Safety Culture in Sea and Aviation Transport

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Abstract

The research presented in this thesis investigates sea and aviation transport safety culture, with a focus on perceptions and attitudes. A safety culture reflects the attitudes, beliefs, perceptions, and values that individuals share in relation to safety. Safety culture is often identified as being essential to an organization's ability to manage safety-related aspects of its operations. The aims of this research are: to assess individual perceptions and judgments of safety culture in practical contexts by using nine aspects of safety culture found in the safety culture literature; to increase knowledge about the safety culture aspects by conducting comparative studies in three transport branches; and to investigate relationships between safety culture aspects and organizational climate dimensions. The approach to safety culture presented in this thesis focuses on good organizational learning and investigates nine aspects: *Learning*, *Reporting*, *Justness*, *Flexibility*, *Communication*, *Attitudes towards safety*, *Safety-related behaviours*, *Risk perception*, and *Working situation*.

Studies were conducted in airport ground handling (one site), passenger shipping (six ships), and air traffic control (three sites), where the safety culture was assessed using observations, questionnaire packages, interviews, and collection of facts. In total, 949 subjects completed a questionnaire package containing nine scales, one for each safety culture aspect, and 80 interviews were conducted. Ekvall's organizational climate questionnaire, which focuses in part on an organization's ability for innovation and change, was completed by 719 subjects.

The nine scales representing the nine safety culture aspects were found to function well with good reliability in the three transport settings, and may constitute valuable methods for monitoring and improving safety culture in working environments. Obtaining both questionnaire data (the nine scales) and interview data was valuable; the questionnaire package provided comparative data across transport branches and allowed establishment of reference data concerning safety culture aspects in each of the three branches. The interviews provided knowledge and examples of positive and negative expressions of safety culture that the interviewees had experienced.

The comparative studies of safety culture aspects were conducted using a multiplex approach of data collection, which provided valuable knowledge about safety culture in practical contexts.

The comparisons of average scores for the nine safety culture aspects showed that air traffic control often had somewhat higher average scores than the other two branches, while the ground handling ramp organization generally had the lowest average scores.

Compared to employees, managers generally had somewhat more positive perceptions and judgments of safety culture aspects, but the two groups differed very little in their perceptions and judgments of the organizational climate. Managers' expectations and goals concerning safety culture aspects were compared to employees' actual questionnaire scores. Employees' reports of the safety culture aspects were often poorer than both managers' estimations of reality and managers' lower acceptable limits for safety culture aspect scores.

Individual characteristics, such as gender, age, and time in company, were found to have very little effect on how the safety culture aspects were perceived and judged.

The organizational climate on board three passenger/cargo ships was found to be somewhere in between the normative 'innovative' and the 'stagnating' organization types, and very often closer to the 'stagnating' type. The organizational climate at each of the three air traffic control sites was similar to the climate in 'innovative' organizations.

Relationships existed between safety culture aspects and organizational climate dimensions. In passenger shipping, better *Challenge/Motivation* among personnel and a higher level of *Support for ideas* were significantly positively related to most safety culture aspects. In air traffic control, a higher level of *Support for ideas* and a lower level of *Conflicts* were significantly positively related to many safety culture aspects.

The results show that learning processes are better developed in the air traffic control setting than in passenger shipping and airport ground handling ramp activities. Compared to the other two branches, air traffic control can be characterized by a more mature approach to reporting anomalies and by having a more developed procedure for analysing limitations and implementing improvements.

Further research in the safety culture field should concentrate on developing methods for assessing the behavioural and situational areas of safety culture; testing the relation of safety culture to safety management and safety behaviour; determining which aspects and items are important for measuring safety culture; and finding indications of what elements influence safety behaviours, and how they exert this influence.

Sammanfattning

I forskningsarbetet som presenteras i denna avhandling har säkerhetskulturen studerats inom sjö- och flygtransportbranscherna med fokus på individers attityder och uppfattningar om säkerhetskulturen. En säkerhetskultur avspeglar de attityder, uppfattningar och värderingar som individer i en organisation delar när det gäller säkerheten. Säkerhetskulturen identifieras ofta vara grundläggande för en organisations förmåga att hantera säkerhetsrelaterade aspekter. Målsättningarna med forskningsarbetet har varit: att i praktiska sammanhang undersöka individers uppfattningar och bedömningar av nio aspekter av en säkerhetskultur vilka återfinns i litteraturen inom forskningsområdet; att få ökad kunskap om de nio säkerhetskulturaspekterna genom att genomföra jämförande studier i tre transportbranscher; att undersöka relationer mellan säkerhetskulturaspekterna och dimensioner i organisationsklimatet. Den säkerhetskulturansats som presenteras i avhandlingen fokuserar på gott organisatoriskt lärande och undersöker nio aspekter: *Lärande, Rapporterande, Rättvisa, Flexibilitet, Kommunikation, Attityder till säkerhet, Säkerhetsrelaterade beteenden, Riskperception* och *Arbetssituation*.

Studier genomfördes i följande branscher: inom en rampverksamhet på flygplats, inom passagerarsjöfart (sex fartyg) och inom flygtrafikledning (tre enheter). Säkerhetskulturen studerades genom att använda observationer, frågeformulärpaket, intervjuer och insamling av fakta. Totalt fyllde 949 subjekt i frågeformulärpaketet som innehöll nio frågeformulär (en för varje säkerhetskulturaspekt) och 80 intervjuer relaterade till säkerhetskulturen genomfördes. 719 subjekt fyllde i Ekvalls organisationsklimatfrågeformulär vilket delvis fokuserar på att mäta en organisations förmåga till innovation och förändring.

De nio frågeformulären som representerade de nio säkerhetskulturaspekterna visade sig fungera bra (med god reliabilitet) i de tre transportbrancherna, och kan utgöra värdefulla metoder för att monitorera och förbättra säkerhetskulturen i praktiska sammanhang. Att samla in data genom både frågeformulär och intervjuer var värdefullt; frågeformulärpaketet gav data som tillät jämförelse mellan transport-branscher och en möjlighet att skapa ett referensmaterial inom varje transport-bransch. Intervjuerna gav kunskap om och exempel på positiva och negativa yttringar av säkerhetskulturen som de intervjuade hade fått erfarenhet av.

Jämförelser av de nio säkerhetskulturaspekternas medelvärden visade att flygtrafik-ledningen ofta hade något högre medelvärden jämfört med de andra två branscherna, medan ramporganisationen generellt sett hade de lägre medelvärdena.

Jämfört med anställda så hade ledare generellt sett mer positiva uppfattningar om säkerhetskulturaspekterna, men de två grupperna skiljde sig mycket litet åt i hur man uppfattade organisationsklimatet. Ledares förväntningar och mål när det gällde säkerhetskulturaspekterna jämfördes med anställdas verkliga värden på säkerhets-kulturaspekterna erhållna från frågeformulärdata. De värden/bedömningar som

anställda gav för säkerhetskulturaspekterna var ofta lägre/sämre än både ledares uppskattning av verkligheten och ledares lägsta acceptabla gräns för värden på säkerhetskulturaspekterna.

Individfaktorer som kön, ålder, tid i företaget visade sig ha liten effekt på hur säkerhetskulturaspekterna uppfattades och bedömdes.

Organisationsklimatet som studerades ombord på tre av de sex fartygen kunde till sin karaktär placeras mellan de normativa 'innovativa' och 'stagnerade' organisationstyperna, och ofta närmare den 'stagnerade' typen. Organisationsklimatet inom de tre enheterna inom flygtrafikledningen var i huvuddrag mest lik klimatet i 'innovativa' organisationer.

Man kunde hitta relationer mellan säkerhetskulturaspekterna och organisationsklimatdimensionerna. Inom passagerarsjöfarten var bättre *Utmaning/Motivation* hos personalen och ett bättre *Idéstöd* signifikant positivt relaterat till de flesta säkerhetskulturaspekterna. Inom flygtrafikledningen, var ett bättre *Idéstöd* och färre *Konflikter* signifikant positivt relaterade till många säkerhetskulturaspekter.

Resultaten visade att processer för lärande är bättre utvecklade inom flygtrafikledningen än inom passagerarsjöfart och rampverksamhet. Jämfört med de andra två branscherna, kan flygtrafikledningen karakteriseras ha en mer mogen ansats till att rapportera anomalier och ha en mer utvecklad process för att analysera och implementera förbättringar.

Fortsatt forskning inom säkerhetskulturområdet bör fokusera på att utveckla metoder för att mäta beteendeelement och systemelement hos en säkerhetskultur; testa relationen mellan säkerhetskultur, säkerhetshantering och säkerhetsbeteenden; bestämma vilka aspekter och specifika frågor som är viktiga vid mätning av säkerhetskultur; samt söka finna vilka komponenter som påverkar säkerhetsbeteenden och hur dessa komponenter utövar sitt inflytande på säkerhetsbeteenden.

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My dearest friend Tom, to whom I dedicate this scientific research, for providing encouragement and being who you are.

Åsa Ek, Lund, May 2006

List of papers

This thesis is based on the following four papers, which will be referred to in the text by their Roman numerals.

I   Ek, Å. and Akselsson, R.
Aviation on the ground: Safety culture in a ground handling company
Accepted for publication in the International Journal of Aviation Psychology.

Ek formulated the objectives and methods of the study. Ek designed and performed the safety culture assessment (observations, questionnaire package survey and interviews). Ek designed and carried out the data analysis and wrote the paper. Both authors reflected on the results presented in drafts of the article.

II   Ek, Å. and Akselsson, R.
Safety culture on board six Swedish passenger ships
Maritime Policy & Management 32 (2), 2005, 159-176.

Ek formulated the objectives and methods of the study. Ek designed and performed the safety culture assessments (observations, questionnaire package surveys and interviews). Ek designed and carried out the data analysis and wrote the paper. Both authors reflected on the results presented in drafts of the article.

III   Ek, Å., Akselsson, R., Arvidsson, M. and Johansson, C.R.
Safety culture in Swedish air traffic control
Submitted to an international scientific journal.

Ek and coauthors were members of the HuFa group (Human Factors in Air Navigations Services) which was responsible for assessing safety culture aspects, organizational climate, psychosocial work environment, situational leadership, and team climate within Swedish air traffic control. Ek was responsible for the safety culture part of the assessment. Ek and Arvidsson planned and performed the questionnaire package survey of the five concepts. Ek conducted the interviews in the safety culture assessment. Ek formulated the objectives of the study, designed and carried out the safety culture data analysis, and wrote the paper. All authors reflected on the results presented in drafts of the article.

IV   Arvidsson, M., Johansson, C.R., Ek, Å. and Akselsson, R.
        Organizational climate in air traffic control: Innovative preparedness for implementation of new technology and organizational development in a rule governed organization
        Applied Ergonomics 37, 2006, 119-129.

        Ek and coauthors were members of the HuFa group (Human Factors in Air Navigations Services) which was responsible for assessing safety culture aspects, organizational climate, psychosocial work environment, situational leadership, and team climate within Swedish air traffic control. Arvidsson was responsible for the organizational climate part of the assessment. Ek and Arvidsson planned and performed the questionnaire package survey of the five concepts. Arvidsson formulated the objectives of the study, designed and carried out the organizational climate data analysis, and wrote the paper. All authors reflected on the results presented in drafts of the article.

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Paper I   Aviation on the ground: Safety culture in a ground handling company
Paper II   Safety culture on board six Swedish passenger ships
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1 Introduction

Previously, the primary focus for the cause of large-scale accidents and incidents has involved human and technical aspects. It is commonly stated that the human factor, or operator error, contributes to 60-80% of the major accidents (Perrow, 1999). After a series of disasters during the 1980s such as Three Mile Island, the space shuttle Challenger and Chernobyl, a wider perspective was gained on what causes major accidents. The current conclusion is that there is a complex combination of organizational, group, individual and technical factors behind major accidents. The term 'organizational accident' is used (as compared to 'limited individual accidents') and it is characterized as having multiple causes and involving people on different levels in an organization or company (Reason, 1997). The causes are characterized as built-in latent conditions that may be present for many years in a system (Reason, 1997), or multiple failures in design, equipment, procedures, operators, and environment (Perrow, 1999). Serious accidents could therefore be said to be defects in a system and not a simple result of the carelessness or errors by individuals (O'Toole, 2002).

The continuous developments in technology provide us with new possibilities in production and transport, but they also generate new risks. Most high-risk systems have special characteristics that make accidents inevitable. These characteristics are described by Perrow (1999) as 'interactive complexity' and 'tight coupling', i.e. the way failures interact and the way the system is tied together. These characteristics lead to 'normal accidents' or 'system accidents', i.e. multiple and unexpected interactions of failures that are inevitable (Perrow, 1999).

Improvements in safety usually happen soon after a serious accident has occurred, but such a tendency towards safety improvement diminishes with the passage of time. As serious accidents rarely happen, organizations tend to overlook and forget the different types of risks that they face. Thus, as time passes, an organization can begin to exceed the limits of safe practice (Rasmussen, 1997). The consequences are an increased risk for accidents. One approach to prevent this increase is to continuously maintain an awareness of risks and to shape and promote safe organizational behaviour, all of which relate to safety culture.

A safety culture reflects the attitudes, beliefs, perceptions, and values that employees share in relation to safety (Cox and Cox, 1991). Safety culture in an organization concerns having an awareness of risks and the knowledge, ability, and willingness to prevent them. Safety culture is often identified as being fundamental to an organization's ability to manage safety-related aspects of its operations (Glendon and Stanton, 2000). Major accidents have been described as resulting from a breakdown of an organization's safety culture (Toft and Reynolds, 1994).

Both safety and safety culture are affected by stress from the surrounding world. Change processes can have a negative impact on existing safety cultures and on safety. It has been recognized that organizational changes such as downsizing have contributed to major accidents such as in the chemical industry sector (Baram, 1998; Erlandsson, 2001). Pressure towards cost-effectiveness can cause systematic migration of organizational behaviour, resulting in major accidents (Rasmussen, 1997). The serious accident of the roll on/roll off ferry *Herald of Free Enterprise* in 1987 is one such example. Another example from the aviation transport branch in which the prevailing safety culture very much contributed to an aircraft accident was at the Milan Linate Airport in Italy in 2001. The accident investigation revealed that shortcomings in instructions, training, and working conditions had led to air traffic control personnel lacking the prerequisites necessary for control of airplane movements on the ground. The airport also lacked a working safety management system (Swedish Accident Investigation Board, 2004).

Safety culture is a relatively unexplored area and there is a need for more research to clarify the field (Hale, 2000). Issues regarding definitions, models and measurements of safety culture require clarification, as well as a safety culture's relations to other aspects in an organization (Hale, 2000).

One approach to safety culture focuses on good organizational learning (Reason, 1997; Sorensen, 2002). Learning is a process of deliberate questioning of the adequacy of current practice and of continuously and systematically searching for deficiencies and vulnerabilities in the organization. Organizations with a 'good' safety culture have mechanisms in place to gather safety-related information, measure safety performance, and bring people together to learn how to work more safely (Ostrom et al., 1993). Reason (1997) suggests that a safety culture is an informed culture where fear is minimized generating good reporting of incidents, and where the organization has updated knowledge about human, technological, organizational and environmental factors that determine the safety in the system or organization.

Major disasters have triggered strong public concern over the management of hazardous activities (Hale et al., 1998). Governments have traditionally regulated safety through detailed prescriptive standards. Beginning in the 1970s, the pace of technological developments increased so dramatically that such regulatory systems became impractical, the detailed prescriptive standards quickly becoming outmoded by perpetual technological changes.

Governments thus relinquished their role as detail regulators and moved towards a goal-oriented perspective in which responsibility for the development, use and improvement of safety management systems was placed directly on the individual company's management (Hale et al., 1998). Company safety performance is thus evaluated through internal and external audits.

It is believed that successful safety management depends on the existing safety culture in an organization (Bailey, 1997; Kirwan, 1998). The safety management, in turn, has an impact on the safety of operations (Wright et al., 2004).

It is vital to obtain more knowledge regarding the characteristics of safety culture and the components that influence it. One aspect would be to learn more about the characteristics of safety culture as it exists in different practical situations or settings; another would be to compare it across the different settings. The characteristics associated with good safety culture and functioning could in principle be transferred, or applied to settings with a poorer safety culture or functioning. In pursuit of this knowledge, the research on which this thesis is based has studied aspects of safety culture in the areas of sea and aviation transport.

In the absence of absolute norms concerning what represents a 'good/acceptable/poor' safety culture, another aspect would be to create a 'reference system' allowing comparison of relative safety culture levels in different contexts. Reference data concerning safety culture have therefore been established in the current research in the areas of sea and aviation transport.

One of the main factors that has been found to influence safety culture is the organizational culture/climate (Neal et al., 2000), where climate is defined by Ekvall et al. (1983) as a conglomerate of the attitudes, feelings and behaviours that characterize life in an organization. A better understanding of the organizational climate's effect on the safety culture could be obtained by investigating the relationship between safety culture aspects and organizational climate dimensions in the same organization. This knowledge can be vital in the process of improving and developing a safety culture and providing evidence of construct validation of its measurement.

In order to obtain more knowledge about safety culture in practical contexts, comparative studies of safety culture were conducted, using a multifaceted methodology focusing primarily on organizational learning and the application of information systems for safety.

2 Research objectives

The research presented in this thesis is part of a larger research programme about safety culture. It aims to contribute to the development of methods of assessment that can support continuous improvement processes for safety in an organization. The current research focuses on the attitudinal and perceptive areas when assessing safety culture. The larger research programme also aims at developing methods for assessing the behavioural and situational areas of a safety culture, which lie outside the scope of this thesis.

2.1 General research aims

The general aims of the research presented in this thesis were:

I. Based on nine aspects of safety culture found in the safety culture literature, to assess individual perceptions and judgments of safety culture in practical contexts, as well as individual and organizational characteristics that influence these perceptions and judgments of safety culture aspects.

Included in this practical aim was to collect data that characterize safety culture in a given setting such that the results can support changes towards more effective safety management.

Since the current research was based on safety culture aspects identified by other researchers, the goal was not to test the basic dimensional structure of safety culture reflected in the items studied (e.g. through factor analysis).

II. To increase knowledge about safety culture aspects in practical settings by conducting comparative studies of safety culture in three different transport branches: airport ground handling, passenger shipping, and air traffic control.

A better understanding of different safety culture aspects can be reached by studying their differences and similarities in a variety of practical settings. Furthermore, the data collected can be used to establish reference data concerning safety culture aspects in each of these three transport branches.

III. To investigate relationships between safety culture aspects and organizational culture/climate dimensions.

In the process of improving and developing a safety culture, it is vital to gain more knowledge of the organizational climate's effect on the safety culture in different settings.

2.2 Objectives of the individual studies

The thesis is based on four studies presented in four separate papers (see Appendix II). The general aim of the studies was to obtain increased knowledge about the characteristics of the safety culture in each of the three transport branches. The more specific objectives are presented here:

Test a method for safety culture assessment in an airport ground handling setting (Paper I).

Yield reference data for safety culture aspects suited for comparison within and across branches. Calculate average scores for the nine safety culture aspects, and identify specific topics in the safety culture (items within safety culture aspects) that were found to be problematic by a notable subgroup of participants (operationally, at least 20% in the study) (Papers I-III).

Investigate perceptions and judgments of safety culture and employees' characteristics. Investigate whether characteristics such as the individual's position in the organization (Papers I-III), age, time in company (Papers I, III), time in current position, gender (Paper III), and in-house education (Paper I) have an influence on the individual's perceptions and judgments of safety culture aspects.

Test the stability of individuals' assessments of safety culture aspects over a 20-month interval (Paper III).

Investigate organizational climate dimensions using Ekvall's (1990) questionnaire that partly focuses on an organization's ability for innovation and change. Calculate average scores for organizational climate dimensions and make comparisons with existing reference data for innovative and stagnated organizations (Ekvall, 1990) (Papers II, IV).

Investigate whether the individual's position in the organization has an influence on the individual's perceptions and judgments of organizational climate dimensions (Papers II-III).

In the study presented in Paper IV, the aim was to investigate the organizational climate in the Swedish air traffic control organization with respect to change and innovation. Attention was paid to differences between air traffic control centres, between operative and administrative work, and between managers and non-managers.

Investigate relationships between safety culture aspects and organizational climate dimensions. Investigate whether these relationships exist using multiple regression analysis, where the organizational climate dimensions were treated as explanatory variables and the safety culture aspects as outcome variables (Papers II-III).

Investigate managers' expectations and goals versus reality. Investigate management's expectations and goals concerning safety culture aspects and how these correspond to employees' evaluations (Papers I and III).

Analyse results from interviews. Analyse safety culture findings obtained from interviews with staff to gain in-depth knowledge about their perceptions and judgments of safety and safety culture, and to collect examples of positive and negative expressions of these concepts that they had experienced (Papers II-III).

3 Three research settings for empirical data collection

This thesis reports on comparative studies of safety culture aspects conducted in three transport branches: airport ground handling, passenger shipping, and air traffic control. This section presents a short description of the operative work in each of these research settings.

3.1 Airport ground handling

Figures 1 and 2. The airport ramp working area for the ground handling company studied.

Ground handling operators (Figures 1 and 2) are responsible for the operations performed during the time an aircraft spends on the ground between flights. The study concentrated on the work tasks performed on the ramp. When an aircraft arrives at the ramp, it is parked at a gate and connected to ground power units and jetways; various types of cargo are unloaded and loaded; refuelling and sanitation services are performed. During winter, de-icing is carried out when needed. On departure, the aircraft is towed and pushed back from the gate and the engines are started through communication between the pilot and a ramp operator.

Safe and efficient performance in handling aircraft has to be maintained and concerns both the aircraft and frontline personnel. Aircraft can be unintentionally damaged due to improper management of heavy vehicles in their direct vicinity. Safety and economy are strongly coupled in this type of operation. Aircraft are extremely expensive to repair, and delays or cancelled flights due to aircraft damage can result in substantial indirect costs. Well functioning safety management work plays a decisive role in minimizing the risk for both small-scale accidents (e.g. work injuries; minor damage to aircraft) and large-scale aircraft accidents.

3.2 Passenger shipping

A ship with its crew (Figures 3 and 4) can be seen as a separate social environment, where the isolation from the rest of society requires that all necessary competences exist on board (Hansson, 1996). The crew is hierarchically divided into officers and crew and the master has the overall responsibility on board.

Figures 3 and 4. *Exterior and engine control room interior on passenger ships studied.*

A ship's work organization is divided into three separate departments: deck, engine, and catering. Each department has its own clearly defined work tasks and specialized competence. The deck department is responsible for the ship's navigation, communication, cargo monitoring, and deck maintenance. The engine department is responsible for the ship's propulsion system, hull and the technical maintenance of the entire ship. Engine room personnel work primarily with system supervision and maintenance. The catering department is a form of hotel service and is responsible for attending to the crew and passengers' needs for food, rest and hygiene.

Parallel with this work organization, there exists a *safety organization* on board in which every crew member (by his/her position/function on board) has an assigned role. Usually, the safety organization consists of a number of assigned groups, for example, fire fighting groups, evacuation groups, and a man-over-board group (MOB). Some of the groups consist of crew members from several departments. However, the engine department mainly leads the fire fighting and the supervision of the fire fighting equipment on board. The catering department mainly handles the evacuation of passenger cabins in emergency situations.

The STCW Convention (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) contains a list of the work tasks performed by the individual officers and crew members. This means that the basic tasks and how they should be carried out on board are determined by formal rules, independent of the opinions of ship owners and masters.

A ship can be owned by a shipping company, but also by banks and investors. The latter often lack experience of ship operations and usually engage a management company. These management companies provide a variety of services such as manning of ships, maintenance, etc (Jense, 1999).

Two types of passenger vessels were included in the study of this transport branch: high speed crafts (HSC) and passenger/cargo ferries (Ropax). The two types of

vessels constitute different concepts in passenger shipping. The lightweight HSC carries a large number of passengers (and less cargo), and the size of the crew (especially in the catering department) varies with the number of passengers. This variation also requires a more flexible safety organization concerning the size and the fact that crew members can be placed in varying positions in the safety organization. The Ropax ship is a traditional vessel carrying both passengers and cargo (trucks and cars), and has a crew of fixed size and a fixed safety organization.

3.3 Air traffic control

Figure 5. An air traffic controller at an air traffic control centre.
Photo: Öiwind Berggren

The purposes of the air traffic control service (Figure 5) are to expedite and maintain the orderly flow of air traffic and to prevent collisions between aircraft. The air space is organized into adjacent sectors each controlled by one, two or more air traffic controllers. Air traffic control is a complicated interplay between specially trained staff, advanced technology, and elaborate work procedures driven by imperative safety requirements. The activity is built on international regulations and agreements, and uses English as the common language. Air traffic controllers give pilots instructions and permissions and continuously supervise the aircraft positioning in the air space. At an air traffic control centre (ATCC), the air traffic controllers are usually divided into handling either the arrival and departure flight phases or the en-route flight phase.

In Europe there are significant variations in procedures and equipment across different air traffic control centres. To overcome variations in working practices, Eurocontrol (European Organization for the Safety of Air Navigation) is working to establish and maintain standardized and interoperable air traffic management systems throughout Europe. This work is a key step towards the establishment of a Single European Sky. (See e.g. Luftfartsverket, 2005; Eurocontrol, 2005.) When change processes take place in an organization, it is vital to monitor their possible effect on the safety culture, the foundations of safety work, and safety.

4 Theoretical framework

The concepts of safety culture and climate have their origin within the concepts of organizational culture and climate. Before entering the area of safety culture, a brief overview will be given of the distinctions and similarities between organizational culture and climate, as well as a definition of each concept.

4.1 Organizational culture and climate

Organizational culture is a concept borrowed from anthropology and introduced by Pettigrew (1979). According to Reichers and Schneider (1990), he showed how related concepts (symbolism, myth, ritual, and so on) could be used in organizational analysis. Organizational climate has a long history in the fields of industrial and organizational psychology and organizational behaviour (Reichers and Schneider, 1990).

The concepts of organizational culture and climate have been very much debated within the organizational literature concerning the nature of the concepts, their definitions and the distinctions between them. For example, Guldenmund (2000) concludes that '…it is of major significance whether one considers organizational culture a collection of — observable — practices (e.g. Hofstede, 1991), a finite set of — conscious — attitudes (e.g. Jones and James, 1979) or a small amount of — unconscious — basic assumptions (e.g. Schein, 1992). Clearly, such diverging views will result in different research questions, paradigms, methods and outcomes'.

Reichers and Schneider (1990) conclude that culture is a common set of shared meanings or understandings about the group/organization and its problems, goals, and practices. Climate is defined as the shared perceptions of organizational policies, practices, and procedures, both formal and informal.

Schneider and Gunnarson (1991) argue that climate tells us *what* happens in an organization (visible practices, procedures and behaviour), whereas culture helps explain *why* things happen in a particular way (latent assumptions, values, and philosophies).

Another definition that has been debated is whether culture is something an organization *is* or something an organization *has* (Smircich, 1983). The is-approach is mostly exploratory and descriptive in nature, whereas the has-approach examines organizational cultures as systems of shared meanings, assumptions, and underlying values (Reichers and Schneider, 1990; Schein, 1985). Furthermore, the has-approach encourages the investigation of the causes (i.e. the founder; the societal context) and effects (i.e. organizational performance) of organizational culture (Reichers and Schneider, 1990). A distinction between organizational culture and climate can also be distinguished in terms of the methodologies used when studying the concepts. Climate has usually been assessed with quantitative methods (usually

questionnaires), and culture has usually been studied using qualitative approaches (Rentsch, 1990; Glick, 1985).

Schein (1992) acknowledges that culture is manifested at different levels (i.e. the degree cultural phenomenon is visible to the observer): basic assumptions, espoused values, and artefacts. Artefacts are overt manifestations of culture (language, technology, products, visible behaviour, and so on), easy to see but hard to decipher. Members of a group or an organization use espoused values, norms and rules of behaviour as a way of depicting the culture for themselves and others. Unconscious basic assumptions are considered by Schein to be the essence of culture and are taken-for-granted beliefs, perceptions, thoughts and feelings. Culture can be studied at the different levels, but the deepest level, the shared basic assumptions of a group, have to be understood before the espoused values and behaviours can be deciphered (Schein, 1992).

Researchers have also discussed the holistic characteristic of culture and climate versus the reductionistic approach, where culture and climate are assumed to be described by a limited number of dimensions (Guldenmund, 2000). The level of aggregation or the existence of subcultures within organizations or groups has also been put forward. An aggregation of the organization into meaningful divisions, units or functional levels provides a more correct view of the culture or cultures (Jones and James, 1979).

4.1.1 Similarities between organizational culture and climate

Reichers and Schneider (1990) believe that climate and culture are very similar concepts with substantial overlap, and agree with Schein (1985) that climate can be understood as a manifestation of culture. Guldenmund's (2000) review also concludes that organizational culture expresses itself through organizational climate. Other researchers (for example, Ekvall, 1983) have rejected the position that the two concepts are synonymous. Nevertheless, Ashforth (1985) says that the conceptual step from shared assumptions (culture) to shared perceptions (climate) is believed not to be large.

Denison (1996) concludes that the culture and climate research traditions 'should be viewed as differences in interpretation rather than differences in phenomenon'. Both traditions address 'the creation and influence of social contexts in organizations'. He emphasizes a better integration between the culture and climate research traditions in future studies of organizational contexts.

Some researchers say that shared values represent the core of an organizational culture. However, Hofstede et al. (1990) empirically show shared perceptions of daily practices to be the core of an organization's culture. They conclude that 'founders' and leaders' values become members' practice'. This is taken as evidence for the congruence between culture and climate.

4.1.2 Definitions of organizational culture and climate
Formal definitions of organizational culture and climate will be presented here.

Schein (1992) defines the culture of a group as:

'A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems'.

This definition emphasizes shared basic assumptions and learning. Schein explains the concept of shared basic assumptions by how he believes the learning process proceeds in a new group or organization: 'The founder of the new group starts with some beliefs, values, and assumptions about how to proceed and teaches those to new members through a whole variety of mechanisms'. 'This process always starts with beliefs and values that represent predictions about how things are (beliefs) and statements of how things ought to be (values). As they get validated for the group, what was originally a value comes to be gradually transformed cognitively into an assumption (a belief about how things are, now based on experience, and therefore no longer in need of being tested). As the group builds up more common experience, it gradually transforms its values and beliefs into assumptions'.

Ekvall (1983) distinguishes organizational climate from culture. He divides an organization's social system into culture, social structure, climate, and labour relations, and argues that they are distinguishable, although they affect one another and the boundaries between them are unclear. According to Ekvall et al. (1983), the organizational climate *is a conglomerate of the attitudes, feelings and behaviours that characterize life in an organization*. The organizational climate affects different organizational and psychological processes such as communication, problem solving, decision-making, learning and motivation.

Theoretical application in the thesis
Ekvall's definition of organizational climate is applied in this thesis. In the studies presented in Papers II-IV, the organizational climate was investigated using Ekvall's method, which assesses the climate in part with a focus on an organization's ability for innovation and change. A positive climate stimulates the innovation processes and contributes to testing and in some cases implementation of ideas (Ekvall, 1990).

4.2 Safety culture and safety climate
Safety culture is often seen as a subset of organizational culture where the beliefs and values refer specifically to matters of health and safety (Clarke, 1999). The distinction between the concepts of safety culture and safety climate, as well as organizational culture and organizational climate is not clear-cut. Several

definitions of safety culture/climate concepts exist: Guldenmund (2000) lists 16 definitions, but he suggests that safety climate refers to the attitudes towards safety within an organization, while safety culture concerns the underlying beliefs and convictions of those attitudes. Generally, the term safety culture is more embracing than that of safety climate (HSL, 2002) and a safety climate can be seen as sensing surface features of employees' attitudes and perceptions at a given point in time (Cox and Flin, 1998). The terms safety culture and safety climate are often used interchangeably (Cox and Flin, 1998).

One of the most widely used definitions of safety culture is the one developed by the Advisory Committee on the Safety of Nuclear Installations (ACSNI) (HSC, 1993):

'The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization's health and safety management.

Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures'.

Cooper (2000) draws attention to the term 'product' in this definition and argues it has led to an overly narrow emphasis on safety climate (attitudes and perceptions about safety) at the expense of the multifaceted nature of the concept of safety culture. In the pursuit to find a model of safety culture that takes antecedents, behaviours and consequences into account, Cooper recognizes the presence of an interactive or reciprocal relationship between psychological, situational and behavioural factors in accident causation models, which also can be found in relation to cultural change initiatives. Cooper bases the model on Bandura's reciprocal models (Bandura, 1977; Bandura, 1986) that '…explain psychosocial functioning in terms of triadic reciprocal causation, whereby an individual's internal psychological factors, the environment they are in and the behaviour they engage in, all operate as interacting determinants that influence each other bi-directionally' (Cooper, 2000). The adapted reciprocal model (Figure 6) reflects the multifaceted concept of safety culture and encompasses subjective internal psychological factors (i.e. people's attitudes and perceptions of safety and safety culture), observable safety-related behaviours (safety performance) and objective situational features (e.g. structure of the organization, safety management systems, working procedures). Additionally, the model emphasizes a triangulated set of quantitative and qualitative measurement instruments of safety culture.
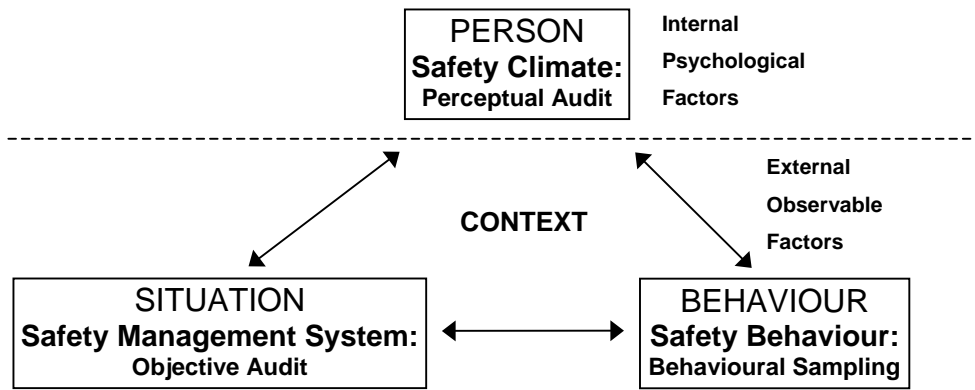
Figure 6. Reciprocal safety culture model (from Cooper, 2000).

The same multifaceted view on the safety culture concept is taken in the research studies presented in this thesis. However, the current assessments focus on measuring the perceptual and attitudinal areas of the safety culture. The assessments of the behavioural and situational areas are due for further development and research and are not included in this thesis.

Grote and Künzler (2000) suggest a socio-technical model of safety culture based on the joint optimization of technical and social subsystems and a flexible organizational approach in obtaining this optimization (in safety) by use of self-regulated work teams. Their model also emphasizes the proactive integration of safety into organizational structures and processes. The optimization of the subsystems and the proactive integration of safety should take both material and immaterial characteristics of the organization into consideration (Grote and Künzler, 2000).

In Rasmussen's (1997) system perspective for controlling safety, the socio-technical perspective takes an even broader view (Figure 7). In a system perspective, the awareness exists that a socio-technical system is divided into levels (legislative [both national and international], regulatory, managerial, work planning and system operational) and that these levels need to have well functioning coordination for safety. The system faces different sources of stress that can affect safety, such as fast pace of technological change, increasingly aggressive and competitive environments, changing regulatory practices and public pressure (Rasmussen, 1997). If the system is to cope and adapt to these sources of stress, it is vital to have strong connections between the levels in the form of goal directedness with feedback, learning and action within and across levels. This will more effectively update the system, resulting in better understanding of the characteristics of the system that could cause accidents and identifying the weak links when controlling the system's risk sources. The existing safety cultures on the different levels in the system, and how they affect each other, play an important role in this risk management approach. They will affect each other since the safety culture is part of an organizational

culture, which in turn is a part of an industrial culture and, at a higher level, the national culture (Helmreich and Merritt, 1998).

Environmental Stressors

Changing political climate and public awareness

Changing market conditions and financial pressure

Changing competency and levels of education

Fast pace of technological change
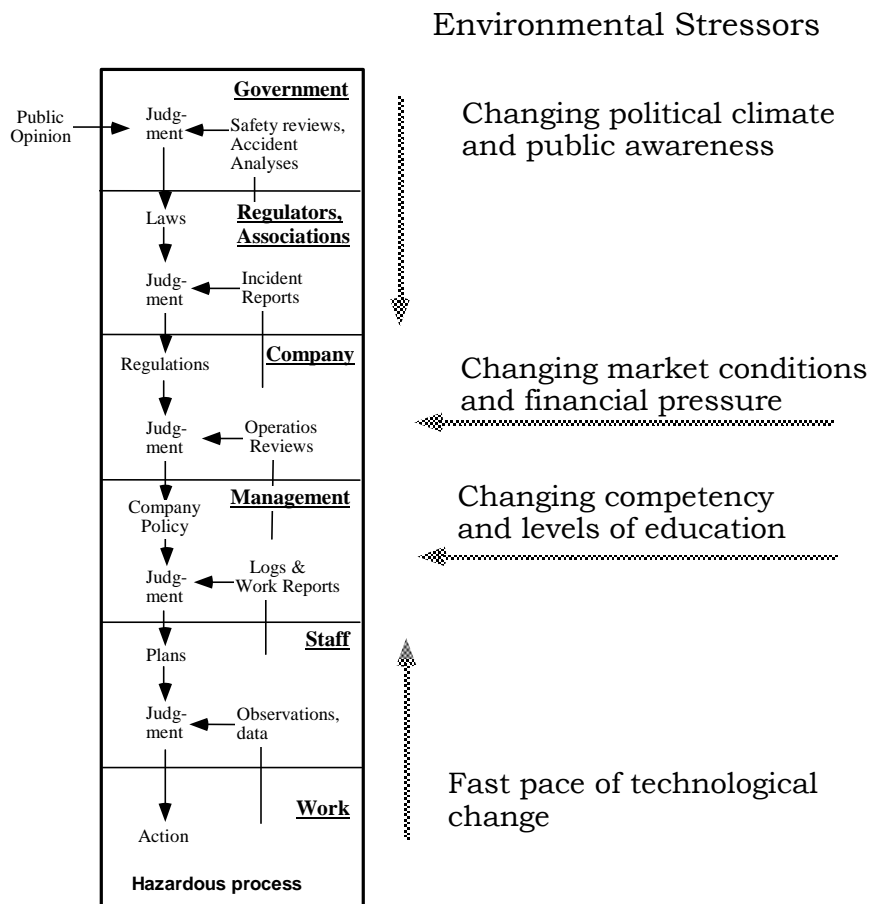
Figure 7. Risk management in a dynamic society is an adaptive systems control problem (from Rasmussen, 1997).

4.2.1 Safety culture and organizational culture

Helmreich and Merritt (1998) point out that it is the organizational culture that shapes the perception of safety, the relative importance placed on safety, and organizational members' activities regarding safety. Sorensen (2002) refers to Apostolakis and Wu (1995), who '…question the wisdom of separating safety culture from the culture that exists with respect to normal plant operation and power production. The dependencies between them are much stronger because they are due to common work processes and organizational factors'. Sorensen (2002) also refers to Reason (1997) who 'notes that the quality of production and protection depend on the same organizational processes'. Neal et al. (2000) found that safety climate was related to the organizational climate. Their findings suggest that interventions to improve organizational climate also might have a positive impact on safety climate, and interventions aimed at improving safety climate would be more effective if the organizational climate is already positive.

4.2.2 Learning – a proactive approach to safety

Definitions of safety culture can differ somewhat, but usually they include the proactive stance to safety (Lee and Harrison, 2000). Learning in an organization is associated with having a proactive approach to safety, which means collecting, monitoring, and analysing relevant information on safety and health and thus having updated knowledge about how work and safety are functioning. Thus a *learning* culture (Reason, 1997) is created where one learns from the information gathered, and is willing to introduce changes when needed. In Reason's approach to safety culture, he further identifies three critical aspects: *reporting, justness* and *flexibility*. In a reporting culture the organization has succeeded in creating trust and commitment in reporting incidents and anomalies in a good manner (and thereby also having a well functioning reporting system). Quick feedback with meaningful information to the reporter is emphasized. This is closely connected to a just culture where a well-balanced blame approach enhances the willingness to make such reports. A just culture also has to do with defining safe behaviour. Flexibility in an organization concerns the ability to transform the work organization in order to stand prepared for changing demands, e.g. during periods of high workload. It also comprises respect for individuals' skills and experiences. Cooper (2000) relates Reason's safety culture approach to the elements of the reciprocal model in Figure 6, and the interactions between the subcultures, i.e. psychological (e.g. just cultures), behavioural (e.g. reporting cultures) and situational (flexible and learning cultures) elements.

Koornneef and Hale (2004) suggest that the goals of an organization (e.g. safety goals) are realized through processes run by organizational units. They emphasize the close link between the risk assessment process (which specifies what risks there are), the risk management process (which establishes risk controls), the operational process (which carries out the controls), and the *learning process* (which assesses and improves the controls).

Continuous improvements in an organization imply a willingness to change and a condition that the organization regularly faces critical reviews. The organization thus needs to question its way of thinking and looking at things, and new tools and working practices that support continuous improvements must be found and accepted (Klefsjö et al., 1999). A systematical approach to continuous improvement is to work iteratively according to the PDSA improvement cycle (Plan Do Study Act) (Deming, 1993; Deming and Kilian, 1992).

4.2.3 Features or dimensions of safety culture

Guldenmund's (2000) review of the safety culture concept reveals that there is a wide range of safety culture features or dimensions assessed. The fact that different researchers label dimensions differently and include a variation of items within dimensions makes comparisons of the safety culture research somewhat difficult. Nevertheless, Guldenmund's (2000) review of the safety culture/climate research

showed that the dimensions most often measured were *management*, *risk*, *safety arrangements*, *procedures*, *training* and *work pressure*. Flin et al. (2000) examined the thematic basis of 18 safety climate scales in the industrial sector, and found that the most common themes related to *management* (perceptions of management attitudes and behaviours in relation to safety and production), *safety systems* (different aspects of the safety management system), and *risk* (own risk taking, risk perceptions, attitudes towards risk and safety). Although less frequent, themes relating to *work pressure* (mostly work pace and workload) and *competence* (perception of the general level of workers' qualifications, skills and knowledge) were also found (Flin et al., 2000).

Flin (2003) concludes that one of the major factors in the managing of an organization's safety is the degree of *management commitment* to safety and how the workforce perceives it. O'Toole (2002) concludes that there is a relation between management's leadership and approach to safety, the employees' perception of safety management, and accident/injury rates. Thompson et al. (1998) found that management plays an important role in promoting a safe workplace, but that managers and supervisors do so in different ways. Managers influence safety (indirectly) by affecting the politics of communication (or the work climate), and supervisors influence (directly) by the fairness by which they interact with employees. Rundmo and Hale (2003) analysed the relations between managers' safety attitudes, behavioural intentions and their self-reported behaviour. They found that safety attitudes might be an important causal factor for managers' behavioural intentions and behaviour. What seemed to be ideal attitudes for managers to display were high management safety commitment, low fatalism, low tolerance of rule violations, high worry and emotion, low powerlessness, high safety priority, high mastery and high risk awareness (Rundmo and Hale, 2003).

As a positive safety culture depends on the development of trust and mutual understanding between organizational levels, Clarke (1999) argues that accurate *inter-group* safety perceptions are vital to this development. Clarke studied *safety culture perceptions* amongst British Rail train drivers, supervisors and senior managers and found that there was a shared perception of the importance of safety, but inter-group perceptions were not realistic and revealed biased views of the safety attitudes of other levels.

Helmreich and Merritt (1998) point out that there exist many *subcultures* in an organization based on factors such as profession, work history, position, location, gender, age, etc. If these subcultures are united by the common values and beliefs of the organizational culture, this will have a positive impact on safety. However, the development of a strong, shared culture can be difficult if employees or divisions within a company have little opportunity to interact with each other (Schneider and Gunnarson, 1991). People at different locations in the organization will have different customs and practices and perceive different levels of risk which will

influence the management of safety at that location (Cooper, 1998). Fung et al. (2005) compared safety culture divergences among three levels of construction personnel in the Hong Kong construction industry: top management, supervisory staff and front line workers. It was found that the management group had higher mean scores on the safety culture factors studied than the supervisory staff, followed by the worker group. However, no statistically significant differences between the management group and supervisor group were found concerning the factors. Statistically significant safety culture divergences were mainly found between management and worker groups, and supervisor and worker groups.

Mearns et al. (1998), in their study of human and organizational factors affecting safety on 10 offshore installations, found indications of safety attitudes varying as a function of age, whether the individual was supervisor or not, occupation, shift worked and prior accident involvement. Nevertheless, Rundmo and Hale's (2003) study of attitude and behaviours among managers showed that age and job experience were insignificantly associated with attitudes, behavioural intentions, or self-reported behaviour.

Research has concluded that when studying subcultures within groups, the 'group' does not necessarily have to be within the boundaries of a company or a division (Hale, 2000). McDonald et al. (2000) studied four aircraft maintenance organizations, and the results concerning safety attitudes and compliance with task procedures suggested a strong professional subculture among aircraft technicians relatively independent of organization.

The achievement of a shared safety culture across subculture groups puts emphasis on *good communication* and listening skills across groups and individuals, in order to reach a shared situational awareness with respect to risk and safety. Mearns et al. (2001) suggest that conflicts of opinion and misunderstandings between subcultures and individuals can often be precursors to accidents and incidents. Good communication can prevent errors and also trap and mitigate errors. Furthermore, a diversity in safety attitudes can be beneficial, as subcultures can bring new perspectives 'that can provide a forum for learning, innovation and development' (Mearns et al., 1998). It has been found that within organizations where safety and safety issues were given high priority, frequent contact existed between workers and management, creating good communication (Zohar, 1980), which also can result in better safety standards and effect of safety policies (Holt, 2001).

How an organization handles safety-related information can greatly affect the foundations for building an efficient information system for safety and therefore probably also affect how the safety culture develops in an organization. Westrum (1992) discerns three types of organizations depending on their way of receiving and acting on information that concerns the organization's safety. The first type,

with a *pathological* culture, denies the existence of safety-related problems and no measures are taken. The second type, with a *bureaucratic* culture, acknowledges problems on a local basis with local measures taken, but a holistic view is not taken. The third type has a *generative* culture and actively seeks safety-related problems from a broader perspective and introduces in-depth changes to overcome these problems. The three cultures will most certainly have different implications for the possibility of change within an organization.

Research has shown that *attitudes towards safety* are associated with *risk perception* and *safety-related behaviours*. An individual lives and works within networks of informal and formal relationships which are manifest in social and institutional arrangements (Royal Society, 1992). HSC (1993) states that 'as people become socialized they adopt the definition of what is risky and what is not from the social groups and organizations to which they belong'.

It has been found that misperceptions of the seriousness of risks occur frequently at all levels in an organization (HSC, 1993). The perception of risk or people's judgments of riskiness is influenced by different attributes of hazards: controllable-uncontrollable, familiar-unfamiliar, high or low benefit, voluntary-involuntary, personal or societal threat, and natural or man-made risks (Royal Society, 1992). Additionally, faith in institutions and trust in those who manage the risks are considered to be important to the understanding of risk or risk perception (Slovic, 1993). The context, or the *working situation*, can also determine an individual's perspective on risk and safety. Misjudgments of risks may cause risk behaviour and inappropriate decisions with regard to safety measures and ordinary occupational accidents as well as large-scale accidents (Rundmo, 1997). However, having accurate risk perceptions does not necessarily result in correct risk or safety-related behaviours. Ignorance or deliberate violations of safety rules and procedures are often due to employee attitudes towards risk and safety (HSC, 1993).

Rundmo's (1997) study of employees on Norwegian oil platforms showed a significant and positive correlation between perceived risk and risk behaviour. However, risk perception was not found to predict risk behaviour. In Rundmo's (2000) study of safety climate, attitudes and risk perception within Norsk Hydro, it was shown that safety climate, employee attitudes and accident prevention contributed significantly to the variance in occupational risk behaviour. Ulleberg and Rundmo (2003) found that the relation between personality traits among young drivers and risky driving behaviour was mediated through attitudes.

Teo et al. (2005), in their study of safety culture in Singapore's construction industry, found that both workers' and supervisors' adoption of safe work behaviours is important to ensure site safety. They found that the willingness of workers to adopt safe work practices also depended largely on their perceptions of safety, level of safety education and training received, cultural backgrounds and

communication between fellow workers, supervisors and managers. In Cooper and Phillips's (2004) study of a packaging production plant, they found that the perception of the importance of safety training was predictive of actual levels of safety behaviour.

Van der Pligt concludes in his review article that risk information is generally not sufficient to yield changes in behaviour. Factors such as the efficacy and costs of preventive behaviour, social pressure and perceived self-efficacy play a major role when changing people's behaviour (van der Pligt, 1998).

Dedobbeleer and Béland (1998) reviewed nine safety climate studies and the employee risk perception factor was identified in two of the studies. They also found that worker risk perception in other studies was associated with worker perception of control, and therefore that the two variables were related to workers' involvement or responsibility for safety. Dedobbeleer and Béland advance the connection to 'democratic management, which stresses the importance of creating structures and processes that provide access to decision-making and enables participants to actively influence organizational decisions (Sass, 1989)'. Hale (2003) also advances the shared purpose in safety performance, i.e. the involvement felt by all parties in the organization, especially the workforce, in the process of defining, prioritizing and controlling risk.

Theoretical application in the thesis
Based on the theoretical framework on safety culture, brought forward in the literature review, the approach when assessing safety culture in the studies presented in this thesis focuses on nine aspects of safety culture, namely: *Learning*, *Reporting*, *Justness*, *Flexibility*, *Communication*, *Attitudes towards safety*, *Safety-related behaviours*, *Risk perception*, and *Working situation*.

4.2.4 Safety culture maturity levels

Fleming (2001) draws attention to the fact that organizations in the early stages of developing a safety culture are likely to require different improvement techniques from those with well-established safety cultures. Safety improvements in the form of behavioural and cultural approaches are more effective when an organization has reached a maturity level where technical and systems problems have been overcome. He suggests that an organization must meet a number of criteria in order to be relevant for the application of safety culture maturity levels: implementation of a Safety Management System; behavioural and cultural failures causing the majority of accidents; compliance with health and safety laws; and safety driven by the desire to prevent accidents—not prosecution. In Figure 8, Fleming presents a safety culture maturity model with five stages, and proposes that organizations progress sequentially through these levels, by building on the strengths and removing the weaknesses of the previous level.

Safety culture maturity model
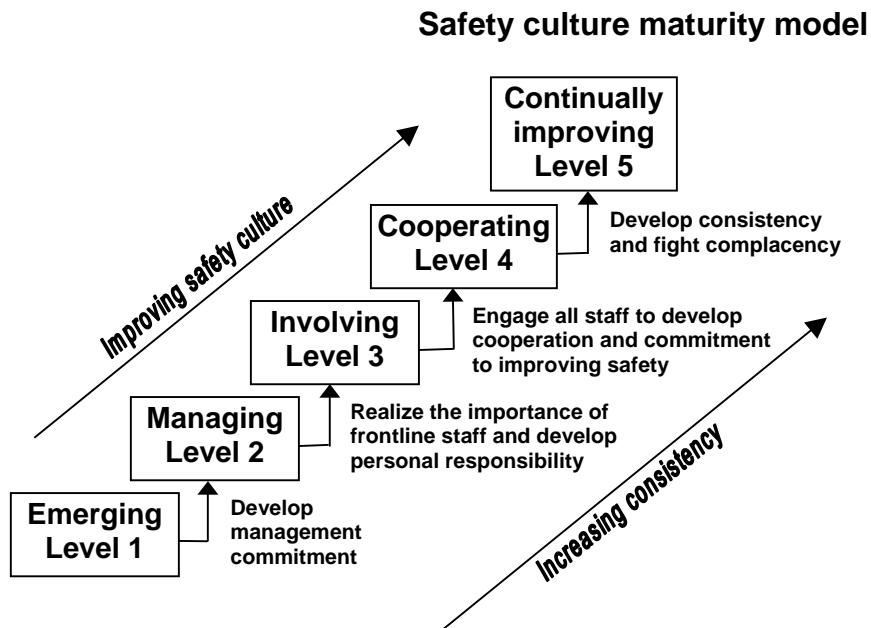
Figure 8. Draft safety culture maturity model (from Fleming, 2001).

4.3 Safety management

As stated in the Introduction, major disasters have triggered strong public concern over the management of hazardous activities (Hale et al., 1998). Governments have traditionally regulated safety through detailed prescriptive standards, but the standards quickly became outmoded by perpetual technological changes. Governments have moved towards a goal-oriented perspective in which the individual company's management is responsible for the development, use and improvement of safety management systems. Safety management relates to the actual practices, roles, and functions associated with remaining safe (Kirwan, 1998). Safety management in an organization is carried out via the documented and formalized safety management system including policies, rules, procedures and resources (Kennedy and Kirwan, 1998). How efficient and how successful the safety management system will be in reality depends largely on the attitudes and the commitment to safety that exist in the organization, especially on the management level (Bailey, 1997; Clarke, 1999; Kirwan, 1998; Kennedy and Kirwan, 1998; O'Toole, 2002). The safety culture, therefore, becomes the important denominator, as it constitutes the underlying perceptions and attitudes of the employee as well as behaviours on all levels in an organization. In McDonald et al.'s (2000) study of four aircraft maintenance organizations, a strong professional subculture among aircraft technicians emerged, independent of organization, which was likely to mediate between the organization's safety management system and safety outcomes. This subculture was an indication of differences in job perception between technicians and management. Technicians believed safety procedures were there to support them in the exercise of knowledge, skills and values. Management, however, believed the role of technicians was to follow the procedures explicitly

(even though clearly leading to production delays). McDonald et al. (2000) suggest two sides of the same coin: one is the ability to flexibly deal with new and unplanned situations; the other is that a difference between actual and official ways of working makes it difficult to have an objective standard of safety.

A number of guidelines concerning the implementation and operation of health and safety management systems exist, often linked to pre-existing standards of quality management as for example, the ISO 9000 series (Kennedy and Kirwan, 1998; Hale, 2003). In the maritime domain, the International Safety Management Code (ISM Code) has been adopted by the International Maritime Organization and provides an international standard for the safe management and operation of ships and for pollution prevention (International Maritime Organization, 1997). The Code is expressed in broad terms, based on general principles and objectives, and can therefore be applied to ships operating under a wide range of conditions. The code begins by stating that the cornerstone of good safety management is commitment to safety from the top. In matters of safety and pollution prevention, it is the commitment, competence, attitudes and motivation of individuals at all levels that determine the end result (International Maritime Organization, 1997).

Hale (2003) draws attention to the static characteristics of models for safety management systems. All hazards and risks are difficult to predict in advance, therefore the safety management system needs to be re-designed and constantly adapted to new technology and organizational changes and developments (Hale, 2003). Thus, good organizational learning is vital for a good safety management system (Hale, 2003), which can also be said to be the basic component of a good safety culture (Reason, 1997).

4.4 Risk, accident and safety

Short definitions of the terms "risk", "accident" and "safety" will be given here.

Risk

There are many perspectives on risk depending on the framework: safety engineering, social science, risk perception research, and economic decision analysis (Aven and Kristensen, 2005). In general, risk can be defined as the chance of a defined hazard occurring (Royal Society, 1992), or the possibility of an undesired consequence (Harms-Ringdahl, 2001). Risk is often quantitatively expressed by probabilities of occurrence, and the possible consequences expressed by quantities (e.g. loss of lives, amount of money). The perceived risk may be different from the 'objective' risk. Considering the subjective aspects of risk, it can also be a synonym for danger or threat.

Accident

Harms-Ringdahl (2001) defines an accident (incident) as an undesired event that (almost) causes damage or injury. Perrow (1999), taking a 'normal and system

accident' perspective, divides a system into levels and states that, 'Accidents involve damage to subsystems or the system as a whole, stopping the intended output or affecting it to the extent that it must be halted promptly. Incidents involve damage to or failures of parts or a unit only. …System accidents involve the unanticipated interaction of multiple failures'. Reason (1997) divides accidents into 'those that happen to individuals and those that happen to organizations'. An 'organizational accident' is characterized as having multiple causes (built-in latent conditions) and involving people on different levels in an organization or company.

Safety
Royal Society (1992) defines safety as the freedom from unacceptable risks of personal harm. Implied is a balance of risk against some criterion of acceptability, a balance between safety and risk. Rochlin (2003) identifies safety as a positive characteristic of the relative success of an organization. He forwards characteristics of high reliability organizations, where safety is more than avoidance of risk and management of error; it is a positive engagement shown in the organization that seeks to anticipate and plan for unexpected events. Reason (1997) introduces the 'safety space' and the place an organization will occupy in it. When the number of accidents in an organization is very low, the occurrence or non-occurrence of negative outcomes does not reveal the organization's position in the safety space. It is instead determined by the quality of the organization's processes to manage its risk sources (Reason, 1997). Rasmussen (1997) suggests safety to be the *margin* between normal operation and the loss-of-control boundary: ' …safety must be based on an identification of the boundary of safe performance by analysis of the work system, and the criteria that drive the continuous adaptive modification of behaviour. …The resulting level of safety consequently depends on the recovery characteristics of the system'.

Safety in the organizations studied
The studies of safety culture in the current thesis have been conducted in three transport branches: airport ground handling, passenger shipping, and air traffic control. The organizations studied are all safety-critical organisations where the term safety has three important aspects. The first concerns safety in relation to major accidents with serious human, production, economical, and environmental consequences. This aspect was in focus in a majority of the items in the question-naire package used to assess the safety culture in the organizations studied. The ground handling study focused on air safety, specifically damage to an aircraft fuselage. The passenger shipping study focused on vessel safety, specifically severe damage to the vessel. The air traffic control study focused on air safety. The second aspect concerns safety of the individual operator, i.e. seamen and ground handling operators in relation to work and body injuries. A few items in the safety culture questionnaire package related to work injury. The third aspect concerns the safety of third parties, i.e. the safety of passengers. This aspect of safety was not generally represented in questionnaire package items.

5 Methods and material

5.1 Research process
A short description of the applied research process (Figure 9) will be presented here.
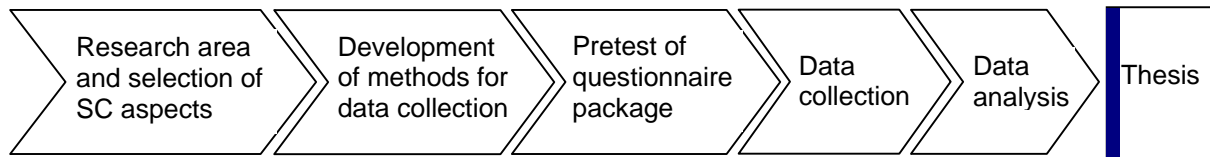
Figure 9. *Illustration of the research process in six steps. SC=safety culture.*

When the author first approached the safety research literature, her interest very quickly focused on the area of safety culture. After reviewing the relevant research, a methodology was developed that assesses individual perceptions and judgments on nine safety culture aspects existing in the literature. The methodology made it possible to study safety culture in practical contexts. The current approach to safety culture focuses on the ability of an organization to create and preserve a learning organization, where Reason's (1997) aspects — *Learning*, *Reporting*, *Justness*, and *Flexibility* — are central. The methodology consists of observations, a questionnaire package, interviews, and collection of facts. The questionnaire package contains nine scales, one for each safety culture aspect. Some of the items in the questionnaire package were taken from the literature review, while others were constructed by the author. Several field studies were also conducted in ground handling and passenger shipping settings in order to formulate items in a relevant manner for measurement of the safety culture aspects in those specific contexts. Leaders in central roles in each of these settings evaluated the proposed items for their relevance and appropriateness. A pilot study on board a passenger ship was also conducted to test the questionnaire package in a real situation. Thereafter, the studies were conducted in a similar manner.

5.2 Methodology

5.2.1 Methodological approach for assessing safety culture aspects
The methodology (observations, questionnaire package, interviews and collection of facts) was intended for practical application for studying and improving safety culture in specific real-life settings.

The approach to measuring safety culture that was chosen was to select safety culture aspects that have been previously investigated in other studies. Each aspect was then represented in the questionnaire package as a scale with a number of relevant items that are homogeneous (acceptable internal consistency). This approach may lead to average scores for different aspects (scales). The advantage of

this approach is that the average scores for safety culture aspects represent identifiable and recognizable characteristics of safety culture, and the results of the study can be placed within the contexts of previous research investigating such aspects.

Another approach would be to organize a large number of unspecified safety culture items using factor analysis. Factor analysis can be used to simplify the description of data by reducing the number of necessary variables (Anastasi and Urbina, 1997); to search for underlying patterns among items or variables (Streiner, 1994); to confirm a model (confirmatory factory analysis) (Streiner, 1994); or to look for variables that may be superfluous or not perform as expected (Streiner, 1994). None of these goals have been an objective in the research presented in this thesis. In the assessment of safety culture in the studies presented here each of the nine aspects says or describes something about a safety culture; the aspect could be about the effects of a safety culture or could be a prerequisite for the existence of a safety culture. The nine aspects are not necessarily independent or uncorrelated, but they are easy to use in practical settings. In a factor analysis, orthogonal or uncorrelated factors are produced which make it possible to theoretically discuss each factor without regard to the others, but the factors produced are not always easy to work with or understand in practical settings. Factor analysis of individual study data could possibly lead to safety culture factors that are not easily identified in or applicable in the context of the existing safety culture literature. Streiner (1994) proposes that it is often more realistic to assume that the factors obtained through factor analysis are correlated to some degree (oblique rotations can be used that do not require the factors to remain orthogonal when they are rotated). Streiner (1994) says 'the trade-off is between a more accurate reflection of the phenomenon *versus* greater difficulty in explaining the pattern of factor scores'. Additionally, items or variables can be factorially complex, in that they load in a meaningful manner on more than one factor and these items and variables are therefore sometimes removed or scored only for the factor on which they load the highest. However, these items or variables can, based on their content, be highly relevant when assessing a safety culture aspect, in that they give valuable input in change and improvement processes within an organization.

The nine aspects used in the current methodology for safety culture assessments can be found in the safety culture literature, and the author believes that these aspects provide a valuable and practically useful view of a safety culture within organizations.

The author preferred a questionnaire package with many items reflecting specific safety culture aspects of the setting (rather than reducing the number of items to an absolute minimum). Nevertheless, the objectives of factor analysis just stated are interesting for future studies of safety culture. In the research to be conducted after this thesis is completed (and when the data collection has been completed in the air

traffic control project and preferably data also collected in other branches), factor analysis might very well be conducted with the goal of determining which aspects and items are important for the measurement of safety culture. This would also be useful if researchers wished to reduce the questionnaire package to an essential minimum (which has not been the goal of the research presented here).

5.2.2 Nine aspects of safety culture

The current method for assessing safety culture is based on nine aspects of safety culture existing in the literature. An overview of the content of each aspect will be presented here.

Working situation

The individual's perceived *Working situation* involves items such as cooperation, support, appreciation of work, fatigue, adequate training in work practices, staff sizes and having an influence in the design of work. The aspect contains issues that can affect the employees' work performance as well as the possibility to live up to established safety rules and demands. The issues included under the heading *Working situation* have in various ways been touched upon in other studies (Zohar, 1980; HSC, 1993; Coyle et al., 1995).

Communication

Functioning routines concerning *Communication* in the normal daily work in an organization are vital to assure that the right persons are kept informed of the state of the system in order to make the appropriate decisions. The safety culture aspect *Communication* comprises items such as the receiving of and clarity of information, communication between people and between work groups, training in communication during accidents, and clarity about whom to contact concerning safety issues. The aspect is used in studies by such researchers as Ostrom et al., 1993; and Glendon and Stanton, 2000.

Learning, Reporting, Justness and Flexibility

Learning, Reporting, Justness, and *Flexibility* are four aspects based on Reason's (1997) perspective where a safety culture is equivalent to an informed culture. In a learning culture there exists the will and competence to learn from experience and the readiness to implement improvements. The aspect contains items concerning: whether employees have a habit of looking for safety problems on their own; encouragement to pay attention to lack of safety; the actions taken or not taken upon receiving information about safety deficiencies; and proactiveness in improvements in work and safety.

A reporting culture is one that succeeds in creating trust and commitment that results in good reporting of incidents and anomalies using existing reporting systems. This aspect comprises such items as: being able to express your opinion about safety at work; if management listens to employees regarding safety matters;

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the reaction you receive if you report anything concerning safety; providing reasons why employees would refrain from reporting damages to equipment.

In a just culture, a well-balanced blame approach enhances employee willingness to report and seeks to establish a clearer line between what is acceptable and unacceptable behaviour concerning safety. Items reflecting this aspect include: if it is believed that fair judgments are made when something goes wrong at work; if you hesitate to take the initiative at work because of fear of what would happen if it turned out wrong; acknowledgement for safe work; and attention when not performing the work in a safe manner.

A flexible culture manifests respect for skills, experiences and abilities among operators and supervisors. This means utilizing staff resources and being prepared to deal with unusual situations in the organization. Items include: appreciation of knowledge and experiences of all employees; encouragement to put forward ideas and suggestions for improvements at work; if you have been asked to solve a problem at work; and if it is acceptable to suggest changes in somebody else's area of responsibility.

Attitudes towards safety

Attitudes towards safety constitute individual and organizational attitudes concerning the importance of safety. Examples are: belief that top and middle management as well as operators are working for good safety; managements' interest in the well-being of operators; encouragement of safe practices; appreciation of safe work; personal responsibility for safety; if education and training are deemed important by management; and employee participation in planning for safety. This aspect can be found in many safety culture studies (e.g. Mearns et al., 1998; Niskanen, 1994).

Safety-related behaviours

Safety-related behaviours constitute both individual and organizational behaviours in relation to safety. The aspect includes items such as: general discussions about improvements leading to increased safety; encouragement of orderliness from supervisors; encouragement from fellow workers to work safely; pressure from different levels to take short cuts; taking unnecessary safety risks; usability of safety rules; and sufficient training for emergency situations. Safety-related behaviours have been touched upon in various ways in other studies (e.g. Geller, 1994; HSC, 1993).

Risk perception

Risk perception (e.g. Mearns et al., 1998; Rundmo, 1997) contains items concerning the belief that the work is carried out safely; the size of risk for the individual getting injured on the job or that one's work could lead to others being injured; the experience of having influence on safety at work; trust for middle management

concerning safety at work; and the belief that work is carried out with good safety margins.

5.2.3 Safety culture questionnaire package

The nine safety culture aspects were represented by nine labelled scales in a questionnaire package with the purpose of yielding quantifiable measurements in order to obtain comparable results from safety culture studies in different organizational settings. The specific items in the questionnaire package representing a given aspect of safety culture (e.g. *Communication*, *Learning*, *Risk perception*) (see Appendix I) were labelled as such, in order to focus the responder's attention on that particular aspect of safety culture while answering that group of items (scale).

The majority of the items are answered using a *five-point scale* (e.g. 'Not at all, Barely, A little, Much, Very much,' or 'Never, Seldom, Sometimes, Often, Very often'), where a higher value on the scale indicates a better safety culture. It would have been possible to use a larger number of points or categories in the scale (e.g. seven or nine), but as indicated by Wärneryd (1986), there is increasing doubt that a person can differentiate between much more than five categories. Furthermore, the increasing spread in standpoints you receive by using more categories is partly a result of increasing chance. Fewer categories than five could result in a scale that is too 'blunt', which can mean a loss of information since the responders are not able to find the standpoint that expresses their point of view.

The number of items representing each safety culture aspect (scale) is given in Table 1. The questionnaire package concludes with an open-ended question, with the purpose of giving the responder an opportunity to comment on work and safety in the organization, and to forward issues that have not been touched upon in the items for the nine safety culture aspects.

The aim was for the questionnaire package to be filled in anonymously by all staff in the organizations studied in order to gain a picture of the perceptions and judgments of safety culture aspects that was as representative as possible.

5.2.4 Reliability analysis of the nine safety culture aspects (scales)

Questionnaire package pretest

The safety culture aspect scales were tested for usability on 48 crew members on a Ropax ship in international traffic on the Baltic Sea. Specifically, what was tested was a) if the responders could complete the scales in the questionnaire package, b) if the items yielded an acceptable distribution of scores across different individuals, and c) if the items used to measure a given safety culture aspect (scale) were homogeneous, i.e. to determine the internal reliability of the scales.

To determine the reliability of the safety culture aspect scales, the internal consistencies of the nine aspects (scales) were assessed using the Cronbach's

coefficient alpha test. The Cronbach's coefficient alpha (Nunnally, 1978) ranges from zero to one, and a low value of alpha indicates that the instrument has little internal consistency, i.e. the items do not all refer to the same underlying aspect and thus the scale needs to be restructured. A high alpha value indicates good internal consistency. If the alpha values exceed .70, the instrument could be said to have sufficiently good reliability or internal consistency (Hair et al., 1998).

In the questionnaire package pretest, it was found that the responders were able to complete the nine scales with few unanswered items. Acceptable variation across subjects was also found for the scores for all items. Alpha coefficient values of >.70 were obtained for seven of the nine aspects (scales) of safety culture. The remaining two aspects, *Risk perception* and *Justness*, had alpha values of < .70.

Reliability analysis of the surveys presented in the thesis

The Cronbach's coefficient alpha test for each of the nine safety culture aspects (scales) in the questionnaire package was performed on the data from the ground handling, passenger shipping, and air traffic control surveys and the results are presented in Table 1. The analyses showed that the nine scales had sufficiently good reliability or internal consistency in all three studies, as almost all alpha values exceeded .70 (Hair et al., 1998). The *Flexibility* aspect (scale) had alpha values < .70 but > .60. The alpha value for *Risk perception* was notably lower for air traffic control (.43) than for the other two transport settings, which may reflect the highly regulated nature of the air traffic controller's work.

Table 1. Cronbach's coefficient alpha for the nine safety culture aspects (scales) in the three studies.

Safety culture scale	n of items*	Study		
		Ground handling	Passenger shipping	Air traffic control
Working situation	21 21 19	.90	.87	.80
Communication	11 10 8	.86	.85	.70
Learning	12 12 9	.83	.90	.82
Reporting	12 12 7	.83	.86	.74
Justness	12 12 9	.82	.84	.65
Flexibility	7 7 7	.64	.69	.61
Attitudes towards safety	14 15 15	.91	.88	.83
Safety-related behaviours	13 15 15	.86	.87	.72
Risk perception	7 8 6	.74	.75	.43

*Number of items when calculating average scores in the respective studies.

5.2.5 Interviews

Interviews were conducted to provide qualitative data that could validate the quantitative data from the questionnaire package surveys, and to gain more in-depth knowledge about the interviewee's perceptions and judgments of safety and safety culture. Through the interviews, it was possible to collect examples of positive and negative expressions of these concepts that the interviewee had experienced in his/her work.

As the fully structured interview technique is not intended to yield qualitative data and the unstructured interview can yield incomparable results (King, 1997), the choice fell on the semi-structured interview technique. This technique rests on a fairly detailed yet flexible interview guide (King, 1997). This guide lists the main questions in different areas that the interviewer wants to cover; they are designed as open questions. In the current case, the main questions concern the nine safety culture aspects.

All interviews were conducted at the workplaces studied with co-workers at different positions in the organizations.

5.2.6 Observations and collection of facts

The aim of the two sub methods, observation and collection of facts, was to provide enriched and complementary information. Observations of the operative work were conducted above all in the ground handling and passenger shipping studies and in combination with informal interviews with operators in which they shared their daily work experiences and existing risk and safety situations. The collection of facts concerned such items as: work procedures documentation, existing reporting systems, size of staff, and working hours.

5.2.7 Triangulation

The purpose of this combined methodology was to gain a multifaceted picture of the safety culture aspects within an activity. It was a way to confirm and validate the sub methods, but also complement each other. The use of different methods falls back on the principle of triangulation, the main idea of which is to overcome distortion in the results by triangulation with a maximally different method (Tschudi, 1995). This implies that it is unlikely that two totally different methods should share the same distortion. Tschudi advocates that if we concede that quantitative and qualitative methods generally are different, then triangulation is a strong argument for combining the two. In this case it is the combination of a quantitative questionnaire method with a qualitative interview method.

5.3 Organizational climate assessment

The organizational climate was assessed using Ekvall's (1990) questionnaire containing 50 statements. Subjects answered the questionnaire using a four-point scale (0-3) ('Not at all, To some extent, Fairly, To a high degree'). The organizational climate assessment includes ten dimensions that are relevant for an organization's ability for innovation and change. Most of the dimensions are also important for an organization's functioning in other aspects, but some are more specifically related to innovation (Ekvall, 1990). The ten dimensions are: 1) *Challenge/Motivation*: employees' involvement in and commitment to the organization. 2) *Freedom*: extent to which employees are allowed to act independently in the organization. 3) *Support for ideas*: overall attitude towards new ideas. 4) *Trust/Openness*: emotional security and trust in the relations within the

organization. 5) *Liveliness/Dynamics*: dynamics within the organization. 6) *Playfulness/Humour*: easiness that exists in the organization. 7) *Debate/Diversity*: extent to which different views, ideas and experiences exist in the organization. 8) *Conflicts*: presence of personal and emotional tensions. 9) *Risk taking*: willingness to tolerate uncertainty in the organization such as new ideas, news and initiative, rather than hazardous risk taking. 10) *Idea-time*: time devoted to development of new ideas.

The organizational climate average scores from the passenger shipping and air traffic control studies were compared with existing reference data for innovative and stagnating organizations (Ekvall, 1990).

The Cronbach's coefficient alpha values for the ten organizational climate dimensions from the two studies, and Ekvall's (1990) reference alpha values are given in Table 2. The analyses showed that the survey instrument had sufficiently good reliability or internal consistency, as almost all alpha values exceeded .70. The dimension *Risk taking* had alpha values < .60 but > .52.

Table 2. Cronbach's coefficient alpha for the ten organizational climate dimensions in the passenger shipping and air traffic control studies and reference alpha values (Ekvall, 1990).

OC dimension	Passenger shipping	Air traffic control	alpha - Ekvall 1990
Challenge/Motivation	.79	.74	.81
Freedom	.72	.62	.67
Support for ideas	.88	.88	.88
Trust/Openness	.77	.76	.76
Liveliness/Dynamics	.71	.78	.76
Playfulness/Humour	.82	.78	.70
Debate/Diversity	.69	.72	.67
Conflicts	.85	.85	.84
Risk taking	.53	.55	.66
Idea-time	.79	.73	.78

5.4 Material

5.4.1 Airport ground handling
The airport ground handling (ramp division) study was performed at Sweden's third largest airport. Field studies were conducted before and during data collection by interviewing the ramp manager and also by taking part in the operative work carried out over a three-day period. The following methods were used in the study: collection of facts, observations, questionnaire package survey, and interviews. The questionnaire package survey had a response rate of 75% (50/67). Interviews were conducted at the airport with ten subjects varying in age, work experience, day versus night shift, and positions within the company.

5.4.2 Passenger shipping

The passenger shipping study was performed on six passenger ships (two high speed crafts [HSC] and four passenger/cargo ferries [Ropax]), in a total of three shipping companies. The author spent two to three days on each ship applying the following methods: collection of facts, observations, questionnaire survey, and interviews. In total, interviews were conducted with 31 officers and 21 members of the crew from the three departments on board the ships. A total of 508 seafarers employed on the six ships completed the safety culture questionnaire package. The organizational climate questionnaire was administered to the employees on board three of the Ropax ships, in conjunction with the safety culture questionnaire package. A total of 328 seafarers completed the organizational climate questionnaire.

In the first shipping company, one Ropax ship (Ropax A) and one HSC (HSC E) were studied. Both ships operated the same route in the Baltic Sea, i.e. Trelleborg, Sweden – Travemünde, Germany. The Ropax A and HSC E questionnaire package surveys had response rates of 80% (57/71) and 93% (52/56), respectively.

In the second company, one Ropax ship (Ropax B) and one HSC (HSC F) were studied. Ropax B operated the route Gothenburg, Sweden – Kiel, Germany and HSC F the route Gothenburg, Sweden – Fredrikshavn, Denmark. The Ropax B and HSC F questionnaire package surveys had response rates of 60% (72/120) and 61% (69/114), respectively.

In the third company, two Ropax ships (Ropax C and Ropax D) were studied. Ropax C operated the route Stockholm, Sweden – Helsinki, Finland, and Ropax D the route Stockholm, Sweden – Åbo, Finland. The Ropax C and Ropax D questionnaire package surveys had response rates of 92% (184/200) and 49% (74/150), respectively.

5.4.3 Air traffic control

The air traffic control study was conducted at three locations within the Swedish Air Navigation Services (ANS), i.e. the two main air traffic control centres (ATCCs), and the ANS division head office. The study is longitudinal with three planned measurement rounds of which the first two have been completed. The subjects included in the study were assigned a code number in order to make it possible to follow individual changes in perceptions over time. The methods of assessment that have been applied have mainly focused on questionnaire package surveys and interviews. In this study the questionnaire package contained the nine safety culture aspects (scales), the organizational climate questionnaire, and questionnaires measuring psychosocial work environment, situational leadership, and team climate. The latter three are not included in this thesis. Interviews were conducted in the first measurement round with nine employees each (both managers and operators) at the two ATCCs. The questionnaire survey had the following response rates in the first and second measurement rounds, respectively:

ATCC A: 66% (141/213) and 61% (121/198), ATCC B: 56% (130/233) and 55% (118/213), and ANS head office: 63% (120/189) and 35% (66/189).

5.5 Statistical analysis

The statistical analyses in the four papers presented in the thesis are generally based on average scores for all the safety culture aspects and organizational climate dimensions. Cronbach's coefficient alpha was used to assess the internal consistency of the aspects (scales) in the safety culture questionnaire package (Papers I and III) and the dimensions in the organizational climate questionnaire (Paper IV). In Papers I-III, differences in average safety culture scores between subgroups were tested using the Student t-test (2-tailed) or one-way analyses of variance (ANOVA). In Paper IV, differences in average organizational climate scores between subgroups and air traffic control centres were tested using 2x2x2 factorial ANOVA and 3x2 factorial ANOVA. In Papers I-III, Pearson correlation coefficients were calculated to determine the strength of relationship among the nine safety culture aspects. In Papers II-III, multiple linear regression analyses were performed to examine the relationships between each of the nine outcome safety culture aspects and the ten explanatory organizational climate dimensions. In Paper III, the intraclass correlation coefficient (ICC) was obtained from a one-way random effects model (single measure) in order to test the stability of individuals' assessments of safety culture between the two measurement rounds.

Parametric and non-parametric analysis
The average scores were calculated based on the individual's answers to the items associated with the particular aspect or dimension. Subjects answered the safety culture items using a five-point scale (1-5) where a higher value on the scale indicated a better safety culture.

Within the statistical domain, there are differing approaches concerning the interpretation of measurement scales and the associated appropriate statistical methods. One approach suggests that scales (as the above) could be assumed to have equal (or approximately equal) intervals between the scores on the scale (Gunnarsson, 2002). Interval measurement means that scores can be added, subtracted, multiplied, and divided (Greene and d'Oliveira, 1999), and therefore an average score can be calculated based on the sum of the items representing an aspect.

Another approach suggests that scales, as the above, should be considered as an ordinal scale (Gunnarsson, 2002). Ordinal measurement means that each of the scores on the scale can be graded in the order of being larger or smaller than the other scores (the intervals between contiguous scores are not assumed to be equal) (Greene and d'Oliveira, 1999). This means, for example, that average scores would not be calculated and another approach would be used (e.g. an aspect would be

represented by the median of the items included). Non-parametric statistical tests would also be used.

Aron et al., 1994 states that 'In the vast majority of psychology research focus is mostly on numeric, equal-interval variables (or variables that roughly approximate equal-interval variables)'. In the statistical analyses in the studies presented in this thesis, it was also assumed that the questionnaire package data were collected using an interval scale measurement and parametric tests were therefore used in the analyses. Parametric tests require that scores are measured on an interval scale, and that scores are normally distributed or at least roughly symmetrical around the midpoint, and that the variability of scores in each condition should be roughly the same (Greene and d'Oliveira, 1999). As a safety precaution, analyses were also re-calculated secondarily by comparable non-parametric tests. In all instances, the parametric and non-parametric analyses yielded the same results regarding statistical significance.

6 Summary of papers

This thesis is based on four papers, which present results from: an airport ground handling safety culture assessment; passenger shipping and air traffic control safety culture and organizational climate assessments. This chapter summarizes the papers with a focus on the results.

Paper I. Aviation on the ground: Safety culture in a ground handling company

Ground handling work performance is an important part of the civil aviation flight cycle. Safe and efficient performance in handling aircraft when refuelling, loading/unloading, towing, and so forth has to be maintained. Well functioning safety management for minimizing the risk for accidents is vital and dependent on the safety culture. The aim of this study was to develop and test a method for assessing safety culture based on nine safety culture aspects in a ramp division in a ground handling company, and to yield reference data on safety culture aspects in this transport branch.

The ramp division consisted of 67 men, among whom 50 (16 managers and 34 operators) completed the questionnaire package, resulting in a response rate of 75%. Semi-structured interviews were conducted at the airport with ten of these subjects.

The results of the safety culture assessment revealed a generally good existing safety culture, from an average-score point of view. *Attitudes towards safety* and *Communication* received high average scores, while *Flexibility*, *Justness*, *Learning*, and *Risk perception* received somewhat lower scores.

Analyses were conducted to see whether individual characteristics such as time in company, age, and in-house educational level among personnel had an effect on how safety culture aspects were perceived and judged. It was found that none of the characteristics or variables had a significant explanatory effect. Furthermore, concerning the possible effects of individuals' hierarchical position in the company, the result showed that the management group almost always gave higher average scores on safety culture aspects (eight of nine aspects) than did operators, these differences reaching statistical significance only for *Flexibility*.

Concerning the strength of relationships among the nine safety culture aspects, positive and statistically significant correlations were found among all nine aspects. Especially strong correlations were found between *Risk perception* and both *Attitudes towards safety* and *Safety-related behaviours*.

The questionnaire package survey identified 30 items on which 20% or more of the responders gave negative responses (i.e. 1-2 on the five-point scale). The work

conditions on the ramp that were reported by responders to negatively affect compliance to safety rules were time pressure, small staff size, and high workload.

Six managers in the organization were asked to make three judgments on each of eight questions representing eight of the nine safety culture aspects (*Working situation* was excluded due to its multifaceted content). The judgments concerned their estimation of the percentage of their personnel who would describe a good/very good safety culture on that question ('estimated reality'), what percentage would be desirable ('managers' goal'), and what lower percentage level would indicate the need for improvement ('lower limit of acceptability'). For every safety culture aspect, an average score across the six managers was calculated for each of the three areas of judgments, and these average manager estimates were compared with the employees' actual scores for the eight questions obtained through the questionnaire package survey. Not unexpectedly, managers' goals were uniformly high. However, for seven of the eight aspects, the actual scores of the employees were, on the average, lower (i.e. poorer) than the managers' lowest acceptable limit for safety culture. *Communication* was the only aspect on which employees scored above the managers' lowest acceptable limit.

Paper II. Safety culture on board six Swedish passenger ships

Maritime safety has previously concerned primarily technical aspects, which have been conceived of as the main cause of accidents. After a series of maritime accidents, other aspects such as management, human factors, and increasingly, safety culture, are now being emphasized as vital for safety. The aims of this study were to increase knowledge about the characteristics of safety culture in the maritime setting and the relationship between safety culture and organizational climate. This knowledge can be vital in the process of developing and improving safety culture.

The safety culture was studied on board six passenger ships (two high speed crafts [HSC] and four passenger/cargo ferries [Ropax]) belonging to three shipping companies. The ships operate routes in the Baltic Sea and the Kattegatt (the strait between Denmark and Sweden). A total of 508 seafarers employed on the six ships completed the safety culture questionnaire package. Among these, 328 seafarers employed on three of the Ropax ships completed the organizational climate questionnaire. Semi-structured interviews were conducted with 31 officers and 21 members of the crew from the three departments on board the six ships.

In total, the study yielded generally positive evaluations for the safety culture aspects on all ships. A similar safety culture pattern emerged for the separate ships: *Learning*, *Justness*, and *Flexibility* received somewhat lower average scores than the rest of the safety culture aspects. Only small and non-significant differences in average scores were found for HSC versus Ropax ships.

A very similar organizational climate pattern was found on board each of the three Ropax ships. All organizational climate dimensions for the three ships had significantly lower average scores compared to norms for innovative organizations. A majority were above the norms for stagnating organizations, while three dimensions were just at or below the stagnating reference level.

Comparisons between officers and crew on board each of the six ships concerning their perceptions and judgments of safety culture aspects showed that officers generally had more positive perceptions than the crew. While statistically significant differences between the two groups were most often seen for the total ship crew, they were somewhat scattered across safety culture aspects, ships, and the three departments.

On the three Ropax ships where the organizational climate was investigated, many statistically significant differences in perceptions/judgments between officers and crew were found on board Ropax B (officers more positive), but not on board Ropax C and D.

For the three Ropax ships where the organizational climate was assessed along with the safety culture, we studied whether relationships existed between each of the nine safety culture aspects and the ten organizational climate dimensions. The results showed that the organizational climate dimensions, *Support for ideas* and *Challenge/Motivation,* were most frequently and positively related to the safety culture aspects. *Freedom* (allowed to act independently) and *Playfulness/Humour* were negatively related to several safety culture aspects.

The main findings from interviews showed that HSC crew members believed the commitment to safety was better on board an HSC than on a Ropax ship, and pointed to the flexibility of the safety organization on board and to the HSC's physical design, as explanations for this difference. The construction of the vessel has led to eliminating boundaries between the deck and engine departments, resulting in shorter channels of communication and improved cooperation between the two departments. Relatively few incident reports were written on board the six ships, but those that were written concerned near-misses. Only a small amount of organized exchange of information or learning took place between ships within the same company concerning, for example, experiences of incidents and quality of equipment. The safety equipment on board the ships was given generally positive evaluations by the crew. However, the crew often suggested other concerns in relation to this equipment and in relation to safety: the crew members assigned to handling the equipment were perhaps the weakest link. Factors such as advanced age, physical problems, and poor physical fitness of the crew were seldom taken into consideration in safety planning.

Paper III. Safety culture in Swedish air traffic control

European air traffic control is undergoing changes in organization and technology in order to increase efficiency in air traffic. Change processes can have a negative impact on existing safety cultures and safety itself. The aims of this study were to gain a better understanding of the safety culture aspects in an air traffic control setting in general and, specifically, to obtain baseline data concerning the safety culture aspects and the relationships between safety culture and organizational climate before major organizational and technical changes were implemented in Swedish air traffic control.

The assessments were conducted at the two main air traffic control centres and at the Air Navigation Service division (ANS) head office in Sweden. In this four-year longitudinal study still in progress, two of three planned measurement rounds have been completed, the first providing baseline results and the second and third providing results regarding changes. In the baseline measurement round, a total of 391 individuals employed at the three study locations completed the safety culture questionnaire package and the organizational climate questionnaire.

While the average scores for safety culture aspects sometimes differed somewhat across the three locations, the patterns of the curves containing the average scores for safety culture aspects were the same. The administrative ANS unit had generally somewhat lower scores compared to the two operative ATCCs. *Communication*, *Justness*, and *Flexibility* generally received somewhat lower average scores than the rest of the safety culture aspects.

Individual characteristics such as gender, age, time in company, and time in current position had almost no effect on how safety culture aspects were perceived and judged. Managers had more positive perceptions and judgments of the safety culture aspects than did non-managers (with many statistically significant differences between the two groups). In contrast, only a few statistically significant differences between managers and non-managers were found concerning perceptions and judgments of organizational climate dimensions.

Subjects at each of the three study locations showed notable individual stability on safety culture measurements across the 20-month interval from measurement round one to round two. Average intraclass correlation coefficients (across the nine safety culture aspects) were .58, .61, and .60 for ATCC A, ATCC B, and ANS, respectively.

The investigations concerning existing relationships between safety culture aspects and organizational climate dimensions showed that the two dimensions, *Support for ideas* and *Conflicts,* were positively and most frequently related to the various safety culture aspects (a high score on *Conflicts* means a low level of conflict). This was so

for the two ATCCs. However, very few relationships were found between the safety culture and organizational climate concepts at the administrative ANS head office.

At each of the two ATCCs, five managers were asked to make three judgments on each of eight questions representing eight of the nine safety culture aspects (*Working situation* was excluded due to its multifaceted content). The judgments concerned their estimation of the percentage of their personnel who would describe a good/very good safety culture on that question ('estimated reality'), what percentage would be desirable ('managers' goal'), and what lower percentage level would indicate the need for improvement ('lower limit of acceptability'). For every safety culture aspect an average score across the five managers at each ATCC was calculated for each of the three areas of judgments, and these average manager estimates were compared with the employees' actual scores for the eight questions obtained through the questionnaire package survey. Managers' goals were uniformly high. For the aspects *Communication*, *Reporting*, and *Attitudes towards safety*, the managers' estimated reality responses were in accordance with the employees' actual ratings. For the other five safety culture aspects, the actual scores of the employees were, on the average, lower than the managers' lowest acceptable limit for safety culture.

The main findings from interviews showed that the reporting culture within the ANS organization was good, with an open dialogue in a blame-free context, in which operators shared their learning experiences and were not afraid of reporting safety problems. The terms 'quality' and 'safety' have now become a more structured part of the air traffic control activity, compared to a few years ago. Safety assessments precede organizational and technical changes that can affect air safety. Safety assessments have naturally been carried out in other forms previously, but not as structured at present, and not with the same amount of documentation. A local safety manager now assists the ATCCs with these safety assessments as well as with risk and consequence judgments. The safety manager role has been well received at the ATCCs, leading to increased education in safety management and the development of a safety management system. The ANS transition into commercialized spheres has led to a new distinction between functional activity and financial control, and the decentralization of these questions in the organization. This was believed to be positive among the interviewed ATCC managers, pointing at increased clarity of existing units within the ANS and, above all, clearer goal setting from top management to bottom. A goal-oriented leadership approach is now being applied in the total organization, and this was believed to have had a positive effect on the feedback process, with clearer and more comprehensive communication.

Paper IV. Organizational climate in air traffic control: Innovative preparedness for implementation of new technology and organizational development in a rule governed organization

Because of ongoing organizational and technical changes within the Swedish air navigation services, a study concerning the organizational climate for changes and innovations was conducted to investigate the organization's capacity to cope with changes. A positive innovative climate is of importance in order to manage and easily adapt to changes. Such a climate usually has difficulties evolving in organizations closely governed by rules and regulations, such as in the air traffic control setting. The aim of this study was to examine the organizational climate with respect to changes and innovations, by paying attention to differences between types of air traffic control centres (arrival-and-departure versus en-route air traffic), between operative and administrative work, and between manager and non-manager groups.

The study was conducted at the two main air traffic control centres and at the ANS head office in Sweden. The organizational climate was assessed using Ekvall's (1990) questionnaire. A total of 390 individuals employed at the three study locations completed the questionnaire.

Comparisons with reference data representing innovative and stagnating organizations showed that the organizational climate at each of the three studied locations was similar to the climate in innovative organizations. Even though the air traffic control activity is governed by rules and regulations, a rather innovative climate seemed to exist.

The results showed that differences in organizational climate existed between the arrival-and-departure centre and the en-route centre. Compared to the en-route centre, the arrival-and-departure centre reported statistically significantly higher average scores on *Trust*, *Playfulness/Humour*, and *Conflicts*, and lower scores on *Idea-time*. The results also showed that the administrative personnel at the two ATCCs assessed the organizational climate as more positive (more creative) than did the operative personnel on three of the 10 dimensions: *Freedom*, *Support for ideas*, and *Debate*. No differences were found between managers and non-managers in how the organizational climate was perceived and judged in any of the three units that were studied.

7 Discussion

The general aims of the studies presented in this thesis were: to assess individual perceptions and judgments of safety culture in practical contexts, as well as individual and organizational characteristics that influence these perceptions and judgments; to conduct comparative studies of safety culture aspects in three transport branches and establish reference data concerning the aspects in each of these three transport branches; and to investigate relationships between safety culture aspects and organizational climate dimensions.

Studies were conducted within airport ground handling, passenger shipping, and air traffic control, where the safety culture was assessed using observations, questionnaire packages, interviews, and collection of facts. In total, 949 subjects completed the safety culture questionnaire package and 80 interviews were conducted. The organizational climate questionnaire (Ekvall, 1990) was completed by a total of 719 subjects.

This chapter discusses methodological issues and the results found in the studies, as well as reliability and validity issues.

7.1 Methodological issues

The nine scales representing the nine safety culture aspects were found to function well (with a good level of measurement reliability) in the three transport settings, and may constitute valuable methods for monitoring and improving safety culture aspects in working environments.

As studies in this field generally lack absolute norms for what constitutes a 'good safety culture', it may be helpful to use the current multiplex approach of: (a) describing the general (average) levels for the nine safety culture aspects; (b) reporting specific topics in the safety culture (items within safety culture aspects) identified as problematic by a notable subgroup of participants for potential improvement (operationally, 20% or more of responders); (c) comparing reality (i.e. operators' reports) with management's expectations and 'acceptable lower-limits' for safety culture aspects; and (d) investigating the stability of individuals' assessment of safety culture aspects over time. Furthermore, investigating safety culture aspects in association with the organizational culture/climate also proved to be a valuable step in gaining a broader understanding of the relations between the two concepts.

The questionnaire and interview methods have strengths and weaknesses (as do most other methods). Hammond (1995) suggests that questionnaires are often criticized as a researcher tool because of the problem with distorted answers by responders, i.e. answers that are not truthful. There can be many reasons for these distortions. One can be that the responder simply does not know the answer to a

question and therefore guesses. Another can be that the responder would like to make a good impression. The safety culture questionnaire package in this thesis contains sensitive items. For example, it has questions about behaviours and attitudes towards safety of both the individual responder and of work colleagues in the organization. Instead of answering honestly, the responder may answer the way he/she believes to be *socially desirable*. The responder can be disappointed with him/herself for having a particular attitude, or feels he/she is letting the work colleagues down by answering in an honest way. This researcher believes that the responders' answers are generally honest in the studies presented, as both negative and positive answers where obtained concerning delicate matters. However, one case where the results were found to be due in part to an effect of social desirability emerged in the ground handling study. One item in the questionnaire package asked whether reports were made when an employee accidentally damaged equipment used on the job, and an overwhelming majority (98%) responded that it was always reported. Nevertheless, few such reports were filed, and the ramp manager had knowledge of the low commitment in reporting such incidents and anomalies. He had emphasized the existing no-blame approach to human error and had also encouraged increased reporting. However, comments during interviews with the staff revealed existing problems concerning trust in key persons, and lack of anonymity when writing a report. The staff was aware of the importance of reporting deficiencies in technical equipment and therefore gave responses that were in line with what was socially desirable in the ramp division. This finding illustrates the value of obtaining both questionnaire and interview data.

The reliability of interview data can be affected by various sources of error, some of which can be attributed to the subject and some to the interviewer. Breakwell (1995) mentions 'researcher effects', where the characteristics of the interviewer, for example, clothing, dialect, gender, etc., can affect the responder's willingness to participate in the interview and give proper answers. One way to overcome this, Breakwell concludes, is to use the same interviewer in all interviews in order to keep the conditions constant, which also was done here.

The basic components in both questionnaires and interviews are, of course, the questions and their design. Great effort was made to make the questions as clear and understandable as possible. Both emotionally charged wording and leading questions were avoided. This increases the chances of obtaining reliable answers from the responders.

As the perceptions and judgments of safety culture can be different for different individuals, positions, departments, etc., efforts were made to include all subjects at all levels in the organizations studied in order to get a representative view of the safety culture aspects.

In the air traffic control study, which is longitudinal with three planned measurement rounds (where the first two have been completed), *feedback meetings* were held at the three study locations concerning the results of the measurements. In this study, a basic purpose of the safety culture measurement (and the other organizational aspects) was that it should yield results that can be used in discussions at the air traffic control centres and the ANS head office to find out what measures are needed to improve safety culture aspects. This represents a step in their continuous improvement processes. The feedback meetings may also generate new issues to be handled in relation to safety. The idea was to have an interactive dialogue between researchers and members of the air traffic control setting to allow the researchers to meet and adjust to the concrete needs in a realistic manner. At the same time, the researchers could provide the organizations with usable knowledge.

7.2   Three transport branches: comparison of results

The comparison of average scores for safety culture aspects across transport branches (Figure 10) showed that air traffic control often had somewhat higher safety culture scores compared to the other two branches, while the ground handling ramp organization generally had the lowest scores. Additionally, in the air traffic control study it was found that the administrative ANS head office had somewhat lower average scores on several safety culture aspects than did the two operative air traffic control centres.

The differences in safety culture level (average scores of aspects) could be a reflection of several components, which probably can affect safety culture aspects in different ways. One component could be the nature of the work (or the working situation), where the physically heavy ramp work (compared to air traffic controllers, for example) could lead to a more pessimistic view among personnel. Furthermore, differences in average scores for safety culture aspects between operative and administrative organizations within air traffic control, can also be a reflection of type of work, since scores for *Risk perception* and *Reporting* can have a different meaning to the two groups and can be higher among operators than among the administrative staff. Other components concern the safety management system and leadership within an organization. The ramp work is not as standardized and regulated as within air traffic control and on board ships, which could influence the manifestation of safety culture in everyday practice. Similarly, the fact that air traffic controllers (as compared to administrators) should comply with safety management procedures and need to have another awareness of risks, could be an explanation for the differences in safety culture perceptions and judgments between these two groups. Furthermore, if the local management at the different study locations has made deliberate attempts to create or form a certain safety culture, or parts of it, this can also be reflected in differences in average scores for safety culture aspects. The differences in average safety culture scores between the branches could also be a manifestation of the maturity level in safety culture.

Air traffic control could thus be said to be the most 'mature' among the three branches.

Figure 10. Comparison of average scores for safety culture aspects from three transport branches (identical item sets within aspects): air traffic control (operative units), passenger shipping, and airport ground handling (ramp organization).

In the ground handling study, the results showed that hierarchical position had little effect on how the different safety culture aspects were perceived and judged, although managers generally had somewhat more positive perceptions and judgments compared to the staff. Comparisons between officers and crew on board the ships concerning their perceptions and judgments of safety culture aspects showed that officers generally had more positive perceptions than the crew (often statistically significant). Also in the air traffic control study, managers often had a more positive view of the safety culture aspects (statistically significant) than did non-managers/operators. Similar results were found by Fung et al. (2005) in the Hong Kong construction industry, in which the management group had higher mean scores on the safety culture factors studied than did supervisory staff and especially the workers. It could very well be that individuals who advance in a system to management positions already have a greater commitment to safety culture, and/or develop such a commitment in association with their increased responsibility for the operative work and their staff. This may result in more positive perceptions and judgments of safety culture aspects compared to non-managers.

Interestingly, officers and crew on board the ships, and managers and non-managers/operators within air traffic control, differed very little in their perceptions and judgments of organizational climate dimensions. This is perhaps not so

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surprising. In the shipping industry there exists a strong culture with deep traditions. Very often a crew member (especially in the deck and engine departments) has advanced in the functional hierarchy and has along the way been taught and learnt the values and the ways to perceive and think. In the air traffic control study, a majority of the managers had started their careers as air traffic controllers and had therefore through education, training and by profession been very much cast in the same mould as the others and shaped by the existing organizational climate. In both branches, professional advancement in the organization has probably not altered the individual's perceptions and judgments of the organizational climate.

In both the ground handling and air traffic control studies, selected managers made judgments on 'estimated reality' (i.e. percentage of their personnel who would describe the safety culture as good/very good), 'managers' goals', and 'lower limit of acceptability' concerning safety culture aspects. It could be concluded that in both studies the reality reported by the staff often was somewhat poorer than that estimated by managers, and that the reality consistently was somewhat poorer than the acceptable lower limit. In short, the reality regarding operators' reports of safety culture was often poorer than both managers' estimations and lower acceptable limits.

In both the ground handling study and the air traffic control study, individual characteristics such as gender, age, time in current position, overall time in the company, and in-house educational level were found to have very little effect on how the safety culture aspects were perceived and judged. This lack of relationship is similar to the findings of Rundmo and Hale (2003), but different from Mearns et al. (1998), who found age to relate to safety attitudes.

The organizational climate questionnaire (Ekvall, 1990), used in the passenger shipping and air traffic control studies, is partly aimed at measuring the capacity for innovation and change in an organization. A positive climate stimulates the innovation processes and contributes to testing and in some cases implementing ideas (Ekvall, 1994). An innovative climate is often characterized by openness in the exchange of information, which among other things is important for the psychological value of promoting trust (Ekvall, 1994). An innovative climate usually has trouble evolving in risk managing organizations which are governed by rules and regulations (Ekvall, 1994), such as the air traffic control organization. Detailed instructions to guarantee safety offer few opportunities for new ideas. Organizations with control-oriented cultures are more likely to fail at implementation of new technology compared with organizations with a more flexible-oriented culture (Zammuto and O'Connor, 1992). The results in the passenger shipping study showed that the organizational climate on board the three Ropax ships was somewhere in between the normative innovative and the stagnating organization types, and very often closer to the stagnating type. In the air traffic control study,

the organizational climate at each of the three units was similar to the climate in innovative organizations.

Even if there are some innate differences between an innovative organization and a safe organization, the hypothesis is that some characteristics in an innovative organizational climate (e.g. support for new ideas) are correlated in a positive manner to safety culture aspects, while other characteristics (e.g. more conflicts) are correlated to the safety culture aspects in a negative manner. In both the passenger shipping and air traffic control studies, relationships were found between safety culture and the organizational climate. In the passenger shipping study, better *Challenge/Motivation* among personnel and a higher level of *Support for ideas* were significantly related to most safety culture aspects. At the two ATCCs in the air traffic control study, a higher level of *Support for ideas* and a lower level of *Conflicts* were positively related to many safety culture aspects. However, very few relationships were found between the organizational climate dimensions and safety culture aspects at the administrative ANS head office. *Support for ideas* concerns the way new ideas are met in an organization. If positive, the spirit is positive and constructive, and initiatives are encouraged and listened to (Ekvall, 1990). The results from the passenger shipping and air traffic control studies showed that *Support for ideas* seem to be related to a safety culture as well as being a central dimension in an innovative climate. In the process of improving and developing a safety culture this knowledge can be vital.

Learning
As a whole, the air traffic control organization studied can very much be characterized as a learning organization where one important aspect is the reporting culture for incidents and anomalies. The results show that learning processes are better developed in the air traffic control setting than in passenger shipping and airport ground handling ramp activities. Air traffic control can be characterized by a more mature approach to reporting anomalies and by having a more developed procedure for analysing limitations and implementing improvements. This is perhaps due to the more obvious direct risks associated with air traffic control activities. Using Westrum's (1992) terminology, it can be characterized as a *generative* organization. In shipping companies and on board ships that comply with the ISM Code, a reporting system for incidents and anomalies should exist. This researcher believes there is a need for increased reporting and improvement of the learning processes within this branch. The last steps in learning, i.e. analysing reports and implementing changes, are more difficult and demand more of the companies and crews. The ships and shipping companies studied could be said to have a generally high level of commitment to safety issues, which leads the researcher to suspect that there are flaws in the learning processes and in the safety cultures in other shipping and management companies as well. It will most likely take some time before the maritime area reaches the level of maturity concerning reporting that can be found, for example, in air traffic control in countries in

Northern Europe. It is possible that the blame culture that has existed for a long time in the maritime area and still does (Veiga, 2002) could be a hindrance on the path towards good reporting. The maritime setting could therefore be characterized as being a *bureaucratic* organization. Study results suggest that the airport ground handling (ramp) organization also represents a *bureaucratic* organization.

7.3 Reliability and validity

Reliability and validity are complex, multi-dimensional phenomena (Kerlinger, 1969; Hammond, 1995), in which reliable measurement is a necessary condition for valid measurement (but not vice versa).

Reliability of measurement generally concerns whether the measurements are accurate, dependable, stable and predictable, and is typically measured in terms of *internal consistency* of the variable(s) in question (Cronbach's coefficient alpha), their *stability* over time (by test-retest correlations for repeated measurements by the same individuals) and *inter-observer agreement* (by correlations across different individuals concerning measurement of the same characteristic).

The first two types of reliability are most appropriate for the current thesis. Acceptable internal consistency was demonstrated by alpha coefficients for each of the nine safety culture aspects (Table 1, average alpha value of .79). Furthermore, re-tests of safety culture aspect scores for the same subjects within the air traffic control study showed a significant individual stability over a 20-month period (intraclass correlation coefficient) of approximately .60 across all nine aspects. Inter-observer agreement was not studied here.

Validity generally concerns whether one is measuring what one intends to measure. Validity can be represented in terms of *face validity* (whether the items appear to the observer to represent the topic under study), *content validity* (whether the items are judged to adequately represent the total content of the topic under study), *concurrent validity* (whether the scores positively relate to scores produced by a different, independent, validated method measuring the *same* phenomenon), *predictive validity* (whether the scores accurately statistically 'predict' some other phenomenon, e.g. a particular outcome or behaviour, past—present—or future) (Kerlinger, 1969).

<u>Regarding face and content validity in safety culture measurement</u>: When assessing safety culture in the studies presented in this thesis, nine aspects found in the safety culture literature were chosen to represent the safety culture concept. Safety culture is a rich, multifaceted concept that probably will not be captured by a limited number of aspects, and some aspects in a safety culture may exist that have not been assessed or touched upon in the current or even other studies. However, questionnaire surveys with a limited number of aspects or dimensions may be useful for comparative organizational studies (Reichers and Schneider, 1990). The

author's ultimate goal is to find the key features of a good safety culture that could be assessed by a method with high usability and efficiency, for example, by standardized questionnaires in combination with interview. The procedures are described above for choice of the current aspects and items, based on previous research. The current questionnaire package consists of nine aspects (scales), thus covering more aspects than in some previous research.

Above all, individual perceptions and judgments have been the focus in the current assessment of safety culture. To gain a more comprehensive view of the state of the safety culture, safety behaviours and 'the system' (or situation) could also have been explored in greater detail, and should be included in future studies. For example, are there safety management systems in place? Are they well functioning? Do laws contradict the development of a good safety culture?

The current safety culture studies have been conducted in three transport branches with different characteristics. This raises the question whether all nine safety culture aspects are equally important in all settings. We can learn a lot about the differences and similarities in aspects between branches. What constitutes a good safety culture in one branch can be different from a good safety culture in another branch. The aspects should not be regarded as *generic* features of a safety culture.

<u>Regarding concurrent validity in safety culture measurement</u>: While several different questionnaires and scales for measuring safety culture exist, to our knowledge, no other directly comparable methods with the very same contents exist, hindering the testing of concurrent validity.

<u>Regarding predictive validity in safety culture measurement</u>: The evaluation of the safety culture data in relation to other 'outcome variables' of some type (e.g. accident statistics) has thus far received little attention. Such a validation of the assessment method has not been made so far. One reason is that in the shipping industry, incident and accident data are not well recorded due to fragmented reporting. If incomplete accidents/incidents statistics were used, then a low number of reported accidents could actually reflect poor reporting rather than truly good safety. Good reporting of incidents and accidents may be more characteristic of settings with a good safety culture, while settings with poor safety culture may be poor in reporting accidents/incidents. A study of safety culture's relationship to accident/incident statistics of good quality is an important task for future research. This would be a way of finding out if the aspects used in the assessment are indicative of the state of safety.

8 Conclusions and further research

The approach when assessing safety culture in the studies presented in this thesis was focused on nine aspects of safety culture found in the literature: *Learning, Reporting, Justness, Flexibility, Communication, Attitudes towards safety, Safety-related behaviours, Risk perception*, and *Working situation*.

The safety culture was studied using observations, questionnaire packages, interviews, and collection of facts. The nine scales representing the nine safety culture aspects were found to function well (with a good level of measurement reliability) in the three transport settings, and may constitute valuable methods for monitoring and improving safety culture in working environments. Obtaining both questionnaire and interview data was valuable; the questionnaire package provided comparative data across transport branches and allowed establishment of reference data concerning safety culture aspects in each of these three branches. The interviews provided knowledge and examples of positive and negative expressions of safety culture that the interviewees had experienced in their work.

The comparative studies of safety culture aspects were conducted using a multiplex approach of data collection, which gave valuable knowledge concerning the safety culture aspects.

The comparisons of average scores for safety culture aspects showed that air traffic control often had somewhat higher average safety culture scores compared to the other two branches, while the ground handling ramp organization generally had the lowest average scores.

Managers generally had somewhat more positive perceptions and judgments of safety culture aspects compared to employees. However, the two groups differed very little in their perceptions and judgments of the organizational climate dimensions. Individual characteristics such as gender, age, time in current position, overall time in the company, and in-house educational level were found to have very little effect on how the safety culture aspects were perceived and judged.

Managers' expectations and goals concerning safety culture aspects as compared to reality (i.e. employees' actual scores obtained through the questionnaire package survey) were investigated in the ground handling and air traffic control studies. In both studies, the reality regarding operators' reports of safety culture aspects was often poorer than both managers' estimations of reality and managers' lower acceptable limits for safety culture aspect scores.

The organizational climate on board the three Ropax ships was found to be somewhere in between the normative innovative and the stagnating organization types, and very often closer to the stagnating type. In the air traffic control study,

the organizational climate at each of the three units was similar to the climate in innovative organizations.

Relationships existed between safety culture aspects and organizational climate dimensions. In the passenger shipping study, better *Challenge/Motivation* among personnel and a higher level of *Support for ideas* were significantly positively related to most safety culture aspects. In the air traffic control study, a higher level of *Support for ideas* and a lower level of *Conflicts* were positively related to many safety culture aspects.

It was found that the learning processes are better developed in the air traffic control setting than in passenger shipping and airport ground handling ramp activities. Compared to the other two branches, air traffic control can be characterized by a more mature approach to reporting anomalies and by having a more developed procedure for analysing limitations and implementing improvements.

Further research in the safety culture field should concentrate on:

1) developing methods for assessing the behavioural and situational areas of safety culture,

2) testing the relation of safety culture to safety management and safety behaviour,

3) determining which aspects and items are important for measurement of safety culture, for example, in order to reduce the questionnaire package to an essential minimum, and

4) finding indications concerning what elements influence safety behaviours, and how they exert this influence.

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Appendix I Questionnaire package

The specific items representing each of the nine aspects of safety culture (scales) are presented here.

Your work situation
-Do you like your job?
-Do you get on well with your co-workers?
-Do you think you have received enough education/training in order to perform your job assignments in a safe manner? regarding air/ship safety / re work injury*
-Do you have access to the equipment needed in order to perform your work in a safe manner?
-Do you think you have received training in how to use the machinery on the job?
-In general, how do you experience the condition of the equipment handled in you work?
-During a normal working week, how often do you feel physically exhausted when you are working?
-During a normal working week, how often do you feel mentally exhausted when you are working?
-During a normal working week, how often do you feel stressed when you are working?
-Do you experience that you get the support you need in your work from your foreman/supervisor?
-Do you experience that you get the support you need in your work from your co-workers?
-Do you feel that you can influence your own work situation?
-Has it been made clear who is supposed to do what at work?
-How often do you find yourself in a situation were it is unclear what you should do?
-How do you experience cooperation within the operation?
-Do uncertainties arise on the job due to the use of different languages?
-Do you feel the staffing is sufficient to perform the work in a safe manner? re air/ship safety / re work injury*
-Do you ever feel that the work setting/work situation is chaotic?
-Do you feel your work is appreciated?

_____
* not in air traffic control study

Flexibility
-Do you experience that the knowledge and experiences of all employees are appreciated?
-When a problem arises, is it the most knowledgeable person who gets to solve it?
-Is it acceptable to make suggestions for change concerning somebody else's area of responsibility?
-If a task closely related to your own hasn't been carried out, do you tell the person who should have done it?
-If a task closely related to your own hasn't been carried out, do you do it yourself?
-How often have you been asked how to solve a problem that arises at work?
-Do you feel employees are encouraged to put forward ideas and suggestions for improvements concerning work?

_____

Communication in normal work
-Do you receive the information you need to be able to carry out your job a safe manner? re air/ship safety / re work injury*
-Does the information you need on the job come at the proper time?
-Do you receive clear instructions from your foreman/supervisor?
-Do you think you have received sufficient training in how communication should work in

emergency situations?

-How do you think the communication functions between different teams/units at work? Is it easy to talk with other team members about the work on board?

-How do you think the communication functions between the ship/ramp/ATCC and the shipping company/'expeditionstjänst'/ANS?

-How do you think the communication functions during change of shift (e.g. information at hand over)?

-Is it clear who you should contact to discuss questions of safety? re air/ship safety/re work injury*

-Do you receive clear instructions through the loading instruction report (LIR)? R

_____

* not in air traffic control study

R in ramp study

Reporting

-Are you satisfied with how you are informed about safety issues that affect you?

-How much information do you receive about incidents and accidents that occur at work? re air/ship safety / re work injury*

-Do you think enough information is collected to check if machines/technical equipment are functioning?

-Do you think enough information is collected to check if the work routines are functioning?

-Do you think enough information is collected to check if the safety and fire fighting equipment are functioning? S

-Do you experience that you can say what you think about the safety at work? re air/ship safety / re work injury*

-If you happen to damage the equipment used on the job, do you report it? R

-What reaction do you receive if you report anything concerning the equipment used on the job? (Choose all appropriate alternatives.)   R, A

    ❑ taken seriously   ❑ get a good response ❑ rewarded

    ❑ rejected   ❑ get a bad response   ❑ thanked

    ❑ ignored   ❑ punished

    ❑ other_____

-What reaction do you receive if you report anything negative about aircraft safety/safety on board/ air safety? (Choose all appropriate alternatives.)

  As above.

-For what reasons would employees refrain from reporting damages to equipment used on the job? (Choose all appropriate alternatives.)   R, S

    ❑ unclear how to report   ❑ lack of time   ❑ does not lead to any improvement

    ❑ can not be done anonymously ❑ fear

    ❑ other_____

    ❑ no known reasons

-Are there routines for anonymously reporting safety problems at work?

    ❑ yes   ❑ no   ❑ do not know

-If you experience a near miss (i.e. an event that could have led to damage to an aircraft/ship/affected air traffic control work), do you report this (either orally or in writing)?

-Do you think the management listens to employees regarding safety matters? re air/ship safety / re work injury*

-If you happen to hurt yourself on the job, do you report it?*

_____

* not in air traffic control study

R in ramp study

S in shipping study,

A in air traffic control study

Justness

-Do you feel it is accepted that you sometimes can make a mistake in your work?
-Do you think you and your co-workers are fairly judged when something goes wrong on the job?
-Do you think that the operators/crew are worried about being blamed for mistakes?
-Do you hesitate in taking the imitative on the job because of anxiety of what could happen if something went wrong?
-Do you think it has been made clear were the line is drawn for acceptable and unacceptable behaviour at work?
-Do those who perform their work in a safe manner receive acknowledgment for this?
  re air/ship safety / re work injury*
-Do those who <u>do not</u> perform their work in a safe manner receive attention for this?
  re air/ship safety / re work injury*
-Do you experience that you and your co-workers receive praise for calling attention to deficiencies in safety? re air/ship safety / re work injury*
-Do you experience that they want to find a scapegoat when something goes wrong at work?

_____
* not in air traffic control study

Learning

-Do you think the operators/crew have a habit of looking for problems concerning safety on their own?
-Do you experience that you are encouraged to call attention to deficiencies in safety in your daily work?
-Do you talk about near-misses that occur on the job (i.e. events that could have led to damage to an aircraft/ship/affected air traffic control work)?
-If you detect deficiencies on the job that can affect aircraft/ship safety/air safety, do you think improvements then are made?
-If you have reported something concerning the aircraft/ship safety/air safety (orally or in writing), do you feel measures are taken within reasonable time?
-Do you think the company calls attention to and takes seriously the problems regarding safety that arise on the ramp/on board/on the job in air traffic control?
  re air/ship safety / re work injury*
-Do you experience that those responsible for the ramp/on board/ATCC operations act on information about safety deficiencies? re air/ship safety / re work injury*
-When improvements in safety have been addressed, do you experience that follow-ups are carried out to ensure that the improvements have actually occurred?
  re air/ship safety / re work injury*
-When as a rule, are improvements in work and safety made?
  ❑ always before something negative happens
  ❑ often before something negative happens
  ❑ before and after something negative happens
  ❑ often after something negative happens
  ❑ always after something negative happens

_____
* not in air traffic control study

Safety-related behaviours

-Do you experience that you generally talk about how the work can be improved in order to lead to increased safety? re air/ship safety / re work injury*

-Do your superiors encourage orderliness on the job?

-Do you experience that your co-workers encourage one another to work safely? re air/ship safety / re work injury R

-Do you think the operators/crew work in a safe manner?

-Does it happen that unnecessary safety risks are taken regarding the aircraft/ship/air traffic control work?

-Do you experience that the safety rules and routines for preventing aircraft/ship damage/problems in air traffic control function in reality?

-Do you think your job can be more safely performed by leaving out some rules?

-Do you think your job can be performed faster by leaving out some rules? R, A

-Does it occur that co-workers pressure you to take shortcuts in your work?

-Does it occur that middle management pressures you to take shortcuts in your work?

-Do you think the passenger safety/safety within air traffic control is sufficient? S, A

-Do you think the safety training on board is sufficient? S, A

-Do you think the safety equipment on board is sufficient? S

-Does it occur that shortcuts are taken in your work that can involve a risk on air safety? A

-How often do conditions at work result in you not being able to follow safety rules meant to prevent aircraft/ship damage/problems within air traffic control?

If this occurs, why? (Choose all appropriate alternatives.)
- ❏ time pressure   ❏ workload   ❏ work schedule   ❏ other divisions at work
- ❏ staffing   ❏ equipment ❏ work routines   ❏ safety equipment
- ❏ weather   (❏ air traffic)
- ❏ other_____

-Do you think you receive sufficient training in what to do in emergency situations? S, A

_____

* not in air traffic control study
R in ramp study
S in shipping study
A in air traffic control study

Attitudes towards safety

-Do you think the management is working for good safety?
  re air/ship safety / re work injury

-Do you think the middle management is working for good safety?
  re air/ship safety / re work injury

-Do you think operators are working for good safety? re air/ship safety / re work injury

-How much personal responsibility do you feel for aircraft/ship safety/safety in air traffic control?

-How often have you taken part in the planning for safety? (e.g. meetings, discussions)

-Do you think it is worthwhile to talk about near-misses (i.e. events that could have led to damage to an aircraft/ship/affected air traffic control work) in order to learn from them?

-Do you think safety exercises are useful/valuable? S, A

-Do you experience that working in a safe manner is appreciated?

-Do you think the management takes interest in the crew's/operators' well-being?

-Do you think the management actively encourages safe work?

-Do you think the management finds education and training important?

-Do you think that your foreman/supervisor believes safety is a part of daily work?

_____

S in shipping study
A in air traffic control study

Risk perception
-Do you think the work is carried out in a safe manner? re air/ship safety / re work injury*
-Is there a risk that you will be injured on the job?*
-How great is your confidence for middle management concerning safety at work/air safety?
-How do you experience the passenger safety/air safety? S, A
-Do you feel you have an influence on safety in your work?
-Is there a risk that your work could lead to others being injured?
-Do you experience the work as being carried out with good safety margins regarding the
  aircraft?/Do you experience the ship as having good safety margins?

_____

* not in air traffic control study
S in shipping study
A in air traffic control study

Appendix II Papers

Paper I

Aviation on the ground: Safety culture in a ground handling company

Ek, Å. and Akselsson, R.

Paper II

Safety culture on board six Swedish passenger ships

Ek, Å. and Akselsson, R.

Paper III

Safety culture in Swedish air traffic control

Ek, Å., Akselsson, R., Arvidsson, M. and Johansson, C.R.

Paper IV

Organizational climate in air traffic control:
Innovative preparedness for implementation of new technology
and organizational development in a rule governed organization

Arvidsson, M., Johansson, C.R., Ek, Å. and Akselsson, R.