2013

The importance of using ship bridge simulation training to enhance the competency of masters and watch-officers : a case study of the iraqi dredging fleet

Al-Kabie Mazin Da Wood Salman
World Maritime University

WORLD MARITIME UNIVERSITY
Malmö, Sweden

The Importance of Using Ship Bridge Simulation Training to Enhance the Competency of Masters and Watch-Officers:

Case study of the Iraqi dredging fleet

BY
AL-KABIE MAZIN DAWOOD SALMAN
Iraq

A dissertation submitted to the World Maritime University in partial Fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE
In
MARITIME AFFAIRS
(MARITIME SAFETY AND ENVIRONMENTAL ADMINISTRATION)

2013

DECLARATION

This dissertation presentation is my original work. Every effort was made to acknowledge and clarify contributions, of others who are involved in collaborating with this research.

The content of this dissertation reflect my own personal views, and not necessarily endorsed by the university.

(Signature)……………………………………..

(Date)……………………………………..

Supervised by: Professor Michael Baldauf

World maritime university

Assessor: Professor Jens – Uwe Schröde

Institution/organisation: World maritime university

Co-assessor: Professor Stephen Cross

Institution/organisation: Maritime Institute Willem Barentsz Terschelling West the Netherlands

ACKNOWLEDGEMENTS

First of all, I would like to thank the almighty God, who is the source of my strength and wisdom. I would also like to extend my gratitude to the Iraqi Transport Minister and the General Director of General Company for Ports of Iraq for providing me the opportunity to join the World Maritime University.

In addition, I would like to express my heartfelt gratitude to Professor Michael Baldauf for supervising me in providing valuable advice and ensuring that this research was focused on track and also, I extend my sincere thanks to Professor Neil Belefontaine and Professor Schroder-Hinrichs for their support.

I also extend my sincere thanks to Professor Stephen Cross for his valuable information that he provided me and his continuous guidance in the right way .

Many thanks are also extended to Mrs Anne Pazaver for her careful linguistic supervision, Mr. Chris Hoebeke and all the librarian staff for their assistance in finding research materials.
Special thanks also goes to my colleague in my company Chief Eng. Abbas Kadhim and the class of 2013 MSEA students, especially, Farhan Al-Fartoosi, Sameer Abdali Marzoq, Salem Jabbar, Gunawardhane, Wanniarachchi K. and Samantha and Ofa Fisher and for their assistance and encouragement with special thanks to MET student, Amr Moneer Ibrahim for his assistance.

Lastly, this dissertation is in the loving memory of my dear mother who lived her life likes a candle in the wind and also I express my profound gratitude to my father for his unbounded love, blessings and sacrifices. Also, special thanks go to the love of my life, my beloved wife, for her encouragement and patience during my studies.

ABSTRACT

The Importance of Using Ship Bridge Simulation Training to Enhance the Competency of Masters and Watch-Officers
Case study of the Iraqi dredging fleet

Master of Science Degree

The use of simulation technology for training purposes has been a feature of several industries for many years. The aircraft industry is one outstanding example of the use of simulation. By using their learning tools and learning outcomes the maritime shipping industry will gain benefit from their experience in that field. Conducting simulation training to enhance the competency of masters and watch-officers will help to prevent marine accidents and environmental pollution. And also it is important to evaluate the knowledge and performance of seafarers. This dissertation points out the importance of structured ship-bridge simulation training to enhance the competency of seafarers regarding the STCW Manila amendments, that came into force on the first of January 2012, which reflects that it is a major priority to train ship's officers with sufficient skills, which can provide sufficient safety at sea and, as a result, protection of the marine environment. And in parallel, the dissertation refers to the importance of using simulation training to enhance the competency of masters and watch-officers of the Iraqi Trailing Hopper Suction Dredgers (TSHD) fleet.

Key words: simulation, competency, assessment, STCW and training.

LIST OF ABBREVIATIONS

ARPA	Automatic Radar Plotting Aids
CAS	Computer Assisted Solution
CBT	Computer-Based Training
CGI	Computer Generated Imagery
COLERGS	International Regulations for Preventing Collisions at Sea 1972
CRT	Cathode-Ray Tube
CSD	Cutter suction dredger
C/O	Chief Officer
DGPS	Differential Global Positioning Systems
DNV	Det Norske Veritas
DOF	Degree of freedom
DP	Dynamic Position
DT	Dynamic Tracking
DTPS	Dredge Track Presentation System
ECDIS	Electronic Chart Display and Information System
E-GMDSS	Electronic Global Maritime Distress and Safety System
E- Learning	Electronic Learning
ENC	Electronic Navigational Chart
ETA	Estimated Time of Arrival
EU	European Union
FAA	Federal Aviation Administration
GCPI	General Company for Ports of Iraq

GMDSS	Global Maritime Distress and Safety System
GPS	Globule Positioning Systems
HMI	Human-Man-Interface system
HRM	Human Resource Management
IHC	IHC system Netherlands
IMDC	International Marine & Dredging Consultants
IMO	International Maritime Organization
IMSF	International Maritime Simulator Forum
I/O	Input/output
ISM	International Management System
JMR	Journal of Maritime Research Spain
KUP	Knowledge, Understanding and Proficiency
m	meter
MARINE	Maritime Research Institute Netherlands
MARSAT	Morsvyazsputnik
MCA	Maritime and Coastguard Agency
MET	Maritime Education Training
MLC	Maritime Labour Convention
MSC	Marine Safety Committee
MSCW	Maritime Simulation Center Warnemuende
MTI	Maritime Training Institute Holland
m^3/year	cubic meter per year
m^3/hr	cubic meter per hour
PC	Programmable Controller

PIP	Picture-In-Picture
PLC	Programmable Logic Controller
QSS	Quality System Standards
RCDS	Raster Chart Display System mode
RNC	Raster Navigational Chart
ROTI	Remotely Operated Tanker Inspection System
SAR	Search And Rescue
SEA	Simulator Exercise Assessment
SES	Ship-Engine-Simulator
SHS	Ship-Handling-Simulator
SMS	Safety Management System
SPMs	Signal Point Mooring
SST	Safety and Security Training
STCW	International Convention on Standards of Training, Certification and Watch-keeping for Seafarers
STW	Sub-Committee on Human Element, Training and Watch-keeping (HTW) - formerly STW
TEU	Twenty-foot Equivalent Unit
TID	Training Institute for Dredging
TNO	MARITIM COMPANY
TOTS	Tanker Officers Training Standards
TSHD	Trailing Hopper Suction Dredger
UK	United Kingdom
ULCC	Ultra Large Crude Carrier
UMS	Unmanned Machinery Space

USA	United States of America
USCG	United States Coast Guard
VHF	Very High Frequency
VLCC	Very Large Crude Crier
VTS	Vessel Traffic System
WBL	Web-Based Learning
2/O	second officer
3D	Three Diminutions

Table of Contents

List of Figures

List of Tables

Chapter I

1. Introduction

Many industries consider the use of simulator techniques as a major contributing factor to the fundamental increase of competency. The Aviation industry is one remarkable example that motivated the first attempts to manufacture ship bridge simulation in Sweden and the Netherlands in the sixties; [The elementary designs manufactured were limited for research purposes] only. The Swedish state shipbuilding experimental simulator in Gothenburg, which was founded in 1967, introduced the first use of computer generated imagery (CGI) to produce mainly nocturnal pictures on 7 black and white CRT (cathode-ray tube) receivers. In 1973 a significant improvement took place where the training programs were related to translating ship action in maneuvers at sea, and approaching and entering a port, while environmental effects were limited to wind and current only (Muirhead, 2001).

1.1. Definition of Simulator

A simulator is defined as, "A device, designed to satisfy objectives which mimics part of real situation in order to allow an operator to practice and/or demonstrate competence in an operation in a controlled environment" (Hensen, 1999, p. ix). Moreover, maritime institutes use simulation technology for maritime training and nautical studies, in order to imitate specific environments, for instance channels, fairway, port approach areas and operations of entrance for certain types and size of ships (Hensen, 1999).

1.2 Simulators growth and development

Radar simulator, at the end of fifties, precisely in 1959, initial specifications were invented. The first radar simulator course offered radar observer techniques, plotting skills and blind navigation without outside vision (Muirhead, 2001).

Radar and navigation simulator, the States specialized in manufacturing and improving simulator technology, continuing its progress by adding more options to the system to improve their efficiency. For example, in 1965 navigation aids were added and, CAS system has introduced, several own ship stations which integrated bridge systems, such as, instrument, environmental effects, also ARPA radar has become available, and as a result of that ship models become more sophisticated (Muirhead, 2001).

More development happened to simulator technique, for instance in 1967 when it became easier to get simulators with full mission capability and motion platform alternatives. The scenery of the simulators became wider, and dynamic and hydrodynamic effects were added along with software enhancement on visuals to existing blind navigation simulators. Emergency response training and manned models as simulators were also added to simulator programs (Muirhead, 2001).

Fisheries simulator, in the sixties a fisheries simulator was founded and it including operations of handling of gear, and all types of manoeuvers, for instance; trawling, purse seining and long lining. In addition to that integration of equipment has occurred, for example, fish sonar, CAS navigation systems and effective fishing operations (Muirhead, 2001).

Navigation instrument simulator, in the 1970s the navigation instruments that stand alone or are linked were included in simulators such as, Decca, Loran, Omega, Transit, Log, Gyro and Echo-sounder. Additionally, integration of navigation systems occurred in systems like GPS, Loran-C, DGPS, Doppler log, ROTI and ECDIS (Muirhead, 2001).

Dredging ships simulator, in the nineties, many simulators were used for navigation and dredging operation training. Those simulators are full of realistic controls and software. Furthermore, there are several companies specializing in manufacturing and developing ship dredging simulators, such as IHC system in the Netherlands. However, modern simulators are located in Belgium and the Netherlands (Mourik & Braadbaart, 2003).

Other types of simulators, according to Muirhead (2001, pp.10-11) there are several types of simulators, as follows:

- Stability and stress simulator (1965)
- Liquid cargo handling simulator (1976)
- Marine diesel simulator (1980)
- GMDSS simulators (1992)
- Unmanned machinery space (UMS) simulator
- Dynamic positioning simulator
- Ballast distribution simulator
- Steam propulsion simulator

1.3 Goals and objectives

The main Goals and objectives in this dissertation will be divided into two parts.

1. The first objective is to highlight the importance of training and the role of simulation techniques in improving competency and efficiency of Masters and Watch-officers on board ships.

2. The second objective is to, suggest a proper simulator system to use in training individuals, and assessing standards of competence in ship handling simulator.

1.4 The methodological approaches

The first objective of this study is directly focused on the outcomes of using simulator training for the shipping industry, and how it will contribute in enhancing the safety at sea. Regarding the second objective of this dissertation, the Manila amendment opens up scope for the comprehensive use of simulators for the training and assessment of competency. A simulator can be a powerful tool in the learning process; hence, it is important to have sufficient knowledge of IMO conventions related to simulator training and certification. The STCW Convention is the legislative text that standardizes the training, certification and watch-keeping for seafarers.

Moreover, the change in maritime legislative demands, both national and international, has had a significant impact on training and education within the maritime domain. The dissertation, in this regard, will suggest for the Iraqi decision makers in the GCPI (General Company for ports of Iraq) the use of simulators technology for training purposes. It will represent an effective contribution to enhance the competency of the Iraqi masters and watch-officers of the Trailing Suction Hopper Dredgers (TSHD), while complying with IMO standards.

In this dissertation a literature study of the available documents and references concerning the topic of the dissertation will be implemented; moreover, it will make a comprehensive survey of the IMO conventions and codes such as STCW related to the dissertation topic. Furthermore the dissertation will be supported by statistics which provide numbers for the existence of ship handling navigation simulators with a visual capability worldwide.

Chapter II

2. Simulators in STCW

2.1 Introduction

The international maritime organization (IMO) is a specialized agency of the United Nations. The responsibility of the IMO is to create standards to improve the safety of international shipping and prevent marine pollution from ships. Hence, the IMO determined the fundamental requirements that all masters and watch-keeping officers must be well trained. The training should be taken ashore and before watch-keeping officers are assigned to their tasks on navigational watch in order to be qualified and competent to conduct such tasks. As a result of that, the safety level on board ships and at sea will increase. Moreover the IMO has decided to amend the STCW 1978 Convention in order to enhance safety at sea (Swift, 2004).

2.2 IMO Revision

The IMO decision has come as result of the increase of the maritime accidents, committed by masters or watch-officers through human error. It also responds to the concerns of the maritime community, representing ship-owners, operators and marine administration. Generally the revision processes started in March 1993, and under the supervision of the 24th Secretary General of the IMO, the STW subcommittee started re-amending and updating the Convention. The process included maintaining the existing Convention, with an emphasis on the acquisition and evaluation of skills, while urging the use of simulators as an effective training tool (Chislett, 1996).

In 1991, STW made amendments to the Convention to improve IMO’s instrument, by including engine and cargo control simulators. Regarding the use of simulators as an essential means for training, STW and the Maritime Safety Committee (MSC) have consulted the International Maritime Simulator Forum (IMSF). Moreover, in 1991, MSC requested member states to provide information concerning simulators, in order to make a decision on simulation training; until that time ship bridge simulators were not mentioned. In 1992, IMO noted the difficulty of obtaining information because many states lacked knowledge about that technology (IMSF, 1994).

A questionnaire was introduced by IMO to collect information regarding the use of, ships bridge simulators. This time the international maritime organization made a comparison with the aviation industry in respect to training and use of simulators, according to Chislett (1996). The prospective of maritime simulators in skill procurement and valuation was implicit; however, the viewpoint of the IMO convention is that technical solutions should be economical to the majority. The United States and United Kingdom supported the idea of using simulators in training. While countries that had experience with simulators encouraged the use of that technology, countries unfamiliar with the technology did not support the idea.

The STCW Convention represents a legal frame work with technical standards through its articles and annex. Part A of the STCW Code, which is mandatory, provides minimum standards of competence for seafarers, and requirements for radar and automatic radar plotting aids (ARPA) simulator training. Moreover, part B introduces assistance for the trainer or those involved in assessing the competence of seafarers, or those who are involved in applying STCW Convention provisions (Chislett, 1996).

2.3 Implementation

The adoption of the Convention is an important step forward because seafarers with high levels of training and certification are the target to restore the reliance in seafarer’s standards. The Convention stresses the necessity of controlling the issue of seafarer certificates. The foreign certificate should be recognizing by the flag state, and the system should ensure that the new competence standards are applied. The states must provide proper training and certification resources to accomplish the objectives of the Convention. The IMO will play the role of assessor for the implementation and enforcement of the regulations through its MSC, which will decide the acceptability of certification. Furthermore, the maritime community supports the amended Convention because it corresponds with the practical realism (Chislett, 1996).

In general the International Maritime Organization is; still working on developing its instruments, related to improving the efficiency and competency of the Masters and Mates in order to achieve safety at sea and prevent pollution. In other words, the IMO expends a lot of efforts to ensure that the shipping industry is provided with highly competent human resources. For more knowledge, it is important to make a comprehensive survey of the STCW Convention and Codes that stress on improving competency, especially by using simulators training (Swift, 2004).

2.4 STCW Convention and Code

The International Convention on Standards of Training, Certification and Watch-keeping for Seafarers, 1978 was adopted on 7th July 1978 and entered into force 28th April 1984. Since then many amendments have been adopted for instance, in 1991, 1994, 1995, 1997, 1998, 2004, 2006 and 2010. The 1995 amendments concerned the seafarer training, certification and watch-keeping (STCW) Code. Furthermore, in both parts of STCW code A and B there were recommendations to the parties to give the provision of the code power to earn fulfillment and completeness. And then in 1998 more amendments were made to the Convention and to part A of the Code concerning the training of seafarers on specific types of ships such as passenger and Ro-Ro passenger ships. Moreover, in 2010 more amendments were made to the Convention and the Code through the conference of STCW Convention parties in Manila, Philippines. The amendments renew standards of competence laid down especially in the use of advanced technologies to enhance the competency of seafarers and, also suggested a new training and certification requirement and methodology. For more clarification and sufficient understanding of the STCW requirements related to simulator based training, it is important to discuss those requirements under three titles as follow:

a. Use of simulators

b. Training and assessment

c. Minimum standards of competencies

STCW95 point out the possibility of using simulators as an effective tool during the discussion on Training and Assessment of seafarers as under;

1- Regulation-I/6-Training and Assessment
2- Section A-I/6-Training and Assessment (Mandatory)
3- Section B-I/6-Guidance regarding Training and Assessment

2.4.1 Regulation-I/6-Training and Assessment

This regulation has requested all parties to ensure that the training and assessment of seafarers is in accordance with the STCW Code. Furthermore, part A has mentioned that all the trainers and assessors involved in simulator training programs must have knowledge with high qualification and competency to carry out their task (STCW, 1995).

2.4.2 Section A-I/6-Training and Assessment (Mandatory)

This section is part of provisions of the annex to the STCW Convention which concludes standards of competency of the trainer. In addition, it determined the abilities in the standards of competence and collected them as appropriate, under the following seven functions:

1. “Navigation
2. Cargo handling and stowage
3. Controlling the operation of the ship and care for persons on board
4. Marine engineering
5. Electrical, electronic and control engineering
6. Maintenance and repair
7. Radio communications” (STCW, 1995, p.73)

All the functions above are under a responsibility level, for instance, management level, operational level and support level. Moreover, functions and levels of responsibility are defined clearly in Chapter I section A-I/1, and the definitions of functions and levels are identified in the tables of standards of competence which are listed in chapter II, III, and IV of part A.

Moreover, this section stresses that if the “training is being conducted by using a simulator the designated Instructor should have received appropriate guidance in instructional techniques involving the use of simulators, and have gained practical operational experience on a particular type of simulator being used for the training”. Also, when assessment is being done using simulators, the assessor should have obtained practical assessment experience on a particular type of simulator to the satisfaction of an experienced assessor. In other words, the qualification of instructors and assessors is covered in some detail (STCW, 1995).

2.4.3 Section B-I/6-Guidance regarding Training and Assessment

This section is related with providing guidance on how to comply with the corresponding section of part A, and it mentions IMO model courses for instructors and for examination and certification of seafarers. Moreover, the instructors and assessors must be highly qualified to conduct training and assessment. In other words, those who practice in service training should have enough knowledge of instructional techniques and of training methods.

Moreover, there is a dedicated part of STCW, which highlights the use of simulators, as under:

1- Regulation I/12 Use of simulators.
2- Section A-I/12-Standards governing the Use of Simulators (Mandatory).
3- Section B-I/12-Guidance regarding Use of Simulators.

2.4.4 Regulation-I/12-Use of simulators

This regulation provides a legal frame work for the performance standards of marine simulators being used for the training and assessment of seafarers and their certification in compliance with STCW.

2.4.5 Section A-I/12-Standards governing the Use of Simulator (Mandatory)

This section has two parts:

Part 1 provides the performance standards of the simulators that can be used for the training and assessment of seafarers separately. Additionally, STCW recommends that the scenario design is very important in getting the best training value from an individual exercise on a simulator. Moreover, a realistic simulator with a realistic visual capability is required. The input of the vital operating conditions, which will bring desired actions and responses by the trainees and create an effective imitation of reality with real situation pressures, will be beneficial to the training and assessment objectives. The most important aspect of the performance standards in STCW is the requirement of simulators to provide the simulator instructor with control (Hensen, 1999).

Part 2 provides other provisions where training and assessment procedures have been discussed, for the simulator trainers and assessors to have standards for conducting simulator training. STCW foresees that briefing, planning, familiarization, monitoring, and debriefing be part of any simulator based exercise. It also highlights the importance of guidance and exercise incentives by instructors during monitoring and use of peer assessment techniques during the de-briefing stage. Simulator exercises are required to be designed and tested by the simulator instructor to ensure their suitability for the specified training objectives (Cross, 2010).

2.4.6 Section B-I/12-Guidance regarding Use of Simulators

STCW has made only the RADAR / ARPA simulator training mandatory for seafarers and in this section, it gives detailed guidance on how to use the RADAR, ARPA simulator for training and assessment purposes. In addition, concerning **RADAR** Simulator, STCW (1995, pp. 292-293-294-295) highlights the following areas of the radar simulator when being used for training and assessment of seafarers;

- “Factors affecting performance and accuracy.
- Detection of misrepresentation of information, including false echoes and sea returns.

- Setting up and maintaining displays.
- Range and bearing.
- Plotting techniques and relative motion concepts.
- Identification of critical echoes.
- Course and speed of other ships.
- Time and distance of closest approach of crossing, meeting or overtaking ships.
- Detecting course and speed changes of other ships.
- Effects of changes in own ship's course or speed or both.
- Application of the International Regulations for Preventing Collisions at Sea".

ARPA Simulator, STCW (1995, pp. 296-297) highlights the following areas of the ARPA simulator when being used for the training and assessment of seafarers;

- "Possible risks of over-reliance on ARPA.
- Principle types of ARPA systems and their display characteristics.
- IMO performance standards for ARPA.
- Factors affecting system performance and accuracy.
- Tracking capabilities and limitations.
- Processing delays.
- Operational warnings, their benefits and limitations.
- System operational tests.
- Manual and automatic acquisition of targets and their respective limitations.
- True and relative vectors and typical graphic representation of target information and danger areas.
- Information on past positions of targets being tracked.
- Setting up and maintaining displays".

STCW has competency tables along with KUP (Knowledge, Understanding and Proficiency) for Deck and Engine Room both, in Chapter II, III and IV (Code A) for Management and Operational levels. These tables also contain columns for method of demonstrating competencies where simulators are listed as one of the means that can be used for demonstration of competencies. For instance, in Chapter II and under the title standards regarding the master and deck department, Section A-II/1, are mandatory minimum requirements for certification of officers in charge of navigational watch on ships of 500 gross tonnages or more, with stress on standard of competence. Every candidate for certification shall be demanded to explain the competence to undertake, at the operational level, the tasks, duties and responsibilities listed in column 1 of table A-II/1; (STCW, 1995).

2.5 Oil and Chemical tankers in STCW

In STCW Code, as amended part A, Chapter V and under the title; standards regarding special training requirements for personnel on certain types of ships, section A-V/1-1 as mandatory highlights the minimum requirements for training and qualifications of masters, officers and ratings on oil and chemical tankers. Furthermore, it establishes standards for competence for every candidate who is going to work on board such type of ship. In addition to all requirements listed in column 1 of table A-V/1-1-1, it is important to note that column 3, which has the title "the methods for demonstrating competence" indicates that the examination and assessment of evidence should be obtained from one or more of the following:

1- "Approved in- service experience
2- Approved training ship experience
3- Approved simulator training
4- Approved training programme" (STCW, 1995, p. 188)

2.6 Maritime Education and Training in ISM

The ISM Code is major goal, as noted in the introduction of the code (ISM Code, 1994) is "to provide an international standard for the safe management and operation of ships and for pollution prevention". Hence, by implementing Safety Management System (SMS) the goals of the ISM Cod will be achieved.

The most important element in the shipping industry is the crew. For instance, regulation 6 of the ISM Code, “Resources and personnel”, stressed on that; the shipping company is enforced to guarantee that the master and crew of its ships had practiced sufficient training and are medically appropriate for their occupations on board.

Furthermore, the International Chamber of Shipping (2010, p. 30) inferred this regulation by stating “shipping companies should only employ masters and crews who are medically fit, have the appropriate level of training and hold valid certificates of competency compatible with STCW requirements and its physical ability standards”.

Paragraph (6.2, p. 14) stated “The Company should ensure that each ship is manned with qualified, certificated and medically fit seafarers in accordance with national and international requirements” the paragraph stresses on the importance of training for the crews of ships, for the purpose of maintaining the human life’s and property and to prevent pollution (ISM Code, 1994).

Moreover, paragraph (6.5, p. 14) mentioned “The Company should establish and maintain procedures for identifying any training which may be required in support of safety management system and ensure that such training is provided for all personal concerned”. It is clear the aim of the above paragraph; is to guarantee that the seafarers whom are required to support the SMS have had conducted sufficient training, especially seafarers engaged in critical safety and emergency operations. Moreover, these training courses should be all, in compliance with STCW standards (ISM Code, 1994).

2.7 Simulators in Classification society

Classification is a system for safeguarding life, property and the environment due to operational consequences. In addition, classification implies a process of verifying objects and systems against a set of requirements. In order to enhance this chapter of the dissertation, it is important to refer to the role of the classification society in evaluating simulators and ensuring that those simulators are qualified to use in assisting the competency or for training purposes. Furthermore, it is significant to select one of the world's leading maritime classification societies(ISO, DNV) to get complete understanding about the scope, applications and classification principles to be followed by states and training centers and also to get the ultimate simulator with high qualifications and compliance with international standards (DNV, 2011).

The classification society has its own principles to issue a certification for the simulator itself in order to assist maritime academies, shipping companies or the training centers to select a proper simulator for training purpose to demonstrate competence or assessment. Moreover, it should ensure that the maritime simulators are going to be used for training comply with the requirements of the STCW 1995 regulations with its amendment. In other words, the purpose of the standards is to ensure that the simulations provided by the simulator include an appropriate level of physical and behavioral realism in correspondence with recognized training and assessment objectives (DNV, 2011).

Moreover, and as mentioned in the previous pages of this chapter, the STCW convention and code has referred to the use of simulators in several places. For instance, there are general performance standards for simulators used in the training and assessment of competence as well as other provisions for training and assessment procedures (See Figure 1). Some simulator training is considered essential and is therefore mandatory for complying with the STCW convention. Mandatory training in simulators is Radar and ARPA training and special conditions apply to these kinds of simulators. STCW (1995) has stated it is up to each party to ensure that every simulator used in the training and assessment of competence required under the convention satisfies the performance standards. However, to aid maritime administrations with this work, the class society Det Norske Veritas (DNV) has developed classification rules for maritime establishments. So, if a maritime simulator complies with standards of certification No. 2.14 maritime simulators, it is considered to fulfill the performance standards listed in the STCW convention (DNV, 2012).

General performance standards for simulators used in assessment of competence

- ➢ Each party shall ensure that any simulator used for the assessment of competence required under the convention or for any demonstration of continued proficiency so required shall:
- be capable of satisfying the specified assessment objectives;
- be capable of simulating the operational capabilities of the shipboared equipment concerned to a level of physical realism appropriate to the assessment objective, and include the capabilities, limitations and possible errors of such equipment;
- have sufficient behavioural realism to allow a candidate to exhibit the skills appropriate to the assessment objectives;
- provide an interface through which a candidate can interact with the equipment and simulated environment;
- provide a controlled operating environment, capable of producing a variety of conditions, which may include emergency, hazardous or unusual situations relevant to assessment objectives; and
- permit an assessor to control, monitor and record exercises for the effective assessment of the performance of candidates.

Figure 1: General performance standard for simulators used in assessment of competence

Source: **STCW Convention and STCW Code. 1995, IMO (1995)**

Det Norsk Veritas DNV

One of the important classification societies in the European Union and the world, established in 1864, Det Norske Veritas is an autonomous foundation with the objective of protection of life, property and the environment. Moreover, as one of the world's leading maritime classification societies, DNV establishes rules for the construction of ships and mobile offshore platforms; about 25 per cent of all ships currently on order will be built to DNV class (DNV, 2011).

2.8 Standards for Certification

Since its establishment the DNV has initiated to create serious standards for certification. However, these standards are publications that contain ideologies, approval criteria and practical information related to the society's consideration of objects, personnel, organizations, services and operations. Standards for certification also apply as the basis for the issue of certificates and/or declarations that may not necessarily be related to classification. The society reserves the exclusive right to interpret, decide equivalence or make exemptions to this standard for certification (DNV, 2011).

Moreover, the DNV addresses certain issues concerning simulators. For example, in section 1 and under the title Application and Certification the DNV addresses the following:

- A. Scope and Application
- B. Classification Principles
- C. Definitions
- D. Documentation
- E. Tests

Section 2 under the title General addresses:

- Simulator Equipment
- Instructor and Assessor facilities

Section 3 under the title Bridge Operation addresses:

- A. Simulator Class- Bridge Operation
- B. Simulator Objectives
- C. Simulator requirements

In addition, in this section the DNV classifies simulators according to the function area, and determines the capability of each class of the simulators, for more precise detail about the simulation objectives, (See Appendix A).

Chapter III

3. Ship-handling Simulation

According to Cross (2010) it can be said that any dynamic process or complex operational equipment is suitable to stand as a model for a simulation system. Moreover, skills training, concept training and understanding of interactivity of systems can be achieved by proper use of qualitative simulator systems. As mentioned in the first chapter of this dissertation, there are many types of simulators. However, the type that will be under examination and related to the topic of this dissertation is ship-handling simulator or as it is known ship-bridge simulator.

3.1 Simulation Philosophy

Van der Rijken (2008) has stated that simulators are developed to serve the professional maritime world in studies and training with complex realistic simulation environments. Moreover, simulators are an extension of model testing enabling the performance of simulations based on ultimate hydrodynamic data and geographical database derived directly from the model tests. The direct implementation of the hydrodynamic data is possible because the simulator technology used is based on software developed according to real life locations. The resulting mathematical maneuvering model for instance, (vessel, tug or any other floating object) are six-degrees-of-freedom (6 DOF) models responding realistically to environmental conditions (wind, waves and current) and hydrodynamic interactions. In addition, other real-life phenomena such as back suction, squat and trim are depth/draft dependent modeled.

According to Van der Rijken, (2008) the companies that manufacture simulators can offer a large database of mathematical maneuvering models based on previous model tests to meet the professional maritime world. When a dedicated model is required, the experts basically focus on such a mathematical model derived on available model tests or maneuvering tests. The technical simulator design enables almost any mathematical relations to be used for the mathematical maneuvering model. For example, towing of fast-craft, large off-shore modules, semi-submersibles or submersibles can all be accommodated in the simulators.

Moreover, Van der Rijken (2008) has pointed out that the importance of accurate modeling of hydrodynamic effects on ship maneuvering behavior; also, a realistic simulation environment increases the realism of simulated maneuvers. The simulation environments are basically designed with two techniques the bridge design and the projected visuals. The bridge as in real ships is module-based, providing a flexible and realistic set-up of the instruments required corresponding with the bridge layout of the designed vessel. The projected visuals have been developed recently with the implementation of special visual software used in the computer game industry to increase the realism of the simulations. The new technology allows for special effects such as, snow, mirroring, shadowing, and the use of spray, light breaking, foam, 3D fog, smoke and fire; however, it is gradually implemented

3.2 Shiphandling simulator and its fundamental components

Hensen (1999, p. 14) has stated that the equipment found on the real ship bridge should be available on the simulator bridge to add more realism. In other words, the simulator bridge layout should be such that navigation and maneuvering tasks can be performed as they would in real life. The Fundamental components of Ship Bridge are as follow:

- Rudder control and rudder indicator
- Engine/propeller control, including indicators for engine and/or propeller revolutions for fixed pitch propellers or controllable pitch propellers; in case the ship is equipped with more than one propeller, separate controls and indicators for each engine/propeller combination are necessary.
- Transverse thruster controls and transverse thruster indicators; the ship can be equipped with a bow thruster as well as stern thruster, or with only a bow thruster.

- Compass, speed log, water depth indicator, wind speed and direction indicator, navigation lights, whistle, ARPA radar; the ARPA radar should have appropriate low range setting for close-quarters navigation and correct presentation of the area under consideration. In ice navigation conditions, traces of ship and ice edges should be reproduced on the simulated radar display.
- Communication equipment for VTS communication, communication with tugs and simulator operator.
- Line handling possibilities and anchor handling controls and monitors.
- Chart table

Furthermore, the following instruments:

- Doppler log, rate of turn indicator, GPS or DGPS, LORAN and Electronic Chart Display and Information System(ECDIS) equipment, which can display (ENCs)Electronic Navigational Chart, which are vector charts, in the ECDIS mode, and (RNCs) Raster Navigational Chart in the (RCDS) Raster Chart Display System mode.
- For the ships propelled by thrusters or podded propulsion unit. Thrusters or podded propulsion units are to be controlled as on the real ship, and may comprise separate and/or combined controls, thruster or podded propulsion unit direction indicators, propeller revolution indicators or propeller revolution and pitch indictors.

- For ships equipped with joystick control, the joystick control system indicators and characteristics as on the real ship should be modeled (Hensen, 1999, p. 14)

3.2.1 Features to enhance virtual realism

Hensen (1999) stated there are additional features that can contribute to enhance the realism in the simulation atmosphere, for instance, wind indicator. This indicator is essential and should clearly show the relative wind direction, which will enrich the feeling of realism. Furthermore, ship motions are important to add or to include with other features. It will fulfill the motivation of training on simulators. Additionally, simulation, real time is a technique that imitates the ship passage or maneuvers according to time scales as in realty.

Moreover, Hensen (1999) has mentioned, that in the 1960s, it was found sufficient to simulate the horizontal plane motions of surge, sway and yaw only because the ships were relatively slow. And when high speed container ships entered service the necessity to include roll motion as the fourth degree of freedom became obvious. However, rolling motion and angles of heel caused by normal maneuverings even in calm weather cannot be ignored. Further extension adopted to include the vertical plane motions of heave and pitch caused by the action of waves became possible as computer power increased and simulation technology advanced.

3.2.2 Degrees of freedom (DOF)

Sandaruwan (2010) has stated under the title "A Six Degrees of Freedom Ship Simulation System for Maritime Education" the simulator's capabilities should contain the ship motions in which it can be imitated in the basic mode of:

- Three degrees of freedom 3DOF: surge, sway and yaw
- Four degrees of freedom 4DOF: surge, sway, yaw and roll
- Five degrees of freedom 5DOF : surge, sway ,yaw, roll and pitch
- Six degrees of freedom 6DOF :surge, sway, yaw, roll, heave and pitch

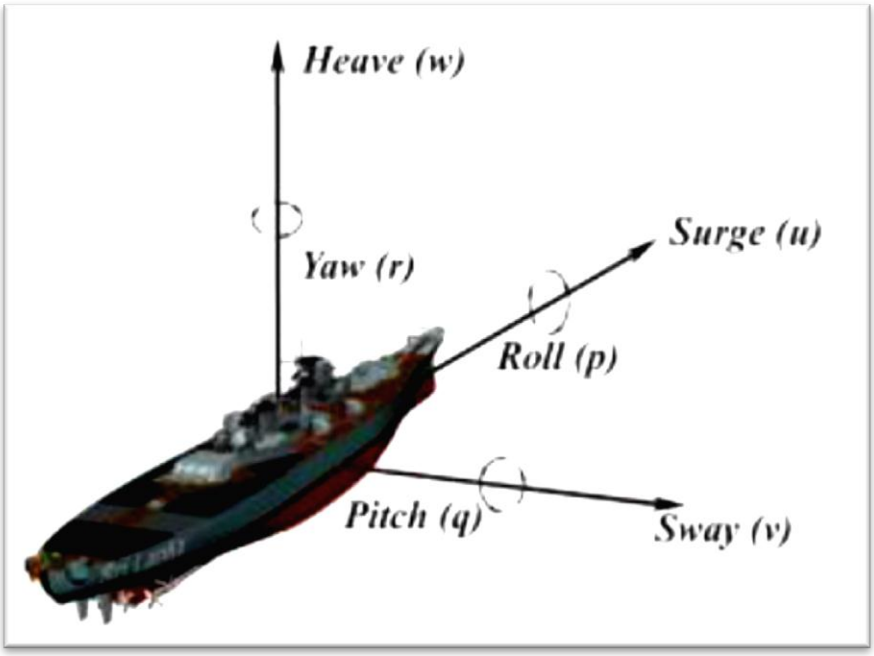

Figure 2: Six degrees of freedom of ship motions

Sources: Sandaruwan, D., Kodikara N., & Keppitiyagama, C. (2010). *The International Journal on Advances in ICT for Emerging Regions 2010 03 (02): 34 – 47. The International Journal on Advances in ICT for Emerging Regions 2010 03 (02): 34-47.* Retrieved July 2013, from www.sljol.info/index.php/ICTER/article/download/2847/3771

On one hand, the selection of 4, 5 or 6 DOF, depends on the environmental conditions in the simulated area and training requirements or research study in the absence of waves and swell. 4DOF would normally be sufficient; on the other hand, for imitation of squat effects, a full 6 DOF model is appropriate. Finally, for research studies, for instance, a design for an approach channel in an open sea environment, according to Hensen (1999) simulation of ship motions in horizontal as well in vertical plane due to waves, is a requirement leading to the implementation of a 6 DOF model for the ship.

3.2.3 Out of window view of Ship-bridge simulator

According to Hensen (1999), for sufficient training and for realistic performance on ship bridge simulator, especially navigation and maneuvering in restricted waters, the out of window view through electronic screens is very important. Because, masters and pilots depend on their own visual observation in making decisions, they base their decisions of rudder, engine and tug movements to a large degree on visual information, for instance, ship's speed, drift, heading, rate of turn and distances obtained from the outside world. On the simulator, this information should be offered directly because it is so significant to the watch officer. For more information, the most important aspects of out of the window view need to be validated.

3.3 Simulation of ports approach or waterways and of ship's profile

Pianc (1992) mentioned that a typical simulator training or study project cannot be conducted without collecting sufficient and accurate data concerning the area intended to be simulated. For example, weather, tides, current, and wave condition. Also the same may apply to ships to be simulated, when all relevant data is obtained, implementation of the data for the training purpose or research project can be started. Moreover, for the simulation of area under consideration; a site visit is recommended to have a comprehensive look at the location. It is also important to collect all relevant data about the ship that will be the subject of simulation from the ship's manual or the shipyard documentation. For extended information about the procedure that should be followed in collecting data for simulating ports approaches, waterways and ships; it is possible to enquire from a specialized simulation institute.

3.4 Remarks

3.4.1 Simulation methods

According to Hensen (1999), there are two methods of simulation, namely:

a) Non-interactive simulation

In this method the whole navigation process is mathematically modeled. The instructor does not interact with the process. This type of simulation is called fast time simulation.

b) Interactive simulation

In this method the simulation operation takes place with interaction of a human operator. However, this represents real time simulation, which takes place on ship bridge simulators. This type will be presented in this dissertation as a typical means for training.

3.5 The main type of simulator considered

The major type of simulator considered in this dissertation is the full mission bridge simulator; Hensen (1999) has stated, as the number of full mission simulators becoming obtainable in recent years has increased significantly, it is considered desirable and very sophisticated.

3.5.1 Types of full mission bridge simulators

According to Mourik & Braadbaart (2003), there are several types of advanced full mission marine simulators manufactured or offered by many well-known companies worldwide with service centers to maintain those devices. As it is mentioned in the introduction of the dissertation, one of the goals of this dissertation is to introduce to the decision makers in Iraq such a technology as a lower cost means for training and enhancing the efficiency and competency of the seafarer.

It will be useful to present two of the available products on the market, for an example, especially established to enhance the knowledge of seafarers about the existing technology in this regard.

3.5.2 Full-mission Bridge Simulator combined with (SST)

According to Baldauf, Nolte-Schuster, Benedict & Felsenstein (2012), the advanced level of sophisticated simulation with combined SST and ship-handling simulation allows for more detailed in depth study of the effectiveness of safety and security plans and procedures on board different types of ships.

This type of simulator is placed in the Maritime Simulation Center Warnemuende (MSCW) in Rostock; and it is also placed in the recently established maritime simulation laboratory at World Maritime University in Malmo-Sweden (See Figure 3). This simulator has been developed for the purposes of research and training with specific features of maritime Safety and Security Training to enhance the safety of the passengers on board Ro-Ro ships and Ferries. Additionally, 4500 TEU container vessel are modeled. The theoretical implementation of this type of simulation system is depicted through 3D visualization. However, it has been interfaced into the SST to assist officers of watch to be familiar with safety and security challenges. The simulator delivers and supports application environments, meeting and supporting STCW standards. Moreover, SST simulator is certified and/or approved by Det Norske Veritas (DNV).

According to Benedict et al., (2011), the Maritime Simulation Centre Warnemuende at Wismar University, Department of Maritime Studies provides accommodations consisting of six advanced simulators, implementing a common network, and including four ship-handling bridge systems with varying levels of equipment, a ship's engine system and a VTS capability. Furthermore, the complete assembly of the MSCW implements new standards for training in all phases of maritime safety by not only wide-ranging simulation of all ship-handling operation combining emergency measures and operation of machinery, but also by realistic simulation of operational exchanges between navigators and VTS centers. The collaboration of many components is a major feature of the center. At the same time, it additionally provides a typical platform for a wide range of research and development.

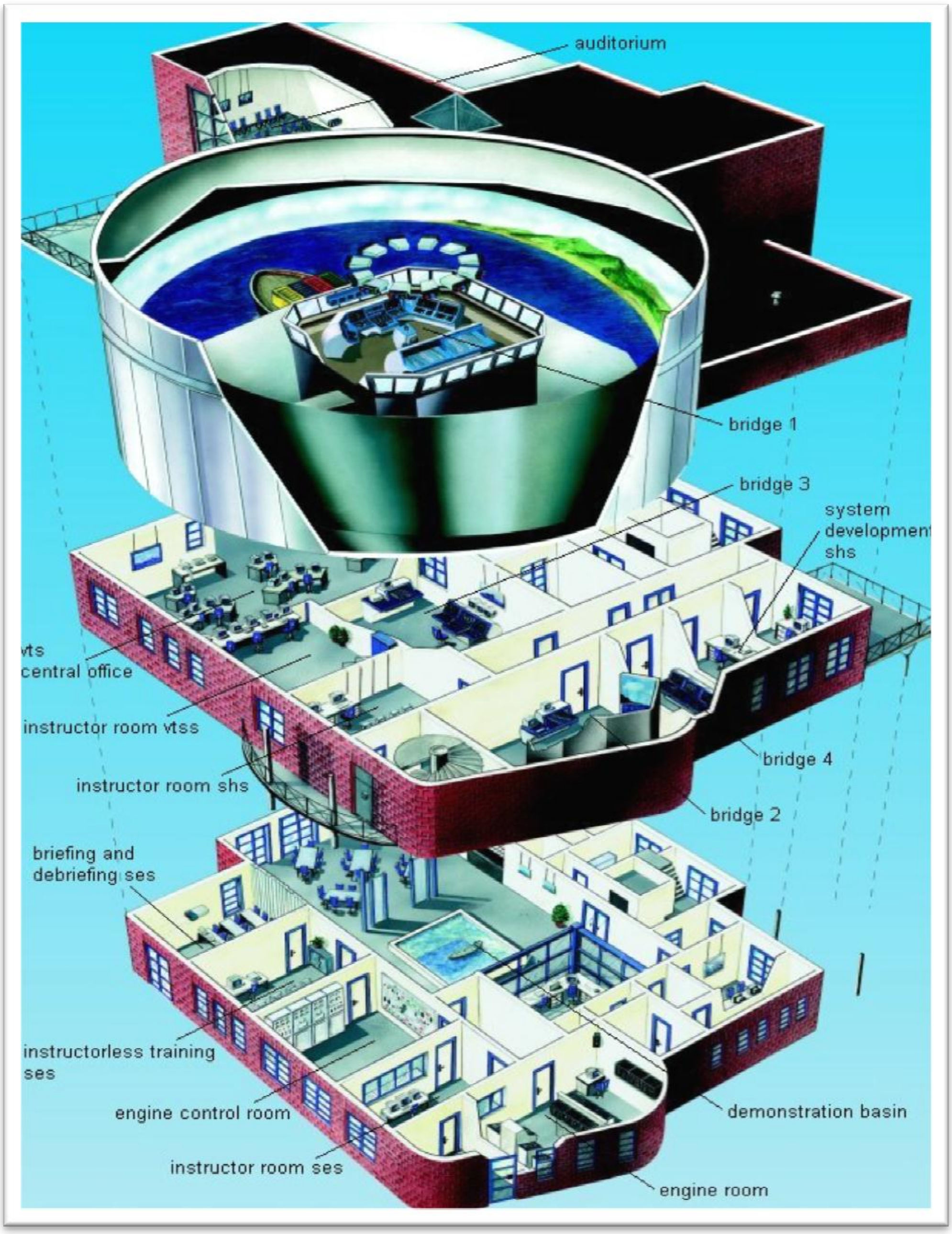

Figure 3: Wismar University's Maritime Simulation Centre at Warnemuende (MSCW) which comprises a series of 6 handling ship engine and VTS simulators

Source: Baldauf, M. Nolte-Schuster, B. Benedict, K. & Felsenstein C. (2012). Maritime Safety and Security. Learning objective oriented development of simulation exercises, *in Maritime Transport V – Technological, Innovation and*

Research, Fransesco Xavier Martinez de Osés & Marcella Castells I Sanabra [Eds.] IDP: Barcelona, pp 868 – 887

3.5.2.1 SST functionalities

According to Rheinmetall (2011, p.3), the simulator offers and supports exercise environments, meeting and supporting STCW standards and includes the following functionalities:

- Provision and implementation of exercises to meet STCW, ISM, ISPS and other relevant regulations like (TOTS) Tanker Officers Training Standards.
- Conduct and management of crisis situations in order to train emergency processes and communication under stress.
- Team training conditions in order to train management level as well as local teams.
- Training in virtual 3D scenarios, for example, on-board of different types of ships as well as on-board of type specific ships.
- Physical, thermodynamic and hydrodynamic mathematical models close to reality, taking corresponding effects into account, for example, flash over, back draft, stability.
- Data recording of all exercise data as well as communication, in order to replay and repeat recorded exercises.

3.5.2.2 (SST) basic layout

The basic layout of (SST) is shown in Figure 4 and consists of (Rheinmetall, 2011):

Hardware

- Instructor Station
- Communication Computer
- Trainee Station

Software Licenses

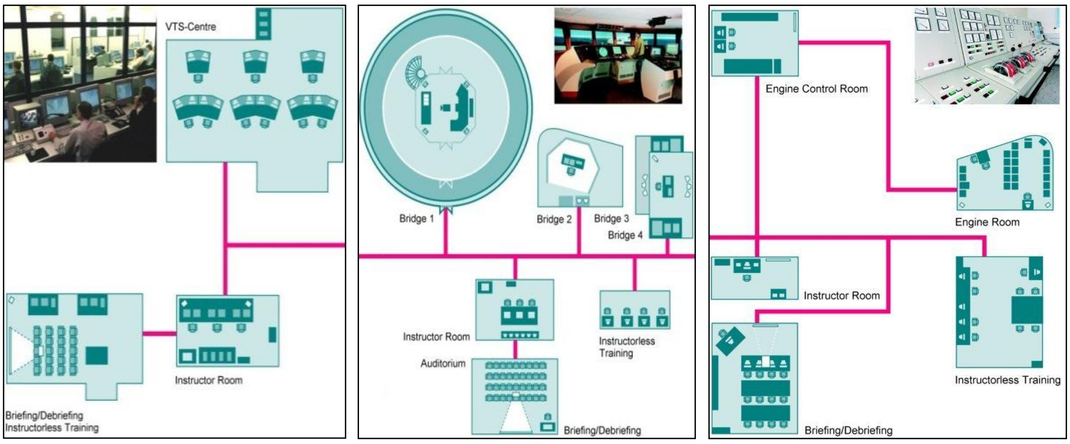

Figure 4: Components and Structure of the Simulator Segments: VTS-Simulator (VTSS), Ship-handling Simulator SHS and Ship-engine-simulator (SES)

Source: Baldauf, M. Nolte-Schuster, B. Benedict, K. & Felsenstein C. (2012). *Maritime Safety and Security*. *Learning objective oriented development of simulation exercises, in Maritime Transport V – Technological, Innovation and Research*, Fransesco Xavier Martinez de Osés & Marcella Castells I Sanabra [Eds.] IDP: Barcelona, pp 868 – 887

3.5.2.3 Research and Investigation Software SST

This special software addition package back and permits the use of the **SST** for scientific research and investigation tasks like:

- Accident analysis
- Reassessment of safety and security procedures
- Preparation of new safety and security procedures and routines (Rheinmetall, 2011).

3.5.2.4 Interaction between SST and SHS

Hardware and software interface between **SST** and SHS in order to develop cooperation and training possibilities. It enables the instructor to generate and execute special exercises for Emergency Response Training (Rheinmetall, 2011).

3.5.2.5 Extension Ship Handling Simulator SHS

According to Rheinmetall (2011), the SST can be interfaced to ship-handling simulator SHS in order to provide realistic emergency response management training. The SHS is offered as an extension to the SST. The addition to SHS consists of 1 instructor station and 1 bridge cubicle, including a handle box for ship-handling and a 3 channel visual system on monitors. Moreover, it consists of:

- Simulation System
- Visual System
- Exercise Area / Ship Models
- Software
- Documentation
- Functional Testing
- Services

3.6 Polaris Ship's Bridge Simulator

According to Kongsberg (2009), Polaris Ship's bridge simulator is recognized as one of the advanced and flexible ship's bridge simulators available in the market today. It can be designed to meet every feature of bridge-simulator training and research requirements, offering relevant training possibilities. However, from desktop to full mission systems this company is devoted to make this type available to as many users as possible. Polaris can be designed from a PC desktop simulator to a full mission ship-handling simulator. In addition, Kongsberg provides an e-learning (web-enabled) module. According to Baldauf, Carlisle, Patraiko & Zlatanov (2011), this simulator is a composite training system involving computer databases, computer controlled and virtually simulated subsystems, control panels and précised visual systems.

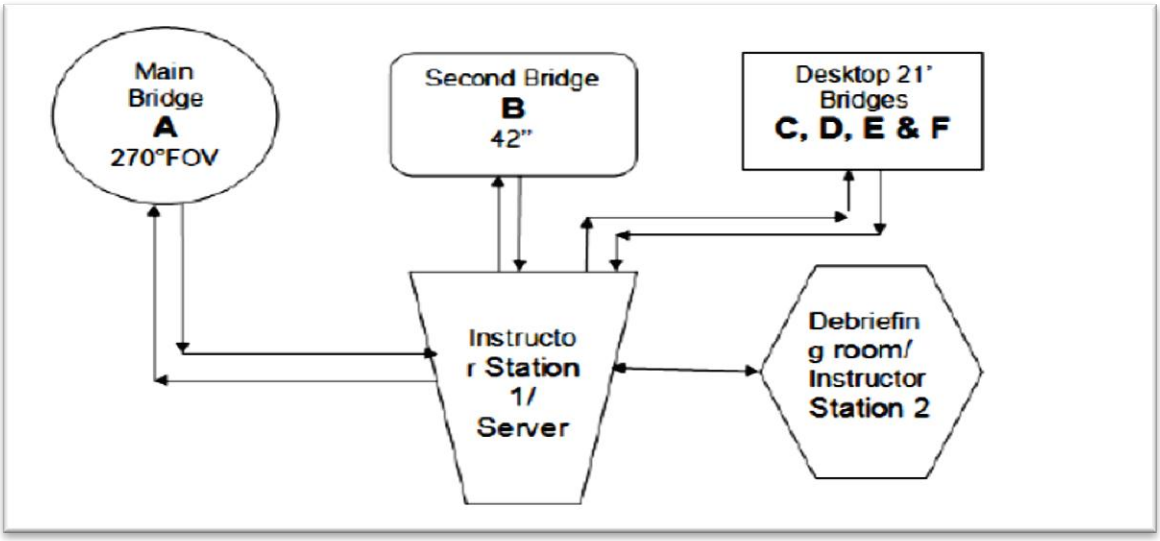

Figure 5: Basic structure of the Polaris Bridge simulator

Source: Baldauf, M. Carlisle, J. Patraiko, D. Zlatanov, I. (2011). *Maritime Training Platforms. TeamSafety - Technical Work package report. World Maritime University, Malmö, September 2011*.

According to Kongsberg (2009), full range of simulation systems are available with cost effective solutions to fit in to the requirements. The simulator can be expanded at any time with "additional instruments, workstations or complete integrated bridge systems. Several special task simulators are also available, including riverboat, anchor handling and dynamic positioning simulators, with other special simulation functions such as ice navigation, anti-terror and SAR-training". Moreover, the Polaris provides a complete training environment. For instance, a ship's bridge simulator can be connected with communication, engine room and cargo ballast simulators, allowing students to train and interact as required in real ship operations. Currently the system contains ability of realistic imitation of 18 hydrodynamic models of different types of ships including:

- Bulk-carriers, car-carriers, container vessels, LPG carrier, cruise ships, VLCC, tugboats, supply vessels, patrol ships and yachts.

In addition, Baldauf et al., (2011, p. 33) stated that the provided 10 typical sea areas comprise, in terms of maritime navigation the following, challenging geographical regions : Australia - Sydney; China - Hong Kong, Turkey – Istanbul Strait (Bosporus) Turkey - Chanakkale Strait, Dardanelles, Japan-Tokyo Bay; Malaysia - Malacca Strait; Egypt - Suez Canal, Morocco / Spain - Gibraltar; Netherlands Europort; Singapore Strait; English Channel - Dover-Calais.

Furthermore, according to Kongsberg (2009), the range of its products, from desktop to 360º full mission Polaris ship's bridge simulators, exceeds the existing STCW requirements. Polaris ship's bridge simulators are certified and/or approved by the following organizations: Det Norske Veritas (DNV) Standard for Certification 2.14 Maritime Simulator Systems of October 2007 - Classes A, B and C (See Appendix A). Maritime and Coastguard Agency (MCA), UK; USCG (United States Coast Guard) approved courses, USA; the Russian Federal State Unitary Enterprise, Morsvyazsputnik (MARSAT), Russia; and the Norwegian Maritime Directorate, Norway.

Figure 6: Polaris Ships Bridge Simulator

Sources: Kongsberg. (2009). *Kongsberg Maritime Simulation & Training Ship's Bridge Simulator.* Retrieved July 2013 http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/CF21FD409713420CC12575C5003C8B54/$file/KM_ShipsBridge-brosjyre.pdf

According to Baldauf et al., (2011, pp. 33-34), the simulator provides the following capabilities:

- Simultaneously conducting of several different exercises.
- Absolute control of the environment and hydro-meteorological conditions in accordance with the objectives of the exercise.
- Taking into account the real effect of wind, waves, currents, tides and shallow waters on own ship.
- Simulation of emergency situations including oil spillage incidents.
- Navigating with pilot on board and interaction with a helicopter.
- Simulation of maneuvering with multiple targets.
- Maneuvering with tugs and mooring operations for going alongside or departure from a quay.
- Ability of planning, assessment, execution and monitoring of a sea voyage
- Use of various means of communication, radar / ARPA, ECDIS
- Coordination and execution of SAR operations, SAR training, initial studies and Aftermath SAR efficiency assessments (Baldauf et al., 2011, pp. 33-34)

Chapter IV

4 The Need for Simulators in Maritime Industry

4.1 Different tasks-different needs

According to Kongsberg (2009), investment in maritime simulators has become not limited to just the largest academies and organizations. In the present time simulator customers represent a wide-ranging mix of different organizations, from public training academies, universities and training centers, to shipping and oil and gas companies; in addition, military training organizations including Navies, Coast Guards and Maritime Police. Accordingly, ship's bridge simulators must be elastic to meet the users' various needs. Simulators today can be delivered (tailor-made) ideally, ensuring that both functionality and cost meet the exact requirements of the user (See appendixes B & C).

Moreover, it is important to have a look at the current availability of marine simulators in maritime training institutions. It is noticeable that delivery of simulators to developing countries has increased in speed over the last few years. Furthermore, this applies particularly in relation to radar, navigation and engine room simulators (IMO, 1993).

> "Simulator-based training is one of the key factors in any considerate MET institution nowadays. The necessity for the simulator is caused by financial and environmental pressures that are leading to insufficient availability of training grounds. Moreover, simulators are becoming easier to manufacture and cheaper to purchase" (Muirhead, 1993).

According to Cross (2011) the simulator exercise is essentially of a psycho-motoric nature. "Simulator environment allows cadets to practice skills/competences that he/she would take a longer time to obtain, especially with the trend of short sailing times and shorter port-stays".

4.1.1 The importance of simulator realism

At the highest levels, simulators situate seafarers in circumstances and situations they cannot be face in their daily routine. “It is a necessity that the simulation training is highly realistic and adaptable to real life situations”. The latest maritime simulation technology provides impressive 3D-graphics to depict true-to-life vessel models and exercise areas, ensuring quality simulation training in realistic environments, which is adaptable to real life ship handling situations. The difference is that the consequences of error or failure during simulation training cannot be compared to the consequences of failure or error during training on the real ship. Such safe training and the least expensive and fast became; cannot be dispensed for officers wishing promotion to higher levels or who wish to move to leadership position (Kongsberg, n.d.).

4.1.2 Simulator as assessment tool

Furthermore, simulator if used as an evaluation tool must provide three assessment elements (objectivity, reliability, and validity) and then this method will reflect the efficiency level of the seafarer’s. Using simulators in assessment may be influenced by the assessor as an individual, which jeopardizes the assessment’s objectivity. However, Nautical Institute (n.d.) states that the SEA system (Simulator Exercise Assessment) “was presented mainly to avoid subjectivity in assessing performance in simulator-based training. It developed an automatic assessment method to assess performance against hard parameters inserted by the instructor, while leaving the soft skills to be assessed subjectively”. (Nautical Institute, n.d.).

4.1.3 Simulation capability

On the other hand simulators are like any other electronic device liable to breakdown if not used correctly, therefore, it requiring qualified instructors to operate it. Additionally, misapplication of simulators may result in over/under confidence of the trainee, Cross (2010). says “having the training program too easy/too hard may have unsatisfactory consequences. Poorly-designed programs would not deliver required competences. Therefore, excellence training under competent instructors is the only manner to guarantee satisfactory results”.

Furthermore, the ability to support the use of larger, relatively costly and sophisticated training systems by part task training tools is now made possible by the availability of excellent PC Programmable Controller based maritime software programs. Such technology can be described as the first level of simulation technology (Cross, 2010).

4.2 Use of Simulators in Assessment, training and Teaching of Seafarers

According to Kobayashi (2005) high standard shipping depends on the availability of typical human resources both at sea and ashore. Typical human resources at sea necessitate well-trained seafarer's who are proficient of steering ships safely. For instance, many maritime accidents and incidents have point out the important role that seafarer's have in avoiding casualties and maintaining oceans clean.

Moreover, Muirhead (1993) stated that the matter of giving certificates of competency to individuals to entitle them to work as officers on ships indicates that these individuals have been found competent to perform certain task on board; furthermore, they are qualified to meet national and international training standards. In other words, they pass through serious assessment.

4.2.1 The need for objective assessment

Cross (2013) has stated that; training without proper assessment is considered a wasted effort; if one cannot or does not assess then why bother with the training any way. However, in his article which is based on the research and development work done by the Japan Maritime Simulator and Simulation Committee of the Japan Institute of Navigation, Kobayashi (2005) stated that the objective assessment is considered the core to ensure the value of training for ship-handling. However, for running objective assessments, it is important to explain what needs to be assessed and the features thereof. The necessary features of safe navigation have to be recognized and proficiencies in them should be evaluated objectively in order to satisfy the STCW Code requirements. Navigation and ship handling simulators can very well be used for such a valuation. Usually, the knowledge component is evaluated in written or oral examinations.

4.2.2 Assessment method

One of the essential points of Kabayashi's (2005) article is to highlight and discuss means of assessing practical navigational competencies objectively. Also, the necessary techniques and competencies for safe navigation are explained in order to clarify the aims of assessment. Moreover, Kobayashi (2005, p. 58) suggested that the methods of assessment should be outlined. Thereafter, the standards for assessment of the various competencies should be discussed. Hence, the following should be defined in the context of safe navigation:

"What should be assessed?"

"How should it be assessed?"

Furthermore, Kobayashi (2005) stated that the definitions for (technique) and (competency) are used because they represent key words for assessment. "Technique, is a defined process for performing a task, whereas, competency is the ability to perform a task to a required standard. Consequently, mastering certain tasks by using appropriate techniques is the prerequisite for competency in safe navigation".

However, in order to prepare for the identification of the elemental techniques shown in Table 1, Kobayashi (2005) suggested an analysis of the STCW Convention to identify and categorize the tasks required for safe navigation. Moreover, he conducted a survey by questionnaire of 100 experienced navigators on what they considered to be the necessary tasks for safe navigation. A section of this questionnaire is shown as Table 2. Additionally, in that questionnaire, he categorized, the necessary tasks by classes of licensed seafarer (2/O-second officer, C/O-chief officer, master). However, the necessary techniques for safe navigation must be mastered before seafarers can qualify for being in charge of a navigational watch. Moreover, Kobayashi shows an example of an assessment sheet for the training of cadets (See Appendix D) (Kobayashi, 2005).

Table 1: Section of Questionnaire on Necessary tasks for Safe Navigation

No.	Task	Required competency		
		2/O	C/O	Master
1	To plan the navigation schedule considering own ship, sea and weather condition	Yes	Yes	Yes
2	To estimate ETA at important for the navigation	Yes	Yes	Yes
:	:	:	:	:
8	Actions abided by law when meeting with two or more vessels	Yes	Yes	Yes
:	:	:	:	:
17	To fix the position by more than one method	Yes	Yes	Yes
18	To carry out the parallel indexing	Yes	Yes	Yes
:	:	:	:	:
23	To use the Standard Maritime Communication Phrases properly	Yes	Yes	Yes
24	To communicate with VTS using VHF and required information	No	Yes	Yes
:	:	:	:	:
43	To understand the ability of crew and conduct the bridge team as a leader	No	No	Yes

Source: Kobayashi, H. (2005). *Use of Simulators in Assessment, Learning and Teaching of Mariners.* Retrieved August 2013, from http://link.springer.com/article/10.1007%2FBF03195064#page-1

Table 2: Nine Elemental Techniques for Safe Navigation

1	Lookout	The technique to identify and recognize the moving targets and the fixed targets and to gather information of the direction, distance and speed and to estimate the future situation of the targets
2	Positioning	The technique to fix the position of ship by selecting and recognizing proper obstacles by visual observation, radar etc.
3	Manoeuvring	The technique to control own ship's course, speed and her position by steering rudder and controlling main engine etc.
4	Instrument manipulation	The technique to properly utilize instruments for lookout, positioning, manoeuvring etc.
5	Communication	The technique to exchange information among members on the bridge and inside and/or outside the ship
6	Rules of the Road	The technique to navigate according to the Regulations for Preventing Collision at Sea etc.
7	Planning	The technique to gather information concerning the navigational environment conditions and to make an operational plan and the navigational plan
8	Emergency	The technique to repair malfunction of the main engine and a steering system etc. and the associated proper reaction
9	Management	The technique to make good use of members abilities to enhance the bridge team's performance etc.

Source: Kobayashi, H. (2005). *Use of Simulators in Assessment, Learning and Teaching of Mariners.* Retrieved August 2013, from http://link.springer.com/article/10.1007%2FBF03195064#page-1

4.2.3 Required technique

In addition, Kobayashi (2005) identified in his article, the required elements and required techniques for competencies in safe navigation, and the training to obtain these competencies in simulators and proposed methods for their assessment. The implementation of appropriate valuation methods makes it possible to measure the seafarer's efficiencies in safe navigation quantitatively and constantly through the training period in the simulator. Such measurement shows the learning process of improvement in competencies by clarifying the learning process of the techniques which are illustrated in Figure 7. An average training time to achieve these competencies can be set (Kobayashi, 2005).

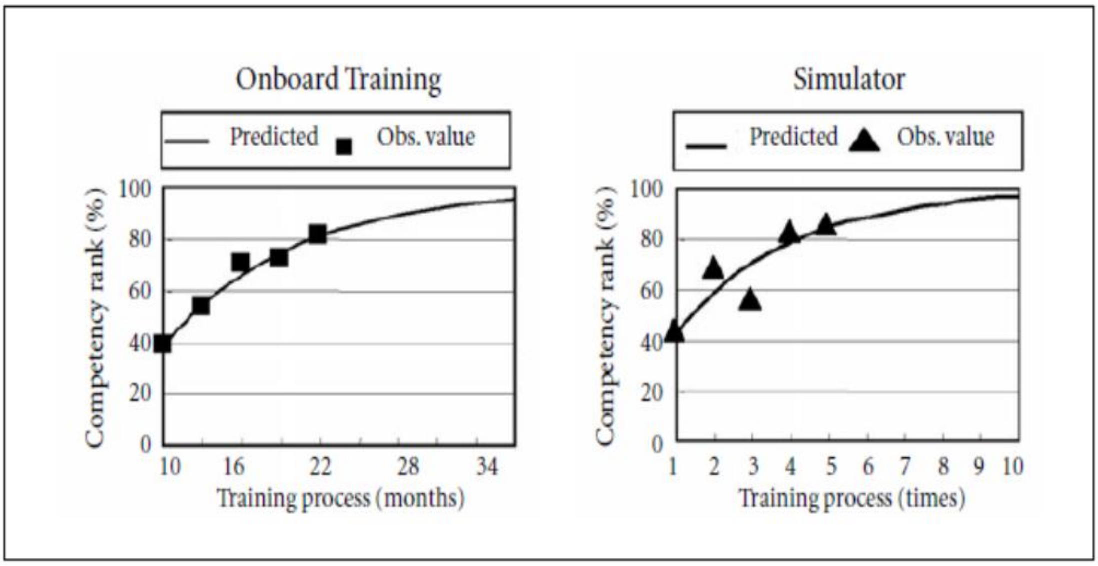

Figure 7: The Learning Process of on-board Training and Simulator Training

Source: Kobayashi, H. (2005). *Use of Simulators in Assessment, Learning and Teaching of Mariners.* Retrieved August 2013, from http://link.springer.com/article/10.1007%2FBF03195064#page-1

4.3 Effective simulator training

According to Kobayashi (2005) by obtaining sufficient efficiency, seafarer will exercise navigation safely and keeping the environment clean. To obtain sufficient competency, such training has to be exercised in accordance with the principles of education, training and evaluation. In a conventional training system without simulators, a major part of the training used to be exercised on board. However, more effective training methods have been submitted regarding to the availability and use of maritime simulators in recent decades.

Figure 8 shows the importance of training for a seafarer. For instance, in the two right graphs, the “horizontal axis relates to navigational conditions and the vertical axis to seafarers behavior”. When seafarers with insufficient competency face the conditions indicated, their behavior shows a wide variation. After training, seafarers with sufficient competency are able to concentrate on the required behavior, and the variation of their behavior is much narrower.

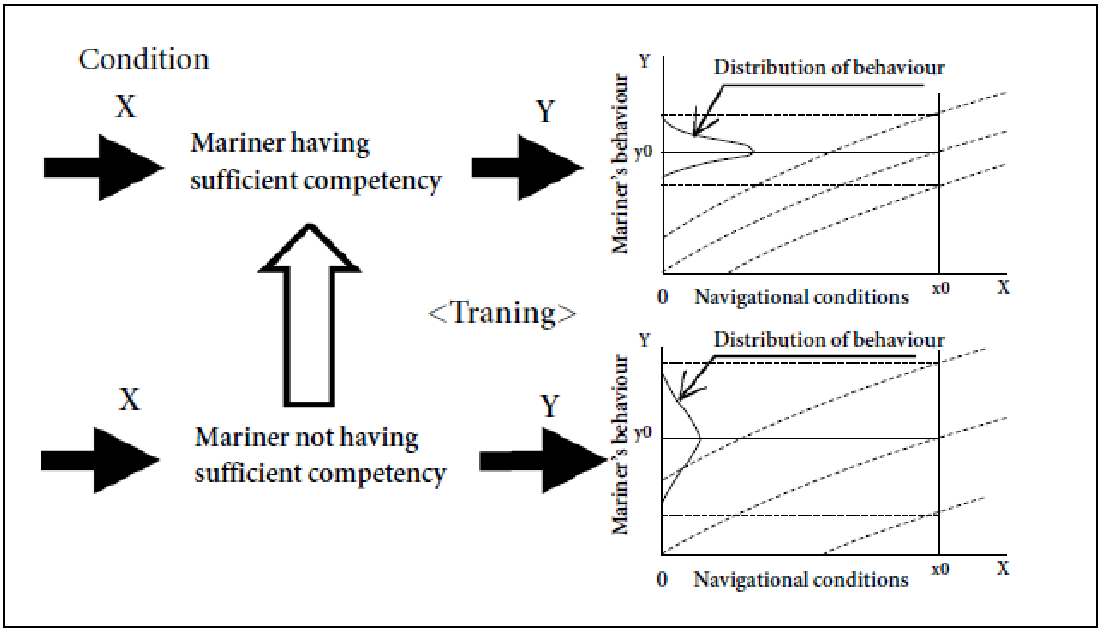

Figure 8: The Meaning of Training Concerning a Change in a Mariners competency

Source: Kobayashi, H. (2005). *Use of Simulators in Assessment, Learning and Teaching of Mariners.* Retrieved August 2013, from http://link.springer.com/article/10.1007%2FBF03195064#page-1

According to Stammers & Patrick (1975) the simulator, if used effectively, will provide an alternative medium in which to obtain many of the necessary skills in a risk free environment. Moreover, some one can ask how we can make sure that simulator training will be effective. First of all it is important to define training. Stammers & Patrick (1975) define training as the methodical improvement of the skill performance pattern required by an individual in order to preform effectively a particular duty or work.

4.3.1 Key element

In addition, there is a key element concerning simulator training which is that training tasks must be related to real life or daily work. However, the main criteria to enhance the skill levels of masters and watch-officers of any type of ship are that aspects of the selected task are relevant to the training objective. In other words setting clear training objectives is essential. Furthermore, exercising pre-briefing, control, monitoring and de-briefing techniques are understood and used effectively by the instructor (Muirhead, 1993).

However, it has been suggested by IMO consultants that guidelines on the use of simulators should include a list of basic skills at watch-keeper and senior officer level. Such guidelines will enable maritime institutions to found training programs that focus on exact skills, corresponding with the capabilities of the simulator system operated. Thus a program structure can be advanced and designed to ensure that it meets the chosen training objectives and results in ideal performance. Consideration of a number of IMSF simulator training programs around the world shows remarkable conformity in training objectives and outcomes (Muirhead, 1991).

Moreover, effective training concerns the role of the instructor. Hammel (1981) stated that "the instructor has greater influence on the efficiency of deck officer simulator based training than any of the specific simulator characteristics investigated. In addition, the training device should directly discourse and assist the instructor in conducting training".

4.4 Validation of Training

How do we know whether the purpose of training has been achieved? This important question can be answered through the validation of a training program related to the capacity of outcomes of training to make sure the behavioral objectives specified in the program have been met. On one hand, internal validation is determined by measuring the performance of the trainees on standards established by the training program (Cross, 2011).

Furthermore, a comprehensive understanding of the role of the trainer of the trainee's in the workplace is needed in promoting instructional objective and tasks. Obviously, it is important to consider the use of the simulator as an extra step that will test the competence of the trainee, for example, the ability to perform a specific task in a safe and efficient way. On the other hand, external validation is related to how effective the training is in respect to the simulator's demands and limitations (Cross, 2012).

According to Cross (2010,p. 9), the verification of training legitimacy follows a number of steps and those steps for simulator instructors are significant and they are an integral part of the program, the steps can be briefly mentioned as follow:

1. Conducting a task examination to identify the behavioral (training) goals to be achieved by the trainee
2. Selecting tasks related to the training purpose
3. Preparing an proper simulator training environment
4. Preparing the trainee or candidate(briefing, familiarization)
5. Operating the isometrics(guidance, cueing)
6. Observing and assessing trainee performance(observation, recording, feedback)
7. Collecting related information(pre/post-tests, recording, plotting)
8. Questioning and evaluating performance(debriefing, peer review)

4.4.1 Task analysis process

- Was the isometrics practiced as planned?
- Did it come across the training objectives
- Were the system characteristic and levels of fidelity appropriate?
- Were there any inconstant factors interfere with training consequences? (Cross, 2010, p. 9).

4.4.2 The trainee

- Did the trainee react to the exercise stimuli?
- Did the trainee meet definite safety and operational standards?
- Did the trainee take in account all existing substitutes?
- Was all relevant information considered?
- Did the trainee use the simulator equipment in a valid method? (Cross, 2010, p. 9).

Furthermore, the results of the above questions are collected together by the trainer to improve comprehensive measurement of training outcomes, and to determine whether or not all relevant information was considered where training proven to be ineffective then it may be that stated objectives are unsuitable or there are insufficiencies in the instruction process. Moreover, when it comes to evaluating individual competence, performance standard must be established on an objective and not subjective basis. Some qualitative comparison against real world operations is necessary in setting the parameters if confidence in the transfer of such skills to the workplace is to be achieved (Stammers & Patrick, 1975).

4.4.3 Performance outcomes

In the final analysis of the validation of the training, the trainer must take into consideration that the chosen measures of performance are reliable and relevant to the training tasks, and the results are frequentative in nature. Positive measurement of proficiency attainment can be made on simulators given that the standard for effective simulator training is achieved. In other words, the instructor is well trained and is provided with effective recording and monitoring equipment; moreover, clear performance criteria comparable to real environment operations are recognized. The following questions should be asked to determine the performance outcomes:

- Are the operational outcomes of an acceptable standard?
- Did action outcomes meet the designed training objective?
- Did interactions with others meet designed behavioral objective?

- Has the trainee demonstrated that they can perform the given tasks safely and effectively? (IMO, 1993 as cited by Cross 2010, p. 9)

4.5 The impact of using simulation training in raising competency

In this part of the thesis it will be significant to highlight some studies and research made by universities, nautical institutes, and official organizations to illustrate the importance or the impact of using simulators in training and how it contributes to enhancing the competency of ship masters and watch officers, which lead to achieve the aim of the dissertation.

> National Research Council Staff, (1996) stated "The data are not available to determine whether ship-bridge simulator-based training is more effective and efficient than traditional training. The analysis does suggest that the ability to control the learning process (including the ability to design scenarios, monitor performance, and debrief cadet participants), in contrast to the lesser control over learning situations on ships at sea, leads to improvements in efficiency".

However, critics of marine simulator training state that it is no substitute for real on board experience; it is a point of view no one can disagree with. However, several studies show that many watch-keepers and senior officers are not getting the opportunity to obtain key practical skills due to practical safety and operational reasons. As mentioned in previous chapters of this dissertation, the simulators, if used effectively will provide an alternative medium in which to obtain these operational skills in a risk free environment. Barnett (2002) stated that the use of simulation in providing solutions to the problems of risk and crisis management and the optimal use of crew resources has a long established pedigree in maritime training.

4.5.1 JMR study

A study has been made by researchers and students from Constanza Maritime University and published by (JMR) Journal of Maritime Research in April 2008 under supervision of the Spanish society of maritime research and under the title "Reducing of maritime accidents caused by human factors using simulator in training process”. The study aimed to highlight dangerous situations at sea based on human factors. In this respect has been used a web-base simulator, bridge and liquid cargo handling simulators.

Over the last 40 years, the shipping industry has concentrated on improving ship structure and the reliability of ship systems in order to reduce casualties, protect the ocean environment and increase efficiency and productivity. It can be noticed in the improvements in hull design, stability systems, and propulsion system in addition to the development of navigational equipment. In other words modern ship systems are technologically advanced. In spite of all that advanced technology, the rate of maritime incidents is still high.

Furthermore, regarding the increasing predominance of automatic systems on board ships, it is important that the human element is considered throughout their design, implementation and operational use. “Automation can be useful to operators of complex systems in terms of a decrease in workload or the discharge of resources to perform other onboard duties”. However, it can also potentially be detrimental to system control through increasing the risk of unintended human error leading to accidents and incidents at sea (Hnzu, Barsan & Aarsenie, 2008).

However, ship structure and reliability of equipment represent a relatively small part of the safety equation. The maritime system is widely depending on human resources; consequently, human errors are the main reasons causing accident (Hnzu, el al., 2008). Moreover, a careful study of accident reports has stated that 85% of all accidents are either directly committed by human error or are associated with human error by means of unsuitable human response (Ziarati, 2006).

Additionally, Ziarati (2006) has stated this meets with the findings of a recent paper (IMO, 2005) that 80% of accidents at sea are caused by human error. The Turkish Government is also aware that collision is the most common type of accident in Turkey and this was again confirmed by the latest data published by the Main Search and Rescue Coordination Centre of Turkey in 2009. Collisions amounted to 60% of all accidents if grounding and contacts are included. Furthermore, in Figure 9 the common factors in groundings are illustrated in addition to the common factors in collisions, illustrated in Figure 10 (Ziarati, 2006).

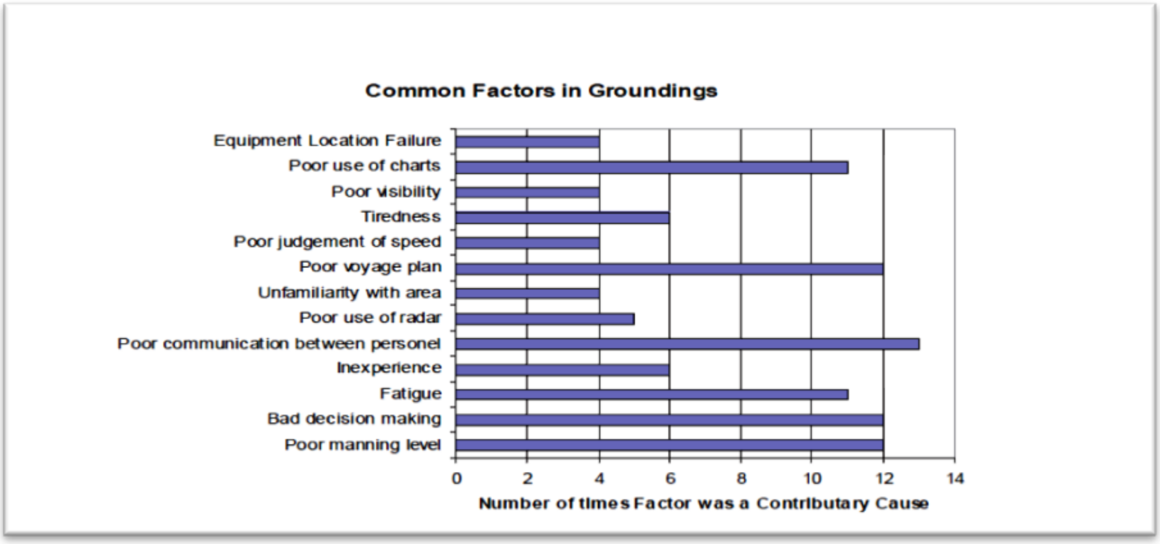

Figure 9: Common factors in Groundings

Ziarati, R., (2007). *Review of Accidents with and on Board of Vessels with Automated Systems – A Way Forward, AES07, Sponsored by Engineering and Physical Science Research Council in the UK (EPSRC), Institute of Engineering and Technology (IET, Previously IEE), Institute of Mechanical Engineers (IMechE), IMarEST, 2007.* Retrieved August 2013, from *http://www.marifuture.org/Publications/Papers/Collisions_and_groundings_major_causes_of_accidents_at_sea.pdf*

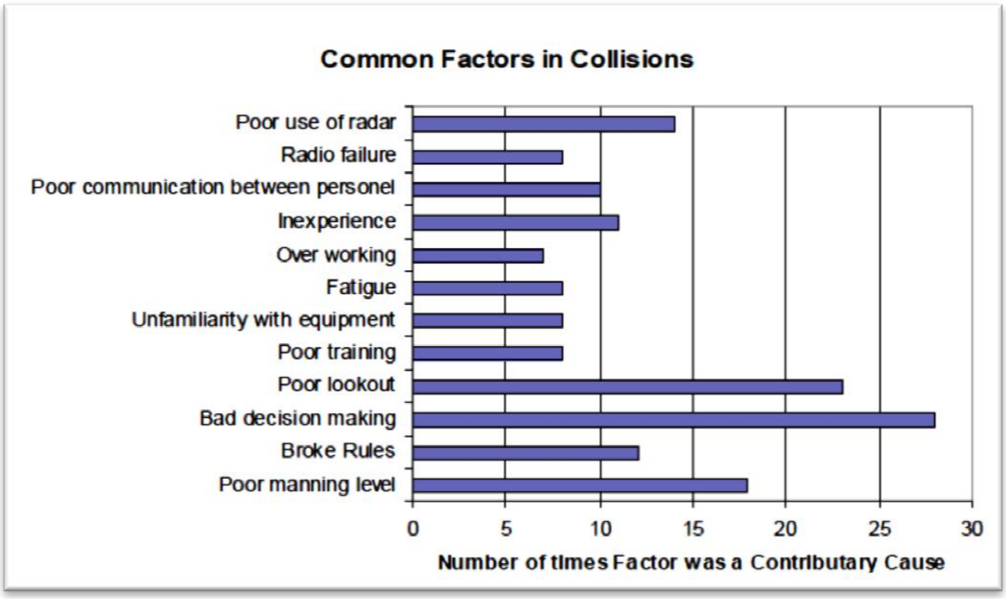

Figure 7: Common factors in Collisions

Ziarati, R., (2007). *Review of Accidents with and on Board of Vessels with Automated Systems – A Way Forward, AES07, Sponsored by Engineering and Physical Science Research Council in the UK (EPSRC), Institute of Engineering and Technology (IET, Previously IEE), Institute of Mechanical Engineers (IMechE), IMarEST, 2007.* Retrieved August 2013, from *http://www.marifuture.org/Publications/Papers/Collisions_and_groundings_major_causes_of_accidents_at_sea.pdf*

A major has been undertaken through the cooperation of several major MET centers in several EU countries: Holland, Poland, Finland, Slovenia, UK and Turkey with taking into account the Lenardo project. The partners have participated in Lenardo e-learning projects (E-GMDSS 2006-08, E-GMDSS 2008-10 and MarTEL2007-09). The main consequence is an online and novel education and valuation stage simplifying the correct implementations of; International Regulations for Preventing Collisions at Sea 1972 COLERG, resulting in significantly decreased accidents at sea. The impact of the project will be substantial as it is related to the training of all deck cadets and officers and up-dating course for those on job in the sector.

Finally, (Hnzu, el al., 2008) study considers that e-learning including training on simulators has a great and positive impact on the maritime education sector. Moreover, learning combined with training will be by far the most effective way to increase and enhance skills and competence. Furthermore, the study has recommended that simulation training represents an important capability to ensure that innovation delivers on its promise of improved activity. To achieve these goals concentrated effort is required to incorporate maritime simulation modeling and Web-based training process into the innovation cycle.

4.5.2 Chalmers university study

At Chalmers University of Technology, the students in tanker-handling prove their competence in a cargo handling simulator and their knowledge and understanding through a written examination (Lindmark, 2012).

Moreover, the valuation of proficiency is divided into two parts. The first part is a computer-assisted evaluation and a more subjective assessment made by the instructor. The system meets the demands but is a not sufficiently comprehensive and could be improved by a revision. To ensure objectivity and good quality it would be useful to reduce as much as possible the more subjective judgment made by the instructor. This can be achieved by developing the computer-based system. The second part is the combination of the written examination and assessment of practical exercises and by this method the students will meet the demands that are required by the STCW convention and Code.

Lindmark (2012) has mentioned that the tanker-handling course is, in general, valued by the students but demands have been voiced to increase the time in the simulator, especially time to practice on their own. The students also sought a clearer link between the course literature and the practical exercises. One of the main objectives of this study is to evaluate how new legislative demands have changed tanker education with an emphasis on the use of cargo-handling simulators.

4.5.3 US National Research Council study

The committee on ship-bridge simulation training and the US national research council has authored a book under title “Simulated Voyages”. In its conclusion and recommendation it has stated that simulation training has been used to train seafarers since the sixties. Moreover, simulation possible introduce more than the traditional test of knowledge in testing and assessing skills and abilities, if used in an effective manner. However, concerns that have prevailed in the shipping industry about marine casualties and mariner proficiency and competence have led the U.S. Coast Guard (USCG) to examine the probability of enlarged use of simulators in the programs under its authority.

Furthermore, the committee on ship-bridge simulation training found that simulation can be an operative exercise device, especially in bridge resource management and bridge team management, for instance, docking and undocking, ship-handling evolutions, rules of the road, bridge watch-keeping, and emergency procedures. Moreover, simulation introduces to the USCG an opportunity to decide whether seafarers’ are competent or not in a much more inclusive manner. Furthermore, the impact will be substantial as it concerns the training of all deck cadets, officers and marine pilots, also an up-dating course for those already working in the sector (USCG, 1994).

USCG (1993) has stated, even though there are not adequate statistics to judge the complete significance or influence the use of simulators has had in changing or improving seafarer performance, but, there is satisfactory experience to ensure its sustained and even extended use. However, for the USCG to use simulation effectively for training and licensing it is important that a stronger research base be developed and that the agency address issues of standardization and validation has discussed in its own report. Moreover, the committee’s conclusions and recommendations provide a technical framework for expanding the use of ship-bridge simulation for seafarer training, licensing assessment, and evaluation.

4.6 Approaches to aviation industry

4.6.1 Simulation in the commercial air carrier industry

Chislett (1996) has mentioned that in the 1990s the IMO through its questionnaire to include ship's bridge simulators in STCW, comparisons were made with the airline industry, considered to have an excellent safety record, regarding training and use of simulators.

However, in using simulators for training and certification, the implementation of simulators in the aviation industry represents an indispensable issue. The modern aircraft simulator is an invaluable resource for commercial pilot training and certification, due in part to the influence and instruction of the (FAA) Federal Aviation Administration (NRC, 1992).

> "Instructors who pride themselves in creating a realistic emotional atmosphere may be interested by an aviation event where a unique and valuable set of data enable comparisons to be made between two pilots experiencing inflight emergencies, and two pilots experiencing the same emergencies on a simulator. Both of the inflight emergencies were associated with a 50% increase in heart rate, while the simulator emergencies, both 'crashes', produced no increase in heart rate" (Wilson, 1993, p. 10).

4.6.2 A Comparison between civil aircrafts and civil ships

It is important to mention that continuing training on simulators is mandatory in the aviation industry, while it is mandatory for specific parts of bridge simulators used in the maritime industry. The operation of civil aircraft differs significantly from civil ships with respect to operating atmosphere, operating platforms, and professional regulation. The regulatory concepts used in the civil air carrier industry differ greatly from maritime transportation. For instance, professional certification in the aviation industry is platform-specific, whereas marine certification is necessarily much more generalized. In addition, the duties and responsibilities of maritime watch-officers are very wide ranging from watch-keeping to conducting ship's business. According to the Royal aeronautical society (2009) "commercial air carrier pilots, in general, have a much narrower range of responsibilities”. Despite these differences, it is possible to identify concepts and frameworks within the commercial air carrier system that could be adapted and applied to the marine industry. Although the most obvious goal of using simulation is improving performance, there is a common factor between the two industries represented by cost effectiveness, in which is considered critical to the success of both industries.

4.6.3 The impact of flight simulation in aerospace

Chislett (1996) has mentioned that on July 20, 1969, two astronauts landed and walked on the moon. There is no need to say they could not do that without having training on a simulator before their landing at that time. According to the Royal aeronautical society (2009) “flight simulation has not only fundamentally changed flight training methods, reducing the training risk and improving training quality, it has also resulted in substantial improvements in flight safety”. Moreover, many flight simulators are operated intensively for over 20 hours each day, producing significantly less Carbon emission and environmental noise than equivalent aircraft training.

4.7 Cost effectiveness of using simulators

Even though the most evident aims of using simulation is improving competency, cost effectiveness is also important. Simulators in the aviation industry and maritime industries generally cost less to construct and operate than the operational gear being simulated. For instance, the aviation industry is able to conduct transition training to a new aircraft entirely in simulators and at substantial savings over costs of the same training conducted entirely in an actual aircraft (USCG, 1994).

Moreover, the Royal aeronautical society (2009) has stated that airline flight crews must go through two days training and checking in a flight simulator every six months. “The ratio of simulators to aircraft is 1 to 30 for narrow body aircraft increasing to 1 to 15 for wide body aircraft, with capital costs pay off over 15 years”. For an airline with 1,000 pilots, recurrent training and checking and using aircraft would cost 60 million US dollars annually. “Flight simulator operating costs are less than one tenth of this amount". According to Cross (2010), unfortunately there is no calculation available related to the maritime industry except that the cost of simulator training per individual student is 120 to 420 US Dollars per hour which is incomparable to go through on board ships.

4.8 Sea-time Reduction Using Simulator-Based Training

In order to indicate the importance of simulator training, a number of studies have shown sea service can be replaced by simulator training. For example, a study has been made by TNO/Marine Safety International (1994), suggesting "30 days of sea time be replaced by 40 hours of simulator time" with a performance level of 50% equaling the level after practical training on board ship. Moreover, the Nautical Institute (1994) believes that sea service equivalency should be limited to one week for one month at sea.

STCW forcing trainees to undertake their training for a period of 12/18 months at sea before accepting them to work as officers in responsibility of a navigation/engineer watch. However, some countries have developed a system that allows to use of simulation training as a substitute for training at sea by joining training courses on simulators covering deck, engine, and cargo, during which, the student will practice exercises growing his competence in these fields.

According to Cross (2012), this started in Norway in 1987 due to a lack of second engineers. The Norwegian authority presented a plan to decrease sea-time from "18 to 12 months plus six weeks engine room lab plus three weeks engine room simulator". It was adopted in the Netherlands in 1994, following a study concluding that students had improved their performance by "83% after 120 hours of simulation. Therefore, a reduction of sea-time by 60 days is granted if the student successfully attends 120 hours of simulator training".

Reduction systems are used in India, Hong Kong, USCG and many countries, where the practice of simulators is common, knowing that STCW has not precisely restricted the training to ship-board training. However, the anxiety still exists that seafarers with reductions will be not as much of competent as seafarers with complete sea-time.

> "The main idea behind sea-time is that seafarers earn all the skills they need un-structurally to be qualified as an officer of charge, according to their working level. Sea-time remission is simply transforming training from unstructured to structured. Therefore, the main question shall be, is structured training of any added-value over unstructured training? And if it is, will experiences and skills lost when replacing sea-time degrade seafarer's competence?" (National Research Council, 1996)

This investigation was introduced by the National Research Council (1996) assessing the use of marine simulators as a substitute for sea-time training.

It is obvious now that any MET institution that intends to allow sea-time reduction should take responsibility in guaranteeing the quality of its simulator training programs, and provide distinctive-training with qualified/certified instructors with specified training objectives that would justly reward deducted sea-time. As Barsan (2009) mentioned "You could have the most expensive and up to date simulator on the market, but without well-designed simulation scenarios, the training aims will not be achieved".

To summarize, shipboard training was the only way for the development of traditional skills and competence of seafarers and it is still to a large extent. However, it will be illogical turning our backs to the grace of modern technology of Marine Simulation technology and its role in enriching the efficiency of the seafarers.

Nevertheless, for the purpose of getting positive results, training must be controlled and well-designed. Any training program to reduce the training period at sea must ensure the efficiency of the seafarer, which is not compromised by carefully designing programs concentrating on skills that structured simulator-based training would be more effective in, such as ranges where ship's safety maybe endangered.

Chapter V

5 The use of dredgers simulators as a training toll

In this chapter of the dissertation, the simulator-based training courses designed for training Trailing Hopper Suction Dredger (TSHD) officers will highlighted in relation with the latest simulators dedicated for this purpose, taking into account the considerable progress in the field of training programs and the use of dredge simulators by the developed countries to enhance the competency of dredgers crews, in addition to creating qualified persons to operate those expansive ships.

According to Riddell (1996), an alternative approach to simulator provision was described by M. Harms from the Maritime Institute, Willem Barentz, the Netherlands; Harms has declared that dredging companies have for many years tended to recruit post graduate merchant navy officers to operate trailing suction hopper dredgers, hence, Harms suggested that the on the job training conventionally used to improve both sailing and dredging skills was no longer appropriate. Also he stated that there is now an urgent request for special training courses specified for the officers for the operational functions on board trailing suction hopper dredgers Harms mentioned that this has resulted from changes in ship management practice and from the highly competitive economic circumstances in which dredging companies now operate.

5.1 Training course for hopper dredgers crews

It is important to consider that most of the Iraqi dredger fleet is from IHC Company. IHC system (2010), has stated, that training simulators are used to familiarize operators with the manual control of the dredging installation on board dredgers, to teach them to get the best out of automatic control systems and to train appropriate responses to difficult situations and failing equipment.

The training program may cover a single process or a selection taken from all the components of total operational training. The trainee operates the control levers and is expected to deliver a correctly dredged site. Normally, the trainer provides the operator with a fully operational vessel. If the response of the trainee falls short, the system generates calamities such as blocked tools, clogged pipes and overloaded diesel engines. As trainees start to feel familiar with the virtual dredger, the trainer can involve other events, such as equipment failures; failing hydraulic pumps, leakages, worn impellers (IHC system, 2010).

Trainers can alter settings and introduce calamities and equipment failures by altering values on their soft control console. Fellow trainees can follow training, either alongside their colleague at the control levers, or on a screen in the trainer's room. After a session, the system generates a trip report. Moreover, for realistic training, trainees should not see more than they would on board the dredger during training. That is the view that is presented to them. On the other hand, for evaluation purposes and for trainees looking over the shoulder of the trainer, it is considered beneficial to observe the physical effects of their actions (IHC system, 2010).

Moreover, the main presentation can be extended to include picture-in-picture (PIP) features; relevant subsystem (puffin) views are inserted in the main display, allowing for a comparison between the real thing and the process pages in the simulator. This feature significantly enhances the rapid gaining of understanding of the dredger's possibilities and limitations in practice (IHC system, 2010).

Several companies in the world are specialized in manufacturing different types of simulators for different types of dredgers, for example, Cutter Suction Dredger (CSD) simulator, Trailing Suction Hopper Dredger (TSHD) simulators and Excavator dredger simulators. However, this dissertation is restricted to (TSHD) simulators. It is important to mention that there are simulators which only simulate the dredging process and are used for training dredge masters; they do not include the navigation part of the dredger. Both types are going to be explained in the dissertation (IHC system, 2010).

5.2 Trailing suction hopper dredger (TSHD) simulator training

Operators training to handle a TSHD learn about the complete loading and unloading processes, including suction pipe handling, the aspiration process at the drag-head, jet water handling, the pumping process, hopper settlement, unloading through bottom doors, pumping ashore, rain-bowing within the constraints of tide, current, waves and weather. The trainee learns to operate and sort out the vessel's auxiliary systems and about the specifics of those systems. Any process situation can be saved, and be re-used at a later stage at the start of a new training module. Optionally, operators can learn how to operate and make the most of automation, the one-man operated bridge, DP/DT, DTPS and ECDIS (IHC system, 2010).

5.2.1 (TSHD) simulator components

According to IHC system (2010, p. 4), the main components of TSHD are as follow:

- A complete copy of the dredger's control consoles and instrumental panels.
- A powerful PC. This PC communicates with the HMI and also with the PLC system, controlling and reading the latter's 'soft' I/O (input/output). It also generates realistic sounds taken from the real vessel and manipulated by the models.
- Outside and artificial camera views picture-in-picture suitable for wide-screen presentation.
- A programmable logic controller (PLC), supervised by a human-man-interface system (HMI) consisting of a fast PC network, video screens/touch screens and operator keyboard-trackballs.
- A desk for the trainer with a 'soft' control console, which is in fact an extension of the HMI system, providing a mixture of physical presentations and the familiar interactive dialogue windows.
- Simulation of Differential Global Positioning Systems (DGPS).

IHC system (2010, p. 4) has stated that a simulator must imitate the behavior of the real-life dredger, so the system is involved with physical models that are integrated in an overall model. The models use a range of sources literature and standard modules from the public domain knowledge from external knowledge centers, expertise and models from IHC Merwede's R & D Institute, MTI Holland, and IHC specializing Training Institute for Dredging (TID). Standardized modules serve the modularity of the system and allow for the configuration of the simulator for more than one dredger of the same type. The simulator is highly multipurpose. It can contain all a dredger's features, such as:

- The number of pumps (submerged and in-board), their power provision and multi-stage gearboxes.
- The length and configuration of suction tubes, ladders, booms, sticks, spuds, spud carriers, anchor booms, backhoe upper carriers and other mechanical parts.
- The type of drag-heads (active or passive), cutter heads, buckets, backhoes and, for example, hammers.
- The number and arrangement of bottom doors, self-emptying doors, visors, swell compensators, winches, jet water and dredging-circuit sluice valves, and so on. (IHC system 2010, p. 4)

5.3 Integrated bridge training simulator

5.3.1 The simulation of trailing hopper dredgers integrated dredging and navigation console

Dredgers are different from other normal ships such as container ships, tankers and bulk carriers, where only the hull interacts with the water. In contrast, on a dredger, when lowering or raising the suction pipes or dredging with the suction head down, this additional equipment interacts with the water and the sea bead, adding many forces to be considered with other known forces. For instance, the changes in water currents, composition and level of the bottom or the speed and direction of the vessel all have substantial influence on the behavior of the ship. Thus, it requires specific treatment and anticipation from the person on the bridge. It is important to know how to react in emergencies involving the suction pipe, for example when it gets stuck or damaged (Mourik & Keizer, 2006).

5.4 Zeebrugge integrated simulator

As a result of the common efforts of many parties, for instance the Belgian government, dredging and fishing industry with other maritime partners. A new integrated simulator has been delivered to the center of maritime education in Zeebrugge (See Figure 11), where the navigation and the dredging aspects of a hopper dredger have been combined for the first time. Moreover, the contract of the new simulator has been delivered to a consortium of three Dutch companies and each of them has involved in specific knowledge as follows: (“Anew integrated”, 2005)

1. IHC systems have manufactured the dredging part of the simulator.
2. Imtech Marine and offshore has participated in manufacturing the hardware and overall project management.
3. MARINE nautical center participated in drawing the ship behavior in general

Figure 8: Zeebrugge integrated simulator outside view projection

Source: IHC systems. (2005). A new integrated bridge training simulator for Zeebrugge, Belgium. *Ports and dredging*. Retrieved August 2013, from http://www.dredgingengineering.com/dredging/media/LectureNotes/miedema/2005_ihc/pd163.pdf

The simulator is provided with bridge consoles and projectors create a 330 degree 'real time' view of the sea-scape. Furthermore, the simulator is connected with the instructor's desk/debriefing station (See Figure 12), so the instructor can send all kinds of data such as, position, speed, extreme weather conditions and specific data that can influence the dredging process. However, the debriefing station is where each simulated situation can be evaluated. Additionally, a bird's eye view projection on the wall screen can be provided in some cases (IHC system, 2005).

Figure 9: Instructors desk/debriefing station

Source: IHC systems. (2005). A new integrated bridge training simulator for Zeebrugge, Belgium. *Ports and dredging*. Retrieved August 2013, from http://www.dredgingengineering.com/dredging/media/LectureNotes/miedema/2005_ihc/pd163.pdf

Finally, the main purpose of the Zeebrugge simulator is navigation training where the instructor outside the simulator or a second person on the bridge simulator can operate the suction pipes as an input for the training of the captain or watch-officer at the controls. Moreover, a hopper of 5000 cubic meters to 16000 cubic meters can be simulated. Furthermore, the Zeebrugge simulator is currently being used by several Belgian maritime organizations, educational facilities and the two main dredging companies DEME (Dredging, Environment and Maritime Engineering) and Belgian dredging group (Jan De Nul).

5.5 Cost effectiveness of use of dredgers simulators

Dredger simulation has made a major contribution to improve safety. It also offers considerable financial savings to the dredging industry. In other words, it achieves cost effectiveness and dredge productivity at the same level. Mourik & Keizer (2006, p. 3) stated “it is very clear that this kind of training on a real dredger during operations will be far more costly due to production losses than doing this in a virtual simulator environment”.(See Figure 13)

50 million (or more) Euro playground or 1 million Euro playground!

Figure 10: Cost effectiveness

Source: Mourik, B., & Braadbaart, J. (2003). *Moderndredge Simulators and Training Means to get a Dredge Crew more efficient*. Sliedresht: IHC systems.

Chapter VI

6. Existing challenges in Iraqi dredging sector

The aim of this chapter is to clarify the importance of dredging works for the Iraqi ports and waterways. It also highlights the difficult work environment of the Iraqi Trailing Suction Hopper Dredgers (TSHD) fleet, whereby an increase in the number of ships that proceed to these ports leads to ship-to-dredger interactions. Moreover, it highlights the problem facing the dredging sector in the present time, which is represented by a shortage of competent masters and watch officers to operate these dredgers.

6.1 Geographical location of Iraqi ports

Iraq is located in the North West of the Arabian Gulf region and is connected with two main navigational channels, leading to its major ports. The first one is called Khor-Abd-uallah channel which is 50 nautical miles in length and of 200 to 300 meters in width and it leads to Umm Qasser ports (Southern port and Northern port) and Khor Al-Zubair port. The second one is called Shatt al-Arab channel, which is 90 nautical miles long and 400 to1500 meters wide, and it leads to Abu-Floos port and Al-Maaqal port; however, these ports are inland-ports. Additionally, there is a new port under construction called Al-Faw Grand port which is located in the South of Khor-Abduallah channel.

A few kilometers away Iraq has two oil terminals. The first is one called Al Basra Oil Terminal. It is a deep sea Island offshore crude oil terminal located approximately 31Nautical miles South East of the Iraqi Al-Faw port; the second one, Khowr Al-Amaya, is located approximately 6 Nautical miles away from the first terminal. Most of the oil exports of Iraq flow into supertankers that berth in these two terminals in addition to the new two SPMs (Signal Point Moorings) which were commissioned in 2012. The maximum sailing draft is 21 meters, which is considered a restriction for ULCCs proceeding to the above terminals (Office of the special inspector general for Iraq reconstruction, 2007).

6.2 Sedimentation

6.2.1 Natural variations of Sedimentation

The estuary of the Khor Al-Zubayr and the Khor Abd Allah consists of an old arm of the river delta. It is characterized by large marsh areas on its Eastern coast and by the ports of Umm Qasser and Khor Al-Zubayr on its western shores. The estuary receives drain water from the main Outfall Drain and is connected to Shatt Al-Arab by means of the Basrah Channel. An overview for the area is given in Figure 14 (IMDC NV, 2007).

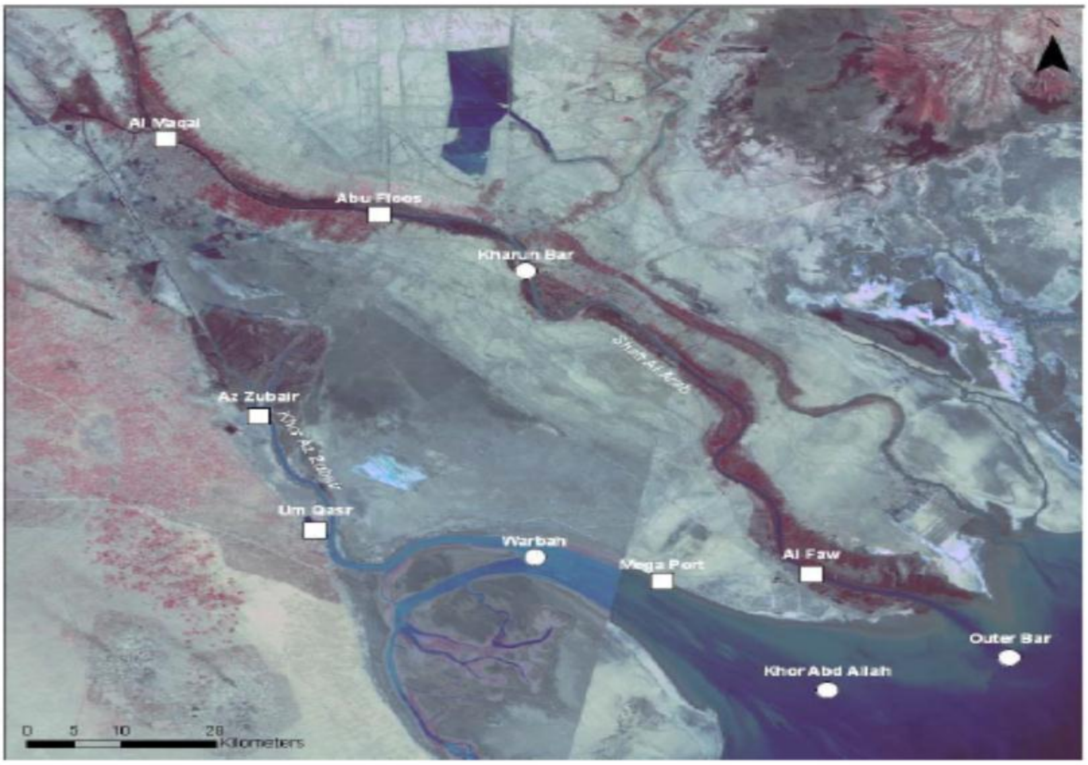

Figure 11: Iraqi Ports approaches

Source: International Marine Dredging Consultants N. V. [IMDC NV]. (2007). *Study of Transport Corridor from Umm Qasr via Basrah to Baghdad Dredging Strategy* [pdf].

6.2.2 Sediment Volumes to be dredged

Moreover, about 6 million m³ of natural siltation in the area is removed each year. (See Table 3). An inventory of the actual sedimentation conditions in the ports of Umm Qasser and Khor Al-Zubair as well as in the navigation channel towards these ports has been taken. Based on this analysis, a strategy has to be developed concerning the dredging works necessary to maintain the water depth in those waterways and ports at an acceptable level, in order to be able to accommodate relatively large ships. For instance, Umm Qasser port currently receives vessels up to about 12m draft (IMDC NV, 2007).

Table 3: Review of volumes to be dredged

Scenario	*Base (million m³)*	*Present (million m³)*	*Target (million m³)*
Capital dredging			
Az Zubayr	5.1	0.0	1.0
Umm Qasr (New Port)	2.4	0.0	1.6
Umm Qsasr (Old Port)	1.3	0.0	0.1
Khor Abd Allah	5.0	0.0	6.0
Total (average volume)	**13.8**	**0.0**	**8.7**
Minimum volume	**12.4**	**0.0**	**7.8**
Maximum volume	**15.2**	**0.0**	**9.6**
Maintenance dredging			
Az Zubayr	2.5	1.0	0.5
Umm Qasr (New Port)	2.5	2.3	2.04
Umm Qsasr (Old Port)	0.1	0.0	0.1
Khor Abd Allah	3.0	2.0	3.2
Total (average volume)	**8.1**	**5.3**	**5.8**
Minimum volume	**5.7**	**4.2**	**4.1**
Maximum volume	**10.5**	**6.4**	**7.5**

Source: International Marine Dredging Consultants N. V. [IMDC NV]. (2007). *Study of Transport Corridor from Umm Qasr via Basrah to Baghdad Dredging Strategy* [pdf].

6.2.3 Under performance dredging works

The difficult conditions of the past 35 years in Iraq have resulted in an under performance and a significant accumulation of the dredging operations. Dredging works are necessary to restore and maintain target water depths in the Iraqi ports and waterways for safe operations in the ports and safe navigation in the channels. The depths almost have to be maintained daily. It is important to illustrate the locations of the potential dredging sites in the Iraqi ports and waterways, for more knowledge about the size of dredging operations in the area, also to highlight the difficulties are facing the dredging crew regarding the locations narrowness (See Figure 15) (IMDC NV, 2007).

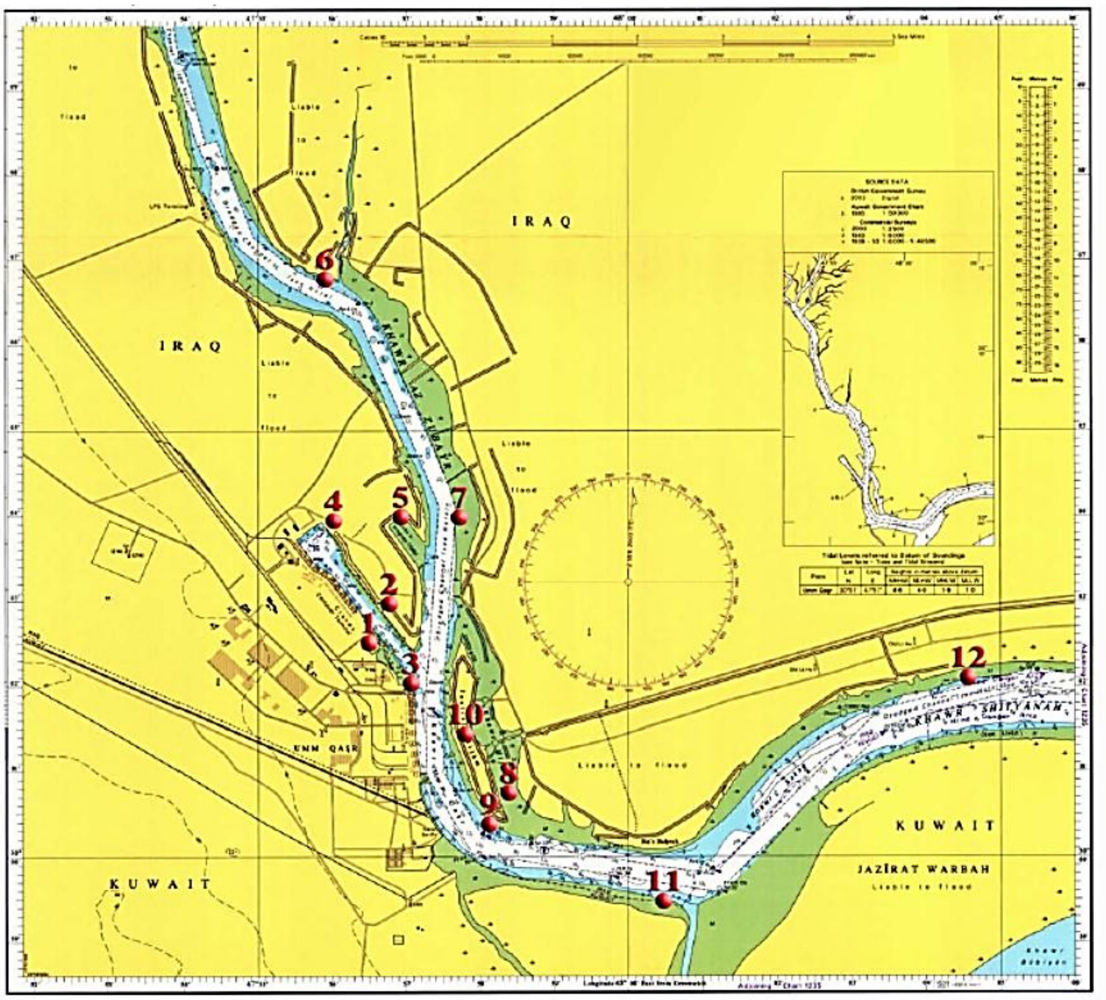

Figure 12: Review of potential dredging site

Source: International Marine Dredging Consultants N. V. [IMDC NV]. (2007). *Study of Transport Corridor from Umm Qasr via Basrah to Baghdad Dredging Strategy* [pdf].

6.3 Iraqi dredgers fleet

6.3.1 A review of onsite Iraqi dredgers fleet

It is important to highlight the main types of dredgers owned by the Iraqi authority, supported by the numbers of these dredgers with general descriptions for each type. (See Tables 4, 5, 6).

6.3.2 Types of Iraqi Dredgers

The Iraqi dredging fleet consists of three main types as follow:

6.3.2.1 Trailing Suction Hopper Dredgers (TSHD)

The trailing hopper suction dredger is a ship, suited to inland, coastal or deep sea navigation, which has the ability to load a hopper contained within its structure by means of a centrifugal pump or pumps whilst the vessel is moving ahead. Most trailing suction dredgers have a high degree of maneuverability. The trailing dredger is normally rated according to its maximum hopper capacity, which can nowadays be in the range of 750 to 45 000 cubic meters. Loading of the TSHD takes place with the ship moving slowly ahead. The trailing suction dredger travels between sites by its own power. The dredger is usually self-contained and ready to begin work immediately upon arrival at the work site (Bray, Bates & Land, 1997).

6.3.2.2 Cutter Suction dredger (CSD)

The cutter-head of the cutter suction dredger is mounted at the extremity of the “ladder”, which also supports the suction pipe and sometimes an underwater-pump. At the upper end the ladder is attached to the main hull by heavy hinges, which permit rotation in the vertical plane (to lower the cutter on the seabed). The ladder assembly is lowered and raised by means of a hoisting winch controlled from the bridge. However, this type of dredger is non-propeller (Bray et al., 1997).

6.3.2.3 Grab hopper dredgers

Grab dredgers, sometimes also called clamshells, can exist in pontoon and self-propelled forms; furthermore, the modern designs usually including a hopper within the vessel and, they are therefore, called grab hopper dredgers (Bray et al., 1997).

Table 4: Review of the Trailing Suction Hopper Dredgers on site

Name	Al Zubayr	Al Basra	Al Marbid	Al Threer	Karbala	Tieba	Umm Qasr
Length	90 m	78.29	90	90	93	99.6	119.2
Width	16m	15	16.4	16	18	19	22
Draught	7m	6.5	6.14	7	6.50	6.45	9.2
Installed power	2750 kW	1.800	5.500	5.500	1940	1741	3500
Year of constructio n	1975	1993	1975	1976	2012	2006	2012
Country of origin	The Netherlands	Germany	The Netherlands	The Netherlands	The Netherlands	CHINA	CHINA
Type of engine	M.A.K.	DOUTZ/M WM	M.A.K.	M.A.K.	M.A.K.		Dihtso
Max dredging depth	30 m	25	30	30	25	25	30
Pipe diameter	800 mm	550	800	800	600	800	800
Hopper volume	3.500 m³	1.800	3.500	3.500	3.500	4.500	8000

Source: International Marine Dredging Consultants N. V. [IMDC NV]. (2007). *Study of Transport Corridor from Umm Qasr via Basrah to Baghdad Dredging Strategy* [pdf].

Table 5: Review of Cutter Suction Dredgers on site

Name	Unit	AL Nassiryah	Ramallah	Saif Al- Karar
Length	m	46	74	69
Width	m	7.3	14.5	14
Draught	m	1.8	3	3.5
Installed power	kw	1,000	3,250	3,750
year of constriction		1988	2001	1980
Country of origin		France	Vietnam	Japan
Type of engine		Caterpillar	Cammens	Nigata
Max dredging depth	m	8	25	25
Pipe diameter	mm	500	800	900
Estimated capacity	m^3/hrs	1150	1500	1500

Source: International Marine Dredging Consultants N. V. [IMDC NV]. (2007). *Study of Transport Corridor from Umm Qasr via Basrah to Baghdad Dredging Strategy* [pdf].

Table 6: Review of Grab Hopper Dredger on site

Name	Unit	Dohuk
length	m	50
width	m	12
draught	m	3.90
Installed power	kW	554
Year of construction	-	2012
Country of origin	-	The Netherlands
Type of engine	-	Yanmar
Max dredging depth	m	25
Hopper volume	m^3	500
Status	-	operational

Source: International Marine Dredging Consultants N. V. [IMDC NV]. (2007). *Study of Transport Corridor from Umm Qasr via Basrah to Baghdad Dredging Strategy* [pdf].

6.4 Ongoing development

Dredging works are considered strategically important in the Iraqi ports and waterways for the short term and long term. Regarding reconstruction of the infrastructure in Iraq, rapidly growing volumes of domestic trade have happened after 2003, and the ports operations have increased. It is expected for domestic demands to be increased; hence, there will be an increasing number of ships proceeding to the Iraqi ports through its navigational channels. Consequently, it will be necessary for the channels depth to be maintained for safe navigation (Iraqi National Investment Commission, 2009).

Moreover, The Ministry of Transport and the General Company for Iraqi Ports (GCIP) had prepared a short and long term development plan for all of Iraq's ports. For instance, the ministry started in the beginning of 2003 to work on the Iraqi Transport Master Plan, when the Italian government agreed with the Coalition Provisional Authority to establish the Italian Consortium for Iraqi Transport Infrastructure with the objective of drawing up the Iraqi Transport Master Plan. Furthermore, the ministry also plans to nearly double the current capacity of all Iraqi ports. The current total capacity of Iraqi ports is approximately 19 million tons/year, while the country imports 30 million tons/year, of goods. One of the further expansions is the project of grand port Al-Faw, which will consist of 50-100 berths. At the present time, a significant number of Iraqi imports pass through the ports of neighbouring countries, especially those with outlets on the Gulf, such as Kuwait, United Arabia Emirates and others such as Jordan, Syrian and Turkish ports, where goods are transported overland into Iraq. As a result of the expected expansion, all of those imports will be transferred directly to the Iraqi ports. Eventually, that will increase the number of ships proceeding to the Iraqi ports (Iraqi National Investment Commission, 2009).

6.5 The environment work of the Iraqi dredgers fleet

As shown in Figure 15 and in previous parts of this section it is clear that the Iraqi dredgers work environment is critical and it is subject to accidents. Furthermore, to proceed with a dredger in restricted waterways with special operations such as dredging and lowering or raising dredge heads in addition to other forces, such as, water current and wind have an important influence on the dredgers behaviour. Moreover, with the existence of other ships in the same location, persons well-trained with high competency to steer the dredger in such complex circumstances are required.

6.6 Human resources in the Iraqi dredging sector

Moreover, the wrong policy of the former regime in Iraq which eventually led to clash with neighboring countries such as the war with Iran from 1980 to 1988 and the Kuwait invasion in1990, led the United Nations to put the Iraqi State under sanctions in the 1990s and finally to the United States invasion in 2003. As a consequence, the infrastructure of the country has been destroyed, including the dredging sector. Dredging equipment has been destroyed and human resources decreased.

Recently, the Iraqi authority has started to purchase new Trailing Suction Hopper Dredgers (TSHD). All these units are equipped with high technology, thus requiring professional individuals to operate them. However, the Iraqi division of dredging has had a serious problem in recruiting qualified personnel. Furthermore, the expected expansion in the Iraqi ports will consequently lead to increasing the dredging works, which will lead to an increase in the dredging fleet. As a consequence, the demand for competent crews to operate that fleet will increase too.

Hence, there is a major problem in the present time facing the dredging sector. The shortage of competent masters and watch officers to operate these modern dredgers will substantially lead to or create a dangerous accident with the ships proceeding in the Iraqi waterways and as result of that will lead to closing those waterways, or, potentially, environment pollution.

7 Conclusion and Recommendation

7.1 Conclusion

Based on what has been discussed through the preceding chapters concerning the importance of using ship bridge simulation training to enhance the competency of masters and watch-officers, the following conclusion can be made.

A careful study of the accident reports reveals that 85% of all marine accidents are either directly initiated by human error or are associated with human error by means of incompetent masters and watch-officers, as mentioned in chapter 4 of this dissertation. Hence, this problem has been highlighted by the International Maritime Organisation, specialised nautical institutes and the shipping industry. Correspondingly, the IMO has made revisions to STCW to ensure the minimum standards of competence and certification for seafarers by using simulator training and as a result, reducing the possibility of marine accidents and prevent marine environmental pollution.

Moreover, the IMO through the ISM Code has committed shipping companies to ensure that masters and watch-officers on board its ships have an appropriate level of training and hold valid certificates of competency to comply with STCW requirements. In addition, the classification societies have a significant role in evaluating the simulators and ensuring that those simulators are qualified for use in assessing competency, as mentioned in chapter 2.

International Maritime Organization standards emphasize the use of simulators in training, as do the standards initiated by several classification societies worldwide and the growing number of the marine industries which are using marine simulation training in improving the competency and certification. A substantial advantage has been achieved by international shipping companies by using simulation technology.

As a training tool, simulators have a number of significant advantages: simulators can be used to train regardless of weather conditions, instructor can terminate training scenarios at any time, training scenarios can be repeated, training scenarios can be recorded and played back, and training takes place in a safe environment.

Moreover, simulation training will contribute to solving the problem of the shortage of experiential learning of entry-level officers or lost apprenticeship in the dredging division in GCPI. Especially since no education on shore is available for that purpose. While in developed countries, substantial progress has been made in the field of training programs and the use of dredge simulators for Human Resource Management (HRM), the Iraqi dredging sector lags behind. These factors need to be developed for future sustainable dredging operations in GCPI.

Furthermore, several international dredging companies have made considerable use of dredger simulators in training their dredger's crews. Therefore, it is important for the General Company for Ports of Iraq to take significant advantage of training programs in qualifying the Iraqi dredger crews to be competent with a high quality of performance. Those highly qualified crews can significantly contribute to reducing the following problems:

- Over-dredging
- Environment pollution
- Energy consumption
- Emission
- Ecological side-effects
- Operational cost
- Marine accidents

7.2 Recommendations

According to the previous aspects, the following recommendations are suggested for the decision makers in the GCPI:

- It will be significantly beneficial to establish a new division for simulation training in the ports training center in order to enhance the competency of on service watch-officers of TSHD and to train a new cadets.

- Simulator instructors employed in the ports training center for training of the seafarers should undergo some formal training on use of simulation for competency based-training. This training package for simulator instructor will better serve the training purpose if it is designed and promulgated through IMO/STCW Convention. Only a qualified simulator instructor can ensure quality as per the standards laid down in the Convention. However the instructor can be more important than simulation in meeting training objectives.
- Make the necessary preparations for technical and administrative staff to manage Centers and delegate individuals to different specialized training centers in the developed countries for the purpose of producing the trainer.
- Even though, there is currently no international and regional systematic program, to accumulate and analyse performance data for past contributors in simulations, it is important to design a systematic program to be able to effectively apply simulator technology. It is important to systematically measure and analyse simulator effectiveness for training and to develop a mechanism to use simulators to improve the effectiveness of the transfer of skills and knowledge.

  Therefore, it is recommended that those responsible for the suggested training centre in GCPI to assess and document the training sessions to evaluate the effectiveness of the simulation training programme. This will be a major service to our coming generations in the maritime industry to enhance their knowledge.
- Coordination between the General Company for ports of Iraq and World Maritime University for the purpose of benefitting from the existing expertise in the field of training in this university and the training courses offered by the university to train the trainer.
- Coordination between the General Company for ports of Iraq and Arabian Gulf Academy in Basra for the purpose of taking advantage of its existing experts in the field of training, being one of the ancient academies in the region.

- Iraqi Ports Authority must make it mandatory for its masters and watch officers to get certification on simulator training before getting on board its Trilling Suction Hopper Dredgers.

References

Baldauf, M. Carlisle, J. Patraiko, D. Zlatanov, I. (2011). *Maritime Training Platforms. TeamSafety - Technical Work package report. World Maritime University, Malmö, September 2011*

Baldauf, M. Nolte-Schuster, B. Benedict, K. & Felsenstein C. (2012). Maritime Safety and Security. Learning objective oriented development of simulation exercises, in *Maritime Transport V – Technological, Innovation and Research*, Fransesco Xavier Martinez de Osés & Marcella Castells I Sanabra [Eds.] IDP: Barcelona, pp 868 – 887

Barsan, E. (2009). *Sea service equivalency for full mission simulators training. Maritime Transport & Navigation Journal, 1(1), 14-23*. Retrieved August, 2013, from http://www.ronomar.ro/resource/maredu/issue1_article2.pdf

Benedict, K. Gluch, M. Kirchhoff, M. Felsenstein, C. Herberg, S. Baldauf, M. & Klaes, S. (2011), *Advanced Maritime Simulation combining Conventional Ship Handling with Fast Time Simulation and using Gaming Technology for Safety & Security Training. 13th International Conference Maritime Transport and Infrastructure, Latvian Maritime Academy Riga, pp 192-197 ISSN 1691-3817*

Bray, R. N., Bates, A. D. & Land J. M. (1997). *Dredging, A Handbook for Engineers*. New York: Arnold.

Chislett, M. S. (1996). *Marine simulation and ship manoeuvrability*. Rotterdam: A. A. Balkema.

Cross, S. (2011). *Quality MET through quality simulator applications*. *International conference IMLA 19, Opatija*. Retrieved August 2013, from http://www.pfri.uniri.hr/imla19/doc/015.pdf.

Cross, S. (2012). *Quality aspect of simulation in MET*. 17th international navigation simulator lecturer's conference, Rostock.

Cross, S. (Director) (2013). Computer based technologies for training and assessing seafarers: benefits and non-benefits. *Technology in MET*. Lecture conducted from World Maritime University, Malmo.

Cross, S. J. (2010). *Maritime Simulation*. [Class Handout]: World Maritime University, Malmo, Sweden. From

DNV. (2011). *Standard for certification no. 2.14 maritime simulator SYSTEMS.* Retrieved June 3013, from http://exchange.dnv.com/publishing/StdCert/2011-01/Standard2-14.pdf http://www.dnv.com.

DNV. (2012). Standards for certification No. 2.14 Maritime Simulation Systems Høvik, Norway. Retrieved June 3013, from DNV: http://exchange.dnv.com/publishing/StdCert/Standard2-14.pdf

Hense, H. (1999). *Ship bridge simulators*. London: Nautical Institute.

Hnzu, R., Barsan, E. & Aarsenie, P. (2008). *Reducing of maritime accidents caused by human factors using simulator in training process*. Retrieved August 2013, from http://www.jmr.unican.es/pub/00501/0050101.pdf

IHC systems. (2005). A new integrated bridge training simulator for Zeebrugge, Belgium. *Ports and dredging*. Retrieved August 2013, from http://www.dredgingengineering.com/dredging/media/LectureNotes/miedema/2005_ihc/pd163.pdf

IHC systems. (2010). *Dedicated to Efficient Dredging.* Retrieved August 2013, from *http://www.ihcsystems.com/fileadmin/IHC_Systems_-_ihcsystems.com/Brochures/SY_brochure_2010_Simulators-2.pdf*

IMO, (1993). Sub-committee on Standards of Training and Watchkeeping, Report of the first session of Intersessional Working Group (ISWG), STW25/3/13, 23 September 1993, London

International Chamber of Shipping [ICS]. (2010). *Guidelines on the application of the IMO, International Safety Management (ISM) code: With additional guidance on risk management, safety culture and environmental management*. London: Marisec Publications.

International Marine Dredging Consultants N. V. [IMDC NV]. (2007). *Study of Transport Corridor from Umm Qasr via Basrah to Baghdad Dredging Strategy* [pdf]

International Safety Management Code 1994, IMO, (1994).

Iraqi National Investment Commission. (2009). *Investment Opportunity Al-Faw Port.* Retrieved September 2013, from http://iraqcomattache.org/i/files/docs/Investment_Opportunity_Al-Faw_Port.pdf

Kobayashi, H. (2005). *Use of Simulators in Assessment, Learning and Teaching of Mariners.* Retrieved August 2013, from http://link.springer.com/article/10.1007%2FBF03195064#page-1

Kongsberg. (2009). *Kongsberg Maritime Simulation & Training Ship's Bridge Simulator.* Retrieved July 2013 http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/CF21FD409713420CC12575C5003C8B54/$file/KM_ShipsBridge-brosjyre.pdf

Kongsberg. (n.d.). *Courses by training centre - Kongsberg Maritime - Kongsberg Maritime. Home - Kongsberg Maritime*. Retrieved August, 2013, from http://www.km.kongsberg.com/ks/web/nobkj0407.nsf/WebTrainingCentresOverview?ReadForm

Lindmark, O. (2012). *A teaching incentive The Manila amendment and the learning outcome in tanker education, CHALMERS UNIVERSITY OF TECHNOLOGY, Report No. NM-12/23, Sweden 2012*. Gothenburg: Chalmers University of Technology

Mourik, B., & Braadbaart, J. (2003). *Moderndredge Simulators and Training Means to get a Dredge Crew more efficient*. Sliedresht: IHC systems.

Mourik, B., & Keizer, C., (2006). *The use of dredge simulators as a training tool.* Retrieved August 2013, from http://www.ihcsystems.com/fileadmin/IHC_Systems_-_ihcsystems.com/Tekstfiles/simulator_IHC_Systems_2006_Marocco.pdf

Muirhead, P. (2001). *Maritime Simulation AN Overview*. Malmo: WMU.

Muirhead, P.M, and Smith I., (1993). *Marine Simulation Performance and assessment : Methodologies and Validation techniquis – a critique, Newfoundland, Canada, Proceding of Mersin 93*

Muirhead, P.M, and Tasker R. L., (1991). *Towwards achieving an IMSF Goal of International Recognition of Shipsimulator Training Course, Venice, IMSF Workshops*

Nautical Institute. (n.d.). *Accreditation. The Nautical Institute*. Retrieved August 20, 2013, from http://www.nautinst.org/en/accreditation/index.cfm

NRC (National Research Council). (1992). Shiphandling Simulation. W. Webster, ed. Committee on Shiphandling Simulation, Marine Board. *Application to Waterway Design*. Washington, D.C.: National Academy Press.

NRC (National Research Council). (1996). Simulator-based training and sea-time equivalency. *Simulated voyages using simulation technology to train and license mariners* (pp. 143-157). Washington, D.C.: National Academy Press.

Office of the special inspector general for Iraq reconstruction. (2007). *Report on the Al-Basrah Oil Terminal report Number SIGIR PA-06-096*. Retrieved September 2013, from http://www.sigir.mil/files/assessments/PA-06-080.pdf.

Pianc. (1992). Capability of Ship Maneuvering Simulation Models For Approach Channels and Fairways in Harbours, *Report of Working Group no.20*. Brussels: Permanent Technical Committee II, Supplement to Bulletin No. 77

Rheinmetall. (2011). *Combined Safety and Security / Ship Handling Trainer for World Maritime University / Malmö.*

Riddell, J. F. (1996). *The Role of Education and Training in Dredging.* Retrieved August 2013, from http://www.iadc-dredging.com/ul/cms/terraetaqua/document/0/3/9/39/39/1/terra-et-aqua-nr63-01.pdf

Royal Aeronautical Society. (2009). *the impact if flight simulation in aerospace*. Retrieved August 2013, from http://aerosociety.com/Assets/Docs/Publications/DiscussionPapers/The_impact_of_flight_simulation_in_aerospace.pdf

Sandaruwan, D., Kodikara N., & Keppitiyagama, C. (2010). *The International Journal on Advances in ICT for Emerging Regions 2010 03 (02): 34 – 47. The International Journal on Advances in ICT for Emerging Regions 2010 03 (02): 34-47.* Retrieved July 2013, from www.sljol.info/index.php/ICTER/article/download/2847/3771

STCW Convention and STCW Code. 1995, IMO (1995).

Swift, A. J. (2004). *Bridge team management*. London: Nautical Institute.

USCG (U.S. Coast Guard). (1993). *Marine Safety Council Proceedings Magazine*. Retrieved August 20, 2013, from http://www.uscg.mil/proceedings/archive/1993/Vol50_No2_Mar-Apr1993.pdf

USCG (U.S. Coast Guard). (1994). *Licensing Activity by Port*. Washington, D.C.: Author.

Van der Rijken, W.W. J.L. (2008). *Capability statement of mscn simulators.* Retrieved July 2013, http://www.marin.nl/web/Facilities-Tools/Simulators/Simulator-Facilities/Full-Mission-Bridge-Simulators.htm

Wahren, E. (1993). *Application of airline crew management training in the maritime field.* Newfoundland: Marsim 1996.

Wilson, J. F. (1993). *Progress in the psychophysiological assessment of work load.* Ohio: Armstrong Laboratory Human engineering Division.

Ziarati, R., (2006). *Safety At Sea-Applying Pareto Analysis", Proceedings of World Maritime Technology Conference (WMTC 06), Queen Elizabeth Conference Centre, 2006*. Retrieved August 2013, from http://www.marifuture.org/Publications/Papers/Collisions_and_groundings_major_causes_of_accidents_at_sea.pdf

Ziarati, R., (2007). *Review of Accidents with and on Board of Vessels with Automated Systems – A Way Forward, AES07, Sponsored by Engineering and Physical Science Research Council in the UK (EPSRC), Institute of Engineering and Technology (IET, Previously IEE), Institute of Mechanical Engineers (IMechE), IMarEST, 2007.* Retrieved August 2013, from *http://www.marifuture.org/Publications/Papers/Collisions_and_groundings_major_causes_of_accidents_at_sea.pdf*

Appendix A: Standard for Certification No.2.14, January 2011

SECTION 1
APPLICATION AND CERTIFICATION

A. Scope and Application

A 100 General

101 This standard gives requirements for the performance of maritime simulator systems.

102 It is required in the STCW (Standards of Training, Certification and Watchkeeping) Convention that simulators, when used for mandatory simulator-based training, when used as a mean to demonstrate competence (assessment) and/or when used to demonstrate continued proficiency required by the same Convention, shall be approved by the relevant maritime administration (see STCW Regulations I/12).

This standard proposes one way of carrying out such approval.

A 200 Objective

201 The purpose of the standard is to ensure that the simulations provided by the simulator include an appropriate level of physical and behavioural realism in accordance with recognised training and assessment objectives.

A 300 Application

301 The main target group for the standard is the following:

a) A training provider, which uses a simulator for examination.
b) A training provider, which uses a simulator for mandatory simulator training.
c) A training provider, which uses a simulator for demonstration of continued proficiency.
d) A training provider, which is in the process of buying/installing a new simulator, which is to be used for examination or mandatory simulator training.
e) A manufacturer offering a simulator for examination or mandatory simulator training, and shall document the compliance of the simulator to the buyer.

302 This standard is under the sole ownership rights and copyrights of DNV. It is prohibited by anyone else than DNV to offer and/or perform certification or verification services including issuance of certificates and/or declarations of conformity, wholly or partly, on the basis of and/or pursuant to this standard without DNV's prior written consent. DNV is not responsible for the consequences arising from any use of this standard by others.

A 400 Scope

401 The standard gives criteria for the simulated functions, the equipment and the environment, considered necessary for specified tasks in maritime operations.

402 This standard does not prioritize the reliability of specific equipment or software used in the simulator, e.g. redundancy, environmental testing nor maintenance. It is assumed that the simulator is built from parts of sufficient reliability.

403 It is assumed that the training provider addresses the operation of the simulator (i.e. using the simulator for training and/or assessment in a training programme) in a quality standard system (STCW Regulations I/8). In such quality standard system the instructor and assessor qualifications (STCW Regulations I/6) shall be addressed and the course curriculum shall be approved by the relevant maritime administration (see the relevant standard of competence in STCW-95).

404 It is understood that the management of a training provider ensures that the simulator complies with all additional mandatory requirements, e.g. electrical installation of such equipment, which are not covered in this standard.

405 *Simulator types not covered in this standard:* The society can issue a statement of compliance for simulators used to create realistic situations for some of the competence requirements listed in DNV competence standards or training courses certified to DNV standard for certification of learning programmes. Such simulators can be:

— crises management
— oil spill
— MOU in accordance with IMO recommendations on training of personnel on mobile offshore units
— HSC in accordance with IMO guidelines in the international code of safety for high-speed craft, 2000
— WIG in accordance with IMO general principles and recommendations for knowledge, skills and training for officers on wing-in-ground (Wig) craft operating in both displacement and ground effect modes
— fishery
— other.

B. Classification Principles

B 100 Certificate

101 Maritime simulators that comply with the requirements of this standard will receive a Product certificate for "Maritime simulator". The simulator's function area and the class according to this standard will be stated on the certificate.

102 The Product certificate will make reference to the appropriate competencies, which are the simulation objectives of the simulator.

103 The "Maritime simulator" Product certificates will have a validity period of five years. Provided the results from annual tests are satisfactory, the certificate may be renewed for another five year period.

104 A manufacturer offering a simulator for examination or mandatory simulator training that complies with the requirements of this standard may request verification to obtain a "Statement of Compliance".

105 The "Statement of Compliance" will make reference to the appropriate competencies, which are the simulation objectives of the simulator.

106 The "Statement of Compliance" will have a validity period of five years. Provided the results from renewal tests are satisfactory, the "Statement of Compliance" may be renewed for another five year period.

B 200 Certification principles

201 Certification of maritime simulators shall generally be carried out according to the following principles:

- document evaluation (hardware and software)
- approval of performance according to functional requirements based on approved test programmes (initial tests)
- issue of the certificate
- annual tests to retain the certificate (see E300)
- tests for renewal of the certificate at the end of the validity period.

202 When an alteration or addition to the approved simulator is proposed, which will substantially change the performance of the simulator, plans shall be submitted to the Society for approval. The alterations or additions shall be carried out to the satisfaction of the auditor from the Society.

Guidance note:

With substantial changes are meant changes to the simulator, in which the learning objectives of a training programme may be affected. Minor changes to documents, hardware and software, and the use of comparable modules (e.g. different brands of simulated equipment) should be documented and verified in conjunction with the next annual tests, in order to retain the certificate.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C. Definitions

C 100 General terms

101 *Maritime simulator:* A creation of certain conditions by means of a model, to simulate situations within maritime operation.

Guidance note:

For process simulation the model is defined as the simulated propulsion type, in cargo handling the simulated ship type.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 *Simulator class:* A three grade scale for levels of performance capabilities of maritime simulators. The three classes are Class A (full mission), Class B (multi-task), Class C (limited task). In addition, Class S (special tasks) is used for simulators where the performance is defined on a case by case basis.

103 *Function area:* A division of maritime simulators with regard to function. Maritime simulators are divided into simulators for: bridge operation, machinery operation, radio communication, cargo handling, dynamic positioning, safety and security, vessel traffic systems, Survival Craft and Rescue Boat Operation, Offshore Crane Operation and ROV operations.

104 *Bridge operation simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in STCW Chapter II.

105 *Machinery operation simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in STCW Chapter III.

106 *Radio communication simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in STCW Chapter IV.

107 *Cargo handling simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in STCW Chapter II, Chapter III and Regulation V/1.

108 *Dynamic positioning simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in the IMCA (International Marine Contractor's Association) M117.

109 *Safety and Security simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in STCW, chapter VI and ISPS B/13.1.

110 *VTS* (vessel traffic services) *simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) recommendation V-103.

111 *Survival Craft and Rescue Boat Operation simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in STCW Chapter II.

112 *Offshore Crane Operation simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in the Offshore Mechanical Handling Equipment (OMHEC) *training standard Crane Operator and Banksman Offshore North-Sea/Europe.*

113 *Remotely Operated Vehicle Operation simulator:* A simulator with the objective to create realistic situations for some of the competence requirements in the IMCA C 005 competence requirements for ROV operators.

114 *Physical realism:* To what degree the simulator looks and feels like real equipment. The realism shall include capabilities, limitations and possible errors of such equipment.

115 *Behavioural realism:* To what degree the simulator resembles real equipment in order to allow a learner to exhibit the appropriate skills. The realism shall include capabilities, limitations and possible errors of such equipment.

116 *Operating environment:* The environment surrounding the simulated functions, which gives input to the learner e.g. vessel traffic pattern, engine power demands, oil terminal operations, radio message traffic and/or weather conditions.

117 *Realistic environment:* The impression perceived by the learner, experienced in a training programme, regarding the simulator, comprising of physical realism, behavioural realism and the operating environment.

118 *Competence-based assessment:* A carefully considered judgement of the workplace performance to demonstrate that individuals can perform or behave to specific standards.

119 *Learner:* A person who is gaining knowledge, skills and/or changing attitudes in a training programme.

120 *Instructor:* A person who is conducting training of a learner in a training programme. The instructor shall have qualifications and experience in accordance with STCW Section A-I/6 clause 4 and 7.

121 *Assessor:* A person who is conducting assessment of competence of a learner, which is intended to be used in qualifying for certification under the STCW Convention. The assessor shall have qualifications and experience in accordance with STCW Section A-I/6 clause 6 and 7.

122 *Dynamic behaviour:* The behaviour of a system or component under actual operating conditions, including acceleration and vibration.

D. Documentation

D 100 General

101 Documentation shall be submitted as required by Table D1.

Table D1 - Documentation requirements

Function	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Simulator system functions description	D202 - Simulation philosophy	The general purpose of the simulator system	AP
	D203 - User interface description	The user interface between the simulator and the learner(s)	AP
	D204 - Instrument and equipment list		AP
	D205 - Descriptions of functions covered by software		AP
	D206 - Operation manual		AP

Table D1 - Documentation requirements (Continued)			
Simulator performance description	D301 - simulation objectives		AP
	D302 - operating capabilities		AP
	D303 - Variety of conditions		AP
	D304 - Integration protocol	Only if one ore more simulators are interconnected	FI
Test programmes for functionality	E401 - Test programmes		AP

Guidance note:

It is sufficient to submit an electronic copy of the documentation to the Society for approval.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 The documentation shall be limited to describing and explaining the relevant aspects governed by the requirements in this standard.

103 Symbols used in the documentation shall be explained, or reference to a standard code shall be given.

D 200 Simulator system functions description

201 The following requirements for the description of the simulator shall address the simulator itself as well as the supporting functions e.g. the facilities for the instructor and the assessor.

202 *Simulation philosophy*

A document describing the philosophy and the general purpose of the simulator system, including the principles of training and assessment that could be utilised.

Guidance note:

The simulation philosophy is a 1-2 pages document describing how the simulator centre is using the simulator system. The purpose with the simulator and in principal how training and assessment is done.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

203 *User interface description*

The user interface between the simulator and the learner(s), the instructor and the assessor shall be documented by:

a) A drawing showing the physical layout and dimensions of each module.
b) A description of the functions allocated to each keyboard and screen.
c) A description of individual screen views (schematics, colour prints, etc.).
d) A description of how menus are operated.
e) A list of all alarms and operator messages. When the alarms or messages are not self-explanatory additional explanations shall be included.
f) A description of software "help" systems.

When recognised real maritime equipment or operational controls are used, it is sufficient to identify such products (see 204).

Guidance note:

In case the user interface is already covered in the operation manual then it is not necessary to go into great details of items c-e.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

204 *Instrument and equipment list*

A list stating for each key component as applicable:

a) System.
b) Name of manufacturer.
c) Type etc., necessary to identify the component.

Guidance note:

The purpose of the instrument and equipment list is mainly to identify the key components. A table with name and number is sufficient. The manufacturers "scope of supply" list may be one alternative.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

205 *Descriptions of functions covered by software*

a) A list of all main software modules installed per hardware unit stating names and version numbers.

b) Description of application software (not program listings) with detail level sufficient to understand its function.

c) Tools for system set-up and process equipment configuration.

206 *Operation manual*

A document intended for regular use at the simulator centre, providing information as applicable to, but not limited to:

— operational mode of all modules, for normal system performance (baseline starting point)
— operating instructions for normal operating mode.

D 300 Simulator performance description

301 It shall be documented that the simulator can be used for all of the defined simulation objectives.

Guidance note:

The documentation may include one or more of the following:

a) Cross reference between the STCW Convention competence requirements and simulation scenarios.

b) Description of training exercises, including learning objectives, for each element of competence.

c) Specification of the training type such as: emergency; optimization; procedures; maintenance; troubleshooting; decision-making; teamwork; operator; part-tasking; component etc.

d) Outline of how each element of competence can be assessed.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

302 It shall be documented that the simulator can simulate the operating capabilities of real equipment concerned and includes the capabilities, limitations and possible errors of such equipment.

303 It shall be documented that the simulator is capable of producing a variety of conditions, which may include emergency, hazardous or unusual situations relevant to the simulation objectives.

304 When one ore more simulators are interconnected, the integration protocol used together with a description of which functions that are interfaced shall be documented.

D 400 Test programmes for functionality

401 Test programmes for the functionality of the simulator shall be submitted for approval. The main purpose is to verify the performance described in 300. The manufacturers "site acceptance test" (SAT) may be a point of origin.

402 The tests are only to cover requirements given by this standard. The test programmes shall specify in detail how the various functions shall be tested and what shall be observed during the tests.

403 Each test programme shall include a description of each test item and a description and justification of the acceptance criteria for each test.

Guidance note:

In general the test program shall focus on operational tests in accordance with operational procedures of the simulation objective. i.e., from start-up to full operation like in a sea trial, all relevant operations in cargo handling, etc.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

E. Tests

E 100 General

101 All tests shall be carried out according to test programmes approved by the Society.

102 The tests and visual examination shall verify that all relevant standard requirements are met.

103 The tests shall include the correct function of individual equipment packages, together with establishment of correct parameters for alarm, control and safety (time constants, set points, etc.).

104 Copies of the approved test programmes shall be kept with the simulator.

105 A change-log shall be kept updated with all changes and maintenance carried out on the simulator. The change-log shall at least include action, alteration achieved and date. A copy of the change-log shall be submitted to the Society in connection with renewal of the certificate.

E 200 Initial tests to attain the certificate

201 The tests shall be conducted when the simulator is fully assembled to a complete and final unit. The tests shall be witnessed by an auditor from the Society.

E 300 Annual tests to retain the certificate

301 The annual tests shall be conducted when the simulator is under normal operation. The tests shall be witnessed by an auditor from the Society.

302 Under the condition that the training provider has a certified quality standard system, either an ISO 9000 certificate awarded by any accredited body or a certificate according to the DNV Standard for Certification of Maritime Simulator Centres, then the annual tests may be carried out solely by the simulator centre.

303 The test results and a copy of the change-log shall be submitted to the Society for approval and recording.

E 400 Tests for renewal of the certificate

401 The tests shall be conducted when the simulator is under normal operation. The tests shall be witnessed by an auditor from the Society.

SECTION 2
GENERAL

A. Simulator Equipment

A 100 General

101 Each piece of equipment installed in the simulator shall have a similar functionality to corresponding real equipment used.

102 If any piece of equipment does not correspond to a specific make, the applicable IMO (International Maritime Organization) performance standard (functionality requirements only) for such equipment shall be followed. If such a performance standard does not exist, then the functionality of the equipment shall, as a minimum, be the same as for any recognised genuine equipment of that type, in use.

103 Each piece of equipment shall resemble the behavioural characteristics, e.g. accuracy, reaction time and other limitations, related to corresponding equipment in use.

104 User manuals for the simulator equipment and operational controls shall be available to the learners for use during exercises.

105 If emulated instrumentation is used the following requirements apply:

a) Digital and analogue instrumentation shall be grouped and positioned into realistic function areas.
b) The visual proportion of the emulated instruments shall be close to real instrumentation.
c) Scale and range shall be in accordance with real instrumentation.
d) It shall be possible to dim indication lamps and digital readings where applicable.
e) When computer generated sound indicators, buzzers and sirens are used, it shall have adequate loudness and similar tone and repetition frequency as for real instrumentation.

106 In cases where instrumentation is accessed through a PC monitor and/or touch screen, these general measures to user displays and limitation of functionality may apply:

a) The related application(s) shall start up automatically with no user interactions upon start-up.
b) Other applications (e.g. Program Manager, File Manager, Notepad or other word processors, etc.) shall not be accessible.
c) Hot keys normally giving access to other functions (Alt+Tab, Ctrl+Esc, Alt+Esc, double-clicking in background, etc.) shall be disabled.
d) Quitting of main application shall be disabled (e.g. Alt+F4, File Exit, etc.).
e) For applications where main window is meant to be present at all times, control buttons in header (minimise, resize and control normally including restore, minimise, exit and switch) and moving and resizing by drag-and-drop of banners and borders, etc., shall be disabled.
f) The learner should not have access to configuration files (e.g. autoexec.bat, config.sys, system.ini, etc.).

B. Instructor and Assessor facilities

B 100 General

101 The simulator shall include instructor and assessor facilities where exercises may be controlled.

102 The instructor and the assessor shall be able to:

a) Start, halt, reset in time and place, and restart an exercise.
b) Change the operating environment during an exercise.
c) Communicate with the learners (i.e. simulate the outside world) on relevant communication channels.
d) Follow the conversations of the learners (Class A to B only).
e) Visually follow the proceedings of an exercise by any method.
f) Plot conducted exercises (e.g. ship tracks, targets, and coastline) by any method (bridge operation only).
g) Activate simulation of relevant failures in all equipment used.

103 The instructor and the assessor shall have access to an operation manual or equivalent with contents as outlined in Sec.1 D206.

104 It shall be possible to replay a full exercise showing the actions performed by the learners. The replay shall be possible in time other than real time (i.e. slow motion and rapid speed). The purpose is to trace and replay sequences of special interest in the exercise.

105 The instructor and assessor facilities shall include possibilities to set up a scoring or grading method to assess performance of the learner.

Guidance note:
A scoring and grading possibility may include:

a) Monitoring of selected parameters, continuous or at selected stages.
b) Comparing these with norm values, weighing and counting the deviation.
c) Presenting these values and deviations in an understandable manner upon completion of the exercise.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

106 The instructor and assessor facilities should include possibilities to set the exercise to any position in the replay and let the learner start over from the set time.

Guidance note:
When real equipment is interfaced, it might not be possible to playback all data in the same application. It will in those cases be acceptable to have a video logger that is able to save screens and data from other systems provided that this can be synchronised and displayed in the playback.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

SECTION 3
BRIDGE OPERATION

A. Simulator Class - Bridge Operation

A 100 General

101 Simulators for the function area bridge operation may be divided into the following simulator classes:

Table A1 Simulator classes for the function area bridge operation	
Class A (NAV)	A full mission simulator capable of simulating a total shipboard bridge operation situation, including the capability for advanced manoeuvring in restricted waterways.
Class B (NAV)	A multi task simulator capable of simulating a total shipboard bridge operation situation, but excluding the capability for advanced manoeuvring in restricted waterways.
Class C (NAV)	A limited task simulator capable of simulating a shipboard bridge operation situation for limited (instrumentation or blind) navigation and collision avoidance.
Class S (NAV)	A special tasks simulator capable of simulating operation and/or maintenance of particular bridge instruments, and/or defined navigation/manoeuvring scenarios.

B. Simulation Objectives

B 100 Class A - Bridge operation

101 The simulator shall be capable of simulating a realistic environment for all of the applicable STCW competence requirements referred to in the column for Class A in Table B1.

B 200 Class B - Bridge operation

201 The simulator shall be capable of simulating a realistic environment for all of the applicable STCW competence requirements referred to in the column for Class B in Table B1.

B 300 Class C - Bridge operation

301 The simulator shall be capable of simulating a realistic environment for all of the applicable STCW competence requirements referred to in the column for Class C in Table B1.

B 400 Class S - Bridge operation

401 The simulator shall be capable of simulating a realistic environment for selected STCW competence requirement referred to in the column for Class S in Table B1.

402 Overriding the requirement in 401, the simulator may be capable of simulating any equipment and/or scenario, for bridge operation, for any competence requirement defined. In such a case the relevant equipment and/or scenario, and competence requirements will be stated or referred to in the certificate.

B 500 Class notations - Bridge operation

501 In addition to the main class A, B, C or S a class notation in accordance with DNV Rules for Classification of Ships can be obtained for describing special features and capabilities of the simulator.

B 600 Competencies addressed by bridge operation simulator class

601 The competencies addressed by bridge operation simulator classes are given in Table B1.

Table B1 Competencies addressed by bridge operation simulator class

STCW reference	*Competence*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
Table A-II/1.1	Plan and conduct a passage and determine position	A	B		(S)
Table A-II/1.2	Maintain a safe navigational watch	A	B		(S)
Table A-II/1.3	Use of radar and ARPA to maintain safety of navigation	A	B	C	(S)
Table A-II/1.4	Use of ECDIS to maintain the safety of navigation	A	B	C	(S)
Table A-II/1.5	Respond to emergencies	A	B	C	(S)
Table A-II/1.6	Respond to a distress signal at sea	A	B	C	(S)
Table A-II/1.8	Transmit and receive information by visual signalling	A	B	C	(S)
Table A-II/1.9	Manoeuvre the ship	A	B	C	(S)
Table A-II/2.1	Plan a voyage and conduct navigation	A	B		(S)
Table A-II/2.2	Determine position and the accuracy of resultant position fix by any means	A	B		(S)
Table A-II/2.3	Determine and allow for compass errors	A	B		(S)
Table A-II/2.4	Co-ordinate search and rescue operations	A	B		(S)
Table A-II/2.5	Establish watchkeeping arrangements and procedures	A	B		(S)
Table A-II/2.6	Maintain safe navigation through the use of information from navigation equipment and systems to assist command decision-making	A	B	C	(S)
Table A-II/2.7	Maintain the safety of navigation through the use of ECDIS and associated navigation systems to assist command decision making	A	B	C	(S)
Table A-II/2.10	Manoeuvre and handle a ship in all conditions	A			(S)
Table A-II/2.11	Operate remote controls of propulsion plant and engineering systems and services	A			(S)
Table A-II/3.1	Plan and conduct a coastal passage and determine position	A	B		(S)
Table A-II/3.2	Maintain a safe navigational watch	A	B		(S)
Table A-II/3.3	Respond to emergencies	A	B	C	(S)
Table A-II/3.4	Respond to a distress signal at sea	A	B	C	(S)
Table A-II/3.5	Manoeuvre the ship and operate small ship power plants	A			
Table A-II/5.2	Contribute to berthing, anchoring and other mooring operations	A	B	C	(S)

Guidance note:
Table A-II/3 covers specification of minimum standard of competence for officers in charge of a navigational watch and for masters on ships of less than 500 gross tonnage engaged on near-coastal voyages, hence the realism shall be adapted to correlated equipment in use for smaller ships of less than 300 gross tonnage.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C. Simulator requirements

C 100 Detailed requirements

101 The bridge operation simulator shall, according to class, fulfil the requirements given in Table C1, Table C2 and Table C3.

Class S requirements will be dependant upon the type of simulated equipment and/or scenario, and the defined competence requirements.

Table C1 Physical realism

Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
1.1.1	Equipment, consoles and workstations are to be installed, mounted, and arranged in a ship-like manner in accordance with design criteria described in DNV Rules for Classification of Ships and/or DNV Rules for Classification of High Speed, Light Craft and Naval Surface Craft as appropriate to the ship types represented in the Simulator.	X	X		
	The following equipment shall at least be included in the simulator:				
1.1.2	Controls of propulsion plant operations, including engine telegraph, pitch-control and thrusters. There shall be indicators for shaft(s) revolutions and pitch of propeller(s). There shall be controls for at least one propeller and one bow thruster.	X	X		
1.1.3	Controls of propulsion plant operations.			X	
1.1.4	Controls of propulsion plant for mooring operations. By any method, it shall be possible to observe the ship's side and the dock during operation of such controls.	X			
1.1.5	Controls of auxiliary machinery. There shall be controls for at least two auxiliary engines, including electric power supply control.	X			
1.1.6	Steering console, including recognised facilities for hand steering and automatic steering with controls for switch over. There shall be indicators of rudder angle and rate of turn.	X	X	X	
1.1.7	Steering compass and bearing compass (or repeater) with an accuracy of at least 1 degree.	X	X		
1.1.8	Steering compass.			X	
1.1.9	At least one Radar/ARPA display/unit (Automatic Radar Plotting Aid). It shall be possible to simulate both a 10 cm and a 3 cm radar. The radar shall be capable to operate in the stabilised relative motion mode and sea and ground stabilised true motion modes (see STCW Section A-1/12.4. and 5 and paragraph 2 of section B-I/12).	X	X	X	
1.1.10	Communication equipment in accordance with GMDSS (Global Maritime Distress Safety System) frame-work, covering at least the requirements for relevant area (where simulated navigation is planned for). (See STCW paragraph 72 of section B-I/12 and section 5 of this standard)	X	X		
1.1.11	Communication equipment including at least one VHF (Very High Frequency) radio with DSC features.			X	
1.1.12	The simulator shall include a Communications system that will allow for internal ship communications to be conducted.	X	X		
1.1.13	ECDIS (electronic chart display and information system) displaying selected information from a system electronic navigational chart (SENC) with positional information from navigation sensors like AIS and Radar to assist the mariner in route planning and route monitoring, and by displaying additional navigation-related information. (See STCW paragraph 35 of section B-I/12)	X	X		
1.1.14	GPS (Global Positioning System), echo-sounder and speed log showing speed through the water (1axis) for ships below 50 000 GRT and in addition speed and distance over ground in forward and athwart ship direction for ships above 50 000 GRT.	X	X	X	
1.1.15	Instrument for indication of relative wind- direction and force.	X	X	X	
1.1.16	Sound panel according to the "rules of the road".	X	X	X	
1.1.17	Instrument for indication of navigational lights.	X	X		
1.1.18	Function for transmitting visual signals (Morse lamp)	X	X		
1.1.19	Control system for fire detection, fire alarm and lifeboat alarm.	X	X		
1.1.20	AIS (Automatic Identification System)	X	X		
1.1.21	Ship borne meteorological instrument.	X			
	1.2 Additional requirements for simulators intended for training in ice navigation (Ref. STCW Section B-V/g Guidance regarding training of masters and officers for ships operating in polar waters)				
1.2.1	Two speed and distance measuring devices. Each device should operate on a different principle, and at least one device should be capable of being operated in both the sea and the ground stabilized mode.	X	X		
1.2.2	Searchlight controllable from conning positions.	X	X		
1.2.3	Manually operated flashing red light visible from astern to indicate when the ship is stopped.	X	X		

Table C1 Physical realism (Continued)

Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
1.2.4	VDR (Voyage Data Recorder) or capability for vessel history track and learner actions log from the instructor and the assessor position.	X	X		
1.2.5	Equipment capable of receiving ice, icing warnings, and weather information charts.	X	X		
1.2.6	Anchoring and towing arrangements	X	X		
1.3 Additional requirements for simulators intended for training on Integrated Bridge Systems including Integrated Navigation					

1.3.1	Workstation for navigating and manoeuvring consisting of:
	— radar / radar plotting
	— ECDIS
	— automatic visual position indicator
	— information of position fixing systems
	— information of Automatic Ship Identification System (AIS)
	— (adjustment) heading / track control system
	— controls for main engine(s) incl. crash manoeuvres, emergency stop
	— controls for main rudder (incl. override facility)
	— controls for thruster
	— indications for:
	  — for propeller revolutions (actual and desired)
	  — main engine revolution in the case of reduction geared engine
	  — propeller pitch in the case of controllable pitch propeller
	  — torque
	  — starting air
	  — lateral thrust
	  — speed (possibly longitudinal and lateral)
	  — rudder angle
	  — rate-of-turn
	  — gyro compass heading
	  — magnetic compass heading
	  — heading reminder (pre-set heading)
	  — water depth incl. depth warning adjustment
	  — time
	  — wind direction and velocity
	  — air and water temperature*
	  — group alarms (with aids for decision-making).
	— signal transmitter for:
	  — whistle
	  — automatic device for fog signals
	  — general alarm
	  — Morse signalling light.
	— automatic device for emergency alarm
	— controls for console lighting
	— two-way VHF radiotelephone (walkie-talkie) with charging connection and/or paging system
	— internal communication equipment
	— public address system
	— VHF point with channel selector
	— remote control for search light
	— rudder pump selector switch
	— steering mode selector switch
	— steering position selector switch
	— controls for windscreen wiper, washer, heater
	— night vision equipment
	— sound reception system
	— acknowledgement of watch alarm.
		X	X	X	

	* Located at the workstation for navigating and manoeuvring or at the workstation for planning and documentation.				

Table C1 Physical realism (Continued)

Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*

1.3.2	Workstation for monitoring consisting of:
	— radar / radar plotting
	— signal transmitter for whistle
	— acknowledgement of watch alarm
	— indications for:
	  — propeller revolutions
	  — pitch of controllable pitch propeller
	  — speed
	  — rudder angle
	  — gyro compass heading
	  — time
	  — rate-of-turn
	  — water depth
	  — alarms.
	— internal communication equipment
	— VHF point with channel selector.
		X	X	X	

1.3.3	Workstation for manual steering (helmsman's) consisting of:
	— steering wheel / steering lever
	— rudder pump selector switch
	— indications for:
	  — gyro compass heading
	  — magnetic compass heading
	  — pre-set heading
	  — rudder angle
	  — rate of turn.
	— talkback to bridge wing workstation.
		X	X	X	

1.3.4	Workstation for docking (bridge wing) consisting of:
	— controls for main engine(s
	— controls for thruster
	— controls for rudder
	— controls for whistle
	— steering position selector switch
	— indications for:
	  — gyro compass heading
	  — propeller revolutions
	  — main engine revolution in the case of reduction geared engine
	  — propeller pitch in the case of controllable pitch propeller
	  — lateral thrust
	  — rate-of-turn
	  — rudder angle
	  — longitudinal and lateral movement of ship
	  — wind direction and velocity.
	— system for external communication with tugs, pilot boat (VHF point)
	— controls for Morse lamp and searchlight
	— acknowledgement of watch alarm.
		X	X	X	

Table C1 Physical realism (Continued)					
Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
1.3.5	Workstation for planning and documentation consisting of: — ECDIS including navigation planning station — route planning devices — chart table — position fixing receiver — retaining device for drawing triangles, dividers, magnifying lens, pencils, etc. — weather chart plotter — main clock — chronometer with receiving facility for time signals — radio direction finder — log, incl. distance indicator, course plotter — echograph — barograph — indication for air and water temperatures — command printer — VHF point.	X	X	X	
1.3.6	Workstation for safety consisting of: — fire alarm for areas machinery, superstructure/ accommodations, cargo — remote control and monitoring of fire-extinguishing system — remote control and monitoring of watertight doors/fire doors (open/ closed) — emergency stop for air condition, ventilation and refrigerating installations — controls for anti-rolling device — indicator for bilge monitor — indicator for strength load incl. alarm — indicator for further safety systems — clinometer — keys and control-elements for lights and signals (navigation lights, signal lamps, bridge lighting, deck lighting searchlights, as well as all fuses) — internal communication system, in particular to muster stations — adjustment of watch alarm system and acknowledgement button — status indication for bow-, rear-flap — controls/indications for ballast water handling — tools for documentation — main station for two-way VHF radiotelephone (walkie-talkie).	X	X	X	
1.3.7	Workstation for communications consisting of: — GMDSS equipment as required for the applicable sea area: — VHF-DSC, radiotelephone — MF-DSC, radiotelephone — MF/HF-DSC, NBDP, radiotelephone — Inmarsat-SES — NAVTEX/EGC/HF direct printing telegraph — EPIRB trigger — main station for two-way VHF radiotelephone (walkie-talkie)*.	X	X	X	
	* Located at the safety or communication workstation.				
1.3.8	All systems related to the integrated bridge system shall included failure control(s) and method(s) to train and assess the learner in the use of advanced equipment, technology and enable familiarization and training to understand the limitations of automatic systems.	X	X	X	
	1.4 Additional requirements for simulators intended for training in Anchor Handling operations (Ref. STCW Section B-V/e, Offshore supply vessels performing anchor-handling operations)				
1.4.1	Engine telegraph with pitch control for 2 propellers located at forward bridge as appropriate to the simulated vessel(s).	X			
1.4.2	Thruster control for bow and stern thrusters located at forward bridge as appropriate to the simulated vessel(s).	X			
1.4.3	Thruster control for azimuth propeller located at forward bridge as appropriate to the simulated vessel(s).	X			
1.4.4	Control for 2 rudders (synchronic and independent) located at forward bridge as appropriate to the simulated vessel(s).	X			

Table C1 Physical realism (Continued)					
Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
1.4.5	Engine telegraph with pitch control for 2 propellers located at aft bridge as appropriate to the simulated vessel(s).	X	X		
1.4.6	Thruster control for bow and stern thrusters located at aft bridge as appropriate to the simulated vessel(s).	X	X		
1.4.7	Thruster control for azimuth propeller located at aft bridge as appropriate to the simulated vessel(s).	X	X		
1.4.8	Control for 2 rudders (synchronic and independent) located at aft bridge as appropriate to the simulated vessel(s).	X	X		
1.4.9	A joystick giving possibility to control manoeuvring equipment as selected located at aft bridge.	X	X		
1.4.10	Winch control panel located at aft bridge that will display line tension, payout, and speed.	X	X		
1.4.11	Winch computer located at aft bridge.	X	X		
1.4.12	Clutch panel located at aft bridge.	X	X		
1.4.13	Control handles for winches enabling, haul in, pay out, and control of spooling gear located at aft bridge.	X	X		
1.4.14	Two monitors where the winch operator chooses between a selection of cameras showing the different winches to give a full coverage of the winch.	X	X		
Class S requirements will be dependant upon the type of simulated equipment and/or scenario, and the defined competence requirements.					

Table C2 Behavioural realism					
Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
2.1.1	The simulation of own ship shall be based on a mathematical model with 6 degrees of freedom.	X	X	X	
2.1.2	The model shall realistically simulate own ship hydrodynamics in open water conditions, including the effects of wind forces, wave forces, tidal stream and currents.	X	X	X	
2.1.3	The model shall realistically simulate own ship hydrodynamics in restricted waterways, including shallow water and bank effects, interaction with other ships and direct, counter and sheer currents.	X			
2.1.4	The simulator shall include mathematical models of at least the types of own ship relevant to the training objectives.	X	X		
2.1.5	The simulator shall include at least one tug model that can realistically simulate tug assistance during manoeuvring and escort operations by any method. It must be possible to simulate pull, push, reposition towing and escorting.	X	X		
2.1.6	The tug model shall be affected by own ship's speed and as such include degrading performance depending on the type of tug simulated. It should be possible to operate with both conventional and tractor tugs having different characteristics and response times.	X			
2.1.7	The simulator shall include exercise areas including correct data for landmass, depth, buoys tidal streams and visuals as appropriate to the nautical charts and publications used for the relevant training objectives.	X	X		
2.1.8	The simulator shall include exercise areas including correct data for landmass, depth, buoys and tidal streams as appropriate to the nautical charts and publications used for the relevant training objectives.			X	
2.1.9	The radar simulation equipment shall be capable of model weather, tidal streams, current, shadow sectors, spurious and false echoes and other propagation effects, and generate coastlines, navigational buoys and search and rescue transponders (see STCW Section A-1/12.4.2).	X	X	X	
2.1.10	The ARPA simulation equipment shall incorporate the facilities for: — manual and automatic target acquisition — past track information — use of exclusion areas — vector/graphic time-scale and data display — trial manoeuvres. (see STCW Section A-1/12.5)	X	X	X	

Table C2 Behavioural realism (Continued)

Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
2.1.11	The ECDIS simulation equipment shall incorporate the facilities for: — integration with other navigation systems — own position — sea area display — mode and orientation — chart data displayed — route monitoring — user-created information layers — contacts (when interfaced with AIS and/or radar tracking) — radar overlay functions (when interfaced).	X	X	X	
2.1.12	The simulator shall provide an own ship engine sound, reflecting the power output.	X	X		
2.1.13	The simulator shall provide capabilities for realistically conduct anchoring operations by any method. The model shall realistically simulate own ship hydrodynamics in interaction with applicable anchor and chain dimensions with different bottom holding grounds, including the effects of wind forces, wave forces, tidal stream and currents.	X			
2.1.14	The simulator shall provide capabilities for realistically simulate the function of mooring and tug lines and how each line functions as part of an overall system taking into account the capacities, safe working loads, and breaking strengths of mooring equipment including mooring wires, synthetic and fibre lines, winches, anchor windlasses, capstans, bitts, chocks and bollards.	X			
2.2 Additional requirements for simulators intended for training in ice navigation (Ref. STCW Section B-V/g Guidance regarding training of masters and officers for ships operating in polar waters)					
2.2.1	The own ship model shall realistically simulate hydrodynamics in interaction with solid ice edge.	X	X		
2.2.2	The own ship model shall realistically simulate hydrodynamics and ice pressure in interaction with solid ice.	X	X		
2.2.3	The own ship model shall realistically simulate the effects of reduced stability as a consequence of ice accretion.	X	X		
2.2.4	It shall be possible to simulate the effect of the following ice conditions with variations: — ice type — ice concentration — ice thickness.	X	X		
2.2.5	It shall be possible to realistically simulate the towing of own ship – own ship, and own ship target ship and target own ship. It shall be possible to introduce different towing gear like rope or steel wire with different strength and elasticity, forward, stern and side towing.	X	X		
2.3 Additional requirements for simulators intended for training on Integrated Bridge Systems including Integrated Navigation System					
2.3.1	The INS should combine process and evaluate data from all sensors in use. The integrity of data from different sensors should be evaluated prior to distribution.	X	X	X	
2.3.2	The INS shall ensure that the different types of information are distributed to the relevant parts of the system, applying a "consistent common reference system" for all types of information.	X	X	X	
2.3.3	The INS shall provide the information of position, speed, heading and time, each clearly marked with an indication of integrity.	X	X	X	
2.3.4	The INS shall be able to automatically, continually and graphically indicate the ship's position, speed and heading and, where available, depth in relation to the planned route as well as to known and detected hazards.	X	X	X	
2.3.5	The INS shall, in addition, provide means to automatically control heading, track or speed and monitor the performance and status of these controls.	X	X	X	
2.3.6	Alarms shall be displayed so that the alarm reason and the resulting functional restrictions can be easily understood. Indications should be self-explanatory.	X	X	X	

Table C2 Behavioural realism (Continued)					
Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
2.4	*Additional requirements for simulators intended for training in Anchor Handling operations (Ref. STCW Section B-V/e, Offshore supply vessels performing anchor-handling operations)*				
2.4.1	The simulator shall include mathematical models of at least two types of anchor handling own ships. The own ships should be set up with wire on winches: — wire length — dimensions and type on three winches — work wire, dead man wire. Possibility for the instructor to change wire set up during exercise and place objects, anchors and buoys on deck.	X	X		
2.4.2	The simulator shall include mathematical models of at least two semi submersible oil rigs operated by the instructor. It shall be possible to change: — crane positions — anchor patterns — anchor selection — crane ready with PCP (permanent chaser pennant) — anchors racked in bolster / anchor on sea bed — anchors to be laid by position latitude, longitude, or by instructor — rig to be set up with winches, each winch having a chain and an anchor — possibility to insert a wire in the system as to make the system consist of the anchor, connecting link and chain.	X	X		
2.4.3	The simulator shall include mathematical models of at least two tugs / assisting vessels) that can be connected in the anchor systems and/or at the towing bridle operated by the instructor.	X	X		
2.4.4	The forces from the environment (wind, current and waves) and forces acting on the anchor handling wire must act on the own ship.	X	X		
2.4.5	When breaking load is reached on a wire, the wire should break and be slack on deck and have no effect on the vessels model.	X	X		
2.4.6	When the handles of the winch is operated the winch must respond in a realistic way. It has to run with the speed corresponding to the handle settings, the load on the winch and brake settings.	X	X		
2.4.7	All values needed by the winch information system shall be calculated. The effect of band brakes, disc brakes and water brakes to be calculated. Holding power reduced due to increased diameter must be included in the calculations.	X	X		
2.4.8	The own ship control by instructor shall include control of winch operation, "shark jaws", "tuggers", towing pins/guide pins and capstans.	X	X		
2.4.9	Forces from the wires / chains that are acting on the "shark jaws", guide pins or stop pins shall have effect on vessel movement.	X	X		
Class S requirements will be dependant upon the type of simulated equipment and/or scenario, and the defined competence requirements.					

Table C3 Operating environment

Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
	Targets				
3.1.1	The simulator shall be able to present different types of target ships, each equipped with a mathematical model, which accounts for motion, drift and steering angles according to forces induced by current, wind or wave.	X	X	X	
3.1.2	The targets shall be equipped with navigational and signal - lights, shapes and sound signals, according to "rules of the road". The signals shall be individually controlled by the instructor, and the sound signals shall be directional and fade with range. Each ship shall have an aspect recognisable at a distance of 6 nautical miles in clear weather. A ship under way shall provide relevant bow- and stern wave.	X	X		
3.1.3	The simulator shall be equipped with targets enabling search and rescuing persons from the sea, assisting a ship in distress and responding to emergencies which arise in port. Such targets shall at least be: — rocket parachute flares — hand flares — buoyant smoke signals — SART (search and rescue transponder). — Satellite EPIRB (emergency position-indicating radio beacon). — Lifeboat — Liferaft — Rescue Helicopter — Rescue Aircraft — People in water.	X	X		
3.1.4	The simulator shall be able to present at least 100 target ships at the same time, where the instructor shall be able to programme 20 voyage routes for each target ship individually. (see STCW Section A-1/12.4.3)	X	X	X	
	Outside view				
3.1.5	The simulator shall provide a realistic visual scenario by day, dusk or by night, including variable meteorological visibility, changing in time. It shall be possible to create a range of visual conditions, from dense fog to clear conditions.	X	X		
3.1.6	The visual system and/or a motion platform shall replicate movements of own ship according to 6 degrees of freedom.	X			
3.1.7	The view shall be updated with a frequency of at least 30 Hz measured in a typical visual scene for the intended exercises and have an angular resolution of ≤ 2.5 arc minutes.	X	X		
3.1.8	The projection of the view shall be placed at such a distance and in such a manner from the bridge windows that accurate visual bearings may be taken to objects in the scene. It shall be possible to use binocular systems for observations.	X			
3.1.9	The visual system shall present the outside world by a view around the horizon (360 degrees). The horizontal field of view may be obtained by a view of at least 240 degrees and where the rest of the horizon may be panned (to move the "camera").	X			
3.1.10	The visual system shall present a vertical view from the workstations for navigation, traffic surveillance and manoeuvring enabling the navigator to detect and monitor objects visually on the sea surface up to the horizon within the required horizontal field of view when the ship is pitching and rolling. In addition by any method, it shall be possible to observe the ship's side and the dock during mooring operations.	X	X		
3.1.11	The visual system shall present the outside world by a view of at least 120 degrees horizontal field of view. In addition, at least the horizon from 120 degrees port to 120 degrees starboard must be able to be visualised by any method.		X		
3.1.12	The visual system shall present all navigational marks according to charts used.	X	X		
3.1.13	The visual system shall show objects with sufficient realism (detailed enough to be recognised as in real life).	X	X		
3.1.14	The visual system shall show mooring and towing lines with sufficient realism in accordance with the forces effecting the tension.	X			

Table C3 Operating environment (Continued)

Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
3.1.15	The visual system shall provide a realistic set of bow wave, sea spray and wakes in accordance with ships power output, speed and weather conditions.	X	X		
3.1.16	The visual system shall provide a realistic set of flue gas emission and "Waving Flag Effect" in accordance with ships power output, speed and weather conditions.	X			
	Outside sound				
3.1.17	The simulator shall be capable of providing environmental sound according to conditions simulated.	X			
	Navigated waters				
3.1.18	The navigated waters shall include a current pattern, changeable in time, according to the charts used. Tidal waters shall be reflected.	X	X	X	
3.1.19	The simulation shall include the depth according to charts used, reflecting water level according to tidal water situation.	X	X	X	
3.1.20	The simulator shall provide at least two different wave spectra, variable in direction height and period.	X	X		
3.1.21	The visual system shall provide a realistic set of wind waves including white caps according to the Beaufort Wind Force Scale.	X	X		
	3.2 Additional requirements for simulators intended for training in ice navigation (Ref. STCW Section B-V/g Guidance regarding training of masters and officers for ships operating in polar waters)				
3.2.1	The visual system shall be capable of showing concentrations of solid and broken ice of different thickness.	X	X		
3.2.2	The visual system shall be capable of showing the result of icebreaking including opening, twin breaking and compacting channel.	X	X		
3.2.3	The visual system shall be capable of showing the effects of searchlight.	X	X		
3.2.4	The visual system shall be capable of showing the effects of the ice accretion to the own ship model.	X	X		
	3.3 Additional requirements for simulators intended for training on Integrated Bridge Systems including Integrated Navigation System				
3.3.1	The view of the sea surface from the navigating and manoeuvring workstation should not be obscured by more than two ship lengths or 500 m, whichever is less, forward of the bow to 10° on either side under all conditions of draught, trim and deck cargo.	X	X		
3.3.2	There should be a field of view around the vessel of 360° obtained by an observer moving within the confines of the wheelhouse or may be panned (to move the "camera").	X	X		
3.3.3	The horizontal field of view from the navigating and manoeuvring workstation should extend over an arc of not less than 225°, that is from right ahead to not less than 22.5°, abaft the beam on either side of the ship.	X	X		
3.3.4	From the monitoring workstation, the field of view should extend at least over an arc from 90° on the port bow, through forward, to 22.5° abaft the beam on starboard.	X	X		
3.3.5	From each bridge wing the horizontal field of view should extend over an arc at least 225°, that is at least 45° on the opposite bow through right ahead and then from right ahead to right astern through 180° on the same side of the ship.	X	X		
3.3.6	From the main steering position (workstation for manual steering) the horizontal field of view should extend over an arc from right ahead to at least 60° on each side of the ship.	X	X		
	3.4 Additional requirements for simulators intended for training in Anchor Handling operations (Ref. STCW Section B-V/e, Offshore supply vessels performing anchor-handling operations)				
3.4.1	The anchors shall be movable on deck by use of "tugger" and capstan winches. Anchors to be connected / disconnect to chain, or wires on deck.	X	X		

Table C3 Operating environment (Continued)					
Item	*Requirement*	*Class A (NAV)*	*Class B (NAV)*	*Class C (NAV)*	*Class S (NAV)*
3.4.2	Anchors of types commonly used should be available. At least 2 different types should be available. This could be: — stewpris — stewmanta — bruce — dennla — torpedo.	X	X		
3.4.3	"shackles/ connections commonly used should be available. This could be: — shackle — pear link — kenter link — detachable link — swivel.	X	X		
3.4.4	The Shark Jaws, the wire lifter, guide pins and stop pins shall be visible and show the movement when operated. When raised the Shark Jaws, the wire lifter, guide pins and stop pins shall affect the wire.	X	X		
3.4.5	Wire and chain shall bend around objects such as wire guides.	X	X		
3.4.6	When the vessel is chasing an anchor the wire or chain must jump as the wire passes over chain links.	X	X		
3.4.7	Slack wire and chain shall be shown as slack. Any tension should make the wire lift from the deck, indicating a catenary curve.	X	X		
3.4.8	When breaking load is reached on a wire or chain, they should break and be slack on deck.	X	X		
3.4.9	Capstan winches shall be situated on aft deck, one on the port and one on the starboard side. On the capstan a wire should be used as dead man wire.	X	X		
3.4.10	"Tugger" winches shall be situated forward on deck, one port and one starboard side. On the "tugger" a wire should be used as dead man wire.	X	X		
3.4.11	It shall be possible to command and view the deck crew to prepare the capstan /"tugger" wire. This action can be controlled by the instructor. The capstan and "tugger" wires should have the possibility to be connected to all main winches and gipsy wheels and also to be laid ready on deck on predefined positions.	X	X		
3.4.12	It shall be possible for the instructor to control the anchor handling winch of the helper station vessel (target or own ship) including the ability to adjust speed on winch, pay out and haul in.	X	X		
Class S requirements will be dependant upon the type of simulated equipment and/or scenario, and the defined competence requirements.					

Appendix B: Example of assessment sheet

No.	Task	Object	Elemental Technique	Assessing item	+1	0	-1	Score
1	<General>							
	Positioning		Positioning	Positioning every 15 min.	attained	lacked		
	Recognition on		Positioning/planning	Recognizing current effect and correct course	attained	lacked		
	situation	FB	Lookout	Detecting objects in the proper way	attained	lacked		
2	<Alt. Course>		Manoeuvring	Handling the ship in accordance with the Guidelines	attained	lacked		
	Manoeuvring		Positioning	Positioning after altering course	attained	lacked		
	Positioning		Positioning/manoeuvring	Correcting course if deviating	attained	lacked		
3	<Ship crossing>		Lookout	Detecting objects in the proper way	dist>5'	5'-3'	3'>dist	
	Recognition		Rules of the Road	Performance based on Rules of the Road	attained	lacked	missed	
	Stand on		Lookout/communication	Understanding intention of applying VHF or horn	attained	lacked		
	VHF	#17	Communication	Making initial contact	attained	lacked		
			Communication	Applying IMO standard marine communication phrases	attained	lacked		
	Avoid Collision		Lookout/manoeuvring	Time to start collision avoidance	dist>3'	3'-1'	1'>dist	
			Lookout/manoeuvring	Distance at CPA is proper	dcpa>1'	1'-0.5'	0.5>dcpa	
			Manoeuvring	Handling the ship in accordance with the Guidelines	attained	lacked		
4	<Ship same way>		Lookout	Detecting objects in the proper way	dist>5'	5'-3'	3'>dist	
	Recognition		Rules of the Road	Performance based on Rules of the Road	attained	lacked	missed	
	VHF		Lookout/communication	Understanding intention of applying VHF or horn	attained	lacked		
		#8	Communication	Making initial contact	attained	lacked		
	Avoid collision		Communication	Applying IMO standard marine communication phrases	attained	lacked		
			Lookout/manoeuvring	Time to start collision avoidance	dist>3'	3'-1'	1'>dist	
			Lookout/manoeuvring	Distance at CPA is proper	dcpa>1'	1'-0.5'	0.5>dcpa	
			Manoeuvring	Handling the ship in accordance with the Guidelines	attained	lacked		
5	<Vessel end on>		Lookout	Detecting objects in the proper way	dist>5'	5'-3'	3'>dist	
	Recognition		Rules of the Road	Performance based on Rules of the Road	attained	lacked	missed	
	VHF		Lookout/communication	Understand the intention applying VHF or Horn	attained	lacked		
		#15	Communication	Making initial contact	attained	lacked		
		#8	Communication	Applying IMO standard marine communication phrases	attained	lacked		
	Avoid collision		Lookout/manoeuvring	Time to start collision avoidance	dist>3'	3'-1'	1'>dist	
			Lookout/manoeuvring	Distance at CPA is proper	dcpa>1'	1'-0.5'	0.5>dcpa	
			Manoeuvring	Handling the ship in accordance with the Guidelines	attained	lacked	missed	
6	<Report to Capt.>		Positioning	Confirm distance to reporting position to Captain	attained	lacked		
			Communication	Inform Captain at defined position	attained	lacked	missed	
			Lookout/communication	Report surrounding situation to Captain	attained	lacked		

Appendix C: Estimates of Global Marine Simulator Types
(As at1September 2001)

	Number
Simulators with a visual ship manoeuvring capability	140
Radar and Radar Navigation	>350
Engine room	>100
Navigation Instrument	60
Cargo & ballast control	l 50
Fisheries	35
GMDSS	>300
Oil Spill Management Trainer	5
VTS 10	
High Speed Craft	5
Riverboat	3
	Total 1058

Source: Muirhead 2001

Appendix D: Survey of shiphandling simulators 1967-2001 shiphandling/navigation simulators (with a visual capability)

No	Name and Location	Year	Type	Manufacturer
1	SSPA, Goteborg, Sweden		CGL/TV	SSST
2	SMS, TNO-Delft, Netherlands		Shadowgraph	IWECO-INO
3	MARIN, Wageningen, N'Lands		Shadowgraph	IWECO-INO
4	SSS, Hiroshima Uni, Japan		Slide/CGI	University
5	Bremen Poly, W.Gerrnany		Slide projectn	VFW-Fokker
6	IHI, Tokyo, Japan	1 975/92	Slide/CGI	IHI/NAC 2
7	SHS, Osaka Uni, Japan	1975	Shadowgraph	University
8	Navy, DenHelder, Netherlands	1975	Nocturnal	Navy
9	TNO-Soesterberg, Netherlands	1 976	Modelboard	TNO
10	CAORF. K.Pt, New York, USA	1976	CGI	Sperry
11	Marine Safety Int, NY,USA	1976	Modelboard	Sperry
12	MARI'N, Wageningen, Nethlarids	1976	Nocturnal	TNO
13	Warsash College, S'Ton, UK	1977	Nocturnal	Decca 3
14	TUMM, Tokyo, Japan	1978/83	Shadow/CGI	NAC/Uni 4
15	Bremen Poly, W.Germany	1978	Nocturnal	VFW-Fokker
16	Mitsubishi, Nagasaki, Japan	1978	Slide Projectn	MHI
17	Ship Analytics. N.Stonington,USA	1979	CGI Ship	Analytics
18	SMS Trondheim, Norway	1979/95	Nocturnal/CGI VFW	Norcont
19	Danish Mar.Inst, Lingby,	1980	CGIJTV	DM1
20	Warsash College, STon, UK	1981	Nocturnal	Decca
21	MITAGS, Baltimore, USA	1981	Nocturnal (2) VFW-	Fokker
22	Shipsim, S.Shields College, UK	1982	Nocturnal	Decca
23	CASSIM, UWIST Cardiff Wales	1982	CGllTepigen	Marconi 5
24	SUSAN, Hamburg, W.Germany	1982/97	CGI	Krupp Atlas
25	Shipsim, Glasgow, Scotland	1982	Nocturnal	Decca
26	SMS, Trondheim, Norway	1 982	Slide Projectn	VFW-Fok,ker
27	RSSC, Leningrad, USSR	1983	Nocturnal	Norcontrol
28	Mann, Wageningen, Netherlands	1983	CGllGraphic	TNO
29	Toledo, Ohio, USA	1983	CGI Ship	Analytics
30	USAAEWES, Vicksburg, USA	1983	CGI	USAEWES
31	Flanders Hydraulics, Belgium	1984	CGI	MSCN/Sindel
32	Navy, Sydney, Australia	1985	CGI	Krupp Atlas
33	AMC, Launceston, Australia	1985	CGI	Krupp Atlas
34	TUMM, Kobe, Japan	1985	CGI	na
35	Taiwan Maritime College, Taiwan	1985	CGI	Krupp Atlas
36	Piney Point, Maryland, USA	1985	CGI	Ship Analyti
37	USCG, New London, Ct, USA	1985	CGI	Ship Analytics
38	Finsim, Espoo, Finland	1986	CGI (2)	Racal/Mconi
39	MTC, Ashiya, Japan	1986	CGI	MTC
40	Navy, Kiel, W.Gerrnany	1987	CGI	Krupp Atlas
41	Plymouth Polytechnic, UK	1987	CGJ	Racal/Decca
42	Ship. Res. lnst, Tokyo, Japan	1988	CGI	na
43	Korean Mar. TI. Pusan,Korea	1988	CGI	Norcontrol
44	FETI Vladivostok Russia	1989	CGI	Norcontrol
45	Petropavlovsk Russia	1989	CGI	Norcontrol
46	Instituto Osservatori Genoa	1989	CGI	Sindel
47	Nova Scotia Nautical Inst. Canada	1989	CGI	Norcontrol
48	ENMM St Malo France	1989	CGI	NorcontlThom
49	Sakhalin Shipping Co Russia'	1989	CGI	Norcontrol

50	Chabahar Iran	1989	CGI	Norcontrol
51	Bulgarian MTI, Bulgaria	1990	CGI	Norcontrol
52	Haugesund Mar.College Norway	1990	CGI	Norcontrol
53	NIOC Teheran Iran	1990	CGI	Norcontrol
54	Danube Shipping Co, USSR	1990	CGI	Norcontrol
55	Danish Mar.Inst,Lyngby,Dmark	1990	CGI	Norcontrol
56	KMTRC Korea	1990	CGI	Ship Analytics
57	Inst. Tecnico Nautico Venezia,It	1990	CGI	Sindel
58	Kesen Inst. Piraeus,Greece	1990	CGI	Sindel
59	Sakhalin Ship Co. Russia	1991	CGI	Norcontrol
60	State Uni NY	1992	CGI’	Norcontrol
61	Seamans Ch. Inst, New York, USA	1992	CGI(2)	Norcontrol
62	MSCN, Wageningen, Netherlands	1992	CGI	MSCN
63	Marine Inst, Newfoundland, Can	1992	CGI	Norcontrol
64	Vestfold Poly,Tonsberg, Norway	1992	CGI	Norcontrol
65	World Trade Centre,Singapore	1992	CGI	Norcontrol
66	Indian Navy Bombay	1992	CGI	Ship Analytics
67	Kotha,Finland	1992	CGI	Sindel
68	SMS Trondheim Norway	1992	CGI	Norcontrol
69	Britannia RNC UK	1992	CGJ	Norcontrol
70	Maine Maritime Academy USA	1992	CGI (2)	Norcontrol
71	Inst.Tecnico Nautico, Palerrno, It	1992	CGI	Sindel
72	Kotka Inst.Naut Studies,Finland	1992	CGI	Sindel
73	Yusen Marine Sc. Tokyo, Japan	1992	CGI	Yusen
74	CEDEX, Madrid, Spain	1992	CGI	MSCN
75	Kalrnar Marine Academy, Sweden	1993	CGI	Norcontrol
76	NizhnyNovgorod Russia	1993	CGI	Norcontrol
77	Far Eastern TI. Vladivostok	1993	CGI	Norcontrol
78	Mariehamn Finland	1993	CGI	Norcontrol
79	STC Sydney Australia	1993	CGI	Norcontrol
80	Port of Singapore, Singapore	1993	CGI	Ship Analytics
81	State Uni.St Petersburg,Russia	1993	CGI	Sindel
82	Southampton Inst.H.E, UK	1993	CGI	Norcontrol
83	W.Japan Dynam Inst, Sasebo,Japan	1993	CGI	na
84	Star Centre Dania,Florida USA	1993	CGI (2)	Norcontrol
85	MSTC Terschelling,Netherlands	1993	CGI	MSCN
86	SMS Trondheim	1993	CGI	Norcontrol
87	FMSS Navy, Brazil	1993	CGI	Ship Analytics
88	Panama Canal Commission,Panama	1993	CGI	Ship Analytics
89	Tromso College Norway	1993	CGI	Norcontrol
90	STAR Toledo, Ohio USA	1993	CGI	Norcontrol
91	KRISO, Taejon, Korea	1993	CGI	KRISO
92	IHI High Speed,Tokyo,Japan	1993	CGI	IHI
93	IHI Compact,Tokyo, Japan	1994	CGI	IHI
94	WSM Szczecin Poland	1994	CGI	Norconrtol

95	PDV Marine Venezuela	1994		Norcontro]
96	MSR Rotterdam	1994	CGI (2)	MSI
97	TLlrkish Navy	1994	CGI	Ship Analytics
98	HMS Dryad Portsmouth UK	1994	CGI	Norcontrol
99	West Coast STAR Seattle,USA	1994	CGI(2)	Norcontrol
100	US Navy, San Diego	1994	CGI (2)	MSI
101	Bombay, India	1994	CGI	Ishikawajimi
102	R.T.Navy, Thailand	1994	CGI	STN Atlas
103	Volgo Tanker Company Russia	1994	COl	Norcontrol
104	CCG,Sydney NS,Canada	1994	CGI	Norcontrol
105	Danish Mar.Inst, Denmark	1994	CGI	NorcontDMl
106	RNN, Den Helder,Netherlands	1994	CGI	MSCN
107	Marconi, Genova,Italy	1994	CGI	Sindel
108	Nautical Sch. Palerrno, Italy	1994	CGI	Sindel
109	Singapore Water Police	1995	CGI	STN Atlas
110	Gijon, Spain	1995	CGI	Norcontrol
111	TNCMT, Toyama, Japan	1995	CGI	AME
112	TAMU, Galveston, Texas,USA	1995	CGI	ShipAnl/TMO
113	SNSS Texas A&M, USA	1995	CGI	Ship Analytics
114	Svendborg Nav.Sch,Denrnark	1995	CGI	Norcontrol
115	Sydney Tech.Coll, NSW,Australia	1995	CGI	Norcontrol
116	Singapore Police, Singapore	1995	CGI	Ship Analy
117	AMTA,Alexandria,Egypt	1996	CGI	Ship Analytics
118	Turku Mar.Inst	1996	CGI	Sindel
119	Navy, Chittagong, Bangledesh	1996	CGI	Sindel
120	Sticheting Coll, Rotterdam, Holland	1996	CGI	Norcontrol
121	DMI,Lyngby, Denmark	1996	CGI	Norcontrol
122	Hogskole, Alesund, Norway	1996	CGJ	Norcontrol
123	Suez Canal Authority, Egypt	1996	CGI	Norcontrol
124	ENMM, Nantes. France	1996	CGI	Norcontrol
125	CIAGA/CIABA, Brazil	1996	CGI	Ship Analy
126	SCANTS, USCGA, New London	1996	CGI	Ship Analy
127	Taiyo Electric, Yokyo, Japan	1996	CGI	Norcontrol
128	M.O.Consulting, Hiroshima,Japan	1996	CGI	MO Consult
129	NAROV Curacao, N.Antilles	1996	CGI	Norcontrol
130	Navy, Victoria, BC, Canada	1997	CGI	Norcontrol
131	Kobe M.U, Kobe, Japan	1997	CGI	Norcontrol
132	Navy, Brest, France	1997	CGI	Norcontrol
133	Navy, Sydney, Australia	1997	CGI	Norcontrol
134	USCGA, New London,USA	1997	CGI	Ship Analy
135	SOS AMC Tasmania Australia	1997	CGI	STN Atlas
136	SUSAN, ISSUS, Hamburg	1997	CGI	STN Atlas 0
137	Seamans CI: Inland Waters Paducah	1997	CGI	W Norcontrol
138	S.Shields Marine College UK	1998	CGI	Norcontrol

139	HMS Dryad, Portsmouth UK	1 998	CGI	Norcontrol
140	Massachusets Mar.Academy USA	1998	CGI	Adv.Mar.Ent
141	Warnernunde MSC Rostock Ger.	1998	CGI	STN Atlas
142	Italian Navy Livorno	1998	CGI	STN Atlas/Sindel
143	Norwegian Navy Bergen Norway	1998	CGI	STN Atlas
144	US Centre for ME Kentucky USA	1999	CGI	Norcontrol
145	Glasgow CNS	2000	CGI	Transas
146	Liverpool Lairdside Mar.Centre	2000	CGI	KMSS
147	Star Cruise Port Klang	2000	CGI	STN Atlas
148	OOCL Zhoushan China	2000	CGI	Transas
149	Tromso Maritime Polytechnic	2001	CGI	Poseidon
150	Naval Academy Vama Bulgaria	2001	CGI	Transas
151	Star Centre (Diesel Elec)	2002	CGI	KMSS
152	Alaska Vocational Training Centre	2002 S	CGI	KIvIS

Source: Muirhead 2001