Jon Ivar Håvold

From Safety Culture to Safety Orientation

DEVELOPING A TOOL TO MEASURE SAFETY IN SHIPPING

Thesis for the degree of doktor ingeniør

Trondheim, October 2007

Norwegian University of
Science and Technology
Faculty of Social Sciences and Technology Management
Department of Industrial Economics and Technology
Management

NTNU
Innovation and Creativity

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Preface/Acknowledgements

This thesis reports the results of research I conducted while at the Department of Industrial Economics and Technology at the Norwegian University of Science and Technology and at Ålesund University College.

This thesis addresses safety orientation in a maritime context and consists of six papers, five of which have been published in international journals, and one of which has been submitted for review. The papers form the core of the dissertation submitted to the Norwegian University of Science and Technology, Faculty of Social Sciences and Technology Management, Department of Industrial Economics and Technology Management for the degree of doktor ingeniør (PhD). An introductory essay describes the framework for the thesis, its purpose and objectives, the relationship among the papers presented in the thesis, the research approach, results, discussion and conclusions. The published and submitted papers are presented as they appear in the journals.

I am indebted to many people who have helped me and have contributed to my work.
At the Norwegian University of Science and Technology (NTNU), I would like to thank my supervisor Professor Jan Hovden, for his support and guidance, both at the academic and social level, and for never losing faith in me. I would also like to thank my two assistant supervisors, Professor Kristen Ringdal for his guidance on methodological questions, and Professor Svein Kristiansen for his guidance regarding the shipping business and safety at sea, as well as Jorid Øyen for her efficient administrative services, and Kyrre Svarva who assisted me with questionnaire layout and provided valuable help in the scanning process. I would also like to thank Professor Torbjørn Rundmo, Associate Professor Steinar Ilstad, and Professor Annik Magerholm Fet.

I would also like to thank my colleagues at the Institute for International Marketing at Ålesund University College: Steinar Nistad, Øyvind Helgesen, Erik Nesset, Jacob Valderhaug, Åse Mørkeset, Terje Voldsund, Henry Norton, Øivind Strand and Aitor Yraola, for letting me work on my project. Additionally, I would like to thank Alfred Angelfoss, Karl Johan Skårbrevik and Siri Heggem, from the University College administration.

Among people from the shipping industry, I would like to thank Nils Telle (the Norwegian Shipowners' Association) for writing a letter of recommendation, which was important

when contacting the ship owners, and Sverre Oksvold and Arild Kalnes, who let me use data they had collected as part of their bachelor thesis for one of my papers. I would also like to thank Per Olaf Brett at DnV (Det Norske Veritas), Sigmund Eriksen from the Council for Labour Supervision on Norwegian Ships, and Marianne Riddervold from the Norwegian Maritime Directorate.

It is impossible for me to thank everyone from the shipping industry who contributed to my work, because they are so numerous -- and anonymous. The data reported in the collection of papers come from 17 shipping companies, 156 vessels and close to 3000 persons. Thanks goes to the owners, managing directors, HMS managers, personnel managers, the contact people aboard the ships and the contact people at the ship owners' office; without their help, my data would surely be far less useful.

At Aberdeen University I am grateful to the staff of the Industrial Psychology Group, Department of Psychology, for my stay during the summer of 2001, particularly the contributions from Kathryn Mearns, but also Rhona Flin, Rachael Gordon and Angela O'Dea.

I also thank Nancy Bazilchuk for her efficient and service-minded proof reading, Joan Harvey from Newcastle University, who helped me with the final British polishing for one of my papers, and Bjørn Sandvik for helping me with the figures in this thesis.

I would like to thank Ålesund University College, CEFOR (the Central Union for Marine Underwriters), If Insurance and Zürich Insurance Norway for financial support of my work, and DnV for paying for the printing of questionnaires used in the main survey.

The deepest gratitude goes to my family, my wife Gunhild and my sons Ole Kristian and Jon Magnus, who have been the ones who have suffered from less quality time than they deserved. Even when my body was present my mind could be miles away. I thank them so much for their patience with me.

Ålesund, October, 2007
Jon Ivar Håvold

TABLE OF CONTENTS

SUMMARY

This study was intended to develop a tool to measure safety orientation (SO) in shipping. SO should be considered a practical safety culture assessment instrument, indicating the degree of orientation towards safety in a group or an organisation. The definition of the construct follows below:

"Safety orientation consists of the cultural and contextual factors that create the attitudes and behaviour that influence occupational health and safety. Organisations with a positive safety orientation are characterised by a perception of the importance of health and safety, and by confidence in the efficacy of their chosen measures to create the necessary behaviour for avoiding or limiting accidents and to continuously improve health and safety." (Håvold, 2005a p.97).

An extensive literature search in the maritime and safety fields revealed that there has been almost no previous research dealing with safety culture in the maritime context. The study therefore examines the literature dealing with safety culture and climate in areas other than shipping. Many of the factors identified by these investigations assisted the study in the development of a first culture assessment instrument to measure SO at sea. Paper 1 is a review paper covering culture in maritime safety, Paper 3 reviews newer scales used for measuring safety culture in different industries leading to the safety orientation definition and model. Paper 4 tests safety culture theory and hypotheses on a sample of seafarers on Norwegian-owned vessels. Paper 6 validates and simplifies the scales and items presented in Paper 3.

The main study was designed to represent as broadly as possible the safety attitudes, safety climate and safety culture of seafarers employed aboard Norwegian-owned vessels.
The study was based on a quantitative research approach using two questionnaires for data gathering, generating two datasets. These datasets provide the basis upon which the analyses were conducted. The total number of seafarers who participated in the two surveys numbered more than 2800. Analysis of the datasets enabled the safety orientation construct to be described comprehensively and to be tested using different quantitative methods. Details of the methods, results and implications can be seen in Papers 4 and 6.

Further work is needed to verify the empirical results and refine the safety orientation construct and model. This can be done by applying the model and validating it with new samples of seafarers.

Acronyms:

ACSNI	Advisory Committee on the Safety of Nuclear Installations	**KAB**	Knowledge, Attitude, Behaviour
ANOVA	Analysis of Variance	**KAP**	Knowledge, Attitude, Practice
ATSB	Australian Safety Transport Bureau	**KPI**	Key Performance Indicator
BSC	Balanced Score Card	**LL**	Load Line
CFA	Confirmatory Factor Analysis	**LRCSS**	Latent Root Criterion Short Scale
CMI	The Comité Maritime International	**LTI**	Lost Time Injury rate
COLREG	Collision Regulations	**MANOVA**	Multivariate Analysis of Variance
CRM	Crew Resource Management	**MARPOL**	International Convention for the Prevention of Pollution from Ships
DnV	Det Norske Veritas	**MDA**	Multiple Discriminant Analysis
DWT	Dead Weight Tonnes	**MORT**	Management Oversight & Risk Tree
EFA	Exploratory Factor Analysis	**NIS**	Norwegian International Ship Register
FA	Factor Analysis	**NTNU**	Norwegian University of Science and Technology
GAIN	Global Aviation Information Network	**OECD**	Organisation for Economic Co-operation and Development
GLM	General Linear Model	**PA**	Parallel Analysis Criterion
HRO	High Reliability Organization	**PCA**	Principal Component Analysis
HSE	Health and Safety Executive	**PSC**	Port State Control
IAEA	International Atomic Energy Agency	**SHE**	Safety Health and Environment
IATA	International Air Transport Association	**SO**	Safety Orientation
ILO	International Labour Organisation	**SOS**	Safety Orientation Scale
IMCO	International Maritime Consultative Organisation	**SOLAS**	International Convention for the Safety of Life at Sea
IMO	International Maritime Organisation	**SMS**	Safety Management System
ISM	International Safety Management Code	**STCW**	Standards of Training, Certification and Watchkeeping
ISO	International Standards Organisation (e.g. ISO 9000 and ISO 14000)	**TQM**	Total Quality Management
IUMI	International Union of Marine Insurers	**VSM**	Values Survey Module

Introduction

1.1 Purpose, overall aims and rationale

This thesis focuses on defining, describing and testing a safety orientation (SO) construct. The research aims fall into two categories; to contribute to theory testing of selected hypotheses related to safety culture (Papers 4 and 5) and to contribute to the development of a tool to measure safety orientation in shipping (Papers 3 and 6). However, the main purpose is to develop a tool to measure SO in shipping.

SO is closely related to, and can be looked at as, an operational definition of safety culture. The SO model is presented in Figure 1.1 and a definition of safety orientation is presented on p. 2.

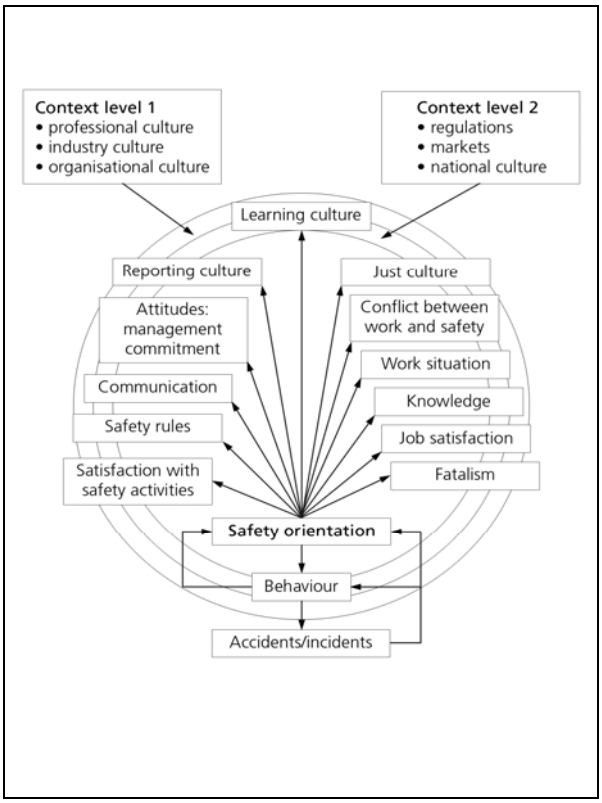


Figure 1.1 Preliminary model describing; Factors and consequence of safety orientation (Håvold, 2005a p.98)

The idea of SO emerged from scientific papers on organisational culture and climate, safety culture and climate, marketing orientation, organisational learning and psychological literature, all of which discuss the link between attitude and behaviour. Theories influencing the safety orientation model and definition are presented in Chapter 3 and the factors included in the safety orientation model (Figure 1.1) are described in more detail in Chapter 4 and in Papers 3 and 6.

A definition of safety orientation has been proposed in Paper 3:
"Safety orientation consists of the cultural and contextual factors that create the attitudes and behaviour that influence occupational health and safety. Organisations with a positive safety orientation are characterised by a perception of the importance of health and safety, and by confidence in the efficacy of their chosen measures to create the necessary behaviour for avoiding or limiting accidents and to continuously improve health and safety." (Paper 3: Håvold, 2005a p.97).

Parts of the model have been tested in a maritime context as a step towards developing a tool to measure safety orientation in shipping. A strong focus on performance measurement coupled with reporting on safety performance to stakeholders seems to help in raising an understanding of safety as a strategic business objective and thereby improves decisions and safety performance in organisations (Fuller, 1999; HSE, 2001). A more detailed discussion can be found in Paper 2: Mearns and Håvold (2003).

The process of developing the tool that is reported in this thesis is outlined below:

1. Review of safety climate and safety culture papers, and relate them to maritime safety.
2. Propose a definition of a "new" construct: "safety orientation".
3. Draw a preliminary model of antecedents, context and outcomes related to safety orientation.
4. Describe safety orientation and test some of its antecedents/factors using surveys conducted aboard Norwegian-owned vessels.
5. Explore if the most important factors of safety orientation are transferable from other industries to the maritime industry.
6. Explore the consistency in attitudes among groups of employees on Norwegian-owned vessels, for example based on occupation, nationalities, vessels and ship owners.
7. Validate the safety orientation model by using confirmatory factor analysis.
8. Evaluate a simplified model of "safety orientation" on the basis of the studies (safety orientation revisited).

Safety, health and environment (SHE) is important ashore, but may be more so at sea because seafarers are often far from hospitals and doctors if something happens.

In 1997 the HSE published a report entitled *The Cost of Accidents in which they claim that incidents might account for as much as 37 per cent of annualised profits for a transport company, 8.5 per cent of the tender price for a construction company and 5 per cent of running cost for a hospital (HSE, 1997).* Paper 2 (Mearns and Håvold, 2003) discusses in more detail how accidents can influence both organisations and individuals, and how a large accident can be damaging for a company and result in production losses, lower quality and lost goodwill, as well as affecting worker morale, and at its worst, even lead to bankruptcy.

According to the International Maritime Organization (IMO), shipping is one of the most dangerous of all the world's industries. The organisation states that the best way to improve safety at sea is by developing international regulations and for companies to work with safety culture. The IMO further maintains that the key to achieving a safety culture is to recognise that accidents are preventable through following correct procedures and established best practice; and by constantly thinking safety and seeking continuous improvement (www.imo.org).

It is important to work with safety in shipping because occupations at sea are high risk compared to most other occupations. The relative difference in fatal injuries between the workforces ashore and at sea seems not to have diminished over the years (Statistical Yearbook, 2000), a fact supported by a survey carried out amongst Danish seafarers from 1986 to 1993 (Hanson, 1996), which showed that fatal injuries at sea were 11.5 times higher than average rates among the Danish male workforce ashore. Roberts and Marlow (2005) subsequently found that the mortality rate in British merchant shipping during the years from 1976 to 2002 was 27.6 times higher than in the general workforce in Great Britain at the same time. These findings demonstrate that both the companies and the maritime industry have the potential to improve safety performance substantially, and indicate therefore the need for research on safety at sea.

1.2 Main research questions

Håvold (2000) reviewed culture in maritime safety in Paper 1. The review indicated that no research had been done on safety culture and climate in shipping, a finding later confirmed by Sten and Fjerdingen (2003). Most safety climate and culture research had been done on offshore oil platforms, nuclear power production, air and rail transport, chemical factories and construction work. The question then becomes whether it is possible to transfer findings and factors found in industry and air safety to maritime safety. Would a survey of seafarers show the same dimensions as other industries, indicating that there might be an "industry standard?"

The paper's research questions were related to building and testing the safety orientation model, and testing theory for the practical use of the SO construct:

Question 1: Are safety culture factors found from studies in other industries transferable to a maritime context?

Question 2: Are the most important factors found in other industries also the most important in a maritime context?

Question 3: Model building: Is it possible to build and test a model measuring safety orientation in shipping based on a review of literature covering safety culture?

Question 4: Is it possible to find factors/dimensions that discriminate sufficiently among vessels, occupations, nations and other factors to become a useful tool in the improvement of safety?

Question 5: Validation: If safety orientation can be measured in this way, which dimensions can be used to measure it; and how does these dimensions relate to what is known about safety and risk from existing theory and research?

The hypothesis is that safety orientation is partly predetermined by organisations, industry, nationality, and task. In operational terms, the issue is whether membership in one organisation or group rather than another explains a significant share of the variance in member answers to questions dealing with safety-related matters.

1.3 Assumptions

Safety culture and safety climate are seen as the same construct. Guldenmund (2000), who lists 18 definitions of safety culture and safety climate in a review paper, says that some authors perceive safety climate and culture as separate constructs (safety culture is manifested through safety climate) and some perceive the two as one phenomenon.

The absence of a large accident in the history of an organisation does not prove that the organisation is a safe one or even that it has a better safety orientation than other organisations. Research shows that a company can have LTI-rates close to zero and still have a relative high probability of a large accident (Hovden, 2001). Many organisations with nearly error free records have a track record of concealed accident and safety breaches (Sagan, 1993). So a low accident rate even over a period of many years is no guarantee that risks are being controlled. This might be particularly true in organisations where there are low probabilities of accidents, but where major hazards are present.

One might make distinctions between proactive and reactive methods (Kristiansen, 2005). A reactive approach is based on knowledge about historical accidents while a proactive approach is built on an understanding of the causes of accidents and organisational knowledge. SO can be used to predict and prevent accidents from happening in the future and are as such a proactive approach.

Management and owners might have an intrinsic interest in communicating that their organisation are safe because organisations that are perceived as safe are more attractive customers for insurance companies and banks, more attractive for local communities and present and future employees, as well as for investors, suppliers and customers (is discussed in Paper 2: Mearns and Håvold, 2003). Managers might therefore give biased answers if asked about safety. It is therefore important to ask or observe the people at the sharp end, the sailors on the vessels, to determine their values, norms, attitudes, beliefs and actions to get to know the antecedents to safe or unsafe behaviour in an organisation.

One has to bear in mind that no organisation is just in business for being safe; most businesses are in business for reasons such as earning long-term profits for their owners. But one cannot argue that being safe has no bearing on long-term profitability; for example,

Germaniche Lloyd states clearly on its web page: "*Central to our thinking is the optimising of operational safety and the associated increases in profitability we achieve for our clients*" (http://www.gl-group.com/start.htm). Paper 2 discusses also the costs of *not* including health and safety in the calculation of long-term profits, and the fact that many people do not realise how expensive accidents are.

1.4 Delimitations and their justification

The main paradigm in this thesis is that elements of culture are measurable by using questionnaires and quantitative methods. Traditionally, culture as a scientific topic in social sciences was studied by anthropologists. Since the 1980s an ongoing debate on whether culture can be measured using quantitative methods seems to have split the scientific society in two. Some are opposed to the idea (e.g. Trice and Beyer, 1993); others see no profound objections (e. g. Hofstede, 1991 and 2001 and Bernard, 1988). A mixed approach (quantitative and qualitative research) with in-depth interviews, observational or action research in addition to surveys would certainly have improved the validity of my research, but the lack of time and money left me with a quantitative research design.

There are many threats to external validity that cause the results of a study to be specific to some limited group of people and/or set of conditions. These threats are (a) those dealing with generalisations to populations (What population of subjects can be expected to behave in the same way as the sample subjects?), and (b) those dealing with the "environment" of the study (Under what conditions, i.e., settings, treatments, experimenters, dependent variables, and so on, can the same results be expected?).

By limiting the scope of research to a sample of seafarers working on Norwegian-owned vessels only, the research employing the chosen research methods could be conducted within an acceptable time limit. By choosing a sample spread all over the world and moving all the time, the research methods chosen were feasible and accomplishable. By defining the objectives of this research as a step towards the development of a model, indicators, and a methodology for measuring safety orientation at sea, any compilation of information can be deemed as a positive contribution by adding to our understanding of various aspects surrounding safety at sea.

1.5 Structure of the thesis

The thesis consists of six papers. The links between the six papers and the introduction and conclusions can be seen in Figure 1.2.

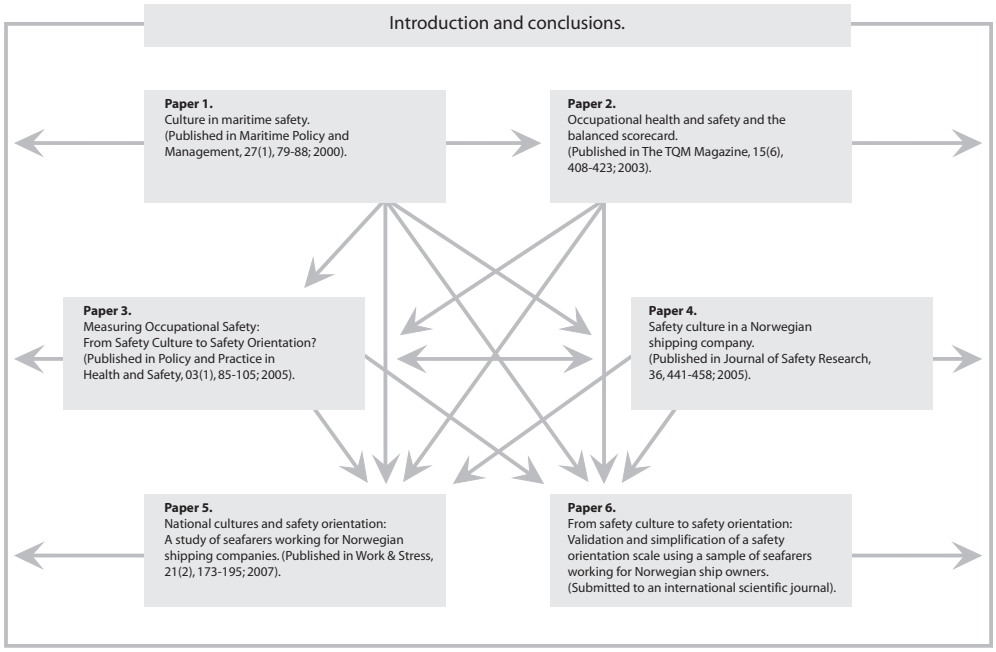


Figure 1.2 Structure of the thesis.

The first paper reviewed "safety culture" in a maritime context and found that no research on safety climate/culture had been done in that industry up to 1998. Literature and findings are updated in later papers and in the framework of the thesis. The second paper discussed the reasons why health and safety should be reported in a balanced scorecard (BSC) and which indicators measuring health and safety should be chosen to populate the scorecard. Interviews were conducted with senior managers about the use of BSC with regards to health and safety indicators.

The third paper reviewed measures of safety culture and climate and discussed factors and items with respect to factor name and importance, reliability and validity. A new and more practical construct called "safety orientation" was proposed. The fourth paper tested theory and hypotheses related to safety culture. The fifth paper discuss national culture's influence on the SO core model. The sixth paper validated the SO core model.

2 Background

History is a tool not only for remembering the past but also for shaping our understanding of the present. In the analysis of an industry or a national tradition, history is important. Every nation and industry shapes its values and culture in a historical context.

2.1 Norway as a shipping nation

In the Viking era the ship became an important symbol of knowledge and power. The shipbuilders at that time went for lightness, strength and resilience in their vessels. Vikings were knowledgeable about shipbuilding, seamanship and navigation. A Viking with a large longship that had been decorated with carvings was a powerful man. Besides allowing the Vikings to travel great distances, their longships provided tactical advantages in battles since they could perform very efficient hit-and-run attacks, in which they attacked quickly and unexpectedly and left before a counter-offensive could be launched. Longships could also sail in shallow waters, allowing the Vikings to travel far inland along rivers (Forte et al., 2005). The Vikings founded cities such as Jorvik (York), Kyvi and Dublin. The Norwegians travelled most to the north-west and west, to the Faroe Islands, Orkney, Ireland and the northern parts of England. Apart from Britain and Ireland, Norwegians mostly found largely uninhabited land and established settlements such as Iceland and Greenland, and at about the year 1000 A.D., North America (Vinland) was discovered (Atkinson, I., 1979; Christensen, A.E., 1982).

In the 18th century the Norwegian fishing industry flourished, lumbering became an important industry, the merchant class grew, and Norway became a naval power. But in early 1800, the post-Napoleonic Wars economic crisis and the decline of world trade reduced Norway's fleet by a quarter (Andersen and Collett, 1989). After the Napoleonic Wars, Norwegian shipping concentrated on traditional and well-established freight and markets, carrying Norwegian exports – lumber, fish and iron – from Norwegian to foreign ports. However, a great expansion of the Norwegian fleet came later in the 1850s, and was closely linked to free trade. In 1849, the British Parliament ended its Navigation Act, which had restricted foreign shipping in British ports. This change provided new opportunities for Norwegian fleets to carry cargoes between third countries. The

Navigation Acts were a series of acts of Parliament that were passed beginning in 1381 to protect English shipping from foreign competition and to ensure monopoly trading between Britain and its colonies (Svendsen, 1999; Pape, 2003). The Navigation Act of 1381 remained virtually a dead letter because of shortage of ships. The first of what is called "The famous Navigation Acts" were passed in 1651 (Encyclopedia Britannica Concise, 2007).

From 1850 to 1880 the Norwegian merchant fleet increased substantially; measured in tonnes, the fleet increased five times over the period, to become third among shipping nations as measured in net registered tonnes (Andersen and Collett, 1989). The fleet then entered a period of slower growth, until a new acceleration period around the First World War. During the interwar period, Norway acquired a modern fleet of tankers and changed from steam to diesel as a means of propulsion. At the end of the 1930s, 60% of the total fleet consisted of motor ships, a higher proportion than in any other country.

After 1945 came 30 years of continuous growth, but a crisis in the economy in the 1970s resulted in a crash in the oil market, and half the tanker fleet was laid up. As a result of the economic crisis in the 1970s and high costs in the early 1980s, many ship owners registered their ships abroad. To revitalise Norwegian shipping, the Norwegian Parliament passed the Norwegian International Ship Register (NIS) Act in 1987. In 1990 Norway's merchant fleet was once again the third largest in the world as measured by country of owner, a position it still holds today. As of January 1, 2005, the Norwegian foreign-going fleet was comprised of 1,614 ships employing some 62,000 people of more than 60 different nationalities aboard ships and rigs. In addition, almost 11,000 were employed onshore. More than 90 per cent of the Norwegian merchant fleet never calls at a Norwegian port, but conducts cross-trade between third countries (Norwegian Ship-owners Association, 2007).

2.2 Seafaring on Norwegian vessels - a high-risk occupation

Statistics for Norwegian sailing ships showed that casualties for Norwegian ships as a percentage of the world's fleet was on average 6% yearly from 1890 to 1910, which is twice as high as the world's fleet excluding the Norwegians.

The year 1894 was an “annus horribilis” in Norwegian sea transport when as many as 308 sailing ships and 15 steamships sank, and a total of 567 people lost their lives as a result (Fig.2.1).

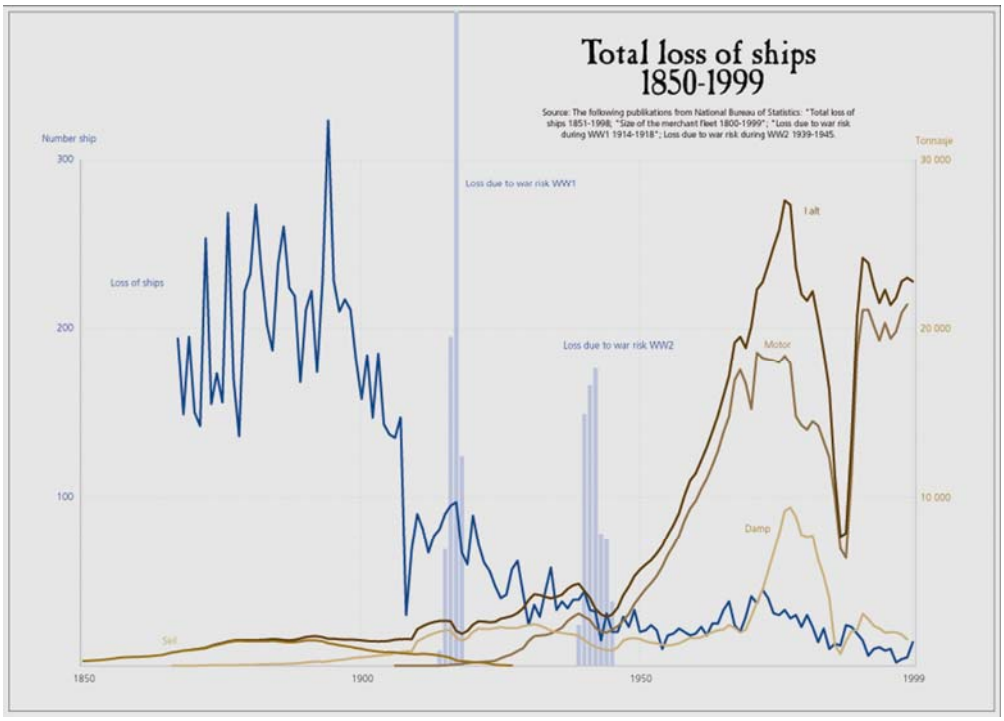


Figure 2.1 Ship losses 1850-1999 (Source: National Bureau of Statistics) http://www.ssb.no/emner/historisk_statistikk/artikler/art-2000-11-01-01.html

In fact, 1894 was an exceptional year, but in 11 out of the 20 years from 1874 to 1894, more than 200 lost lives were registered as a result of vessels sinking. However, capsizing and sinking was only one of many risks for seafarers; only 27% of the deaths during the period resulted from vessels sinking. Nearly as many (22%) were killed as a result of accidents aboard and 51% died because of disease (Statistical Yearbook, 2000) showing that the many deaths was an occupational health and safety problem.

The Norwegian merchant marine was in poor condition, but not all losses were fatal for the crew. Of the 198 wooden sailing ships that were lost in 1895, 94 ran aground, 48 were abandoned by the crew, 28 were condemned because of their bad condition, and 14 were lost at sea. Explanations for the loss of ships and life included poor quality ships, incompetence of masters and crew, drunkenness, moral hazards associated with marine

insurance, poor charts, poor harbours, the carrying of deck loads and strong currents and ice including icebergs in the North Atlantic (Sjostrom, 2000). According to "Anchor and Balance", Det Norske Veritas (DnV) history from 1864 to 1989 the slow transition from sail to steam was the main reason. The numerous accidents happened because the low-cost sailing fleet posed a serious safety problem. In 1890 only 16% of the Norwegian fleet consisted of steamers, compared to 60% in the German fleet and 75% in the British fleet (Andersen and Collett, 1989).

Safety problems at sea consequently became a major public concern, and as early as 1877, Henrik Ibsen published *Pillars of Society,* with a plot that centred on a shipbuilder deliberately operating an unseaworthy ship. The background for Ibsen's play was Samuel Plimsolls book *Our Seamen* from 1872, where he pointed out the unacceptably high number of sailors who were lost with unseaworthy ships. Plimsoll called special attention to the problems from overloaded ships and demanded a load line to mark the minimum freeboard allowed with full loading (now known as the Plimsoll line). As a result of this, parliamentary members (notably Christian Michelsen and Gunnar Knutsen, later prime ministers) were active participants in discussions on safety at sea and chaired the committee and commission that led to the Act of Seaworthiness, which was put into force in 1906. The act established the Maritime Office as a public control body responsible for controlling and surveying the seaworthiness of merchant ships.

Fishermen also had an extremely high the accident rate. Eilert Sundt (1971/1858) documented the problem in his book *Harham*, which is about a fishing community outside of Ålesund:

"This community of just 1866 souls lost 117 people to the sea over 37 years (more than 3 each year). This is more than twice of what it would be if the conditions in this community were the same as elsewhere in Norway, and Norway may be the country in Europe where these matters are most tragic" (Eilert Sundt, 1971/1858 p. 52).

Two periods with extensive losses of ships and crew were the First and Second World Wars (Fig. 2.1). In spite of being neutral during the First World War, Norway experienced some of the heaviest losses of all merchant fleets during the war years 1914 to 1918; the total loss was 2,000 seafarers and half the fleet. The shipping industry was accused by some of sending sailors to their death in World War I. Bjørnstjerne Bjørnson's 1868 title *"Our*

Honour and Glory has white sails us brought" was used by Nordal Grieg (1952) as the basis for a play called "*Our Honour and Glory,"* which shows the garish contrast between seafarers and ship owners from 1917 to 1935, and describes cynical ship owners and agents gambling with sailors' lives, while they themselves earned good money and lived a life of luxury. When after the war, the sailor remains an alcoholic, living as a nervous wreck in a cheap hostel, the ship owners continued their hedonistic existence.

Following the German invasion in 1940, the Norwegian government exiled in London requisitioned almost the entire merchant fleet. Norwegian seafarers sailed in the service of the Allies and 3,400 of them died, and nearly three-fifths of the fleet was lost.

National statistics (Statistical Yearbook, 2000) show a clear trend in the risks posed by seafaring from the late 19th century to the present day, from more than 100 vessels and around 200 lost lives each year in the 1890s, to on average eight Norwegian vessels and 14 lost lives from 1990 to 1998 (Fig 2.1). The positive trend seems to continue and statistics from 2000 to 2005 shows on average seven Norwegian vessels totally lost and 4.5 lost lives (Statistical Yearbook, 2006).

2.3 The context of maritime safety

At the beginning of the 20th century, it was possible to build a ship more or less whichever way one liked, and to equip it with whatever instruments one liked, operate it according to whatever standards one liked, and sail it whatever way one liked on any ocean. Only a few common navigational rules had emerged. In 1879, nineteen nations adopted joint rules in London for an international signal code; in 1880 an international convention set the first rules for preventing collisions, and in 1881 the first convention on health and safety for steam packet navigation was signed.

Accidents and major disasters encouraged nations to cooperate in the search for safe, efficient maritime transport. It was realised that only an agreement among nations that established minimum standards to be met by a particular ship performing a particular service could offer a satisfactory long-term solution to safety. One example is freeboard legislation. Two identical vessels, but of different nationalities, might compete on the same

route. If one of them was more heavily loaded than the other, one ship owner would earn a higher profit than the other, but would also expose his ship to greater dangers, and a correspondingly lower level of safety. If the same freeboard was displayed on the hulls of both ships by a loadline, overloading would no longer be an acceptable commercial tactic. Several international organisations, such as the Comité Maritime International (CMI) and the International Labour Organisation (ILO) tried to harmonise national safety rules. This move towards internationalisation of the law took place in several stages. First, the local regulations were made uniform through bilateral treaties, agreements or understandings among the leading maritime nations. Next, these same nations held international conferences, in order to set up genuinely universal rules. Finally, intergovernmental organisations took over and encouraged the adoption of international instruments to regulate safety at sea and protection of the marine environment.

After the Second World War, international conferences on safety at sea were held. In 1947 the Oslo Convention introduced a new registered tonnage system and in 1948, the British government invited all nations that had signed the SOLAS Convention to attend an international conference, in order to revise the provisions on safety of life at sea. A new version was adopted in June by twenty-seven nations, which came into effect on 19 November 1952.

IMO International Maritime Organisation

In 1948, a convention was signed in Geneva to establish the International Maritime Consultative Organisation (IMCO), which was designed to assume responsibility for safety issues at sea; its name was changed in 1982 to the International Maritime Organisation (IMO). The IMO is the most important international organisation dealing with safety issues at sea.

The present purposes of IMO as summarized by Article 1 (a) of the Convention are:

"to provide machinery for co- operation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships."

Several international regulations have been agreed under the IMO framework (or pre-IMO framework) focusing on safety at sea. The first of these was the Safety of Life at Sea (SOLAS) Convention, which in its successive forms has generally been regarded as the most important of all international treaties concerning the safety of merchant ships. The first version was adopted in 1914, in response to the sinking of the Titanic. The first International Convention on Load Lines (LL), adopted in 1930, was based on the principle of reserve buoyancy, although it was recognised then that the freeboard should also ensure adequate stability and avoid excessive stress on the ship's hull as a result of overloading. The Torrey Canyon disaster of 1967, in which 120,000 tonnes of oil were spilled, led to the International Convention for the Prevention of Pollution from Ships (MARPOL). It covers not only accidental and operational oil pollution but also pollution from chemicals, goods in packaged form, sewage, garbage and air pollution. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW), was the first to establish basic requirements at an international level for training, certification and watch keeping for seafarers. Previously, individual governments established standards for training, certification and watch keeping for officers and ratings, usually without reference to practices in other countries.

A number of very serious accidents occurred during the late 1980s identified management as an important contributing factor. The IMO adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the ISM Code) in 1993. In 1998, the ISM Code became mandatory. The Code establishes safety management objectives and requires a safety management system (SMS) to be established by "the Company". The Company is then required to establish and implement a policy for achieving these objectives. This includes providing the necessary resources and shore-based support. Every company is expected "to designate a person or persons ashore having direct access to the highest level of management". The procedures required by the Code are to be documented and compiled in a Safety Management Manual, a copy of which must be kept on board. The last but not least important step towards safer seas is the Port State Control (PSC). PSC is a ship inspection program whereby foreign vessels entering a sovereign state’s waters are boarded and inspected to ensure compliance with various major international maritime conventions, such as SOLAS, MARPOL, STCW, LL, as well as the Convention on the International Regulations for Preventing Collisions at Sea (COLREG)

and the International Labour Organization Convention No. 147 Merchant Shipping (Minimum Standards) (ILO 147).

All in all, the focus on safety at sea has shifted from the technical arena to the organisational and human factor arena and from a single factor to multiple factors contributing to accidents. The Secretary-General of the IMO, Mr. William A. O'Neil, in connection with the World Maritime Day in 2002, stated it this way:

"However, it has also been recognized that the one area to which most accidents have been attributed - namely the human factor - while not being totally neglected in the past, was in need of greater attention. Therefore, the theme selected for World Maritime Day this year reflects the importance and advantages of creating a genuine safety culture in the people involved in all components of the shipping industry."

Regulatory changes introduced by the IMO take between 5 and 10 years to implement. One conclusion regarding the development of international maritime regulations is that the international maritime regulations regime seems reactive at best, since many of the regulations are result of major disasters, not strategic choices by the IMO. However, by introducing ISM, PSC and voyage data recorders in recent years, the IMO seems to have moved towards becoming more proactive.

Classification societies

Due to the undesirable state of affairs in shipping safety during the 17th and 18th centuries, the first 'classification societies' were founded to be a neutral assessor of the seaworthiness of vessels. The classification societies were established to develop and monitor standards of design, construction and maintenance of ships and thereby help insurers in underwriting risks. The first classification society was Lloyd's Register (17th century). Today there are more than 50 marine classification organisations worldwide, with the "big three" being Lloyd's Register, Det Norske Veritas and the American Bureau of Shipping.

Ship owners seek to have their vessels classified so as to satisfy marine insurers, who require that ships in fact be "classed" before underwriting the risks. However, the International Union of Marine Insurers (IUMI) has criticised what it sees as a "conflict of interest" in the classification system. They question the fact that ship owners employ

classification societies to provide them with classification certificates while, at the same time, the owners could be required by the societies to spend money to enhance the safety of their ships. This may tempt ship owners to employ classification societies that don't require costly safety improvements, and IUMI has argued that the prospect of losing a client might "encourage" a society to lower its standards. After the loss of 25 bulk carriers in 1990 and 1991, insurance companies in the UK allowed 'The Salvage Association' inspect a sample of bulk carriers. The statistics published in September, 1993 revealed that some 80% of the 200 classed ships surveyed required extensive repairs.

Marine insurance

Marine insurance is generally considered to have been the very first type of insurance. The oldest tangible evidence of this insurance is a policy written in 1343. In a different form, however, marine insurance can be traced back to the bottomry bonds and respondentia bonds used in ancient Greece and Rome and, even further back, to the relationship between Babylonian traders and their darmathas. By the 17th century, marine insurance was being transacted by individual underwriters who congregated in London coffeehouses, most notably Edward Lloyd's coffeehouse, which was the predecessor to the modern Lloyd's of London.

Presently, however, the competitive marine insurance market has resulted in fewer ships being surveyed by insurers. It appears that some insurers are willing to take insurance risks "at face value" due to the difficult market conditions, but it is absolutely vital that the underwriter knows the background details and knows if the ship owner is trying to do something to improve matters.

A problem for safety that has been raised by insurers in recent decades is the "trend" to agree to unrealistically high vessel values for insurance purposes, which may tempt ship owners to "allow" their vessels to be lost, as an escape route out of financial difficulties. Marine insurers rely on the certificates provided by classification societies when issuing coverage for vessels. Such certificates permit an insurer to make a reasonable assumption as to the state of a vessel and its risk, before insuring the vessel.

As a result, it appears that competition among insurance companies and among classification companies may lead to less focus on imposing safety measures on vessels and ship owners.

2.4 Safety culture/climate studies at sea

As described earlier in the thesis Sten and Fjerdingen (2003) concluded that no research had been done on maritime safety culture:

"We have not found any papers reporting research on safety culture aboard ships. It is known that Norway has used identical CRM training (Crew Resource Management) for crews on ships and crews on aeroplanes, but this has not identified by scientific publications" Sten and Fjerdingen, 2003, p. 22).

In recent years, however, a few papers, reports and PhD theses on maritime safety culture/climate have been published. Heterington et al. (2006) reviewed 20 studies of seafaring that concerned fatigue, stress, health, situation awareness, teamwork, decision-making, communication, automation, and safety culture. The paper concluded that monitoring and modifying human factors could contribute to maritime safety performance. Ek (2006) investigated safety culture at sea and in aviation transport for her doctoral thesis (Lund University) and concluded that air traffic control showed a better learning process than passenger shipping, and was characterised by a more mature approach for reporting anomalies and by having better procedures for analysing limitations and implementing improvements. Two NTNU doctoral theses touching on safety culture in a maritime setting have also been published in recent years (Soma, 2005; Hansson, 2006). Soma (2005) found that safety is a quality of the ship owner rather than the vessel, and that accidents do not happen -- they are "made". Hansson (2006) documented and developed a methodology called the SMO methodology (safety management for prevention of occupational accidents) with the objective of proposing safety measures for the prevention of accidents. An action research approach was used in an operational setting in the offshore supply services in Statoil. This approach was reported to give good results. Hansson's PhD research was done on a project at Studio Apertura, which is an interdisciplinary research group at NTNU that is currently conducting research projects with the aim of improving safety on oil rigs and vessels sailing for Statoil. In his PhD (University of Tasmania), Shea (2005) investigated the effect of organisational culture on accidents and seafaring

leadership. Shea (2005) found that head of departments displayed two distinct behavioural characteristics when they work aboard ships. The first behaviour type was positive and demonstrated support towards subordinates, the other showed indifference towards subordinates and their activities. When the head of a department displayed the latter behaviour, the study indicated a negative impact on the safety climate of a ship. The study also showed a linkage between the organisational culture aboard ships and marine accidents.

An industry with a resemblance to shipping is offshore oil exploration and production. By searching in the Science Direct Database (Elsevier), two papers dealing with safety climate /culture in shipping were found, as compared to seven dealing with safety climate/culture in the offshore oil industry. By searching the database for safety in shipping and safety offshore, 74 and 204 papers were found, respectively. Far more papers are published on safety culture and climate in offshore oil production and exploration than in shipping (e.g. Adie et al. 2005; Mearns et al. 2002; O'Dea and Flin, 2001; Cox and Cheyne, 2000), indicating a stronger focus on safety in that industry. One can speculate about the difference; one reason might be that offshore oil exploration is a young and profitable industry, with powerful players and a lot of political interest paired with spectacular accidents such as the capsize of the Alexander Kielland, a floating accommodation unit in which 123 people died in 1980; and in 1988 both the Piper Alpha disaster, in which 167 people died, and the Ocean Odyssey accident, in which 45 people died. These kinds of dramatic accidents might very well lead to a willingness to finance research on offshore oil safety in the North Sea.

Two "competing" theories that have both used examples from seafaring are the theory of High Reliability Organisations and Normal Accident Theory. The theory of High Reliability Organisations (Weick, 1987; LaPorte and Consolini, 1991; Roberts 1993) is based on the belief that accidents can be prevented through good organisational design and management. Normal Accident Theory clams that it is impossible to prevent severe accidents in sufficiently complex system (Perrow, 1984/1999). In his book, Perrow used examples from marine, nuclear, dams and aircraft as examples of industries with complex systems that made accidents unavoidable. High reliability organisations are

the prime examples of the system approach. Safety is the primary organisational objective for High Reliability Organisations. Redundancies, simulations, a strict organisational structure, decentralised decision-making, learning from mistakes, mindfulness, good training, and experienced personnel are seen as important requisites for being are highly reliable organisation. Managers anticipate the worst and equip themselves to deal with it at all levels of the organisation. For these organisations, the pursuit of safety is about making the system as robust as is practicable. By conducting research on U.S. Naval battleships, Roberts (1993) and her colleagues found that reliable groups requires that all system members cooperate and openly share communication, reduce status differentials at sea, and let people with the salient information and training make decisions; when those factors are in place, then accidents can be avoided.

According to Normal Accident theory does Perrow claim that large accidents always will happens no matter what you do: "Accidents are inevitable and happens all the time, serious ones are inevitable though infrequent; catastrophes **are inevitable but extremely rare**" Perrow (1999:71). Roberts (1989) define high reliability organizations as" Hazardous organizations that engage in **nearly error free** operations" .Sagan (1993) differentiate Normal Accident Theory as pessimistic and High Reliability Theory as optimistic and from my point of view the two theories seem to agree, they just looks at the same problem from different viewpoints. Just look at the definitions above: Is the bottle half-full or half-empty?

As the only international body responsible for making rules and setting universal maritime safety standards, IMO's handling of research on safety and safety culture might be of interest. In recent years, the IMO has promoted discussion of, and has written about, safety culture (www.imo.org), but the organisation does not appear to have conducted any substantial research activities on the issue.

3 Theoretical framework

The theoretical framework described in this chapter is broad and will cover several aspects and theories that influence safety orientation. Many authors have focused on the broadness and complexity of safety culture to illustrate the fact that it does not operate in a vacuum but affects, and in turn is affected by, other non-safety related operational processes or organisational systems.

Hale and Hovden (1998) described the broadness and change in "paradigms" with respect to how to interpret and manage safety problems, moving from technical paradigms, through human to management, organisations and culture paradigms. Reason (1993) recognised that personal, situational and behavioural factors are the immediate precursors of unsafe acts. Rasmussen's (1997) model "Risk management in a dynamic society" showed that safety includes many research disciplines and theories, including political science, economics, sociology, law, decision theory, organisational theory, psychology, human factors, man–machine interactions and mechanical and electrical engineering. Cooper (2000) said that to a greater or lesser degree, accident causation models recognise the presence of an interactive or reciprocal relationship among psychological, situational and behavioural factors. He also focused on the influence of contextual factors on safety culture.

3.1 Organisational climate and culture

The constructs of organisational climate and culture have been subject to discussions concerning definition, content and unit theory measurement analysis. The methodologies used to study these concepts have generally distinguished between organisational climate and organisational culture. Climate has usually been assessed using quantitative methods, while culture is generally examined with qualitative methods (Glick, 1985). Paper 1 discusses further whether organisational climate and organisational culture are the same and found no clear advice to give; some papers use the terms alternately and others describe them as two distinct constructs, however, I have chosen to treat them as one construct in my papers.

Both Schein (1985) and Bolman and Deal (1991) suggest that the values and norms of an organisation are important when it comes to setting priorities and establishing behaviour. In

other words, if an organisation has established a safety culture, either good or bad, new members of the organisation will be socialized into it.
The interest in organisational culture during the 1980s and 1990s stems from four different sources: climate research, national cultures, human resource management and from the conviction that approaches that emphasise the rational and structural nature of organisations cannot offer a full explanation for organisational behaviour (Brown, 1995).

Schein is probably the most significant scholar in this approach, which looks at culture as an integrative mechanism, like the "social glue" between its members (Schein, 1992). Common values and assumptions are the consistent shared element. Other representatives of the integration perspective link the approach to managerial prerogatives, and attempts to implement top-down control and change of culture (Peters and Waterman, 1982; Deal and Kennedy, 1982; Hofstede 1991). From this perspective, one culture is seen as the dominant one, whereas others are represented as sub-cultures. Schein's (1985) definition of organisational culture is the one that seems to be most widely accepted and most referenced in the academic literature:

"Organizational culture is a pattern of basic assumptions - invented, discovered, or developed by a given group as it learns to cope with 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 (Schein, 1985)."

Schein (1999) also describes culture as found at every hierarchical level in an organisation, where an organisational unit has a common occupational core and common experience.
Rasmussen (1997) suggests that the most important unit of analysis might be the "business unit" or the organisation, but in larger organisations the business unit seems to be appropriate rather than the company. This because the company might be safety oriented to different degrees, depending upon sub-cultures in different departments or on different ships. Subcultures form based on factors such as age, nationality, education, job task, profession, etc. (Parker, 2000; Alvesson, 2002; Schein 2004, Reiman, 2007). The existence of subcultures can be considered an indication of a weak organisational culture (Brown, 1995). On the other hand, a strong culture can counteract questioning and independent thinking, which can prevent people from acting or considering alternatives in unforeseen and critical situations. This in turn can lead to less safety (Reiman, 2007; Sagan, 1993; Weick, 1998).

3.2 National culture

Does one's national culture affect one's work and behaviour? Geert Hofstede's study (1991, 2001) shows value differences between national cultures. Do these differences have an effect on safety? Helmreich and Merrit (1998) replicated Hofstede's study to determine to what extent Hofstede's dimensions were relevant to safety in 9000 male commercial airline pilots in eighteen countries. They concluded that national culture should be added to the list of influences on a pilot's approach to work. Particularly in situations where the national values and the organisational values were in conflict, the risk increased because the conflict could lead to stress.

In Paper 5 statistically significant differences between nationalities (10 countries) and most factors in the safety culture questionnaire (N=2558) is found. This research also indicated that the number of nationalities on a vessel could influence safety. It showed that a single-nation crew and a crew from more than two nations would result in a more positive attitude toward safety than a crew from two nations. A possible explanation for this was that if the crew hailed from a single nation or was multinational there could never be a majority and minority, while if the crew hailed from two nationalities, attitudes, values and norms might come into conflict and lead to stress.

Douglas and Wildavsky (1983) recognised that modern attitudes towards risk had many causes, but they believed the dominant factor remained cultural. The things we choose to fear reflect our values more than our knowledge of actual risks. We choose to fear those things that convince us that our deeply held prejudices are valid. For example, a young man from a West African culture explained that he did not wear a motorcycle helmet as he had consulted the traditional priest and knew he was in no danger (Dixey, 1999).

Lamvik (2002) wrote his PhD thesis about Filipino seafarers sailing on Norwegian vessels. He has since conducted research on national cultures and safe work practice (Lamvik and Ravn, 2006; Lamvik and Bye, 2004) and has concluded that national culture is an important factor to consider in safety culture.

3.3 Professional culture

Professional culture reflects the attitudes and values associated with an occupation (DeWitte and Muijhen, 1999; Brown, 1995; Merritt, 1997). Professions are characterised by their members' expertise and create a form of thinking. Professionals can deliver services that the lay person cannot (Hughes, 1958). The process of acquiring expertise usually requires the novice to undergo a long training process. Professions typically employ symbols that differentiate them from lay persons (Greenwood, 1957). The norms and values of a profession are exemplified by its senior members and passed on to recruits (socialisation). Members of a strong professional culture are typically proud of their membership and place great value on their work. Strong professional cultures might have both positive and negative aspects. Dedication to the job and good safety behaviour under extreme situations might have saved many lives but employees who have unrealistic attitudes about their personal capabilities and invulnerability might be a danger to themselves and others.

3.4 Industry culture

All industries have some characteristics that are related to the industry they work in. Let us use the shipping industry as an example: The technology and environment are relatively similar for all ships (compared to other industries), and technical standards are similar within the industry because of requirements from the IMO and inspections by classification societies. The expertise demanded by the industry is the same for all ships, and is guaranteed through certificates and international schools.

Bourrier (1998, 1999) compared practices in four nuclear maintenance units in France and the USA. She noted differences between the units and found that each plant had its own official or unofficial way of following procedures. A newer study that confirmed these findings is Reiman (2007), who studied safety management from a cultural perspective in nuclear power plant maintenance organisations in Finland. One could expect that a "High Reliability Organization HRO" industry such as nuclear power production had many common procedures and routines that focused on safety. Reiman found that the industry culture showed a fragmented picture of the challenges of safe and effective maintenance.

Only technicians formed an occupational subgroup that potentially shared some characteristics across domains.

Schein (1985) suggests a variety of strategies for culture change. In one strategy, leaders are imported from another culture in the hope that they will place their stamp on the organisation through coercively mandating behavioural changes. For example, nuclear power plants that have trouble with regulators might hire Navy admirals into senior management positions on the assumption that the Navy has an effective and disciplined way of doing things and the admiral will be able to make the plant more Navy-like (O'Reilly and Chatman, 1996). However, the research literature suggests that such a culture is successful only if the new leader gains credibility with the employees and mandates changes that make some sense in the present culture (Dyer, 1986). Carroll and Quijada (2004) ask if it makes sense for hospitals to hire from the Navy or the airlines? Could such people function effectively in the culture of health care? Do they have the necessary technical knowledge and familiarity with the work? Or should the health care industry cannibalise other health care organisations that are considered progressive and successful by hiring away their leaders?

Individuals are member of many groups and many "cultures". The same person can be member of a work group, a department, an organisation, an industry, a profession, a nation and a family. The cultures discussed above are embedded in each other, and when the roles / expectations of the different cultures clash this might lead to stress and influence occupational health and safety. When differences surface in organisations, or communities, culture is always present, shaping perceptions, attitudes, behaviours, and outcomes.

3.5 Learning culture

According to Reason (1997), the learning culture is probably the easiest culture to engineer but the most difficult to make work. Some scholars of organisational learning, such as Schein (1985), Senge (1990) and Argyris and Schön (1996), offer prescriptions that are useful at least as guides as to the kind of organisational structures, processes, and conditions that may function as enablers of productive organisational learning.

A learning organisation continuously improves safety because it is determined to learn from information and has a willingness to change and adopt improvements; in other words, it promotes proactive integration of safety into organisational structures and processes.
Peter Senge (1990) observes: “Learning disabilities are tragic in children, but they are fatal in organizations. Because of them, few corporations live even half as long as the person – most die before they reach the age of forty.”

Pidgeon and O'Leary (2000) underscore the importance of organisational learning in safety work: "*What is common to many accounts, however, is the emphasis upon organizational learning as a key component of appropriate safety cultures and organizational designs*" (Pidgeon and O’Leary, 2000, p.19). According to Pidgeon and O'Leary (2000), the two main barriers to organisational learning are information difficulties (e.g. the 1986 Challenger shuttle disaster) and blame, organisational politics and cover-up (e.g. the 1984 Bhopal chemical disaster).

A problem with working with organisational learning as a factor in safety orientation is the lack of explicit definitions and tools with which to measure the construct (Gallagher and Fellenz, 1999).

3.6 Safety climate and culture

Cox and Flin (1998) discuss safety culture under the heading “nature and measurement of organisational culture for safety”, suggesting that they perceive safety culture to be a subset of organisational culture.

The concepts of safety climate and culture are subject to an ongoing discussion that is similar to the discussion of organisational climate and culture (Bang, 1995). Many approaches and definitions have been offered (Guldenmund, 2000). Zohar (2000) considers safety climate as a primary culture, particularly with reference to management priorities, while others have adopted a wider definition that includes more multilevel content (Cheyneet al., 1998; Flin et al., 2000; Guldenmund, 2000). Several studies have been devoted to understanding which variables are related to or determine the occurrence of

accidents and unsafe behaviour. Much attention has been paid to personal characteristics such as educational level and gender, which have been proposed as significant predictors of accidents (Ferguson et al, 1984; Leigh, 1986). Cognitive factors such as perception of risk, and/or attitudes towards safety have also been forwarded as important in motivation and behaviour. Within this framework, the workers' perception of management's attitudes and actions has a direct and indirect effect on behaviour (Drever, 1995; Coyle et al, 1995). Lee and Harrison found that almost all 28 safety-culture/-climate factors from a factor analysis reached acceptable levels of statistical significance for one or more accident criteria used (Lee and Harrison, 2000). A survey among oil workers in the North Sea found associations between several safety climate scales and accidents as measured by official statistics in the previous 12 months (Mearns et al., 2000).

This thesis addresses safety climate and culture as one construct (Håvold, 2005a).

3.7 Accident models

Accident models form the basis for investigation and analysing accidents and as such, have been found to influence the prevention of new accidents. Kjellen (2000) maintains that it is important for people using risk and accident information in decision-making to share their frame of reference. Accident models can establish a shared understanding of how and why accidents happen, which in turn makes communication, goal-setting and decision-making easier. Accident models are simplified representations of what is happening in real life. Each accident model has characteristic causal factors it represents, and therefore, no single best model of accident causation exists. Many models might reflect either the professional bias of the author or a particular type of accident or control measure.

There have been numerous attempts to "model" the accident process. These models range from the extremely simple, with a focus on direct causes, to the extremely complex, with a focus on the systems safety, such as "MORT" the Management Oversight Risk Tree (Johnson, 1980).

Heinrich's 1931 book "Industrial Accident Prevention – A Scientific Approach" was the first comprehensive book on industrial accident prevention and was considered the "bible"

for many who worked with accident prevention. Heinrich's book presented his "iceberg theory", using a ratio of one accident, 29 near accidents and 300 dangerous situations. Heinrich's "iceberg theory" has been much criticised; however, much of the criticism might be based on the misunderstanding that that the cause of the different accident categories in the model were the same. Heinrich made no such claims; on the contrary, he warned about such misunderstandings. Research shows that a company or group can have a Lost Time Injury rate (LTI) close to zero, but can still have a large risk of severe accidents or a bad work environment (Hovden, 2001).

Accident models and the theories behind them have been structured using different perspectives: Hollnagel (2004) structured accident models from the perspective of "complexity" and Leveson (2004) from the perspective of "engineering".

Hale and Hovden (1998) structured accident models from the perspective of "time", identifying three stages of development in safety management. The "first age" focuses mainly on legislation and technical actions, because safety is mainly looked at as a technical problem. The human factor was added gradually during the 1960s and 1970s, leading to the "second age" of safety management. The "third age" evolved as a result of work done amongst others from the Advisory Committee on Safety in the Nuclear Industry (ACSNI, 1993) and focused directly on the structure and functioning of management.
The author built on Hale and Hovden's structure of accident models and introduced a five stage time perspective on the development of accidents and risk theories (Table 3.1).
Each stage relies on different remedial actions based on the causes attributed to the accidents; the author also explains why safety culture and safety orientation are of interest when creating a 'toolbox' for organisations wanting to improve safety. However, old accident models and remedies seem to have survived in parallel with models based on scientific research, even if the weight and focus has changed over the years.

Table 3.1 Five stages in the development of accident attribution and remedial actions

Stage	Accidents attributed to:	Remedial action: regulation regimes
5	*Cultural; since the 1980s*	Safety orientation, improving culture; training
4	*Managerial, system faults; since the 1970s*	ISM-code; ISO 9000, ISO 14000
3	*Individual fault; since the 1910s*	Disciplinary measures, dismissing workers
2	*Technical faults; since the 1800s*	Certification, design changes and improvements
1	*Fate; since man evolved*	Nothing anyone can do about it

In stage one, accidents are attributed to fate, *"An act of God*", or that things just happen and there is not much anyone can do about it. Fate is still a major explanatory factor for many people (Hovden and Larson, 1987; Douglas and Widlavsky, 1982) and the degree of fatalism differs between groups of people and between nationalities.

Stage two focuses on *technical faults*. The rating of technical quality of vessels was overseen by classification societies. A society like Lloyds was founded as early as 1760 "to examine merchant ships and 'classify' them according to their condition", while DnV was founded in 1864.

In stage three *the accident-prone person* was commonly accepted as an accident theory and the accident risk might be reduced substantially by removing the accident-prone person from hazardous jobs. Human errors were focused on. A human error occurs when human actions transgress some norms or limits of what is planned/intended, or what is normal or acceptable. Authors claimed that from 60 to 90% of all accidents were primarily caused by dangerous acts of the worker (Heinrich, 1931; Perrow, 1999; Kjellen, 2000). The remaining was either "Acts of God" or due to technical failures.

Stage four focused on *organisational safety* and complex systems. This approach was adopted by Vaughan (1997) when she analyzed the Challenger accident and by Perrow (1984/1999) in his book *Normal Accidents*. Perrow (1984/1999) identified a social component of technological risk and accidents and argued that systems fail because of extensive complexity and that the engineering approaches that employ warnings and safeguards are not sufficient to prevent accidents.

In stage five, during the 1990s, an interest in *safety culture and safety climate* exploded and many international organisations like the International Atomic Energy Agency (IAEA), IMO, and International Air Transport Association (IATA) started to employ the concept of safety culture in their discussions and communications, and as explanatory factors for accidents and near accidents. In the late 1990s and in 2000, the academic publication Safety Journals came out with special issues where safety culture was the focus, indicating that

safety culture was an interesting and useful addition to the safety debate (e.g. Work and Stress, Volume 12, Issue 3, 1998, and Safety Science Volume 34, Issues 1-3, 2000).

Attribution theory is interesting in this context because the safety management process is influenced by the explanation given for the behaviour. The perceived causes of behaviour may actually influence judgments, actions and behaviour. If everyone in a society attributes accidents to an "Act of God", there is not much that can be done to prevent accidents from happening. If a manager attributes an employee's poor safety performance to personal traits, he or she may be terminated. If the manager instead perceives that an employee's poor performance is due to a lack of knowledge, he may require the employee to undergo further training or provide more instruction or coaching. Attribution theory's influence on safety work has been discussed by DeJoy (1985, 1994, and 2005) and LaCroix and DeJoy (1989).
If causes of accidents are attributed to safety culture/safety orientation, as is done in this thesis, improving cultural factors and training are viable remedial actions. As such, measuring organisational culture and safety culture factors then becomes more interesting.

3.8 Theories regarding attitude's influence on behaviour

Empirical studies suggesting a weak relationship between attitudes and behaviours first appeared in the 1930s, but have continued to appear in the literature (e.g. Kutner Wilkins and Yarrow, 1952). Not much interest was shown to the empirical link between attitudes and behaviours except for some criticism by the sociologists Blumer (1955) and Wicker (1969) on the empirical weakness of the relations between the two elements. That inconsistency led to further research on attitude-behaviour relationships and several variations on attitude – behaviour models have been presented, amongst them Ajzen and Fishbein's (1980) Theory of Reasoned Action and Fazio's Attitude Behaviour Process Model (Fazio and Roskos-Ewoldsen, 1994).

The dominant theory used in safety culture and climate literature to explain the link between attitudes and beliefs and behaviour are Ajzen and Fishbein's (1980) Theory of Reasoned Action, which maintains that an individual's intention is influenced by the previous attitude that they have toward the behaviour and the prevailing subjective norms ("the person's belief that specific individuals or groups think he should or should not perform the behaviour and his motivation to comply with the specific referents"). Most

people weigh the possible outcomes that could result from a decision that is being made. This model implies that the attitude a person has is their "positive or negative evaluation of performing the behaviour" (Fishbein 1967). The *attitude that you hold toward the behaviour* is affected by whether or not you think the act will lead to a favourable outcome. The theory of reasoned action (Ajzen and Fishbein, 1980) argues that behaviour can be predicted if an observer knows the person's attitude to the particular behaviour, the person's intention to perform the behaviour, what the person believes are the consequences of performing the behaviour, and the social norms that govern the behaviour. Aizen and Fishbein's model and theory are referred to by several scientists who conduct safety research (e.g. Rundmo and Hale, 1999; Cox and Flin, 1998).

An affirmation of the relationship between safety culture and safety performance can be found in research by many scientists, such as Zohar (1980), Glennon (1982) and Lee and Harrison (2000); however, in contrast, Glendon and Litherand (2001) failed to find any relationship between the two.

There has been much discussion as to whether it is attitudes that influence behaviour or whether it is behaviour that influence attitudes (Festinger, 1957; Bem, 1967), or if attitudes and behaviour represent correlated co-effects of a process in which modification of one factor produces change in the other (Bandura, 1969).

Risk homeostasis or risk compensation is a psychological theory developed by Gerald Wilde (1982). The theory of risk homeostasis states that an individual has a built-in target level of acceptable risk that does not change. This level varies among individuals. When the level of acceptable risks in one part of the individual's life changes, there will be a corresponding rise/drop in acceptable risk elsewhere. Wilde (1982) said that both theory and data indicated that safety- and lifestyle-dependent health are unlikely to improve unless the amount of risk people are willing to take is reduced. Risk homeostasis theory claims that people at any moment in time compare the risk they perceive with their target level of risk and will adjust their behaviour in an attempt to eliminate any discrepancies between them (Wilde 1998).

3.9 Critique of the concept of safety culture

In recent years there has been a great deal of interest in safety culture (Cheyne et al. 2002; Mearns et al., 2004; Sorensen, 2002; Glendon and Litherand 2001, Harvey et al., 2002; Guldenmund, 2000). Some authors believe that the cultural framework lacks a normative framework (Grote and Künzler, 2000; Lawrie et al., 2006). Analyses tend to involve descriptions of the norms and assumptions more or less shared by the members of the organisation and more or less supportive of fulfilling the organisation's goals, but generally no conclusions about whether culture is "good" or "bad" can be drawn.

Mats Alvesson (2001) describes culture as a tricky concept, because it can easily be used to cover everything and consequently nothing. That certain researchers are interested in "culture" – or at least use the term – does not mean that they have very much in common. Frequently, "culture" seems to refer to little more than a social pattern, e.g. it refers to surface phenomena rather than exploring the meanings and ideas behind them. It could therefore be advocated that in many cases the term should be abandoned in favour of something like "informal behavioural patterns", "norm system" or simply "social pattern".

Sorensen (2002) also refers to the phenomenon's many definitions and how the scope, depth, terminology and perspective vary from one study to the next:

"The first source of difficulty is terminology. There is general agreement on the concept of safety culture, and some agreement on attributes. Many of the studies relating management and organizational factors to safety of operations do not use the term safety culture. If it is used, it may denote a narrowly defined element of a larger set of management and organization factors being investigated. One study can only be compared with another by looking at the organizational attributes that are actually measured. The study of safety culture might benefit substantially if a consensus were developed on its definition, and, most importantly, its measurable attributes (Sorensen, 2002, p.200)."

In connection with a special issue on "safety culture" in Safety Science, editor Andrew Hale (2000) debated the safety culture concept in an editorial called "Culture's confusion". He seemed not to be completely satisfied with the safety culture construct, but chooses to use it anyway because, he says, "*I know how hard it is to modify such ingrained use*":

"Most definitions, including that used by the International Atomic Energy Authority (IAEA, 1991) of ACSNI (1993), quoted in a number of the papers, treat it as an entity. The psychometric approach, resulting in a number of scales, clearly treats it as such. However, the view taken by Guldenmund and implied in some other papers is that we would do better to place organisational culture centrally and focus our measuring instruments on understanding that. Only as a secondary step should we then ask what the implications of

the dimensions we find there could be for the way we can and should manage safety to achieve good safety performance. Perhaps then we will find a better way through the jungle of scales, which the attitudinal research has produced. Hudson (1999), basing his analysis on Westrum's "generative" level of development that it really places safety centrally enough in its basic values and their associated beliefs occupy the central focus of the organisation and safety problems and poor performance are then a spin-off of the centrality of other values. To be consistent in this approach, we should in the future only talk about (organisational) cultural influences on safety and not safety culture. However, I know how hard it is to modify such ingrained use, so I will use the latter term in the rest of this editorial, as do the papers in this issue (Hale, A., 2000 p 5)."

Nick Pidgeon (1998) discusses safety culture theory and its fragmentation in the field of terms and definitions. He focuses on the many measures now on offer grounded in different industrial contexts, with few attempts to reconcile underlying frameworks or conduct meta-analysis across databases. Pidgeon summarized it this way: *"Taken as a whole it is probably no surprise, then, to find a proliferation of various methodologies, conceptual frameworks, recommendations and empirical findings in the safety culture field (Pidgeon, 1998, p.204)."*

Rosness (2003) suggested that safety culture is yet another "buzzword" designed to hide confusion, which is a view endorsed by Zangh et al. (2002), who called safety culture a "chaotic concept."

Cooper (2000) discussed the limitations of safety culture and proposed a model drawn from social cognitive theory, emphasising the role of contextual factors and saying that safety culture does not operate in a vacuum.

This critique of the safety culture concept might pave the way for a new construct, safety orientation. The main reason why safety orientation is a better construct than safety culture is in its theoretical and scientific ambitions. Safety orientation is meant to be a construct for practical purposes, making communication easier amongst other employees and management, management, consultants, classification societies and insurance. Since safety culture is such a tricky construct, it seems easier to explain to the workforce why their safety orientation is good or bad than to explain why their safety culture is good or bad. Culture is also a "neutral" construct, and even if a scientist can detect differences in culture as such, conclusions regarding whether a culture is "good" or "bad" are difficult to draw

(see Grote and Künzler, 2000; Alvesson (2001), Lawrie et al., 2006). The reasons for proposing "safety orientation" as a new construct are also discussed in Paper 3 (Håvold, 2005a).

3.10 My position on safety culture

Management and employees operate in an organisational / behavioral context determined by the organisational culture, structure, systems and management practices. I believe that managing through culture is the most efficient way to manage an organisation. Safety culture is a subset of organisational culture.

New technology, skills and infrastructure are often introduced to improve safety and health. Technology, skills and infrastructure also apparently increase an individual's confidence; Wilde (1998), for example, has found that safety equipment such as airbags and ABS brakes give drivers the confidence to operate vehicles aggressively, faster, carelessly and with less distance between the car in front than drivers without this equipment. At sea, radar and electronic charts can increase safety in many situations; however, in other situations risk homeostasis might lead to radar-assisted and electronic chart-assisted accidents (Holta, 2005). I believe that safety behaviour is found between a person's ears. Attitudes, values and norms are antecedents to safety culture, which in turn influence safety behaviour. Wilde's (1982) theory of risk homeostasis shows how safety culture can influence both how risks are perceived and how high an individual's target level of risk is set, thereby resulting in adjustments to an individual's behaviour.

I believe that safety culture can be measured, and thus support the use of surveys to measure safety culture. I agree completely with Lord Kelvin, who said: *"When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind…." (*William Thompson (Lord Kelvin), 1824-1907).

This does not mean that using surveys to investigate culture is the only right approach. In another setting or situation, a qualitative or mixed approach could be chosen as the research design. However, I argue that there are many similarities between qualitative and quantitative *data*. After all, qualitative data typically consist of words, while quantitative data consist of numbers. These aren't fundamentally different, because all qualitative data can be coded quantitatively and all quantitative data are based on qualitative judgment. These values can then be manipulated to help us achieve greater insight into the meaning of the data and to help us examine hypotheses.

4 Model development

The safety orientation model (Fig.1.1) is intended to describe the most important features and attributes that influence SO. The development of the model has been shaped by a review of safety climate/culture models and tools/measures and contextual factors, such as organisational culture, national culture, professional culture, industry culture, regulations and markets. Nine newer papers, seen to be representative in both the work of principal institutions involved in safety culture/climate research and of a wide range of industries were reviewed and 438 items from them (Appendix 2) were chosen for the item pool used when the questionnaire to the main survey was developed. The safety culture factors that occurred with the highest frequency in the papers reviewed (Håvold, 2005a) were chosen to be included in the safety orientation model main questionnaire (Appendix 2), together with items covering the learning culture and just culture factors, as reported by Reason (1997).

4.1 Safety climate/culture models and measures

Mearns and Flin (1995) proposed a socio-cognitive model for risk perception in hazardous work environments based on the core path, attitude/beliefs, behaviour and incidents/accident/injuries. The same core path has also been used in a recent model by Lund and Aarø (2004). Helmreich and Willhelm (1998) proposed a model describing a relationship between professional culture, organisational culture and national culture and safe behaviour, using safety climate and safety culture as intermediate variables.
Lund and Aarø (2004) and Rasmussen (1997) claim that the most obvious shortcomings of the theories borrowed from social psychology, such as the Theory of Reasoned Action, are their neglect of factors beyond their domain. These theories neglect factors like legislation, enforcement of legislation, economic factors and aspects of cultural, organisational and psychical surroundings that are widely accepted as crucial in changing safety and health behaviour.

|In social medicine, the KAP and KAB model (Knowledge, Attitude, and Practice/Behaviour) have become popular when discussing behavioural change. Traditionally, preventive care has emphasized knowledge as a precursor of behavioural change. The KAP/KAB-model presupposes a one-way causal relationship from knowledge through attitudes to behaviour. Accordingly, clinicians often try to install positive

expectations about behavioural change by emphasizing health threats and enhancing long-term positive outcome expectations using information (e.g. HIV, anti-drinking and anti-smoking campaigns). However, the relationship between knowledge and behaviour is not well documented empirically, and preventive care based on such principles may prove less effective (Lund and Aarø, 2004).

Even if most safety culture research assumes that attitudes have a significant effect on behaviour (e.g. Zohar, 1980; Glennon, 1982; Lee and Harrison, 2000) and thereby on incidents and accidents, there are also alternative explanations (Lund and Aarø, 2004). Lund and Aarø (2004) include attitude modification (campaigns, posters, films, education in classrooms or small groups), behavioural modification (instructions, skill training, feedback with focus on behaviour, rewards for desired behaviour) and structural modification (legislation, environmental and product modification) as influential factors in their model for accident prevention; they emphasise human, structural and cultural factors. Lund and Aarø (2004) claim that the positive effects of measures such as behavioural modification may be accompanied by changes in attitudes, but they might also occur in the absence of attitude change.

Measuring safety by using surveys was introduced by Zohar's (1980) work, where he surveyed employee's perceptions with regards to the organisation's safety climate.
Several health and safety climate/culture tools have been developed the last 5 -10 years covering a variety of safety critical industries; a selection of tools is briefly described in Table 4.1 below. The review gives some background for my research, indicating that there is a market and a need for these kinds of measurement tools. Several of the tools are based on research done at institutions represented amongst the papers reviewed in Paper 3 (Håvold, 2005a), where the proposed safety orientation model is presented.

It seems as if most of the safety climate/culture tools developed in the USA is for use in health care, while most of the tools developed in UK cover the offshore oil industry and the focus in Australia is on air transport. Merchant shipping does not seem to have any "tailor made" tools currently in use.

Table 4.1 A selection of safety climate/culture tools			
Name and type of tool	**Developed by organisation/ country**	**Industry**	**Type of tool Content**
Health and Safety Climate Survey Tool[i] (Survey)	Health and Safety Executive (HSE), UK	General	71 items organised into 10 factors.
Robert Gordon University Computerised Safety Climate Questionnaire[i] (Survey)	Robert Gordon University, UK	Offshore and contracting	49 items organised into general information, job and safety attitudes.
Offshore Safety Climate Questionnaire[i] (Survey)	Aberdeen University, UK	Offshore, gas and power generating industries	80 items organised into 6 factors.
Safety Climate Assessment Toolkit[i] (Survey)	Loughborough University, UK	Offshore industry	47 items organised into 5 factors.
Safety Climate Questionnaire[i] (Survey)	Quest Evaluation and Databases Ltd, UK	Offshore drilling	319 items organised into 12 factors.
Rail Safety Standards Board Safety Culture Tool[i] (Survey)	Rail Safety Standards Board, UK	Rail	66 items organised into 9 factors.
John Hopkins University Safety Climate Questionnaire[ii] (Survey)	John Hopkins University, USA	Hospitals	20 items organises into 6 factors.
Oprators Fflight Safety Handbook[iii] (Survey)	The Global Aviation Information Network (GAIN)	Aviation	25 items. No factors/dimensions seem to be extracted.
ATSB Aviation Safety Survey[i] [iv] (Survey)	Australian Transport Safety Bureau, Australia	Aviation	38 items organised into 4 factors.
Institute for Healthcare Research Improvement Safety Climate Survey [v] (Survey)	University of Texas, USA	Hospitals /Healthcare	21 items. No factors/dimensions seem to be extracted.
Agency for Health Care and Quality Survey [vi] (Survey)	Agency for Healthcare Research and Quality USA	Hospitals	42 items organised into 12 factors/areas.
TRIPOD [vii]	Leiden and Manchester Universities, Holland and UK	General	Profile is produced based on 11 basic risk factors.
The Hearts and Minds safety programme [viii]	Shell; Leiden, Manchester and Aberdeen universities, Holland and UK (Multi tool)	Oil /General	Uses a range of tools and techniques known as the Hearts and Minds Toolkit.

[i] HSE (2005)
[ii] http://www.jhsph.edu/publichealthnews/press_releases/PR_2000/hospital_workers.html
[iii] http://204.108.6.79/products/documents/GAIN_OFSH_Issue_2.pdf
[iv] http://www.atsb.gov.au/publications/2004/Safety_climate_factors.aspx
[v] http://www.ihi.org/
[vi] http://www.ahrq.gov/qual/
[vii] http://www.tripodsolutions.net
[viii] http://www.energyinst.org.uk/heartsandminds/

The review identified numerous tools covering several industries. One characteristic is that the selection of safety climate and culture tools showed no universal consensus regarding the definition of safety climate or safety culture, and that different tools seem to focus on different aspects. All safety climate and safety culture tools assessed in this review consisted of self-assessment questionnaires.

4.2 Performance indicators

Kjellen (2000) suggests six important criteria in shaping a good performance indicator: *Observable and quantifiable, Valid indicator of the risk of loss, Sensitive to change, Compatible, Transparent and easily understood and Robust against manipulation.* Performance indicators provide an effective way of measuring how an organisation is performing in relation to safety activities. There are many different types of performance indicators. The most common are outcome indicators and process indicators. Outcome (results) indicators show if an organisation is achieving (or failing to achieve) its targets, while process indicators measure the positive actions an organisation has taken to achieve its targets. Achievement as measured against process indicators should ensure improved performance against outcome indicators. For example, better attitudes or safety orientation should lead to a better safety performance and less accidents. The ultimate aim of implementing a performance measurement system is to improve the performance of an organisation. If you can get the performance measurement right, the data will tell you where you are, where you are going and how you are doing.

A "safety" research programme for the offshore oil industry launched by the Norwegian Research Council in 2002 specifically focused on the need to develop relevant proactive performance measures for safety health and environment (SHE) so accidents could be avoided at an early stage:

"Most indicators used to describe the development in SHE level use statistical registrations which show how often near misses / incidents happen in the organization. Actions taken on this basis are important but reactive. Particularly when near misses / incidents happen seldom (low frequency) it will take time before those indicators are able to show a trend. It is therefore important to supplement these kinds of indicators with risk-based indicators … The use of risk-based indicators will therefore give a more proactive grasp of the SHE work (Norwegian Research Council, 2002 p.6)."

The Balanced Scorecard (BSC) is the most widely used of the many different performance measurement systems that use key performance indicators (KPIs). Kaplan and Norton (1996) starts their article "The Balanced Scorecard – Measures that Drive Performance" in the Harvard Business Review with these words: *"What you measure is what you get",* and in doing so, underscore the importance of measuring the right things.

Paper 2 (Mearns and Håvold, 2003) discussed occupational health and safety and the balanced scorecard. The paper was based on a benchmarking study done at Aberdeen University based on interviews conducted with senior managers in the UK and Norwegian oil and gas sector about use of the BSC in general, and with regard to health and safety performance indicators in particular. The senior managers both in UK and Norway had a positive attitude towards BSC; however, those who had implemented it indicated that there was a lot of room for improvement in choosing and including new indicators in the scorecards. The interviews revealed that the companies using BSC had mainly included outcome measures, but that process measures had started to find their way into the scorecards of some of the organisations surveyed in the study.

When integrating safety into a company-wide performance measuring system like the BSC it is important to use at least some indicators that are proactive like the measure "safety orientation" suggested in this thesis.

4.3 The safety orientation definition and model

The safety orientation idea emerged from the market orientation construct (Narver and Slater, 1990; Tellefsen, 1993; Kohli and Javorsky, 1993). A marketing-oriented firm is one that allows the wants and needs of customers and potential customers to drive the firm's strategic decisions. If this idea is rewritten and put into a safety context, we can say that a safety-oriented firm is committed to values important in creating safety for its employees, potential employees, and customers.

The continuous improvement aspect of the approach is closely related to ISO 9000 (2002) and ISO 14000 (2002) standards, the ISM code (2002). The philosophy of continuous improvement advocates a system of perpetual and meaningful change. The new quality standards require that organisations establish "a system level procedure to facilitate

continual improvement." The new standard further requires that not only product output be measured, but that process measures and their analysis are included in management reviews. In other words, the new standard requires constantly striving to find better ways of improving hazard control and process performance. However, the most important parts of the model are drawn from the literature on safety, organisational and national culture.

The factors in the model (Figure 1.1) are based on a literature review (Håvold, 2005a; Paper 3). The model has a simple "core" path: *attitudes/beliefs – behaviour – incidents/accidents/injuries* as found in models by Mearns and Flin, (1995) and Lund and Aarø (2004). The model also includes contextual factors such as professional culture and organisational culture as described by Helmreich and Willhelm (1998).

To construct the model, I first reviewed the major conceptual literature on organisational culture, safety culture/climate, quality (TQM), and organisational learning to identify the principal common threads. To be able to develop a model that could be tested for construct validity, I used what I found in the literature and "merged" it into the safety orientation construct.

The readings resulted in a definition and a description of a safety orientation model with a construct that is multidimensional and comprised of several psychological, situational, organisational and behavioural factors. Safety orientation might be viewed as continuous rather than a dichotomous construct. This conceptualisation facilitates measurement by avoiding certain difficulties inherent in asking informants to indicate whether or not the organisation is safety oriented. The proposed definition of safety orientation suggests that one need only access the degree to which a company is safety oriented and takes actions based on it. As such the "safety orientation" construct is introduced as an operational safety culture construct that can be used for several purposes, such as:

- *benchmarking between and within companies;*
- *monitoring safety campaigns and processes;*
- *safety motivation;*
- *setting priorities for safety activities;*
- *discussions with insurance companies, bank, authorities, trade unions and other similar organisations.*

The idea behind the model in Figure 1.1 is to measure indicators/dimensions/factors of safety culture and see how they interact with outcome measures in different contexts. The conceptual idea is that if an organisation is to consistently achieve an above normal safety performance, it must create an above average safety orientation. Safety orientation as a safety culture assessment instrument can indicate the degree of orientation towards safety in a group or an organisation. The desire to create an above average safety performance drives the organisation to create and maintain a safety orientation that will produce the necessary behaviour.

4.4 Core factors of the model

The literature contains many definitions of safety culture/climate constructs. Most definitions of safety culture/climate are global/implicit and therefore allow considerable latitude for interpretations; as one example, Guldenmund in a review article in Safety Science in 2000 provides a list of 18 different definitions (Guldenmund, 2000). Almost all papers reviewed on safety culture / climate include the factors: "Management commitment/attitudes to safety" and "Safety rules/compliance to rules" (Zohar, 1980; Rundmo, 1995; Brown and Holmes, 1986; Weick, 1987; Dedobbeleer and Beeland 1991, Mearns et. al, 2000).

Safety culture is by its nature multidimensional, so that the most widely used analysis techniques in papers that analyse safety culture and climate has been factorial analysis (FA)/ principal component analysis (PCA). The number of dimensions found differs enormously, ranging from 2 (Dedobbeleer and Beeland, 1991) to 28 (Lee and Harrison, 2000).

Several organisations and authors have measured safety climate and culture using surveys and FA/PCA analysis (Håvold, 2005a; Paper 3). The proposed dimensions of the safety orientation core model described above have resulted from the findings presented in Paper 3 where nine papers was reviewed Cox & Cheyne (2000); Glendon & Litherand (2001); Grote & Künzler (2000); Harvey et al. (2002); Lee & Harrison (2000); Håvold (2002); Mearns et al. (2000); Rundmo & Hale (1999); Williamson et al. (1997). These nine papers should not be understood as the only papers suited for review. Rather, they were selected for detailed analysis because they were seen as being

representative both of the work of institutions involved in safety culture/safety climate research, and of a wide range of institutions. The safety factors that were mentioned most frequently in these nine papers were: Safety rules (8 papers), Management commitment and attitudes (7 papers), Communications (5 papers), Work situation (5 papers), Knowledge and competence (4 papers), Job satisfaction (4 papers), Satisfaction with safety activities (3 papers), Reporting culture (3 papers), Conflict between work and safety (3 papers) and Fatalism (2 papers). Further, James Reason's (1997) learning culture and just culture were included in the model. (Figure 1). Learning culture and just culture were included because several reports published by Health and Safety Executive (HSE) (http://www.hse.gov.uk/) .Behaviour were included as an outcome variable in six out of nine reviewed papers. The next step in the process was to decide on the research design to test both hypotheses related to theory, and testing the safety orientation construct.

Table 4.2 SO factors and outcome variables (behaviour) included in the model[a]

Name	**"Content"**	**References**[b]
Satisfaction with safety activities	A comprehensive measure of safety activities at work, including training, housekeeping, controls, inspections and safety improvements.	Mearns et al., 2000; Håvold, 2001.
Safety rules	Refers to how practical and easy the rules are in terms of understanding and following without conflicting with work practices or when a job is rushed.	Harvey et al. 2002; Mearns et al., 2000; Cox and Cheyne, 2000.
Communications	Refers to the degree of openness and extent to which communications reach all levels in the organisation.	Harvey et al.2002; Mearns et al. 2000; Cox and Cheyne, 2000; Rundmo and Hale, 1999.
Attitudes/ Managements Commitment to safety	Is the most important factor in this model where attitudes as an indicator of safety performance are discussed. The attitude dimension includes management commitment and involvement in safety work, the degree of openness and extent to which communications reach all levels in the organisation.	Lee, 1998; Rundmo 1992; Rundmo and Hale, 1999; Harvey et al., 2002; Mearns et al., 2000; Grote and Künzer, 2000; Cox and Cheyne, 2000.
Reporting culture	How prepared employees are to report their errors and near misses. Such a culture depends upon how organisations handle blame and punishment. This does not mean amnesty for all unsafe acts, because that will reduce credibility in the eyes of the workforce.	Reason, 1997; Mearns et al., 2000; Cox and Cheyne, 2000.

Learning culture	To become a learning organisation is to accept a set of attitudes, values and practices that support the process of continuous learning within the organisation. See also chapter 3.5	Reason, 1997; Senge, 1990.
Just culture	A just culture is nurtured when people are encouraged, even rewarded for providing essential safety-related information, but the people working are also clear about where the line must be drawn between acceptable and unacceptable behaviour.	Reason, 1997.
Conflict between work and safety / Risk perception	One of the main characteristics of a positive safety culture is that every individual member of an organisation accepts the responsibility to behave as safely as possible to avoid and prevent accidents.	Harvey et al.2002; Cox and Cheyne, 2000; Lee and Harrison, 2000)
Work situation	Work situation addresses how people perceive their work. Several authors include work situation as one of the main factors influencing behaviour. Work situation includes conditions such as job satisfaction, psychic work environment, training for work and safety, time pressure, workload, stress, and clear rules and division of labour.	Glendon and Stenton, 2000; Rundmo et al., 1998; Cheyne et al., 1998; Glendon and Litherand, 2001; Mearns et al., 2000; Grote and Künzer, 2000; Cox and Cheyne, 2000; Lee and Harrison, 2000.
Knowledge	Knowledge and training are in themselves insufficient for developing a safety culture or safety orientation; however, research suggests that safety knowledge is an important factor in predicting safety compliance. The factor includes knowledge and understanding of rules and regulations, of how to behave regarding the policies, routines, processes, laws and systems that affect safety.	Hofmann et al.,1995; Cooper, 1998; Mearns et al., 2000; Grote and Künzer, 2000; Håvold, 2001; Neal et al., 2000.
Job satisfaction	Employees who are more satisfied with their work believe that the organisation will be satisfying in the long run, care about the quality and safety of their work, are more committed to the organisation and are more productive.	Harvey et al., 2002, Glendon and Litherand, 2001; Grote and Künzer, 2000; Rundmo and Hale, 1999.
Fatalism	This characteristic reflects an individual's belief in destiny, that all events have been predetermined and that there is not much that can be done about what happens. This is a social construction of risk perspective.	Rundmo and Hale, 1999; Williamson et al., 1997.
Behaviour (OUTCOME VARIABLE)	Behaviour seems to be well correlated with accident performance, and behaviour can be observed every time a job is performed. How organisations and members in organisations behave when it comes to work and safety does influence safety culture. On an individual level, a person's beliefs about a risky behaviour as well as his/hers attitude towards accident prevention does affect risk perception, behavioural intentions and behaviour.	Ajzen and Fishbein, 1980; Rundmo, 1998.

[a] The different aspects of safety culture/safety orientation following the order from left to right in the safety orientation model Figure 1.1.
[b] Main references

4.5 Contextual factors

In addition to contextual factors, organisational culture, national culture, professional culture and industry culture (described in the theory chapter), regulations and markets have been found to be interesting contextual factors in the model.

Regulations

According to Reason (1997), regulations are important for reducing accidents: *"Regulators are placed to function as one of the most effective defences against organizational accidents."* (p. 182). According to Lund and Aarø (2004), legislation and regulations influence attitudes and beliefs and the way they are enforced and controlled will influence the effect. Rasmussen and Svedung (2000) see legislation as a major external determinant of judgement and actions in enterprises. The theoretical basis for legislation and regulations are the positivist philosophy, which maintains that law is a purely human construct that society uses to maintain order. Regulatory approaches can be used to interpret the authorities' significance in accident prevention. Regulations and how the regulations are implemented might influence decision-making in the companies differently, dependent on cultures and subcultures. Regulations might differ between industries, branches or type of vessel. A legislative framework often forms the basis of the occupational health and safety system, along with policies in the work place and international regulations that have been agreed within the IMO framework focus on safety at sea.

Markets

The theory behind markets has its basis in behavioural economics, which is a combination of psychology and economics that investigates what happens in markets where human limitations and complications appear (Simon, 1987).

It might not be easy to put safety first when the company's existence is at stake. Perrow (1999) suggests an explanation as to why he believes management does not put safety first: *"For example; few managers are punished for not putting safety first even after an accident, but will quickly be punished for not putting profits, market share, or agency prestige first." (p368).*

How markets might function is described by OECD's Maritime Transport Committee (2003), which shows how unscrupulous operators realise significant savings of up to US$ 1

million each year for an average tanker not meeting minimum safety requirements, exchanging profits for safety.

Organisational culture are dealt with in chapter 3.1, National culture in chapter 3.2, Professional culture in chapter 3.3 and Industry culture in chapter 3.4.

5 Materials and methods

At the heart of any research activity is the development of an effective research design and finding the most suitable methods of investigation. One has to decide on research instruments, sampling plan and the types of data to collect.

5.1 Research design

Both quantitative methods and qualitative methods have strength and weaknesses. Quantitative methods can provide a high level of measurement precision and statistical power, while qualitative methods can supply greater depth of information about attitudes, perceptions, relationships and performance in a particular research setting. The research design for this project depends on the objectives, delimitations and assumptions given earlier in the paper. The design has also been influenced by personal inclinations and technical and financial restraints.

However, employing the quantitative method allows:

- A statement of the research problem in very specific, definable, and set terms;
- The specifying of independent and the dependent variables clearly and precisely;
- The original set of research goals to be followed;
- The achievement of high levels of reliability in data gathered due to a mass survey approach;
- Testing of the research hypotheses;
- And arriving at more objective conclusions by minimizing judgement subjectivity.

Deductive research is conducted using a quantitative cross-sectional approach to measure variables. This does not suggest that qualitative, inductive research couldn't improve answers given by the quantitative survey approach, for example during the initial phase, when working with focus groups or when experience surveys could have improved the selection of items and scales.

As has been stated on page 2, the aim of the research designs used for Papers 4, 5 and 6 in this thesis is to: undertake surveys testing elements of "safety orientation" on individuals, companies, nationalities on a population of seafarers working for Norwegian-owned shipping companies.

5.2 Development of questionnaires

Two questionnaires have been developed and used in the papers presented in this thesis.
It is important that an item pool be a rich source containing a large number of items that are relevant to the content of interest, from which a scale can emerge. Loevinger (1957) offered the classic articulation of this principle:

"The items of the pool should be chosen so as to sample all possible contents which might comprise the putative trait according to all known alternative theories of the trait (p.659). "

Clark et al. (1995) suggest that questionnaires include content that ultimately will be shown to be tangential or even unrelated to the core construct. Redundancy with respect to content is an asset (DeVillis, 1991; Anastasi & Urbina, 1997). Paul Spector (1992) describes the importance of using existing scales in the process of constructing a survey instrument:

"If scales exist to measure the construct of interest, the content of these existing scales may help scale development. It is not unusual to develop a scale out of existing scales. This may be done in domains where a high quality scale does not exist. The items from several scales can be used as a starting point in writing an item pool. These would be modified and more items added to create the item pool from which the final scale will be developed." (Spector 1992:16)

Questionnaire 1 (40 items) / paper 4.

Two nautical students I supervised who were doing their BSc thesis at Ålesund University College collected the material for Paper 4. Initial development of the questionnaire was based on a literature review. Two items were selected from a questionnaire measuring concentration of authority (Aiken and Haige, 1968) and 17 items from safety questionnaires (Rundmo and Hale, 1999; Mearns et al., 2000; Cox and Cheyne, 2000, Lee and Harrison, 2000; Grote and Künzler, 2000). Some of the items were slightly changed to fit the hierarchical structure found aboard a vessel. Twenty-one items were developed for that particular survey. A pilot study (n = 6) was carried out before the study. The questionnaire was produced only in English because it was the working language in the shipping company. All items used a 6–point Likert scales, ranging from strongly agree to strongly disagree. The items included in the questionnaire are shown in Appendix 1 in Paper 4 (Håvold, 2005b).

Questionnaire 2 (147 items) / paper 5 and 6.

According to Hale (2000) there has been a tendency in safety culture research to start from scratch when scales and items have been developed: "*hardly any scales have been reused in the same form in several studies, and when that has happened, the factor structures and results have not usually been replicated."*

Based on extensive review of the safety climate and culture literature, several aspects of the safety orientation measure were identified. The questionnaire was designed to cover key factors found in a literature review of safety culture and climate. An item pool of 438 items was drawn from nine newer papers and reports discussed in Paper 3. The 438 items were screened for redundancy before scales and items were chosen according to the safety orientation model (Håvold 2001, 2005a) shown in Figure 1.1.

An important variable in this model is behaviour; four different scales measuring behaviour were chosen for inclusion in the questionnaire. The questionnaire has a total of 147 items; 20 national culture items (Hofstede's VTM questionnaire); 97 safety items that should be answered by all and 20 safety items only for officers. In addition, the questionnaire had 14 nominal questions asking information about age, sex, education, occupation, how long they had been a sailor, how long they had worked for their present employer, whether they have been involved in accidents or dangerous situations the last year and in their career as a seafarer.

The Likert scale was selected as the format of measurement for safety orientation because it is the most widely used instrument measuring opinions, beliefs and attitudes, and it is relatively easy to construct compared to other interval scales. Most scales measuring organisational culture and safety culture/climate also use the Likert format. According to some statisticians, the Likert scale should be treated as ordinal, unless we can prove otherwise. However, to able to perform calculations, I have adopt a pragmatic view often followed by social researchers and have treated the ordinal Likert scale as if it was an interval.

Appendix 2 shows the safety questionnaire used in Paper 5 and 6.

Table 5.1 Aspects of safety culture included in the 97-item safety questionnaire [b]

Factor	Number of items	Reference
Satisfaction with safety activities	8	Mearns et al. 2000, Alpha 0.89
Rules and regulations	4 + 3	Mearns et al. 2000, Alpha 0.63 Håvold (2001; 2005b) Alpha 0.72
Communications	5	Mearns et al. 2000; Alpha 0.7 Cox & Cheyne 2000, Alpha 0.73
Attitudes/Management commitment	8 + 6	Mearns et al. 2000; Alpha 0.87 Håvold (pilot study);Alpha 0.76
"Reporting culture"	5 + 2 + 1	New development Mearns et al. 2000, Alpha 0.76 Cox and Cheyne. 2000
"Learning culture"	4	New development
"Just culture"	3	New development
Conflict between work and safety	6	Cox & Cheyne 2000, Alpha 0.78
Work situation	6	Glendon and Litherand, 2001 Alpha 0.89
Knowledge	5	Håvold (2001; 2005b) Alpha 0.84
Job satisfaction	6	Lee and Harrison 2000, Alpha 0.84
Fatalism	7	Rundmo & Hale, 1999, Alpha 0.76
Behaviour	4 + 4 + 4 + 4	Williamson et al 1997, Alpha 0.84 Håvold (2001; 2005b) Alpha 0.68 Mearns et al. 2000, Alpha 0.90 Mearns et al. 2000, Alpha 0.70
All in all item	1	

[b] The different aspects of safety culture/safety orientation following the order from left to right in the safety orientation model shown in Figure 1.1.

The finalised questionnaire measured 12 antecedents of safety orientation and one outcome variable, behaviour. The different aspects covered and where the items and scales were taken from are shown in Table 5.1. For the "behaviour" outcome variable, four different scales were included in the questionnaire. Three different scales covering different aspects of work situation were included for the work situation variable. Two scales measuring management commitment were also included.

All scales used in the paper were Likert scales, using a six-point response format (e.g. from "strongly disagree" to "strongly agree" with no neutral middle point), even though other authors have used five- or seven-point Likert scales in their research. DeVellis (1991) suggests that either odd or even number of choices can be used for the response scale depending upon the phenomenon being investigated and the goals of the investigator. Norwegians, Australians and UK researchers created the scales and items used in the

questionnaire, and as such the study contains a "European" bias. The questionnaire was pilot tested amongst 20 nautical students and experienced seafarers attending a course at a simulator centre. It was produced originally in an English version, which was translated into a Norwegian equivalent. The questionnaire was then retranslated into English to cheek the translation.

5.3 Sampling and collection of data

Two questionnaires have been used in the empirical papers in this thesis. DeVillis (1991) suggests that 300 people is an adequate number when constructing scales, but he writes that scales have been successfully developed with smaller sample. Both surveys consist of more than 300 completed returns and can therefore seen to be adequate for constructing scales.

The research presented in Paper 4 is based on data collected from employees at a big Norwegian shipping company with multiethnic crew. The ships names were drawn from a fleet-list provided by the ship-owner. The vessels in the sample were mainly Bulk/Container ships ranging in size from 39 000 DWT (Dead Weight Tonnes) to 51 000 DWT, built from 1982 to 1998, with a crew of around 25. The questionnaire was sent by e-mail to 20 vessels (N = 486) where the shipmaster made copies and handed it out to the entire crew. The first page of the questionnaire emphasised that replies were anonymous, that respondent participation was voluntary, and that they should answer it honestly. When the question form was completed it was collected by the shipmaster and returned by mail. The data was collected at the end of March and the beginning of April in 2001. Respondents came from 15 out of 20 ships, and for vessels that answered, the response rate varied from 48% to 100%, with an average of 80%. When the five vessels that did not answer were taken into consideration, the response rate was 60%. In addition the questionnaire was handed out by one of the students who collected the data to a seminar for officers that the ship owner held in Manila. A total of 349 questionnaires were collected, 287 from the ships and 62 from the seminar in Manila.

The sampling used in Paper 6 was conducted in two stages. First, 24 shipping companies were randomly drawn from three strata (tank, dry cargo and passenger) taken from the ship-info com database (http://www.ship-info.com). On stage two between 2 and 12 vessels were

randomly selected from each shipping company depending on the size of the shipping company, which is a sampling method called cluster sampling. In this case, each vessel was a cluster where the whole crew was selected. There were several reasons for the choice of sampling design: first of all I wanted to compare ship owners and vessels in some analyses, and secondly a simple random sampling would be difficult because the rotating system in shipping would make it complicated and expensive. However a list of ship owners and vessels (clusters) was ready available at a database (www.ship-info.com). A letter explaining the project and asking for permission to collect data aboard their vessels was sent to the shipping company's managing director or the ship owner, with a letter from the Norwegian Ship owners' Association recommending the project (Appendix 3). Two of the 20 shipping companies had no vessels at the time the survey was performed and two companies turned down the invitation for different reasons, so the final version of the questionnaire was distributed to vessels from 16 shipping companies. A package containing the agreed number of questionnaires in English and Norwegian was sent to an agreed contact person aboard the vessel together with an information letter for the contact person, and "posters" telling the seafarers what the data was to be used for. The completed questionnaires were sent from the vessels to the ship-owner in a sealed envelope, which was then forwarded directly to the author. The survey was conducted between June and September 2002. The survey has an estimated response rate of 70 %. A total of 2558 questionnaires from 16 shipping companies with seafarers from 27 countries was part of the survey.

The participants voluntarily took part in the study, and information on project aims and confidentiality preceded the collection of data. To protect confidentiality, the names of vessels and ship-owners have not been reported, and results from a group level have only been reported for work groups exceeding 10 persons.

5.5 Statistical analyses

Paper 4 (Safety culture in a Norwegian shipping company) used PCA, canonical correlation, multiple regression analysis, multiple discriminant analysis and correlation analysis as statistical tools. PCA was chosen because it is the predominant view in the literature that PCA best describes the original data in a simplified way, with minimal

loss of information (Collins, 1980; Hair et al. 2006). The goal of both correlation and regression analysis was to test hypotheses investigating relationships between variables, and whether change in one variable was associated with changes in another. Canonical correlation allows the investigation of relationships between two sets of variables. In this case the relationship between three variables measuring "level of safety" and all safety items in the questionnaire, as well as four factors from the factor analysis was investigated. Canonical correlation was chosen because of a recommendation from one of the paper's reviewers. The reason for choosing multiple regression analysis was to learn more about and test the relationship between the factors from the factor analysis (independent variables) and Port state control ratio (dependent variables). Multiple discriminant analysis (MDA) adopts a perspective similar to PCA, but PCA and MDA are mathematically different in what they maximize. MDA maximizes the difference between the values of the dependent variables, whereas PCA maximizes the variance in all the variables accounted for by the factor.

Principal component analysis (PCA) revealed 11 factors when the Kaiser eigenvalue rule was used and 4 factors when the scree test criterion was used. The factor structure found in the material confirmed structures found by researchers in other industries. The relative importance of the factors found in the factor analysis of behavioural measures was tested by regression analysis and the results confirmed that several factors were influential across industries. Two canonical correlations was performed, the first between three "level of safety" dependent variables and 38 "safety items" as independent variables, second between three "level of safety" variables as dependent variables and four "safety" factors as independent variables. The results showed that the dependent variables measuring "level of safety" were all significantly correlated with each other, with two of the factors and 15 of the items.To determine whether differences existed between occupations, between nations and between vessels, the factors from the PCA were subjected to MDA. Significant differences between occupations, between nations and between vessels were found for one or more of the factors from the PCA, but different factors were shown to be responsible for the findings. Knowledge was a significant discriminator between occupations, while employees and management's attitude to safety was a significant discriminator between vessels and between nationalities.

Paper 6 (From safety culture to safety orientation: Validation and Simplification of a safety orientation scale using a sample of seafarers working for Norwegian ship owners) combined exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) as its analytical tools. The sample of seafarers was split in two sub-samples, a calibration sample and a validation sample, as recommended by Hair et al. (2006) and van Proijen and van der Kloot (2001). EFA was used on one sub-sample to generate theories about the constructs underlying SO; the analysis was then followed up with a CFA using the other sub-sample. Different criteria for factors to extract and retain in an EFA was discussed which resulted in a shortened scale of the Latent Root Criterion (LRCSS) and the Parallel Analysis Criterion (PC), which were analysed further in the CFA. The results from the CFA showed that all measurement models (Tables 5, 6, 7, 8 and 9 in Paper 6) had acceptable fit indices. However, the LRCSS models showed a better fit than the PC models. The structural models (Tables 10 and 11 in Paper 6) show the estimation results from eight models based on the LRCSS and PC approach, confirming the results found in the measurement models.

Several assumptions like normality, linearity, homoscedasticity, absence of correlated errors in the data were checked and addressed before statistical analyses were performed (Hair et al. 2006). See Papers 4, 5 and 6 for a more detailed discussion.

5.6 Validity and reliability

Reliability

Scales are reliable to the extent that they are comprised of reliable items that share the common latent variable (safety orientation). The most common way to measure reliability of a scale is to use Cronbach's alpha. Cronbach's alpha corresponds closely to the classical definition of reliability as the proportion of variance in a scale that is attributable to the true score of the latent variable. Cronbach's alpha is used as reliability measure in Papers 4 and 6. Papers 6 also use variance extracted and construct reliability to indicate convergent validity.

Validity

One of the main aims in Paper 6 (From safety culture to safety orientation: Validation and simplification of a safety orientation scale using a sample of seafarers working for Norwegian ship owners) is to validate the safety orientation scale (SOS).

Content validity, criterion-related validity and construct validity were established. The *criterion-related validity* is established if the scale performs as expected in relation to other variables or criteria. In this paper, two different criteria show evidence of criterion validity in the SOS. The summated SOS score was first correlated with the summated score self-reported work behaviour and then with an all-in-all question on safety. Both correlations are significant and indicate criterion-related validity.

Content validity is the extent to which individual scale items provide adequate coverage of the problem. This kind of validity is assessed in a more subjective way. It is closely related to theory, but lacks well defined objective criteria upon which it can be based. The measures developed for the SOS were derived from an exhaustive literature review and by evaluation by both practitioners and academics. Although the judgements about content validity are subjective, the procedures used are consistent with ensuring content validity (DeVillis, 1991; Spector, 1992).

Construct validity (Cronbach & Meehl, 1955) is directly concerned with the theoretical relationship of a variable (e.g. score on some scale) to other variables. It is the extent to which a measure "behaves" the way that the construct it purports to measure should behave with regard to established measures of other constructs. This is taken best addressed with the CFA approach. Paper 6 adopts a two-step confirmatory modelling strategy with a focus on construct validation (convergent, discriminant and nomological) in both steps. An important part of scale validation is the testing and interpretation of the structural model (step two). Section 3.4.1 in Paper 6 is where all measurement models were tested for convergent and discriminant validity. Despite some minor problems with both convergent and discriminant validity for a few of the concepts, the overall fit and the correlations between the constructs indicated congruent and concentric measurement models. Figure 2 sums up the main findings based on the Latent Root Criteria short scale (LRCSS). All seven antecedents/factors were well defined concepts passing both convergent and (conservative)

discriminant validity tests. All path coefficients had the expected sign, and the overall fit for the structural model was good.

6 Research papers

The following summarises findings from the 6 research papers listed in Appendix 1. Figure 1.2 “Structure of the thesis” describes the relationship between the six papers and the introduction and conclusion.

6.1 Culture in maritime safety (Paper 1)

(Published in Maritime Policy and Management, .27(1),, pp. 79-88 2000)

Culture in maritime safety is the first step of the thesis. This paper reviewed research on safety culture/climate in a maritime context up to 1998. Since the literature used is rather old, later papers (Papers 2 to 6) and the introduction and conclusion cover more recent research on safety culture/climate.

The paper indicated that very little research had been done on maritime safety culture and climate. A broader scope had to be taken, and material from industry and air safety was included in the review. With this broader view several factors appeared to influence safety culture/climate, amongst them management commitment and employee involvement were the most important. However research indicated that safety culture/climate had an effect on intermediary variables like communications, decision-making, conflict-solving, attitudes, motivation, and leadership. The research reviewed in this paper also indicated a clear link between the intermediary variables and accidents. National culture was the most intriguing of the contextual factors that could influence safety culture.

The papers reviewed also supported a multi-causal nature of accidents and multidisciplinary and multilevel aspects of safety and risk, showing the need for close cooperation between different levels to reduce risk.

Some researchers consider climate and culture to be almost the same construct, while others might say that climate is only one indicator of a broader culture construct. The review found the “competing” culture and climate constructs (organisational climate/culture and safety climate/culture) to be “cooperating” constructs with a very large overlap.

Further studies were recommended in four areas:

- Transfer of findings in industry and air safety to maritime safety.
- Determine the most important cultural factors affecting maritime safety.
- Investigate the effects of culture on risk aversion and risk taking, and how culture can affect safety in times of increasing production pressures and in critical situations.
- Develop indicators for maritime safety, which can be used by classification and insurance companies.

6.2 Occupational health and safety and the balanced scorecard (Paper 2)

(Published in The TQM Magazine, 15(6), pp. 408-423 2003.

This paper took the performance indicators used in an offshore health-and-safety benchmarking study carried out by Aberdeen University on 13 offshore installations operating on the UK Continental Shelf and related them to the balanced scorecard (BSC) framework. The results from the benchmarking study were discussed from the perspective of suggesting which indicators should populate each aspect of the BSC: financial, customer, internal business and learning and growth. In addition, the paper included the results of interviews conducted with senior managers in the UK and the Norwegian oil and gas sectors about the use of the BSC in general and with regard to health and safety indicators in particular. The reasons for including occupational health and safety in the BSC and reports/papers covering occupational health and safety indicators and the BSC were discussed. The costs of an accident are often underestimated, particularly indirect costs, which might be from 8 to 37 times the recoverable insured costs. The interviews with managers indicated that occupational health and safety was important for the companies in oil and gas related industries that had implemented BSC. The companies using BSC had mainly included outcome measures in their approach, but process measures are starting to find their way onto scorecards.

6.3 Measuring occupational safety: from safety culture to safety orientation? (Paper 3)

(Published in Policy and Practice in Health and Safety, 03(1), pp. 85-105, 2005)

This paper reviewed measures of safety culture and safety climate, and took the view that broadly defined; the two measures can be regarded as one construct. Many authors have

criticised the safety culture concept because it is too broad, has too many definitions, is too confusing/vague, the contextual factors are not focused, or that it lacks validation. These criticisms together with considerable disagreement among scientists as to how safety culture should be defined have influenced how practitioners perceive the usefulness of this concept in their organisations. Sometimes neither management nor employees understand the content and antecedents of the cultural concept. This critique of the safety culture concept suggests that a more pragmatic approach using its "best" parts might be useful in an organisational context. The paper proposed a new construct called "safety orientation", which is an operational construct of safety culture/climate and as a first step towards a more practical instrument for benchmarking safety.

The main emphasis in this paper was to review scales and items used to measure safety climate and culture in the social, psychological and organisational psychology traditions. Nine newer papers were selected for a detailed review, representing some important areas that used surveys to measuring safety culture/climate. The criteria for selection of papers are described in Paper 3. The safety culture and safety climate factors occurring with highest frequency in the reviewed papers were selected to be included in the safety orientation model proposed on p.98 in the paper. These were: Safety rules, management attitudes to safety, safety behaviour, communications, work situation, job satisfaction, knowledge, conflict between work and safety, satisfaction with safety activities, reporting culture and fatalism; additionally, two of James Reason's (1997) factors, learning culture and just culture, were included in the model. The model also included six contextual factors: professional culture, industry culture, organisational culture, regulations, markets and national culture.

The review showed that almost all safety culture and climate scales and items were "new" developments, even though many of papers reviewed stated the importance of moving towards a set of core scales and items in measuring safety culture. Scales were used by more than one survey/author in only a few exceptional cases. Hale (2000) also says: "*there is a tendency for each researcher to start from scratch again*" (p.11) and "*no researcher can claim that the questionnaires and scales they have developed and used are anything like fully validated*" (p.11).

The analysis suggests that researchers have found it difficult to move from first, exploratory stages to confirmation and causal stages that would allow for agreement on industry standards that could be used as benchmarks. However, the review also detected encouraging signs that the field may be moving in that direction.

This paper included a careful evaluation of Andrew Hale's critique of the research domain. Validated and reliability-tested scales to measure safety climate and culture were adapted from the nine papers/ questionnaires reviewed in the process of constructing the proposed safety orientation questionnaire, which was later used to collect data for Papers 5 and 6.

Further research was suggested in testing the model or parts of the model, finding reliable outcome variables, performing multilevel analyses, simplifying the indicators and models, and a large scale research project covering several industries and countries was proposed.

6.4 Safety culture in a Norwegian shipping company. (Paper 4)

(Published in Journal of Safety Research 36/5 pp. 441-458, 2005).

The paper focused on some elements of the safety culture construct in a Norwegian shipping company. The paper tested five hypotheses:

H 1*: That the factor structure obtained from the data would confirm previous research in other industries.*

The factor analysis supported the hypothesis by producing a factor structure that was very similar to the factor structure produced by research in industries other than shipping. The factors that loaded strongest were knowledge, management's attitude to safety, safety behaviour, attitudes to safety rules and safety and quality experience.

H 2: *The relative importance of the factors obtained would confirm previous research from other industries.*

Two canonical correlations indicated a significant relationship between "level of safety" and several factors from the factor analysis. Some of the most important factors reported from other industries also seemed to be among the most important in shipping. A regression analysis indicated that the most important factor that explained the variation in the Port State Control ratio was employee and management's attitude to safety and quality, which fits well with findings from other industries. Hypothesis 2 seems therefore to be supported by the data analyses.

H 3: *The perception of the importance of safety issues across nationalities would be shared.*

The analysis showed that this hypothesis is not supported. National cultures discriminated significantly for two of the factors from the factor analysis: employee and management's attitude to safety and quality, and safety and quality experience.

H 4: *The perception of the importance of safety issues across occupations would be shared.*
The analysis showed that this hypothesis was not supported. The result showed that all occupational groups shared the perception that safety is important. However, significant differences emerged for the "knowledge" factor. The officers and especially the masters reported better knowledge than the rest of the crew, and the galley section and ratings registered somewhat less positively than the rest of the crew.

H 5*: The perception of the importance of safety issues across vessels will be shared.*
The findings did not support this hypothesis. All vessels showed factor scores on the positive side. However, significant differences between vessels for factors from the PCA analysis supported the view that each vessel is a small society, with its own sub-culture.

The problem of finding reliable and valid outcome measures for risk and safety was discussed. This is a challenge because accidents are subject to random fluctuations, and data on near accidents are difficult to collect.

Port State Control is the inspection of foreign ships in national ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these rules. It is possible to calculate a Port State Control ratio by using the number of non-conformities as a percentage of the number of Port State Controls, which can then be used as a kind of outcome variable for each vessel.

The research indicated an empirical link between a set of safety culture perceptions and safety behaviour as measured by the Port State Control ratio. A regression showed that the factor "employee and management's attitude towards safety and quality" explained 50% of the variance of the Port State Control ratio.

6.5 National cultures and safety orientation: A study of seafarers working for Norwegian shipping companies (Paper 5)

(Work & Stress, 21(2), pp. 173-195; 2007)

The main objective of this paper was to examine the influence of national cultures on safety orientation.

This was achieved by using the "safety orientation" model (Figure 1) and Hofstede's dimensions of national culture (Hofstede, 2001) on a multinational sample of sailors working on Norwegian-owned vessels. The paper tested four hypotheses:

- ***H1:*** *The factors found in an individual-level factor analysis will not be replicated in a national-level factor analysis.*
  The findings supported that hypothesis. The individual level factor analysis produced 16 factors, while the ecological factor analysis (national level) produced four factors. Many of the items that loaded in the individual factor analysis did not load on the ecological factor analysis and vice versa. The four factors from the ecological factor analysis explained 83.7% of the variance, while the 16 factors from the individual factor analysis explained less of the variance (57%).

- ***H2:*** *The perception of the importance of safety issues measured by the factors from the factor analyses will not be shared across nations.*
  The findings partly supported this hypothesis. All nations seemed to show positive attitudes towards safety and risk issues; however, significant differences between regions and countries were found. The findings indicated that there might be "regional" cultures (Northern Europe, Eastern Europe and South East Asia) on all four factors in the ecological factor analysis.

- ***H3:*** *There will be a difference between vessels having a multinational crew and vessels having crews from a single country with respect to perception of risk and attitudes toward safety.*
  The findings partly supported this hypothesis. GLM-MANOVA showed that crew from a single nation and crew from more than two nations seemed to be grouped together in having significantly more positive attitudes towards safety than vessels with crew from two nationalities.

- ***H4:*** *National culture as measured by Hofstede's factors will be related to attitudes toward safety and risk as measured via the factors of the factor analysis.*
  This hypothesis was supported. A significant correlation between some factors from the factor analysis and the indices for national culture was found.

Several areas of future research were suggested. For example, some factors in the safety orientation model may have a greater effect on safety behaviour than others. It would be important to examine which factors in the model are the most important in order to simplify the safety orientation model presented in Figure 1. Another area of research might be to investigate if a sailor's loyalty is to his country, to the shipping company, to his peers in the profession, or to his colleagues. A research project that

examines whether or not there is an increased safety risk when national culture conflicts with the values and norms of an organisational or professional culture would be a natural next step in expanding the understanding of safety orientation and national culture.

6.6 From Safety Culture to Safety Orientation: Validation of a safety orientation scale on a sample of seafarers working on Norwegian-owned vessels. (Paper 6)

(Submitted to Safety Science)

The paper had three main goals. The first was to see if scales were stable across industries and cultures, the second was to focus on retention rules for factor retention in EFA, and the third was to validate the SO model. Several authors have suggested that at least some safety culture/climate factors could be stable both across industries and cultures. Table 1 (in Paper 6) shows that the A Priori Criterion of EFA produced scales with very good internal consistency. The 12 scales replicated had Cronbach's alphas ranging from .65 to .93, whilst the original Cronbach's alphas were from .60 to .90. From the present research it appeared that scales and items measuring SO were stable across nationalities, industries and organisations, and the findings appeared very promising for developing a general tool measuring safety orientation.

The second aim was to focus on the retention rules in EFA. EFA is the preferred procedure for use in safety culture and safety climate scale development. Factor retention seems to be the most important choice to be made because it as appears that there is robustness across the choice of factor analysis methods and types of rotation (Zweck and Velicer, 1986; Hayton et al. 2004). Several rules were used to determine the number of factors and individual items to be retained (A Priori Criterion; Latent Root Criterion; Percentage of Variance Criterion; Scree Test Criterion and Parallel Criterion); however, the process described in the paper left only a short form of the Latent Root Criterion (LRCSS) and Parallel Criterion (PC) for further analyses. This research indicated that LRCSS was superior to the PC.

The third aim was to validate and simplify the SO model. Criterion-related validity, content validity and construct related validity were all assessed. The summated safety orientation scale performed as expected in relation to two different criteria, a summated score of self reported behaviour and an all-in-all question on safety both indicating criterion-related validity. Criterion –related validity of a scale is established if the scale performs as expected in relation to other variables that have been selected as meaningful criteria. Content validity is defined as the extent to which individual scale items express the meanings included in the concept. The measures developed for SO were derived from an exhaustive literature review and by an evaluation by both practitioners and academics. Although judgements about content validity are subjective, the procedures used are consistent with ensuring content validity (DeVellis, 1991; Spector, 1992). The paper adopted a two-step confirmative modelling strategy with a focus on construct validity (convergent, discriminant and nomological) in both steps. The measurement models were tested for convergent and discriminant validity. The overall fit and correlation indicated congruent and concentric measurement models. In the second step the structural models were validated through testing and interpretation, indicating good validity (see Figure 2 in Paper 6).

The SO model revisited (Figure 7.1 in Paper 6) showed that the process described in the paper resulted in a much simpler model than the one presented in Figure 1.1. The re-specification of the model on the basis of the CFA for four different behavioural measures gave a simplified and well-defined model with seven factors and 22 items.

7 Discussion

The present study defines, describes and tests parts of the SO model, which can be looked at as an operational definition of safety culture. The main purpose was to develop a tool to measure SO in shipping. The research aims have been both to contribute to the testing of selected hypotheses regarding to safety culture (Papers 4 and 5) and develop a tool to measure safety orientation in shipping (Papers 3 and 6). The theoretical framework described in section 3 is taken into consideration in the following discussions.

7.1 Substantial findings

One might expect that the high accident rates among seafarers -- 11 to 26 times higher than the average among the workforce ashore (Hansson, 1996; Roberts, 2002) -- would have resulted in research on safety climate/culture in the maritime sector. The author found that no such research on safety climate/culture in the maritime sector had been done (Paper 1: Håvold, 2000). This finding was later confirmed by Sten and Fjerdingen (2003). However, some research has been published in recent years on the safety climate/culture in the maritime sector (see chapter 2.4).

The author found that most of the factors in the SO model could measure safety across both industries and cultures. Most research on safety culture and climate has been conducted in the areas of air and rail transport, nuclear power production, the chemical, processing and construction industries and offshore oil production. Based on this previous research, the current study presents an instrument to measure safety orientation among seafarers. The twelve scales developed and presented in Paper 3 were further developed in Paper 6 and replicated surprisingly well on the sample of seafarers working for Norwegian ship owners. The multinational sample of seafarers produced a Cronbach's alpha ranging from .65 to .93 on the twelve scales, whilst the original Cronbach's alphas were from .63 to .90, indicating that scales can be used across both industries and nationalities.

EFA is the preferred procedure in safety culture and safety climate scale development. Factor retention seems to be the most important choice to be made. A variety of researchers investigating this subject (Hayton et al, 2004; Zwich and Velicier, 1982, 1986; Velicier et al., 2000; Glorfeld, 1995; Ledisma et al., 2007) maintain that parallel criteria for factor

retention is the approach that most accurately recovers the true number of factors in a dataset. They also seem to have a limited confidence in the latent root criteria for factor retention. This research found that a short form of the latent root criteria was superior to the parallel criteria (Paper 6: Håvold and Nesset, 2007; Tables 7, 8,9,10 and 11).

National cultures as measured by Hofstede's indices seem to discriminate significantly between several safety factors and should therefore be included as one of the contextual factors that influence safety. Paper 4 (Håvold, 2005b) indicated that vessels with an all-Indian crew were the most positive on the safety culture scales. Paper 5 (Håvold, 2007) confirmed that national cultures discriminated significantly for the safety orientation factors on all four factors from the ecological factor analysis and all 15 factors from the individual factor analysis.

The Tukey HSD post hoc test, which groups dependent variables into homogenous subsets, grouped Norway and the Netherlands together in the same subset for 4 out of 4 factors; Poland and Latvia into the same subset for 4 out of 4 factors; and Philippines and India into the same subset for 3 out of 4 factors. This might indicate "regional" cultures for all four factors from the ecological factor analysis (Paper 5: Håvold, 2007).

A MANOVA indicated significant differences among vessels with crew from one, two, and more than two nations for all factors from the ecological factor analysis. Post hoc tests showed that having a single nation crew or a crew comprising more than two nations indicated a more positive attitude towards safety for three out of four factors. A possible explanation for this might be that if the crew hails from two nationalities, attitudes, values and norms might come into conflict and lead to stress (Paper 5: Håvold, 2007).

Factor analyses on both an individual and national level (ecological level) of analysis were conducted (Paper 5: Håvold, 2007). The ecological factor analysis was performed according to Hofstede's (2001) recommendations, and to empirically justify aggregation interrater reliability. Intra-class correlation coefficients were calculated and found to be within the normal range reported in the literature. The individual and national level factor analyses showed that the variables and factors at the individual and national levels of analysis were different. See Paper 5 for a more detailed discussion.

By comparing Hofstede's original country scores and scores calculated on sailors on Norwegian-owned vessels, the results suggested that sailors from collectivistic countries have become more individualistic, whereas sailors from more individualistic cultures had become more collectivistic (Paper 5: Håvold 2007).

Correlations between the scores calculated on sailors on Norwegian-owned vessels and the correlations between the scores on the five national culture dimensions as obtained in Hofstede's study (Power Distance; Individualism; Masculinity; Uncertainty Avoidance and Long-Term Orientation) showed that Power Distance and Uncertainty Avoidance were replicated best (Paper 5: Håvold 2007).

The country scores calculated on sailors correlated with factors from the ecological factor analysis indicated that high power distance, high uncertainty avoidance and a high score on individualism were positive for safety (Paper 5: Håvold, 2007).

Organisational sub-cultures (occupation, ship owners and vessels) showed significant differences for safety factors. All occupational groups shared the perception that safety was important; however, the officers and especially the masters reported a more positive attitude than the rest. By inspecting the items behind the significant differences between vessels, one could infer that the safety culture of the master and officers could be influential on the outcome. Another aspect to consider is that the differences in scores might be rooted in the nationality of the crew. The three vessels with an all-Indian crew showed the most positive safety culture whilst the vessel with an all-Norwegian crew showed the least positive safety culture. (Paper 4: Håvold 2005b).

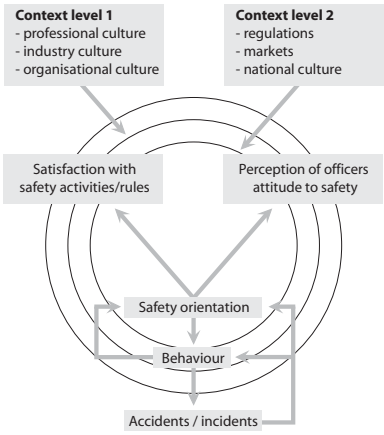
It appears that some factors/antecedents influence negative safety behaviour while others seem to influence positive safety behaviour. To avoid negative safety behaviour, it is important to work to make safety routines as clear, simple, and easy to understand as possible; to avoid boring and routine work as much as possible; to avoid protecting the management if anything bad happens; and to avoid a laissez-faire culture and fatalism. To influence positive safety behaviour, one should ensure that employees are satisfied with safety activities and the management's attitudes and actions in regards to safety. This

corresponds with Herzberg's famous findings on hygiene and motivation factors (Herzberg, 1996; Paper 6: Håvold and Nesset, 2007).

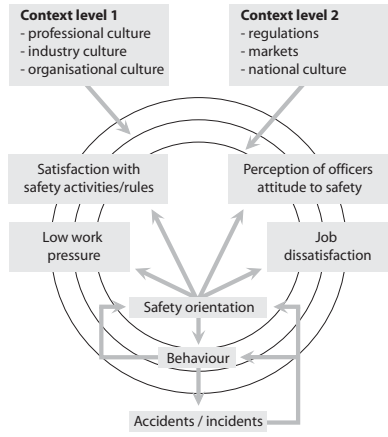
7.2 The safety orientation model revisited

Figure 7.1 sums up the significant findings of the structural model based on the latent root short scale approach discussed in paper 6. It shows that only seven factors/antecedents and 22 items are used to measure the four behavioural constructs in the refined model. The seven antecedents of the four behavioural constructs are well-defined concepts passing both convergent and discriminant validity tests. The SO scales shown in the figure are a graphical presentation of the significant findings reported in Table 10/ Paper 6. In the development of the SO scale, the author started with a total of 438 items. The items were first screened for redundancy, which led to a 96-item safety questionnaire and a safety orientation model that was presented in Figure 1.1. Through refinement and development the final scales ended up with 22 items and seven factors.

Figure 7.1 shows that two of the four behavioural variables measure positive safety behaviour: "Positive management behaviour" and "Precautious behaviour" (Williamson et al. 1997; Håvold, 2002) while the other two measuring negative safety behaviour: "Laissez-faire behaviour" and "Laissez-faire behaviour under pressure" (Mearns et al. 2000).

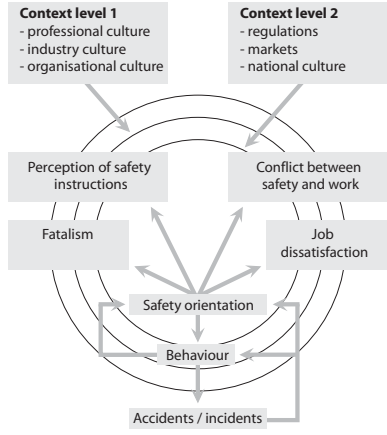


Positive management behaviour



Precautious behaviour

Laissez-faire behaviour



Laissez-faire u/pressure behaviour

Figure 7.1 Revisited model describing; factors and consequence of safety orientation

7.3 Practical use and implications of SO

The empirical paper built on "large" samples drawn randomly with high participation. Paper 4 built on 349 respondents from fifteen vessels (response rate of 60%), while Papers 5 and 6 had 2558 respondents from 141 vessels and 16 shipping companies (response rate of 67%); both were well within recommendations from Spector (1992) and DeVellis, (1991), who suggested that 300 respondents was a minimum sample size for scale development. In addition, many nationalities were represented in both samples. The most common loss of external validity came from research on small samples obtained from a single geographical location. The result reported in these studies might be transferable across merchant shipping in general because of the industry characteristics. As mentioned in chapter 3.4, the technology and environment is relatively similar for all ships with the same standards for education and certificates, ships are classified by international classification societies, and most sailors are male, as in the samples used for Papers 4, 5 and 6.

Most of the scales used in this research have been replicated from other industries. The exploratory factor analysis EFA (Table 1 in Paper 6) suggests the potential existence of at least some scales that can cover more than one industry. Many of the scales used in the SO questionnaire have been replicated from questionnaires used to measure safety climate/safety culture in the North Sea offshore sector, an industry with a demography that is not unlike merchant shipping.

As a performance indicator

How does the SO indicator correspond with the criteria for a good performance indicator (Kjellen, 2000)?

SO can be *quantified* by applying a recognised data collection method or by observation. In Paper 6 (Håvold and Nesset, 2007) SO and its antecedents were measured/quantified through a survey using a Likert scale.

The indicator should also be a *valid indicator for the risk of loss* by measuring what it is intended to measure (criterion-related validity) Criterion validity is discussed in Paper 6 (Håvold and Nesset, 2007) and the conclusion was that it was satisfactory.

The indicator seems to be *sensitive to change* to allow for early warnings, by capturing changes in a system or in the context. The SO indicator seems to be sensitive to change and

discriminates between vessels, occupations, and nationalities. The link between attitudes, behaviour and accidents was discussed in earlier chapters, and since attitudes are seen to be antecedents to behaviour and accidents, it is clear that changes in attitude can sound early warnings. The inclusion of contextual factors would be more complicated but not impossible.

The indicator should be *compatible* with other performance indicators to prevent decision makers from receiving contradictory signals. The safety orientation indicator can be used in addition to and in co-ordination with other assessment tools.

The indicator should be *transparent and easily understood* with respect to the user's theoretical mental models and understanding, and it should be *robust against manipulation.* The safety orientation model and the safety orientation construct with its antecedents seem to be easy to grasp by the many employees, managers and safety practitioners I have presented it to. The indicator is transparent and since the indicator is constructed by asking questions of many people in the organisation using validated and reliability tested scales, it seems to be robust against manipulation. All in all, the safety orientation indicator appears to support Kjellen's six important criteria for a good performance indicator.

I will suggest two additional requirements for a good performance indicator that appear to be important: *It has to be simple in use*. If the indicator is easy to use it can be used to monitor the business more closely and cheaply. It must also be *easy to communicate* because one of the important reasons to use performance indicators is to "educate" the staff and involve and motivate them to increase safety (see Figure7.2). The safety orientation indicator seems to support the two last criteria as well (see Figure 7.3).

Continuous safety improvements

For an organisation to become safety oriented, the idea of safety orientation has to be sold to the organisation. One has to remember that measuring safety orientation is only the beginning of the process of improving safety. In essence, the real work of setting priorities for action, making changes aimed at improving safety, and then to re-measure the effect begins after the results from the initiating "survey" has been communicated to the employees.

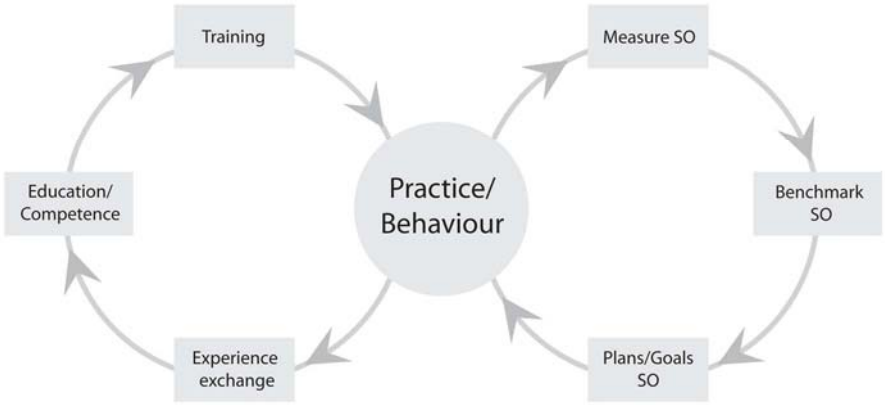


Figure 7.2 The SO process

Initiatives to create and sustain a positive safety orientation should be a part of an ongoing process (continuous improvement) as is shown in Figure 7.2. Key elements in the process are: (1) Measure safety orientation, (2) Identify safety concerns and establish benchmarks, (3) Set goals and make priorities, (4) Establish forum for experience exchange (5) Provide training and education, (6) Re-measure safety orientation.

The process in the left circle of the figure show how the continuous improvements can be implemented (like described in the SO definition); the right circle shows the measuring process necessary to benchmark improvements and decide on new goals.

In benchmarking

An important part of the SO process is benchmarking, because it can assess progress in improving safety. The absence of performance measures prevents the identification of best practices and impedes improvement in safety management throughout the organisation and between organisations. Table 7.1 shows how the sixteen ship owners represented in this

sample are rated on the seven factors represented in the four models in Figure 7.1. The highest and lowest values on each of the seven factors are shown in bold.

Table 7.1 The sixteen ship owners in the sample benchmarked using seven SO factors[a]

Ship owner	F1f	F2f	F3f	F4f	F5f	F6f	F7f
1	4.91	4.80	4.06	2.77	3.61	**2.55**	3.43
2	4.56	4.73	4.19	2.41	2.74	2.15	3.28
3	5.16	5.07	4.65	2.36	3.42	2.11	3.09
4	4.99	5.00	**4.74**	2.33	3.57	2.19	3.09
5	4.99	4.93	4.58	2.34	3.55	2.13	3.12
6	4.54	4.69	4.14	2.44	2.66	2.22	3.16
7	5.12	5.13	4.68	2.25	3.59	2.08	3.11
8	4.63	4.78	4.11	2.39	3.10	2.27	3.53
9	**5.32**	**5.20**	4.61	**2.11**	3.41	**1.90**	2.89
10	5.18	5.07	4.72	2.16	3.00	2.08	2.84
11	4.13	4.64	3.79	3.03	2.66	2.26	3.52
12	**3.89**	4.72	3.58	2.94	**2.15**	2.13	3.58
13	4.48	4.80	3.78	2.33	2.40	2.14	3.35
14	4.50	**4.22**	3.42	2.17	3.00	2.17	**2.67**
15	4.99	4.94	4.73	2.52	**3.90**	2.35	3.40
16	3.97	4.72	**3.04**	**3.25**	2.94	2.50	**4.22**
Mean sample	4.84	4.91	4.39	2.41	3.19	2.17	3.21
Mean 16 ship owners	4.71	4.84	4.18	2.48	3.11	2.20	3,27

F1f: Satisfaction with safety activities; F2f: Perceptions of officers' attitude to safety; F3f: Low work pressure; F4f: Job dissatisfaction; F5f: Fatalism; F6f: Perception of safety instructions; F7f: Conflict between safety and work.

[a]The highest and lowest values on each factor are shown in bold

Figure 7.3 shows a "radar chart" for how the measured performance can be presented and compared.

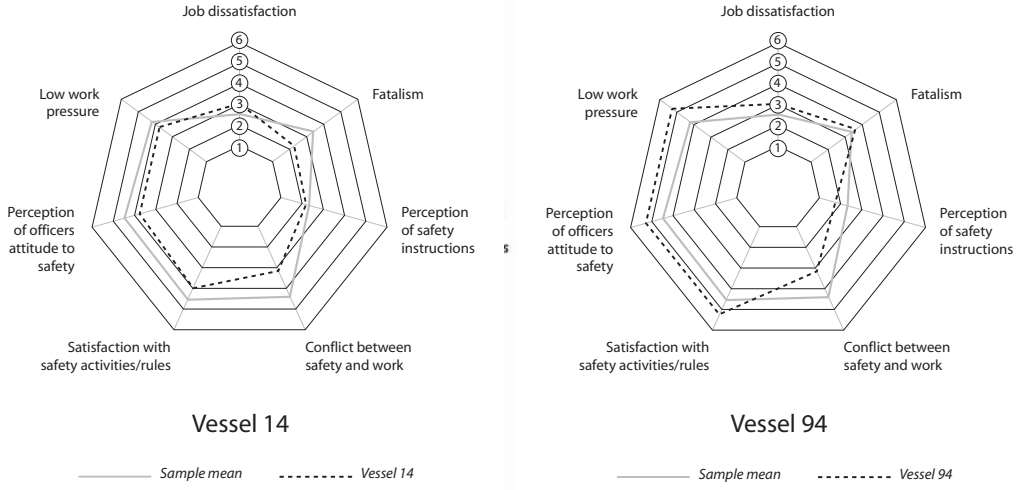


Figure 7.3 Example of a graph presenting SO

The main advantage of using graphs like the ones in Figure 7.3 is for presentation and communication purposes. This work does not produce any predictors. Predictors can be used to tell results in advance with a high degree of precision. The antecedents in Figure 7.3 might become predictors with extensive use, experience, and research. Many of the antecedents (indicators) have been tested statistically in the papers, with significant association with outcome variables. These findings can then indicate the existence of certain conditions and be used to suggest alternative approaches.

Despite some limitations, the SO construct developed through this study has potential for managerial applications. First, the scale presents a practical way of measuring the extent to which a company or department (vessel) has achieved a satisfactory level of safety. Second, the scale can be used in benchmarking as a KPI, or as an indicator in a balanced scorecard type of management tool. An analysis of data at different levels would allow an evaluation of overall SO performance, permitting managers to identify problem areas and concentrate resources on improving particular aspects of SO. Third, the results could be used in discussions with insurers, banks and customers to make safety work more visible. Fourth, by making safety work more visible, the workforce might become more motivated in the continuous process of improving safety.

Organisations as such should therefore regularly survey and benchmark their SO and identify potential issues and improvements.

By evaluating an organisation's SO through a survey instrument, we are able to produce a picture of the vessel and/or ship owner at a particular point of time. This suggests that it can be used to plan and implement change. The measurement of safety orientation can provide management in an industry like shipping with the capacity to measure the degree to which the underlying dimensions in SO influence behaviour. We found that the scale was internally reliable and provided a valid construct when tested on a sample of seafarers on Norwegian-owned vessels. These results show that the questionnaire satisfies Baker's criteria (1991) for an adequate scale: it has construct validity, it is internally reliable, and it appears to measure the same constructs when applied to new groups of employees, which Baker terms transferability.

In order to prevent negative safety behaviour by the crew the most important initiatives seem to be reducing the general perception of job dissatisfaction, and making safety

instructions less confusing. However, activities directed at ease conflicts between safety and work, and actions that counteract to spread of "fatalism" may be useful in reducing negative safety behaviour. On the other hand, activities to stimulate positive safety behavior should mainly focus on the creation of satisfaction with safety rules and procedures among the crew - in particular actions giving support to safety representatives on board and the provision of good and adequate information on safety matters - and actions that support the creation of good and visible safety attitudes among the officers (the "opinion leaders").

However, one should also be aware of pitfalls. Examples of pitfalls might be: unreal expectations, difficulties in maintaining enthusiasm over a long period of time, reluctance on the part of employees in being measured, and the need for trust between management and employees in connection with implementation. It can be especially problematic to implement a system to measure safety orientation in organisations where employees have bad experiences or believe that the information could be used negatively as a "weapon".

7.4 Limitations of the results

The use of self-reported measures to access all dimensions of the safety orientation model is a clear limitation of the current study. Estimates of relationship amongst the measures may therefore be confounded by common method of variance. Finding better ways / more objective measurements of safety behaviour and safety outcomes using new samples will be necessary to validate the impact of safety orientation on workplace outcomes.

Another limitation of the study is its cross-sectional measurement. It was not possible to test all causal relationships proposed in the model and longitudinal assessment would have provided further validation of specific relationships.

The theory of safety orientation as a process is in its infancy. Development of theory, measurements and documentation might improve our understanding of safety orientation. This in turn will improve the ability of managers to implement a higher degree of safety orientation in their organisations.

Further research and findings outside the fields covered in this thesis or included in publications in other languages than Scandinavian or English might extend or modify the model.

8 Conclusions and recommendations

A safety orientation definition and theoretical model has been suggested using inductive reasoning and taking into account current research from several academic fields. However, the main source of information has been the safety climate and safety culture literature. Parts of this model have been tested empirically in the papers. The cultural paradigm used in this research is a version of functionalism, which looks at culture as an integrative mechanism where common values are the consistent shared element, and culture as such can be measured and changed.

This research has not started from scratch, but has built on reusing whole scales employed by others, as has been recommended by Hale (2000). The scales in this study replicated surprisingly well, contrary to Hale's observation that "Hardly any scales have been reused in the same form in several studies, and where that has happened, the factor structure and results have not usually been replicated" Hale, 2000, p. 11). (See Tables 1 and 2 in Paper 6).

Notwithstanding the limitation of this study, the results provide strong empirical support for the proposed theoretical model. The study demonstrates that several of the proposed ascendants in the model influence the safety orientation construct, and that safety orientation influences safety behaviour. The findings described in this thesis provide valuable guidance for researchers and practitioners trying to identify areas in which they can improve safety at sea.

It is essential that actions are taken as a result of the findings. Measuring safety orientation should not be a paper exercise; the entire process will be a waste of time and resources if the findings are not used for improvements or measuring towards a goal. The safety orientation measurement should be an integral part of the company's management system.

Further research can be proposed in several areas. The papers and thesis are only a step in developing a tool to measure safety orientation at sea. The next step might be to test parts of the model not covered in present research and papers. By looking at the preliminary safety orientation model in Fig. 1.1 and the model revisited in Fig. 7.1, the following research can be proposed:

- *The model must be tested on other industries. To develop a core of generic factors and items for benchmarking purposes, a large-scale research project covering several industries and countries would be required.*

- *The contextual influences resulting from industry culture, regulations and markets have to be tested. Do rules and regulations have an effect on safety behaviour and safety orientation? If so, why and how? Does competition influence safety behaviour and safety orientation? If so, why and how?*

- *A sailor's loyalty can be to his country, to the shipping company, to his peers in the profession or to his colleagues. Multilevel analysis could be used to investigate the degree of influence these different potential loyalties have on safety orientation.*

- *What are the impacts on safety behaviour and safety orientation of rapid organisational and technological change?*

- *What effects will "safety campaigns" and/ or training directed to the profession, the industry or the organisation have on safety behaviour and safety orientation?*

- *Do work on quality culture like quality campaigns and the introduction of TQM have an effect on safety behaviour and safety orientation?*

Additional proposals:

- *How will various preventive measures used in combinations function?* For example how do attitude changes in combination with "attitude modification", "structural modification" influence behaviour?

- *Studies using multiple methods, both quantitative and qualitative (data/method triangulation), should be launched at an international level.*

International bodies such as the IMO, IATA, IAEA, and the ILO could cooperate in financing international research in this area.

The development of such a tool could be of special interest and use to safety-oriented companies for benchmarking, for insurance companies in underwriting and for classification companies in assessment. Nevertheless, as has been stated earlier, the process is in its beginning stages, and both more research as proposed above and development must be undertaken before a safety orientation tool could be a launched as a product.

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