JOURNAL OF MARITIME RESEARCH

Vol. IX. No. 3 (2012), pp. 3 - 10

ISSN: 1697-4840 www.jmr.unican.es

Simulation-Based Team Training for Maritime Safety and Security

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ARTICLE INFO

Article history:
Received 02 June 2012;
in revised form 04 June 2012;
accepted 30 July 2012

Keywords:
Maritime Education and Training, Simulation Exercise, Maritime Safety and Security

ABSTRACT

Emergency Response, Crew Resource and Crisis Management are some of the most important parts in maritime education and training. The STCW Manila Amendments set into force on 1st January 2012 reflect that there is a major priority to train ship's officers and crew with sufficient skills and appropriate procedures which can provide adequate protection and ensure the safety of all passengers and crew especially on ferries and cruise ships. The best way to achieve experience and to gain corresponding skills are practice runs on specially designed simulators which realistically represent the complex shipboard conditions on such vessels after emergency alerts. This paper introduces the basic concept of a safety and security training simulator and describes research work related to the implementation of training scenarios. Selected results of a case study will be presented. A shorter version of this paper (Baldauf, Nolte-Schuster et al., 2012) was presented at the International Conference "Maritime Transport V" in Barcelona in June 2012 and is extended and substantially reviewed.

1. Introduction

Emergency Response, Crew Resource and Crisis Management are one of the most important parts in maritime education and training of nautical officers and engineers. The STCW Manila Amendments coming into force on 1st January 2012 (IMO, 1993, IMO, 1996 and IMO, 2010) reflect that there is a major priority to train ship's officers and crew with sufficient skills and appropriate procedures which can provide adequate protection and ensure the safety of all passengers and crew especially on ferries and cruise ships (Martínez M. 2009). The best way to achieve experience and to gain corresponding skills are practice runs on specially designed simulators which realistically represent the complex shipboard conditions on such vessels after emergency alerts.

Simulators are well recognized as beneficial for ship handling training in real time on well equipped bridges. A new type of simulator was developed for training and research specific aspects of Maritime Safety and Security. Apart from existing regulations as e.g. SOLAS, STCW, ISM, ISPS etc. it is essential to adopt a permanent process of change and development with regard to new precautionary measures to ensure the safety of ship operation and to be prepared in case a hazard occurs on board vessels. Training of human mentality and motivation is vital to create a permanent underlying safety culture.

In his research work World Maritime University's Maritime Risk and System Safety (MaRiSa) research group on is dealing with the development, implementation and integration of simulation-based modules into training units and course schemes. With its new simulation laboratory providing a combined Ship Handling and a Safety and Security Simulator enhanced test facilities are available. The safety and security training simulator allows for 3D visualization of ship spaces. This simulator, certified by Det Norske Veritas, is a procedure trainer and enables officers and crew to move around inside the vessel using safety equipment and available emergency systems on board which can be activated by interactive consoles on bridge or engine control room (Bornhorst, 2011 and Benedict & Felsenstein et al., 2011). In cooperation with the Wismar University's Maritime Simulation Centre in Rostock training concepts and scenarios are developed and tested for training on basic, advance or management level. Functional tests of the developed system are

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running successfully and first practice courses have been carried out. Preliminary studies on user acceptance have shown good results. The new and enhanced simulation laboratory allows also for a wide range of scientific studies. The effects of safety and security plans and planned procedures on board can be tested in a simulation environment and enable more detailed evaluation of their effectiveness under varying conditions and during different courses of events by a different series of simulation runs.

This paper introduces the basic concept of a safety and security training simulator and describes the research work related to the learning objective oriented development of a training scenario. Selected results of a case study will be presented.

2. Enhanced soft- and hardware for integrated simulation exercises

Although there are existing international regulations – as e.g. SOLAS, STCW (including the Manila Amendments), ISM, and ISPS - it is useful and necessary to apply a permanent process of correction and development with regard to improving safety and security precautionary measures both in port as well as on board. This also includes a constant review of training methods. Training is vital for creating a permanent high level of safety and security awareness on board to guard against human complacency on duty and to better motivate ships' crews.

Specifically for such training but also for research purposes a new type of simulator has been developed. Among others, the conceptual implementation of the enhanced simulation system is characterized by 3D visualization design. The enhanced simulator was originally developed by manufacturer Rheinmetall Defence Electronic Bremen in collaboration with the Maritime Simulation Centre Warnemuende (MSCW) of Hochschule Wismar in the frame of a funded research project (Felsenstein & Benedict at al, 2009). Recently such a safety and security training simulator (SST) is also established in the Maritime Simulation Laboratory of MaRiSa research group at World Maritime University, Malmö (Sweden).

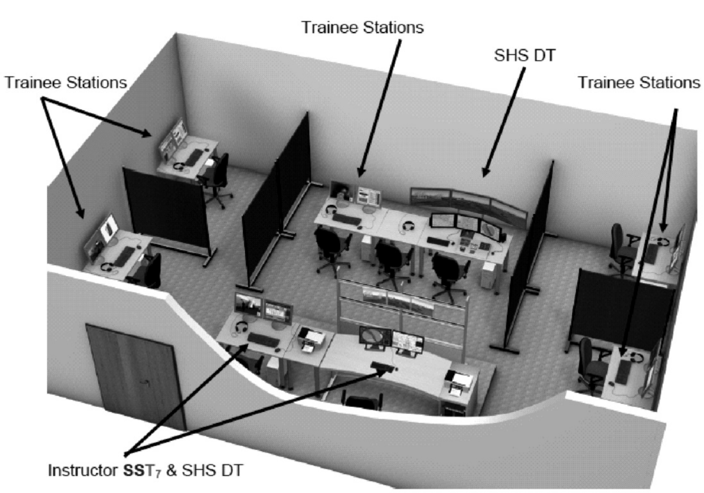

Figure 1: Configuration of the combined Ship-handling and Safety and Security Training Simulator

As a particular unique feature of WMU's system outline the SST is combined with a Ship-handling simulator. This configuration allows for a wide range of applying simulation in MET, including complex team training of safety related scenarios. The combined simulator will also be used for research, e.g. for more detailed in-depth study of the effectiveness of safety and security plans and procedures on board or more profound evaluation and scientific investigation of their efficiency under different conditions and during varying courses of events that can be generated in individually created simulation runs.

However, while having available more and more sophisticated simulators with various facilities and its technical options it becomes more and more important to thoroughly consider the processes of the accumulation of knowledge in general and to ensure effective learning. In this regard the learning environment is mainly structured by means of multimedia which itself can be seen as a different and challenging approach for learning, especially compared to the rather conventional and "traditional" methods. Therefore and in order to define the design and control functionalities of any simulation platform, it might be useful and necessary to sum up the main aspects of the related substructure. With regard to the computer simulation the next chapter is to look at the cognitive aspects of the underlying methodology.

3. A systematic approach to develop training scenarios

From spotlight reviews it is known that even today, the most common method in use for the development of simulation exercises is event driven. Very often scenarios of real accidents or near-misses (mostly experienced by one of the instructors) are implemented in order to discuss what mistakenly has been done or just gone wrong, which failures happened and should be trained to avoid by trainees in such reconstructed scenarios. In the same way as sometimes engineering is driven by the identification of a specific lack or failure that lead to the development of a new technical device or another additional sophisticated safety system, it is expected that accidents of such type will never happen again. But, despite new technical systems, despite new rule and regulations and despite more and more realistic simulation systems, unfortunately, accidents still occur. Having this in mind it is assumed, that the approach of event-driven design of training scenarios is not yet effective enough.

Therefore and as a consequence of thorough studies into learning theories (as e.g. Atkinson & Shiffrin, (1968) and Sweller (1988)) it seems to be more appropriate to focus on the learning objective-oriented simulation and its specific scale as a tool for maritime education and training. With view to the increasing number of sophisticated simulators with various facilities and technical options, it becomes obvious that simulators technically provide wide-ranged options for increased learning effectiveness. However, the process of a trainee's knowledge-accumulation has to be taken into account when implementing training scenarios. Especially educational potential of the simulation platform design and its control functionalities has to be identified accordingly. This can be realized when the event-driven scenario design is at least accompanied or even substituted by a learning-objective oriented development of training scenarios.

4. Learning objective oriented development of training scenarios

Based on a comprehensive literature survey (i.a. Carson-Jackson, 2010, de Jong, 1998, Kristiansen, 1995, but also Nikitakos & Sirris, 2011, Prasad, Baldauf & Nakazawa, 2011, and Rigaud et al., 2012) and further investigations into principles of development of scenarios for simulator training carried out by (Baldauf & Carlisle et al., 2011) a systematic approach for scenario development was described. The core elements of this approach basically developed in the frame of the MASSTER project (de Jong, 1998) are visualized in the following figure.

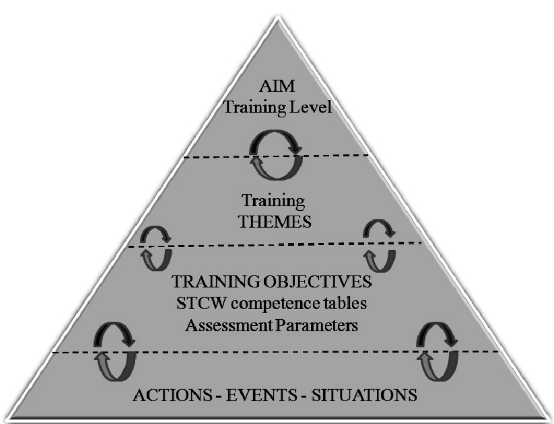

Figure 2: Principle layers and elements of scenario development process.

The four principle layers represent the main basic phases of the development process. Furthermore feedback arrows from the training objectives to the general training aim and from the sequence of events to the training objectives are depicted. Feedback between the different layers is essential for the efficient development of well adjusted training scenarios. The first feedback loop, covering AIM and THEMES, takes place between the simulator operator and the 'customer'. The following loops are the most important ones to be carried out by the training institutions. These loops are foreseen for consideration of the appropriateness of the sequence of events in relation to the training objectives within a specifically selected theme. It is seen that the training objective(s) should define the sequence and course of events of the scenario.

Because each and every simulation exercise is dedicated to fulfill a well defined goal, there is a compelling need to clearly define the general objective within a certain course program. They are dependent, among others, from the trainees' initial level of qualifications and skills and the required competencies to be reached.

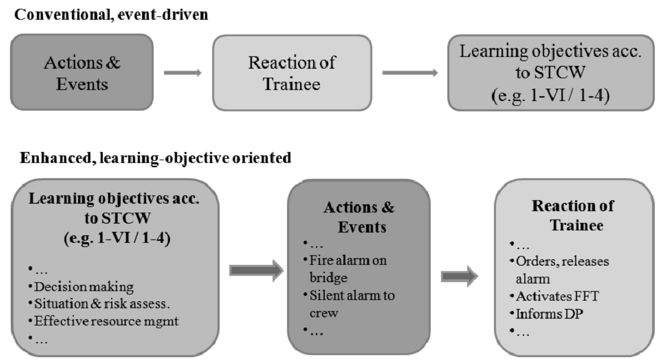

Figure 3: Basic steps for conventional and enhanced learning objective-oriented approach to scenario design.

From the general objectives several detailed objectives have to be derived. Finally, during the evaluation and assessment the trainees' performance will be mirrored and compared to the corresponding requirements.

5. Applying STCW competence-based training objectives

In this section the exemplary application of the sketched method will be explained by means of the STCW required learning objective "Crowd-management" with its relevant actions in case of evacuation. Evacuation has risen again to the top of discussed subjects after the "Costa Concordia" disaster (Schröder-Hinrichs, Hollnagel & Baldauf, 2012). Crowd management training is listed in STCW A- V/2 as a "*mandatory minimum requirement for the training and qualification of masters, officers, ratings and other personnel on passenger ships*". In the detailed description of the required competence for this subject, the STCW – Code firstly mentions "*the awareness of life-saving appliance and control plans, including*:

1. Knowledge of muster lists and emergency instructions,
2. Knowledge of the emergency exits,
3. Restrictions of the use of elevators.

As a competence of this STCW requirement the trainee should be able to assist passengers en route to muster and embarkation stations. On a more detailed level it is stated that the trainee should be able to:

1. *"Give clear reassuring orders,*
2. *Control the passengers in corridors, staircases and passageways, and*
3. *Maintain escape routes clear of obstructions".*

The further description of the required competences of the trainee mentions also the "*methods available for evacuation of disabled persons and needing special assistance*" and also the "*search of accommodation spaces*".

Finally the STCW- Code requires the knowledge of mustering procedures, which means more specifically that the trainee is able to "*use procedures for reducing and avoiding panic*". Generally he should be aware of the importance of keeping order and he should know how to use passenger list for evacuation counts. Overall the trainee should be able to ensure *"that the passengers are suitable clothed and have donned their lifejackets correctly".*

The implementation of the exemplarily mentioned learning objectives in a training scenario can be structured in different directions. With respect to available options of a particular training-platform it can be stated that the trainee e.g. can show a certain response by 'interaction' with avatars or he may give a spoken or written answer (alternatively reply to a multiple choice question or similar option as integrated) or any other option that might be appropriate to demonstrate knowledge and specific competence respectively. In general the response of the trainee might be internal and implemented in the scenario and then also modify the development and course of following events of the training scenario or it might be external by given answers as part of a direct assessment. After clear definition of the objectives, they can be implemented into either a dedicated scenario but also combined e.g. with a complex fire fighting scenario to provide realistic situational background. A potential exercise is summarized in the table 1.

Table 1: Draft framework for a suggested simulation training scenario

Draft sample exercise scenario	
Identifying number	**Shipboard Emergency Situation - FIRE -** response actions after fire detection by fire-alarm system on the bridge
Training objective(s)	• actions to be taken relating to co-ordination, conduction of search and rescue, actions to be taken by a ship in distress and by an assisting ship); distress signals; log-book entries • action in the event of fire; handle emergencies situations; radio distress traffic
Simulator tool	(Preferably) Full mission simulator – with integrated Safety & Security components
Standard of competence	Master and chief mate (management level) Chief and engineers
Configuration	RoRo-Passenger Ferry (L_{oa} > 200 m)
Traffic situation	Simple (e.g. only two or even just only one further ship in the scenario)
Environment	Coastal area, daylight, moderate wind & sea; no current, good visibility
Duration	Long, > 30 min
Event description	• fire-alarm system on the bridge is indicating fire in on car deck (e.g. Advisory System Ship's Safety - indicates smoke on car deck by an acoustical alarm and CCTV screen as well) • OOW starts alarming procedures; fire-fighting team to be equipped and instructed to investigate the situation and prepare for fire-fighting • FFT gets fire under control (or not – needs reinforcement) • Team leader informs the bridge all team members have left the deck and all doors and other apertures are closed, use of fire sprinkler system • simultaneously beginning preparation of evacuation preparing the system (communication with engine room) and releasing the system • temperature indicator indicates normal temperature on car deck • fire has been extinguished

6. From real situation to simulation-based training

During the studies and investigations performed to develop a systematic methodology for scenario design and control, comprehensive material (i.a. DMA, 2010, MAIB, 2011, Schröder, Baldauf & Ghirxi, 2011 and Ziarati, Ziarati & Acar, 2011) of a real fire onboard accident has been reviewed and analysed and a basic event chart (as it is used in accident investigations) has been drafted.

Based on such diagrams and further material gathered during field studies on board including the participation in real life fire-fighting drills, basic input was provided for the development of the detailed reference scenario (Baldauf & Carlisle et al., 2011). According to the learning objectives to be applied by the customer, decision points can be integrated to further develop the event chart and the simulation scenario accordingly.

As first step for drafting the reference scenario, an actors-and-action graph for the initial situation was developed. This graph visualises the specific events and conditions with the actors with an estimated timeline for the scenario script.

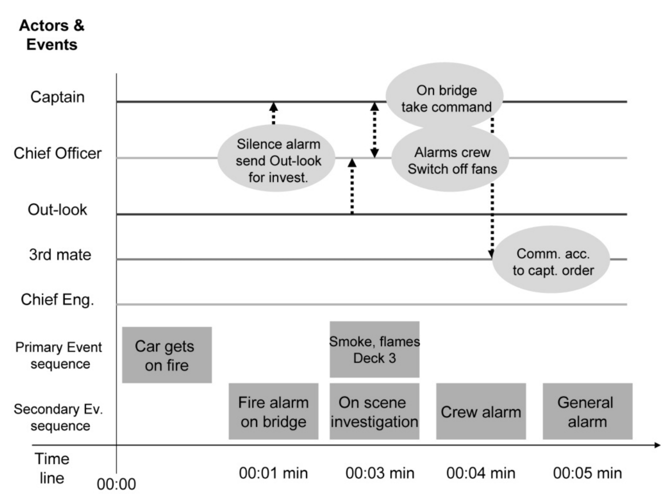

Figure 4: Actors-and-action graph of the reference scenario's initial situation.

Following this, the processes of action and communication were drafted (see next figures) for the main chain of events. In order to create foremost a general approach the potential activities as described in the ISM procedural listings are taken as the recommended actions. The action steps (for OOW on bridge) up to the point when the Master takes command of the vessel are described as "Call the Master", "Bring bridge to alert status", "Raise General alarm", "Obtain charted position" and at least "Proceed to fire station". When the Master takes the Command of the ship the following step is characterized by internal and external communication.

Action and communication processes for the complete scenario needs to be drafted and decision points, e.g., for fire-fighting tactics and crowd management, have carefully and reasonably to be integrated. An example is given in the figure below.

The exemplarily shown decisions, to be made at this point of the sequence of events and actions, are foremost linked to fire fighting tactics. The main aspect of this section therefore refers to gaining information of the various parts of the ship involved (cargo information, weather condition, ships plan, etc) and, according to these information the question how to follow up with organising the fire fighting.

The learning objectives can be set according to company specific rules and regulations of the ISM Code and further international regulations as e.g. SOLAS as relevant for the training scenario and the individual situation awareness of the trainee.

Based on the decisions made in this section and especially the decision if there is a need for evacuation and abandon the ship, the scenario should be followed up with the specific steps which are linked to the specific tactics, chosen as an alternative action.

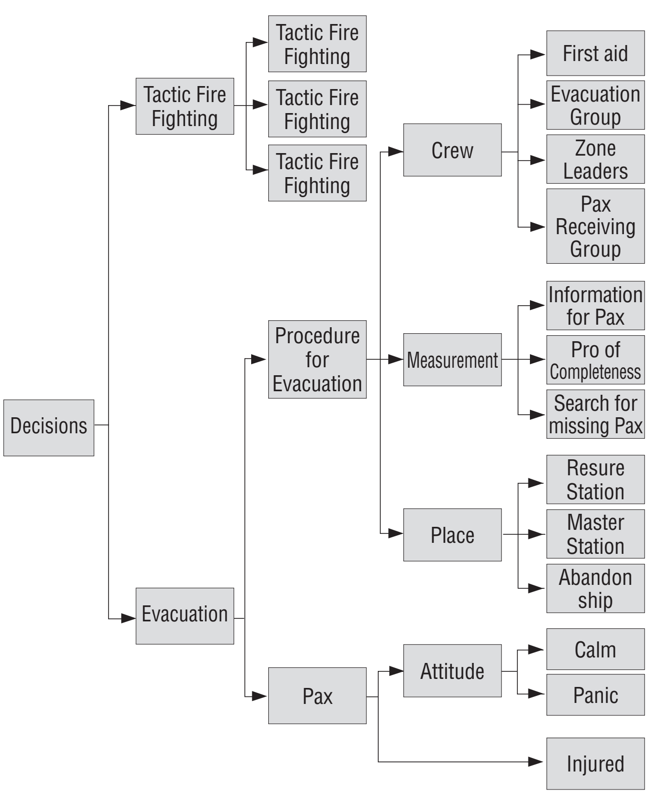

Figure 5: Integration of "Decision points" into a training scenario.

In principle, the working steps of the methodology can be applied to every individual scenario that a shipping company wishes to be trained.

As already mentioned, one of the main aspects when determining the general learning aims with its specific learning objective (according to STCW 95), is the difficulty that every course of action generates an adjusted response and in this meaning a different continuation of the planned and constructed scenario. The difficulty is to measure the appropriateness of the chosen course of action so it might be helpful to create some kind of standard reply patterns for some different scenario- options.

When considering the various aspects of the cognitive model of the learning process it has become obvious that it is either a bottom-up and top-down process of accumulating information and several steps are developing in an unrealized way. For first tests of the methodology and the potential of simulation-based team training the described emergency scenario was implemented in the simulation environment to be used as a basic training module of the MSc course programme at WMU.

Figure 6: Fire on car deck (SST snapshot) and situation assessment and decision making by the bridge team (left).

The students were briefed about the scenario in an extended familiarization session to support handling and controlling the simulations and to get a principle overview of the environment of the ferry implemented in the simulator. The training session was carried out two times in groups with different assignments of tasks, functions and positions of the students (each with mariners' background). The overall task to be performed was to detect a fire on the car deck and to organize and coordinate the fire-fighting on board according to the given generic emergency plan and ISM rules as well as to ensure efficient internal and external communication with all involved parties. The simulation sessions were assessed together with the students during the debriefing using recorded communication and live replay of the actions of the students. The focus of the simulation trials was to learn about the scenario and its potential for varying courses of events and actions. Shortcomings and lacks of the scenario should be identified as well as needed modifications and amendments.

The students were very much motivated and quickly assimilate the handling, controlling of the avatars in the environment. A very important item identified in these tests was that the number of students involved in such a complex exercise has to be carefully determined well in advance and especially take into consideration the capacities (technical capacities of the simulation system but also of monitoring by instructors and co-instructors). It became obvious that for the sake of monitoring and assessing the trainees' performance and behaviour in a simulation session there is a further and substantial need for suitable supporting tools.

7. Summary and conclusion

The Manila Amendments to the STCW Convention and Code require a bundle of new and challenging technical and non-technical skills. With regard to these challenges, state of the art simulation technologies offer a great variety of supporting facilities to meet the related needs for maritime education and training. Nevertheless the provision of high performance graphic visualisation and sophisticated process models and moreover elements of augmented reality by state of the art simulators should not hide the fact that the scientific verification of the learning effectiveness is still pending.

In its research work the MaRiSa research group at WMU in collaboration with the Institute of innovative ship simulation and maritime systems (ISSIMS) at Maritime Simulation Centre Rostock-Warnemuende of Hochschule Wismar develops a learning concept which combines in a novel approach the technique-technological options of modern simulation and the methodological needs for inert learning.

By working on a reference scenario "Fire on-board a RoRo-Pax-Ferry" which in its final stage leads to an evacuation situation including its specific challenges regarding communication, decision-making and leadership, the functional requirements and prerequisites as e.g. an appropriate number of trainees for a simulator training exercise is identified and the basically systematic for learning-objective related simulation could be laid.

Beside first optimistic results it has become obvious that the work on the evaluation of the efficiency of simulator training and its impact on the behaviour and the performance have to be continued.

Acknowledgements

The materials and results presented in this paper have been obtained partly in the research project "TeamSafety" performed under the 7th Framework Program of the European Union, funded by the EC and supervised by the Research Executive Agency. Further research related to the safety and security training simulator is carried out within the LEONARDO project METPROM. Finally, substantial part of the presented material was elaborated under the cooperating project VeSPerPLUS, performed under the Germany's Security Research Program funded by the German Federal Ministry of Research and Education and supervised by VDI Technologiezentrum GmbH, Projektträger Sicherheitsforschung.

References

Atkinson, R.C.; Shiffrin, R.M. (1968) Human memory: A proposed system and its control processes. In: Spence, K.W.; Spence, J.T. *The psychology of learning and motivation* (Volume 2). New York: Academic Press, 89–195.

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

Baldauf, M.; Nolte-Schuster, B.; Benedict, K.; Felsenstein, Ch. (2011) Maritime Safety and Security. Learning objective oriented development of simulation exercises. *Maritime Transport V – Technological, Innovation and Research*. Barcelona, pp 868-887.

Benedict, K.; Felsenstein, Ch.; Puls, O.; Baldauf, M. (2011) Simulation for Navigation Interfacing Ship Handling simulator with Safety & Security Trainer (SST). *Navigational Systems and Simulators*. pp 101-108, Taylor & Francis.

Bornhorst, C.: Safety and Security Trainer SST7 (2011) New Way to Prepare Crews Managing Emergency Situations. *Navigational Systems and Simulators.* pp 101-108, Taylor & Francis,

Carson-Jackson, J. (2010). *A Simulation Instructor's Handbook*. The Nautical Institute, London.

de Jong, J. (1998) EC Waterborne Transport Project 6.4.4 Task 46, *MASSTER*, Final Report, Issued by FSSH Hamburg.

DMA - Danish Maritime Authority (2010) *Pearl of Scandinavia Fire*. Danish Maritime Accident Investigation Board, Copenhagen.

Felsenstein, Ch., Benedict, K., Baldauf, M. (2009) Development of a Simulation Environment for Training and Research in Maritime Safety and Security. *Journal of Marine Technology and Environment*, Editura Nautica 3(2), pp. 77-89.

IMO (1993). *International management code for the safe operation of ships and for pollution prevention (International safety management (ISM) Code)*. IMO Document Res. A.741(18). IMO, London.

IMO (1996). *International Convention on Standards of Training, Certification and Watch keeping for Seafarers, 1978, as amended in 1995 (STCW Convention), and Seafarer's Training, Certification and Watch keeping Code* (STCW Code), International Maritime Organization (IMO), London.

IMO (2010). *The Manila Amendments to the annex to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)*, Manila.

Kristiansen, S. (1995). An approach to systematic learning from accidents. *The institute of Marine Engineers Conference Proceedings on Management and Operation of Ships – Practical Techniques for Today and Tomorrow (IMAS 95).* Volume 107, No. 2. London: The Institute of Marine Engineers

MAIB - Marine Accident Investigation Branch (2011) *Report on the investigation of the fire on the main vehicle deck of Commodore Clipper while on passage to Portsmouth 16 June 2010.* Southampton, November.

Martínez M. J.E. (2009) The security of the citizen's ports. *Journal of Maritime Research.* Volume 6, Issue 1, Pages 33-42.

Nikitakos, N., Sirris, I. (2011) Learning with 3D games. A framework for design and develop educational games in Maritime Education and Training. *The Digital Ship Magazine,* May.

Prasad, R.; Baldauf, M.; Nakazawa, T. (2011) Collaborative Learning for Professional Development of Shipboard Engineers. *International Journal of Engineering Science & Technology*, Vol. 3 Issue 3: 2308-2319

Rigaud, E.; Lützhöft, M.; Kircher, A. Schröder-Hinrichs, j.U.; Baldauf, M.; Jenvald, J.; Porathe, T. (2012) *Impact: More Than Maritime Risk Assessment.* Procedia - Social and Behavioral Sciences, Elsevier, Volume 48: 1848 – 1854.

Schröder-Hinrichs, J.-U.; Hollnagel, E.; Baldauf, M. (2012) From Titanic to Costa Concordia - a century of lessons not learned. *WMU Journal of Maritime Affairs*, Springer, Heidelberg, October, Vol. 11 (2): 151-167.

Schröder, J.-U., Baldauf, M., Ghirxi, T. K. (2011) Accident investigation reporting deficiencies related to organizational factors in machinery space fires and explosions. *Journal of Accident Analysis and Prevention*, 43(3) pp. 1186-1197.

Sweller, J. (1988) Cognitive load during problem solving: Effects on learning. *Cognitive Science* 12 (2): 257-285. doi:10.1016/0364-0213(88)90023-7.

Ziarati, R.; Ziarati, M.; Acar, U. (2011) *Developing Scenarios Based on Real Emergency Situations*. IMLA 19, Opatija 2011.