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Improving Co-operation on the Bridge
Preliminary Study

Merenkulkulaitos

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Improving Co-operation on the Bridge – Preliminary study

Abstract

This report is based on the project carried out by Huperman Oy for the Finnish Maritime Administration about the needs to improve co-operation of the bridge personnel for enhanced safety at sea. The objective of the project was to identify current practices on the bridge, assess their effectiveness from a threat and error management point of view, and define how current training and instructional guidance affects the actual behaviour of bridge personnel. The analysis was based on a review of accident reports, studies about current practices in Bridge Resource Management training and related literature, and interviews of the operational personnel and representatives of the authorities, shipping companies, and training organisations.

It was found that the strategies the bridge personnel uses for managing threats and errors vary a lot between different organisations, vessels, and bridge crews. Both very effective and essentially weak practices for managing human errors could be found. Crew training and instructional guidance provided for the crew members were considered as the major contributing factors. It could be seen that current training and available instructions do not provide sufficiently practical tools for bridge personnel to manage threats and errors effectively. The content of the training and the instructions given are often on a too general level and are therefore difficult to implement into real-life operations.

It was notable that both crew members and organisations were very willing to improve their operations and current practices. But it was considered to be difficult without further guidance and better understanding of the different models of crew-operation.

The report identifies some clear needs of improvement which could contribute to the safety of the operations.

Keywords

shipping, maritime safety, Bridge Resource Management, co-operation on the bridge,

Miscellaneous

This report has been published in this publication series also in Finnish language under the title " Komentosiltayhteistyön kehittäminen – Esiselvitys" (no. 1/2007)

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Improving Co-operation on the Bridge – Preliminary study

Tiivistelmä

Tämä raportti käsittelee Merenkulkulaitoksen tilaamaa ja Huperman Oy:n toteuttamaa selvitystyötä komentosiltayhteistyön kehittämistarpeista merenkulun turvallisuuden parantamiseksi. Hankkeen tavoitteena oli selvittää vallitsevia käytäntöjä komentosillalla, arvioida niiden riittävyyttä tehokkaan uhkien ja virheiden hallinnan kannalta sekä selvittää, millä tavoin nykyisellä koulutuksella ja ohjeistuksella voidaan vaikuttaa henkilöstön toimintaan komentosillalla. Selvitys perustuu onnettomuustutkintaraporttien antamaan tietoon, nykyisten koulutussisältöjen ja ohjeistuksen tutkimiseen sekä operatiivisen henkilöstön ja varustamoiden, viranomaisen ja koulutusorganisaatioiden edustajien haastatteluihin.

Selvityksessä havaittiin, että uhkien ja virheiden hallintaan liittyvät käytännöt vaihtelivat merkittävästi varustamoiden, alusten sekä miehistöjen välillä. Selvityksessä löydettiin sekä erittäin kehittyneitä inhimillisten virheiden hallintaan liittyviä käytäntöjä että oleellisesti puutteellisia toimintamalleja. Vallitsevia käytäntöjä selittävien tekijöiden osalta keskityttiin erityisesti koulutuksen ja toiminnan ohjauksen rooliin. Selvityksen perusteella näyttäisi siltä, että nykyinen koulutus ja toiminnanohjaus eivät tarjoa komentosiltahenkilöstölle riittävän käytännönläheisiä välineitä tehokkaaseen uhkien ja virheiden hallintaan. Koulutussisällöt ja ohjeistus jäävät liian yleiselle tasolle ja ne koetaan vaikeasti sovellettavaksi käytännön toiminnassa.

Merkillepantavaa oli selvitykseen osallistuneiden miehistön jäsenten ja organisaatioiden tahtotila kehittää toimintaa ja vallitsevia käytäntöjä. Tämä koettiin kuitenkin hankalaksi ilman parempaa ohjausta ja ymmärrystä miehistöyhteistyön käytännön toteutustavoista.

Selvityksessä on kuvattu joitakin selkeitä kehittämistarpeita, joilla toiminnan turvallisuuteen voitaisiin myötävaikuttaa.

Avainsanat (asiasanat)

merenkulku, turvallisuus, Bridge Resource Management, komentosiltayhteistyö, inhimillinen virhe

Muut tiedot

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Improving Co-operation on the Bridge – Preliminary study
(Utvecklande av samarbetet på kommandobryggan – Preliminär utredning)

Referat

Rapporten berör ett utredningsarbete utfört av Huperman Oy för Sjöfartsverkets räkning om behovet att utveckla samarbetet på kommandobryggan för att förbättra säkerheten till sjöss. Syftet med utredningen var att klargöra rådande praxis på bryggan, bedöma hur effektivt risker och felbeteende hanteras och utreda hur man med nuvarande utbildning och anvisningar kan påverka personalens agerande på bryggan. Utredningen baserar sig på haveriutredningar, en undersökning av nuvarande studieinnehåll och anvisningar samt intervjuer med operativ personal, representanter för rederier, myndigheter och utbildningsorganisationer.

Utredningen visade att rutinerna för hanteringen av risker och fel skiljer sig markant mellan olika rederier, fartyg och besättningar. Man fann både mycket utvecklade rutiner och sådana som uppvisade väsentliga brister. Bland de faktorer som förklarar dessa rutiner koncentrerade man sig särskilt på utbildningen och handledningen. Utredningen visar att utbildningen och handledningen inte ger bryggpersonalen tillräckligt konkreta medel att effektivt hantera risker och felbeteende. Studieinnehåll och anvisningar är alltför allmänt hållna och upplevs som svåra att omsätta i praktiken.

Sjöfolk och organisationer som medverkade i utredningen visade prov på anmärkningsvärd vilja att utveckla både verksamheten och rådande rutiner. Det upplevdes dock som svårt utan bättre handledning och bättre förståelse för hur samarbetet inom besättningen kan förverkligas i praktiken.

I utredningen redogörs för vissa klara utvecklingsbehov som kunde främja den operativa säkerheten.

Nyckelord

sjöfart, säkerhet, Bridge Resource Management, samarbete på kommandobryggan, mänskligt fel

Övriga uppgifter

Denna rapport har publicerats i denna publikationsserie också på finska under titeln " Miehistöyhteistyön kehittäminen – Esiselvitys" (nr. 1/2007)

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Foreword

The bridge is the focal point of the management of operations on a ship. Due to its functional character, it can best be described with the term "nerve centre." In order to ensure safety and efficiency of the ship's operations it is important that all the bridge operations have been appropriately organized into a seamless co-operation of the watchkeeping personnel. It is also necessary that the personnel can take the best advantage of the vessel's technical systems. In order for the ship to function efficiently it is important that the personnel and especially the master of the ship are familiar with co-operational methods and current regulations as well as the characteristics and technical systems of the ship.

IMO committees have paid attention to bridge operations, or their deficiencies, on many levels. It is expected that the current deficiencies will be corrected by international regulations. Finalizing of these regulations may take years, and after the national recognition of this problem it is not practical to stay put and wait for the improvement of the state of affairs.

This development report concentrates especially on the role of the watchkeeping personnel as a part of the bridge operations, and on the capacity of the individual in a high-pressure work environment.

This report can be regarded as a preliminary study which will lead to further research and to the directing of the watchkeeping crew's bridge work with a directions model.

Helsinki, 2 February, 2007

Paavo Wihuri
Director of Maritime Safety of the Finnish Maritime Administration

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1 Introduction

1.1 Background and Starting Point

This report is based on the need identified by the Finnish Maritime Administration to assess how the current training and work direction can affect the operations of bridge personnel on a practical level. Finnish Maritime Administration (FMA) also wanted to analyze how bridge operations can be improved for enhanced safety at sea. The research was carried out by Huperman Ltd.

Researches concerning maritime safety often point out that hazardous situations are mostly results of human error (E.G. SOLAS, Annex 24). On one hand this problem has been addressed by developing technical solutions to reduce the risk involved with the operations of the bridge personnel, and on the other hand by trying to affect the operations and individual performance of the bridge personnel with training and instructions.

The maritime long history has established strong and deep-seated operation culture and practices connected with it. Attempts have been made to improve maritime human error management with Bridge Resource Management training (BRM). Its goal is to try to find ways to improve the expertise on making the best use of the resources of the bridge personnel. BRM training is based on a framework and training programmes developed in the field of aviation earlier where the aim was to improve cockpit crew co-operation especially with regard to communication, leadership and decision making (FMA, 1997).

According to the background research preceding the report it is safe to assume that, as for its content or method of implementation, BRM training does not fully address the challenges involved in real-life operations. Thus one of the main objectives of the report was to chart ways to affect operations on a practical level with the current training practices.

Background theories of the analysis included some of the latest models applied in improving crew operations in other safety critical industries. Questions were prepared based on these models in order to determine how the crew operates on the bridge in the real life setting, which factors determine the formation of common practices and how the actors themselves interpret their work and work environment. This enabled estimation of how the current working practices of the bridge based on experience or training supported the recent views on the features of safety critical work.

This report especially aimed to highlight the practical point of views of bridge work with regard to bridge personnel. On account of this, examination of environmental and background factors was limited only to those factors that explain the actions of the personnel, or, which were considered to affect these actions directly.

1.2 Objectives and Outlining

The point of this report has been to investigate how the current training and work directions can affect the operations of the bridge personnel on a practical level.
Objectives were:

- to assess if the common bridge practices were able and sufficient enough to address the challenges of the operational environment from the point of view of managing threats and human error,
- to assess how bridge team work should be improved and in which respects, and
- to assess the effects of the current training practices and operational directions on real-life operations.

The primary interest was on bridge team work in merchant shipping having an effect on maritime safety[1)]. The focal point of the report was on real-life working methods and ways of operating as well as on how the bridge personnel rationalises them and understands their significance. The point of view was restricted to addressing the threat factors affecting safety in real-life operations as well as to confirmation practices aiming to detect and avoid human error in critical operations. The central issues were determined to be the effectiveness and adequacy of the current work practices, factors explaining them and possible needs and prerequisites of improving the bridge team work.

1.3 Background Theories of the Report

1.3.1 Threat and Error Management Model

The first background theory of the report is the Threat and Error Management Model (image 1). The model distinguishes four different levels. External threat factors affecting the safety of operations through two mechanisms are described at the top. They contribute directly to increasing the risk levels of operations, and if managed poorly, they alone may constitute hazards or accidents. Moreover, the threat factors make the operational environment more demanding and increase the risks involved with errors made by the bridge personnel. This further increases the likelihood of accidents or hazards. From the safety point of view it is essential how the bridge personnel manages the threat factors affecting operations as well as the human errors induced by these factors. Prerequisites of safe operations include acknowledging and detecting the threat factors affecting operations, understanding their significance and applying operational practices connected with threat management in a meaningful way.

The next level of the model includes the so-called internal threats, that is, errors or defects in the operations of the bridge personnel, which may compromise the safety of operations without functioning mechanisms of error detection and management of consequences. Typical examples among the bridge personnel are deficiencies in being fully aware of the current situation. These can lead to navigational errors and further to hazards.

The third level of the model is comprised of those common practices in the operations of bridge personnel which are developed for threat and error management. Functioning bridge team work and effective resource management are in central roles in this process. Threat management involves effective communications among bridge personnel as well as anticipatory and preparatory practices helping bridge personnel in creating a common plan for ensuring safe operations in spite of the heightened risk levels. Error management includes confirmation practices involved with critical

[1] The report does not investigate operations of the bridge personnel on smaller vessels operating in the field of commercial activities, like inland passenger vessels and tugboats. See more accurate outlining from 2.2.1 Accident and incident reports.

operations, monitoring of operations or, for example, confirmations connected with communications to avoid misunderstandings.

The fourth level of the model describes the results of operations. Operations of the bridge personnel determine whether threats and errors add up to hazards, or can operations be kept safe in spite of the heightened risk levels. Errors may also cause new errors which further increases the probability of hazards.

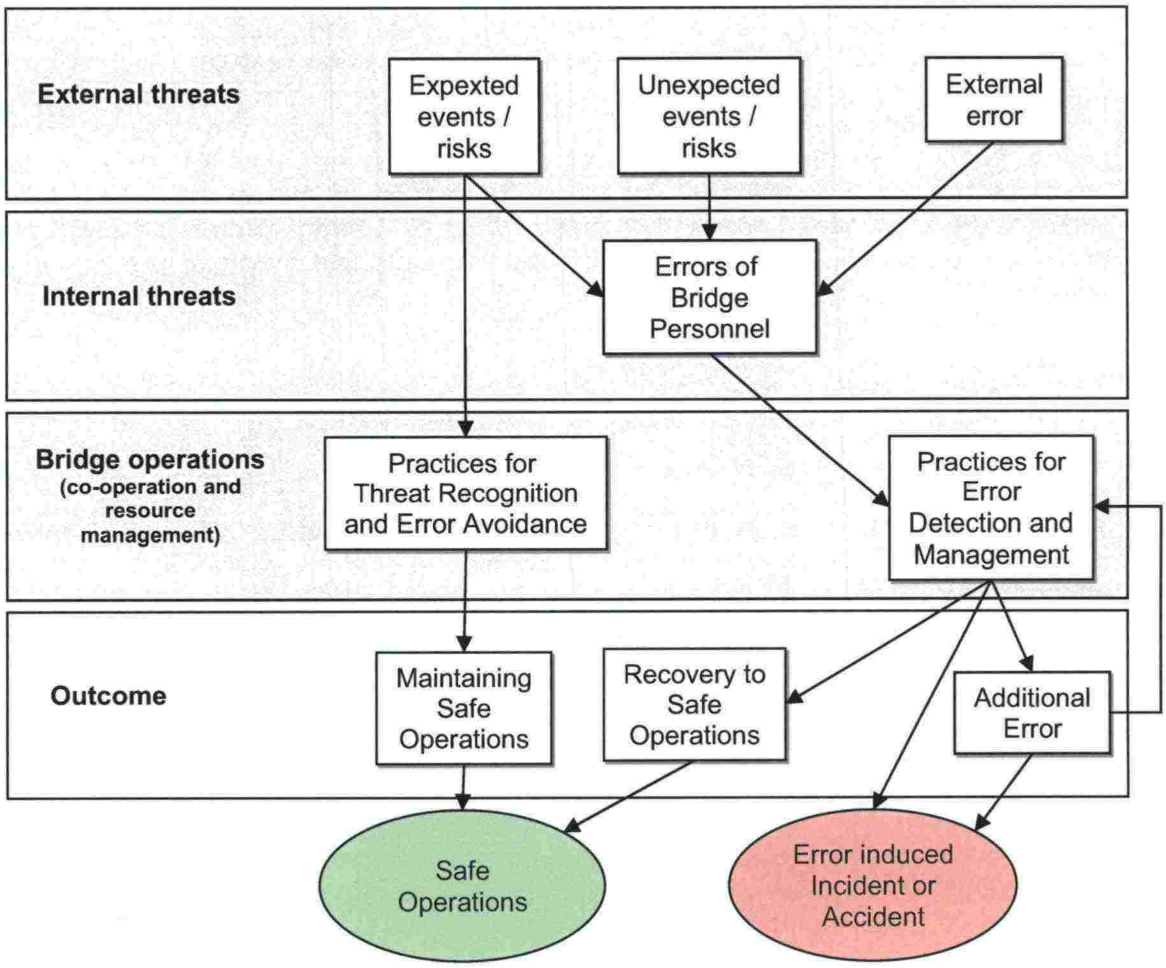

Image 1. *Threat and Error Management Model (according to Helmreich, Klinect, Wilhelm, 1999).*

Analysis focused mainly on the co-operative practices of the bridge personnel presented in the middle section of the model above. Aims of these practices are to recognize and manage threats as well as to detect and manage errors. The objective was to study the operational practices the bridge personnel use in real-life to achieve these goals. Central questions regarding operational practices include:

- Which factors in the operational environment have an effect on the operations of the bridge personnel?
- How do members of bridge personnel communicate these factors to each other?
- How are these factors taken into account in operations?
- Which human errors are typically connected with operations?
- How the errors made in operations are normally detected?
- What particular methods are used in error management?

Essential factors in threat and error management are functioning co-operation among the bridge personnel and co-operation between the bridge personnel and outside actors as well as efficient management of resources. There are various human and technical resources available on the bridge for threat and error management. These can provide essential information and help in error detection, or they can be used in workload management to avoid errors induced by excessive workloads. Use of these resources is based on operational practices helping in prioritising the available resources in a timely manner in the most appropriate way for each situation.

The framework of this report is knowingly restricted in describing operations of the bridge personnel only from the point of view of factors affecting safety and error management of the bridge personnel operations. The model used as the review reference cannot be considered as a comprehensive structural model of work, since it leaves out much of the content which is not directly related safety. However, it helps in focusing in the most essential operational practices and ways of action.

1.3.2 Classification of Human Errors

The aim of this report was to determine what kind of human errors are made at the bridge. This was considered justified because there are various conventions that can be applied to controlling different errors. By recognizing some of the typical errors it is possible to direct development measures efficiently into the most critical stages and tasks of operations.

However, it has to be noted that source books recognize several different approaches in the classification of error types. A universally excepted way of classifying human errors does not exist; each definition is best suited for the pursuit of some specific goals. According to the model used in this report, human errors were divided into the following five main groups (Helmreich, R., et al 1999):

1) intentional noncompliance errors
2) procedural errors (memory lapses, mistakes, slips)
3) communication errors
4) proficiency errors and
5) operational decision errors.

The first type of error is connected with disobeying given instructions or orders. The consciousness and intentionality of the actions is essential in classifying this error. There may be various different motives and reasons underlying the actions, and they can be connected with both the individual and the organization they work in. The person committing the misconduct may, e.g.: think that the regulation he is breaking is not relevant in the situation, commit the misconduct because his work requires it, see the misconduct as an opportunity to work better and faster, or feel that the organization expects him to break regulations in order to ensure smoothness of operations. Although intentional noncompliance errors should not be accepted on the organizational level, it is important to understand why intentional noncompliance errors are made in certain situations.

Procedural errors mean errors taking place in normal routine work of the bridge personnel. Typical errors in work routine include memory lapses, mistakes, and slips. Memory lapse means forgetting of a task, a part of a task, or an individual detail which is included in a task. A mistake means an error where a person performs successfully an operation leading to a certain goal, but the outcome of the operation does not match the person's expectations. A slip refers to a situation where a person tries to perform an operation with a certain outcome in mind, but the performance of the operation fails.

Communication errors refer to errors in internal communications (information exchange, delivery, and understanding) between the crew members of the bridge, or the communications between the bridge and other actors. Communication mistakes are situations where communication is incomplete, erroneous, unclear, or difficult to understand. Also situations in which communication does not begin in time or at all are included in this category. Typically communication mistakes are related to situations in which operatively important information has not been sent, the recipient has not received the sent message, or the recipient has misunderstood the message.

Proficiency errors pertain to explicit deficiencies in technical professional competence which might arise from personal reasons, or appear more widely in an occupational group due to deficient education or distribution of information. This type of errors differ from procedural errors in that they are not based on the failure of an acquired skill but are a consequence of a deficiency in mastering a skill needed for performing the task at hand.

Operational decision errors are situations when a significant decision from safety point of view has been erroneous or poor. These errors are to do with the process of decision making, and not so much with the fact that the expertise needed for decision making would be deficient. Typically in decision making errors not all available information is used in defining problems or assessing alternatives. Then the decision made will be based on a deficient view of the situation. Decision making errors invariably concern situations in which there are no direct instructions or procedures to follow. In situations like these the crew members have to define the problem without clear guidelines, devise possible alternative strategies, assess the risks and benefits involved as well as execute decisions and evaluate their consequences.

1.3.3 Management of Bridge Resources

The concept of resource management and the training tradition connected with it has been under development in aviation since the beginning of 1980s (Helmreich et al 1999). In its early form it was limited to the management of cockpit resources, and therefore it was originally named Cockpit Resource Management, abbreviated CRM. Afterwards the focus of the concept has been widened to include the management of crew resources, Crew Resource Management, because resources relating to safe aviation, such as cabin personnel, also exist outside of the cockpit walls.

The starting point for the need to develop a new training field was aviation accidents and hazardous situations that resulted from human errors. The presented research results indicate that problems were not in technical professional competence but in communications, decision making and leadership (Cooper, white, & Laubert, 1980). Deficiencies in these led to situations where all the available information or resources were not employed efficiently enough to ensure safe operations.

The training of resource management has later spread to other safety-critical fields, including maritime. The need to develop co-operative skills that improve resource management has been recognized also in the operations of bridge personnel.

The concept of resource management is connected with the management of human resources, but it also includes the technical systems that relate to the operations of bridge personnel as well as all the parties outside the immediate working environment offering information or work contribution which can be used in maintaining safe operations.

This report also examines how the members of bridge personnel comprehend resource management on the bridge. The aim was to find out what human and technological resources they knowingly use in managing threats and errors, and which practices they use in executing resource management.

2 Implementation

2.1 Progress of the Report

2.1.1 Stage 1 – Analysis of Accident Reports

Research was begun on Jun 1, 2006. The first stage consisted of the analysis of accident and incident reports in maritime. Some reports were chosen for further examination. These were reports pertaining to accidents in merchant shipping where bridge operations were recognized as a factor in the accident. On the grounds of the analysis, observations were made on the typical circumstances and situations underlying the accidents, and the errors made by the bridge personnel were classified. Written material concerning BRM training, directions, orders and practices was also studied in the first stage.

2.1.2 Stage II - Operational Level Interviews

In stage II of the research semi-structured[1] interviews for the maritime operational level personnel were planned, implemented and analysed. These interviews formed the main research material of this report. The operational level included people who were responsible for the operations, safety and training of shipping companies and Finnish State Piloting Enterprise, and further the masters, navigating officers and pilots involved in the operational work. The interviews were conducted between September and November 2006 at the organizations that took part in the research. The matters that were covered in the interviews were based on the observations of the first stage. The aim of the interviews was to find out:

- If the views of the operational level actors correspond to the observations of the first stage, and on what are these views based?
- If the actors bring forth further matters which were not detected in the first stage, and on what are these potential matters based?
- How do the operational level actors recognize circumstances that add to the risk level of maritime?
- What are the concrete measures taken to control the risks that relate to circumstances?
- How do the actors recognize errors in bridge work?
- What are the concrete measures taken to avoid, detect and manage errors?
- What is the meaning of BRM to the actors?
- How does the present BRM training help with the practical work?
- How should BRM training be developed according to the actors?
- What are the chances of the shipping company to affect the bridge practices?
- How do the bridge personnel see the role of the shipping company and the authorities in developing and supporting bridge work?

2.1.3 Stage III – The Interviews of Training Personnel and Authorities

In stage III of the research semi-structured interviews for the authorities and organizations offering BRM training were planned, implemented and analysed. The questions of the interview were based on the observations of the first and second stages. The aim of the interviews was to outline:

[1] The interview is based on previously prepared framework and questions, but the interviewees will be asked further questions based on their answers.

- What is the content of BRM training?
- How is BRM training organized?
- How is BRM training transferred into the practical work of the bridge personnel?
- Does BRM training fit the requirements of operational work in relation to the accident statistics and the views of the operational actors?
- What has been achieved with BRM training?
- How should BRM training be developed?
- What are the major challenges in BRM training?

2.1.4 Stage IV – Conclusions and Report

In the fourth stage observations made during the research work were analyzed as a whole, the needed additional interviews were conducted and other material collected. A report based on the analysis was written. The research was concluded on Jan 26, 2007, when the report was handed over to the customer.

2.2 Research Material and Participants

2.2.1 Accident and Incident Reports

In the first stage of the research work the reports of Accident Investigation Board Finland (AIBF, in Finnish Onnettomuustutkintakeskus OTK) on accidents and hazardous situations in maritime were studied. The data consisted of all the reports that had been completed during the existence of AIBF (103 altogether), which had been published on the AIBF website (http://www.onnettomuustutkinta.fi/2601.htm) by Jul 31, 2006. 52 reports were chosen for further study, on the grounds of the following criteria:

- Only accidents that involved merchant ships were chosen. All the accidents that had happened to leisure boats or Navy and Coast Guard vessels were excluded, except the accidents (collisions) between a merchant ship and e.g. a yacht. In these cases the accident was analyzed partly from the point of view of the leisure boat.
- Only those merchant ships were included whose deck officers were required to meet the qualifications of a watchkeeping officer at least. This criterion excluded almost all the accidents that had happened to inland passenger vessels, tugboats and fishing vessels. This exclusion was justified with the fact that BRM training is available only in the training of watchkeeping officers.
- Also most accidents involving cargo or caused by a technical fault, a fire etc. were excluded. This exclusion was justified with the fact that in these cases bridge work did not have a clear effect on the accident.
- Accidents clearly caused by fatigue or falling asleep were also excluded. This was justified by the fact that the causes and control of these accidents do not directly relate to the aims of this report. However, fatigue has been taken into account in the analysis of hazardous situations or accidents in which it has had an effect on e.g. decision making.

2.2.2 Shipping Companies

Seven Finnish shipping companies were invited to take part in the research, and all of them participated. All these shipping companies have a well-defined and well-functioning land organization, and they are all experienced shipping actors. The shipping companies included both passenger companies and cargo companies. Two or three deck officers of each company were interviewed, i.e. captains and navigating officers. In addition to this, one land organization officer responsible for bridge directions and/or training was interviewed.

2.2.3 Finnish State Piloting Enterprise

Piloting was studied by interviewing two of the Finnish State Piloting Enterprise pilots and two members of the administrative staff responsible for directions and training of piloting. The amount of pilot interviews was only two, because two studies had been made earlier concerning piloting operations (OTK, 2004 and VTT, 1998). Furthermore, on the grounds of the aim of the report, the study of piloting operations was only conducted in its limited function as a factor in the bridge operations of merchant ships.

2.2.4 Training Organizations

Four navigational training organizations were invited to take part in the research, and all of them participated. People responsible for BRM training from Kymenlaakso and Satakunta Universities of Applied Sciences, Sydväst Maritime, and Meriturva Maritime Safety Training Centre were interviewed for the report. All these training organizations offer BRM training for both professional navigation students and shipping companies. Meriturva Maritime Safety Training Centre does not offer professional navigational degree courses.

2.2.5 Authorities

The point of view of the authorities was included by interviewing three officials from Finnish Maritime Administration. The interviewees came from different functions of the organization, from Vessel Traffic Management and Maritime Safety and Security. The interviewees from Maritime Safety and Security represented both Maritime Inspections Division and Seamen's Division.

2.2.6 Legislation

In the first stage of the research it was examined what kind of legislation concerning bridge work exists and how the legislation directs the BRM operations on the bridge. There are several regulations that concern bridge operations, of which the following are essential from the point of view of BRM operations:

- Maritime Law (674/1994),
- Decree on the Manning of Ships, Certification of Seafarers and Watchkeeping (1256/1997),
- Decision of Ministry of Transport and Communications Finland on Manning Ships, Crew Qualifications and Watchkeeping (1257/1997),
- Pilotage Act (940/2003),

- Government Decree on Pilotage (982/2003),
- Vessel Traffic Service Act (623/2005),
- International Regulations for Preventing Collisions at Sea, 1972,
- STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers),
- SOLAS (International Convention for the Safety of Life at Sea),
- ISM Code (International Safety Management Code 2002) and
- HSC Code (International Code of Safety for High-Speed Craft 1994).

2.3 Method

2.3.1 Methodological Foundation

The methodological foundation of this research was a problem-based study of operations which was directed at predetermined operational practices of the bridge by the usage of a selected research framework. Through this approach it was examined how the bridge personnel understand and interpret their actions and their operational environment. It was also examined how they describe their working methods with which the risks involved in human performance on the bridge could be controlled. By examining the prevailing practices it is possible to formulate models and measures that will help in the further development of operations and practises.

The prevailing practices were studied via interviews. From them it was also possible to examine the opinions and conceptions that underlie the practices. On the grounds of the interviews, it was possible to examine what was the role of experience, training, or the directing of the operations of the organization in the formation of the practices. Thus it was also possible to assess the influencing mechanisms in the organized development of work practices. By comparing our results with the theoretical models on which our research was based on, it was eventually possible to assess the prevailing conceptions and practices of safety in relation to the goals and principles of threat and error management. Accident and incident reports were also used in examining the work practices.

2.3.2 Data Collection and Analysis

The main body of research material consisted of interviews of experts which were conducted in all the organizations that took part in the study. Data was collected during September-November 2006 by visiting all these organizations. The interviewees represented both the operative level actors and training organizations as well as authorities.

The research material preceding the interviews included accident and incident reports of Accident Investigation Board Finland, which were published on the web pages of the Board (www.onnettomuustutkinta.fi) by July 31, 2006. 52 reports were examined further (see section 2.2.1, Accident and Incident Reports). The selected reports were studied, and special attention was paid on the chain of events and operations on the bridge. The following information was searched in each report:

- Type of accident (grounding, collision, capsizing/sinking, other hazardous situation);
- situation / operational environment (departure or arrival to the port, piloting, navigating in confined waters (not piloting), navigating at open waters, other situation);

- crew on the bridge (watchman, mate, master, pilot, other crew member, bridge crew in total);
- nationality of the vessel / crew / shipping company;
- circumstances or other factors that had an effect on the accident (poor visibility, twilight or darkness, wind, snow, sleet, or rain, current, effect of ice, traffic situation, heavy or disturbing radio traffic, other distracting factors);
- other factors that had an effect on the accident (technical fault, system or equipment deficiency, special qualities of the vessel, lack of control of the ship system, deficient skills and knowledge, lack of training or practising, fatigue, problem in bridge team work, deficient directions, lack of standard procedure, lack of memory-based emergency procedure, too small crew at the bridge);
- location of essential information pertaining to prevention of the accident (a person at the bridge, at the bridge, at the engine room, on another ship, Vessel Traffic Service, other location);
- deficiencies in so-called non-technical skills: co-operation, leadership and managerial skills, situation awareness, decision making (Flin et al, 1998);
- deficiencies in threat and error management (anticipation of threats and errors, control of threats and errors, control of non-safe spaces) and
- type of human error (intentional noncompliance errors, procedural errors, communication errors, proficiency errors, operational decision errors).

Summaries of the circumstances and causes of accidents were made on the grounds of the gathered information. Deficiencies in so-called non-technical skills and the management of threats and errors as well as the types of human errors were considered as individual cases. Summary was not made on these factors, as their role in accidents was not necessarily included in the report.

The 52 reports chosen to be examined further were:

- 2004: B1, B7, C3, C4, C7
- 2003: C4, C6, C8 (two separate cases), C9
- 2002: C2, C3, C9, C10, C11, C12, C13
- 2001: B1, C4, C9, C20, C14, Finnreel (MAIB examined)
- 2000: B2, B5, C1, C2
- 1999: C6
- 1998: B1, C1, C2, C4, C5, C8, C9, C10, C11, C13
- 1997: C1, D2, C4, C6, C7, C11, C14, C15, C16
- 1986-1996: 1/1995, 2/1995, 3/1995, 1/1994, Estonia

In the second stage of the research, after the analysis of the research material, the interviews of the operative level officers were planned and conducted, i.e. the personnel of shipping companies and Finnish State Piloting Enterprise. The interviews were semi-structured. The interviewees were first asked open questions, which were then further specified with follow-up questions. As concrete examples and descriptions as possible of the views and practical level work of the interviewees were sought with the follow-up questions. The interviews covered matters brought forward by the interviewees themselves as well as the observations that surfaced in the first stage analysis of the accident reports.

In the third stage the interviews of training organizations and authorities were planned and conducted. The authorities' interviews were also semi-structured in the same way as the second stage interviews of the operative level staff had been. The training organizations were sent their questions before the interviews, because the questions also concerned factual information on BRM training which would have been difficult to present from memory.

The interviews were confidential. Most of the interviews were made in person, with the exception of Meriturva Maritime Safety Training Centre where the answers were given in writing only. In addition to this, the Kotka BRM training organization was interviewed on the phone. The people present at the interviews were the interviewee and a representative of Huperman. At some interviews there were two Huperman representatives present. All the interviews were recorded and later transcribed. After this, a summary was made of the interviews, where the answers to the same questions were pulled together.

3 Findings and Analysis

3.1 Threat Management

3.1.1 Circumstances that Have an Effect on Safety

In this report the factors that increase the risk level of shipping were examined from the point of view of the factors influencing the actions of bridge personnel. Circumstances that have influenced the actions and performance of the bridge personnel have been defined as threat factors, according to the threat and error management model (see section 1.3.1. Threat and Error Management Model). Threat factors are factors that exist outside the crew members' power and elevate the risk level of the crew members' operations. For the crew the factors can be very ordinary and expected, or rare and surprising. The bridge personnel under study also found the errors of other actors which were connected to their work as threat factors. Typical threat factors having an effect on accidents are different working conditions.

Threats influence safety via two mechanisms: Threats bring risk factors into the operations, and if not managed appropriately, may by themselves cause a hazardous situation or an accident. Furthermore, threats require higher level of competence in the work done in the operational environment and add to the risk of errors made by the crew. These in turn add to the likelihood of an accident or a hazardous situation.

On the grounds of the accident and incident reports, conditions have a great effect on the hazardous situations and accidents of sea traffic. In nearly all the accidents chosen to be studied in this report an external factor had an effect on the accident (image 2), such as weather conditions (hard wind and poor visibility), ice conditions, current, confined waters, traffic conditions, heavy radio traffic, or some other individual factor (e.g. poor channel alignment or a faulty navigational aid).

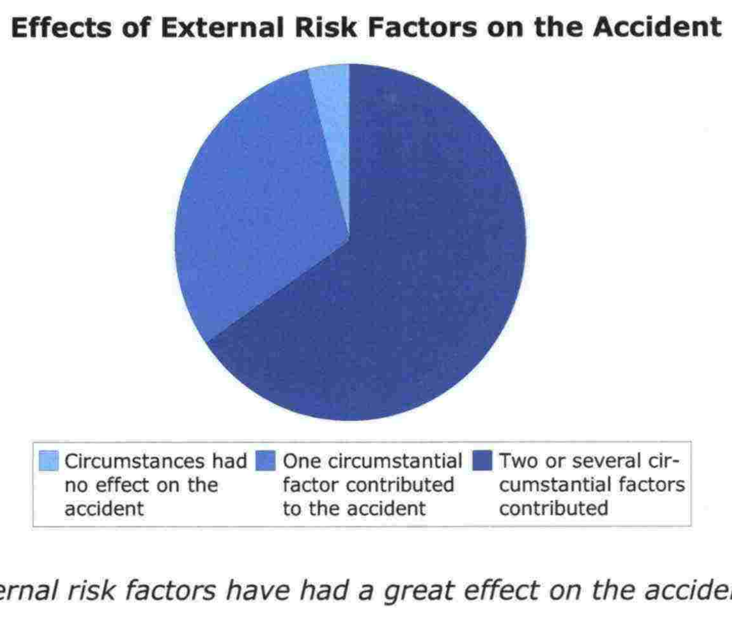

Image 2. *External risk factors have had a great effect on the accident.*

The following figures illustrate the presence of some of the most significant circumstantial or conditional factors in accidents. On the grounds of the analysis of the accident and incident reports, most of the accidents (92%) happened in an archipelago or in confined waters (image 3). The challenges of navigating in confined waters were also invariably brought out in expert interviews.

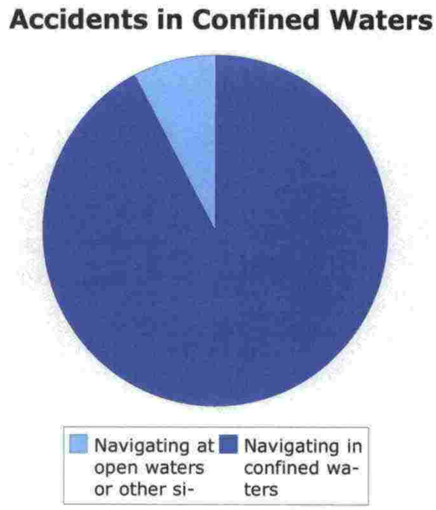

__Image 3.__ Accidents happened mainly in confined waters.

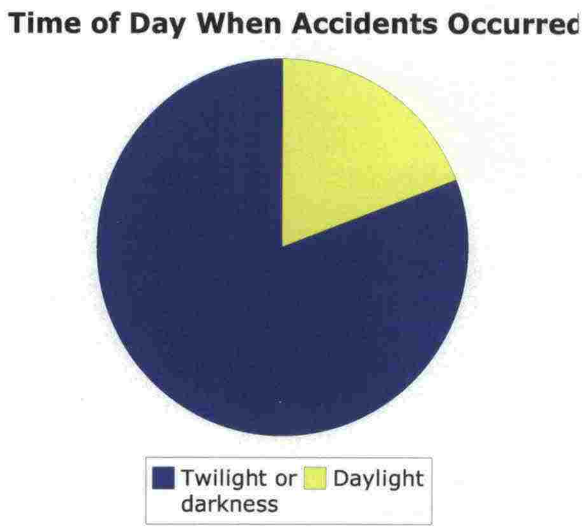

__Image 4.__ A significant amount of accidents happened during twilight or darkness.

On the grounds of analysis of the accident and incident reports it was discovered that most of the accidents happened during dusk or darkness (image 4). However, it was not possible to determine whether darkness had an effect on these accidents based on the reports. The opinions of the interviewees were divided on the matter of an elevated risk level due to darkness. Some thought that darkness did not have an effect on the risk level of operations, because driving in the dark is a part of the normal operations, and on the other hand, the lights of vessels and safety equipment make it easier to navigate the vessel during darkness. Others felt that darkness increased the risk of operations, because then some of the smaller vessels may be left unnoticed, and also judging distances is difficult.

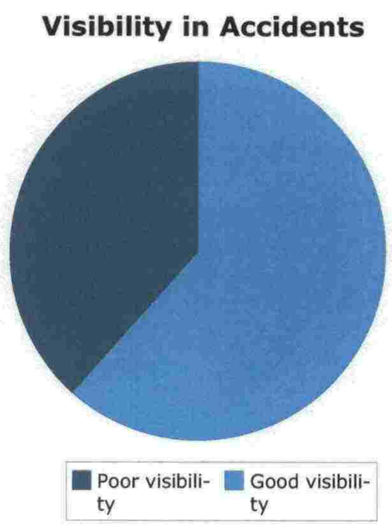

__Image 5.__ Almost 40% of the accidents happened in conditions of poor visibility.

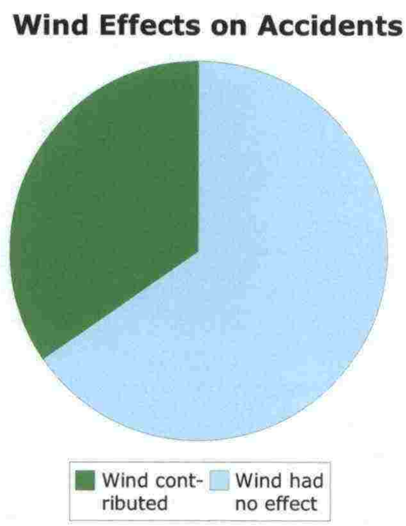

__Image 6.__ Wind had an effect on most of the accidents in our research material.

More than a third of the accidents in our research material accidents happened in conditions of poor visibility (image 5). The interviewees agreed on that poor visibility adds to the risk of operations, and it poses a threat to safety.

Experts mentioned in the interviews that other weather conditions that add to the operations risk level include wind (see image 6), rough seas, and ice conditions. Heavy traffic, fishing boats that behave unexpectedly, and errors made by other vessels such as ignoring the obligation to give way, were brought out as the risk factors caused by other seafarers. Some of the interviewees also mentioned fatigue, tediousness of watches and lowered alertness levels as a result of this, technical failures, automatic alarms, and some unexpected events such as sudden illnesses or fires (more usually happens on passenger vessels) as factors of elevated risk levels. Many interviewees felt that entering and leaving ports as well as piloting were operations susceptible to risks. They felt that the embarkation and disembarkation of the pilot are especially risky, particularly in rough seas. In addition to this, some interviewees felt that piloting elevates operations risk levels because it breaks the normal work routines of the bridge: the pilot is not a member of the normal crew, their role is not considered clear, and the pilot often practically replaces the navigating officer from his driver's seat. Some also felt that as the pilot is not as familiar with the ship as the ship's own bridge personnel, it is possible that this causes problems during piloting.

3.1.2 Threat Management on the Bridge

Threat management means the operations of the bridge personnel with which they try to minimize the risk posed by threats. Threat management includes threat recognition, comprehension, and the choice and use of a suitable operational strategy or procedure with which the threat is avoided, or with which the negative effects of the threat on safety are minimized.

During expert interviews it was noticed that threats are recognized well, but that bridge operations are not changed determinedly to match the elevated risk level. This was noticeable also in the analysis of accident reports. There are different controlling methods used inconsistently on the bridges that relate to risk consideration. Some of these practices are fairly sophisticated, and others are very deficient. Most interviewees mentioned that general alertness and watchfulness increases, and the amount of bridge crew will be increased if necessary. Usually this means summoning the master to the bridge. However, bridge operations are clearly altered only when a so-called two navigator system, also called the pilot – co-pilot method, is used (this is used on both cargo and passenger ships; on cargo ships one of the navigators is the master (and the other is the watchkeeping officer), and on passenger ships usually the company's own pilot).

The interviewees mentioned the following individual practices (among others) in threat management:

- In the dark a lookout comes to the bridge (required in STCW Code, section 8),
- On conditions of poor visibility a lookout is usually summoned to the bridge, and the master is notified at least when visibility decreases under certain level (most often 2 miles). The master makes the decision to stay on the bridge or leave according to the situation.
- When driving in a narrow channel almost all shipping companies use the so-called two navigator method when one person is responsible for steering and

the other for monitoring. Narrow fairways usually involve the obligation to use a pilot. Using a pilot can also be considered as risk management method.

- In hard wind and rough seas the master usually comes to the bridge. In situations like this (as well as in other situations which require his presence on the bridge), the master's role may be that of the monitoring officer (the so-called pilot – co-pilot method) or a supporting officer / adviser, depending on the practices of the shipping company, the vessel, and on the master himself. In some cases the master may have responsibility of steering, and usually the navigating officer will then act as the monitor. If there already are two navigators on the bridge, the company's own pilot and the watchkeeping officer, the master does not have a clearly defined personal role as the third member of the commanding team. Then he rather takes on the role of a supporter / adviser.
- In hard wind the control will be changed to manual steering if necessary, and operations are more focused on steering the ship.
- If the ship enters port in hard wind, some shipping companies use a distribution of work where the steering officer (usually the master) will concentrate on steering the ship and the other officer on the bridge on monitoring the situation (e.g. other traffic) more extensively.
- In ice conditions there is usually a lookout on the bridge prepared to assume the duties of a helmsman, if necessary. The master may also be present on the bridge, if necessary.
- In a heavily trafficked area the lookout or the master will add to the bridge crew.
- If fishing boats or other vessels cause difficult situations, the watchkeeping navigations officer may summon the master to the bridge.
- Fatigue and the tediousness of watches were considered so typically a part of the work at sea that the interviewees felt that everyone should just be able to cope with them themselves. If necessary, a lookout or the master may be called in to give assistance.
- Automatic alarms are usually dealt with by the watchkeeping personnel themselves. In situations which require special attention the master is called to the bridge.
- Unusual events on the ship, such as a technical failure or a sudden illness, usually change the work routines on the bridge. Depending on the situation and the practices of the shipping company, the master usually takes command and decides on necessary measures together with the bridge personnel.

On the grounds of the research, the shipping companies have not given special directions on how to manage threats or operations in risky conditions. However, the amount of directions given varies according to the companies. Some individual procedures were found on which directions had been issued. They were to do with threat management or operations under risky conditions. Mostly the directions related to the bridge crew and often to the calling of the master (also mentioned in watchkeeping regulations). Furthermore, directions have been given on distribution of work, responsibilities, and tasks. Implementing the directions in practical work has been left to the bridges and to the responsibility of the masters of vessels. In the interviews the masters mentioned they considered the current level of direction too general, and some wished for clearer directions.

The ISM Code of the SOLAS Convention requires that the shipping companies establish plans and instructions for shipboard operations (section 7). The code does not clarify, however, what kind and what level directions are required, and the code does not contain instructions for application. Therefore, the shipping companies cannot offer more defined instructions for the definition of directions based on the requirement of the authorities. In connection with the safety management systems audits, the authorities may give direction or offer advice on the practical operations, if necessary.

In the research it was noted that professional maritime training does not include training in threat management. The reason for this might be that the framework of threat and error management is under the process of entering many safety critical industries, where it could be used as a development tool for operations and training. Training does include preparations for different situations, or operations in unusual situations, but it is not systematically examined what kind of threats bridge operations contain, and with what methods these threats can be managed. Even BRM training does not include the point of view of threat management.

3.2 Error Management

3.2.1 Error Types in Bridge Operations

An adapted version of Helmreich Error Classification Model was used in this report to divide errors in five different main groups: 1) intentional noncompliance errors, 2) procedural errors which include memory lapses, mistakes, slips, 3) communication errors, 4) proficiency errors and 5) operational decision errors (Helmreich et al, 1999). All these error types were found in the accident and incident reports. The least deficiencies were found in knowledge and skills. The amount of other error types was almost equal.

Within our research material, it is not possible to report exact statistics on the errors found in the reports. All the errors made in connection with an accident may not have been mentioned in the reports, and a report-based analysis of errors that had an effect on the accident is difficult to do afterwards. The errors found in this research, however, give some indications as to the effects of errors on accidents.

Expert interviews supported the analysis of accident and incident reports. Errors in the realm of skills are fewer than other errors. The interviews also showed that seafarers' awareness of different errors is not extensive. Actors found their own actions and errors in their own performance especially difficult to analyze.

When considering the importance of errors in safety it is good to separate errors and their consequences from each other. Some errors may occur often, but their consequences are not common. Then again some rarely-occurring errors may in all likelihood lead to consequences. It is important also to take the seriousness of the consequences into account.

3.2.2 Intentional Noncompliance Errors

Intentional noncompliance errors mean such activity, actions committed or operations left undone, that the member of the bridge personnel knows to be against the directions or regulations that concern him. The consciousness and intentionality of the actions is essential in classifying this error. Various motives and causes may be behind the misconduct that can pertain to the individual or to the organization. The person committing the misconduct may, e.g.: think that the regulation he is breaking is not relevant in the situation, commit the misconduct because his work requires it, see the misconduct as an opportunity to work better and faster, or feel that the organization expects him to break regulations in order to ensure smoothness of operations. Although intentional noncompliance errors should not be accepted on the organizational level, it is important to understand why intentional noncompliance errors are made in certain situations. By understanding the motives and influencing them it is possible to cut down on the amount of intentional noncompliance errors.

On the grounds of the accident report analysis, intentional noncompliance errors most often concern the neglect of the route plan (OTK 2002c, 1998d and 1998g, among others). First of the three of the most frequent intentional noncompliance errors is the neglect of watchkeeping in one way or another (e.g. the neglect of lookout or the leaving of the previous watchman before the new one has had a chance to familiarize himself with the situation; OTK 2002d and 2001b). The second is failure to follow regulations concerning resting time (and thereafter working in a fatigued state, due to this, OTK 2000b), and the third sailing with too small a bridge personnel (usually a lookout or helmsman was missing; e.g. OTK, 1998e). Other individual intentional noncompliance errors included using Finnish in a piloting situation, although the shipping company regulations required the use of English (Sjöfartsverket, 2003), and failing to use a so-called dead man alarm, although regulations stated that it should have been on in all situations where there were only one person on the bridge (OTK et al, 2000a).

The interviews also revealed some intentional noncompliance errors. These were e.g. letting another vessel too close when navigating in fog or in ice, neglecting watchkeeping by doing something else at the time, such as paperwork, and neglecting the monitoring of piloting against the directions of the shipping company. English accident investigators (Marine Accident Investigation Branch, MAIB) have also noticed that bridge crews commit such intentional noncompliance errors. In their 2005 report (MAIB, 2006) it is stated that well-trained navigations officers, who have proper equipment and who had been given a lot of support in their work, for some reason did not follow regulations and neglected some of the very basic tasks, such as watchkeeping.

3.2.3 Procedural Errors

Procedural errors mean errors taking place in normal routine work of the bridge personnel. Typical errors in work routine include memory lapses, mistakes, and slips. A memory lapse means the normal forgetting of a whole task, a part of a task or an individual detail included in a task. A mistake means an error where a person performs successfully an operation leading to a certain goal, but the outcome of the operation does not match the person's expectations. A slip refers to a situation where a person tries to perform an operation with a certain outcome in mind, but the performance of the operation fails.

On the grounds of the accident report analysis, procedural errors have had an effect on the accident in several cases. For instance, memory lapses were involved in accidents in situations where the bow thrusters control was forgotten to be changed from the bridge wing to the centre console (OTK, 2004a), or the steering control was forgot to be switched from the autopilot to the manual steering (OTK, 2004b). Mistake type errors were found e.g. in accidents that related to monitoring maritime safety equipment. In one case a green sector light was mistaken for a green buoy light (OTK, 2003a), and in another two similar buoys were confused with each other (OTK, 1997c). Other errors included e.g. making a mistake with the radar scale, and therefore getting the distance to the turn reference wrong (OTK, 1997a). An example of a slip was the turning of a NFU steering lever to the left by accident, when it should have been turned to the right (OTK, 1997a).

Most of the interviewees named procedural errors the most typical errors in bridge work. The most important errors mentioned were mistakes in stating helm commands, and mistakes in setting the direction to the autopilot. Furthermore, several interviewees mentioned errors that related to the observation of other vessels or targets. Connected to these, at least partially, were situations where a turn was not tight enough or the vessel started the actions to avoid the collision too late. Also errors in the estimation of speed were recognized as typical errors by several masters of ships.

3.2.4 Communication Errors

Communication errors refer to errors in internal communications (information exchange, delivery, and understanding) between the crew members of the bridge, or the communications between the bridge and other actors. Communication mistakes are situations where communication is incomplete, erroneous, unclear, or difficult to understand. Also situations in which communication does not begin in time or at all are included in this category. These errors are typically found in situations where operatively important information has not been sent, the recipient of the information has not received the message, or the recipient misunderstood the message. It is typical in situations relating to communications errors that bridge personnel or other actors possess relevant information for the situation, which is not be used in the situation.

The accident report analysis was rich with communication errors. In general, it was possible to notice after many accidents that discussion on the bridge was very scarce (e.g. OTK, 2004a and 2002b). This was also implied by the fact that there was no discussion between bridge personnel on the changed circumstances or situations. Examples of this are accidents where the effects of hard wind conditions (e.g. OTK, 2002a, 2001a and 1997c), or traffic situation (e.g. Sjöfartsverket, 2005) had not been discussed. Communications errors were found in piloting situations, too. In the investigation of several accidents it had been noted that preparation for pilotage had been deficient. The ship's crew did not give enough information to the pilot on the characteristics of the ship (e.g. OTK, 1997b and 2002c), or the pilot had not told the crew enough about the route, or the route was not discussed at all onboard (e.g. OTK, 1999 and 1998b). In addition to this, it was noticed that in two accidents the discussion on engine or equipment failure was not sufficient between the bridge and the engine room (MAIB, 2002 and OTK, 1998a). The engine room crew had information on the situation, but for some reason only a part of it was given to the bridge. Then again the bridge possessed information which would have helped in assessing the situation in the engine room.

In the interviews the problems of communications were mostly related to situations where there were two navigators on the bridge. Many interviewees mentioned that then the monitoring officer might, for instance, assume that the steering navigator has also seen the oncoming vessel, and therefore fails to mention it. This communications mistake does not always have consequences, if the assumption is correct, but if the steering navigator has not noticed the vessel in sufficient time, the consequences may be very severe. These kinds of situations were reported to occur in piloting. Then the lack of discussion was considered to relate more to a hindrance in communications caused by authority gradient, and to the fact that the bridge personnel trust the skills of the pilot too much.

3.2.5 Proficiency Errors

Proficiency errors form a group of errors which refer to erroneous action resulting from deficiencies in professional competence and knowledge. The deficiencies may be caused by either personal reasons such as motivation or abilities, or organizational reasons, such as the quality or quantity of guidance and training.

Accident reports contained only a few errors resulting from proficiency errors of the bridge personnel. In some accidents the skill of using the emergency steering equipment was deficient (e.g. OTK, 1998a and 1995). Furthermore, in some accidents the crew was not able to use the automated systems properly (e.g. OTK, 2001a, 1995). These cases seem to be caused by deficiencies in the organizational level. In order to exclude the relevance of training and directions in these cases, it should be shown that these operations had been determined as training goals, and that they were a part of the basic training and revision which the personnel were given.

During the interviews, experts did not mention directly any errors relating to skills, but several interviewees described the ever increasing and more and more sophisticated automation as a problem. Regarding automation, which is meant to increase safety and make the work easier, as a problem may be due to lack of training.

3.2.6 Operational Decision Errors

Operational decision errors are situations when a significant decision from safety point of view has been erroneous or poor. Thus, this error relates to the process of decision making, i.e. the consequence following the decision does not in itself mean a poor decision or an error in decision making. Situations and errors cannot be treated as decision making situations or errors, if sufficient time has not been given to the making of the decision, or alternative ways of action have been unavailable. An error in decision making also occurs if a decision is not made although the situation calls for one. A good decision making process includes defining of the decision situation (the problem), defining the options, defining the risks involved in the options, a plan of action and implementation, timing, monitoring of the situation (the requirements of the decision), monitoring of the consequence of the decision, and the reassessment of the decision. From the point of view of the bridge team work, good decision making should be reflected in the communications of the bridge personnel.

Several decision making errors were found in the accident reports. Some of these were related to the deteriorated circumstances. The ship's voyage was continued despite the poor weather conditions for navigation and steering (e.g. OTK, 1998d, 1998e and 1997b), or berthing was attempted although the wind conditions were extremely difficult (e.g. OTK, 2004c, 2002a and 1997c). In addition to this, in some accidents the bridge crew could have chosen an alternative, safer route in the present conditions, but for some reason did not wish to do so (e.g. OTK, 1999 and 1998f).

Experts did not mention decision making errors in the interviews. However, in some interviews it was noted that the decision of staying in the port in hard wind can be difficult to make. On one hand this can relate to the pressure of keeping the schedule, and on the other hand to certain kind of professional identity – a conception that a professional can control the ship and the situation in more difficult circumstances, too.

3.2.7 Detection and Management of Errors

Error management means the actions of the bridge personnel with which they try to avoid and detect human errors and minimize their consequences to the safety of the operations. Error management is based on the understanding of the errors people usually make. Error management includes the recognition of situations and circumstances in which the making of an error is likely or possible, and the outlining of the possible consequences to safety. On these grounds such a plan of action is chosen with which the possible error will be detected efficiently and early enough, and the possible consequences of the error can be prevented or minimized.

Typical error management practices are timing of the work, managing of the work load, checking procedures, preparation methods, and check lists. Error management methods can be used in individual work performances, but the co-operative methods specifically designed for error management bring significant synergy and safety margins into the bridge work.

During the interviews the experts were asked what kind of errors are usually made on the bridge, and what is the typical way of detecting these mistakes on the bridge. Answering these questions was difficult for the interviewees, because they did not have a clear conception on what the different forms of human errors are. They were able to answer the questions once the subject was clarified and they were given alternatives: is the error usually detected by another member of the bridge crew, or does the person who made the error detect it himself, is the error detected because of an automated error message or possibly after a situation has resulted from the error. The majority of the interviewees felt that most often the error is detected by another member of the bridge crew. This is the case especially when the pilot - co-pilot method is used (there are two navigators on the bridge, who may be e.g. the master and the navigating officer, or the company's own pilot and the navigating officer). Many also felt that people usually detect their own errors at some point, usually after a situation has arisen in consequence of the error. For instance, if a turn has been started too early, it will be detected during the turn, when the turn is not following the intended plan. Or, when there is a situation of reduced alertness, the oncoming vessel is noticed only when it has passed the limit of the normal safe distance. This does not necessarily lead to the failure of the action to give way, but the planning and executing of the manoeuvre has to be done in less time than usually.

On the other hand there were only few predetermined and previously instructed error management methods used on the vessels. In practice, it was noted that there was a varying number of good error management practices in use. The interviews revealed that although all vessels were using some working methods that improve error management, they were not necessarily considered as error management methods. Often the method used was meant to be a practice that would improve safety in general, and it was not meant to prevent a certain error or its consequences. Several interviewees felt that BRM practices are practices which attempt to prevent errors. However, they could not define more closely what would be the effect of different practices on error management.

The most distinct error management method used on all vessels was the check list. Check lists had been made at least for departure procedures, but most vessels also had a check list for arrivals. Other check lists concerned e.g. the changing over the watches, pilotage, and approaching to open seas or coastal waters. The lists were made to ensure that all the important tasks in the situations in question had been done. Almost all the interviewees revealed that the so-called closed loop communications principle (the recipient of the message repeats the key elements of the message) is an important method of ensuring the correctness of communications. However, this general level communications principle had not been more closely defined as far as the contents of the message and the situation were concerned. The interviewees also mentioned that there are some call-outs that are used onboard the vessels. These expressions are not officially defined, however. Monitoring of other members of the bridge crew or the pilot seemed to be an error management method in some situations. Often monitoring was not considered as an action performed in order to detect and avoid errors, and it was not specified as monitoring of predefined critical operations in certain situations. The interviewees presented also other error management practices. For instance, one master had acquired a method of visually enhancing the direction message by pointing a hand to the direction where the ship was turning.

It was significant that although some working methods were considered good, their usage was required, and training was provided, they had not been written down as official directions. The writing down, instructing, and systematic use of good work practices did not seem to be part of the shipping companies' policy.

When reviewing the contents of maritime professional training it was noticed that training does not support the error management work on the bridge. The present BRM training includes short sections on the limitations of human activity, types of human errors, and error management on a general level. However, the training does not systematically cover the real-life operations used for error detection and management.

3.3 Management of Bridge Resources

Management of bridge resources is defined as the use of all the generally available human and technical resources to ensure safe and efficient operations. All such operations that are to do with the use of people, information or equipment can be classified as resource management. On the grounds of the accident and incident reports and expert interviews, in this report observations were made on different resource management practices which are classified under the following headings: Communications Practices, Monitoring Practices, Lookout, and The Use and Management of Automation.

3.3.1 Communications Practices

In safety critical operational environments within the realm of the crew's work there are numerous situations in which significant information to the operations is transferred either between the members of the crew or between the crew and an external actor. As the information is transferred via communications between people, there is a generally recognized risk of misunderstandings. In order to avoid them, many different communications procedures have been developed in several industries. Call-outs (short standardized words or word pairs) and standard phraseology (standardized ways of expressing critical messages) are the most common methods used to avoid misunderstandings.

In maritime call-outs and standardized phraseology are used only little. However, in radio traffic standardized English phraseology is generally used. In internal communications there are some standard phrases used in different commanding situations, such as when giving steering or helm orders or orders for berthing and unberthing.

In safety critical environment it is important for the message sender to make sure that the recipient has received the message and understood it correctly. To ensure this a procedure is used where the recipient shows the sender that he has received and understood the message correctly by repeating the key content of the message. This way, by listening to the reply, the sender may be assured that the communications has been successful. This so-called closed loop communications principle appears to be well-known in maritime. It is likely that the fact that the importance of this principle is emphasized in BRM training has an effect on this matter. This communications principle is applied onboard vessels e.g. in situations when there is two officers on the watch. Then the officer responsible for steering states aloud what he is going to do, and the monitoring officer repeats the gist of the intended procedure.

One significant problem in communicating critical information is the lack of communications. This was detected as having had an effect on several accident reports analysed for this study (see section 3.2.4 Communication Errors). Speechlessness was also named in the interviews as a commonly recognised problem on the bridge. Experts believed that the reason for this is the prevailing authority relations that have an effect on the communications atmosphere and make it harder to communicate openly information which is considered significant. On the other hand, it was also mentioned that there were very different opinions within the bridge personnel on which matters require communicating.

The problems of communications have been tackled at BRM training courses. The features of good communications are covered in the training (a suitable atmosphere, an interactive situation, the closed loop communications principle). Also the importance of briefing and debriefing is emphasized in the training. However, training focussing on attitudes and describing principles does not seem to increase communications as desired. Although the personnel working on the bridge have been given BRM training for over a decade, and all the interviewees had received BRM training, the lack of communications was still seen as a major problem.

In order to improve communications, the situations where it is needed should be defined better. Training and directions should clearly state what, why, and when matters should be communicated and how communicating should be done in order for it to be efficient and safe. Consciousness of the importance of communications is not enough. It became clear during the interviews that although the importance of communications is recognized and the working procedures support open communications, some of the important information is still not communicated further. The reason for this usually is that the bridge crew members feel differently about what information is so essential that it should be communicated to other crew members.

3.3.2 Monitoring Practices

Monitoring refers to the actions of a member of the bridge crew with which he tries to follow and check the events and work in the operational environment. As a concept monitoring can be divided into passive or reactive, and active or anticipatory monitoring.

The difference between passive and active monitoring is related to the control over the human observation process. In a normal situation, it is often difficult for an observer to notice the difference between customs, but in several situations where active monitoring makes it possible to manage an exceptional situation, passive monitoring does not lead to good results.

Passive monitoring means the general following of the operations. The general level following is based on the presence of the monitoring officer and on stimulus-based reacting in situations where a deviation from the normal situation or another such event gives a stimulus strong enough to catch the attention of the monitoring officer. This stimulus can be e.g. a system warning. Weaknesses of passive monitoring are the inability to notice small and slowly-occurring deviations, the inability to react quickly to situations that demand speed, and the decrease in alertness in a monotonous environment.

Active monitoring means an activity when a member of the bridge crew pays conscious attention to individual, previously assigned targets the state or function of which he monitors or checks at certain designated times. When the person monitors several things at the same time, he switches the targets at regular intervals. In order to improve safety, active monitoring requires that either the monitoring officer or the organization has identified the critical things and targets whose monitoring at a certain time is important.

Several experts who were interviewed said that onboard their vessels a specified monitoring practice is in use mainly in pilot – co-pilot navigation situations. Monitoring responsibility is often assigned to the officer in charge of the navigational watch who monitors and supervises the performance of the person responsible for the navigation and steering of the vessel. The task of the monitoring officer is to monitor the location, course, speed, and turns of the ship, and other such operations connected with navigation and steering. He/she also monitors the performance of the steering officer. There are mostly short descriptions of the tasks and responsibilities in the ships' safety management systems or bridge manuals. On the grounds of the interviews it is possible to say that this monitoring task has almost without exception been defined as a very general monitoring of all events. The interviewees said that they were not explained what and when they should monitor. There has been no training for monitoring either. Except for the described monitoring practice, other monitoring duties or tasks are not really defined in shipping companies or onboard vessels. All the bridge crew members are responsible for monitoring "everything important".

The interviews revealed that the concept of monitoring was unfamiliar even despite the fact that it has been covered in maritime training and that it is one of the most important concepts of the BRM training course. The examples the interviewees gave were most often related to operations where the movements of another vessel are monitored on the radar, or the position of own vessel are monitored from the radar, an electronic chart, or by visual sighting. Only one interviewee gave a clear example of what matters and in which order he feels should be monitored e.g. when the ship is making a turn. From the interviews it is obvious that monitoring is mainly of the passive kind, i.e. the position and movement of the vessel is monitored on a general level. It looks as if monitoring practices are not covered in training on a sufficiently detailed level.

3.3.3 Lookout

The most important basic duties of a bridge watchman are defined as safe navigation and especially the avoidance of collisions and grounding. To prevent collisions, the vessel should always keep a proper lookout both by sight and by hearing (COLREGS 5§). Also the regulations on watchkeeping emphasize the importance of lookout (STCW Code, section 8). The safety report on watchkeeping of the English Marine Accident Investigation Branch noted that two thirds of the collided vessels included in the research material had neglected the lookout (MAIB, 2004). Nine of the accidents and hazardous situations examined in the report were collisions (17%). In two of these one cause of the accident was the neglect of the lookout or watchkeeping in general (Sjöfartsverket, 2005 and OTK, 2001b). Furthermore, in one case watching the radar had been neglected when the vessel was navigating in dense fog (OTK, 2004d).

The use of a separate lookout can be considered threat management practice on a general level. If the duty or duties of the lookout have been defined as including the detection of the errors of other members of the bridge crew, this can be considered an error management method. Used correctly, a lookout is a part of the commanding team and a remarkable resource to safety. According to regulations (STCW Code, section 8) a separate lookout has to be present on the bridge at least from sunset to sunrise. In addition to this, a lookout can be called for if the visibility decreases, or when otherwise needed. On passenger ships the lookout is always present at the bridge.

During the interviews experts were asked about the duties of the lookouts and about the instruction given to them. Most interviewees mentioned that normally the lookout informs others only on such targets that he believes are dangerous to the vessel. More experienced lookouts already know which sightings interest the navigating officer and which do not. All the interviewees said that the actions of the lookout differ according to person. They believed the reason for this to be mostly that some of the watchmen are studying to become navigating officers and therefore they are interested in the duties of the officer in charge of the navigational watch. A skilled and motivated watchman can be a better resource and bring more additional value to the safety of the operations compared to those who have only been trained on support level. Furthermore, several interviewees mentioned that different officers in charge of the navigational watch may use the lookout resource in different ways. For instance, some may tell the watchman about the upcoming route and ask him to participate to the monitoring of the ship's navigation. In one shipping company at least this was actually a general procedure. Some interviewees said that they had also begun radar training for watchmen.

The interviews revealed that some shipping companies had given directions on the duties of the lookout. Some of the interviewees said that they assume a watchman knows his duties and knows how to perform them, as they have been covered in training. However, some had noticed that young watchmen are not skilled to do their duties, and that the navigating officers have to teach them how to do their work.

3.3.4 Use and Management of Automation

Sophisticated bridge technology is often referred to as automation. The aim of automation is to improve the safety of maritime. However, in addition to new opportunities the use of sophisticated automation systems also contains risks. Sophisticated automated systems perform tasks in ways which are not possible for human beings.

Automation improves accuracy, speed, economic efficiency and perception, and it also replaces human labour in several tasks. Furthermore, multi-tasking, memory storage and computation capacity of automation systems surpasses human capabilities. Still, technology is no substitute for people, because it is not responsible for actions, and nor does it make decisions. Automation systems cannot perform tasks that are not defined beforehand. Man cannot be replaced by a machine in complex operational environments where the user is required to apply information and estimate risks based on insufficient and uncertain information, under constantly changing conditions. At its best, however, automation is an excellent resource for the bridge crew. This requires the correct usage of it and management of risks involved. Used correctly automation improves the situational awareness of the bridge personnel in demanding conditions, lessens the workload, and frees the resources of the bridge personnel to be used for their main task, i.e. supports them in their threat and error management work. At its worst, automation weakens the situational awareness, adds to the workload, creates an opportunity for the occurrence of errors, and eventually causes an accident. Automation is often described as a double-edged sword. Used correctly it helps the bridge personnel in performing its tasks, but when used incorrectly, makes the situation worse.

Successful use of automation requires defining of the principles and methods with which it is used. The essential points in the defining are managing of information and workload. The use of automation should be planned in such a way that it would produce well-timed, necessary and situationally significant information for the bridge personnel in different situations. Procedures should be defined for reacting to and commenting on the information that the system produces. The system operating duties should be defined and timed so that automation is operated at correct times and with correct procedure, risk-wise, and that one of the bridge personnel will always concentrate on the primary task of navigating the ship. It is typical that automation causes unexpected situations from time to time on the bridge, and preparations should be made beforehand for those by planning procedures and practices. Monitoring of automation in critical situations will also bring more challenges to the definition of bridge personnel operations.

The expert interviews revealed that all the interviewees felt there were risks involved in using steering and navigation systems. Most of the interviewees mentioned overconfidence on the equipment and possible equipment failure as risks. Furthermore, they felt that integrated navigation systems are especially complex, and the poor understanding of how they function forms a great risk. Many systems give many different alarms which are disturbing for the normal bridge operations. The interviewees also stated that today, when bridges are integrated, safety of the vessels has improved. Several interviewees felt that the integrated bridge raises the risk level too high, because automation is not managed properly, and bridge work might easily be turned into "a computer game." In the course of this research it was noticed that the opportunities of increasing safety brought about by technical development have not been utilized in maritime training or operational systems by anticipating threat factors having an effect on the operations, and by checking safety critical procedures. Bringing new technology to the bridge environment has not in itself improved safety. High technology and complex automation systems require new skills from the personnel that are using them. Problems in these skills are also presented in the newest accident and incident reports (e.g. OTK, 2004a and 2001a). The challenge of today is to change the communications between the members of the bridge personnel as well as the communications between the bridge personnel and technology into such that would increase safety. The challenges brought on by the changes in the operational environment should be met by organizing the duties of the users of technology to correspond to the challenges of the work environment.

In 2003 the International Maritime Organization sent a circular letter (MSC/Circ. 1061) in which they gave instructions on how to use an integrated bridge. The instructions state that shipping companies are obliged to include the company policy on the use of automation in the bridge manuals of their vessels. Furthermore, the circular states that explicit instruction should be written in bridge procedure concerning the situations in which the different automation management procedures can or cannot be used. During the expert interviews it was noticed that instructions on the use and exploitation of automation or steering systems and navigation equipments were not available in many shipping companies. Some of the interviewees felt that the automation training situation is bad. However, most of the interviewees were fairly satisfied with the user training they had received. Many considered independent studying of the manual a sufficient way to learn things.

The special characteristics of automation and automated work environment are covered in brief in BRM training. Special attention is paid to the problems of the use of automation. Still, either BRM training nor maritime professional training offers concrete operations models or methods concerning working in an automated environment.

It was apparent in the interviews that there are plenty of personal differences in the use of automation and bridge equipment. Some shipping companies have, perhaps following the advice of the IMO circular, regulated which equipment or systems should be switched on, and which functions should be used. In addition to this, some shipping companies had given directions on when the track controller (when the system is steering the vessel exactly on a planned course) of the integrated navigation and steering system must not be used. Some of the interviewed masters had included instructions on the use of automation and navigation electronics in their standing orders. One interviewed master included instructions on all the systems and equipment up to the adjustment level in his standing orders. He justified this by stating that the best ways of using the equipment do exist, and that inexperienced navigating officers do not always seem to know what the best way is. With his instructions he had also wanted to minimize all the risks involved in the erroneous use of automation. The other interviewees mostly felt that the use of equipment depends very much on the situation and circumstances, and that the bridges should be left some freedom in choosing the correct ways of using the equipment. From the shipping companies' point of view it is difficult to create a set of orders, as all the bridges have not been standardized.

3.4 Factors that Explain the Operations of Bridge Personnel

On the grounds of our research material and especially the expert interviews plenty of background information was gained with which the prevailing practices can be explained. Some of the noted factors are directly related to the direction of bridge work, such as training and the available work methods. Some of the factors have an indirect effect on the operations; they mainly create circumstances where the bridge personnel have to adjust their actions to meet the demands of their environment.

3.4.1 Challenges of Bridge Work

One of the greatest challenges of bridge work is fatigue. This problem has been strongly highlighted lately. Accident Investigation Board Finland is preparing a safety report on fatigue, and the International Maritime Organization (IMO) has designated fatigue as one of their main themes. Any so-called fall-asleep accidents in our accident and incident report analysis were not included, because the issues concerning fatigue fall outside the realm of this report. It is noteworthy, however, that almost all the interviewees named fatigue as one of the most significant risks in maritime. Another problem recognized in the industry is monotony of the work, and decrease of alertness following it. Voyages between ports may take days, and sometimes there are very few events to observe. Maintaining of alertness, which is very important to safety, is a challenging task.

17 of the 52 accident reports examined for this study revealed that there were too few crew members on the bridge at the time of the accident. There might have been two crew members, but the bridge equipment and/or the placement of the equipment combined with poor weather conditions often caused a situation where the work contribution of two people was not sufficient enough to maintain safe conditions (e.g. OTK, 1998d and 2002d). The insufficient amount of bridge crew was not mentioned in the interviews, but on the other hand a bridge team of two officers was considered a clear improvement on safety.

The fact that the same crew may work together for very long periods can also be considered a special feature of maritime. Generally stability of the group has a positive effect on co-operation, because it helps in adopting the ways of action of the other team members, and thus makes co-operation more consistent. However, in safety critical industries the fact that the team learns each other's ways has been considered a special risk. Team stability creates assumptions on how the other team members will act, and this in turn reduces the double-checking communication between the team members. Some of the interviewees mentioned that the reason for the lack of communication sometimes is the assumption that the other person already has a similar view of the situation. Furthermore, together with long-term relationships the risk of culmination of personal disagreements grows. However, such problems were not found in the research matter of this report.

Incompatibility of the bridge equipment and changes in the placement of the equipment can be considered a challenge that relates to the physical work environment. An unstandardized bridge and the multitude of steering and navigation equipment complicate creation of uniform work methods in shipping companies. Finding the best work methods and training the personnel will remain the responsibility of the masters and other members of the bridge crew.

Using pilots has been a part of the maritime culture for a long time. Piloting is meant to increase safety. However, problems in the piloting situation have been detected in this report as well as in many other studies (OTK, 2004e and VTT, 1998). From the point of view of bridge work and the bridge personnel the embarking of a pilot into a sometimes completely unknown vessel near the coast and the port presents a remarkable challenge to the actions of both the pilot and the bridge personnel. It is also noteworthy that co-operation of the pilot and the bridge personnel has not actually been defined either in the shipping companies or in Finnish State Piloting Enterprise. The interviews revealed that in the more specific responsibility – task analysis of piloting - a grey zone can be found between the shipping companies and the provider of piloting services, where no distinct regulations and directions exist. However, this is the zone where the bridge crews have to function.

3.4.2 Contents and Method of Implementation of the Training

In Finland BRM training has been available for over a decade. First there were only individual courses, offered by VTT (Technical Research Centre of Finland) or a private organization. Approximately 10 years ago regular training was begun in maritime colleges. All the present courses are based on a course developed by SAS Flight Academy in co-operation with different organizations (Finnish and Swedish Maritime Administration, Norwegian Shipowner's Association, Silja line AB, and Maritime Pilots' Institute Netherlands).

According to the STWC general agreement (International Convention on Standards of Training, Certification and Watchkeeping) on ships' crew, qualifications, and watchkeeping, BRM training is not compulsory. However, this training is given to all operational-level students studying to be deck officers in Finland today. In addition to this, management-level students may be offered refreshment training, or the course topics are reviewed in the context of other training. BRM training has also begun for students studying to be engineer officers. Shipping companies have sent their older employees to the BRM courses organized by schools, or they have set up their own courses together with the schools. Almost all members of Finnish deck officers (today also engineer officers) have completed BRM training. All the interviewees who took part in this report had completed the basic BRM course at least, and most also the refreshment course.

Today the SAS Flight Academy course has been divided into five modules. The modules are again divided into several different themes. Each theme is first covered with the help of computer based training (CBT) material (the student examines the material independently) and after that the matters are discussed with the help of different accident cases. Some simulator training models have been developed for the course, but schools have adapted them or developed their own simulator exercises. Usually the course includes one simulator exercise (duration c. half a day) towards the end of the course. A typical duration of the course is 3-4 days.

Five of the shipping companies that took part in this report announced that they organize some kind of bridge work related training at intervals of 1-3 years. Mostly these are so-called emergency situation courses, which might include e.g. one BRM module as a theme, or the course contains BRM refreshment training, either the whole course or parts of it. In some shipping company courses this separate BRM module is not included, but attention is always paid to it in the context of simulator exercises.

The interviewed experts mostly regarded the BRM training they had received as useful. Some expressed a wish for the course to include more practical exercises. Opinions were not offered on the contents of the course, however. The interviewees mentioned that the biggest benefit from the course was that it "made them think" e.g. of their own operational practices. They felt that the BRM course focuses more on attitudes and philosophy than on practical operations models. They also said that the BRM course teaches the importance of communication and co-operation. Closed Loop, repeating the message, and the fact that thoughts and actions are stated aloud were mentioned as good communications methods. Co-operation usually referred to the fact that everybody should remember that they are not working alone, and that co-operation leads to better results. However, they were not able to describe how the training had influenced their own actions on the practical level.

The expert interviews revealed that there was no clear role differentiation between the schools and shipping companies responsible for the training. According to STCW Code, the main function of schools would be to offer the basic training of watchkeeping officers, and shipping companies would be responsible for introducing their duties to them onboard the vessel. Some interviewees expressed their discontent with the results of the basic training. On the other hand, the educational organizations of shipping companies are sometimes rather thin. The person responsible for the training of the shipping company personnel might be the Safety Manager of the company. The interviewees also mentioned that the introductory training is insufficient. A few hours' speed training does not turn anyone into a professional.

A decade ago BRM training was considered problematic; people felt that there was no connection between the training and the real needs of the shipping companies (FMA, 1997). People were asking for training that would have been planned from the point of view of the shipping companies. Although nowadays several shipping companies work in co-operation with schools in planning and implementing their own training courses, the courses are still implemented mostly according to the same formula, and the special characteristics of different shipping companies are not really noticed. If the shipping companies have the means to fund a type simulator of their bridges, and if they have people who could give and develop the training, it would be easier to pay attention to their own needs. This kind of activity was reported by some shipping companies involved in this study, but many shipping companies do not have it at all.

The representatives of educational organizations who were interviewed commended the fact that the BRM course was rather substantially altered a few years ago. The structure of the course was rearranged, and some new themes were added. Schools report that the course is now much better defined. However, the interviews revealed that, despite the changes, the course is not developing. Training should also be developed to suit the engine-room and catering personnel better. Nowadays the examples have been taken from the field of deck almost exclusively. The interviews also revealed that there is still room for development in the course contents. Overall, however, BRM training was considered very important, and the interviewees were reasonably satisfied with the course.

The representatives of educational organizations were also asked about the contents of the basic training leading to maritime degree, from the point of view of bridge work and BRM. The interviewees felt that BRM as a theme is regarded as important, and many BRM topics and even themes are taught in the course of the training, although this is not required by STCW Code. The amount and contents of training depend on schools, and on the expertise of individual teachers. The quality of training is not monitored, because maritime training is audited only as far as the STCW requirements are concerned.

In the course of our research it was noticed that despite the fact that BRM training is considered useful and important, this does not seem to have the presumed impact on the formation of operative practices. The training programme contains theory-oriented courses, and it covers working in a safety critical environment only on a rather general level. Despite the efforts of the institutions to include the themes of the course in other basic training, BRM training remains an isolated theme and does not integrate into practical operations. Furthermore, from the viewpoint of the effectiveness of the BRM training, one weakness is the lack of human capacity training. This is covered only very briefly on BRM course as well as on a course called Crowd and Crisis Management; too briefly to give enough knowledge for the students to understand the special characteristics and limitations of human activity.

3.4.3 Direction of Operations

In the shipping companies that took part in this report training has been organized and managed diversely. The interviews revealed that the present manner of directions is regarded as increasing red tape and adding to the work load. Implementation of the directions is often left for the masters and other ship personnel. The interviewees did not require more directions, but they wished that the instructions would be made more explicit. Training should be organized before implementation of a new direction so that its meaning is understood and the crew is able to practise enough. Also documentation of the directions should be looked at.

The great amount of legislation is also seen as a threat. In a recent maritime safety study the interviewed experts regarded the storm of legislation as one weakness in the management of maritime safety. New laws are constantly enacted. They increase the work load on the vessels, and they can become a burden. This burden may turn into a threat to maritime safety. (FMA, 2006.)

The safety policy of shipping companies can be developed, and the bridge operations can be directed also on the grounds of the deviation and incident reports that the ships send. This reporting system is required in the ISM code (International Safety Management Code, 9.1) of SOLAS convention. The code also requires that the shipping company must react and reply to the deficiencies and problems presented in the reports (section 9.2). The interviewed representatives of shipping companies gave some examples on how a problem was approached and how on these grounds directions were changed or increased, and even training organized when necessary. Mostly the interviewees felt that the systems are functioning well. Some even wished for a more extensive database on incident reports, collective to all the shipping companies and possibly managed by the authorities, from which everybody could learn. This system has not yet been constructed in Finland.

On the grounds of the expert interviews most of the deviation reports contain technical faults. Non-conformities on bridges or other human errors are reported rarely. Only a few shipping companies felt that they had been able to create such an open working atmosphere that had enabled reports of human errors. It is noteworthy that in almost all the shipping companies the report can be sent only by the master of the ship, only in a few also the chief engineer and/or the first mate. This operational mode is not likely to produce information on situations where the other personnel have noticed deficiencies in the actions of the master. The interviews also revealed that people are reluctant to report their own errors.

3.4.4 Authority Regulations

Lots of legislation exists that relates to bridge operations. This legislation is dispersed into many sources. The BRM operations are not regulated by an actual law; some directions are given only in the recommendations section of STCW Code (Section B-VIII/2, Part 3-1/5) on how shipping companies should guide the deck officers of their vessels in BRM operations.

The STCW Code defines the minimum requirements for maritime training and qualifications, and for watchkeeping on vessels. The administration of IMO member state (Finnish Maritime Administration in Finland) is responsible for supervising of the requirements. The state of affairs is audited at five-year intervals, when the authorities have to make sure that the training provided by maritime training institutions conforms to the requirements of the STCW Code. Although BRM operations on the bridge or in the engine room are discussed in the B-section (recommendations) of the general agreement, it does not contain a requirement for BRM training. However, it is a prevailing practice in Finland that all students studying to be watchkeeping officers receive BRM training (see section 3.4.2 Contents and Method of Implementation of the Training).

The STCW Code requirements concerning watchkeeping training (Table A-II/I) contains a general level list of contents for the training, and the criteria with which the students can be evaluated. The requirements do not include BRM as a concept, but there is a note in the training contents that can be seen as relating to the BRM requirements, "Thorough knowledge of effective bridge team work procedures." These effective team work procedures of the bridge are not defined in the requirements. The evaluation criteria states on a general level that watchkeeping conforms with accepted principles and procedures. These customs have not been defined, and the evaluation criteria of the bridge team work have not been written down. The International Maritime Organization (IMO) has published model courses to support maritime training. In these model courses the requirements of STCW Code were slightly specified. There is a model course for BRM training as well (Model Course 1.22). Unfortunately the contents of the model course remain on a general level, much in the same way as with the legislation. For instance, one of the aims of the model course (16.1.3) is that the student can present means to prevent internal or external errors. The model course does not designate what these means could be. The references of the model course do not list such books where these means would be clarified. In must be noted, however, that the model course is not a finished training programme. The detailed training goals and contents need to be defined separately.

Watchkeeping operations are described in the STCW Code regulations (Section A-VIII/2, Part 3-1), which in Finland is enforced with a decree (Decision of Ministry of Transport and Communications Finland on Manning Ships, Crew Qualifications and Watchkeeping, 1257/1997). There is no mention on bridge team work during watchkeeping. The regulation only defines the criteria of calling the master and the combination of the bridge watch.

Part B (recommendations) of the STCW Code (Section B-VIII/2, Part 3-1) guides how a shipping company should direct BRM operations on the bridge. On May 20, 2005 guidance was added to the Code concerning the engine room resource management. This guidance is a copy of the guidance on navigational watch (B-VIII/2, Part 3-2). The shipping company is advised to compile appropriate bridge procedures, and support the use of check lists. Furthermore, the company is advised to give the deck officers instructions on how they can continuously evaluate the use of bridge resources. The recommendations are given on a very general level, and they mostly repeat the actual watchkeeping regulations (in Part A). Simply put, the recommendations urge administrations to ensure that the bridge personnel are competent enough, that the amount of watchkeeping personnel is sufficient, and tasks are given and completed efficiently using all the available information and equipment. The recommendations do not state exactly how this should be directed and implemented in practice. One shipping company Safety Manager regretted how little help the regulations offer for making of the instructions. You are ordered by law to write directions, but no one explains what the directions should be like in practice.

The ISM Code of the SOLAS Convention requires the shipping companies to create a safety management system for the ships. Shipping companies should provide safe practices, safeguards against all identified risks, and continuously improve the safety management skills of the personnel (1.2 Objectives). Furthermore, shipping companies must establish a general safety and environmental protection policy, regulations and procedures to ensure the safe operations of the ship, and a reporting system for non-conformities (1.4 Functional requirements for SMS). The Code does not contain a reference to BRM. The Code does not give instructions on creation or maintenance of a functioning safety management system either.

The General section of the IMO Guidelines for Voyage Planning (SOLAS, Annex 24, (Res. annex to IMO Resolution A.893) states that human error contributes to 80% of navigational accidents, and that in many cases essential information that could have prevented the accident was available, but for some reason it was not used. In order to prevent these kinds of accidents, the IMO recommends that all decisions be cross-checked so that possible errors could be detected and corrected as early as possible. Furthermore, deck officers should ensure that all available information is systematically utilized. However, these recommendations remain rather general, and they do not describe any practical implementation methods.

In the rules and regulations the operations of the bridge personnel are guided separately. Bridge team work is discussed very little. Although they require to strengthen the bridge team, no directions on co-operation or operations with augmented bridge personnel have been given. The accident report analysis showed that in only 13 % of the ships covered in the research matter there was only one person on the bridge. (NB the so-called falling-asleep accidents were excluded from our research matter, in which there is typically only one person on the bridge.) Thus, accidents mostly happen in such situations and circumstances where the risk level of the operations has increased (e.g. in poor weather and in confined waters), and the bridge crew has been augmented as required by law.

Generally it can be said that legislation is disintegrated and remains on a general level. Disintegration of the laws is considered a problem also among Finnish shipping experts. A recently completed study of maritime safety designated the fragmented laws, decrees and regulations as one of the threats to maritime safety (FMA, 2006).

4 Conclusions

4.1 Threat Management

Studies show that accidents and hazardous situations happen typically in situations and circumstances where the risk level of operations has been elevated. These risk-elevating circumstances and factors that lie outside the realm of actions of the bridge personnel are called threat factors. In almost all the accidents and hazardous situations that were examined one or more underlying threats could be found in the background. Furthermore, in the expert interviews numerous threats were nominated as factors that elevate the risk level. The findings of this report are in line with the findings made in other safety critical industries.

As far as safety is concerned, it is essential how the bridge personnel manage threat factors. This entails recognition and detection of threats, understanding their effect, and selecting and implementing actions that reduce the effects of the threats. Our research showed that bridge crews do not analyze their operational environment and work systematically from the point of view of risk management. In the expert interviews, risk-elevating threats were recognized inconsistently. Many interviewees were able to name the same risk-elevating factors that had been found to be involved in accidents and hazardous situations. For instance, other studies have found narrow fairways to increase the probability of accidents (e.g. Perrow, 1984), and many interviewees agreed with this. However, only few interviewees could describe special procedures with which the elevated risk level posed by the threat could be reduced. Nevertheless, some interviewees had distinct thoughts about threat management. The report showed, however, great differences between shipping companies and bridges as far as threat management procedures were concerned. The effects of threats to bridge operations and further errors were also poorly recognized.

The foundation of threat management lies on understanding human activity and its limitations. The effect of external disturbing factors on human activity in a demanding stage of work should be understood well enough so as enough attention would be paid to minimizing distractions in practice. Without knowledge about errors as well as the character of human capability and its limitations, the bridge crews cannot be expected to recognize such distracting factors in their operational environment that affect them, or to develop procedures for controlling those factors.

Today, BRM training, in line with other basic professional maritime training, offers weak support in the developing of practical procedures relating to threat management. The training is mainly theory-oriented, and it remains in rather general a level. Also integration of the training to practical work is poor, and the training does not offer concrete practical measures for most problematic operative situations.

Regulations and directions of authorities and shipping companies do not offer sufficient support to the threat and error management work of bridge crews, because they remain on a general level and there are no express instructions as to how to implement them.

The typical maritime threat factors and their management methods have not been systematically defined and documented. Our report shows that on some bridges the crew uses operations systems with which they attempt to manage previously recognized threats. Bringing this so-called quiet knowledge into general use would be useful for development of safety in the industry. Formation of good practices into standard procedures in the entire work community should be the aim of the industry.

Several threat factors were revealed in the course of our research. These are presented in the figure below (image 7).

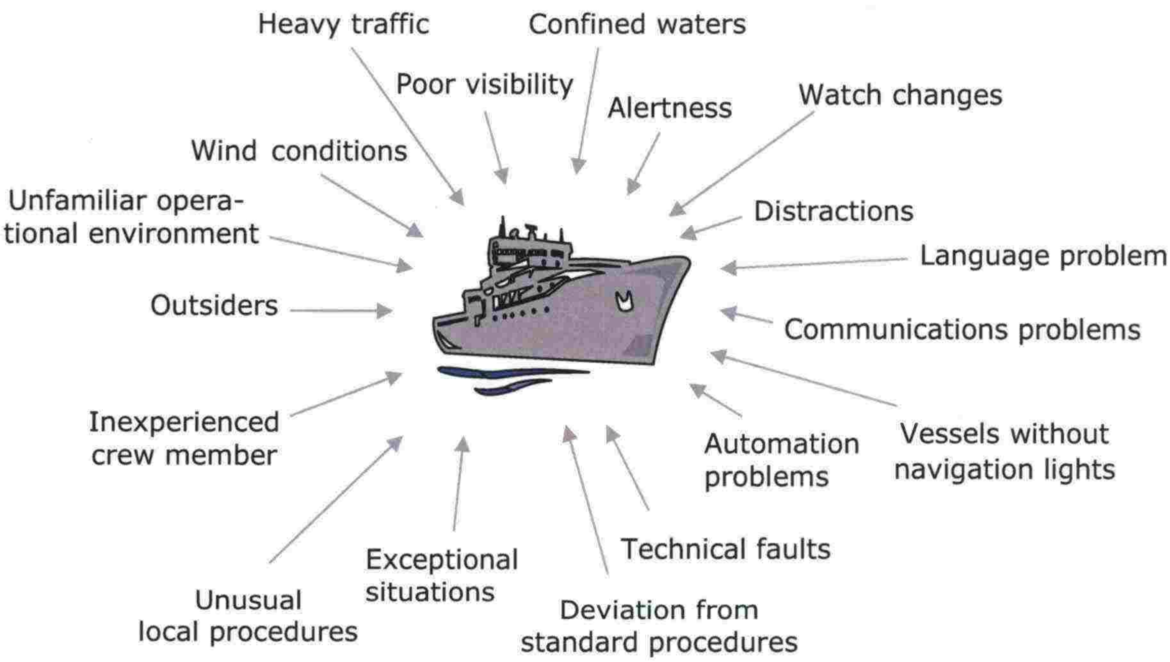

***Image 7**. Threat factors affecting the operations of bridge personnel.*

4.2 Error Management on the Bridge

A typical cause or an effecting factor in an accident or an incident is a human error. Errors are made under all kinds of circumstances, but as the situations become more and more demanding, and more threats are present, the likelihood of making errors grows. It is generally estimated that approximately 80-85 % of maritime accidents are caused by human errors. On the grounds of the accident and incident reports that were analysed for this study, after the accident has happened, it is impossible to analyze all the errors that had an effect on the situation. Therefore exact statistics cannot be made on the errors involved in the reported accidents. However, it can be said that there were one or more errors underlying all the accidents and incidents.

The expert interviews showed that the conception of errors and their management was rather poor among the interviewees. Making errors was not considered a natural part of the work, and recognition of typical situations where errors would occur was difficult. Only few errors and the practices relating to their management were generally recognized. For instance, misunderstanding of an oral report was recognized as a possible error, and the Closed Loop communications principle was designated as a way of managing it. This principle is covered in BRM training. Although the interviews revealed that there are some error management practices in use on bridges, the users did not recognize the methods they were utilizing as error management practices.

Poor understanding of errors is explained by the fact that the current professional maritime training does not contain training of the fundamentals in human capability and error management. Basic training in this field is the prerequisite for understanding and recognizing the limitations of a person's own actions as well as the situations where the risk of making errors is great, and their consequences would be considerable.

Today, error management on bridges is based on the bridge crew's intuitive conception of safe operations. The procedures in use cannot be justified or explained in general. Regulations and directions do not include explicit instructions or descriptions of practices with which error management should be implemented on the bridge.

4.3 Training and Direction of Operations

Work support is divided into two fields: training, and direction of operations. Direction of operations can be viewed as containing the rules and regulations of the authorities, the regulations and instructions of shipping companies, and supervision. Directions are implemented with the master's standing orders. The main function of training and direction of operations is to provide bridge crews with the information they need in order to manage the maritime safety risks efficiently. However, on the grounds of our research matter it seems that the support offered by training and directions for the management of bridge resources is not sufficient. Directions usually only remain general level statements.

The current BRM basic training does not meet the challenges of operations. The training programme contains theory-oriented courses, and it covers working in a safety critical environment only on a rather general level. Despite the efforts of the colleges to include the themes of the course in other basic training, BRM training remains an isolated theme and does not integrate into practical operations. At the shipping companies' own training courses a slightly better connection is established with practical operations. However, refreshment courses mostly lean on the themes of the basic training, and therefore their application level does not differ significantly from the basic training. BRM training is mostly regarded as attitude training and a so-called operations philosophy, and not as procedures and practices that aim to such bridge resource management which the bridge personnel uses in the management of the threats and errors in their operational environment.

The expert interviews revealed that as far as training and direction of operations is concerned, co-operation of different actors is sometimes poor. A recently completed study of the management of maritime safety also highlighted a need for more active participation of business life in maritime training and its development (FMA, 2006). Due to lack of co-operation between the people who are responsible for operations and personnel training, training is not necessarily focused on threats that are most essential for shipping companies. Training should be planned based on operational needs. In this respect shipping companies and training institutions should invest more on reconciliation of their training objectives.

The authorities and the shipping companies felt that managing bridge operations was rather difficult. They felt that bridge crews did not welcome the increasing amount of more specific regulations or recommendations, and therefore they did not consider issuing them a good alternative even if they felt there was need for them. Restricting the master's authority was considered a poor option. There were distinct differences in the directions of shipping companies as to how they limit the authority of the master. Some consideration had been given to increasing the amount of regulations and intervention from the part of the shipping companies. Many masters felt that many current regulations were not useful, and that increasing the amount of regulations might even make their work more difficult. Many masters also felt that the regulations were too general, and that there was no mention on how they should be followed in practice. Instead of regulations, many masters expressed a need for more detailed instructions on how to follow regulations.

5 Recommendations

5.1 Learning from the Best Practices

From the point of view of threat and error management, there are remarkable differences in the quality of bridge operations. In is noteworthy that several bridge teams and individual team members have adopted their own practices in their work, with which they try to improve the safety of their actions. These practices often rise from experience and they are based on intuition. Although the practices are good and well-justified, people often cannot justify their meaning or significance, and they are not perceived as good practices for threat and error management. The safe bridge operations used in many bridges are what is called tacit knowledge, which is transferred from person to person locally and slowly, and therefore cannot be offered for general use.

The existing tacit knowledge, i.e. the safe operational practices which are used and approved by bridge crews, contains a substantial potential for the development of maritime safety. Finding these practices and bringing them to general use as directions should be the goal of future development work. In a written form, good practices will offer concrete operations models and procedures for real operative challenges and problem situations. The authorities and shipping companies should create and develop processes for finding both the shared and individual tacit knowledge of bridge crews. This knowledge should be distributed to everybody via directions and training.

Efficient finding, understanding, and transferring of good practices requires a shared viewpoint from which threats, errors and human conduct are perceived. A shared viewpoint defines the structure and language with which the practices are analyzed, assessed and communicated. By the recommendation of the International Civil Aviation Organisation, a Threat and Error Management Model is generally used in the development and training of aviation safety. This model has been found to be well-suited for the same purpose in other industries as well.

The use and transfer of good practices require that the users understand the fundamentals and significance of these practices. As the practices are based on management of threats and errors, the users should be offered training on the subject. Training will give them a basis to review their own work practices and the meaning they have on safety, and it will help them to accept justified new practices as part of their own work routines. Without basic training there is a danger that these good procedures are seen as new unjustified regulations that will just make work more difficult.

5.2 Development of Operations Procedures

Efficient bridge team work is based on clearly defined roles, areas of responsibility, and distribution of duties as well as on work procedures with which the work and responsibility of others is supported, and, if necessary, interfered. These are prerequisites for smooth teamwork, management of interruptions, avoiding ambiguity and misunderstanding, monitoring, and the mutual support of the bridge personnel. Each member of the bridge team should always be aware of who is responsible for what, and whose responsibility the various situational tasks and monitoring duties are. The teamwork definitions should be done to cover normal procedures and all the foreseeable emergencies. The definitions of responsibilities and roles offer a basis for the situational work distribution performed by the master. These definitions are the realm of the organization, and they should appear as directions and regulations to the end users.

In complex safety critical working environments there are often many ways of performing tasks. Despite this, the choice of how to perform tasks should be based on predefined values, priorities and operational principles which aim to describe the basis of safety in the work. A substantial part of normal work and most foreseeable emergencies can be examined beforehand, and many justified good practices for handling them can be defined to ensure safe management of operations as efficiently as possible. These procedures function as tools and instruments for the bridge crews who have to choose the operating methods that ensure the safety of their work. These tools help them to understand the environmental threats and error-induced risks they have to manage. Development of these procedures is the responsibility of organizations, and this should be done in constant co-operation with the operative level. The procedures should appear as concrete operational directions to the end users.

The essential factors for well-functioning procedures are functionality, appropriateness, practicality, and the users' approval. In general it can be noted that procedures that are regarded as unfamiliar or bad will not be used. The wide usage and approval of procedures requires that the users understand their pedigree and commit to them. The users should be offered training which explains the background of the procedures, and they should be made a part of the development process of the procedures. After the first stage of their implementation, development of the procedures should continue as a process.

5.3 Development of BRM Training

BRM training should meet the needs of the operational environment better. Today BRM training is considered as attitude training, or a philosophy relating to bridge operations. This is, however, only one part of BRM training, and in itself does not offer sufficient support for practical operations. BRM training should be developed into a course which takes BRM away from the principle level and more towards practical operations. The bridge crews should be offered distinct safety enhancing procedures and practices for handling normal situations and foreseeable emergencies. Educational objectives of the training should be defined based on operational requirements. Training should offer solutions for management of predefined operative threats as well as errors made by the bridge personnel. This practice-based course should also be integrated into operations by connecting the educational objectives to simulator training where the procedures can be trained in practice.

Understanding the background of threat and error management practices is vital for perceiving, understanding and utilizing them. Offering the bridge personnel training on human capabilities and error management creates a basis for their risk management operations. This training should give the bridge personnel basic knowledge of the strengths, weaknesses, and limitations of human activity. The current BRM training does not sufficiently highlight the basic starting points and limitations of human activity. Consolidating this training would be extremely important so that the later-stage error management practices and bridge teamwork training, which are built on this foundation, can be delivered successfully.

At the moment the basic BRM training is offered in the form of courses. As BRM practices form a central part of safe routine operations, the objectives of BRM training should be integrated into the operative training given to students. BRM objectives and skill requirements should be listed in the educational contents of operative training.

The concept of BRM should be expanded to relate to all the safety-ensuring non-technical operations of an individual bridge team member as well as the teamwork of the bridge personnel. The concept of resource management should also include management of resources external to the bridge. Furthermore, the importance of automation management training as a central part of BRM training should be increased.

5.4 Development of Direction of Operations

The roles of authorities, shipping companies, and masters should be clarified in directing the operations of bridge personnel. It appears that instead of general regulations and directions, the masters would require concrete instructions and proposals on how the operations should be implemented and instructed. However, the authorities and the shipping companies fear that concrete instructions could be seen as an invasion of the master's territory.

More support for direction of operations should be offered to the masters and the members of the bridge personnel. Instead of unconditional regulations, implementation of current directions and instructions should be clarified. More training and instructions for the application of directions is required. Authorities and shipping companies should give the masters distinct instructions and models on how the regulations and directions can be applied into practical operations. It would be important to see to that regulations and directions would not remain just general remarks on important issues but that they would offer practical tools for the masters who have to consider them in their work. Authorities should also consider adopting a consulting role in order to support the shipping companies and masters in their implementation work. Authorities could also function as the organizers of co-operation between different actors of the industry.

5.5 Development of the Educational Systems of the Organization

This report shows that several shipping companies use a reporting system in which the ship's master reads the bridge crew reports before sending them forward to the shipping companies. In the interviews the representatives of the shipping companies mentioned that few reports are received on the actions of the masters in general, and on the errors made by the ship's personnel in situations that did not lead to consequences.

The reporting system that is managed by the master is not likely to produce information on situations where the crew finds a fault in the actions of the master. Therefore each member of the crew should have an opportunity to file individual safety reports to the shipping company. Reporting should also be confidential in order for it not to cause an unnecessary risk for deterioration of the working atmosphere.

The few reports of the crew on errors which did not lead to consequences indicate that these errors are not recognized, reporting them is not regarded as necessary, or that reporting them is considered a sensitive issue. As little training is offered to bridge personnel on human capability, human errors and error management, it is safe to assume that errors are often not recognized. In any case, the reporting tradition as an information gathering and processing channel for a safety critical system should be developed.

6 Summary

In this report the development needs of bridge co-operation for the improvement of maritime safety were examined. The report is based on research on current bridge operations and the factors that affect them. This research was done by Huperman Ltd, and it was ordered by the Finnish Maritime Administration.

One of the objectives of this study was to assess the sufficiency of the prevailing bridge practices in meeting the demands of the operational environment from the viewpoint of threat and human error management. Other objectives were to define the possible development needs and targets of bridge co-operation, and to estimate the effect of the present educational practices and direction of operations on practical operations. This report is based on analysis of accident and incident reports, study of the directions that regulate bridge work and training related to it, and interviews of operative personnel and educational organizations.

Our research showed that the co-operative practices of bridge crews that relate to threat and error management differ considerably between shipping companies, vessels and crews. It was also noticed that the bridge crew training, and the regulations and directions the crews use, do not give them practical instructions for or distinct understanding of the procedures of threat and error management. In maritime, the concept of Bridge Resource Management is usually understood as a philosophy of bridge communication, not as a group of operational principles and procedures with which the technical and human resources can be utilized in threat and error management as efficiently as possible. The link of BRM training and directions to the practical operations is weak, and no training is offered for managing risk-elevating threats and errors.

It was also found that the seafarers and organizations that took part in this study were very willing to develop the operations and prevailing procedures. But it was considered difficult without further guidance and better understanding of the practical implementations of crew co-operation.

On the grounds of this report development targets were defined. These targets relate both to development of operations, and to direction of training and operations. The aim is to increase safety by developing the procedures of bridge co-operation.

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