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Safety Culture in Sea and Aviation Transport

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Lund, Sweden, 2006

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 transportbranscherna, 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 transportbranscher och en möjlighet att skapa ett referensmaterial inom varje transportbransch. 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 flygtrafikledningen 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 säkerhetskulturaspekterna 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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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.

Contents

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.

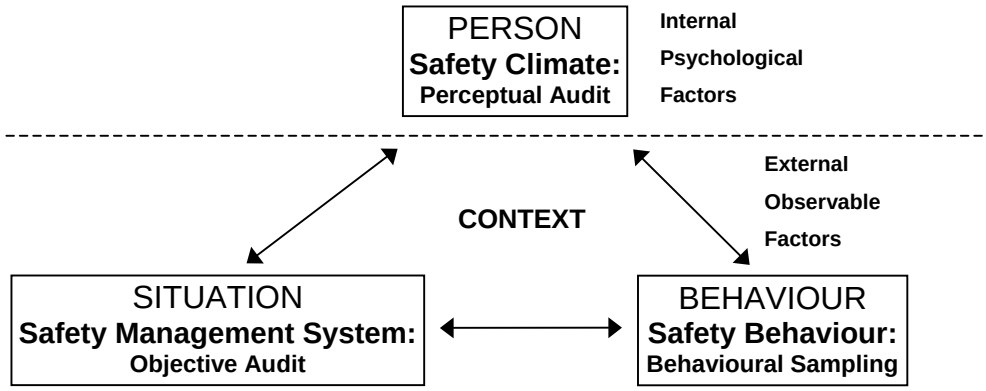

***Figure 6**. Reciprocal safety culture model (from Cooper, 2000).*

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).

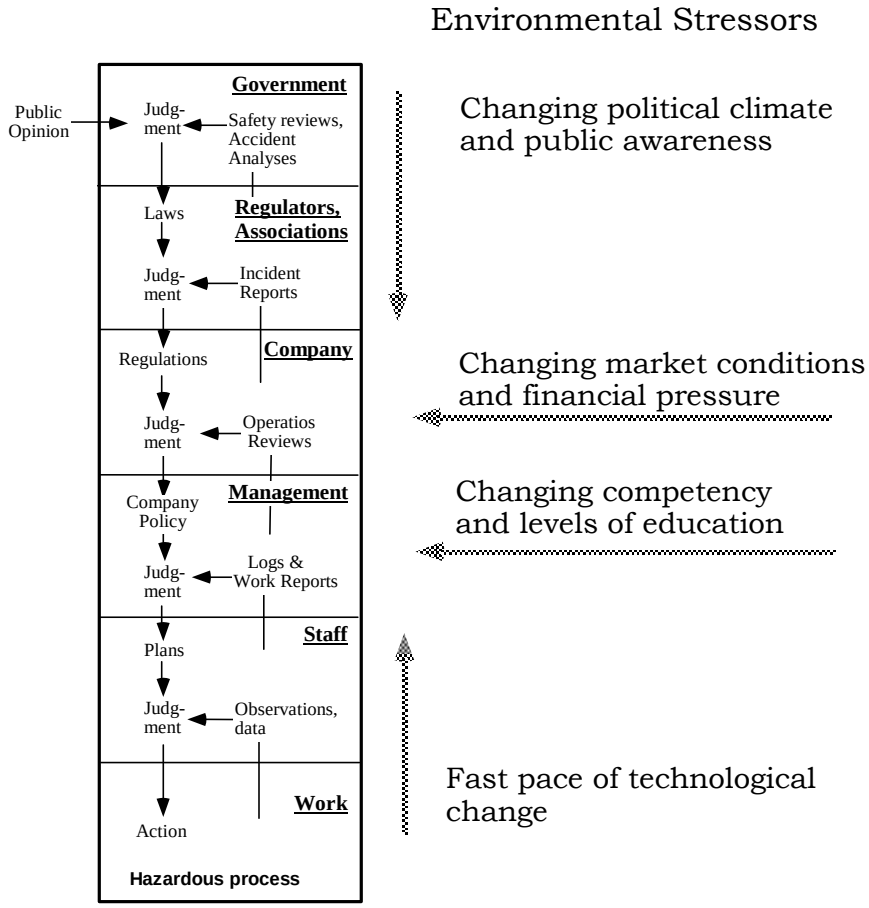

***Figure** 7. Risk management in a dynamic society is an adaptive systems control problem (from Rasmussen, 1997).*

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.

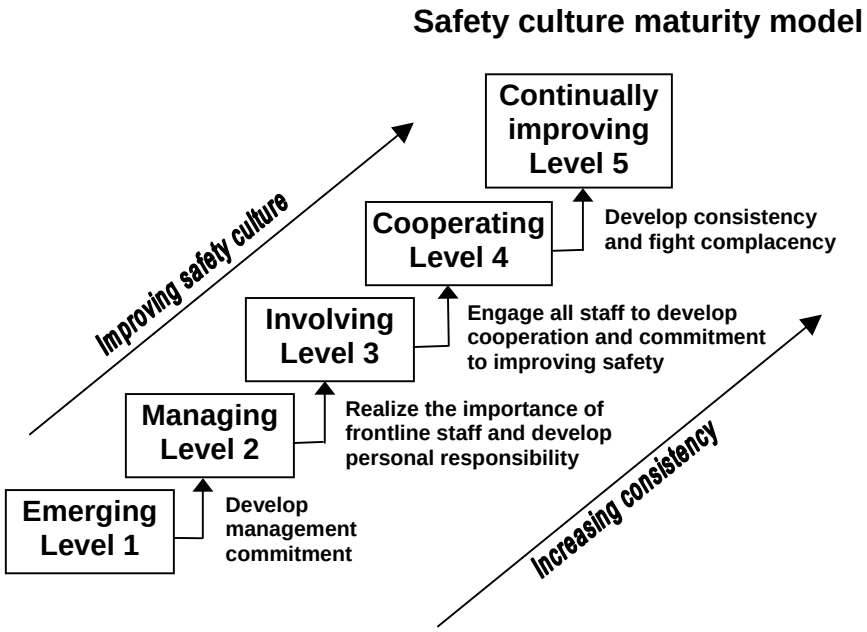

Figure 8. *Draft safety culture maturity model (from Fleming, 2001).*

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 questionnaire 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.

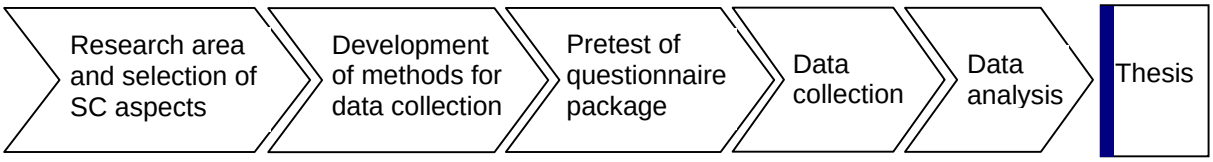

Figure 9. *Illustration of the research process in six steps. SC=safety culture.*

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;

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.

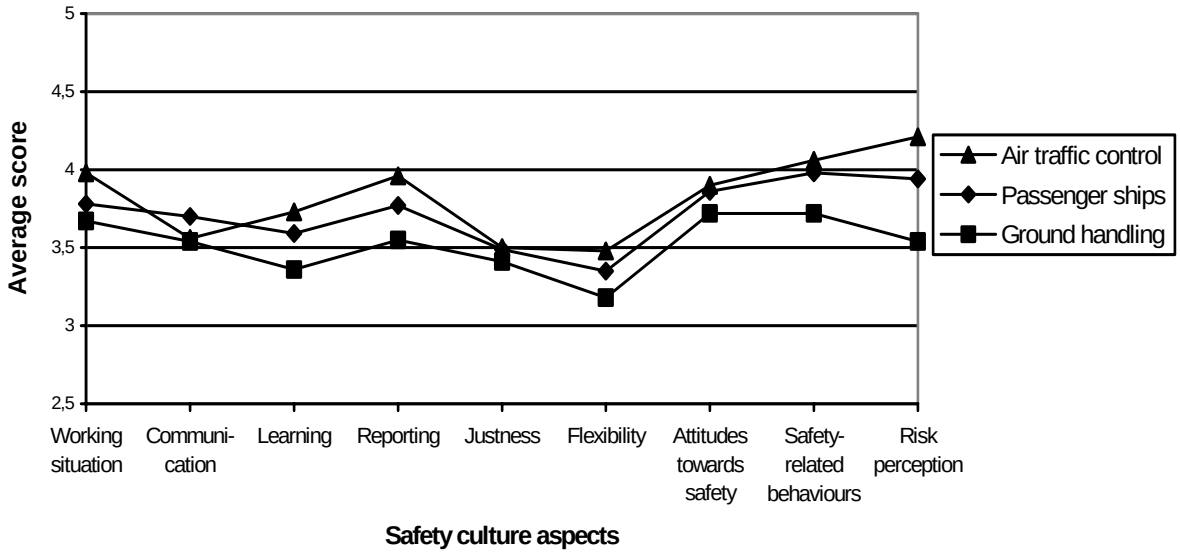

Figure 10. *Comparison of average scores for safety culture aspects from three transport branches (identical item sets within aspects): air traffic control (operative units), passenger shipping, and airport ground handling (ramp organization).*

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

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).

Regarding face and content validity in safety culture measurement: 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.

Regarding concurrent validity in safety culture measurement: 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.

Regarding predictive validity in safety culture measurement: 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?

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* 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

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* 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?*

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* 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 do not 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?

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* 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

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* 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

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* 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?

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* 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.

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Aviation on the Ground: Safety Culture in a Ground Handling Company

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Abstract

Ground handling work performance is an important part of the civil aviation flight cycle. Well functioning safety management for minimizing the risk for accidents is vital and dependent on the safety culture. This article reports on a safety culture assessment of a ground handling company using a multiplex approach method. The study is included in the establishment of reference data concerning safety culture aspects in different transport branches. The results of the assessment reveal a generally good existing safety culture. However, the safety culture is somewhat poorer than that estimated and desired by the managers, and than that in other transport branches.

Introduction

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 attained. Safety concerns both aircraft and frontline personnel. Aircraft on the ramp can be unintentionally damaged due to improper management of heavy vehicles in their direct vicinity. The ramp is also a dangerous and risky working environment for frontline personnel. Safety and economy are strongly coupled to one another in this type of operation. Aircraft are extremely expensive to repair, and delays or cancelled flights due to aircraft damage result in indirect costs that can be substantial. 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, equipment and luggage) and large-scale aircraft accidents. It is believed that successful safety management in an organization depends largely on the existing safety culture (Bailey, 1997; Kirwan, 1998, chap. 4; O'Toole, 2002). Basic values, norms and attitudes concerning safety, as well as the existence of a learning culture with continuous improvements can be crucial.

The current study was part of a joint pilot project between the Swedish Civil Aviation Administration and Lund University which had the aim of adapting a method for assessing safety culture aspects to fit ground handling activities (ramp services) and testing the method in a ground handling company at Sweden's third largest airport. This study is also a part of the establishment of reference data concerning safety culture aspects in different transport sectors. Use of the method provides a way for organizations to self-assess their safety culture and to produce results that can efficiently be included in their continuous improvement processes. Depending on the maturity of the existing safety culture, this would also be a way of introducing or developing the safety culture concept within an organization, in order to increase awareness about hazards and risk factors and to increase personnel participation in safety issues.

Ground Handling Work

In a ground handling company, operators are responsible for the operations performed during the time an airplane spends on the ground between flights. This study concentrated on the work tasks performed on the ramp. In short, when an airplane 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; fuel and water are tanked, and toilet services are performed. During winter, de-icing is carried out when needed. On departure, the airplane is pushed back from the gate, and the engines are started through communication between the pilot and a ramp operator.

The air cargo handling industry has been vulnerable to profit margins, with limited opportunity to invest in operation improvements, and has thus been slow to invest in new technology. Employee education, training and attitudes are known weaknesses in the industry and may be a key to improving ground handling performance (Schwartz, 1999). The European Commission has developed new rules concerning competition, where European Union (EU) airports are to accept at least one ground handling competitor and allow airlines to meet their own handling needs (Council Directive 96/67/EC; Soames, 1997). The objective of the Directive is to eliminate restrictions on freedom to provide ground handling services in the EU, help reduce the operating costs of airlines and improve the quality of service provided to airport users (SH&E, 2002).

Recent years have witnessed a variety of negative influences on the aviation industry, such as a general economic recession (leading to downsizing within the aviation industry), increased competition from railway and low-budget airlines and terrorist attacks. It has been determined that organizational changes, such as downsizing, have contributed to major accidents in other sectors (Baram, 1998, chap. 11; Erlandsson, 2001). This supports the importance of focusing on safety culture in the air transportation sector.

Safety Culture

No generally agreed-upon definition of safety culture exists. However, most investigators agree that a safety culture includes elements such as good communication, organizational learning, senior management commitment to safety and a working environment that rewards the identification of safety issues (Sorensen, 2002). A combination of good organizational learning, reporting, justness, as well as flexibility, is emphasized (Reason, 1997). In a learning culture there exists both the will and competence to learn from experience and the readiness to implement improvements. In a just culture there are just consequences following the reporting of an incident or anomaly. This can enhance the willingness to forward information about work and safety, which is a fundament of a reporting culture and a proactive approach to safety. Flexibility in an organization concerns the ability to transform the work organization in order to manage changing demands, for example, in periods of high workload. It also comprises respect for individuals' skills and experiences (Reason, 1997).

Efficient and successful safety management 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, chap. 4; O'Toole, 2002). Important questions concern what signals emerge from the persons in charge of the safety management system and how operators are motivated to better safety awareness. Good communication between management and operators and safety training are important factors (Zohar, 1980). Important questions also concern what expectations managers have for the safety culture in their organizations, and whether their impressions actually correspond to the employees' perceptions and judgments.

The perceived working situation can be viewed as a mirror of how well developed the actual safety culture and practical safety work are. Components such as education and training in the ramp working situation are highlighted by Schwartz (1999): "... you have a group of people who are forming a link in a chain that's filled with responsible, high-cost, big-asset elements—a link that is largely uneducated and untrained."

An assumed prerequisite for the willingness to implement safety measures for oneself and others could be the awareness or perception of some kind of risk or danger. Risk consciousness, therefore, ought to be a prerequisite for understanding the need to take safety precautions (Enander & Johansson, 1999). Misjudgments of risks may cause risk behavior 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 behaviors. Ignorance or deliberate violations of safety rules and procedures are often due to employee attitudes towards risk and safety (Royal Society, 1992).

With this background concerning safety culture, the following nine aspects of safety culture were included in the assessment of the safety culture in the ramp activities: (1) working situation; (2) communication; (3) learning; (4) reporting; (5) justness; (6) flexibility; (7) attitudes towards safety; (8) safety-related behaviors; and (9) risk perception.

In the assessment of safety culture aspects, the definition of "safety" was divided into two parts, namely, aircraft safety (damage to the aircraft fuselage), and work injuries of frontline personnel such as long-term physical wear and tear and accidents.

Aim of this Paper

This paper presents results from a safety culture assessment at a ramp division in a ground handling company working without competition at Sweden's third largest airport.

The purpose of this paper is to: (1) give short summaries of the nine aspects of safety culture that were assessed, including organizational differences concerning focus on aircraft safety vs. work injuries; (2) investigate what characteristics influence individuals' perceptions and judgments of safety culture aspects, specifically, time in the company, age, in-house education, and level in the organization; (3) describe ramp employees' evaluations of safety culture aspects and how these correspond to management's expectations and goals; and (4) report on the strength of correlations between different safety culture aspects measured by questionnaire package. These correlations concern whether risk perception relates to attitudes towards safety and safety-related behaviors. Further, comparisons are made with results from corresponding safety culture assessments in other transportation branches.

The results of the current assessment of the nine safety culture aspects were used by the ground handling company for improvements in safety culture aspects. However, that part is not reported here.

Methods and Material

Methods

The safety culture in the ramp division of the ground handling company was studied using the following four methods, presented in the order they were used:

1) Collection of facts about the ground handling activity and its operative staff through interviews with the ramp manager. This was supplemented by inspection of documents about ramp work routines and regulations; information about existing reporting systems for anomalies and incidents; staff size; working hours, and so forth.

2) Observations of the operative work carried out over a three-day period, through informal interviews with operators in which they shared their daily work experiences and existing risk and safety situations. The researcher was supervised by a ground handling operator and fully equipped, receiving hands-on experience with all aspects of ground handling work on the ramp.

3) A safety culture questionnaire package (constructed by the authors) administered to the ramp division personnel comprising the nine safety culture aspects or scales mentioned above.

The number of items within each scale is given in Table 1. The majority of the items were answered using a five-point scale (1-5) (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 indicated a better safety culture. In a few items related to aircraft safety (i.e., aircraft damage) and work injuries, the subjects were asked to give two separate answers. The questionnaire package ended with an open item in which the respondent could present additional issues concerning work and safety. On request from the ramp management, extra items were added to the questionnaire package about issues of reporting anomalies in technical equipment. The questionnaires were filled in anonymously during an allocated timeslot on three different company days spent away from the airport. A final allocated opportunity to fill in the questionnaire package was given at the airport.

4) Semi-structured interviews conducted at the airport with ten subjects varying in age, work experience, day- versus night-shift work, and positions within the company. This included operative staff, management and the leader of the in-house education program. The purpose of the interviews was to obtain explanations and background knowledge about the results obtained from the questionnaire package survey.

Material

The ramp division at the ground handling company consisted of 67 men, employed full-time. 50 of them completed the questionnaire package, resulting in a response rate of 75 percent. Non-response to the questionnaire package was due to vacation, sick leave, not wanting to attend a company day, and, probably in a few cases, not wanting to participate in the study. The low dropout rate thus provided a good opportunity to get a representative view of the safety culture aspects in the organization. The average age of the respondents was 34.3 years (range 21–58), the average time in the company was 9.6 years (range 0.7–35) and the ratio of operative managers:operators was 28 percent:72 percent (when the three administrative managers were excluded). All but one of the employees had Swedish as a native language.

Facts About the Company

An understanding of Swedish was a necessity, as all in-house education and training was in this language. Knowledge of English was also required on the job. The theoretical and practical development of competence among the staff had to be carried out according with documents of the Swedish Civil Aviation Administration based on ICAO (International Civil Aviation Organization) regulations. Frontline staff underwent three years of continuous in-house education and training during which they received the various certificates needed for carrying out different operations on the ramp. The certificates for each individual were filed with the company, and the time for renewal was continually monitored. When a certificate expired, the individual had to prove his competence before the certificate was renewed.

Properties of the Nine Safety Culture Aspects (Scales)

The internal consistency of the nine safety culture aspects (scales) in the questionnaire package was assessed using Cronbach’s alpha coefficient: a low value of alpha indicates that the items do not homogeneously reflect the same safety culture aspect (scale) and thus could be divided into two or more groups; a very high alpha suggests that the scale contains unnecessarily many items and hence could be reduced in size. Specific items are illustrated in the results section below. The alpha for each of the nine scales in the questionnaire package is presented in Table 1. Seven of the nine alpha values are at least .82; none is above .91. The Risk perception and Flexibility scales received values of .74 and .64 respectively. This

indicates that we have internal consistency and that we do not have an excessive number of items.

Table 1. Internal Consistency (Cronbach's Alpha), Mean Scores and Standard Deviations for the Nine Safety Culture Aspects

Safety culture aspect	n of items	Cronbach's alpha	Mean score			
			Total group mean	Total group SD	Manager mean	Operator mean
Working situation	21	.90	3.57	.45	3.64	3.54
Communication	11	.86	3.54	.58	3.69	3.47
Learning	12	.83	3.30	.54	3.24	3.33
Reporting	12	.83	3.68	.59	3.75	3.65
Justness	12	.82	3.27	.54	3.39	3.22
Flexibility	7	.64	3.17	.52	3.47	3.03
Attitudes towards safety	14	.91	3.71	.61	3.82	3.66
Safety-related behaviors	13	.86	3.52	.52	3.55	3.51
Risk perception	7	.74	3.32	.50	3.39	3.28

Note. Group differences in mean scores for administrative and operative managers vs. operators were not statistically significant except for Flexibility ($p < .004$, two-tailed). Total group = 50

Statistical Analysis

When the statistical analyses were conducted, it was assumed that the questionnaire package data were collected using an interval scale measurement (Aron, Aron, & Coups, 1994) and parametric tests (t-test, Pearson correlation, ANOVA) were therefore used in the analyses. As a safety precaution, analyses were also re-calculated secondarily, where possible, by comparable non-parametric tests (Mann-Whitney U, Spearman correlation, Kruskal-Wallis). In all instances, the parametric and non-parametric analyses yielded the same results regarding statistical significance.

Results

Overall Picture

The sample's mean score for each aspect of safety culture represented by the nine scales in the questionnaire package was calculated in order to obtain an overall picture of the safety culture aspects in the ground handling company. As shown in Table 1, the study generally yielded positive evaluations for the nine aspects of safety culture in the sense that all areas had a mean value above 3.00, which is on the average more positive than the middle position on the five-point scoring scale. Attitudes towards safety received the highest mean value (3.71), while Flexibility received the lowest (3.17).

Summaries of the Safety Culture Aspects

Short summaries of the results for the safety culture aspects will be presented here. The calculation of the percentage of "negative responses" was arrived at by merging the alternatives 1-2, while "positive responses" represented the alternatives 4-5 from the five-point scoring scale. If 20 percent or more of the respondents gave a negative response on an item, this was considered as reflecting a problem in the safety culture.

Working situation. For the Working situation aspect (M = 3.57), most respondents experienced cooperation within the company as good. They liked their work and a majority seldom got in a situation where it was unclear what to do. The respondents found the education and training given in order to perform their job in a safe way to be sufficient when

it concerned aircraft safety. In contrast, 28 percent of the respondents considered the training and education in preventing work injuries to be insufficient. Two negative components in the working situation were low staffing level and stress. One third experienced the staff to be too small to safely perform the work when it came to aircraft safety, and 42 percent had the same opinion concerning work injuries to the staff.

Communication. The communication between working units on the ramp was considered by most respondents (60 percent) to function well. The results showed that the staff very often had the information they needed in order to perform their work in a safe way in relation to aircraft safety. Most respondents were also of the opinion that they got information in time, and that they received clear instructions from the operative manager. However, one fourth believed they seldom had the information they needed in relation to work injuries. A more negative finding concerned their training in how communication should function in an emergency situation. A rather large group (42 percent, including both operative managers and frontline staff) did not perceive this training as sufficient. A group of both operative managers and frontline personnel thought it was unclear whom to contact to discuss questions about aircraft safety (20 percent) as well as questions about work injuries (24 percent).

Learning. An important component regarding learning in an organization concerns its willingness to act upon experiences and implement improvements concerning safety when needed. Many respondents (44 percent) in the study were of the opinion that the operators were observing potential weaknesses concerning safety on their own, without being asked. A majority felt that the responsible persons on the ramp to a large degree acted upon the information they received about safety deficiencies especially concerning the aircraft. More than half of the respondents thought that improvements often were made when deficiencies affecting aircraft safety were detected. However, 22 percent thought that the improvements were seldom made within a "reasonable time."

Furthermore, many respondents were of the opinion that improvements in work and safety were usually first made after something negative had happened, that is, the organization had a more reactive than proactive approach to work and safety improvements.

Reporting. A great majority did experience that they could express their opinion about the safety at work and that the management listened to employees regarding safety matters. About two-thirds (63 percent) of the respondents almost always reported near misses, that is, events that could have led to damage to an aircraft. An overwhelming majority (98 percent) responded that they always reported when they happened to damage equipment. (In contrast, the ramp manager did not experience that this was the case.) Concerning the collection of proactive risk and safety information in the organization, about one third (including both middle management and frontline personnel) believed that there was not enough collection of information to check if the technical equipment was functioning. The same result was shown concerning information to check if the work routines were functioning.

Justness. In this part of the study the respondents were asked if they thought it was accepted that you sometimes made a mistake in your work and, in that case, if you believed you would receive fair judgment. One fourth were doubtful about mistakes being accepted, and one third were worried about being blamed for mistakes (the respondents in this group belonged to several work categories, and had a wide range in age and in how long they had been working in the ramp division). Nevertheless, most of the respondents believed fair judgments would be made. The majority of the respondents did not hesitate to take initiative in their work because of fears of what would happen if it turned out wrong.

Half of the respondents felt that if employees <u>did not</u> perform their work in a safe way, it would be called to their attention. When the question was asked from an alternative point of view, that is, if those who performed their work in a safe way received acknowledgment for

this, about 50 percent of the respondents were of the opinion that they very seldom received acknowledgment for this concerning both aircraft safety and work injuries.

Flexibility. Many experienced that little value was attached to the knowledge and experience of the employees. A large proportion (36 percent) of both operative management and frontline personnel also experienced little encouragement to suggest ideas and improvements concerning the work. Several respondents (30 percent, all frontline personnel) had very seldom been asked about how a problem at work could be solved. It was also believed by many respondents that it was not especially accepted to make suggestions for changes in something that concerned somebody else's area of responsibility.

Attitudes towards safety. Many respondents (60 percent) had a strong belief that the management actively encouraged safe working performances, and they experienced that the management found education and training to be important (69 percent). Many also experienced that it was worth the time to talk about near misses (i.e., events that could have led to damage to an airplane) in order to learn from them. However, a majority of the respondents (72 percent) had very seldom taken part in safety planning, for example, being invited to meetings which discussed the topic. This concerned both operative management and frontline personnel.

Safety-related behaviors. The majority believed that the operators worked in a safe way and very seldom took unnecessary safety risks regarding the aircraft. A majority also believed that the safety rules and routines for preventing aircraft damage were functioning in reality. One question concerned how often conditions at work affected compliance with safety rules for preventing aircraft damage, and if so, what conditions came to mind. Half (54 percent) of the respondents experienced that it was very seldom that conditions on the ramp had a negative effect on working procedures. However, the conditions that were mentioned that negatively affected compliance to safety rules are given in Table 2. Furthermore, quite a few (46 percent) experienced that they generally did not talk much about how the work could be improved, leading to increased safety. This opinion also existed among operative management.

Risk perception. A majority of the respondents had confidence in the operative management concerning safety at work (66 percent). The respondents generally believed the work on the ramp was performed in a safe way concerning the aircraft. There was a shift towards more negative responses concerning work injuries, and a large group (58 percent) thought that there was a rather large risk for getting injured on the job. One fifth believed that there was a risk that their work could lead to others being injured.

Table 2. Conditions on the Ramp Negatively Affecting Compliance to Safety Rules

Time pressure	Staff size	Weather	Work load	Work equipment	Other groups/units on the ramp	Work routines
34 (74)	32 (70)	12 (26)	19 (41)	10 (22)	3 (7)	7 (15)

Note. Number (%) of respondents choosing the alternative.

Subgroup Analysis of Negative Responders

The questionnaire package survey identified 30 items on which 20 percent or more of the respondents gave negative responses (i.e., 1-2 on the five-point scale). Analyses were conducted to find out if these negative responses were due to a subgroup of individuals who consistently gave negative answers across items or due to more general perceptions of safety culture problems in the total material. A subgroup of individuals was found to account for many of the negative responses. For example, 14 percent of the respondents accounted for one third (158/486) of all the negative responses, while one fourth of the respondents gave more

than half of the negative responses (251/486). No special characteristics were found for this subgroup other than that all but one were frontline operators.

Individual Characteristics' Effect on Safety Culture Perceptions and Judgments

Time in company, age, and in-house educational level. Analyses were conducted to see whether individual characteristics among personnel had an effect on perceptions and judgments of safety culture aspects. Among these characteristics or variables, Time in company and Age were significantly and positively inter-correlated ($r = .68$, $p < .001$, two-tailed). Multiple regression analyses were conducted in order to investigate their explanatory effect on the nine aspects of safety culture. Neither Time in company ($M = 9.6$ years, $SD = 7.9$) nor Age ($M = 34.3$ years, $SD = 8.8$) was found to have any significant explanatory effect.

One-way analyses of variance were also conducted in order to test the effect of in-house educational level on the nine safety culture aspects. Level of in-house education—low (.7-1.5 years, n = 7), middle (1.6-3 years, n = 6), high (> 3 years, n = 37)—had no statistically significant effect on how the safety culture aspects were perceived and judged.

Hierarchical levels. t-test analyses were conducted in order to test the effect of hierarchical position (managers, n = 16; operators, n = 34) on the perceptions and judgments of the safety culture aspects. Statistically significant differences in safety culture perception were found between groups only concerning Flexibility ($p < .004$, two-tailed). The management group experienced higher flexibility. Furthermore, although not statistically significant (Table 1), the management group gave higher average scores on eight of the nine safety culture aspects.

Managers' Expectations and Goals – Comparison With Reality

Three operative managers and the three administrative managers were asked to judge how (a) they themselves and (b) the operators perceived and judged the safety culture in the organization. They were asked eight questions representing eight of the nine safety culture aspects (i.e., one question per aspect; Working situation was excluded due to its multifaceted content). They were also asked to make the following three judgments for each of the eight questions: (1) How many of the operators do you estimate will answer "a good safety culture" (i.e., 4-5 from the five-point scale) to this question?; (2) How many ought to answer "a good safety culture" to this question for you to be satisfied with the results? (i.e., managers' goals for the ramp activity); (3) What is the lowest acceptable limit, i.e., how few employees can answer "a good safety culture" before it is time for improvements to be made?

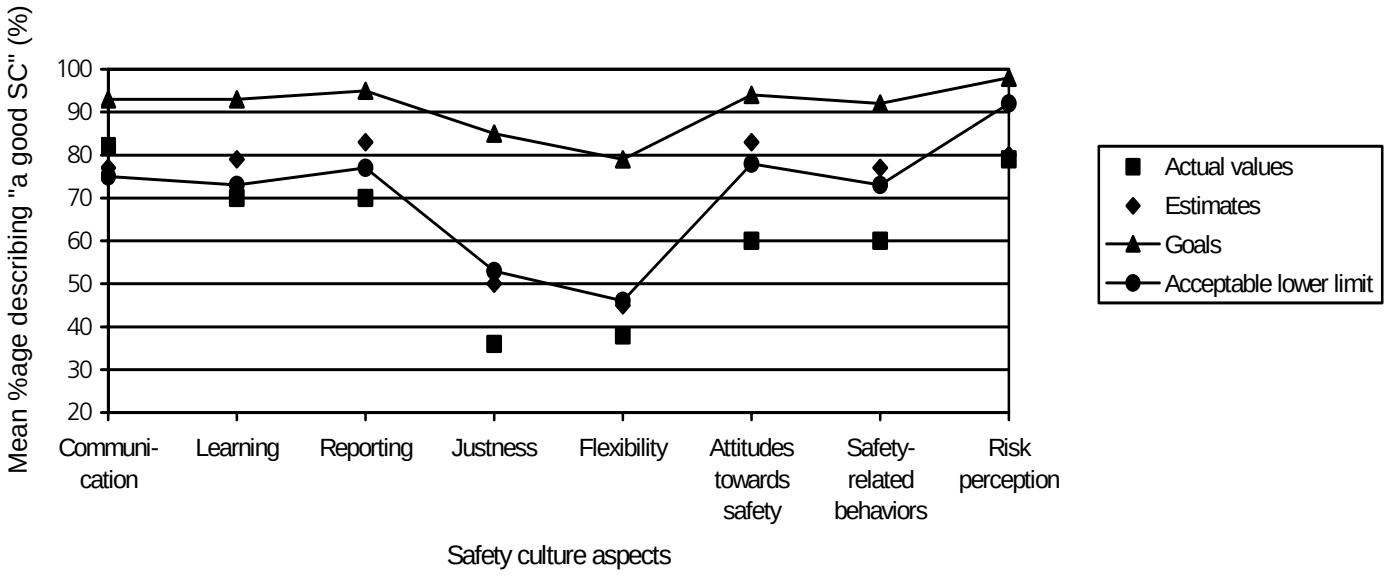

Figure 1. Mean percentage scores of actual values and managers' estimates, objectives and acceptable lower limits concerning the proportions of operators describing "a good safety culture" for eight safety culture (SC) aspects.

In total, 144 judgments were made, and for every safety culture aspect a mean percentage score across the six managers was calculated for each of the three areas of judgments. The mean scores are given in Figure 1 together with the employees' actual scores for the eight questions representing a safety culture aspect obtained through the questionnaire package survey. The actual scores of the employees were, on the average, lower than the managers' lowest acceptable limit for 7 of the 8 aspects, and reality fell within the managers' acceptable limits only for Communication.

Correlations Between Safety Culture Aspects

Pearson correlation statistics were calculated to determine the strength of the relationships among the nine aspects of safety culture. The results yielded positive and statistically significant correlations ($p < .02$, two-tailed) among all nine aspects (Table 3). The correlations ranged from .36 to .76, with an average r level of .59.

Especially high correlations were found between the safety culture aspects Risk perception and Attitudes towards safety ($r = .74$, $p < .001$) and Safety-related behaviors ($r = .71$, $p < .001$), while Communication correlated highly with both Justness ($r = .76$, $p < .001$) and Attitudes towards safety ($r = .75$, $p < .001$). A lower correlation was found between Attitudes towards safety and Flexibility ($r = .36$, $p < .02$).

Table 3. Correlations (Pearson) Among the Nine Safety Culture Aspects

Safety culture aspect	1	2	3	4	5	6	7	8	9
1. Working situation	—	.67	.55	.57	.64	.52	.60	.63	.63
2. Communication		—	.63	.59	.76	.51	.75	.52	.62
3. Learning			—	.59	.67	.42	.65	.68	.66
4. Reporting				—	.68	.38	.56	.52	.56
5. Justness					—	.55	.64	.59	.65
6. Flexibility						—	.36	.47	.44
7. Attitudes towards safety							—	.65	.74
8. Safety-related behaviors								—	.71
9. Risk perception									—

Note. All correlations are significant at $p < .02$, two-tailed. Base $n = 50$.

Discussion

This article reports on an assessment of safety culture aspects using a method adapted for ground handling (ramp) activities. The method consisted of fact finding, observations, a questionnaire package, and interviews. The interviews and observations served as supplementary sources of information to help in the interpretation of the results obtained from the questionnaire package. The questionnaire package with the nine scales proved to function well, with a good level of measurement reliability. The results showed that the method of assessment measures the individual differences in safety culture perceptions and judgments, that is, it captures the range of attitudes and perceptions across the different subjects in the sample, and identifies safety culture topics and areas (items within safety culture aspects) that may require further improvement.

General Findings

The results of the safety culture assessment of the ramp division revealed a generally good existing safety culture, at least from an average-score point of view. The evaluations of

the nine aspects of safety culture were positive in the sense that all had a mean value above 3.00 on the five-point scale. Attitudes towards safety, Working situation and Communication received high mean values, while Flexibility received the lowest. A great majority of the participants in the study did experience that they could express their opinions about the safety at work and also that the management listened to employees regarding safety matters. Furthermore, the participants found the education and training given in order to perform the work in a safe way to be sufficient concerning aircraft safety.

Hierarchical Position

The results showed that the employee's hierarchical position in the ramp organization had very little effect on how the different aspects of safety culture were perceived and judged by the respondents. Statistically significant differences in perception between groups only existed concerning Flexibility. One reason for these conformities could be that all managers except the managing director had started as frontline personnel and were therefore fully aware of the conditions on the ramp concerning the job assignments, equipment, staffing, and weather.

Managers' Judgments of Safety Culture Aspects

When comparing safety culture aspects as perceived and judged by operative and administrative managers vs. operators, it could be concluded that the reality reported by the operators often was somewhat poorer than that estimated by managers, and that the reality was consistently somewhat poorer than the managers' acceptable lower limit. Nevertheless, the managers had set very high levels for the objectives of the different safety culture aspects. Furthermore, management seemed to be aware of how the safety culture really was, as the values from the questionnaire package survey in Figure 1 showed curves corresponding to managers' estimations of reality.

Correlations Among Safety Culture Aspects

The correlation statistics showed that all the safety culture aspects were positively and significantly correlated to one another, and that there were no sub-groupings among the different aspects. Risk perception correlated highly and positively with Attitudes towards safety and Safety-related behaviors. One hypothesis suggests that risk perception ought to affect both attitude and behavior concerning safety of both management and staff. Previous research has not found clear support for this assumption. Examples of varying results are given in van der Pligt's (1998) review of risk, perceived vulnerability, and behavior. For example, Foss (1985) found no relationship between perceived accident risk and parents' use of safety restraints for their children, and Stasson and Fishbein (1990) found that perceived risks do not seem to be directly related to seatbelt use in cars. The latter authors also argued that models incorporating other factors such as attitudes and perceived social norms provide better predictions of actual seatbelt use.

In the current study, perceived Working situation correlated positively with all other safety culture aspects. As a hypothesis, the perceived working situation could be considered a basic variable in an organization affecting the respondents' scores on all the other safety culture aspects. Perhaps one would expect a better working situation to be related to the maturity of the safety culture. In the process of an organization's development toward reaching a safety culture with a higher level of maturity, it can be postulated that a broader perspective on safety is taken. This means that safety is integrated and coordinated with the general management of the "system," resulting in parallel work with improvements concerning safety, working conditions, health, quality, and also environmental issues.

The safety culture aspect Communication correlated highly and positively with Attitudes towards safety and Justness. Good communication existed, with short communication channels and proximity to operative management. This may have increased the clarity of the message from management that they encouraged safe performance and that they regarded training and education as important. Good communication could also have created a style of openness in the area of justness, with discussions leading to increased awareness of such matters. The existing attitudes towards safety in an organization are often considered as being shaped by the leadership and depend on management's attitude towards and commitment to safety (O'Toole, 2002). The investment in training to increase knowledge and skills among personnel is probably also dependent on existing attitudes within the management.

Relationships in a Learning Organization

Situational conditions, incidents, and behaviors that could result in negative outcomes can be captured through a functioning reporting system and in a successful reporting culture in an organization. Reporting of incidents and anomalies becomes a basic component in good organizational learning. Through this, the organization can receive feedback on its performance, representing vital input for continuous improvements. As stated in the introduction, the theories of a learning organization suggest that relationships should exist between the four aspects Learning, Reporting, Justness, and Flexibility. This was found to be the case in the current ramp study. These aspects were all positively and significantly inter-correlated, although Flexibility had somewhat lower correlations with the other three aspects. Items in the questionnaire package brought attention to different issues of the reporting regarding the work equipment used on the ramp. One item focused on whether reports were made when one happened to damage the equipment used on the job. An overwhelming majority (98 percent) responded that it was always reported. Nevertheless, the ramp manager had knowledge of the low commitment in reporting such incidents, especially concerning anomalies in technical equipment. He had emphasized the existing no-blame approach to human error and had also encouraged increased reporting. An interpretation of the results of the questionnaire package survey could be that the staff was aware of the importance of reporting deficiencies in technical equipment and therefore gave responses that were in line with the social desirability in the ramp division (a source of error in the questionnaire methodology [Fife-Schaw, 1995, chap. 12]). Staff behavior of not always reporting deficiencies, and comments during interviews, revealed existing problems concerning trust in key persons. Another item from the interviews and the questionnaire package focused on reasons why employees would not report anomalies, and the responses revealed reasons such as "does not lead to improvements", "fear", but also "no known reasons". Another situational limitation was that if the operator wanted to write a report, he had to ask for a form from the operative manager, which ruled out anonymity. Concerning reporting of near misses, that is, events that could have led to damage to an aircraft, 63 percent of the respondents said that they almost always reported such events and mostly orally. Frontline personnel gathered spontaneously at the operative manager's desk, which was a continuous meeting point during a shift. The loading plans for the aircraft and the distribution of work were available at the desk. Near misses and other problems that emerged were discussed in a natural and open way in this informal gathering.

Comparison With Other Transport Branches

Corresponding safety culture assessments using the same safety culture questionnaire package as in the ramp study have been conducted in other transport branches, that is, in air traffic control (Ek, Akselsson, Arvidsson, & Johansson, 2002) and in the shipping industry

(Ek & Akselsson, 2005). The average scores on the nine aspects of safety culture were generally lower for the ramp than for the other transport branches, suggesting a "poorer" safety culture. The following aspects in particular received lower average scores in the ramp study: Working situation, Safety-related behaviors, Reporting, and Risk perception. While this could indicate a "poorer" safety culture (lower average level), it could also reflect a generally more pessimistic view among personnel because of the nature of the ramp work. The differences in average safety culture scores between the branches could also be a manifestation of the maturity level in safety culture.

Comparisons with the other branches also showed that there were fewer group differences between managers and operators on safety culture aspect perceptions and judgments in the ramp study.

Conclusions

The result of the safety culture assessment of the ramp division revealed a generally good existing safety culture. However, the safety culture was somewhat poorer than that estimated and desired by the managers, and than that in other transport branches. Demands for profit and productivity (e.g., on-time flight departures) are factors that probably affect safety culture. In future studies of safety culture aspects in ground handling companies, it would be interesting to determine what results would be found at an airport with several ground handling companies working in competition.

In general, the current method was found to function well in the assessment of safety culture aspects in the ramp setting and may constitute a valuable method 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) level of employee ratings for the various safety culture aspects; (b) reporting specific topics (items in questionnaire package or interview issues) within safety culture aspects that are identified as problematic by a notable subgroup of participants (operationally, 20 percent in this study) for potential improvement; (c) comparing reality (i.e., operators' reports) with management's expectations and "acceptable lower-limits" for safety culture aspects; and (d) investigating the conceptual structure of safety culture and its relationship to the working environment.

Practical applications

The current ramp study points to many specific topics and areas that could be the focus of continued improvement. Specific suggestions for improvements can be made regarding: (a) anonymous distribution of anomaly reporting forms; (b) education in the area of human error; (c) education about the importance of having a safety culture with continuous improvement; and (d) performing proactive risk analyses. The study methodology and empirical results thus represent usable tools in such a proactive process of evaluating, improving and securing safety culture in an airport ground handling organization.

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Paper II

Safety culture on board six Swedish passenger ships

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Safety culture on board six Swedish passenger ships

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This paper presents the results of a Swedish study on maritime safety culture. The study aims to increase knowledge about the characteristics of safety culture in the maritime setting and about the relationship between safety culture and organizational climate. Such knowledge can be vital in the process of developing and improving safety culture. The paper reports the results of safety culture assessments on board six Swedish passenger ships in international traffic, using observations, questionnaires, and interviews focussing on 508 employees who completed the questionnaires. The results of the assessments revealed a generally good existing safety culture. Differences in individuals' safety culture perceptions were found between ships, vessel type (high-speed craft versus Ropax), and hierarchical working position. Important relationships between organizational climate and safety culture were also found. A comparison with other transport sectors where the same safety culture assessment had been applied yielded that passenger shipping has an average safety culture score level that falls between air traffic control and airport ground handling. The method of assessment, which can be used by shipping companies and vessel crews, identified specific areas of concern in the safety culture that could support continuous improvements of safety and safety culture.

1. Introduction

Serious maritime accidents have put in perspective the importance of good safety culture and management. The overall aim of an ongoing Swedish maritime project entitled 'Safety organization, safety culture, risk management and maritime safety' [1–4] is to study these aspects, as well as port state control in the shipping domain. This paper focuses on a subpart of the project, the purpose of which is to study safety culture and safety management on board Swedish passenger ships.

Maritime safety does not concern the ship only. A system view has to be taken for controlling safety [5]. International and national regulative bodies (e.g. the International Maritime Organization, the National Maritime Administration), ship owners and ship operators, classification societies, insurers, flag and port states, etc., are all players in the maritime system. Well functioning co-ordination for safety, both within and across stakeholders, is needed, as are strong connections in the form of goal directedness, with feedback, learning, and action.

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 (e.g. *Herald of Free Enterprise* and *Scandinavian Star*), other aspects, such as management, human factors, and, increasingly, safety culture, are now being

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emphasized as vital for safety. A safety culture reflects the attitudes, beliefs, perceptions, and values that employees share in relation to safety [6]. The leadership within the sphere of an activity is often said to be of central importance for safety, in that it shapes the basis of the safety culture. In this study, we wanted to obtain increased knowledge about the characteristics of the safety culture in the maritime setting.

According to Kirwan [7], the safety culture expresses itself in observable outputs in the form of safety management practices. The safety culture shapes the safety-related behaviours that, among many things, are incorporated in the development of safety management systems. As the safety management system is developed, applied, and refined, the safety culture most likely changes as well, to take on new forms. An interrelationship therefore exists between safety culture and safety management.

In the maritime area, the International Safety Management Code (ISM Code) is an instrument that has been developed in order to provide an international standard for the safe operation of ships [8]. The existing safety culture determines in part how well the ISM Code is implemented on board ships and in shipping companies, yielding the practical and positive drive towards improved safety in the shipping domain that the Code intends. By the application of the ISM Code or a safety management system, the approach to safety development within the maritime area aims to be more proactive than reactive. However, in spite of the application of regulatory legislative frameworks, a blame culture still exists [9]. This can be an obstacle for the emergence of a 'real' safety culture. This is defined by Veiga as 'that assembly of characteristics and attitudes in organizations and individuals which, establish that, as an overriding priority, maritime safety issues receive the attention warranted by their significance' [9].

Safety culture can be viewed as an enduring characteristic of an organization that is reflected in that organization's consistent way of dealing with critical safety issues [10]. The operational definition of safety culture used in the study presented in this paper consists of nine dimensions. The focus in this definition lies in the ability to create and preserve a learning organization. (1) *Learning* in an organization is associated with having a proactive approach to safety, which means collecting, monitoring, and analysing relevant information, and thus having updated knowledge about how work and safety are functioning. Important characteristics of a learning culture are the existence of a willingness and competence to draw the right conclusions from the safety information system, and, above all, the willingness to introduce changes and implement major reforms when needed. To develop and support the ability to present and make safety information visible, the creation of (2) a *Reporting culture* is vital, where a reporting system exists and where individuals are willing to report incidents and anomalies (concerning, e.g., faulty equipment). This is closely connected to (3) a *Just culture*, where a well-balanced blame approach enhances co-workers's willingness to make such reports. A just culture also involves defining safe behaviour. (4) *Flexibility* in an organization concerns the ability to transform the work organization in order to meet changing demands (e.g. in periods of high workload). It also comprises respect for an individual's skills and experiences. These four dimensions are based on Reason's perspective, where a safety culture is equivalent to an informed culture [11]. The other dimensions in the operational definition are: (5) *Communication* in daily work (e.g. [12,13]); (6) *Safety-related*

behaviours (e.g. [14, 15]); (7) *Attitudes towards safety* (e.g. [16, 17]); (8) the perceived *Working situation* (e.g. [18, 19]); and (9) *Risk perception* (e.g. [16, 20]).

The safety culture dimension 'Communication in daily work' comprises items such as the need for—and clarity of—information, communication between people, and communication between work groups. 'Safety-related behaviours' comprise, among other things, discussions about and encouragement of increased safety, and the compliance with safety procedures. 'Attitudes towards safety' (from both management and staff) concern, for example, commitment to safety. The perceived 'Working situation' involves co-operation, support and appreciation, and having influence in the design of work. The last dimension, 'Risk perception', concerns the perceived risk of harming others or oneself and the experience of having influence over safety in one's work.

There is an ongoing discussion about the possible differences between the concepts of safety culture and safety climate and the extent to which they overlap. Reichers and Schneider [21] conclude that 'culture exists at a higher level of abstraction than climate, and climate is a manifestation of culture'. Cox and Cox [22] conceive of culture as the organization's personality, while climate represents a more transient mood state, sensitive to external pressures. However, the culture and climate concepts share a number of overlapping attributes although a number of researchers have rejected that they are synonymous [23].

Safety culture or climate can be seen as a subset of the organizational climate. The organizational climate can be defined as a conglomerate of the attitudes, feelings, and behaviours that characterize life in an organization [24]. According to Ekvall [24], organizational climate affects different organizational and psychological processes such as communication, problem solving, decision-making, learning, and motivation. Neal, Griffin, and Hart [25] found that safety climate was related to the organizational climate. Their findings suggest that interventions to improve organizational climate may have a positive impact on safety climate. In other words, the effectiveness of interventions aimed at improving safety climate is greater if the organizational climate is already positive. Their results also suggest that safety performance is more strongly related to a specific climate for safety than to the general organizational climate and therefore it is motivated to identify this specific safety climate.

In the current study, the organizational climate was investigated using Ekvall's method, which, among other important aspects, assesses an organization's ability for innovation and change [26]. A positive climate stimulates the innovation processes and contributes to testing, and in some cases implementation, of ideas [26]. This may contradict the needs of a safety culture, since a very innovative organization is probably unsafe. For safety, more precautions are needed, resulting in an organization that is probably not of an innovative nature. Even if there are differences between an innovative and a safe organization, our hypothesis is that there are dimensions in the innovative organizational climate that are also relevant and important for a safety culture, and that these dimensions should be positively related to safety culture dimensions. On board a ship, working procedures are often standardized. Standardized routines and regulations have a negative impact on creativity and seem to prevent an innovative climate from developing [27]. Therefore, we do not expect all organizational climate dimensions to be related to safety culture dimensions—or perhaps they could be related inversely, as they may not function in the same manner. In the current study, we were interested in gaining

more knowledge of what aspects or factors in the organizational climate shape or affect the safety culture in a maritime setting. In the process of improving and developing a safety culture, this knowledge can be vital.

Two types of passenger vessels were included in this study: two high-speed crafts (HSC) and four passenger/cargo ferries (Ropax). The two types of vessel constitute different concepts in passenger shipping. The HSC carries a large number of passengers, and the size of the crew varies with the number of passengers. This variation also requires a more flexible safety organization. The Ropax ship is a traditional vessel carrying both passengers and cargo (trucks), and has a crew of fixed size and a fixed safety organization. We hypothesize that the flexibility of the safety organization on an HSC creates a base for a better safety culture, compared to a Ropax ship.

1.1. *Aim*

This study compares ships and shipping companies in order better to understand the safety culture in the maritime area. The nine-part operational definition of a safety culture was used and applied at different levels within the organization on board ships.

The aim of this paper is to: (1) present general findings of safety culture and organizational climate and identify specific areas in the safety culture that were found to be problematic; (2) present observed differences in the perceptions of safety culture between the two types of vessel; (3) present results of an investigation into whether the perceptions of safety culture and organizational climate are influenced by the individual's hierarchical level on board, and whether this is the same for all investigated ships; (4) report on the strength of correlations between different safety culture dimensions; (5) present the results of an investigation as to whether relationships exist between the safety culture and the organizational climate, where the organizational climate dimensions will be treated as explanatory variables and the safety culture dimensions as outcome variables; and (6) present safety culture findings gained from interviews with crew members on board the investigated ships.

This study is also part of ongoing research that is investigating safety culture, using the same methodology, in three different transport sectors: passenger shipping, air traffic control, and airport ground handling. Reference data concerning safety culture in these different transport sectors have therefore been established. This paper presents comparisons made with the results from these corresponding safety culture assessments.

2. Methods and material

2.1. *Data collection*

On board the ships, research data were collected using the following methods:

(1) *Observations of the operative work* were carried out over a three-day period, including informal interviews with officers and crew from the three departments on board (deck, engine, and catering) in which they shared information about their daily work experiences and existing risk and safety situations. Examples of activities observed were: loading/unloading of trucks and vehicles, safety inspection rounds, fire and safety drills. The observations were supplemented with inspection of documents relating to the safety organization and about existing reporting systems for anomalies and incidents.

(2) *Questionnaire assessments of safety culture and organizational climate*. Safety culture was measured using a standardized questionnaire developed by the authors and comprising the nine safety culture dimensions already described. It was administered to the personnel on board all six ships. The questionnaire contained 97 items, the majority of which were answered using a five-point scale (1–5) (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 indicated a better safety culture. In a few items that related to both ship safety (i.e. ship damage) and work injuries, the subjects were asked to give two separate answers.

The organizational climate was measured using Ekvall's standardized questionnaire [26] on board three of the Ropax ships. The questionnaire contains 50 statements about the organizational climate, which are answered using a four-point scale (0–3) (agreeing: 'Not at all, To some extent, Fairly, To a high degree'). It 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 [26]. The ten dimensions are [26]: (1) *Challenge/Motivation*: employees' involvement in and commitment to the organization; (2) *Freedom*: the 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 within the organization; (6) *Playfulness/Humour*: ease that exists in the organization; (7) *Debate/Diversity*: the 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 insecurity in the organization, such as new ideas and initiatives, rather than hazardous risk taking; (10) *Idea time*: time devoted to the development of new ideas. The results for the current ships were compared with existing reference values for innovative and stagnating organizations [26].

(3) *Semi-structured interviews* were conducted with 31 officers and 21 members of the crew from the three departments on board to gain more in-depth knowledge about their perceptions of safety and safety culture. Through these interviews it was possible to collect examples of positive and negative expressions of these concepts that those questioned had experienced in their work.

The purpose of this combined methodology was to gain a multifaceted picture of the safety culture within the activity. In this paper, however, the emphasis is on the questionnaire portion of the assessment.

2.2. *The ships*

In total, six passenger ships belonging to three shipping companies were included in the study. One Ropax ship and one HSC were studied in each of two of the shipping companies (indicated by '1' and '2' under the 'Vessel' heading in table 1) and two Ropax ships were studied in the third company ('3' under the 'Vessel' heading in table 1). The ships operate routes in the Baltic Sea and the Kattegatt.

2.3. *The respondents*

A total of 508 seafarers employed on the six ships completed the safety culture questionnaire. The organizational climate questionnaire was administered to the employees on board three of the Ropax ships (Ropax B, C, and D), in conjunction with the safety culture questionnaire. A total of 328 seafarers completed the

Table 1. The distribution of 508 officers and crew, average age, and average time on board for the respondents on the six ships.

	Total		Deck		Engine		Catering		Age	Years on board
Vessel	Officers	Crew	Officers	Crew	Officers	Crew	Officers	Crew	M (range)	M (range)
Ropax A1	21	36	8	15	6	5	7	16	39.6 (20–64)	3.8 (0–7)
Ropax B2	21	51	10	7	10	12	1	32	44.1 (20–64)	8.1 (0.1–25)
Ropax C3	34	150	6	14	7	10	21	126	37.7 (18–63)	6.1 (0–16)
Ropax D3	24	50	7	8	9	8	8	34	39.6 (18–62)	5.1 (0–18)
HSC E1	17	35	8	10	7	4	2	21	36.2 (21–59)	3.1 (0–6)
HSC F2	16	53	7	9	8	7	1	37	37.2 (21–63)	3.4 (0.1–6)

The number in the vessel label indicates the shipping company. M = mean value.

organizational climate questionnaire. The distribution of officers and crew on each ship, as well as average age of the respondents and average time on board, are presented in table 1. The following response rates were obtained among the crews directly contacted by the researcher: Ropax A: 80%, Ropax B: 60%, Ropax C: 92%, Ropax D: 49%, HSC E: 93% and HSC F: 61%.

2.4. *Statistics*

In the statistical analyses, all the safety culture and organizational climate dimensions were represented by the average score for each individual's answers to the questions belonging to the particular dimension. Differences in average scores between subgroups were tested using the Student *t*-test (2-tailed). Pearson's correlation coefficients were calculated to study possible associations between safety culture dimensions. Multiple linear regression analyses were performed to examine the relationships between each of the nine outcome safety culture dimensions and the ten explanatory organizational climate dimensions. The significance level was defined as $p < 0.05$, 2-tailed. The statistical calculations were performed using the SPSS and STATISTICA computer programs.

3. Results

3.1. *Characteristics of safety culture*

The average scores for each safety culture dimension across the two HSC and the four Ropax ships are presented in figure 1. The studies yielded generally positive evaluations for the separate safety culture dimensions on all ships in total. A similar safety culture pattern emerged for the separate ships; 'Learning', 'Justness', and 'Flexibility' received somewhat lower scores than the rest of the safety culture dimensions.

The comparative analysis of the HSC versus Ropax ships revealed only small differences in the average scores for safety culture dimensions for the two types of vessel. This was also shown through *t*-test analyses, which resulted in no statistically

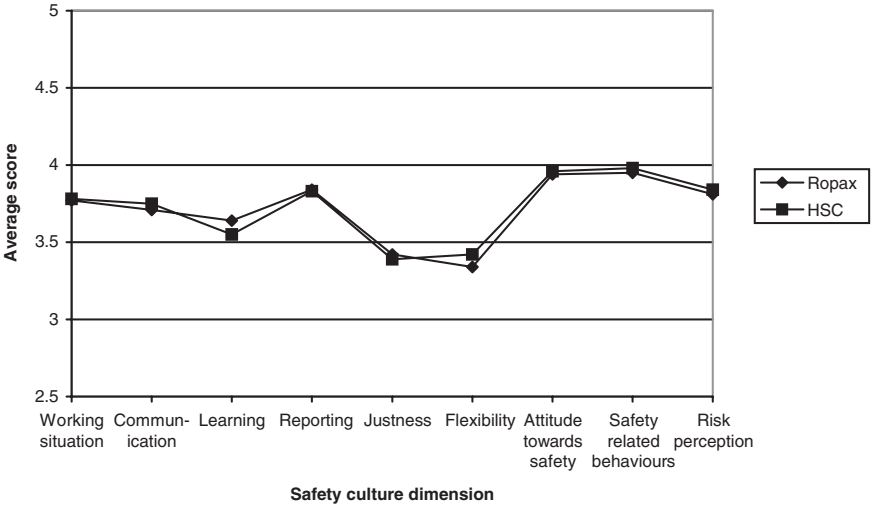

Figure 1. Average scores for safety culture dimensions for two HSC and four Ropax ships combined.

Table 2. The eight safety culture questionnaire items receiving negative responses* from 20% or more of the crew on all six ships.

Safety culture questionnaire item
Working situation
7. During a normal working week, how often do you feel physically exhausted when you are working?
9. During a normal working week, how often do you feel stressed when you are working?
Communication
31. How do you think the communication between the ship and company are functioning?
Justness
52. Do those who perform their work in a safe way receive acknowledgement for this?
Learning
64. When as a rule, are improvements in work and safety made? Before/after something neg. happens
Attitudes towards safety
83. How often have you taken part in the planning for safety (e.g. meetings with discussions)?
87. Do you think the management takes interest in the crew's well-being?
Risk perception
92. Is there a risk that you will be injured on the job?

*Score 1–2 on 5-point scale.

significant differences in perceptions of safety culture dimensions between the two types of ship.

3.2. *Safety culture items receiving negative responses*

The safety culture questionnaire survey identified 43 items on which 20% or more of the respondents on at least one ship gave negative responses (defined as 1–2 on the five-point scale). Eight of the 43 items received at least 20% negative responses on all six ships, and these eight items are presented in table 2. The items concern the

'Working situation' (physically exhausted; stress); 'Communication' (between ship and company); 'Justness' (acknowledgement for safe work); 'Learning' (proactive vs. reactive); 'Attitudes towards safety' (participation in planning for safety, management's interest in crews' well-being); and 'Risk perception' (risk of being injured on the job).

Analyses were conducted to find out if negative responses were due to a subgroup of individuals who consistently gave negative answers across items, or to more common perceptions of specific safety culture problems among the ships' crews. Subgroups consisting of about 25% of the individuals on each ship were found to account for about half of all the negative responses on board the ships. In the subgroups, a majority of the individuals came from the crew rather than officers but were spread across the three departments.

3.3. *Hierarchical levels and safety culture*

T-test analyses were conducted to determine whether differences existed between officers and crew in the reporting of safety culture dimensions. Table 3 shows comparisons between these two groups for each individual ship, both for the total ship crew and for each of the three departments (deck, engine, and catering) separately. A letter in a cell in table 3 denotes that a statistically significant difference existed between officers and crew in the perception of safety culture dimensions ($p < 0.05$, 2-tailed). Cases where officers generally had more positive perceptions of safety culture dimensions than the crew are denoted by the letter 'o'. Where the crew generally had more positive perceptions of safety culture dimensions than the officers, this is denoted by the letter 'c'. In 53 of the 56 cases where a difference in perception was detected, the officers had more positive perceptions of the safety culture dimensions than the crew. The one exception was on board HSC F, where the crew in the engine department exhibited more positive perceptions of the 'Working situation', 'Reporting', and 'Flexibility', than the officers.

Few differences in reported safety culture dimensions were found between officers and crew in the catering departments. No officer–crew comparison could be calculated for the Ropax B and HSC F catering departments, due to groups of officers being too small (only one officer each).

3.4. *Correlations between safety culture dimensions*

Pearson correlation statistics were calculated to determine the strength of the relationships between the nine safety culture dimensions on board each ship. The results yielded positive and statistically significant correlations ($p < 0.05$, 2-tailed) between all nine dimensions for each ship. The average and range for Pearson correlation coefficients for the six ships are presented in table 4. Strong correlations were found, for example, between the safety culture dimensions 'Working situation' and 'Communication' (average $r = 0.75$); 'Communication' and 'Reporting' (average $r = 0.76$); 'Communication' and 'Safety-related behaviours' (average $r = 0.75$); 'Learning' and 'Attitudes towards safety' (average $r = 0.74$); 'Learning' and 'Safety-related behaviours' (average $r = 0.75$); and 'Safety-related behaviours' and 'Risk perception' (average $r = 0.75$).

3.5. *Characteristics of organizational climate*

The average scores for each organizational climate dimension for the three Ropax ships where the organizational climate was investigated are presented

Table 3. *T*-test comparisons between officers and crew concerning perception of safety culture (SC) dimensions ('o' – officers had more positive perceptions than crew, 'c' – crew more positive than officers).

	Vessel																							
	Ropax A				Ropax B				Ropax C				Ropax D				HSC E				HSC F			
SC dimension	T	D	E	C	T	D	E	C	T	D	E	C	T	D	E	C	T	D	E	C	T	D	E	C
Working situation	o	o			o				o	o							o				o	o	c	
Communication	o				o																			
Learning	o				o				o	o														
Reporting	o				o				o	o						o	o				o	o	c	
Justness				o	o								o			o								
Flexibility	o	o			o				o	o		o	o		o	o	o	o	o				c	
Attitudes towards safety	o				o				o	o		o												
Safety-related behaviours	o				o					o														
Risk perception	o				o					o					o	o	o					o		

Group differences are significant at $p < 0.05$, 2-tailed.
Ropax = RORO-passenger, HSC = High-speed craft vessel.
T = Total, D = Deck, E = Engine, C = Catering department.

Table 4. Average correlation (Pearson) coefficients and correlation ranges between the nine safety culture (SC) dimensions for six ships.

SC dimension	1	2	3	4	5	6	7	8	9
1. Working situation	–	0.75 (0.69–0.81)	0.54 (0.42–0.68)	0.66 (0.54–0.74)	0.53 (0.37–0.66)	0.55 (0.36–0.68)	0.57 (0.40–0.68)	0.64 (0.56–0.74)	0.59 (0.51–0.71)
2. Communication		–	0.65 (0.40–0.77)	0.76 (0.49–0.88)	0.63 (0.47–0.71)	0.56 (0.40–0.76)	0.68 (0.50–0.81)	0.75 (0.69–0.82)	0.66 (0.51–0.76)
3. Learning			–	0.73 (0.54–0.83)	0.64 (0.42–0.80)	0.51 (0.36–0.70)	0.74 (0.69–0.80)	0.75 (0.62–0.88)	0.64 (0.49–0.73)
4. Reporting				–	0.65 (0.56–0.75)	0.59 (0.49–0.75)	0.69 (0.55–0.82)	0.67 (0.48–0.85)	0.60 (0.48–0.74)
5. Justness					–	0.59 (0.46–0.72)	0.62 (0.44–0.76)	0.62 (0.42–0.81)	0.58 (0.39–0.75)
6. Flexibility						–	0.58 (0.48–0.71)	0.54 (0.44–0.75)	0.48 (0.35–0.70)
7. Attitudes towards safety							–	0.71 (0.60–0.81)	0.70 (0.55–0.75)
8. Safety-related behaviours								–	0.75 (0.62–0.86)
9. Risk perception									–

All correlations are significant at $p < 0.05$, 2-tailed, base $n = 491$.

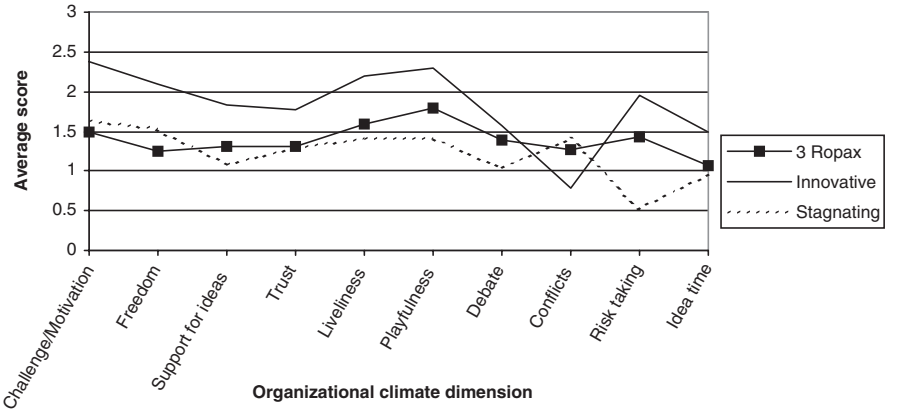

Figure 2. Average scores for organizational climate dimensions for three Ropax ships. For comparison, average reference scores for innovative and stagnating organizations are included in the figure. *Note*: A low score on 'Conflicts' means less conflicts.

in figure 2. The general results revealed very similar organizational climate patterns on board the three separate ships. The average reference scores for innovative and stagnating organizations [26] are included in figure 2. The results showed that the average scores on all organizational climate dimensions for the three ships are significantly lower (t-test, $p < 0.05$, 2-tailed) than those for the innovative organizations. (Although the 'Conflicts' dimension score on the curve appears higher, it has an inverse value.) At the same time, average scores on seven of the dimensions are significantly higher than those for stagnating organizations. Averages for 'Challenge Motivation' and 'Freedom' are lower than, and 'Trust' is the same as, comparable scores in stagnating organizations.

3.6. *Hierarchical levels and organizational climate*

Analyses were conducted (t-test) to determine whether differences existed between officers and crew in the reporting of organizational climate dimensions on board the three Ropax ships where the organizational climate was investigated. As shown in table 5, in all the 16 statistically significant findings, officers had more positive views of organizational climate dimensions than the crew. Many differences in perceptions were found on board Ropax B and also in the total group, but not on board Ropax C and D.

3.7. *Relationship between organizational climate and safety culture dimensions*

For the three Ropax ships where the organizational climate was investigated along with the safety culture, multiple linear regression analyses were performed with the purpose of investigating whether relationships existed between each of the nine safety culture dimensions and the ten organizational climate dimensions. The statistically significant relationships are shown in table 6. Among the organizational climate dimensions, 'Support for ideas' and 'Challenge/Motivation' were most frequently related to the safety culture dimensions. The dimension 'Support for ideas' was found to be positively related to all safety culture dimensions in the total group (all three ships) and on Ropax B. It was also positively related to several safety culture dimensions on Ropax C. 'Support for ideas' concerns the way new

Table 5. T-test comparisons between officers and crew concerning perception of organizational climate (OC) dimensions ('o' – officers had more positive perceptions than crew).

	Vessel			
OC dimension	Ropax B	Ropax C	Ropax D	Total
Challenge	o			o
Freedom	o			
Support for ideas	o			o
Trust	o		o	
Liveliness	o			o
Playfulness				
Debate				
Conflicts	o		o	o
Risk taking	o			o
Idea time	o			o

Group differences are significant at $p < 0.05$, 2-tailed.
Total = 3 Ropax ships.

ideas are met in an organization. If positive, the spirit is positive and constructive, and initiatives are encouraged and listened to [26].

Similarly, the organizational climate dimension 'Challenge/Motivation' was also positively related to many safety culture dimensions. This dimension concerns the organizational members' commitment to and feelings for the activity and its goals. If positive, the staff are motivated and find pleasure and meaningfulness in their work [26]. Similar trends were noted for 'Idea time'.

In contrast, both 'Freedom' (allowed to act independently) and 'Playfulness/Humour' were negatively related to several safety culture dimensions.

4. Results from interviews

As mentioned above, no statistically significant differences in average safety culture perceptions were found between the two types of ship, as measured by the safety culture questionnaire. However, data from interviews with HSC crew members showed that they believed the commitment to safety to be better on board an HSC than on a Ropax ship, and pointed to how the safety organization was managed and to the HSC's physical design, as explanations for this difference.

An HSC is equipped with a 'flexible' crew, i.e. the crew size (especially in the catering department) is adjusted according to seasonal changes in the number of passengers. This means that the size of the safety organization is also adjusted and 'flexible'. For example, a crew member could be placed in varying positions in the safety organization. During the interviewer's visits on board the HSCs, it was suggested by several crew members from all departments that this had positive effects on the commitment to safety on this type of vessel, compared to a more traditional vessel. The flexibility in the safety organization demanded more knowledge on the part of the individual crew member and more co-operation among crew members. The individual crew members have to think actively about which safety routines are going to be applied each particular time. They believed that this fact prevented routine habits from developing and gave rise to increased commitment in safety work.

Table 6. Statistically significant relationships between organizational climate (OC) and safety culture (SC) on board three Ropax ships and as a total.

	OC dimension									
SC dimension	1 Challenge/ Motivation	2 Freedom	3 Support for ideas	4 Trust/ Openness	5 Liveliness/ Dynamics	6 Playfulness/ Humour	7 Debate/ Diversity	8 Conflicts	9 Risk taking	10 Idea time
Working situation	T, B, C, D	−T, −D	T, B	T, C			−B			T, D
Communication	T, B, C	−T, −B	T, B			−C				T
Learning		−D	T, B							
Reporting	T, C	−T	T, B							T, B
Justness			T, B, C	D		−C		T, B, C		
Flexibility	D		T, B, C				D			
Attitude towards safety	T, C		T, B, C	−B		−C				
Safety-related behaviours	T, B, C		T, B		T, C					
Risk perception	T, C		T, B, C							

All multiple regression analyses are significant at $p < 0.05$, 2-tailed.
T = Total, i.e. 3 Ropax ships. B, C, D = a Ropax ship. A minus indicates an inverse relation.

The physical design of the HSC has had spin-off effects that were believed to influence safety culture. On board an HSC, the deck and engine departments are combined into an operations department. The engine department has its control panel on the bridge, beside the deck control panel. This is in some way revolutionary in the shipping world. The construction of the vessel has led to eliminating boundaries between the deck and engine departments. Channels of communication are shortened, co-operation between the two departments is improved and, as one chief said, it has led to a more open atmosphere.

On board each ship, a system existed for reporting incidents and anomalies, and these reports were sent to the safety co-ordinator ashore and in special cases to the National Maritime Administration. Relatively few reports were written, but those that were concerned near-misses. In a recent safety audit protocol, one ship had received a remark concerning low reporting. On another ship, the crew thought that it took too much time to write reports, especially when this did not concern near-misses. And on yet another ship, they perceived that the organization ashore represented slow bureaucracy, resulting in low feedback when a report was submitted. Furthermore, no organized exchange of information or learning took place between vessels within the same company concerning, for example, experiences of incidents and quality of equipment. In contrast, this kind of exchange of information existed in a more informal way when seamen changed vessels within the same shipping company.

After completion of safety exercises debriefing meetings were held, where problems were discussed and summarized. This summary or evaluation was very seldom documented and sent, for example as information, to the organization ashore.

Concerning crew size in relation to safety on board, several crews similarly reported that they believed the crew size to be correct in relation to safety situations that develop on board. But, as they often added, the crew size was correct as long as they had the situation under control, i.e. as long as all crew members were fit and not injured, did not panic or in other ways leave their position in the safety organization. In such situations, individuals would be hard to replace, due to small crew size.

The safety equipment on board the ships was given generally positive evaluations by the crew, although more comfortable life jackets for passengers were sometimes desired. The fire equipment, such as smoke helmets, also received positive evaluations, and crews believed the three Swedish shipping companies in the study provided equipment of good quality. However, the crew often raised other concerns in relation to this equipment and in relation to safety: the crew members assigned to handling the equipment were perhaps perceived to be the weakest link. Factors such as advanced age, physical problems, and poor physical fitness were seldom taken into consideration. For example, the average age in the catering department on board Ropax B was 56 years, and a 64-year-old waitress with problems with her legs was assigned to evacuate passenger cabins in an emergency. This situation could constitute a safety problem.

During interviews it emerged that it was the psychosocial working environment on board that to a large extent determined the crew's commitment to safety. It was the leaders and the crew members who set the standard and quality of the safety work on board. The crew's knowledge, attitudes, and behaviours in relation to safety defined the safety culture on board.

5. Discussion and conclusion

This paper reports on assessments, in the form of questionnaires and interviews, of safety culture on board six Swedish passenger ships, including both Ropax and HSC types. The results of the assessments revealed a generally good existing safety culture for all safety culture dimensions, as defined from an average-score point of view. The safety culture dimensions 'Attitude towards safety' and 'Safety-related behaviours' received especially high scores, while 'Learning', 'Justness', and 'Flexibility' received somewhat lower scores.

Corresponding safety culture assessments using the same questionnaire as in this study have been conducted in two other transport sectors: in air traffic control [28] and in an airport ground handling (ramp) organization [29]. When comparing the passenger shipping safety culture average scores with those from other transport sectors, they were found to be on a level in between the air traffic control's and the airport ground handling (ramp) organization's. The average scores on safety culture dimensions were generally lower for the ramp organization, and generally higher for air traffic control.

Safety equipment on board received generally positive evaluations, while crew members assigned to handling the equipment were viewed as the weakest link. The particular issues often identified as problematic concerned physical weakness, exhaustion and stress, lack of acknowledgement of safely performed work, and lack of involvement in safety planning. About one fourth of the staff on each ship (mostly crew) accounted for about half of the negative evaluations of safety culture.

No statistically significant differences in perceptions of safety culture dimensions, as measured by the questionnaire, were found between the two types of vessel investigated in the study. Nevertheless, interviews indicated that some differences existed in individuals' commitment to safety, depending on the type of vessel, with HSC's flexible safety organization and physical design contributing to a more positive commitment to safety.

Comparisons between officers and crew on board the ships concerning their perceptions of safety culture dimensions showed that officers generally had more positive perceptions than the crew. The one exception was the engine department on board one of the HSCs, where the crew perceived the culture as more favourable than the officers. This was due to a 'high' culture score among engine crew and not to a 'low' culture score among engine officers. While the exact reason for this outcome is unknown, further investigation of this particular situation may suggest a more generally applicable principle.

One safety culture dimension where differences clearly appeared between officers and crew was 'Flexibility'. In the ground handling ramp study, similar results were found: managers generally had somewhat more positive perceptions than the staff; but the only statistically significant difference in perception between managers and staff concerned 'Flexibility' [29]. The ramp organization was flatter and did not have the hierarchical construction found in the work organization on board a ship. The existing differences in safety culture between different organizational levels could be due to different prerequisites at each level that will affect the answers even if the culture is the same.

A reporting system for incidents and anomalies should exist in shipping companies and on board ships that comply with the ISM Code. In our opinion, a need exists for increased reporting and the learning processes should be improved.

The last steps in learning, i.e. analysing reports and implementing changes, are more difficult and demand more of the crews and companies. The ships and shipping companies included in the study could be said to have a generally high level of commitment to safety issues, which leads us 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 so long in the maritime area, and still does exist [9], could be a hindrance on the path towards good reporting.

The current results show that relationships exist between safety culture and the organizational climate on board the three Ropax ships where the organizational climate was also investigated. In particular, 'Challenge/Motivation' and 'Support for ideas' were significantly positively related to most safety culture dimensions. A staff that is motivated in their work and where initiatives are encouraged and listened to in the work organization should probably have a positive impact on safety culture. On the contrary, both 'Freedom' and 'Playfulness/Humour' were significantly negatively related to a number of safety culture dimensions.

The organizational climate method used in this study is aimed at measuring the capacity for innovation and change. The current results 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. A trend towards similar results was found in the air traffic control studies [30, 31].

Our hypothesis was that organizational climate dimensions in general are important for safety culture. However, not all organizational climate dimensions may be relevant for all safety culture dimensions, as a very innovative organization may not be optimally safe in all contexts. For example, the safety culture dimension 'Flexibility' may be most important in situations where unusual conditions arise and require *new* solutions. Under normal conditions, safety may be most dependent on everyone following the established routines, as is the case in air, sea, and land transportation systems. Air traffic control, in which safety is of utmost importance, is not generally characterized by innovation, as stability and maintenance of standardized routines are essential for flight safety.

The method developed for measuring safety culture in these studies is intended to collect valid data that characterize the safety culture in such a manner that the results can support changes towards more efficient safety management. The basic goal is to provide a method that, in co-operation with shipping companies and vessel crews, supports continuous improvements of safety and safety culture and increases participation among the personnel. So far the questionnaire part of the method is the best developed and has proved to capture the range of attitudes and perceptions across the different subjects in the sample; it identifies safety culture areas that may require further improvement. This could serve as a basis for interviews and safety audits. The interviews also proved to be a valuable source of information, revealing facts about possible proactive improvements in safety culture and safety. A long-term goal is the integration of the method into the shipping company's and vessel's safety management systems (which is derived from the ISM code) and audit systems.

The current study identified specific areas of concern in the safety culture on board six ships, which provides a potential basis for continued improvement of safety culture by the companies.

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Paper III

Safety culture in Swedish air traffic control

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Safety culture in Swedish air traffic control

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Abstract

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, the foundations of safety work, and on safety. This paper reports on an assessment of safety culture at one administrative and two operative units in a Swedish air traffic control setting, using questionnaire packages and interviews, and focuses on 391 questionnaire respondents. The objectives of the study were to obtain baseline data of safety culture aspects and relationships between safety culture and organizational climate before major organizational and technical changes were implemented, and to yield reference data on safety culture aspects in this transport branch. The safety culture aspects were generally perceived and judged to be good by the respondents, and notable individual stability was found for safety culture evaluations over a 20-month period. Relationships were identified between the organizational climate and the safety culture at the two operative units, where a higher level of *Support for ideas* and a lower level of *Conflicts* were positively related to many of the investigated safety culture aspects. The general safety culture in the air traffic control setting was found to be on a somewhat higher average score level than that found in the authors' previous studies of passenger shipping and airport ground handling.

Keywords: Safety culture; Safety climate; Organizational climate; Air traffic control

1. Introduction

European air traffic control is undergoing changes in organization and technology in order to increase efficiency in air traffic. To overcome heterogeneous working practices, Eurocontrol (European Organization for the Safety of Air Navigation) is working for standardized and interoperable air traffic management systems throughout Europe. This work is a key step towards the establishment of a Single European Sky, which has the goal of restructuring European airspace according to air traffic flows, rather than according to national boarders. The goal is to create additional air traffic capacity, and to increase the overall efficiency of the air traffic management system (Eurocontrol, 2005).

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). 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

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operations (Wright et al., 2004). However, the direct links between safety culture and safety incidents are unclear (Guldenmund, 2000).

Change processes can have a negative impact on existing safety cultures, the foundations of safety work, and on safety. Pressure towards cost-effectiveness can cause systematic migration of organizational behaviour, resulting in major accidents (Rasmussen, 1997). An example where the prevailing safety culture very much contributed to an aircraft accident was at the Milan Linate Airport in Italy in 2001. A Boeing MD-87 heading for take off on a runway collided with a Cessna 525-A that mistakenly was simultaneously on the same runway. The subsequent investigation (Swedish Accident Investigation Board, 2004), established that the accident was largely attributable to the human factor, in which the Cessna pilots for different reasons chose the wrong ground route when taxiing in poor visibility. It was also determined that the airport lacked necessary routines, procedures and equipment to ensure identification of human errors in order to prevent accidents (Swedish Accident Investigation Board, 2004). For example, shortcomings in instructions, training, and working conditions had led to air traffic control personnel lacking the prerequisites for necessary control of airplane movements on the ground; the airport also lacked a working safety management system. Two of the recommendations that were made in the accident report were the introduction of routines for reporting incidents and deviations, and the improvement of air traffic controllers' prerequisites for correct handling of airport accidents (Swedish Accident Investigation Board, 2004).

Gill and Shergill (2004), reported on employees' perception of safety management and safety culture in the New Zealand aviation industry. They found that especially air traffic controllers and personnel in general aviation perceived that their organizations, in ensuring safety, considered employees' safety responsibilities to be more important than implementing effective safety management systems and encouraging a positive safety culture. Furthermore, the respondents in the study perceived the civil aviation authority to be imperative to safety in the New Zealand aviation industry through its role as educator and regulator. In a study of four aircraft maintenance organizations (McDonald et al., 2000), a strong professional culture among aircraft technicians emerged, independent of organization, which was likely to mediate between the organization's safety management system and safety outcomes. McDonald et al. (2000) concluded that this subculture was an indication of differences in job perception between technicians and management. Technicians believed safety procedures were there to support them in their exercising of knowledge, skills and values. In contrast, management believed the role of technicians was to follow the procedures explicitly (although clearly leading to production delays).

An ongoing joint research project between the LFV Group Swedish Airports and Air Navigation Services (LFV) and Lund University is focusing on human and organizational factors in relation to safety, in the course of adapting Swedish air traffic control to the changing demands for efficiency and organizational and technological development (Ek et al., 2003). In harmonization with EU regulations, the regulatory and provider roles in Swedish air navigation services have been separated from each other, and a Civil Aviation Authority has been established which certifies suppliers of air navigation services (LFV Group, 2004). As it is now possible for other suppliers besides LFV to be selected to carry out air navigation services in Sweden, this fact constitutes a fundamental change in the LFV business environment (LFV Group, 2004). The effect has also been that the Air Navigation Service Division has been divided into commercialized spheres. The air traffic control centres are undergoing organizational changes in the form of new team-based organizations, structural changes in the organizational sub-units, changes in leadership positions, and a transition to a more computerized (and stripless/paperless) air traffic control system.

In the current project, five concepts are being assessed and monitored during the change processes: safety culture, organizational climate, psychosocial work environment, work climate at a team level, and situational leadership effectiveness. All the assessments are being conducted at the two main air traffic control centres (ATCCs) and at the Air Navigation Service Division (ANS) head office in Sweden. In this four-year longitudinal study, two of three planned measurement rounds have been completed, the first providing baseline results and the second (20 months later) providing results regarding changes in the five concepts. The focus of this paper is on the safety culture assessment and related aspects from the organizational climate assessment.

1.1. Safety culture and organizational climate

Nine aspects of safety culture were included in the assessment of the safety culture in the air traffic control activities. Focus is on the ability of an organization to create and preserve a learning organization. Reason's four aspects in his perspective on safety culture are included: Learning, Reporting, Justness and Flexibility, which all interact to create an informed culture (Reason, 1997). He describes these aspects as follows: A 1) Learning culture is associated with having a proactive approach to safety, which means collecting, monitoring, and analyzing relevant information and thus having updated knowledge about how the work and safety are functioning. The willingness to introduce changes is also a basic characteristic of a learning culture. To support the ability to make relevant safety information visible, it is vital to have a 2) Reporting culture in which individuals are willing to report incidents and anomalies using existing reporting systems. A reporting culture is closely connected to a 3) Just culture where a well-balanced blame approach enhances the co-worker's willingness to make such reports. A just culture also involves defining safe behaviour. 4) Flexibility concerns the ability to transform the work organization in order to meet changing demands, e.g. in periods of high workload. It also comprises respect for individuals' skills and experiences.

The other five aspects included in the current assessment of safety culture are as follows: 5) Communication in daily work (e.g. Glendon and Stanton, 2000; Ostrom et al., 1993) concerns, for example, the need for and clarity in information, communication between people and between work groups. The aspect 6) Safety-related behaviours (e.g. Geller, 1994; HSC, 1993) is associated with the existence of discussions about safety issues in the organization and encouragement of increased safety. 7) Attitudes towards safety (e.g. Mearns et al., 1998; Niskanen, 1994) (viewed from both management and staff perspectives) concern, for example, commitment to safety and management's interest in operators' well-being. The perceived 8) Working situation (e.g. Coyle et al., 1995; Zohar, 1980) concerns cooperation, support and appreciation, and having an influence on the design of work. The last aspect, 9) Risk perception (e.g. Mearns et al., 1998; Rundmo, 1997) concerns, for example, the perceived risk of harming others, and the experience of having an influence on safety in one's work.

It is hypothesized that the nine safety culture aspects in the respective organizations will be positively correlated to each other, as they are intended to constitute different and related aspects of a safety culture. Earlier research has shown that attitudes towards safety are associated with risk perception and safety-related behaviours. Good communication and listening skills across groups and individuals are vital in order to reach a shared situational awareness with respect to risk and safety (e.g. Mearns et al., 2001). The context, or the working situation, may also determine an individual's perspective on risk and safety.

A safety culture in an organization could in principle be said to be influenced by two important components, the first concerning the type of work that is conducted, and the second

concerning the leadership and management system. Different safety culture aspects are probably affected differently by these two components. The type of work can yield differences in scores for safety culture aspects in the current study, where two operative and one administrative organization are examined. For example, scores for Risk perception and Reporting can be higher among operators than for the administrative staff. 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 scores for the various aspects of safety culture.

Management has a key influence on safety culture (Flin, 2003; Guldenmund, 2000). Efficient and successful safety management 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; O'Toole, 2002). Important questions concern what expectations managers have for the safety culture in their organization, and whether their impressions actually correspond to the employees' perceptions. In an earlier study by the authors concerning safety culture in airport ground handling (Ek and Akselsson, accepted), it was concluded that the reality reported by employees (measured through the scores for different safety culture aspects) was often somewhat poorer than that estimated by managers, and that the reality consistently was somewhat poorer than the acceptable lower limit that was estimated by managers.

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. Reichers and Schneider (1990) believe that climate and culture are very similar concepts with substantial overlap, and they agree with Schein (1985) that climate can be understood as a manifestation of culture. Guldenmund's review (2000) also concludes that organizational culture expresses itself through organizational climate. 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'.

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. An organization consists of many subcultures based on 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 (Helmreich and Merritt, 1998). 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.

Ekvall (1983) distinguishes organizational climate from culture. He divides an organization's social system into culture, social structure, climate, and labour relations, and he 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. In the current study, the organizational climate was studied using Ekvall's definition and method that in part assesses an organization's ability for innovation and change (Ekvall, 1990). A positive climate stimulates the innovation processes and contributes to testing and in some cases implementation of ideas (Ekvall, 1990). Hilburn and Flynn (2001) state that air traffic controllers are widely believed to be reluctant to change. (However, Hilburn and Flynn's own empirical results challenge this common belief.) The air traffic control setting is

probably not intended to have many innovative characteristics, as the work procedures are highly regulated and standardized. Furthermore, any changes that can affect air safety are preceded by safety assessments. Even if there are some innate differences between an innovative organization and a safe organization, our 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 safety culture aspects in a negative manner. In the current study, we were interested in gaining more knowledge about components in the organizational climate that affect the development of a safety culture. This knowledge can be vital in the process of developing and improving a safety culture.

1.2. Objectives

This study assessed safety culture aspects at the two main air traffic control centres and the administrative ANS head office in Sweden. The main aims of the 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 of the safety culture aspects and the relationships between safety culture and organizational climate before major organizational and technical changes were implemented at the three study locations. This paper is based mainly on results from the first base-line measurement round. Data from the second measurement round 20 months later, are only included in the analysis of the stability of individuals' assessment of safety culture aspects.

The objectives of this study were to: (1) compare average scores for safety culture aspects for the three study locations 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 this study); (2) investigate whether the perceptions and judgments of safety culture and organizational climate are influenced by the individual's position in the organization, whether the perceptions and judgments of safety culture are influenced by the individual's gender, age, time in current position, and time in company; (3) investigate the strength of correlations between the nine aspects of safety culture assessed; (4) test the stability of individuals' assessments of safety culture aspects over a 20-month interval; (5) investigate whether relationships exist between the safety culture and the organizational climate, in which the organizational climate dimensions are treated as explanatory variables and the safety culture aspects as outcome variables; (6) investigate management's expectations and goals concerning safety culture aspects and how these correspond to employees' evaluations of the safety culture aspects; and (7) present safety culture findings obtained from interviews with staff at the two ATCCs.

In the discussion, comparisons will be made with the results from corresponding safety culture assessments, using the same methodology, in the areas of passenger shipping and airport ground handling.

This study is part of a larger research programme with the aim of studying, assessing, and establishing reference data concerning safety culture aspects in three different transport branches: passenger shipping (Ek and Akselsson, 2005), air traffic control, and airport ground handling (Ek and Akselsson, accepted). Using the nine aspects of safety culture presented above, a method for measuring safety culture was used to collect data that characterize a safety culture such that the results can support changes towards more efficient safety management.

2. Methods and material

2.1. Safety culture assessment

The safety culture was studied using the following methods:
1) A safety culture questionnaire package comprising the nine safety culture aspects or scales. The questionnaire package was based on aspects whose contexts were selected from previous studies of safety culture in the research field. A number of relevant items were developed to represent each of the aspects. The majority of the items were to be scored on a five-point scale (1-5) (e.g. "Not at all, Barely, A little, Much, Very much," or "Never, Seldom, Sometimes, Often, Very often"). Items were designed so that high scores always represented a positive safety culture.

As mentioned in the introduction, the current study is part of a larger research programme with the aim of assessing safety culture aspects in three different transport branches. Field studies were conducted in the ground handling and passenger shipping settings in order to formulate items in a relevant manner for measurement of safety culture aspects in those specific contexts. Leaders in central roles evaluated the proposed items for their relevance and appropriateness. A pilot study on board a passenger ship was conducted in order to test the questionnaire package in a real situation (Ek et al., 2000). In the pretest of the questionnaire package, it was found that the responders were able to complete the questionnaire package, with few unanswered questions. Acceptable variation across subjects was also found for the scores for all items. A reliability analysis was conducted using the Cronbach's coefficient alpha test. The test measured the internal consistency of the nine aspects (scales), i.e. it tested whether the different items used to measure a given safety culture aspect were homogeneous. In the pilot study, Cronbach's alpha coefficient values of >.70 were obtained for seven of the nine aspects of safety culture (Ek et al., 2000).

The questionnaire package is based on a content validity approach, in which selection of items representing each safety culture aspect was prioritized. The main purpose of the questionnaire package is to identify specific topics and areas of safety culture (items within safety culture aspects) that need improvement; we have thus retained each specific safety culture aspect as a sub-score. The factor structure of the questionnaire package items concerns a separate research objective that will be studied later. Regarding the internal consistency of the nine safety culture aspects (scales) in the current study, the Cronbach's coefficient alpha test of each scale demonstrated generally acceptable internal consistency and reliability (Table 1). Furthermore, the current paper demonstrated acceptable test-retest reliability over such a long interval as 20 months.

Table 1. Cronbach's coefficient alpha for the nine safety culture aspects (scales) in the questionnaire package in the first and second measurement rounds.

Safety culture scale	n of items round 1/round 2	α round 1	α round 2
Working situation	19/11	.80	.74
Communication	8/4	.70	.63
Learning	9/4	.82	.76
Reporting	7/4	.74	.59
Justness	9/6	.65	.59
Flexibility	7/6	.61	.56
Attitudes towards safety	15/9	.83	.81
Safety-related behaviours	15/9	.72	.67
Risk perception	6/5	.43	.56

In this longitudinal study, two of three planned measurement rounds have been completed. The second round of data collection was conducted 20 months after the first, with the aim of studying stability of safety culture aspects over time. In the second measurement round, the safety culture questionnaire package was reduced to 57 items in order to decrease the workload on the respondents. When selecting the items for the shorter version, one objective was to retain questions that generally received more negative responses in the first measurement round, in order to be able to monitor positive or negative changes in the responses. However, the stability analysis was conducted using exactly the same sets of items from the first and second measurement rounds. The Cronbach's coefficient alpha values of the scales in the reduced questionnaire package are presented in Table 1, and demonstrate generally acceptable internal consistency and reliability.

2) 18 semi-structured interviews were held in the first measurement round with nine employees from each of the two ATCCs. The interviews were conducted with the following subjects: the manager of the ATCC; the three centre managers of Operations, Systems Performance, and Training Unit; one air traffic control assistant; and four air traffic controllers among whom some also had the position as watch supervisor/shift leader or team leader. The interviews each took approximately one hour. The purposes of the interviews were to obtain information on the respondents' work experiences and perceptions and judgments of the safety culture.

2.2. Organizational climate assessment

The organizational climate was assessed using Ekvall's questionnaire (Ekvall, 1990). The questionnaire contained 50 statements about the organizational climate, which were answered using a four-point scale (0-3) (the subject agreeing: "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 important for an organization's functioning even 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.

Only organizational climate results from the first measurement round are reported here.

2.3. Material

The study was conducted at the two main air traffic control centres and at the ANS head office in Sweden. The two ATCCs are equal in size and have more than doubled their staff during the past ten years. ATCC A is mainly an en route centre, while ATCC B deals mainly with air traffic arriving and departing from the main national airport. The questionnaire packages were distributed to a total of 635 employees at the three study locations; of these 391 were returned in the first measurement round. The questionnaire package survey received the following response rates in the first and second measurement rounds, respectively: ATCC

A: 66% and 61%, ATCC B: 56% and 55%, and ANS office: 63% and 35%. Table 2 presents the distributions of age, time in current position, time in company, gender, and position for the respondents at the three study locations in the first measurement round.

In total, 206 individuals returned questionnaire packages in both measurement rounds (79 individuals from ATCC A, 70 from ATCC B and 57 from ANS). Their questionnaire responses were used in the analysis of individuals' stability in assessments of safety culture across the two measurement rounds.

Table 2. Distribution of age, time in current position, time in company, gender, and position for the respondents at the three study locations in measurement round one.

Age	21-30 years	31-40 years	41-50 years	>50 years	Missing
ATCC A	28	54	29	26	4
ATCC B	41	49	25	15	
ANS	11	25	34	48	2
Time in current position	0-23 months	2-5 years	6-10 years	>10 years	
ATCC A	27	52	21	39	2
ATCC B	30	43	23	33	1
ANS	47	34	15	21	3
Time in company	0-23 months	2-5 years	6-10 years	>10 years	
ATCC A	4	28	18	89	2
ATCC B	2	29	23	76	
ANS	11	18	9	79	3
Gender	Male	Female			
ATCC A	73	66			2
ATCC B	63	67			
ANS	89	28			3
Position	Manager	Non-manager			
ATCC A	33	108			
ATCC B	20	110			
ANS	17	103			

ATCC=Air traffic control centre. ANS=Air navigation service (head office).

2.4. Study procedure

The study is part of a longitudinal investigation in which two of three measurement rounds have been completed. Before the safety culture questionnaire packages (including the organizational climate questionnaire) were distributed at the three study locations in the first measurement round, meetings were held at the two control centres, mainly with managers and team leaders but also with union representatives, to discuss the study. The employees were informed about the study by posters and circulars at the two ATCCs. The questionnaire packages were distributed at ATCC A by the researcher in person, and at ATCC B and the ANS office by mail. The internal mail systems distributed the questionnaire packages to the employees. The interviews were held in a private room at the employee's workplace. Feedback meetings concerning the results of the first baseline measurement round were held at all three study locations at the end of data collection round one. This gave the staff the opportunity to further discuss safety culture and organizational climate issues on a local basis. The aim was to have an interactive dialogue between researchers and individuals at the ATCCs and the ANS office concerning the issues measured during the study.

2.5. Statistics

When the statistical analyses were conducted, it was assumed that the questionnaire package data were collected using an interval scale measurement (Aron et al., 1994) and parametric tests where therefore used in the analyses.

Average scores were calculated for each of the safety culture aspects and organizational climate dimensions. Differences in average safety culture scores between subgroups (for example, managers vs. non-managers) were tested using the Student t-test (2-tailed) or one-way analysis of variance (ANOVA). Pearson correlation coefficients were calculated in order to study possible associations between safety culture aspects. 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, i.e. calculate measures of consistency or agreement of values within cases. Multiple linear regression analyses were performed for the purpose of examining the relationships between each of the nine outcome safety culture aspects and the ten explanatory organizational climate dimensions. The significance level was defined as $p \leq .05$, 2-tailed. The statistical calculations were performed using the SPSS and STATISTICA computer programs. 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.

3. Results

3.1. Average scores for safety culture aspects in air traffic control

The average scores for each safety culture aspect (scale) for the two ATCCs and the ANS head office are presented in Figure 1. Similar safety culture patterns emerged for the three study locations, although differences in average scores for safety culture aspects were observed. The administrative ANS unit had generally somewhat lower scores, compared to the scores for the two operative ATCCs. The ANS unit's scores were statistically significantly lower than both ATCCs' scores on four aspects, namely *Working situation*, *Communication*, *Reporting*, and *Risk perception*. Statistically significant differences were also found between the two ATCCs concerning the aspects *Learning*, *Reporting*, *Flexibility* and *Attitudes towards safety*, where ATCC B had the lower average scores.

3.2. Safety culture items receiving negative responses

Safety culture items in the questionnaire package where 20% or more of the work force registered a negative opinion (i.e. 1-2 on the five-point scale) were brought to the attention of the management. The safety culture questionnaire package survey identified 26 items on which 20% or more of the respondents at at least one study location gave negative responses. Six of these 26 items received at least 20% negative responses at all three study locations, while four additional items received at least 20% negative responses at each of the two ATCCs. These ten items are presented in Table 3. The items concern *Communication* (training for emergency situations), *Learning* (proactive vs. reactive), *Justness* (acknowledgement for safe work; attention for unsafe work), *Attitudes towards safety* (participation in planning for safety; management's interest in operators' well-being), *Safety-related behaviours* (sufficient training for emergency situations), *Flexibility* (appreciation of employees' knowledge), and *Risk perception* (risk injuring others).

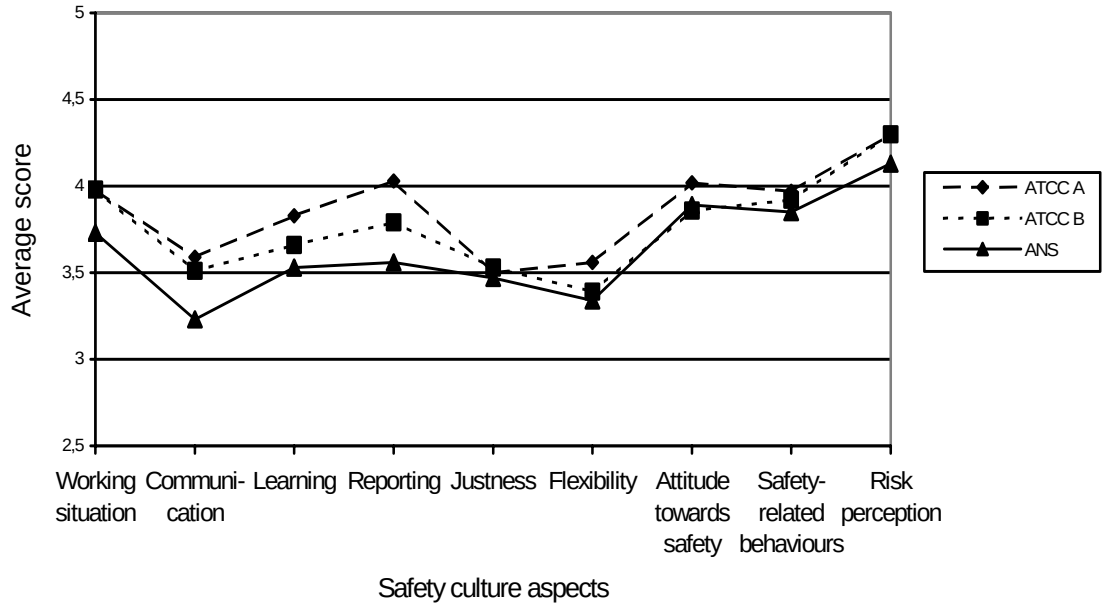

Figure 1. Average scores on safety culture aspects (scales) for the two air traffic control centres (ATCCs) and the Air Navigation Service (ANS) head office from the first measurement round.

Table 3. The six safety culture questionnaire package items receiving negative responses* from 20% or more of the respondents at each of the three study locations and four additional items receiving negative responses at each of the two air traffic control centres.

Safety culture questionnaire package item
Communication
32. Do you think you have received sufficient training in how communication should work in emergency situations? (37, 52, 49)
Learning
62. When as a rule, are improvements in work and safety made? Before/after something negative happens. (33, 43, 33)
Justness
50. Do those who perform their work in a safe manner receive acknowledgement for this? (51, 54, 22)
51. Do those who do not perform their work in a safe manner receive attention for this? (31, 35, 22)
Attitudes towards safety
82. How often have you taken part in the planning for safety (e.g. meetings with discussions)? (33, 38, 41)
Safety-related behaviours
77. Do you think you receive sufficient training in what to do in emergency situations? (47, 52, 51)
Four additional items from the two ATCCs:
Flexibility
20. Do you experience that the knowledge and experiences of all employees are appreciated? (20, 23)
Attitudes towards safety
78b. Do you think the ANS is working for good safety? (regarding work injuries) (29, 35)
86. Do you think the management in ANS takes interest in the operators' well-being? (29, 41)
Risk perception
94. Is there a risk that your work could lead to others being injured? (27, 25)

*Score 1-2 on 5-point scale.
In parentheses, percent of respondents at ATCC A, ATCC B and ANS.

Analyses were conducted to find out if negative responses were due to a subgroup of individuals who consistently gave negative answers across items, or due to more common perceptions of specific safety culture problems among employees. About 25% of the respondents at each study location where found to account for about half of the negative responses at each location. No notable profile regarding gender, age, time in company and time in current position was found for the 'negative-response' subgroups at the three study locations.

3.3. Effect of individual characteristics on perceptions

3.3.1. Gender, age, time in company, and time in current position

t-test analyses and one-way analyses of variance were used to test whether individual characteristics such as gender, age, time in company, and time in current position had an effect on how individuals perceived and judged the different safety culture aspects. Of 108 analyses, only two statistically significant effects were found: at the ATCC B, higher age had a negative effect on how the *Working situation* was perceived ($p < .02$), and at the ANS head office, longer time in current position had a negative effect on how the *Reporting* aspect was perceived ($p < .05$).

3.3.2. Perceptions on different hierarchical levels

t-test analyses were conducted to determine whether differences existed between managers and non-managers in how the safety culture aspects and the organizational climate dimensions were perceived and judged. As shown in Table 4, many statistically significant differences were found between managers and non-managers in perceptions of the safety culture aspects, especially at ATCC A and at the ANS head office. In all instances, the managers had more positive perceptions and judgments of the safety culture than did non-managers. However, only a few statistically significant differences between these groups were found concerning how the organizational climate was perceived and judged. The only differences in perceptions was found at ATCC A and concerned the organizational climate dimensions *Support for ideas*, *Liveliness*, and *Idea-time*; in these cases, the managers also had more positive perceptions than did non-managers.

Table 4. Statistically significant differences between manager and non-manager perceptions of safety culture aspects and organizational climate dimensions ("m" = managers had more positive perceptions than did non-managers).

Safety culture aspect	Study location			Organizational climate dimension	Study location		
	ATCC A	ATCC B	ANS		ATCC A	ATCC B	ANS
Working situation	m			Challenge/Motivation			
Communication	m		m	Freedom			
Learning	m	m	m	Support for ideas	m		
Reporting	m	m	m	Trust/Openness			
Justness			m	Liveliness/Dynamics	m		
Flexibility			m	Playfulness/Humour			
Attitudes towards safety	m	m	m	Debate/Diversity			
Safety-related behaviours	m			Conflicts			
Risk perception			m	Risk taking			
				Idea-time	m		

Group differences are significant at $p \leq .05$, 2-tailed.
ATCC=Air traffic control centre; ANS=Air navigation service head office.

3.4. Correlations between safety culture aspects

Pearson correlation coefficients were calculated to determine the strength of the relationships between the nine safety culture aspects in the three study locations. The results yielded positive and statistically significant correlations ($p \leq .05$, 2-tailed) between all nine aspects for each organization by itself. The average Pearson correlation coefficients for the two operative ATCCs are presented in Table 5. The average correlation coefficients in Table 5 became .04 units larger when the administrative ANS study location was also included in the calculations. High correlations were found between the safety culture aspects *Reporting* and *Learning* (average r = .67); *Reporting* and *Communication* (average r = .66); *Attitudes towards safety* and *Learning* (average r = .62); *Safety-related behaviours* and *Reporting* (average r = .62); and *Safety-related behaviours* and *Attitudes towards safety* (average r = .62).

Table 5. Average (Pearson) correlation coefficients between safety culture aspects for two air traffic control centres.

Safety culture aspect	1 Work sit.	2 Comm.	3 Learn.	4 Report.	5 Just.	6 Flex.	7 Att.	8 Behav.	9 Risk per.
1. Working situation	—								
2. Communication	.47	—							
3. Learning	.46	.56	—						
4. Reporting	.53	.66	.67	—					
5. Justness	.43	.50	.59	.50	—				
6. Flexibility	.39	.43	.46	.55	.42	—			
7. Attitudes towards safety	.49	.53	.62	.60	.45	.42	—		
8. Safety-related behaviours	.47	.44	.57	.62	.40	.32	.62	—	
9. Risk perception	.43	.41	.40	.49	.41	.31	.50	.48	—

All correlations are significant at $p \leq .05$, 2-tailed. Base n = 266.

3.5. Stability

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. As shown in Table 6, average ICC coefficients (across the nine safety culture aspects) were .58, .61, and .60 for ATCC A, ATCC B and ANS, respectively (with a range from .35 to .76 across the total study). Average stability was generally similar across the locations and the safety culture aspects that were studied.

Table 6. Stability of individuals' perception of safety culture (SC) over a 20-month interval.

Safety culture aspect	ICC			Average ICC across SC aspects
	ATCC A	ATCC B	ANS	
1. Working situation	.76	.45	.74	.65
2. Communication	.68	.56	.65	.63
3. Learning	.50	.62	.35	.49
4. Reporting	.53	.71	.65	.63
5. Justness	.53	.57	.71	.60
6. Flexibility	.53	.58	.53	.55
7. Attitudes towards safety	.64	.68	.60	.64
8. Safety-related behaviours	.58	.69	.51	.59
9. Risk perception	.48	.59	.70	.59
Average ICC across locations	.58	.61	.60	
No. of pairs	79	70	57	

ICC=Intraclass correlation coefficient (one-way random effects model, single measure). All correlations are significant at $p \leq .05$, 2-tailed.

3.6. Relationship between organizational climate dimensions and safety culture aspects

Multiple linear regression analyses were performed to investigate whether relationships existed between each of the nine safety culture aspects and the ten organizational climate dimensions. Table 7 presents the statistically significant relationships found at the three separate study locations and for the two ATCCs combined (the total). The two organizational climate dimensions, *Support for ideas* and *Conflicts*, were most frequently related to the safety culture aspects. The dimension *Support for ideas*, was found to be positively related to almost all safety culture aspects, especially in ATCC B and in the total group. 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 organizational climate dimension, *Conflicts*, was also positively related to several safety culture aspects, especially in the total group and in ATCC A (a high score on *Conflicts* means a low level of conflict). This dimension concerns the occurrence of emotional tensions in the organization. When the level of conflict is high, there is animosity between groups and between individuals. When the level of conflict is low, more mature behaviour prevails, with psychological awareness and control of impulses (Ekvall, 1990).

Very few relationships between the safety culture and the organizational climate were found at the administrative ANS head office.

Table 7. Statistically significant relationships between organizational climate dimensions and safety culture aspects at the two ATCCs, the ANS head office, and the two ATCCs combined.

	Organizational climate dimension									
Safety culture aspect	1 Challenge/ Motivation	2 Freedom	3 Support for ideas	4 Trust/ Openness	5 Liveliness/ Dynamics	6 Playfulness/ Humour	7 Debate/ Diversity	8 Conflicts	9 Risk taking	10 Idea-time
Working situation	C		T	A						C
Communication			T, A, B					T, A		
Learning			T, B			-T		T, B	T, B	
Reporting	A	B	T, B					T, A		
Justness			T			B	T	T, A	T	
Flexibility			T, A, B			B				C
Attitude towards safety			T, A, B		T, B	-T, -A	T, A	T, B		
Safety-related behaviours	T, A		T, B		B	-T	T	T, A		
Risk perception			T, A, B					T		

All multiple regression analyses shown here are significant at $p \leq .05$, 2-tailed.
T=Total, i.e. the two ATCCs; A, B=ATCCs, C=ANS head office; a minus sign indicates an inverse relation.
In the analyses, a high score on "Conflicts" means a low level of conflict.

3.7. Management's expectations and goals concerning safety culture aspects

At the two ATCCs, five managers (the manager of the ATCC, centre managers of Operations, Systems Performance, and Training Unit, and one watch supervisor) were asked to judge how they themselves and the operators perceived the safety culture aspects in the organization. They were asked eight questions selected from the safety culture questionnaire package (shown in Table 8), representing eight of the nine aspects of safety culture (*Working situation* was excluded due to difficulty incorporating its multifaceted content into only one question). They were asked to make the following three judgments for each of the eight questions: (1) How many (the percentage) of the operators do you estimate will answer "a

good safety culture" (i.e., 4-5 from the five-point scale) to this question? (i.e. their estimate of reality); (2) How many ought to answer "a good safety culture" to this question for you to be satisfied with the results? (i.e., managers' goals for the air traffic control activity); (3) What is the lowest acceptable limit, i.e., how few employees can answer "a good safety culture" before it is time for improvements to be made?

Table 8. Eight questions representing eight safety culture aspects judged by five managers at the two air traffic control centres.

Communication: Do you receive the information you need to be able to carry out your job in a safe manner?
Learning: Do you think that ANS calls attention to and takes seriously the safety problems that arise on the job in air traffic control?
Reporting: Do you experience that you can say what you think about the safety in air traffic control work?
Justness: Do you experience that you and your co-workers receive praise for calling attention to deficiencies in safety?
Flexibility: Do you experience that the knowledge and experiences of all employees are appreciated?
Attitudes towards safety: Do you think the management within the ATCC actively encourages safe working?
Safety-related behaviours: Do your superiors encourage orderliness on the job?
Risk perception: Is there a risk that your work could lead to others being injured?

For every safety culture aspect, an average percentage score across the five managers at each ATCC was calculated for each of the three judgments. The average percentage scores for the managers in ATCC A are given in Figure 2. For comparison, the actual percentage scores for the eight questions obtained through the questionnaire package survey with the staff are also given in Figure 2.

For the aspects *Communication*, *Reporting*, and *Attitudes towards safety*, the managers' estimates of how many of the personnel would answer "a good safety culture" were in accordance with the staff's actual scores. The estimations and scores of the staff were also very close to the managers' goals and accepted lower limits for these aspects. For the other five safety culture aspects, the actual scores of the staff were, on the average, lower than both the managers' lowest acceptable limits and estimates of staff scores for the aspects.

A similar pattern of results was found for ATCC B.

4. Main findings from interviews

All the interviewees were very positive towards the overall air traffic control job and thought the cooperation with fellow workers functioned well. They thought their job was appreciated, even though the two air traffic control assistants found themselves to be somewhat in the background. The difference in social status between managers and operators was generally perceived as minimal and the line of communication as short. Managers were perceived to be positive towards training, education and creating good working situations. In contrast, the organization's commitment to the prevention of work injuries among air traffic controllers was perceived to be low (as was also found in the questionnaire package survey).

All interviewees thought that the reporting culture within the ANS organization was very good. They referred to the existing open dialogue, in which they were not afraid of reporting safety problems, knowing that the organization's aim was to look for a solution to such problems. A highly developed three-level reporting system was in use, where the lowest level of reports were those written when operators wanted to share their learning experiences with others who might find themselves in a similar situation (at the other two levels, reporting was mandatory).

Figure 2. Average percentage scores of actual sample values (from questionnaire package survey) and managers' estimates, goals and acceptable lower limits concerning the proportions of staff at ATCC A describing "a good safety culture" for eight questions representing one safety culture aspect each.

Through the applied self-monitoring system, the individual air traffic controller is obligated to update his or her practical and theoretical knowledge. A yearly follow-up confirms that this has been accomplished. At the two ATCCs, meetings with cockpit pilots had been arranged where the pilots shared their experiences of the air traffic control situation from a cockpit perspective. The air traffic controllers found these meetings to be very useful and educational.

One issue within the safety culture aspect *Justness* concerns paying attention to unsafe work. The questionnaire package survey showed that at least 20% of the respondents at all three study locations believed that unsafe work was hardly ever or never given such attention. The air traffic controllers who were interviewed thought this to be a very sensitive area. Criticism of another colleague's work quickly touches upon the area of personal integrity and professional pride. Judgements of others' work are also difficult to make, because the observer may not have a complete overview of the specific air traffic situation.

The transition to a more computerized, stripless air traffic control system has created some anxiousness among the air traffic controllers, even though they are all educated and trained for the new system. The anxiousness was believed to be more frequent among older air traffic controllers with less computer experience than among younger controllers. In contrast, the younger controllers have less practical work knowledge and experience than the older controllers, who have been their role models. As was brought up in one of the interviews, the new system can thus result in a change of leadership/tutor roles between younger and older controllers.

The terms "quality" and "safety" have now become a more structured part of the ATC activity, compared to a few years ago. Currently, organizational and technical changes that can affect air safety are preceded by safety assessments. A local safety manager now assists the ATCCs with these safety assessments as well as with risk and consequence judgments. This is a new way of thinking that permeates all their work. Safety assessments have naturally been carried out in other forms previously, but were not as structured, or with the same amount of documentation, as they are today. 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.

ANS's transition and division into commercialized spheres was put into effect both to change the way of managing and to follow up the air navigation service provider activity. One important new principle is the distinction between functional activity and financial control, and the decentralization of these questions in the organization. The transition into commercialized spheres was believed to be positive among the interviewed ATCC managers. It has increased the clarity of existing units within the ANS and, above all, given rise to a clearer goal setting from top management to bottom.

A goal-oriented leadership policy is now being applied in the total organization. The managers who were interviewed indicated that deficiencies had existed earlier concerning the feedback process upwards in the organization, i.e. ATCC managers' feedback to the administrative unit, ANS head office. The communication had not always been clear and had sometimes depended on personal contacts with specific individuals. With the new goal-oriented approach, they believed the feedback process was better, with more clear and comprehensive communication. Managers received clearer communication from the ANS top management concerning the setting of goals, and managers reported back concerning the same goals.

Previously, there had been some criticism of the decision-making process at the head office concerning the operative units and their work. The head office personnel sometimes lacked the necessary operative work expertise and often consulted the personnel in the operative units in order to broaden the basis of their decision-making. Nevertheless, decisions were sometimes made that were not in line with the operative units' goals to produce good air traffic control service. Nowadays, the operative units have more freedom to make these kinds of decisions themselves, which the managers believed to be very positive and constructive.

5. Discussion

This paper reports on an assessment of safety culture aspects at one administrative and two operative units in a Swedish air traffic control setting, using questionnaire packages and interviews as data collection methods. Notable individual stability was found for safety culture evaluations over a 20-month period. The safety culture was generally perceived to be good by the respondents. Nevertheless, the administrative unit had somewhat lower average scores on several safety culture aspects (scales) than did the two operative units. Aspects such as *Communication*, *Reporting*, and *Risk perception* were found to receive lower scores in the administrative unit. For the air traffic controllers, these aspects probably have another meaning than they do for administrators, as controllers need to have another awareness of risks, are dependent on good communication and should comply with safety management procedures that require reporting of incidents. If a similar assessment of safety culture aspects within air traffic control had been performed in other countries, the study would probably have yielded similar results concerning safety culture aspects in relation to type of work.

Differences in safety culture scores could also be discerned between the two operative units, as ATCC A had higher scores than ATCC B concerning *Reporting* and *Learning*. At ATCC A, a trial system for local reporting and analyses of near-incidents and "learning occurrences" had been run by air traffic controllers themselves and supported by the management (Ternov et al., 2004). The project has resulted in some safety improvements and thus in an improved learning process/safety culture. This occurrence might very well have yielded an increase in positive perceptions and judgments of safety culture aspects.

Nevertheless, the general safety culture in the air traffic control study was found to be somewhat better (i.e. on a higher average level) than that found in previous corresponding safety culture studies of passenger shipping (Ek and Akselsson, 2005) and airport ground handling (Ek and Akselsson, accepted). The average scores on safety culture aspects (scales) were generally lowest for the ground handling ramp organization, and the passenger shipping was on a level in between ATC and ground handling.

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. Our results show that learning processes are better developed in the air traffic control setting than in passenger shipping (Ek and Akselsson, 2005) and especially airport ground handling ramp activities (Ek and Akselsson, accepted). Air traffic control can be characterized by a more mature approach to reporting anomalies and 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. The interviews showed that the entire organization's aim was to look for solutions to safety problems instead of scapegoats.

The specific safety culture items most often found to be problematic concerned acknowledgement for safe work/attention for unsafe work, a proactive approach to learning, participation in planning for safety, management's interest in operator well-being, training for emergencies, appreciation of knowledge, and risk for injuring others. Concerning the safety culture aspect *Communication*, the results revealed that large groups at all three study locations thought that they had not received enough training in how communication should function in emergency situations. A similar result was found in Hilburn and Flynn (2001), where over 70% of controllers reported needing more training in unusual situations, such as handling emergencies. In principle, such results can be interpreted in different ways, e.g. that the training is clearly insufficient, that the respondents' ambition concerning safety is very high, or a combination of both factors. Hilburn and Flynn (2001) concluded in their study that a lesson learnt was that training opportunities seem to serve a dual purpose: they educate the ultimate users of the system, but they also send a signal to staff that management is willing to invest in them.

The perceptions and judgments of safety culture aspects were influenced by the individuals' positions in the organization, in that the managers often had a more positive view than did non-managers/operators. In comparison, managers and non-managers/operators differed very little in their perceptions of the organizational climate dimensions. A majority of the managers in the study 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. Their professional advancement in the organization has probably not altered their perceptions and judgments of the organizational climate. The safety culture, compared to the organizational climate, might be more clearly and directly manifested in the every day work, for example, by air safety rules and regulations to be followed. It could very well be that the individuals who advance in the system and receive management positions have a greater interest in certain organizational questions over others, in this case, safety aspects. After the advancement to a manager position, their commitment to safety takes other forms in combination 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, on five of eight safety culture aspects to be judged by managers in the two operative units, the actual safety culture ratings of the staff were, on the average, lower than their managers' lowest acceptable limits of safety culture.

Gender, age, time in current position, and overall time in the company had very little effect on how the safety culture aspects were perceived and judged. A similar result was found in the ground handling study (Ek and Akselsson, accepted). In the current study, this could be an effect of the operative staff being cast in the same mould as a result of education, training and the highly regulated working methods.

ANS's transition and division into commercialized spheres, with a goal-oriented leadership policy, and a clearer distinction between functional activity and financial control, was considered to be positive among the interviewed ATCC managers. It has given rise to a clearer setting of goals from top to bottom and a better feedback process upwards in the organization concerning the same goals.

The current study identified relationships between organizational climate dimensions and safety culture aspects at the two ATCCs. A higher level of *Support for ideas* and a lower level of *Conflicts* were positively related to many safety culture aspects. An organization in which initiatives are encouraged and listened to and where there is a more mature way of handling emotional tensions should probably affect a safety culture in a positive way. Similarly, in the passenger shipping study (Ek and Akselsson, 2005), *Support for ideas* was also positively related to safety culture. In the current study, very few relationships were found between the organizational climate and safety culture at the ANS head office. A meaningful relationship between organizational climate dimensions and safety culture aspects may require a greater participation in operative air traffic control on a daily basis.

The prevailing organizational climates in the three study locations could be characterized as being democratic (Arvidsson et al., 2006). It would be interesting to conduct similar investigations on the relationships between safety culture and organizational climate in other countries were perhaps less democratic organizational philosophies prevail.

One purpose of the safety culture assessment is to yield results that can be used in discussions at the ATC centres and ANS head office, to determine what measures are needed to improve safety culture and safety. This represents a step in the continuous improvement processes, where feedback meetings concerning the results from measurement rounds are included. These interactions also allow the researchers to adjust their methods to the concrete needs in a realistic manner. At the same time as the usability of the methods can be increased, the researchers can provide organizations with practical knowledge and methods to make production safer and more transparent.

6. Conclusions

This paper reports on a safety culture assessment in a Swedish air traffic control setting. Subjects at each of the three study locations showed notable individual stability on safety culture measurements across a 20-month interval. The two operative ATCCs generally had somewhat higher average scores for safety culture aspects than the administrative ANS unit. The general safety culture in the air traffic control study was found to be on a somewhat higher average level than that found in previous studies of passenger shipping and airport ground handling. The learning processes was found to be better developed in the air traffic control setting with a more mature approach to reporting incidents (open dialogues in a blame-free context) and a more developed procedure for analysing limitations and implementing improvements.

Individual characteristics such as gender, age, time in company, and time in current position were found to have 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. In contrast, only a few differences between managers and non-managers were found concerning perceptions of organizational climate dimensions.

Positive relations between safety culture aspects and organizational climate dimensions were found at the two ATCCs, while very few relationships were found between the two concepts at the administrative ANS unit.

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Paper IV

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

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

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Abstract

A positive and innovative organizational climate is of great importance in order to manage and adapt to change. Such a climate seldom evolves in organizations closely governed by rules and regulations. Because of ongoing organizational and technical changes within the Swedish Air Navigation Services Provider, a study concerning the organizational climate for changes and innovations was conducted to investigate the organization's capacity to cope with changes. Study locations were the two Swedish main air traffic control centers and parts of the civil aviation administration headquarters. In the study 390 subjects took part and the CCQ questionnaire was used to measure the organizational climate. The results show that the organizational climate is quite positive despite the rule-governed work. The results also show that administrative personnel assess the organizational climate as more positive than operative personnel. Comparisons between management positions did not result in any differences.
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Keywords: Organizational climate; Innovative preparedness; Air traffic control

1. Introduction

Air transport services today operate in a single European market, yet the Air Traffic Control (ATC) services, which they depend on, are still largely organized and provided on the basis of national boundaries. The result is an air traffic system which is not as efficient as it could be (EC, 2004). In addition, increasing air traffic volumes will put more pressure on the system. Forecasts by the European Commission and the European Organization for the Safety of Air Navigation, Eurocontrol, predict that the air traffic will double by 2020, (Van Houtte, 2004). It is clear that the current system does not have the capacity needed to handle it. In order to meet the forthcoming demands, the Single European Sky initiative (EC, 2004) was recently launched by the European Commission, which seeks to promote a more rational organization of the European airspace, increasing air traffic capacity while ensuring high safety standards throughout Europe. To realize this vision, the upper air space over Europe, which today is managed by about 60 ATC centers, will be restructured and a single airspace will be managed by approximately five to ten main Air Traffic Management

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(ATM) organizations. In this process there is a need for change, improvement and harmonization in technology. In order to succeed in merging ATC centers around Europe, an innovative climate and blame-free organizational atmosphere could be important.

In Sweden the ATC centers in Malmö and Stockholm are preparing to meet the new conditions in mainly two ways: the recent introduction of a new team-based organization and the recent installation of a new ATC system (Luftfartsverket, 2005a). In addition, Sweden reorganized the air space in 2004 in which a single upper air space was created. In cooperation with Denmark the air space has further been divided with regard to air traffic flows rather than to national boundaries. In line with these changes is a prospect called NUAC (Nordic Upper Area Control) in which a more extensive collaboration between Sweden, Denmark, Norway and Finland is under discussion. The intention with NUAC is to create a single upper air space covering a large part of northern Europe (Luftfartsverket, 2005b). These actions are made to meet increasing air traffic volumes, and to prepare for the Single European Sky initiative. The Swedish ATM business thus offers a good case for studying change processes similar to those that will take place around Europe in the near future.

The new conditions will affect each member of the organization in some way. The changes will affect various parts of the organization differently depending of the work that is performed. In order to meet the new conditions and successfully adapt to the forthcoming changes, the organization is not just dependent of the individual employee's ability to cope with new demands but also of the organizational climate. The aim of this article is therefore to study aspects of the *organizational climate* with respect to *changes and innovations* by paying attention to differences between arrival-and-departure and en route ATC centers, between operative and administrative work and between managers and non-managers.

The definition of organizational climate used in this study has been developed from the definition by Payne and Pugh (1976). They describe the climate as, "A molar concept reflecting the content and strength of the prevalent values, norms, attitudes, behaviors and feelings of the members of a social system which can be operationally measured through the perceptions of system members or observational and other objective means" (p. 1141). This definition includes both objective and subjective measures. Ekvall (1990), who has developed the instrument used to measure the organizational climate in this study, defines organizational climate in a similar way as Payne and Pugh. He regards it as "attitudes, feelings and behaviors, which characterize life in an organization" (p. 5). Although there is a close resemblance to Payne and Pugh's definition, Ekvall limits the term to dealing only with psychosocial conditions on a somewhat superficial level. Norms, values and beliefs are considered to be present on a deeper psychological level in the social environment.

The climate is shaped by the interaction between the organization and its members according to Ekvall (1990). The day-to-day contact and confrontation with the organization, its structures and processes create the attitudes, feelings and behaviors that constitute the climate. The individuals within the organization, their personalities, attitudes, knowledge, experiences, etc. have a fundamental impact on the kind of climate that evolves. The organization offers the opportunities, as well as the boundaries, for the possible interaction and the climate that develops. In addition, the management is considered to have a great influence in shaping the climate. Other factors such as the size of the company, the physical environment, the financial situation, etc. can have an impact on the climate as well (Ekvall, 1990).

Organizational climate research also considers whether the climate should be regarded as a whole or as different sub-climates. Some researchers have presented results indicating that the climate concerns the whole organization. Others have pointed out differences between various units or levels within the organization and argue for a sub-system view of the organizational climate (Ekvall, 1985). We share this view.

The method used in this study concentrates on the organizational climate as an important factor for stimulating change and innovation within an organization. A positive climate stimulates the innovation process and contributes to testing and in some cases implementing ideas (Ekvall, 1994). The main force of an organization's ability to change is innovation, which can be described as an attitude helping organizations to see beyond the present and concentrate on the future (Ahmed, 1998). According to Saleh and Wang (1993) an innovative climate is often characterized by openness in the exchange of information. This is important not only because of the technical value to be gained from the available information but also for the psychological value of promoting trust. Trust is essential in creating a climate in which individuals are not afraid to challenge the status quo even if such attempts can lead to failure. Thus there are reasons to believe that the organizational climate can be affected by the blame-free atmosphere, since such an atmosphere has to be built on trust and fairness (cf. Reason, 1997).

In large rule-governed organizations operating in a high-risk environment such as nuclear power plants and Air Traffic Control Centers (ATCCs), positive and innovative climate do not evolve easily. Detailed instructions to guarantee safety describe precisely how things should be done and offer little room or few opportunities for new thoughts or ideas. Standardized routines and regulations therefore have a negative impact on creativity and seem to prevent an innovative

climate from developing (Ekvall, 1994). This resembles what Hedberg and Sjöstrand (1979) call organizational inertia. Inertia is defined as the force within an organization that prevents its members from noticing, identifying and becoming aware of the needs and requirements for change. Strict instructions and manuals often cause organizational inertia. Zammuto and O'Connor (1992) argue that different outcomes are to be expected in cases of implementation of new technology depending on the cultural orientation towards control or flexibility. The control dimension is associated with externalized (coercive) mechanisms of coordination and control, such as rules, policy procedures, etc. Flexibility is associated with internalized (normative) commitment-based mechanisms of coordination and control such as training and socialization (Zammuto et al., 2000). According to Zammuto and O'Connor (1992) organizations with control-oriented cultures are more likely to fail at implementation of new technology compared with organizations with a flexible-oriented culture.

For safety reasons, ATC work is in many ways governed by rules and regulations (ICAO, 2001). The working methods are strictly standardized and so are the training and education of the air traffic controllers. In order to manage air traffic from almost every part of the world, the regulations are founded on an international standard. The communication language is standardized and even the way of speaking is regulated.

In view of the above discussion, there may be reasons to believe that a positive innovative climate may help an organization to manage and more easily adapt to ongoing changes. The first question for this study to answer is therefore, to what extent an organization steeped in rules and regulation such as the ATM business is prepared for current and future changes. This question will be answered by comparing the investigated organizational units with two reference groups in the Creative Climate Questionnaire (CCQ) manual (Ekvall, 1990), i.e. with one group of innovative and one group with stagnating organizations, respectively. The answer to this question is relevant not only for Swedish and European air traffic management as a concern in the implementation of the Single European Sky concept, but also for air traffic management all over the world as demands on organizational and technical changes are boundless and the ongoing changes will occur in and affect the rest of the world (EC, 2004).

Another question the study aims at answering is if the organizational climate differs between different organizational units with different prevailing operating conditions. To answer this question two main ATCCs in Sweden operating under somewhat different conditions will be compared. One is the ATCC in Malmö-Sturup located in the southern part of Sweden about 45 km (28 miles) from the main Danish airport, Copenhagen Airport. It is characterized as an *en route center*. About 35% of the ATC work is connected to air traffic arriving at and departing from different airports in the area. The remaining 65% of the flights are en route flights, implying that the air traffic controllers mostly serve airplanes passing by at high altitudes. Most of the work tasks, therefore, consist of surveillance. At the other ATCC in Stockholm about 90% of the work is connected to airplanes arriving at and departing from different airports in the area, primarily from the main Swedish airport, Stockholm-Arlanda, and from the Stockholm-Bromma Airport. A simplified characterization of the work at ATCC Stockholm would be of an *arrival-and-departure center*. Here the air traffic controllers are rather active, working within fairly small sectors and with airplanes flying at low altitudes.

Both ATCCs have recently (March, 2005) installed the new ATC system but because of the different operating conditions, differences in the preparation for the new technology may be present. The two ATCCs also differ in the progress they have made on the introduction of the new team-based organization. At the time of this study, the arrival-and-departure center had operated the new organization for about a year, at the en route center the time span was about 6 months. The arrival-and-departure center has therefore come a little further in this process, mainly due to the earlier start. Hypothesis I states that there are significant differences in the organizational climate between the arrival-and-departure center and the en route center.

To further answer the question concerning differences in the organizational climate between different organizational units the two ATCCs will be compared with the Air Navigation Services (ANS) unit. The two ATCCs and the ANS unit differ mainly from each other with respect to working tasks and methods that are strictly regulated at the ATCCs. While the main task at the two ATCCs is operative air traffic control the ANS unit is one part of the central head office dealing with general air traffic management issues such as air traffic flow and airspace management. The work is exclusively administrative; no operative air traffic control is conducted. In addition, the two ATCCs are in direct contact with the organizational and technical changes in a way that the ANS unit is not. Hypothesis II states that the organizational climate is experienced as more creative at the ANS unit than at the two ATCCs since the work is less governed by roles and regulations. As no operative control work is performed at the ANS unit only administrative personnel will be included in the analysis of hypothesis II.

The study further aims at answering the question whether there are any differences in the organizational climate between personnel occupied with *operative* and *administrative* tasks at the two ATCCs. These two groups are working within the same organization but with entirely different tasks and under somewhat

different conditions. The operative personnel mainly consist of air traffic controllers and air traffic control assistants. They conduct their work in the operative room, handling the air traffic and solving traffic problems in front of radar and computer screens according to rules and regulations. The introduction of the new ATC system will have a direct impact on this group. The administrative group consists of people working outside the operative room, solely with traditional office tasks. The new ATC system has no direct consequences for this group whereas they are involved in the development of the organizational changes. Hypothesis III states that the administrative personnel experience the organizational climate as more creative than the rule-governed air traffic controllers.

Because the leadership is believed to have an important impact on the kind of climate that evolves (Ekvall, 1990), the last question to be answered in the study is whether there is any difference in the organizational climate reported by *managers* and *non-managers*. As the managers are in charge of daily routines as well as development of future activities and the organization of them hypothesis IV states that the members of the management group experience the climate as more innovative and thus are more prepared to handle future changes than the non-management group.

2. Method

2.1. Participants

The study was conducted during spring 2002 at two Swedish ATCCs referred to as the *en route center* and *the arrival-and-departure center*. The study also concerns the Swedish *ANS unit*. The CCQ questionnaire (Ekvall, 1990) was distributed to all 635 employees at the three units. Out of 635, 390 subjects returned completed questionnaires. Of these, 141 were filled out by employees at the en route center, 130 by employees at the arrival-and-departure center and 119 by employees at the ANS unit. Altogether, 39 respondents did not complete the study for reasons such as maternity/paternity leave, sickness leave, training, vacation, etc. This resulted in a final response rate of 69% for the en route center, 63% for the arrival-and-departure center and 64% for the ANS unit. At the en route center, 74 respondents (52.5%) were men and 67 women (47.5%); at the arrival-and-departure center 63 were men (48.5%) and 67 women (51.5%); and at the ANS unit, 87 were men (73.1%) and 32 women (26.9%). While the gender distribution was similar at the two ATCCs ($\chi^2_1 = 0.365$, $p > 0.05$) the gender distribution at the two ATCCs differed statistically significant from the ANS unit ($\chi^2_1 = 18.331$, $p < 0.001$). The distribution of age, length of service and position of the staff at the three units are presented in Table 1. No statistically significant differences existed between the two ATCCs with respect to age ($\chi^2_1 = 5.3$, $p > 0.05$), length of service ($\chi^2_1 = 1.982$, $p > 0.05$), position ($\chi^2_1 = 2.441$, $p > 0.05$) and task ($\chi^2_1 = 0.327$, $p > 0.05$), whereas the two ATCCs differed from the ANS unit regarding age ($\chi^2_1 = 44.0$, $p < 0.001$) and length of service ($\chi^2_1 = 18.939$, $p < 0.001$) but not regarding position ($\chi^2_1 = 2.488$, $p > 0.05$).

2.2. Instrument

The CCQ questionnaire (Ekvall, 1990) was used to study the organizational climate. It consists of 50 statements formulated in the following way: "People usually feel welcome when presenting new ideas here". The statements are answered on a four-point scale: do not agree at all (0), agree to some extent (1), agree to a great extent (2) fully agree (3). The 50 statements are grouped in 10 different organizational climate dimensions with five statements in each dimension (Ekvall, 1990). The dimensions mainly focus on innovation and

Table 1
Age, length of service, position and task of the staff at the three ATM units—the en route center, the arrival-and-departure center and the ANS unit

Age	21–30 years	31–40 years	41–50 years	>50 years
En route center	29 (20.6%)	54 (38.2%)	29 (20.6%)	29 (20.6%)
Arr./dep. center	41 (31.6%)	48 (36.9%)	25 (19.2%)	16 (12.3%)
ANS unit	10 (8.4%)	26 (21.8%)	34 (28.6%)	49 (41.2%)
Length of service	0–24 months	2–5 years	6–10 years	>10 years
En route center	3 (2.1%)	29 (20.6%)	17 (12.1%)	92 (65.2%)
Arr./dep. center	2 (1.5%)	29 (22.3%)	23 (17.7%)	76 (58.5%)
ANS unit.	13 (10.9%)	17 (14.3%)	9 (7.6%)	80 (67.2%)
Position; Task	Manager	Non-manager	Operative	Administrative
En route center	33 (23.4%)	108 (76.6%)	125 (88.7%)	16 (11.3%)
Arr./dep. center	20 (15.4%)	110 (84.6%)	118 (90.8%)	12 (9.2%)
ANS unit	25 (21.0%)	94 (79.0%)	0 (0%)	119 (100%)

change within an organization, but other aspects are covered as well. Brief descriptions of these dimensions extracted by factor analysis and presented in the manual are as follows (Ekvall, 1990):

Challenge: The employee's involvement in and commitment to the organization.
Freedom: The extent to which employees are allowed to act independently in the organization.
Support for ideas: The overall attitude towards new ideas.
Trust: The emotional security and trust in the relations within the organization.
Liveliness: The dynamics within the organization.
Playfulness/Humor: The spontaneity and ease that is displayed in the organization.
Debate: To what extent different views, ideas and experiences exist in the organization.
Conflicts: The presence of personal and emotional tensions.
Risk taking: The willingness to tolerate insecurity in the organization, such as new ideas, news and initiative rather than the conventional definitions of hazardous risk taking.
Idea time: The time devoted to development of new ideas.

2.3. Procedure

The questionnaires were distributed to the staff through the internal post system. Before the questionnaires were distributed, several informational meetings were conducted, mainly with managers and team leaders but also with union representatives. The employees were informed about the study by posters and circulars at the three units. The questionnaire was answered anonymously and the subjects were asked to report their private opinions and experiences, and to return the questionnaires within 3 weeks.

2.4. Statistical analysis

The CCQ dimensions were calculated as mean scores for each dimension at each unit. To facilitate the interpretation of the CCQ dimension means, they were tested for statistical differences, using *t*-test, independent groups, against available reference data in the CCQ manual, (Ekvall, 1990). The data were collected from 10 organizations described as innovative and five organizations considered as stagnating. The comparison was made on group level for the reference data and on individual level for the study data.

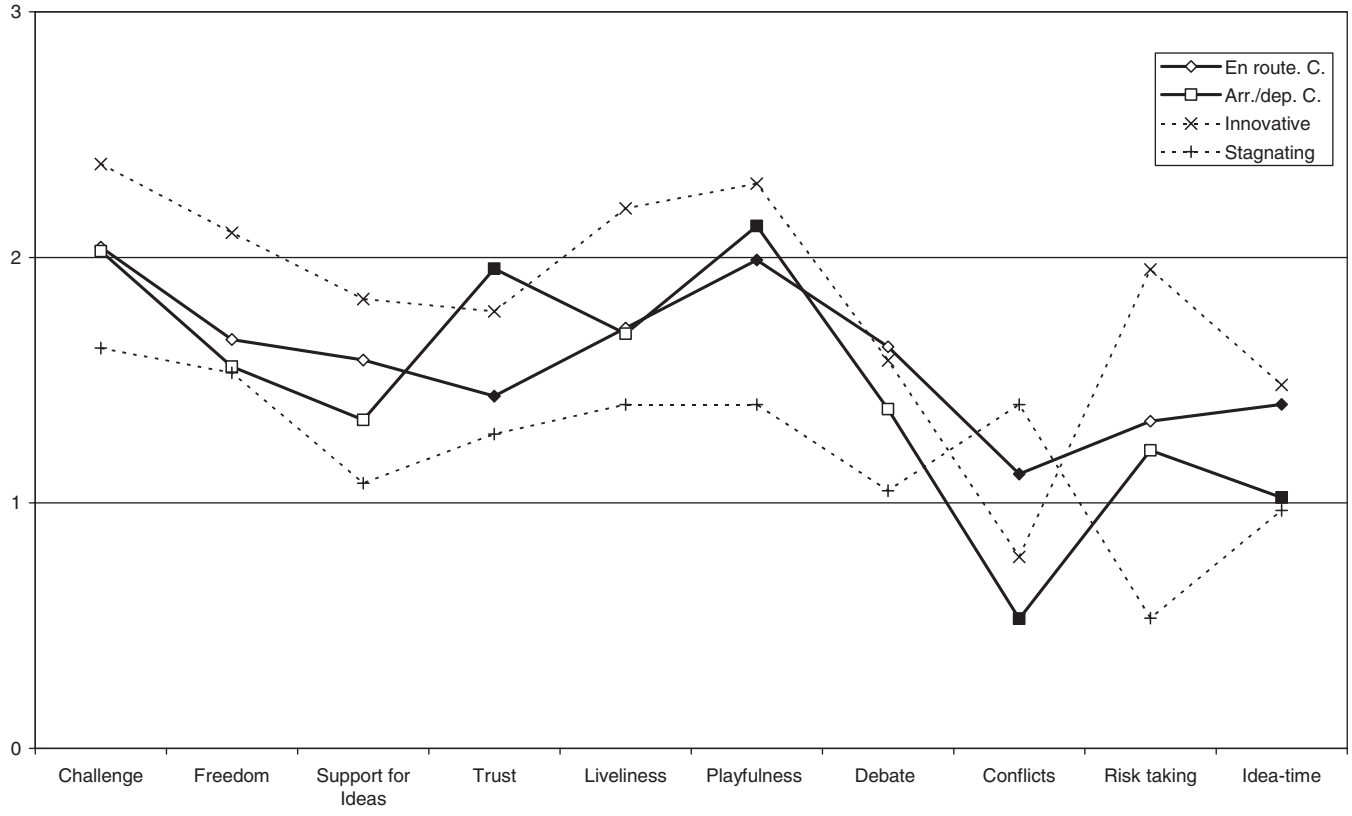

Fig. 1. CCQ mean scores for each dimension and the two ATCCs in comparison with reference data. Filled symbols indicate statistically significant differences between the two ATCCs ($p < 0.05$).

To compare the two ATCCs, the questionnaire data was analyzed using $2 \times 2 \times 2$ factorial ANOVA (Kirk, 1995). The three factors compared were "en route ATCC vs. arr./dep. ATCC", "administrative vs. operative task" and "managers vs. non-managers", respectively. When comparing the two ATCCs and the ANS unit the "administrative vs. operative task" factor was excluded because all personnel at the ANS unit were performing administrative work. In this case, the questionnaire data were therefore analyzed using 3×2 factorial ANOVA (Kirk, 1995) with the factors "en route ATCC vs. arr./dep. ATCC vs. ANS unit" and "managers vs. non-managers", respectively.

Table 2
Cronbach's alpha, means, standard deviations for the 10 CCQ dimensions at the three ATM units and available reference data from 10 innovative and five stagnating organizations

	ATM units	CCQ	En route C.		Arr./dep. C.		ANS unit		Innovative		Stagnating	
	α		*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Challenge	0.74	0.81	$2.05^{I*,S*}$	0.42	2.05^{I*S**}	0.47	2.11^{S**}	0.49	2.38	0.27	1.63	0.10
Freedom	0.62	0.67	1.67^{I**}	0.45	1.55^{I***}	0.47	2.00^{S**}	0.50	2.10	0.16	1.53	0.32
Support for ideas	0.88	0.88	1.59^{S**}	0.54	1.35^{I*}	0.58	1.73^{S**}	0.61	1.83	0.14	1.08	0.23
Trust	0.76	0.76	1.45^{I*}	0.47	1.96^{S***}	0.47	1.74^{S**}	0.54	1.78	0.36	1.28	0.29
Liveliness	0.78	0.76	1.72^{I**S*}	0.45	1.69^{I**}	0.52	1.72^{I*}	0.62	2.20	0.33	1.40	0.22
Playfulness/humor	0.78	0.70	2.00^{I*S***}	0.45	2.13^{S***}	0.45	1.85^{I*S*}	0.56	2.30	0.31	1.40	0.21
Debate	0.72	0.67	1.64^{S***}	0.46	1.38^{S*}	0.43	1.55^{S**}	0.53	1.58	0.31	1.05	0.06
Conflicts	0.85	0.84	1.10	0.65	0.52^{S***}	0.49	0.78^{S**}	0.59	0.78	0.31	1.40	0.14
Risk taking	0.55	0.66	$1.33^{I***S***}$	0.41	$1.21^{I***S***}$	0.38	$1.25^{I***S***}$	0.49	1.95	0.27	0.53	0.15
Idea time	0.73	0.78	1.40^{S**}	0.44	1.02^{I***}	0.42	1.26	0.58	1.48	0.13	0.97	0.26

Note: I refer to innovative organizations, S refer to stagnating organizations and indicate statistically significant differences between the specified unit and reference data.
$^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$.

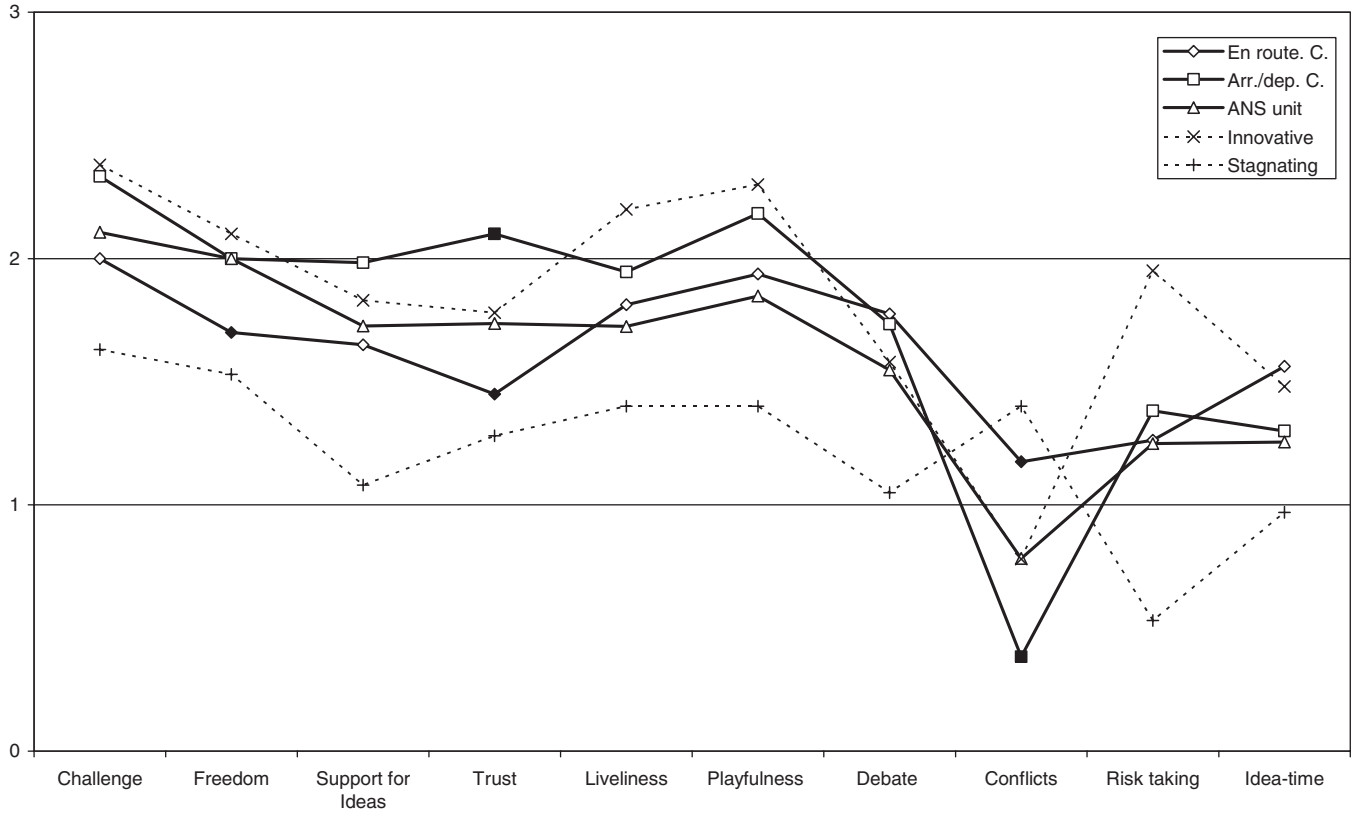

Fig. 2. CCQ mean scores for each dimension and for each ATM unit concerning the administrative personnel in comparison with reference data. Filled symbols indicate statistically significant differences between the ATCCs respectively and the ANS unit ($p<0.05$).

3. Results

3.1. Comparisons with innovative and stagnating organizations

To answer the first question of the study concerning to what extent an organization governed by rules and regulations such as the ATM business is prepared for current and future changes, the obtained CCQ mean scores and available reference data in the CCQ-manual (Ekvall, 1990) were compared as illustrated in Fig. 1 and in Table 2. At the en route center, the dimensions "Support for ideas", "Debate" and "Idea time" resembles to scores in innovative organizations and the dimensions "Freedom", "Trust" resembles to scores in stagnating organizations as no statistically significant differences exist in these comparisons. At the arrival-and-departure center, the dimensions "Trust", "Playfulness", "Debate" and "Conflicts" resembles to scores in innovative organizations and the dimensions "Freedom", "Support for ideas", "Liveliness" and "Idea time" resembles to scores in stagnating organizations as no statistically significant differences exist in these comparisons. As Fig. 2 illustrates, at the ANS unit, the dimensions "Challenge", "Freedom", "Support for ideas", "Trust", "Debate", "Conflicts" and "Idea time" resembles to the reference data from innovative organizations and the dimension "Liveliness" resembles to scores in stagnating organizations as no significant differences exist in these comparisons. The remaining dimensions do not distinctly resemble either the innovative or stagnating organizations in the reference data.

Basic descriptive statistics, statistically significant differences against reference data and Cronbach's alpha for the 10 CCQ dimensions from the three ATM units are presented in Table 2, as well as means and standard deviations from the reference data. The Cronbach's alphas of the ATM-units are in correspondence with the CCQ Cronbach's alpha (Ekvall, 1990).

3.2. Comparisons between units, type of work and management position

Table 3 shows how the analysis of variance was performed and exemplifies the main and interaction effects for the two ATCCs with reference to the CCQ dimension "Trust".

The remaining nine dimensions were analyzed according to the same procedure. Significant main effects are summarized in Table 4 for administrative and operative personnel at the two ATC units and in Table 5 for administrative personnel at all three ATM units. These results will be commented with reference to the hypotheses of the study. For three of the ten CCQ dimensions, "Challenge", "Liveliness" and "Risk taking", no statistically significant effects were noted.

Table 3
Analysis of variance for the CCQ dimension "Trust" at the two ATCCs

	SS	df	MS	F	p
ATCC	7.06	1	7.06	31.81***	0.00
Management	0.08	1	0.08	0.36	0.54
Task	0.18	1	0.18	0.82	0.36
ATCC × Management	0.16	1	0.16	0.74	0.38
ATCC × Task	0.13	1	0.13	0.59	0.44
Management × Task	0.26	1	0.26	1.21	0.27
ATCC × Management × Task	0.11	1	0.10	0.49	0.48
Error	56.39	254	0.22		

***$p<0.001$.

3.2.1. Hypothesis I: the arrival-and-departure center versus the en route center

Statistically significant main effects according to hypothesis I were found for the two ATCCs in four of the CCQ dimensions as Fig. 1 and Table 4 show. The dimensions "Trust" (En route C., $M = 1.45$, SD = 0.47, Arr./Dep. C., $M = 1.96$, SD = 0.47), "Playfulness/Humor" (En route C., $M = 2.0$, SD = 0.45, Arr./Dep. C., $M = 2.13$, SD = 0.45), "Conflicts" (En route C., $M = 1.10$, SD = 0.65, Arr./Dep. C., $M = 0.52$, SD = 0.49), and "Idea time" (En route C., $M = 1.40$, SD = 0.44, Arr./Dep. C., $M = 1.02$, SD = 0.42), were rated differently at the two ATCCs, independent of the air traffic controllers' work and position.

3.2.2. Hypothesis II: ATCCs versus ANS unit for administrative personnel

Table 5 show, with reference to hypothesis II, that statistically significant main effects were found for the ATM unit variable in three of the CCQ dimensions for administrative personnel. At the ANS unit, the dimensions "Freedom" (ANS, $M = 2.0$, SD = 0.50, En route C, $M = 1.70$, SD = 0.40), "Trust" (ANS, $M = 1.74$, SD = 0.54, En route C, $M = 1.45$, SD = 0.45) and "Conflicts" (ANS, $M = 0.78$, SD = 0.59, En route C., $M = 1.18$, SD = 0.42) were rated more positively than at the en route center independent of management position, while "Trust" (ANS, $M = 1.74$, SD = 0.54, Arr./Dep. C., $M = 2.10$, SD = 0.57) and "Conflicts" (ANS, $M = 0.78$, SD = 0.59, Arr./Dep. C., $M = 0.38$, SD = 0.41) were rated more negatively than at the arrival-and-departure center.

3.2.3. Hypothesis III: administrative versus operative personnel at the ATCCs

Statistically significant main effects according to hypothesis III were found for the task variable with reference to the CCQ dimensions "Freedom" (Adm., $M = 1.83$, SD = 0.46, Op., $M = 1.59$, SD = 0.46), "Support for ideas" (Adm., $M = 1.79$, SD = 0.54,

Table 4
Significant main effects for ATC units, administrative and operative personnel, and management position with respect to the 10 CCQ dimensions

CCQ dimension	Challenge	Freedom	Support for ideas	Trust	Live-liness	Play-fulness	Debate	Conflicts	Risk taking	Idea time
	F (1, 258)	F (1, 254)	F (1, 254)	F (1, 254)	F (1, 254)	F (1, 256)	F (1, 255)	F (1, 256)	F (1, 244)	F (1, 259)
En route C.—Arr./dep. C.	3.13	1.04	0.08	31.81** A./d.+	0.52	4.31* A./d.+	2.40	29.05*** A./d.+	0.04	10.81** E. r.+
Administrative-Operative	1.36	4.02* Adm.+	6.11* Adm.+	0.82	1.61	0.13	5.48* Adm.+	0.11	0.18	3.10
Managers-Non-managers	0.18	0.50	0.03	0.37	0.50	0.11	0.01	0.00	0.08	1.70

Note: A./d. refers to Arrival-and-departure center, E. r. refers to En route center, Adm. refers to Administrative personnel; + refers to the group with highest mean.
*$p<0.05$. **$p<0.01$. ***$p<0.001$.

Table 5
Significant main effects for ATM units and management position for administrative personnel with respect to the 10 CCQ dimensions

CCQ-dimension	Challenge	Freedom	Support for ideas	Trust	Live-liness	Play-fulness	Debate	Conflicts	Risk taking	Idea time
	F (2, 138)	F (2, 138)	F (2, 138)	F (2, 138)	F (2, 135)	F (2, 139)	F (2, 139)	F (2, 138)	F (2, 131)	F (2, 138)
ANS unit—En route C.	1.67	7.85* ANS+	2.00	4.13* ANS+	0.06	0.00	0.81	6.78** ANS+	0.63	1.24
ANS unit—Arr./dep. C.	1.41	0.11	0.73	4.08* A./d.+	0.52	2.58	0.37	5.03** A./d.+	0.14	0.01
Manager—Non-manager	0.57	0.18	0.00	1.05	0.52	0.39	0.10	0.16	0.00	0.66

Note: A./d. refers to Arrival-and-departure center, ANS refers to ANS unit; + refers to the group with highest mean.
*$p<0.05$, **$p<0.01$, ***$p<0.001$.

Op., $M = 1.44$, SD = 0.56) and "Debate" "(Adm., $M = 1.76$, SD = 0.48, Op., $M = 1.49$, SD = 0.46) as Fig. 2 and Table 4 show implying that the administrative personnel scored higher than the operative personnel. (Fig. 3)

3.2.4. Hypothesis IV: management versus non-management personnel

No statistically significant main effects were found for the management variable either in the comparison between the two air traffic control centers with administrative and operative employees nor in the comparison between the air traffic control centers and the ANS unit with only administrative personnel.

4. Discussion

The first question to answer was to what extent an organization governed by rules and regulations such as the ATM business is prepared for current and future changes. The overall results indicate that some dimensions of the organizational climate at the three study locations resemble the climate in innovative organization and some dimensions are similar to the climate in stagnating organizations. Even though the work in the ATM business is governed by rules and regulations, the climate could thus not be considered as clearly stagnating. The blame-free atmosphere that is present within the Swedish ATM may contribute to this finding. In case of an incident, the controller will not be held responsible unless mistakes have been done consciously or by severe negligence. This leads to an open reporting, forgiving and learning climate, in which incidents can be reported freely and used by the organization to draw lessons from (Mooij et al., 2001). As mentioned in the introduction, an innovative climate is often characterized by openness and trust. The open, blame-free atmosphere that exists in the Swedish ATM may affect the overall climate and provide an atmosphere in which a climate for innovations can grow despite the rule-governed work. Such an atmosphere is rather unique in the ATM business. Besides Sweden, only a few countries are working with a genuine blame-free atmosphere and a similar reporting system. The need for such an atmosphere in the aviation industry is a worldwide concern. From a pan-European perspective this issue has been addressed within Eurocontrol by the High Level European Action Group for

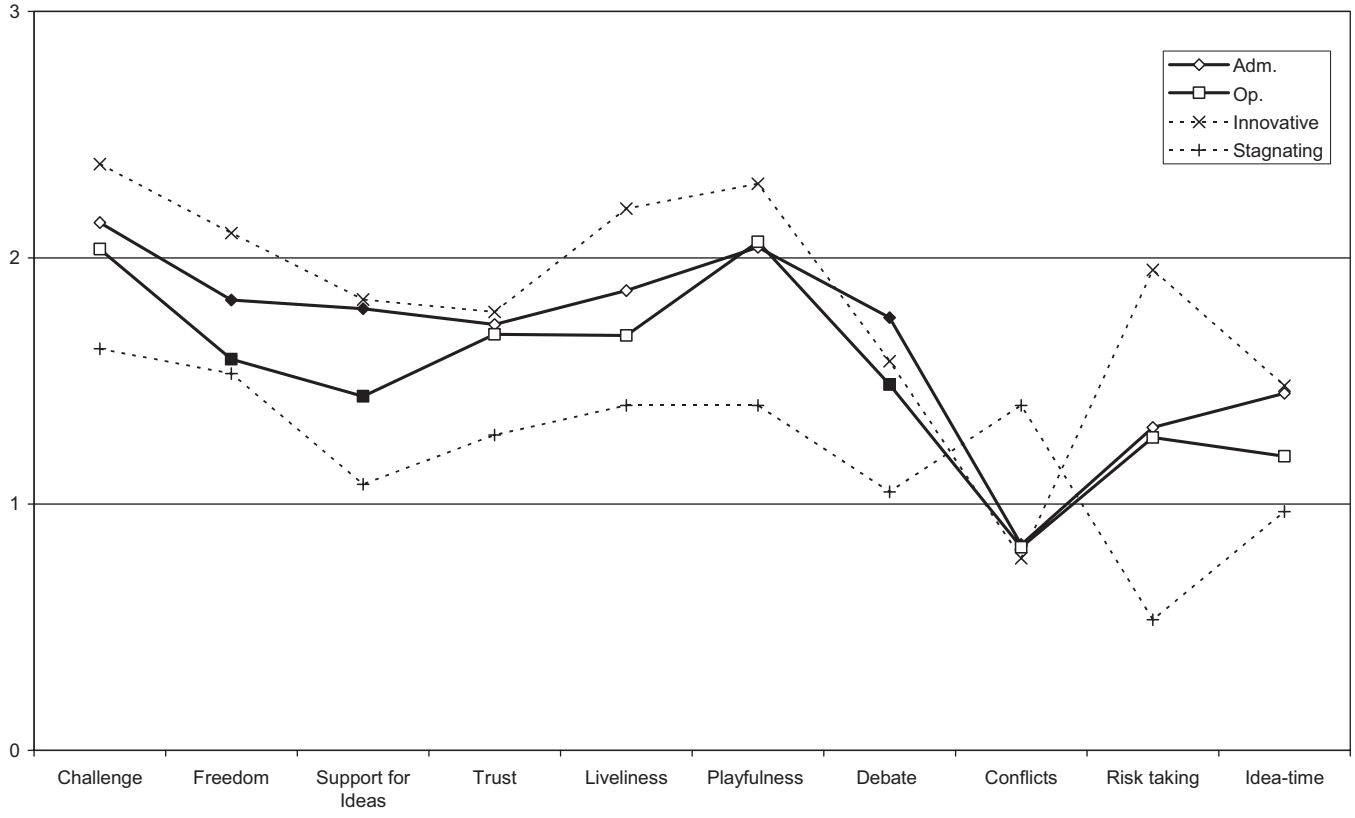

Fig. 3. CCQ mean scores for each dimension concerning the administrative and operative personnel at the ATC centers in comparison with reference data. Filled symbols indicate statistically significant differences between the three ATM units ($p<0.05$).

ATM Safety (AGAS) as they have recommended the implementation and establishment of a just culture as a main objective in their action plan for enhanced ATM safety in a Single European Sky (AGAS, 2003). The International Civil Aviation Organization (ICAO) has also paid attention to this issue (ICAO, 2003a, b).

4.1. Hypothesis I: the arrival-and-departure center versus the en route center

Hypothesis I, which stated that statistically significant differences in organizational climate should exist between the arrival-and-departure center and the en route center, was confirmed. On three organizational climate dimensions of four with statistically significant main effects, the arrival-and-departure center scored more positively than the en route center. One of these dimensions was "Trust" indicating that the emotional security and trust in the relations within the organization were rated more favorably at the arrival-and-departure center than at the en route center. The second dimension rated more favorably at the arrival-and-departure center was "Playfulness/Humor" indicating a more lighthearted and playful organizational climate than at the en route center. Different scores in the "Conflict" dimension further indicate that personal and emotional tensions were less common at the arrival-and-departure center. However, the significant main effect on the dimension "Idea time" in favor of the en route center showed that more time was devoted to the development of new ideas at this unit compared with the arrival-and-departure center.

It is hard to identify the contributing factors explaining the differences between the two ATCCs. Even if the most noticeable difference between the two is the work situation, other reasons for the differences in the organizational climate can be found. The new team-based organization had evolved a little further at the arrival-and-departure center than at the en route center. It seems likely that this might have affected the organizational climate in a positive way. Provided that the implementation of a team-based organization had been successful, it seems reasonable that this affected trust, humor and conflicts in a favorable way. On the other hand, the dimension "Idea time" that is directly related to the innovative climate was rated statistically significant higher at the en route center.

4.2. Hypothesis II: ATCCs versus ANS unit for administrative personnel

The dimensions "Freedom", "Trust" and "Conflicts" were rated more positively at the administrative ANS unit than they were by the administrative personnel at the en

route center. These results indicate that the ANS staff experienced that they were allowed to act more independently than the administrative staff at the en route center. The emotional security and trust in the relations were also regarded as more positive by the ANS staff, and personal and emotional tensions appeared to be less common. When the ANS unit was compared with the administrative personnel at the arrival-and-departure center the dimensions "Trust" and "Conflicts" were rated less positive.

The results illustrate a general pattern for the administrative personnel; the organizational climate at the ANS unit is assed as being less positive compared with the arrival-and-departure center and more positive compared with the en route center. This indicates that the organizational climate at the ANS unit is somewhere in between the climate at the other two ATM units in terms of innovation climate when assessed by the administrative personnel.

4.3. Hypothesis III: administrative versus operative personnel

Hypothesis III stated that the administrative personnel should perceive the organizational climate as more innovative than the rule-governed air traffic controllers. Statistically significant main effects were also found for the three dimensions "Freedom", "Support for ideas" and "Debate" in favor of the administrative staff. According to these results, the administrative personnel appear to have a more positive overall attitude towards new ideas than the operative personnel. The organizational climate assessed by the administrative personnel was further to a larger extent categorized by different views and ideas than that assessed by the operative personnel. These results do not only confirm the hypothesis, they also support the sub-system view of the organizational climate. The differences in three of ten CCQ climate dimensions indicated that two partly different climates were present among the administrative and operative personnel. Differences between the two groups were expected, as the groups perform different type of work tasks. The administrative staffs probably have a more general view of the organization and, as mentioned in the introduction was involved in the development of the organizational changes in a way that the air traffic controllers were not. In addition, the air traffic controllers who spend most of their time behind radar and computer screens were more controlled by the air traffic rules than the administrative personnel. These results are hence in accordance with the view that strictly regulated working conditions could have a negative impact on the innovative climate. From an organizational change perspective the air traffic controllers might therefore need specific attention and support in order to adjust successfully to forthcoming changes and new working conditions.

4.4. Hypothesis IV: management versus non-management personnel

Hypothesis IV stated that the management group should experience the organizational climate as more innovative and as more prepared to handle future changes than the non-management group as managers are in charge of daily routines as well as development of future activities. This hypothesis was not confirmed as no statistically significant differences appeared in the assessment of the organizational climate between managers and non-managers either at the ATCCs or the ANS unit. Although the results of the study give no support for the hypothesis, they might indicate that the two ATCCs have succeeded in creating a flat and egalitarian organizational structure. One of the reasons behind the introduction of the team organization was to increase well being and to give the employees greater influence by flattening the organization.

The two most prominent findings in this study are related to innovativeness in rule-governed organizations and the differences in assessments of the organizational climate between managers and non-managers. Despite the fact that the organizations under study were governed by rules, regulations and instructions, there seemed to be a fairly positive climate for change and innovation. A possible explanation might be the blame-free atmosphere and open-minded reporting, forgiving and learning philosophy that appeared to influence the overall climate in a positive way. Since this philosophy is rather unique, it would be interesting to conduct similar studies in other countries where more repressive organizational philosophies prevail. In addition, if this explanation is valid, the establishment of a similar climate in a pan-European and worldwide environment as recommended by AGAS and ICAO would be advantageous during the implementation of the Single European Sky.

Further, there were no differences found between managers' and non-managers' assessments of the organizational climate, which was assumed. A successful democratic process in which greater influence had been created for everyone in the organizations might explain this. Considering the fact that managers often exercise great influence in the establishment of the organizational climate and in view of the rather positive climate that seemed to exist, another explanation could be that the management group had succeeded in establishing a positive climate among the co-workers.

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