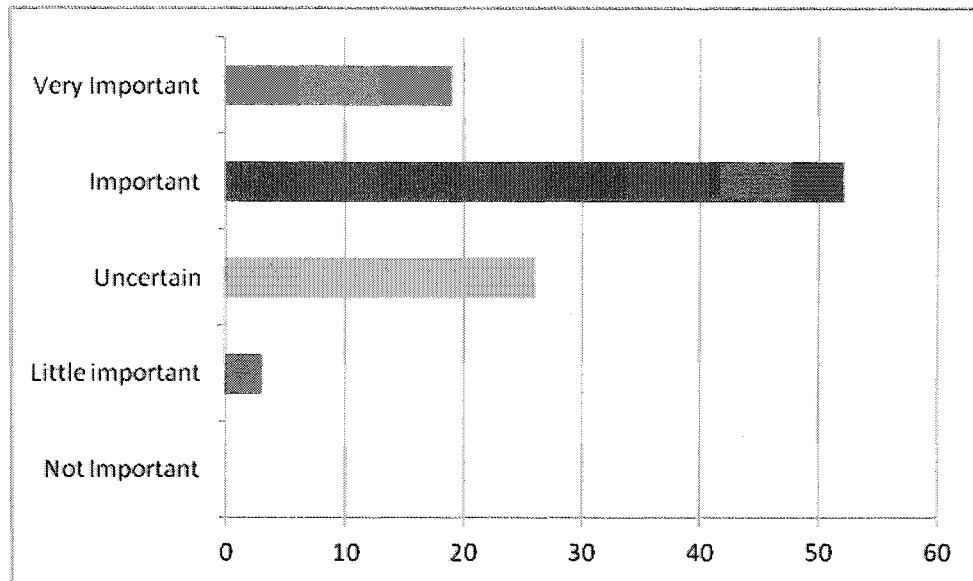
From a complexity perspective, it is essential not to forget history. The comprehension of how people in the system have been trained is vital. Here, an important aspect is input. The organization has to have inputs the whole time to keep it functioning. Thus, it becomes a learning organization.

#### **6.4. Business objective as a factor in promoting Safety Management System**

Business objective as defined earlier is the “positioning and actions taken by an enterprise, in response to or anticipation of changes in the external environment, intended to achieve competitive advantage”, or in short strategy. Business objective in the ICAO context is referred to as ‘production goals’. Meaning, decisions on how the delivery of services is made.

Figure 6.5 show that 71 percent of the responses regard the business objective as an important or very important factor for implementing SMS. However, 26 percent are uncertain of whether the business objective is either important or not, while a 3 percent regard that it has little importance. The average score for all the answers is 3,9.





**Figure 6.5** Business objective as a promoting factor for SMS. (Percent) N=31

The business objective or strategy of the airline operators and service providers in the aviation industry has never been more challenging, in order to survive. The low-cost carriers (LCC) such as SouthWest, Ryanair, Norwegian have created a highly competitive market situation. The international financial crisis that has been going since 2008 is another issue. Globalization and the deregulation of the industry are among many other things.

The business strategy can, however, conflict with the employee’s interest. An example is from an internet article where an anonymous pilot working in Norwegian, meant that Ryanair has become a role model for modern airline and that the work hour in Norwegian is a threat to safety. Åsa Larsson, Head of information-Norwegian, responded in the same article that they look at costs to compete with companies in Europe and emphasized that:

“Strategy is a management responsibility. It is not the employees who set the company strategy”

(det er ledelsen i selskapet, og ikke flygerne, som skal utforme selskapets strategi.

“Piloter Advarer Mot Norwegian” 2012)

Studies show that having a clearly defined and communicated strategy is crucial and vital for any implementation, if not business survival. Therefore, it is an important enabler.

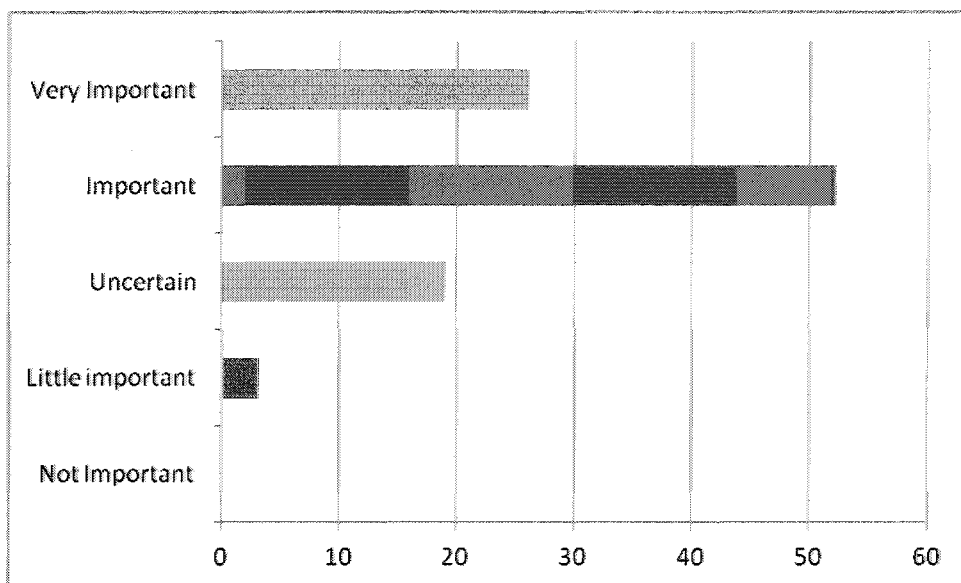
According to the ICAO SMM or EASA’s basic regulation, “the management systems shall correspond to the size of the organization and the nature of the complexity of its activities,

taking into account the hazards and associated risks inherent in these activities” (ICAO, 2009; EASA, 2012). This means that the SMS should be an integrated part of the business objective or ‘production goals.

**6.5. Organizational structure as a factor in promoting Safety Management System**

Organization structure, here relates to how tasks and people are specialized and divided and how authority is distributed within the organization. In the aviation, managerial positions are regulated. These are regulated positions that must meet certain regulatory requirements and must be in place to get an Airline Operators Certificate (AOC) or a license to operate. This means that an organization cannot be approved if key positions are vacant and that for certain positions, one must pass tests arranged by the civil aviation authority. However, organizations are free to structure their organizations and even, to some extent, work titles. In other words “there will be as many organizational charts as organizations may exist in aviation” (ICAO, 2009, p.8-7)

Safety accountability is what ICAO relates to when referring to how SMS should be organized. According to ICAO, the safety accountabilities, responsibilities and authorities of all departmental heads and/or persons responsible for functional units, and in particular line managers, must be described in the organization’s safety management systems manual (SMSM) (ICAO 2009).



**Figure 6.6** Organizational structure as a promoting factor for SMS. (Percent) N=31

Figure 6.6, the results from the respondents show that 52 percent regard organizational structure as important, 26 percent as very important. However, 19 percent are uncertain. The average score for all the answers is 4.

### **6.6. Safety Culture as a factor in promoting Safety Management System**

Gill and Shergill (2004), describes that the relationship between safety management systems, and safety culture has been discussed extensively in the safety literature of high-tech and high-risk endeavours including aviation.

Culture can be described in the simplest terms as a “collective programming of the mind”. Culture influences the values, beliefs and behavior that we share with the other members of our various social groups. Culture binds us together as members of groups and provides clues and cues as to how to behave in both normal and unusual situations. Culture sets the rules of the game, or the framework for all our interpersonal interactions. It is the sum total of the way people conducts their affairs in a particular social milieu and provides a context in which things happen. In terms of the management of safety, understanding culture is as important as understanding context, since culture is an important determinant of human performance (ICAO, 2009)

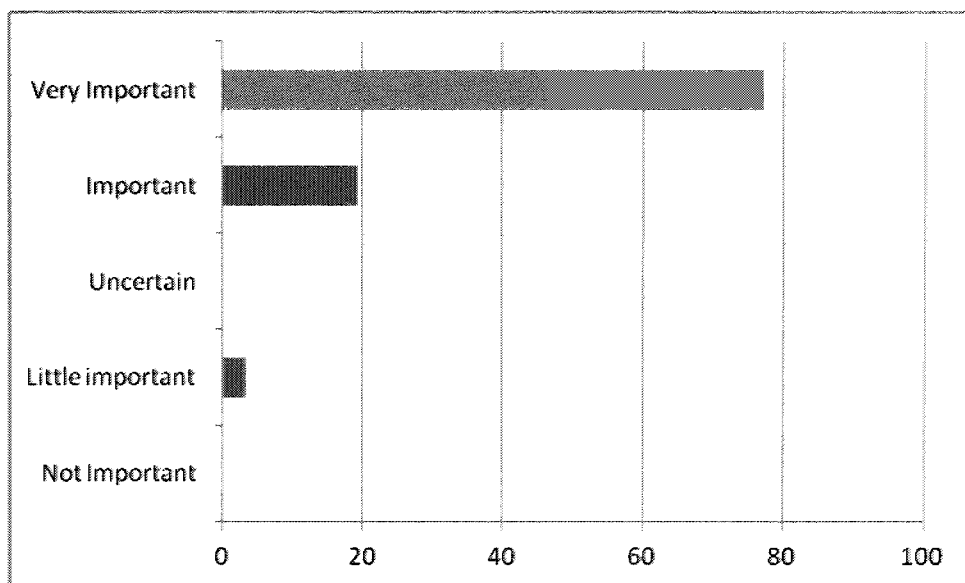
The greatest scope for creating and nourishing an effective, generative culture for the management of safety is at the organizational level. Operational personnel in aviation are influenced in their day-to-day behaviour by the value system of their organization. Does the organization recognize safety merit, promote individual initiative, discourage or encourage safety risk tolerance, enforce strict SOP compliance, tolerate breeches of SOPs or promote open two-way communications? Thus, the organization is a major determinant of the behaviour employees will engage in while performing operational activities that support the delivery of services for which the organization is in business. Organizational culture sets the boundaries for accepted operational performance in the workplace by establishing the norms and limits. Thus, organizational culture provides a cornerstone for managerial and employee decision-making: “This is how we do things here, and this is the way we talk about the way we do things here.” Organizational culture then consists of shared beliefs, practices and attitudes. The tone for an effective, generative organizational culture is set and nurtured by the words and actions of senior management. Organizational culture is the atmosphere created by

senior management which shapes workers' attitudes towards, among others, safety practices.

Organizational culture is affected by such factors as:

- a) policies and procedures;
- b) supervisory practices;
- c) safety planning and goals;
- d) actions in response to unsafe behaviour;
- e) employee training and motivation; and
- f) employee involvement or "buy-in".

The ultimate responsibility for the establishment and adherence to sound safety practices rests with the directors and management of the organization — whether it is an airline, an aerodrome, an ATS or an AMO. The safety ethos of an organization is established from the outset by the extent (ibid)



**Figure 6.7** Safety culture as a promoting factor for SMS. (Percentage) N=31

Figure 6.7 indicates that safety culture is clearly recognized as an important enabler for SMS.

The average score for all the answers is 4,7. It is also the second highest score for factors regarded as important for promoting SMS implementation.

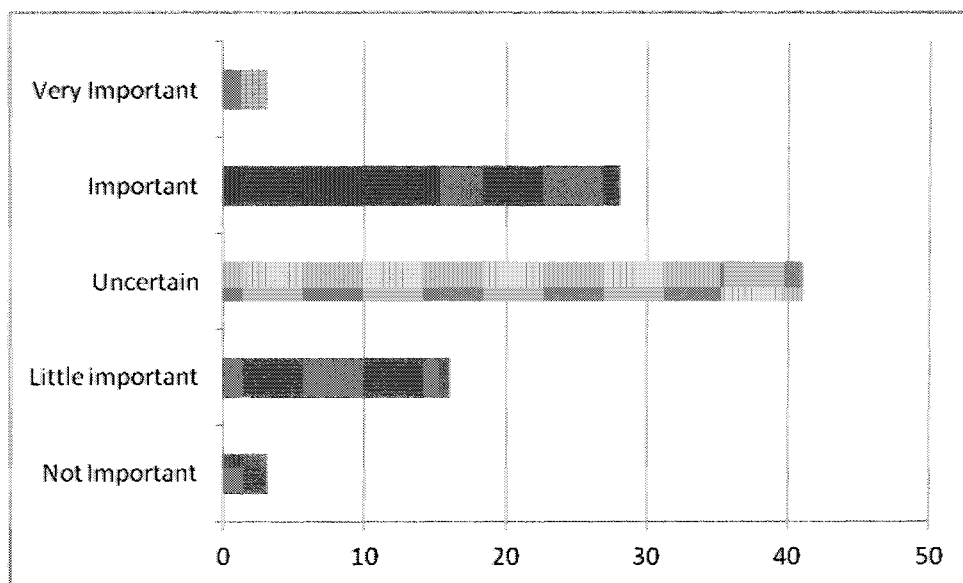
An effective safety culture produce a belief that when safety and production goals conflict, managers will ensure that safety will predominate (Hollnagel et al. 2012).

### 6.7. Software management as a factor in promoting Safety Management System

According to ICAO (2009), aviation organizations are oftentimes described as “a system of systems”. This is because aviation organizations must develop, implement and operate a number of different management systems to achieve their production goals through the delivery of services. Typical management systems an aviation organization might need to operate include:

- a) quality management system (QMS);
- b) environment management system (EMS);
- c) occupational health and safety management system (OHSMS);
- d) safety management system (SMS); and
- e) security management system (SEMS).

Figure 6.8 show that 41 percent of the respondents are uncertain of the importance of software management as an enabler for implementing SMS. However, 28 percent regard it as important, a 16 percent see that it has little importance, a 3 percent see it as very important while a 3 percent see that it has no importance at all. The average score for all the answers is 3.



**Figure 6.8** Software management as a promoting factor for SMS (Percentage) N=31

At first, I thought that probably the question was unclear. After second thoughts, I came to the conclusion that this does not necessary have to be the case. This can be because, it is an area often considered an issue for the IT-department or computer experts. Furthermore, it is not one of those subjects often discussed as a safety issue. However, the optimal use of the

information and how we update this information in our management system is a central issue here.

According to ICAO, there is a developing tendency in civil aviation to integrate all these different management systems. There are clear benefits to such integration:

- a) reduction of duplication and therefore of costs;
- b) reduction of overall organizational risks and an increase in profitability;
- c) balance of potentially conflicting objectives;
- d) elimination of potentially conflicting responsibilities and relationships; and
- e) diffusion of power systems.

ICAO states that aviation organizations should be encouraged to integrate their quality, safety, security, occupational health and safety, and environmental protection management systems. However, “this integration is presently beyond the scope of the harmonized ICAO safety management” (ICAO, 2009 p. 7-12).

### **6.8 Standardization as an inhibiting factor in Safety Management System**

How is standardization conceptualized as an inhibitor in system safety? According to Stephans (2004), this has to do with that there is the lack of standard terms, basic tools, and techniques. Stephans uses a toolbox as a suitable analogy. Ideally, the system safety manager or engineer has well-stocked toolbox of analysis types and techniques and is able to study the particular task at hand and select the appropriate tool or combination of tools to perform the task effectively and efficiently. He argues that, what if there were no “common” tools? Example, what if each box contained a completely different set of tools in a mixture of standard, metric, and unique sizes and even the names of the tools were different? Thus, because no common tools or common names exist, specifying tools or training mechanics – is almost importance. That means; each individual mechanic becomes familiar with certain tools and generally able to select something that will work, but that competence does not alleviate the problem. Since, each time we have to change mechanics, we must retrain them. Stephans stretches that in the real world of system safety, the problems are even greater (Stephans, 2004).

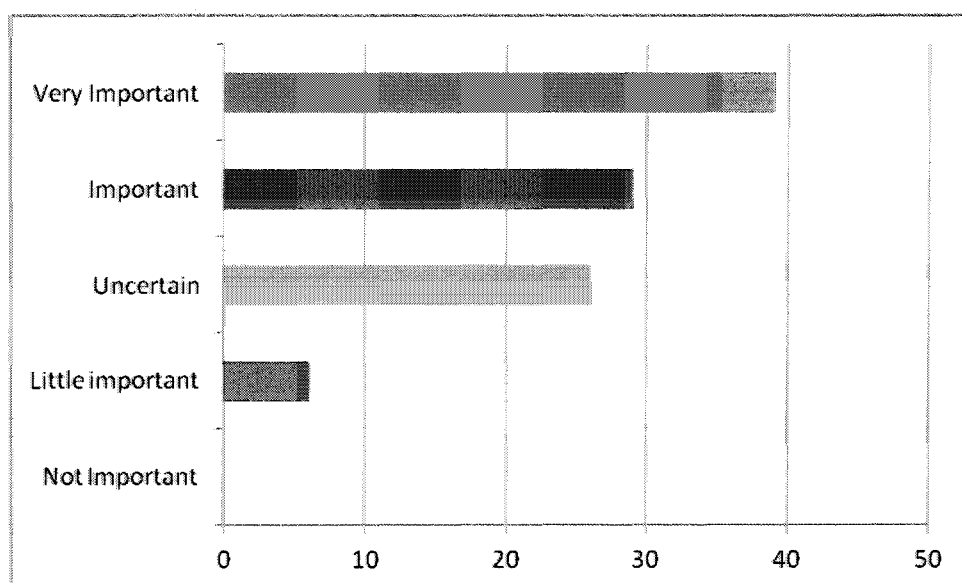
In system thinking, it is not completely correct to conceptualize a system as a toolbox. This brings about the issue that has been illustrated above. Which not only puts into question how certain types of work, assessments and applications are performed, depending on who does the task.

It is therefore wrong from a system point of view the example of what a SMS is as found in the ICAO SMM, where it is stated that:

“An SMS is the toolbox, where the actual tools employed to conduct the two basic safety management processes (hazard identification and safety risk management) are contained and protected. What an SMS does for an organization is to provide a toolbox that is appropriate, in size and complexity, to the size and complexity of the organization” (ICAO, 2009 p. 7-1-7-2)

SMS is a management tool for decision making.

Figure 6.9 shows that 39 percent of the respondents regard that standardization is a very important inhibitor for implementing SMS. However, 29 percent regard it as an important inhibitor, a 26 are uncertain of standardization as a restraining factor, and 6 percent regard that it has only of little importance as a restraining factor. The average score for all the answers is 3.



**Figure 6.9** Standardization as inhibiting factor in SMS (Percent) N=31

## **6.9 Resources as an inhibiting factor in Safety Management System**

Resources can be divided into four main categories. These are human, financial, technical and time. Hollnagel (2009), emphasizes that time because of its special character warrants that it is treated separately.

The perspective of the management of safety as an organizational process and of safety management as a core business function clearly places ultimate safety accountability and responsibility for such function at the highest level of aviation organizations (without denying the importance of individual safety responsibility for the delivery of services). Nowhere are such accountability and responsibility more evident than in decisions regarding allocation of resources. The resources available to aviation organizations are finite. There is no aviation organization with infinite resources. Resources are essential to conduct the core business functions of an organization that directly and indirectly support delivery of services. Resource allocation therefore becomes one of the most important, if not the most important, of the organizational processes that senior management must account for (ICAO, 2009).

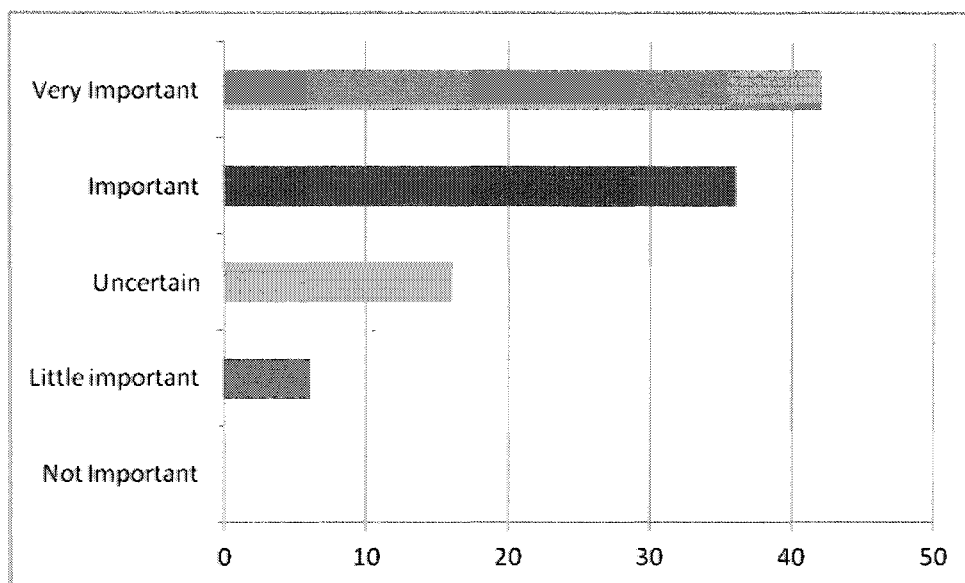
The competition in the allocation of resources can lead to a management dilemma that has been dubbed the “dilemma of the two Ps”. Simply put, the “dilemma of the two Ps” can be characterized as the conflict that would develop at the senior management level of the organization because of the perception that resources must be allocated on an either/or basis to what are believed to be conflicting goals: production goals (delivery of services) or protection goals (safety)(ibid).

The perfect situation is a balance between the resource allocation on safety management and production costs. According to ICAO, regrettably, the history of aviation shows that effective resolution of the dilemma has not been commonplace. They say what history shows is a tendency for organizations to drift into an unbalance in the allocation of resources because of the perception of competition between production and protection. In cases when such competition develops, protection is usually the loser, with organizations privileging production objectives (albeit introducing numerous caveats to the contrary). Thus, the results are being businesses ending up in catastrophe. On the other end, the bias in the allocation of resources is towards the protection side of the balance, thus leading to bankruptcy. Although, this alternative is hard to find in the annals of aviation history, it nevertheless alerts one to the



importance of sensible organizational decision making regarding allocation of resources (ibid).

Financial obligations are monitored by the Civil Aviation Authority. That can be one explanation that it does have to been a catastrophe to go bankrupt but that the authority withdraw the Airline Operation Certificate (AOC), and therefore eliminating that process.



**Figure 6.10** Resources as inhibiting factor in SMS. (Percent) N=31

Figure 6.9 shows that 42 percent of the respondents regard that lack of resources is a very important inhibitor for implementing SMS. However, 36 percent regard it as an important inhibitor, a 16 are uncertain of lack of resources as a restraining factor, and 6 percent regard that it has only of little importance as a restraining factor. The average score for all the answers is 4.1.

### **6.10 Authority regulations as an inhibiting factor in Safety Management System**

This item could have titled communication. Much of communication that leads to different forms of operation in the aviation is an authority responsibility. But aviation authorities through implementing rules set out the 'play field'. However, the same regulations have been adapted different as national levels. The key word here could have been communication.

Three reasons behind naming the question as authority regulation:

- Different national interpretation and practices of ICAO or JAR requirements
- This implies different procedures and level of
- Often leading to new terminologies with different meaning than how the markets conception of the term.

An example is the adaption of Safety Management System in EASA's Basic requirement.

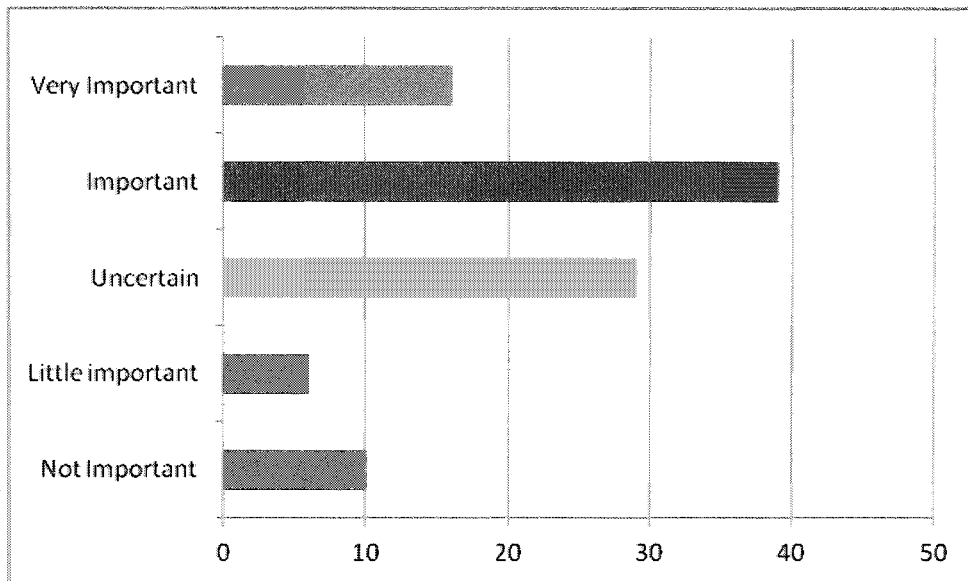
“Regarding ORA.GEN, a majority of reactions (87 out of 93) were made to Section II ‘Management system’, which reflects the volume of AMCs and GM provided in this section. Some of the reactions repeated NPA comments claiming that the EASA proposal on safety management systems (SMS) did not well align with the applicable ICAO provisions.” (EASA, 2012).

The Section II ‘Management system’ in the Organization Aircrew is to a great extent on Safety Management System. Interesting here is that, of the 93 reactions that EASA received on the section, only 4 of the reactions was not related to SMS. The point I am trying to make here is that is that requirements agreed upon in an organization. In this case ICAO, is conceived or interpreted as different when implemented by an authority, in this case EASA.

This is EASA response to the critics:

“Although different in wording, the proposed management system requirements and related AMCs as well as relevant essential requirements set at the level of the Basic Regulation are fully compliant with the ICAO framework. Within Part-ORA these provisions are presented in a way that fits various organizations, whatever their size, nature or complexity of the activities and whatever business model they wish to apply, thus ensuring their proportionate application” (ibid).

Figure 6.11 show that 39 percent of the respondents regard authority regulations as a important inhibitor for implementing SMS. However, 29 percent are uncertain on the issue of indicators as a restraining factor. 16 percent regard it as an important inhibitor, and 6 percent regard that it is of little importance as a restraining factor. The average score for all the answers is 3,5.



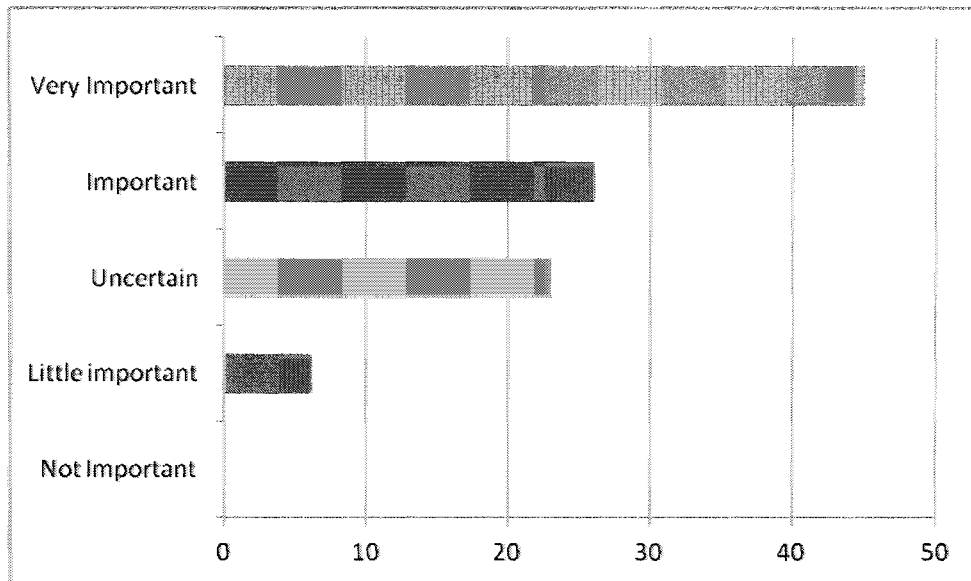
**Figure 6.11** Authority regulations as an inhibiting factor in SMS. (Percent) N=31

### **6.11 Indicators (risk assessment) as an inhibiting factor in Safety Management System**

Stephans (2004), argues that the problem with risk assessment codes RAC), unfortunately, go beyond the lack of standardization. The RAC should provide a valid basis for determining the acceptability of risks, prioritizing risks, and allocating resources to reduce risks. According to Stephans, most RAC matrices use scales that are so subjectively and poorly defined as to be virtually meaningless. Furthermore, he argues that in many cases the severity scales are too restrictive and the probability scales too broad (Stephans, 2004).

The variation in the different approaches to risk assessment is a critical issue not only for the reporting on the level of risks. It can undermine the development of reliable safety indicators.

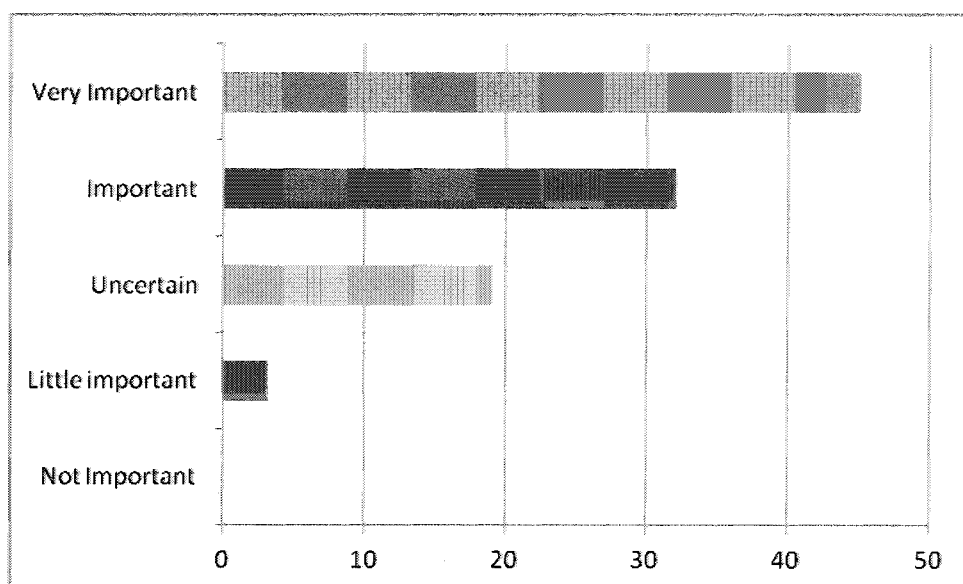
Figure 6.12 show that 45 percent of the respondents regard indicators (risk assessment) as a very important inhibitor for implementing SMS. However, 23 percent regard it as an important inhibitor, a 23 are uncertain on the issue of indicators as a restraining factor, and 6 percent regard that it is of little importance as a restraining factor. The average score for all the answers is 4,1.



**Figure 6.12** Indicators (risk assessment) as an inhibiting factor in SMS. (Percent)  
N=31

### 6.12 Quality data and information as an inhibiting factor in Safety Management System

Quality data and information as inhibitor in SMS implementation implies the lack of systematic cataloging and uniform methods of data analysis. This includes reporting routines. Stephans (2004), states that, even though considerable data exist, they are not necessarily available or in the correct format. He argues that, a well-organized effort to identify and catalog existing databases and develop plans for the systematic collection and dissemination of new data would benefit the entire safety community (Stephans, 2004).



**Figure 6.13** Quality data and information as an inhibiting factor in SMS. (Percent)  
N=31

Figure 6.13 show that 45 percent of the respondents regard lack of quality data and information as very important inhibitor for implementing SMS. However, 23 percent regard it as an important inhibitor, a 19 are uncertain on the issue of Quality data and information as arestraining factor, and 3 percent regard that it is only of little importance as a restraining factor. The average score for all the answers is 4,2.

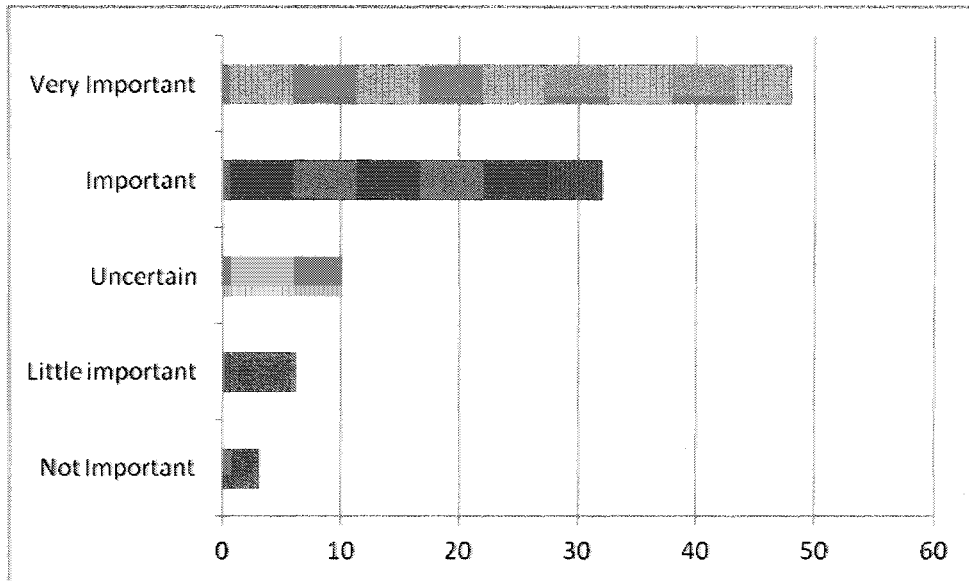
### 6.13 Human Factors as an inhibiting factor in Safety Management System

Woods et al (2010) distinguishes the stages in system safety approach by what they call as first stories which implies the traditional way and the new by what they call second stories.

**Table 6.1** The contrast between first and second stories

First stories	Second stories
Human error (by any other name: violation, complacency) is seen as a cause of failure	Human error is seen as the effect on systemic vulnerabilities deeper inside the organization
Saying what people should have done is a satisfying way to describe failure	Saying what people should have done does not explain why it made sense for them to do what they did
Telling people to be more careful will make the problem go away.	Only by constantly seeking out its vulnerabilities can organizations enhance safety

Source: Woods et al (2010:7)



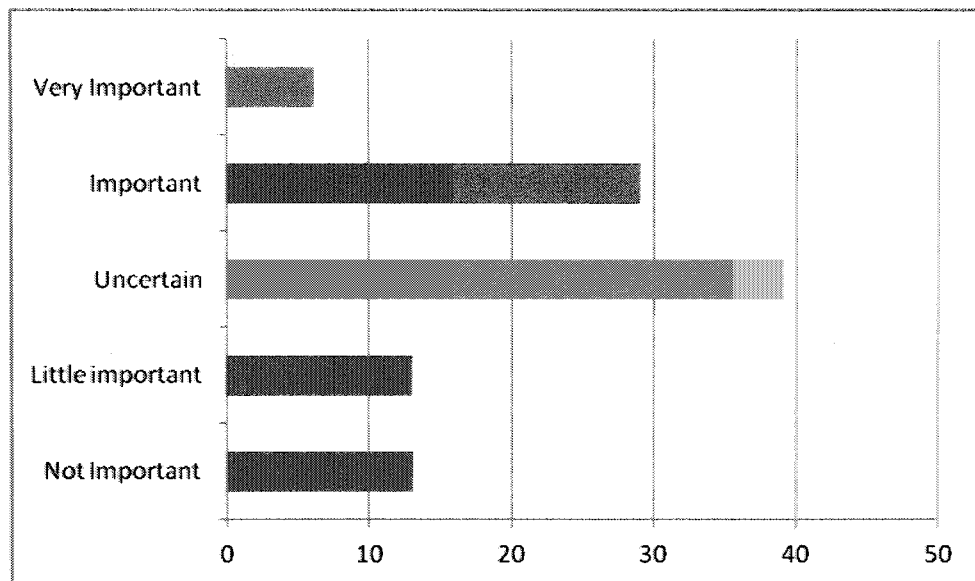
**Figure 6.14** Human factors as an inhibiting factor in SMS. (Percent) N=31

Figure 6.14 show that 48 percent of the respondents regard human factors has a very important restraining factor for SMS implementation while 32 percent regard it as important. 10 percent is uncertain of human factor as an important restraining factor. 6 percent, however, regard that it has little importance. 3 percent of the respondents regard that it has no important all. . The average score for all the answers is 4,2.

#### **6.14 Software knowledge as an inhibiting factor in Safety Management System**

According to Stephans (2004) argues that, what it is not generally recognize in the system safety community, is that there are no safety problems in system design. He explains that, there are only engineering and management problems, which if left unsolved, can result in a mishap.

Figure 6.15 show that 39 percent of the respondents are uncertain of the importance of software management as an inhibitor for implementing SMS. However, 29 percent regard it as important, a 13 percent see that it has little importance, and another 13 percent regard it to have no importance all, while a 6 percent regard that it is a very important inhibitor. The average score for all the answers is 3.

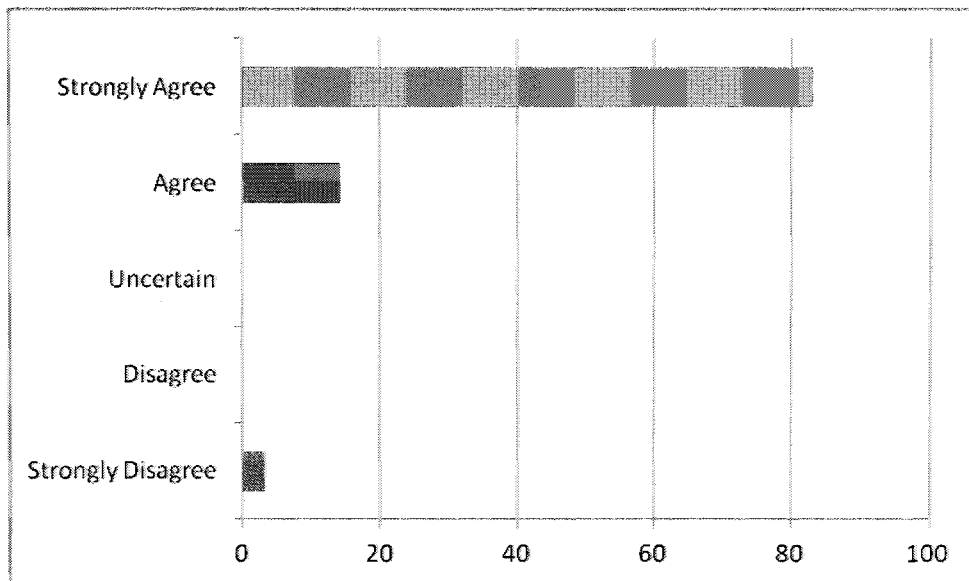


**Figure 6.15** Software knowledge as an inhibiting factor in SMS.(Percent) N=31

### **6.15 Safety Management System relevance to all sectors in aviation**

This question is closely related to the question on knowledge of SMS. Although the question may seem obvious, actually, two of the respondents did not bother to answer it. I have at least four reasons for including this question.

1. There are voices, especially from the General Aviation (GA), who argue that SMS implementation would be too resource demanding, and that their main activities are on a hobby basis. Therefore, SMS is not appropriate or relevant to them.
2. Those who are use to Quality Management (QM) or Compliance Monitoring (CM) to use EASA's terminology, reckon that it is a good enough system for safety.
3. As mentioned about, this topic is related to the question on knowledge. My opinion is that, only by having a good knowledge of SMS, makes it possible to see its relevance.



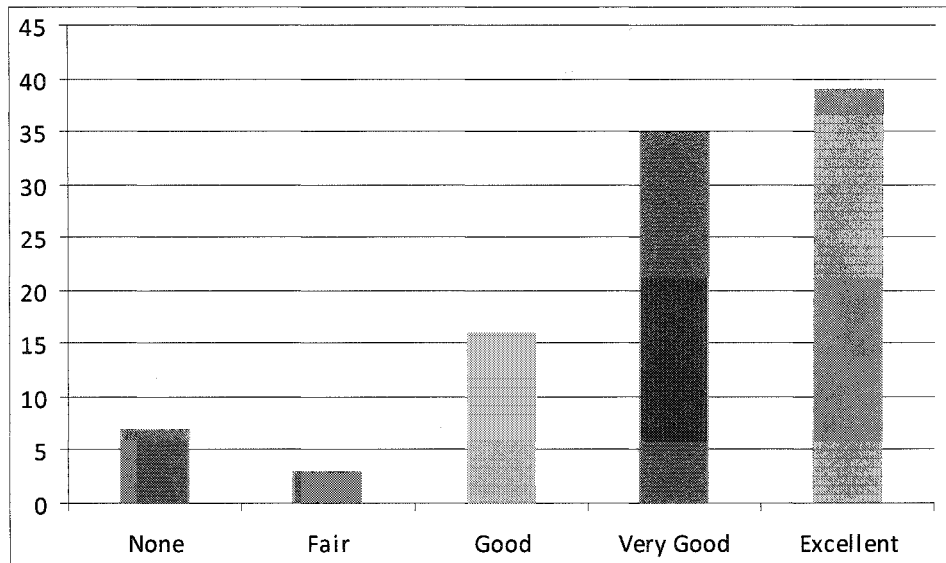
**Figure 6.16** Safety Management System relevance in aviation. (Percent) N=29

Figure 6.16 show that 83 percent of the respondents strongly agree that SMS is relevant in aviation. While 14 percent agree that it is relevant but there is a 6 percent who disagree that it is relevant in aviation. The average score of all the answers is 4,7.

### **6.16 Knowledge of Safety Management System in aviation**

The intention of having this question was to find out how those with knowledge of and those without knowledge of SMS, rated the importance of the promoting and inhibiting factors. However, due to the small sample and that the majority of the respondents rated themselves to have very good or excellent knowledge of SMS, makes impossible to draw any conclusion, whether knowledge of SMS makes a difference in how these factors are rated. Although, based on the results presented earlier. It would not be wrong to say that, with good knowledge of SMS; the higher one would rank the factor as an enabler or an inhibitor.





**Figure 6.17** Knowledge of SMS in aviation (Percent) N=31

Figure 6.17 show that 90 percent of the respondents meant that they had good to excellent knowledge of SMS, (39 percent as excellent, 35 percent as very good and 16 percent as good). The average score of all the answers is 4.

### 6.17 Summary

The findings from the data analysis show that safety leadership and safety culture are regarded as the most important promoters for SMS implementation. From a scale from 1-5, the average score for 'Safety Leadership' is 4,8 and 4,7 for 'Safety Culture'. Interesting is that Software management with the average score of 3. This indicates that either the respondents were uncertain about the question or the importance of Software management as a promoting factor in SMS implementation. Among the inhibiting factors, both the average score for 'Quality Data and Information' and 'Human Factors' was 4,2. The interesting result is that among the ranking of inhibiting factors, 'Resources' was not rated as the most important inhibitor. The average score for 'Resources' was 4,1. However, the difference is very small. 'Software Knowlegde' had the lowest average score of 3, among the restraining factors.

## **Chapter 7 ICAO's Phased approach SMS implementation**

In this chapter, I will present ICAO's phased approach implementation strategy. This approach is an example of how an organization can implement its SMS.

### **7.1 Phased approach implementation**

For a SMS implementation not to turn out to be a completely daunting task. ICAO recommends a phased approach to SMS implementation. Meaning the implementation process should be divided to different set of phases/stages. The phased approach to SMS implementation includes:

- Phase 1: Planning SMS implementation.
- Phase 2: Reactive safety management processes.
- Phase 3: Proactive and predictive safety management.
- Phase 4: operational safety assurance.

Phase 1: Planning SMS implementation. This involves a blueprint on how the SMS requirements will be met and integrated into the organization's work activities, and the accountability framework for the implementation of the SMS.

Firstly, this is done through, basic planning and assignment of responsibilities establishment. Secondly, what is central to Phase 1 is the gap analysis. From the gap analysis, an organization can determine the current status of its safety management process and can begin detailed planning of the safety management processes.

The elements based on the ICAO SMS framework that should be finalized at the completion of Phase 1 are:

- a) Identify the Accountable Executive and the safety accountabilities of managers.
- b) Identify the person (or planning group) within the organization responsible for implementing the SMS.
- c) Describe the system (approved training organizations that are exposed to safety risks during the provision of their services, aircraft operators, approved maintenance organizations, organizations responsible for type design and/or manufacture of aircraft, air traffic service providers and certified aerodromes).

- d) Conduct a gap analysis of the organization's existing resources compared with the national and international requirements for establishing an SMS
- e) Develop an SMS implementation plan that explains how the organization will implement the SMS on the basis of national requirements and international SARPs, the system description and the results of the gap analysis.
- f) Develop documentation relevant to safety policy and objectives.
- g) Develop and establish means for safety communication.

#### Phase 2 - Reactive safety management processes.

The objective of Phase is to implement essential safety management processes. Most organizations will have some basic safety management activities in place, at different levels of implementation and with different degrees of effectiveness. These activities may include inspections and audits reports, analysis of information from accident reports and incident investigations, and employee reports. This phase aims at solidifying existing activities and developing those which do not yet exist. However, because forward-looking systems have yet to be developed and implemented, this phase is considered reactive. Towards the end of Phase I, the organization will be ready to perform coordinated safety analyses based on information obtained through reactive methods of safety data collection.

The elements based on the ICAO SMS framework that should be finalized at the completion of Phase 2 are:

- a) Implement those aspects of the SMS implementation plan that involve safety risk management based on reactive processes.
- b) Deliver training relevant to the SMS implementation plan components and to safety risk management based on reactive processes.
- c) Develop documentation relevant to the SMS implementation plan components and to safety risk management based on reactive processes.
- d) Develop and maintain formal means for safety communication.

#### Phase 3 – Proactive and predictive safety management processes.

The objective of Phase III is to structure forward-looking safety management processes. Safety information management and analytical processes are refined. Towards the end of Phase III, the organization will be ready to perform coordinated safety analyses based on information obtained through reactive, proactive and predictive methods of safety data collection.

The elements based on the ICAO SMS framework that should be finalized at the completion of Phase 3 are:

- a) Implement those aspects of the SMS implementation plan that refer to safety risk management based on proactive and predictive processes.
- b) Develop training relevant to the SMS implementation plan components and to safety risk management based on proactive and predictive processes.
- c) Develop documentation relevant to the SMS implementation plan components and to safety risk management based on proactive and predictive processes.
- d) Develop and maintain formal means for safety communication.

Phase 4 – Operational safety assurance.

Phase IV is the final phase of the SMS. In this phase operational safety assurance is assessed through the implementation of periodic monitoring, feedback and continuous corrective action to maintain the effectiveness of safety risk controls under changing operational demands. At the end of Phase IV, safety information management and analytical processes ensure sustenance of safe organizational processes over time and during periods of change in the operational environment.

The elements based on the ICAO SMS framework that should be finalized at the completion of Phase 4 are:

- a) Develop and agree on safety performance indicators, safety performance targets and SMS continuous improvement.
- b) Develop training relevant to operational safety assurance.
- c) Develop documentation relevant to operational safety assurance.
- d) Develop and maintain formal means for safety communication.

All the four phases should be completed and finalized in a manner that meets the expectations of the civil aviation oversight authority, as set forth in relevant requirements and guidance material.

## **7.2 Summary**

In this chapter I have presented a summarized version of ICAO's phased approach implementation. This is an approach that an organization can apply in order for a SMS implementation not to turn out to be a completely daunting task.

There are definitely many ways of implementing SMS. However, it seems that this approach is not widely known. I also intend to present my own implementation strategy later on. The is that I see the phased approach as a way only to meet regulatory requirements.

## Chapter 8 Discussion

The discussion is based on the model of analysis, literature review, findings that have emerged from the research results and the current debate on SMS. I intend also to include the model of analysis in a larger context by presenting a conceptual model for a successful SMS implementation.

First of all, what is my contribution to existing research in system safety?

The contemporary system safety literature emphasizes the role of the organization as an important factor in developing and keeping a safe system. The authority requirements in the ICAO Safety System Manual (SMM) and the European Aviation Safety Agency (EASA), mandate that Safety Management System (SMS) shall be implemented by organizations in the aviation industry. However, as I can see, neither the theories nor studies in system safety, include in detail, the vital factors for an organization to survive in a competitive business environment. In other words, these factors are in generalized as management, organizational processes or production's goals, etc.

It is worth mentioning that much focus has been on issues of management and culture. However, as I see it, the management of and culture in an organization covers very many different aspects of an organization. In my opinion, by only concentrating on the two issues, it restricts our understanding of other important processes important for the organization (system). The 7-s framework for strategy implementation, in my opinion, can be adopted as a holistic approach to understanding organizational processes especially when implementing a new system. To understand complexity in these processes, a system approach is necessary. A system approach implies having a holistic view.

The sample in the survey conducted was very small. For that reason, it limits the discussion based on the research findings. Furthermore, the results cannot be generalized. However, it creates a foundation for further studies. An important aspect of the study is that even though the sample was relatively small. It is that, a high percentage of those who took part in the survey, ranked themselves to have either good or excellent knowledge of the SMS in aviation. I regard the findings as interesting since it can be used in developing information and learning on SMS.

A topic that I would like to mention in the discussion chapter is what I have come through during the literature review. These are concepts or definitions in official documents that in my view are not correct according to Complex systems theory.

Exempel 1: Predictive method according to ICAO.

“The predictive method captures system performance as it happens in real-time normal operations to identify potential future problems” (ICAO, 2009 p. 3-11)

The point here is that complex systems by nature are unpredictable. So the term predictive or able to predict in this context is hard to understand from a complexity point of view.

Exempel 2: Manual to EASA on Part ORA.

EASA has decided that organizations should be categorized as Complex or non-complex depending on size. My point here is that all aviation organisations are complex from a complexity point of view. Since open systems are complex.

These are issues that may complicate SMS implementation.

### **8.1 Cost-effective safety**

A way of looking at safety management as an investment in the business activity is considering the cost of not having a safety management system in place. Alston (2003) cost measurement happens in several ways, sometimes involving human injury or death, damaged corporate image, or lost potential. Routinely, tangible costs reduce to a currency amount. When a person dies unnecessarily, the organization faces direct and indirect currency value tangibles such as insurance deductibles, training costs and lost production. The intangibles include the obvious emotional cost of grief, sadness, and decreased morale that affects the organization. They are corporate distractions that accompany grief and low morale impact on job performance and in the end production goals (Alston, 2003). However, there are moral dilemmas regarding pricing safety costs when it comes to saying environmental, traffic or workplace accidents. How do we go about pricing the value of human lives or the environment? (Haukelid, 1999). In other words, human lives and the environment can never be replaced when destroyed through negligence or accidents. This brings in the issue of looking at SMS in a wider context by including the stakeholders.

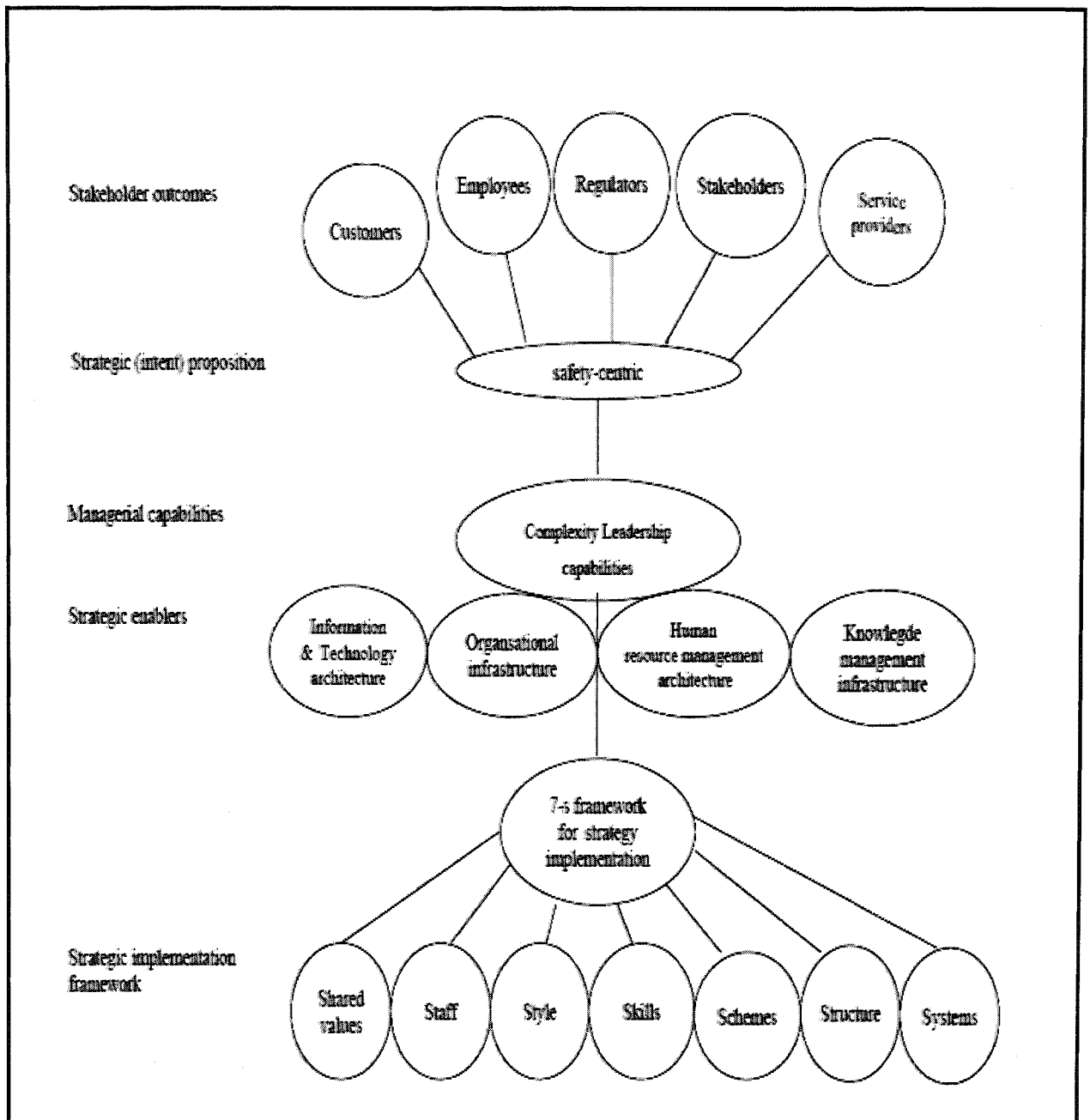
There are certainly many ways of implementing SMS. In Chapter 7, I presented the ICAO's phased approach implementation strategy. As I can see it, the phased approach is helpful in planning SMS implementation as a project, and naturally, it is also a compliance based approach. By compliance based approach, I mean that it focuses mainly on regulatory requirements and for approval from the authorities. The point I am trying to make here is that SMS should not develop to be only a regulatory requirement. This would mean that safety continues to be treated separately from organizational process, and regarded as an added cost. Forgetting or not realizing that actually one of the main ideas behind SMS is cost-effective safety.

I will now present a model for a successful SMS implementation. The model is adapted and modified based on Osarenkhoe (2006). At the top of the conceptual framework are the stakeholders. Stakeholder outcomes; are the constant changing expectation and requirements that need to be monitored and responded to by the organization. A successful SMS implementation in this context means meeting and fulfilling all the expectations from the stakeholders. Safety track record and image are important. Let's not forget that one of the reasons behind the concept of SMS, was a result of the eight commercial accidents in 13 months in the U.S. This was in the 1990s and it brought about public concern (Stolzer et al., 2010).

The implementation strategy for SMS should be 'safety-centric'. My definition of 'safety-centric' is that the system (organization) shall meet all the performance and safety requirements while being cost-effective. The term is not commonly used in aviation today, but I would encourage that it would. My main reason for it is that the motto or slogan "safety-first" is by many regard merely as a cliché. Even ICAO states in the SMM, that "safety is not the first priority of aviation organizations" (ICAO, 2009 p. 3-2). The idea behind this term can be found in Ducas(2007).

The managerial capabilities required in such an organization is complexity leadership capabilities (enabling and adaptive leadership, discussed in section 6.1). The strategic implementation framework and the strategic enablers are continuously monitored to deliver the strategic proposition (safety-centric), to the satisfactory of the stakeholders.





**Figure 8.1** A conceptual model for a successful SMS implementation

## **Chapter 9 Conclusion and future studies**

The question posed for the study is; what inhibits and promotes the implementation of System Management Systems (SMS) in aviation?

Based on the literature review, enabling and inhibiting factors were selected for the study. I constructed a model for analysis related to the question, theory and the literature review. The model is holistic, and I believe my contribution to existing research is a holistic approach to safety system studies. The approach applied in the study is Complexity System Theory.

The findings show that 'Safety Leadership' and 'Safety Culture' are regarded as the most important promoters for SMS implementation. From a scale from 1-5, the average score for 'Safety Leadership' is 4,8 and 4,7 for 'Safety Culture'. Interesting is that Software management with the average score of 3. This indicates that either the respondents were uncertain about the question or the importance of Software management as a promoting factor in SMS implementation. Among the inhibiting factors, the average score for both 'Quality Data and Information' and 'Human Factors' was 4,2. The interesting result is that among the ranking of inhibiting factors, 'Resources' was not rated as the most important inhibitor. The average score for 'Resources' was 4,1. However, the difference is very small. 'Software Knowlegde' had the lowest average score of 3, among the restraining factors. This indicates that either the respondents were uncertain about the question or the importance of 'Software Knowlegde' as a inhibiting factor in SMS implementation.

The dissertation recommends that the inhibiting factors should be reasonable targeted. These factors have to be attended to since they can seriously affect the implementation of Safety Management System. However, the important enablers such as 'Safety leadership' and 'Safety Culture' must be taken seriously. Furthermore, a continuous development and monitoring of the strategic enabling factors are essential. This is important, since the promoting factors also by time need to adapt to the changes in the system, and they can easily become inhibitors.

## **9.1 Future studies**

The sample in the survey conducted was very small. For that reason, it limits the discussion based on the research findings. Furthermore, the results cannot be generalized. However, it creates a foundation for further studies. An important aspect of the study is that even though the sample was relatively small. It is that, a high percentage of those who took part in the survey, ranked themselves to have either good or excellent knowledge of the SMS in aviation. I regard the findings as interesting since it can be used in developing information and learning on SMS.

- Performing such a survey on a larger population or among organization is recommended.
- Longitudinal studies for countries and organizations that have not yet implemented SMS can be fruitful in the long run. It will then be a better performance indicator.
- Content analysis on the websites such as LinkedIn could present some interesting results

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## Appendices





# Safety Management System in Aviation - what inhibits and promotes implementation?

Dear survey participant, The aim of this questionnaire is to identify the most common factors that inhibits and promotes Safety Management System in Aviation. The reasearch is part of a dissertation for my MBA in Aviation Management.

This survey is purely for research purposes, and the information you provide will be STRICTLY CONFIDENTIAL and will be used solely for the purposes mentioned above. No respondents or organization's name will be disclosed in the final report. If you have any questions about this questionnaire, please contact me at the following address: <http://www.linkedin.com/pub/jerry-okema-opira/32/301/144> or [jerryo@online.no](mailto:jerryo@online.no)

\*Må fylles ut

## Safety Management System (SMS) in Aviation

### 1. Rank the following factors on how you mean they are important for you and organization in promoting Safety Management System

(1=Not Important; 2=Little Important; 3= Uncertain; 4= Important; 5= Very Important)

	1	2	3	4	5
Safety Leadership	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Procedures and Policy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training and Recurrent Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Business Objectives	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Organizational Structure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safety Culture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Software Management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### 2. Rank the following factors on how you mean they are important in restraining/ preventing Safety Management system for you or your organization

(1= Not Important; 2=Little Important; 3= Uncertain; 4= Important; 5 =Very Important)

	1	2	3	4	5
Standardization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Authority Regulations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Indicators (Risk Assessment)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Data and Information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Human Factors	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1	2	3	4	5
Software Knowlegde	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**3. Safety Management System is relevant to all sectors in aviation**

1=Strongly Agree; 2=Agree; 3=Uncertain; 4= Disagree; 5=Strongly Disagree)

	1	2	3	4	5
Strongly Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree					

**BACKGROUND INFORMATION**

**4. What is your core business**

Airline Transport / Airline	<input type="radio"/>
Maintenance Engieneering / Airworthiness	<input type="radio"/>
Flight Training	<input type="radio"/>
Airport / Aerodrome	<input type="radio"/>
Helicopter Operations	<input type="radio"/>
Aviation Authority	<input type="radio"/>
Quality Assurance	<input type="radio"/>
Safety Services	<input type="radio"/>
Security	<input type="radio"/>
General Aviation	<input type="radio"/>
Other	<input type="radio"/>

**5. What is your position in the organization**

CEO	<input type="radio"/>
Manager / Head of Department / Section	<input type="radio"/>
Pilot	<input type="radio"/>
Inspector	<input type="radio"/>
Flight Training Instructor	<input type="radio"/>
Air Traffic Controller	<input type="radio"/>

- Maintenance Engineer
- Personell Quality Assurance
- Personell Training
- Safety Officer / Safety Personell
- Flight Examiner
- Cabin Crew
- General Aviation Personell
- Other

**6. How would you rate your knowlegde in Safety Management System (SMS) in aviation**  
(1=None; 2=Fair; 3=Good; 4=Very Good; 5=Excellent)

1 2 3 4 5

None      Excellent

**7. Specify your country of main operation \***

**THANK YOU**

You have reached the end of this questionnaire. I would like to thank you for taking the time to provide your responses

**Please provide any general feedback, question or concerns**

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