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NEW TRAINING CONCEPTS IN MARITIME EDUCATION

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Abstract

Approximately 80% of all navigational accidents at sea are due to human errors. Poor communication and co-operation between crewmembers and other ships seems to cause a significant part of these accidents. Improvement in communication and co-operation among crewmembers and other ships are one of the means for minimizing the number of accidents. This paper describes the development and evaluation of a simulator based training system where communication- and ship handling skills can be trained. A Search and Rescue scenario has been used in the evaluation. The system is coupled via the Internet so widely distributed trainees can take part in the training. A method for the debriefing of the trainees was tested and will be presented.

Introduction

The goal of the Nordunet2[2] project "MARITIME EDUCATION IN SHIP-HANDLING, COMMUNICATION AND CO-OPERATION THROUGH DISTRIBUTED NETWORKED SIMULATORS" is to give maritime students and professionals opportunities to train for real-world operational missions in an environment that is not constrained by cost or safety restrictions. Real-world exercises are costly and will often have restrictions in order not to endanger trainees; such restrictions, in turn, tend to limit the learning process of the participants.

There is agreement among experts that approximately 80% of all navigational accidents at sea are due to human errors. Poor communication and co-operation between crewmembers and other ships seem to cause a significant part of these accidents. To prevent navigational accidents, simulator based maritime Bridge Resource Management courses have been developed, focussing on inter-crew communication and co-operation in crisis situations. These courses are currently offered at a number of maritime education centres using high-realism bridge simulators [2, 3].

Traditionally, engineers supervising and controlling the engine room have been trained at separate institutions using engine room simulators. Recently, however, is has been realized that it would be beneficial to conduct combined Crew Resource Management courses involving the bridge crew as well as the engine room personnel.

Search and Rescue (SAR) operation is another area where the communication between ships has to be coordinated on the accident site in order to achieve the best result in a real-world situation. SAR

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exercises and education involving two or more countries can be carried out in a more cost effective manner.

Offshore operations may involve towing a production platform from the construction site onto the final position in, say, the North Sea. This operation requires the assistance of several tugboats where contributions from all tugboats have to be coordinated. The co-ordination of the operations of the tugboats has to be trained beforehand; and this requires, therefore, that busy tugboat captains have to meet at a simulation facility in order to train the operation.

To facilitate this type of education, physically separated simulators have been networked and course concepts for distributed simulation have been developed. (Pedagogical set-up, scenarios, tools supporting instructors, replay and debriefing). In order to be able to facilitate the development phase it was decided to interface only the Simflex ship simulator, which at the time of development was a stand-alone application. An additional reason for this decision was that the software of this simulator is under the full control of the Danish Maritime Institute [2].

Objectives

The overall objectives for the present project have been to develop course concepts and technologies supporting distributed networked simulation enabling education and training in ship-handling, communication and co-operation (e.g. crisis management in connection with SAR (Search and Rescue) operations) of geographically separated maritime students and teachers.)

These objectives can be further detailed into:

- Development of course concepts for distributed networked simulations (incl. pedagogical set-up, scenarios, instructor-, replay- and debriefing-tools).
- Development of generic network interfaces allowing real time distributed simulation (incl. communication).
- Evaluation of the final product

The concept will be scalable in the same way as e.g. SimFlex is scalable from a single PC running a Part Task training simulation to complete ship bridge environment (Full Mission training). This means that it shall be possible to use the concept to perform distance learning for a single navigational student using his own PC at home as well as distributed distance learning on fully integrated Full Mission simulators like e.g. DMI's Bridge "A" integrated with the Maersk's engine room simulator in Svendborg.

Another benefit is that the developed course concepts and technologies will provide the basis for a more flexible and cost effective use of the Nordic navigational teachers and make it possible to conduct cost effective and high quality education training in remote areas in the Nordic countries like e.g. Faeroe Islands, Iceland, Greenland etc.

The evaluation and demonstration of the final course concept has been carried out using Simflex simulators located at Danish Maritime Institute, Ålands Sjöfartsläroverk and Risø National Laboratory. The instructor was located at the Danish Maritime Institute.

Discussion of training concept

Simulator training contra classroom lectures

During normal classroom education, knowledge about Search and Rescue operations is transferred to the students as declarative knowledge. The students learn the right procedures, but they are not trained in a realistic environment.

In cognitive psychology [4, 5] there is a distinction between two different kinds of knowledge: *Procedural knowledge* and *declarative knowledge*. The former can be compared to "knowing how..." while the last is the formal knowledge about facts, rules, formulas etc.

Under normal conditions these two kinds of knowledge are retrieved fast and efficient from long-term memory, but under severe pressure of time and stress, as under a Search and Rescue Operation, procedural knowledge is retrieved significantly better than declarative knowledge. The access to declarative knowledge can even be totally blocked if the pressure or stress gets too high. It is therefore important, that knowledge that should be used under extreme conditions is of the type procedural knowledge. Declarative knowledge can be transformed into procedural knowledge by repetitive and intensive simulator training.

Simulator training contra in-services training:

The benefits of using simulation compared to in-service training in a real environment are mainly:

- The ability to provide risk-free training of hazardous scenarios.
- Low cost. Real SAR training would require 3 vessels, 3 crews, and oil consumption during the exercise, and the assistance from a radio station. Typical day charter of one vessel would be 2.000 EURO
- High degree of flexibility in choice of geographical location and date and time.
- The ability to fully control the scenario development by which the training transfer is optimized and required training time is minimized.

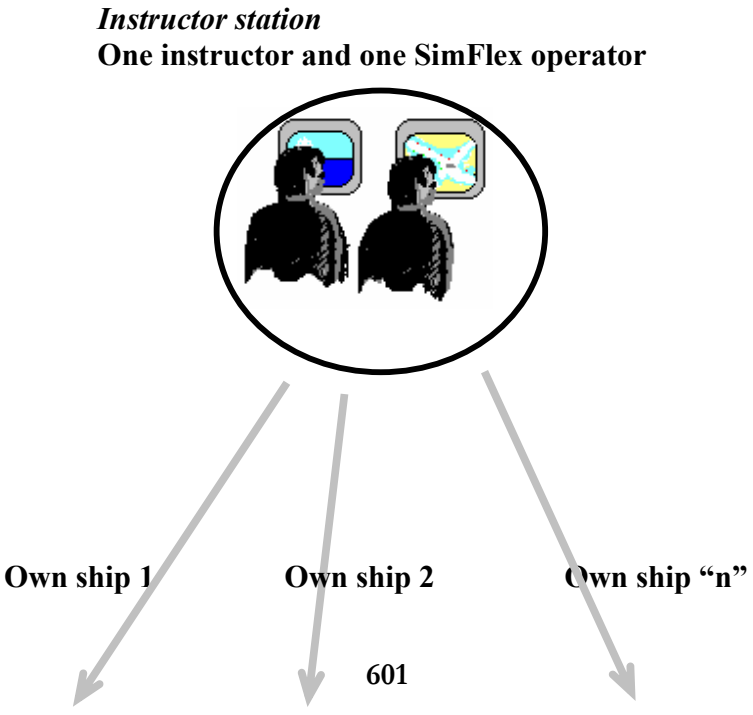
The above main advantages of using simulator based training results in reduced cost for training.

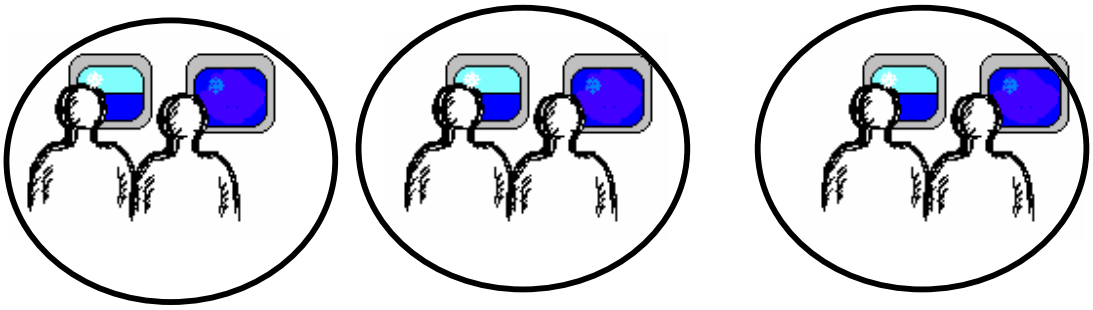
Course concepts for distributed networked simulations

Overall concept

The overall set-up for the distributed networked simulation is illustrated below. The simulators and the instructor station are geographically separated and connected through the Internet. A typical training scenario suited for distributed simulation training is e.g. Search and Rescue training and this scenario has been chosen for the concept demonstration and assessment.

Figure 1





The training concept for distributed simulation which has been developed under the Nordunet2 project comprises of the following phases/activities: in the following, emphasis has been put on the topics which are of special relevance to training of multiple co-operating teams at dispersed geographical locations using real time simulation technology.

- Preparation of detailed schedule
- Briefing of trainees
- Execution of training session
- Documentation and description
- Self evaluation by trainees
- Instructor controlled debriefing

Each activity in the training concept is explained in the following sections.

Preparation of detailed schedule

To ensure successful and effective planning in a distributed training environment timing is of extreme importance. Exact timing of the joined simulation must be planned and agreed in due time.

Briefing of trainees

Before the simulation each participant must be supplied with ”Students Information”, a booklet or E-Mail with all relevant information and documentation. The “Students Information” contains information about: Simulations plans, Time schedule, Ship Information, Exercise Information and checklists.

Execution of training session

The execution of the training session is controlled by the instructor on basis of a detailed scenario description (storyboard) along which the scenario develops.

Documentation and description

At the specified date and time all stations reports to the instructor station, using the embedded simulated VHF system. Under guidance of a navigational instructor, the simulation starts according to the scenario script.

During the whole exercise, the navigational instructor monitors all ships movement and communication. The navigational instructor acts as shore based radio station, broadcasting PAN messages (the PAN PAN message is the distress signal with a severity level just below the MAYDAY message), weather forecast, navigational warnings and other relevant radio communication.

The movements of the vessels are electronically recorded, and later available for replay during debriefing.

For each exercise a detailed script was made. The script describes position, speed and course of all vessels, date and time of simulation, weather conditions and current information. The scope of each exercise is described in the instructors material. In the following section a part of the description of a typical SAR exercise is showed.

Script SAR 2

Exercise area: Baltic west, Fehmarn Belt.
Vessels: Vessel no 1 "Erik Boye" is heading east.
Vessel no 2 "Sonja Grønborg "is trawling east of Fehmarn.
Vessel no 3. "Mette Marit" is heading southeast.

Traffic vessels: The yacht "Seawolf" is heading SSE. Seawolf capsizes at 17.35.
Naval vessel "Søløven" is OSC and is heading WNW.
Other traffic vessels are sailing in the area, but they are not taking part in the SAR operation.

Plot:
17.45 hours LMT.
A small yacht reports, man over board to Lyngby Radio. A woman has reported that her husband has fallen overboard. She is not capable of maneuvering the boat by herself.
Lyngby Radio requests all ships in the area to assist in the rescue operation.
Naval vessel "Søløven" is appointed as OSC (On Scene Commander) by SOK. All vessels take part in a parallel track search.
The yacht "Seawolf" is capsized in position 54.31.1 N 011.25.1 E. One person is at the ships bottom.
MOB (Man Over Board) in position 54.32.4 N 011.27.5. One person is in the water.
In theory Erik Boye will be able to spot the man over board after 1 hour 15 minutes. Sonja Grønborg will be able to spot the yacht approximately 55 minutes after the vessel has started its search.

SAR Exercise No 2			
Exercise: SAR 2		Vessel: 1	Erik Boye: OVXO
Start Position	Course & Speed	Wind & Current	Special information
54°33.5 N 011°16.5 E	115° 9 knot	West 14 m/s, Current 0.3 knots East. Heavy rain showers.	16.45 LMT (ZT -1) 15 November 2001 Visibility les than 5 nm.
Your are on a voyage from Frederikshavn to Gedser Port with a cargo of logs. Please make your planning in Danish chart no 196 Femer Belt 2 hours ahead			
Exercise: SAR 2		Vessel: 2	Sonja Grønborg :OXLU
Start Position	Course & Speed	Wind & Current	Special information
54°29.0 N 011°20.0 E	090 ° 3 knot	West 14 m/s, Current 0.3 knots East. Heavy rain showers.	16.45 LMT (ZT -1) 15 November 2001 Visibility les than 5 nm.

<table>
<tr><td colspan="4">Your are standing by awaiting orders where to unload your cargo of fresh fish.
Please make your planning in Danish chart no 196 Femer Bælt 2 hours ahead</td></tr>
<tr><td colspan="2">Exercise: SAR 2</td><td>Vessel: 3</td><td>Mette Marit:GHLX</td></tr>
<tr><td>Start
Position</td><td>Course &
Speed</td><td>Wind & Current</td><td>
Special information</td></tr>
<tr><td>54°36.5N
011°20.0 E</td><td>135°
5 knot</td><td>West 14 m/s,
Current
0.3 knots East.
Heavy rain showers.</td><td>16.45 LMT (ZT -1)
15 November
2001
Visibility les than 5 nm.</td></tr>
<tr><td colspan="4">Your are standing by for orders, going slow ahead. Your next port of call will probably be Rostock.
Please make your planning in Danish chart no 196 Femer Bælt 2 hours ahead</td></tr>
</table>

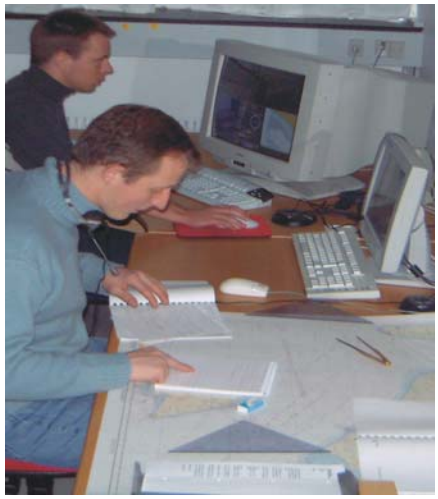
Self evaluation by trainees and Instructor controlled debriefing

A very important part of any training session is to carry out a debriefing of the trainees. The system developed will in its final form only require that the trainees have access to a PC, the Internet and the Simflex software. It is not the intention that every trainee station must have an instructor present at the site where the training takes place. This gives on the other hand the problem in the debriefing phase, as only one central placed instructor is available. The solution adopted in the project was to use a WEB based questionnaire [6]. The goal of this questionnaire was to have the trainees to reflect over what had happened during the exercise. Did they write down important data, which were given over the VHF? Did they correctly report their findings during the exercise etc? They were allowed to use their logbook, which they were expected to update during the exercise. The answers were collected and the instructor had a few minutes to browse through the information. After that there was a "meeting" using channel 16 on the VHF, where the individual crews briefed the other crews of 5 good point and 5 weak point in their own handling of the scenario. This was followed by a short sessions where the instructor replayed the crews manoeuvres on the screen and commented on their ship handling and other points of interest.

Assessment of distributed training concepts

Three sites were used in the evaluation, two in Denmark and one at the Aaland Island. Each site had two PCs running the Simflex software. At each site two teams consisting of two navigational students were hired to participate in the evaluation. Each team started by carrying out an introduction exercise, which were used to familiarise the student with the interface to the Simflex simulator and to the manoeuvring characteristics of the ship they had to control through the interface. All teams at a certain site were given the same ship. The local exercise was followed by either a SAR (Search And Rescue) exercise or an exercise with approximately the same amount of communication. The final exercise SAR 2 were the same for all the teams

Team 1		Team 2
Introduction **Exercise** **Local exercise**		**Introduction** **Exercise** **Local exercise**
Exercise 1 **Training Exercise**		**SAR 1** **Training Exercise**
SAR 2 **Evaluation Exercise**		**SAR 2** **Evaluation Exercise**



Each team had access to two PC's running the Simflex simulator. The teams where allowed to distribute the workload among themselves. A typical distribution was that one person were responsible for controlling the ship, the other carried out the communication and navigational tasks

The interface to the simulator, the small icons in the bottom of the screen give access to expanded views of different instruments. In the exercises the students had the following instruments available: Self-steering instrument, Radar, Steering and speed controls, electronic map and a binocular. Different combination of these instruments can be shown on the screen. In the top of the screen are controls for walking around on the bridge and turning the head in different directions.

The VHF radio developed in the project is modelled after a Furuno model

The local exercise was carried out without connecting the three simulators. The task was first of all to familiarise the student to the simulators controls and the different instruments available on the bridge. A central instructor controlled the Exercise 1, SAR 1 and SAR 2, the exercises were distributed from the Danish Maritime Institute, where the servers for the distribution of the different VHF channels and ship positions were located. The instructor at DMI has the possibility to change parameters in the scenario such as the visibility, location of other ships, location of the capsized vessel (for the SAR scenario) etc.

The teams at each site was observed during the different exercises, see . The observer's role was not to act as local instructors, but only has the task to look at the behaviour of the students during the exercise and to report any relevant observation, which did not come out of the debriefing sessions.

The schedule for each session was as follows:

Telephone meeting and starting up all computers
Instructor launching the exercise
Students fill in checklists
All students reporting by VHF to the instructor
Simulation starts
Simulation stops
Students fill out debriefing questionnaires
Questionnaires are returned to the instructor
Students making self evaluation
The main instructor prepares evaluation of all students
Erik Boye team briefing all other teams on own performances via VHF
Sonja Grønborg team briefing all other teams on own performances via VHF
Mette Marit team briefing all other teams on own performances via VHF
The instructor briefs all teams on their performances via VHF and replay

The last exercise SAR2 was followed by a questionnaire where the students evaluated the overall concept.

Analysis of the final questionnaire

The questionnaire filled out after the completion of all the exercises, was on the other hand aimed at the overall evaluation of the Nordunet2 concept developed. The questions in this questionnaire can be summarized in a number of heading concerning:

- Performance of equipment
- The execution of the exercise
- Learning experience during the exercise
- Expected benefits having access to the tool used in the exercises

The answers in the overall questionnaire have been collapsed in the above shown categories.

Performance of equipment

Table 1 summarizes the user satisfaction with the exercise setup; basically there is a high satisfaction with the performance of the tools and the set-up of the exercises. Looking through the comments received it seems that even with some annoying break downs of the radar in some exercises the students were able to carry out the mission with the remaining instruments

Table 1: Performance of equipment; questions 1 - 3 in the questionnaire		
Very Poor	0	0%
Poor	1	6%
Average	5	28%
Good	11	60%
Very Good	1	6%

The execution of the exercise

A very important step in any exercise is the debriefing phase were the students with the help of the instructor have to reflect on their on behavior and on any other observations they have had during the exercise.

Table 2: Debriefing; question 4 in the questionnaire		
Very Unimportant	0	0%
Unimportant	1	17%
Neutral	0	0%
Important	2	33%
Very Important	3	50%

The big challenge in this project was to setup a system where relevant feedback to the trainees was given. As can be seen from table 2 there are agreement among the trainees that debriefing is important Normally instructors are present both during and after the exercise, as can be seen from table 3 a majority of the trainees do not think that it is important to have an instructor nearby.

Table 3: Physical presence of instructor during and after exercise, question 5-6		
Very Unimportant	1	8%
Unimportant	7	60%
Neutral	1	8%
Important	1	8%
Very Important	2	16%

This could be due to the answers in table 4, where the trainees were satisfied with the debriefing they received.

Table 4: Quality of debriefing, question 7-8		
Very Poor	0	0%
Poor	0	0%
Average	6	50%
Good	6	50%
Very Good	0	0%

Learning experience during the exercise

The trainees were asked to indicate if they felt that the exercise had improved their understanding about the different aspects of participating in Search and Rescue operations. There were here a difference between the answers from the students running the exercise at Aaland and the students carrying out the exercises at DMI and Risø. The students at Aaland had already in their syllabus been going through the SAR material, where the students from Svendborg will go through this material during the current semester. This may explain why the students from Aaland declare that they only had little or no improvement during the filling out of the debriefing questionnaire.

Table 5: Learning experience, question 9-11		
No Improvement	2	11%
Little Improvement	3	17%
Some Improvement	9	50%
Much Improvement	3	17%
A Lot of Improvement	1	5%

Table 5 shows that the majority of the trainees experienced some improvement in their knowledge of SAR operations.

Expected benefits having access to the tool used in the exercises

The trainees were asked to indicate the relevance of having access to a simulator tool as Simflex.

Table 6: Expected outcome using simulator based training, question 12		
No Improvement	0	0%
Little Improvement	0	0%
Some Improvement	2	33%
Much Improvement	2	33%
A Lot of Improvement	2	33%

As can be seen from Table 6, trainees will expect that their education will benefit from access to Simflex. From the free text part of the questionnaire we got the following answer
"It would be optimal if it was possible to conduct exercises as these from your computer at home to a server at school/ in Lyngby or other place". Which nicely summarise Table 6.

Observers comments

A number of observation and comments not picked up by the questionnaire were observed.

- The teams were able to divide the tasks among themselves so one students were responsible for the steering and lookout of the ship whereas the other were carrying out the planning and communication (VHF). One team commentated after the exercises that their task sharing had not been optimal. The students changed roles between the two exercises.

- It was mentioned that normal training in communication were very predictable as they had "standard" answers from the syllabus, whereas the students in the exercises carried out had to judge the current situation and then formulate their answers/questions on the spot.
- There were only observed very few communication errors.

Conclusion

The evaluation of the Nordunet2 project "Maritime Education through Distributed Networked Simulators" shows that even with a limited amount of test subjects used in the evaluation there is a high degree of satisfaction with the developed product.

The main problem foreseen for the project was the debriefing phase, which without direct observation by a skilled instructor could lead to negative training transfer. The solution used in the project with a debriefing questionnaire, followed by a self-evaluation, turned out to be satisfactory both from the trainees' point of view as from the instructors view. This can be seen from the responses to the overall evaluation questionnaire as well as that trainees have experienced an improvement of their overall knowledge of SAR operations.

Acknowledgement

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Biography

Steen Weber got his PhD in reactor physics in 1974. Since 1990 he is a member of the System Analysis Department. He is a Senior Scientist at Risø. He has been local project leader of projects in which various knowledge-based systems were developed. His main research interests are in the development, implementation and evaluation of human-computer interfaces.

Hans H. K. Andersen got a M. Sc. in psychology in 1991 from Aarhus University, Denmark and received his Ph.D. in 1997 from Roskilde University, Denmark. He joined the research staff at the System Analysis Department at Risø National Laboratory in 1992. His research focuses on Human-Machine Interaction within the areas of team situation awareness, usability evaluation methodology, user requirements elicitation and human visual behaviour.