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Published in:
Proceedings of the 17th International System Safety Conference

1999

PROCEEDINGS

17th INTERNATIONAL SYSTEM SAFETY CONFERENCE

Orlando, FL
August 16-21, 1999

Published by the
System Safety Society
P.O. Box 70
Unionville, Virginia 22567-0070

Latent Conditions, Safety Barriers and Situational Factors for Maritime Accidents in the Sound Area – A Pilot Study Focusing on People, Human-Machine-Systems and Organizations as Risk and Safety Factors

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Keywords: maritime risk, safety culture, human-machine interaction

Abstract

The Sound Area, located between Sweden and Denmark, is one of the most intensely trafficked waters in the world with complex traffic patterns and a bridge/tunnel under construction, which will link the two countries. This high level of complexity increases the probability of both maritime accidents and very negative consequences of them. This paper presents the ergonomic part of an ongoing multidisciplinary pilot project with the objective of identifying and describing maritime risks in the Sound Area. This part concentrates upon the role which people, human-machine-systems and organisations on board ships and in association with maritime activity in the area play as risk and safety factors. Information is being collected through literature, marine accident reports, and exploratory case studies. Preliminary findings are presented in the paper.

Introduction

One of the main goals of LUCRAM (Lund University Centre of Risk Analysis and Risk Management) is to initiate and conduct research projects in different risk domains (see note at the end of the paper). In a newly started pilot project the center has taken into consideration the fact that the Sound area contains one of the most intensely trafficked waters in the world, the Sound. The pilot project is a multidisciplinary project with the objective of identifying and describing maritime risks in the Sound area. The results obtained are intended to be used as a basis for further research focusing on the various factors contributing to accidents in this specific water area, and how these accidents can be prevented proactively. Of special interest are latent conditions, safety barriers and situational factors that may have an impact on the causes contributing to accidents. The aim of this paper is to introduce project goals and to present preliminary findings.

The Sound: The Sound, located between Sweden and Denmark, is 55 nautical miles long, with varying width but only 2 nautical miles at narrowest (figure 1). The water area is highly complex, featuring increasing international vessel traffic within intersecting traffic patterns, limited water depths, ports with high activity, numerous ferry-services, transportation of passengers and goods, extensive maritime leisure activity and a bridge/tunnel under construction which will link the two countries. Moreover, the main part of the Sound consists of Swedish or Danish rather than international waters. This high level of complexity increases the probability of both maritime accidents and very negative consequences of them.

Between 1985 and 1996, 160 accidents in the Sound were reported to the Swedish Maritime Administration, the accidents representing the following categories: groundings (41%), collisions between ships (29%), collisions with other objects (e.g. quays, buoys, light houses) (18%), engine failures (7%), fires (2%) and others (i.e. total loss) (3%). Due to the building of the bridge/tunnel connection, temporary Vessel Traffic Service-stations (VTS) have been established on both the Swedish and Danish sides in order to supervise vessel passage through the construction area and give assistance when called upon. The Danish VTS which supervises the channel Drogden (figure 1) registered 324 near misses in this channel from spring 1997 to spring 1999 (ref. 1). 139 of these cases contain elements of violation of International Rules for the Safety at Sea, where for example, 54% of the cases were not obeying the rule that a vessel navigating in a narrow passage must keep to the proper side. 29% of the cases ignored the rule that any action to avoid a

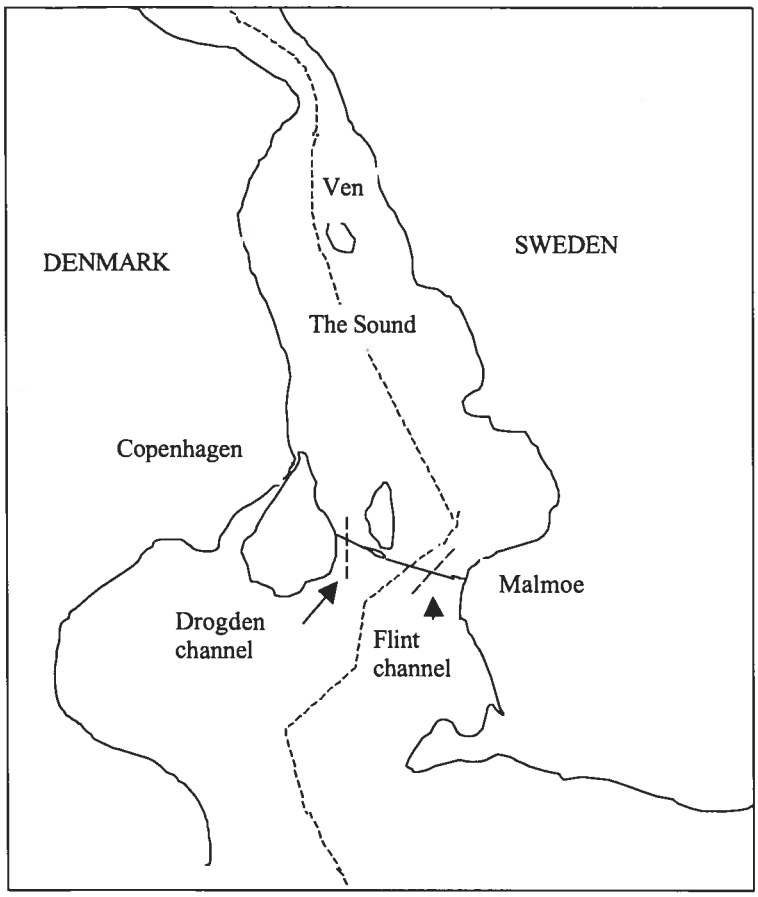

Figure 1 – Map showing the Sound area including parts of the Swedish and Danish countries.

collision must be taken well in advance.

It is well known that accidents in any domain usually have multiple causes. Two accidents in the Sound will illustrate this point. In one case, a large passenger ship left Copenhagen, Denmark, heading north through the Sound and passing east of the island Ven (figure 1). The ship had to give way for intersecting traffic and small fishing boats and therefore fell off course to the east. On board the ship the master had given the order that "either the chief officer or the 'staff captain' should be on the bridge and supervise the passage through the Sound". This unclear order resulted in confusion regarding who was in command, resulting first in both of the officers giving navigation orders, and later both of them stopping giving orders (each thinking that the other was navigating). Due to rather high speed of the ship it was difficult to keep track of the buoys and keep oriented in the picture on the radar screen. The ship finally ran hard aground on the shallows south east of the island Ven, to remain there for several days. A couple of days later a chemical tanker was to head south through the Sound planning to pass west of V en. Due to a lack in communication on board, the chief officer in command was not aware of the existence of the grounded passenger ship south east of Ven. As he observed a large number of sailingboats dead ahead, he changed course and went east of the island instead. The traffic subsequently increased on this side of the island too and the chief officer also observed the large ship lying still in the water. The chief officer on the bridge missed seeing the raised signal for grounded ship, missed important buoys warning for shallow waters and decided to pass between the grounded ship and main land, i.e. headed directly toward shallow waters and ran aground. These two accidents illustrate the multiple factors involved in accidents in this complex nautical environment.

Maritime Risks in the Sound Area: In order to efficiently identify maritime risks and consequences of maritime accidents and to be able to analyze, estimate and decide upon hazardous transport activities, extensive knowledge from different disciplines is needed. The different disciplines involved in the project are economics, engineering logistics, ecotoxicology, risk analysis, and ergonomics. The ergonomics part of the project, which will be the focus of this paper, concentrates upon the role which people, human-machine-systems and organizations on board ships and in association with maritime activity in the area play as risk and safety factors.

Human-Machine-Systems: Operators in different domains have become increasingly remote from the processes they are to control and manage. Increasingly complex machines have become an interface between the human and the physical task. The human-machine interface is provided with more and more automation in order to reduce human involvement in a process and to remove the human source of instability and risk. Automation is used as a way for making human involvement more effective and increase the overall level of control. Another purpose of automation is to reduce the demands on the operator's mental capabilities. Unfortunately this can give the opposite effect if the consequences of the automation are not fully considered and the result becomes 'clumsy automation' (ref. 2). The interaction between ship operators and a ship's technological aids has to function optimally in order to reduce the risk for new types of causal relationships leading to accidents. If the equipment is going to be a reliable aid and improve a ship's operational efficiency and safety, the human-machine interfaces have to be carefully designed. Poor design can result in automation becoming a contributing cause to maritime accidents.

Automation can involve changes in the ship operator's work tasks. The operator has to gain knowledge about the technical systems together with training, in order to safely carry out work tasks associated with the automation.

Organizations and Cultures: When identifying the maritime risks in the Sound area, it is of great importance to study the safety cultures in the different organizations associated with maritime activity. Many researchers argue that the etiology of major accidents is typically comprised of a complex combination of technical, individual, group, organizational and social factors. Accidents may be described as resulting from the breakdown of an organization's 'safety culture' (ref. 3).

According to Reason (ref. 4), important components in a safety culture (or an informed culture) are that it is a reporting, just, flexible and learning culture and that these components interact becoming an informed culture. In an 'informed culture' information from incidents and near misses is gathered and analyzed, and the knowledge and experiences gained from this process are distributed throughout the organization. Furthermore, the organization works proactively to improve safety. Those who manage and operate the organization have a current knowledge about the human, organizational, technical and contextual factors in the environment that determine the safety of the system.

A 'reporting culture' has succeeded in creating trust and commitment which results in good reporting of incidents and anomalies. Anonymity is often used and an independent party is responsible for the analysis. In a 'just culture' the line between acceptable and not acceptable behavior has been made clear. Respect for skills, experience and abilities among operators and supervisors is manifested in a 'flexible culture'. In emergency situations, control and decisions are transferred to local experts and transferred back to the higher levels in the organization when the situation is dealt with. In a 'learning culture' there exists the will and competence to learn from gathered information and the readiness to implement improvements.

Furthermore, a safety culture strives for improved safety independent of the leadership's personality and independent of commercial pressure.

As pointed out by Rasmussen (ref. 5), many major accidents are caused by a systematic migration of organizational behavior under the influence of pressure toward cost-effectiveness in a competitive environment.

Pilot Project: The specific purpose of this pilot project is to 1) identify strengths and weaknesses in the interface design of technical equipment and automation on board ships where special interest is put on latent conditions and safety

barriers, 2) suggest changes to overcome weaknesses in the interface design, 3) identify the possibilities provided for the operators to receive knowledge and continuous training in handling the technology, 4) investigate to what extent those cultures that are crucial for maritime risks in the Sound area, i.e. cultures on board ships, in shipping companies and rescue organizations, can be classified as safety cultures, and 5) to identify possible traces of migration forces in these organizations.

Methods and Materials

Up to this point in the ongoing project the gathering of information has been obtained by a) reviewing literature about the etiology of accidents, b) studying marine accident reports, c) conducting exploratory case-studies on board ships and, d) discussing the topic with experts e.g. VTS-personnel, pilots etc. Case study on board ships has recently begun and will be extended during the course of time. Further on, the case studies will include shipping companies and rescue organizations in the area.

The purpose of studying maritime accident reports is to gain general knowledge about what type of accidents occur in the area, their causes, and existing problems in the human-machine interaction. Unfortunately, a large number of the reports are written in a very superficial way not revealing the contributing causes leading to the accidents. One obtains only a general idea of the causes.

To get a thorough understanding about the work processes on board ships we have begun to conduct exploratory case studies on different routes in the Sound. According to Yin (ref. 6) case studies are the preferred strategy when 'how' and 'why' questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context. Furthermore, to understand the adaptive behavior of socio-technical systems and its influence on a system's safety, careful studies of the normal functioning of the systems are necessary (ref. 5).

In the case studies we have begun to collect data by 1) observing and accompanying on-site key persons (ship's crews) with extensive maritime experience, 2) conducting semi-structured interviews with persons on different levels of the organizational hierarchy, and 3) studying company documents. Through observations we get information about how work routines are implemented and how they are actually performed. The interviews give us insight into the crew's perception of their jobs, their working conditions, their understanding of safety related issues, their experience of working with the technology on board the ship etc. Interviews are conducted using open-ended questions. When analyzing company documents we focus on safety related issues, formal work organizations, formal work procedures, company philosophy and safety programs. Since this is a newly started project the method of being present in an organization, for example on board ships, allows informal discussions with the people and this contributes to the development of research hypotheses which will be subjected to further investigation as the project proceeds.

In the coming study of shipping companies and rescue organizations in the Sound area, we are focusing on the safety culture issues that were discussed in the introduction. We will perform interviews with people in different levels of the organizations and use structured questionnaires.

Preliminary Results and Discussion

The preliminary results indicate that reconstruction of vessels e.g. due to migration forces, can lead to complications in using systems and performing work tasks on board. For example, in one case vital sight during docking was destroyed due to installation of additional equipment on deck. Additions to navigation stations on the bridge can create badly arranged and crowded stations leading to the introduction of latent conditions in the system and increase the likelihood of active failures. Preliminary results also show that it is not only the interface design of the navigation stations, but also the positioning of the station on the bridge that can cause unnecessary problems for the crew.

We have also found that manufacturer standards can stand in the way in the pursuit of making user-friendly interfaces. In one case, design suggestions from the crew could not be obeyed due to the high costs involved in making the manufacturer change their design standards.

Deficiency in communication routines between members of the crew have been noted, especially

in the procedure of handing over responsibility from one person to another.

Situational factors in this specific water area (e.g. limited water depths, intersecting traffic and slow moving sailing boats) represent increased problems for the vessels and require extra attention and increased workload from the crew. Discussions with for example pilots working in the area reveal existing problems with the small and middle-sized fishing boats. This category has developed a behavioural risk pattern, which can jeopardise the safety not only of themselves but above all of the larger ship vessels.

We have also received indications that formal descriptions of work routines on board are too diligently written and do not correspond with every day practise. The preliminary results also suggest that navigational aids that are available tend not to be used optimally. Data collection continues.

Acknowledgement

This work is supported by Savings Bank Foundation Skane.

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Biography

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Note:
A risk research center, LUCRAM (Lund University Centre of Risk Analysis and Risk Management), is currently under development at

Lund University. The center has the objective of gathering and creating new knowledge in the area of risk analysis and risk management through multidisciplinary cooperation. The center is creating a national and international multidisciplinary network of risk researchers from technological, natural sciences, social- and behavioral sciences research organizations, together with industry, governments and other organizations. The center initiates research and education, and wants to serve as a source of risk competence, especially for the Sound area, in the south of Sweden.