Sea Service Equivalency For Full Mission Simulator Training

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ABSTRACT
The STCW 95 imposed a compulsory 12/6-month sea time service for deck/engineer cadets in order to be certified as Third Officers. All Maritime Authorities embraced this provision and put this stipulation in practice with no exceptions.

Computer technology and software capabilities have advanced 50 times over the state of art in 1995. This means that up-to-date full mission simulators can now (re)produce reality at least 15 to 20 times better than in 1995. As presented in the paper, the simulated bridges can include all modern navigation technologies; simulate all types of navigation conditions, breakdowns, emergencies, maritime areas and maneuvering situations.

On the other hand, the number of national flag vessels has decreased constantly, and year after year it is harder and harder to find owners willing to accept cadets on board their ships and able to organize an effective onboard training program.

We believe that the entire maritime academic community must begin sustained and focused actions to promote the official acceptance of simulator training as an equivalent for sea time service. A first step in this direction was already made by the United States Coast Guard (USCG), which grants a 1:6 ratio equivalency. IAMU has the power and duty to present such a point of view at the international level.

1. Introduction

Following the example of the aeronautic industry, the shipping industry made its first steps regarding maritime simulators in the early 80s. At that time, all the navigation equipment used for simulation was real equipment electrical and mechanical interconnected. The visual scene was very difficult to create and the movement of the ship was generated by mobile platforms. These two components entailed a lot of expensive equipment and space. Practically speaking, the owner of such a simulator first had to build a building large enough to accommodate the ship handling simulator components.

Consequently the costs were very high (millions of dollars) and no public or private maritime education institution could afford such an investment. Between 1980 and 1990, worldwide there were only a few ship handling simulation centers.

In the maritime education system, practical training was mainly based on training voyages onboard training ships owned by the maritime schools. At that time, the management and maintenance of a ship, even for a long period of time, was cheaper than a simulator. As a result, most of the maritime education institutions had their own training ship.

After 1990, this situation changed rapidly and dramatically under the pressure of three main factors:

- exponential development of computer capabilities;
- widespread usage of the Windows operation system;
- international regulation and constraints regarding ships' technical and personnel standards.

The first two factors lowered the maritime simulators price and increased their capabilities and performances. The third factor raised the

running cost for training ship maintenance and implied substantial investments in new equipment, ship and crew management.

In addition, the STCW 95 provisions made compulsory the training of deck officers on radar simulators and underlined the importance of training using full mission simulators.

Statistics show that after 1995, the number of maritime simulators purchased by maritime education institutions increased rapidly and the number of traditional training ships decreased year after year.

2. State of art configuration for navigation simulators

From the beginning we have to underline that, in accordance with STCW requirements, the navigation training based on simulation is divided into two main parts:

- radar navigation and use of radar and ARPA;
- ship handling and bridge team management.

Starting from these training aspects, the navigation simulator market offers two main types of products:

- radar simulators;
- full mission ship handling simulators (FMSHS), also known as full mission bridge simulators (FMBS).

After 1997, simulator manufacturers used computer technology on a large scale in order to create virtual navigation equipment and ship handling controls. The main reason for this policy was the reduction of the price for the simulator systems and an easier way to reproduce all the parameters of the ships equipment using fully dedicated software. A combination of real equipment and virtual equipment remained an option for the buyer, but the actual trend is limitation of the real equipment to the steering console and auxiliary panels. This trend is also justified by the new generation of real ships with integrated bridge systems (IBS), where PCs, trackballs, keyboards and monitors replaced many of the traditional knob and push button panels.

Because the number of ships using IBS is still limited, there are many voices among students, deck officers and even instructors, who believe that a good bridge simulator must be a close copy of a traditional merchant ship bridge.

Today, from the manufacturer's point of view, a radar simulator is the cheapest version of a full mission bridge simulator, because, technically speaking, the major difference between these two simulators consists in the visualization system. In other words, a radar simulator with a visualization and projection system could be converted in a full bridge simulator, because the software that generates all the other main tasks is the same. Another important difference between these simulators consists in the complexity of the mathematical model used to generate the ship motion. Most manufacturers offer radar simulators with a three-degree of freedom (DOF) mathematical model for the ships. Six-DOF is a compulsory requirement for Class A FMBS only, in order to meet the IMO requirements for the Bridge Team Management Course (DNV, 2000).

The buyer knows that an affordable radar simulator consists of 2-8 working stations, each one with one, two or three displays, where all the ship's equipment and controls are virtual. In the two or three display configuration, the radar simulator workstation will have a visual channel with a 30^0-50^0 horizontal field of view and also the opportunity to display electronic navigation charts. In order to increase the realism of the simulation, the buyer could ask for a hands-on ship steering console, but this will increase the price of the radar simulator by at least 30%.

When a training institution has enough money to buy a FMBS, you expect a close mock-up of a real ship's bridge. A combination of virtual and hands-on navigation equipment is a must. The strongest point of the FMBS

must be the visual system, which has the main responsibility for creating the realism of the simulated environment. The visual scene and the projection system must cover a 210^0-270^0 horizontal field of view (Cross, SJ; Olofsson M, 2000). Due to the increasing capabilities of video cards, video projectors and 3D image generation software, simulators with a 360^0 horizontal field of view are no longer actual, because the software can rotate the visual scene all around the horizon and change the position of the observer eye all around the ship.

The new generation of visual software engine and hardware projects the visual scene on a cylindrical screen, where the movement of the image is smoother than on a sided screen. More visual effects have been added (waves, whitecaps, sun or moon reflection on the water, stars, different types of clouds, etc.). Another important achievement of the 3D software is the visual generation of the ship movement. This feature contributed to the reduction of the necessary space for simulator installation and offered a much cheaper alternative to the moving platforms.

Realism of the visual scene and realistic ship handling behavior in different environmental conditions are the key aspects for a good FMBS and these requirements are fulfilled by the main simulator manufacturers. Harbour pilots, deck officers and masters who perform voyages on similar ships in the same maritime areas being simulated could very well assess these characteristics. Their positive opinions would be the most valuable quality certificate for the shiphandling simulator being evaluated.

3. What can the new generation of navigation simulators do?

To answer this question we have to compare the STCW 95 training and professional skill requirements with the objectives and tasks posed to the trainee by a FMBS scenario.
The most detailed list of tasks that could be achieved using a FMSHS was found in the EU FP 4 project called MASSTER (Maritime Standardised Simulator Training Exercises Register). This project was finalized in 1998 but we think that most of the conclusions stated there are still valid in 2004.

In accordance with the MASSTER authors, there are at least 140 tasks at operational level and 160 tasks at managerial level that could be taught and assessed using a FMBS class A. These tasks start from basic navigation and deck watch procedures, include voyage planning and ship maneuvering in confined waters, and end with communication procedures, use of maritime English, SAR and emergency navigation. As a result it will be easier to discuss *which training task could not be achieved and which competencies could not be demonstrated using a FMBS*.

In accordance with STCW, examination and assessment of competence for masters, chief mates and officers, regarding navigation at operational and management level (tables AII/1 and AII/2), is based on evidence obtained from one or more of the following:

- approved in-service experience
- approved training ship experience
- approved simulator training, where appropriate
- approved laboratory equipment training.

From the STCW navigation competences category, the following tasks cannot be theoretically carried-out using only the capabilities of most FMBS:

1. celestial navigation
2. proper keeping of different kinds of log in port
3. starting of the gyro-compass and the minimization of settling time
4. forecast weather and oceanographic conditions
5. send and receive Morse signals by flashing light
6. send and receive a message by using the international code flags

7. use of an anchor to dredge down with a current.
8. assessment of damage and post-event actions in case of navigational emergencies
9. use of the emergency steering
10. take on board survivors from rescue boats and survival craft
11. general operation techniques of marine power plants.

I said theoretically, because on some simulators, some of the above tasks could be performed or with some imagination the instructors could find a way to teach these procedures. As a result, from the above list, at operational level, only items 1, 3, 7, 8, and 10 imply sea service experience.

For celestial navigation, sea experience is required in order to acquire practical skills in celestial bodies' altitude measurement. The damage assessment, post-event actions and taking survivors on board are actions that actually happen after an emergency event. The probability that a cadet will experience a real distress situation in the 12-month compulsory on board training period, is under 0.5%. As a result, training for these emergencies procedures is also theoretical, with participation at drills along with the ship's crew.

Of course, other competencies imposed by the STCW cannot be achieved by the cadets without a sea-service period. These training objectives strictly related to the on board training were included in the following STCW competence categories:

- Monitor the loading, stowage, securing and unloading of cargoes and their care during the voyage
- Ensure compliance with pollution prevention requirements
- Maintain seaworthiness of the ship
- Prevent, control and fight fires on board
- Operate life-saving appliances

One the other hand, most of the training aims from the above list are covered by the mandatory IMO courses that each cadet had to accomplish before he could enlist for the Third deck officer certification exam.

Another aspect that has the same importance as the FMBS technical capabilities is the quality and realism of the simulation scenario. 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 at the desired level of performance.

We must emphasize that in this paper we are discussing the training of students and cadets using the navigation simulators. There is a great difference in terms of design and preparation between a scenario arranged for students and a scenario that must be accomplished by already certified deck officers.

In our opinion, in order to obtain a good training scenario for students, the instructor's team must have a well-balanced structure. The scenario design team must include:

- teachers of nautical science, who are well aware of the theoretical level of knowledge of the trainees;
- certified deck officers, sea going experience, who know the practical requirements and responsibilities that must be carried out during the navigation watch;
- personnel with a deep knowledge of the technical capabilities of the simulator and the facilities offered by the simulation software in terms of scenario creation and exercise monitoring.

The ideal solution is to have teachers who meet all this three descriptions and we are convinced that all IAMU members have this kind of teacher-instructor staff for their navigation simulation facilities.

We practice the first contact of the students with the FMBS in the second semester of

the second year of study (in accordance with our curricula), after they have finished all the theoretical courses related to seamanship, coastal navigation and piloting, basic navigation equipment, and had minimal knowledge of navigation watch procedures.

What can be done in FMBS with so little theoretical knowledge?

The most important thing is familiarization with the real time navigation process. Additionally:

- hand steering of the ship on an imposed track;
- visual identification of navigation landmarks and floating navigation aids;
- taking visual bearings;
- reading gyro, compass, soundings, wind, current data;
- feeling different type of ships behavior on various weather conditions ;
- familiarization with distance perception at sea and day and night conditions;

are also very important tasks and skills that could be achieved at that beginning stage.

After that, in the third and fourth year of study, all the other objectives and tasks could be performed on the simulator: radar and electronic navigation, passage planning, ship maneuvering, radio communications, bridge procedures, watch team management, etc.

The realism of a scenario is also very important in training students with no previous sea going experience, even considering that they do not have yet a clear scale for comparing the virtual environment with the real one. We could count at least four reasons in support of this statement:

1. Skills and competences achieved during simulator exercises will be more accurate if the simulation environment is realistic.
2. Once on board a ship the student will be more confident in his actions realizing the similarity between the virtual and the real maritime environment.
3. If the student has a chance to be on board a ship that has similar characteristics as one of the simulated models, or if he will pass through a maritime area that was used as simulation area, he will perform his duties very well, based on the deja vu feeling.
4. After a sea service period the student/ cadet will better appreciate the importance of simulator training and once back in school or training center, he will be more focused and involved in resolving the tasks imposed by the simulation scenarios.

I think that I have the consent of most FMBS instructors, when, in conclusion, I state that based on the new generation of full mission simulators capabilities, we can perform almost all tasks required by STCW in the navigation competencies chapter for operational level.

4. Sea service equivalency for Full Mission Simulators training

As we all know, STCW 95 introduced a compulsory 12-month seagoing service for every candidate for certification as deck watch officer (operational level). At least six months of this period the cadet must perform bridge watchkeeping duties under the supervision of a qualified bridge watchkeeping officer (IMO, 1995). The cadet's achievements during onboard training programs must be documented in an approved training record book.

There were two areas where maritime administrations rushed to implement ad-literam the new STCW requirements: seagoing service periods and IMO compulsory courses.

This one-year sea service period for our cadets raised a lot of logistic problems for our university. The first one was a substantial reorganization of curricula, in order to clear of courses from the entire fifth year of study and to allocate this last year of study entirely for on board training. Even so, it is a very tight schedule, due to the fact that the graduation exam must take place at the end of July.

More than that, the students lose the contact with the university for almost 12 months, and they have to prepare their graduation thesis without periodical tuition and supervision by the teachers.

From the point of view of the university, the main logistic problem lies in finding owners and ships for almost 200 cadets each year. This problem is amplified by the lack of Romanian flagships and the total non-implication of the Romanian Maritime Administration and Ministry of Transport in this matter.

Consequently, every year, we had to sign agreements with various international crewing companies and we managed to embark more than 80% of our cadets. The main problem of this solution is that the cadets are on board international flagships with multicultural crews, and of course multinational officer staff. In accordance with ship-owner policy regarding cadets' training, we experienced many cases where the cadets had access to the bridge and performed watchkeeping duties for only 2-3 months. The rest of the period they worked as helmsman or in most case as AB.

There were also some discriminatory or preferential attitudes towards the cadets due to the nationality of master/officers/cadet.

From our 8-year experience, we identified only 4-5 big ship-owners that had a coherent onboard training programme with the deck officers, were seriously involved in the cadets' training activities.

In conclusion, after the 12- month sea training period, we assessed great differences between the cadets regarding the competences and professional skills achieved.

In a study undertaken by Warsash Maritime Centre (Habberley et al., 2001) regarding the use of simulators for training in emergency situations, the authors run a questionnaire among various shipping companies, shipping organizations and maritime education institution, regarding different aspects of training using full mission ship simulators. One of the questions was related to the preferred method of training of deck officers for routine watchkeeping situations. The answers received are illustrated in Graph no.1. As we can see, there are some differences between the opinions of maritime education institutions and the shipping industry.

The shipping companies prefer the onboard training associated with the sea service experience. The maritime training institutions consider FMBS as the primary tool for routine training of deck officers. It is also interesting that:

- apparently, the shipping industry has more confidence in video training tapes than in simulator training;
- maritime education institutions consider lectures and textbooks less suitable as methods of training, but these methods are suitable for the shipping industry.

In my opinion, the answers given by the maritime training institutions are in accordance with the actual trends in MET and reflect the increasing confidence in simulation and simulator as tools for efficient training. I think that the opinions expressed by the shipping companies reflect their predisposition to minimize the cost of training. Otherwise we could not explain why an owner could consider that lectures are almost equal in efficiency to FMBS training, regarding achievement of practical watchkeeping skills. This assumption is based also on the answers given by the shipping industry to the question regarding preferred means for training in bridge team management (graph no.2). On this subject, maritime education institutions and the shipping industry share the same opinion concerning onboard and simulator training as methods for working out bridge team management procedures. Because the Bridge Team Management IMO model course became compulsory for deck officers at management level, the shipping companies had to pay for the training of their staff. The IMO standard

for this course implies the use of a full mission simulator. The paradox is that at least 60% of this course deals with routine situations, so when you have no alternative for a cheaper training, everyone agrees that simulation is the best way to do it.

Only Maritime Administrations are apparently reluctant to embrace this means of training as an alternative to sea service time. With the exception of the USCG (CSBST, 1996), I do not know any other maritime authority that established an equivalency between on board training and FMBS training. The USCG decisions to grant remission of sea time in ratios, such as 6 to 1, have been based on achievement of licensing objectives, based primarily on a perceived value of simulator-based training. It has authorized sea-time remission to assist the maritime academies in meeting the STCW sea-service guidelines and to encourage training.

Simulated training is expensive even for maritime universities that have their own simulator facilities. As a result, between 1990 and 2000, the numbers of hours of simulated training for a student were very limited. That is the main reason for the lack of systematic research and comparative statistical studies based on the practical achievements of cadets that had only on board training and other groups that had only simulator training. On the other hand, a teaching institution could not undertake such a study, because all its students have the same number of simulated training and very much the same on board training periods.

With the new generation of FMBS, purchasing and training cost decreased considerably. On the other hand, the new technical capabilities increased the flexibility of scenario design allowing the creation of a better-tailored scenario for all kind of navigational tasks and teaching objectives.

Is the 6 to 1 ratio remission of sea time applied by the USCG justified? The study of Marine Safety International Rotterdam and TNO Human Factors Research Institute (DGSM, 1994) revealed that a ratio of 7.25 to 1 could also be considered as pertinent. In 1996, the US Maritime Academy Simulator Committee (MASC) conducted a survey to compare shipboard and full-mission ship-bridge procedures to validate this proposed equivalency of 12 to 1 (CSBST, 1996).

What is the main role of the cadet during watch hours? He is mostly an observer of what, when and how things happen on the bridge deck.

Has the cadet full access to the radar? In at least 70% of the cases, the answer is no. In most of the situations he could use the radar for:

- measuring bearings and distances in order to determine the ship fix;
- measuring bearings and distances to a target ship;
- plotting target ships on an ARPA.

The cadet is not allowed to:

- change without permission the radar motion or radar display stabilization configuration;
- set up his own Parallel Index or NAVLINES;
- make adjustments to the Gain, Rain and Sea clutter controls;
- use the TRIAL function in order to simulate collision avoidance maneuvers;
- approach the radar when Master and/or Pilot are on the bridge.

Has the Cadet the opportunity to make his own collision maneuvers? He has not.

Has the Cadet the opportunity to steer the ship in open waters? In most of the cases, yes.

Has the Cadet the opportunity to steer the ship in confined waters? No.

Has the Cadet the chance to start and setup

the electronic navigation equipment? We do not think so.

How many ship's fixes will be determined by the cadet during the watch? Maybe 6 to 8 fixes, if the officer in charge is very focused on the Cadet training.

Has the Cadet access to the VHF radio-telephone? No.

If we are realistic, we could find another page of arguments to demonstrate that the Cadet's role on board a merchant ship is mainly as an observer.

And now the big question: *Can the Cadet perform, by himself, all the watchkeeping tasks and actions of a Third Deck Officer, during a FMBS scenario?* Of course he can and all his actions will be monitored, assessed and rectified by the teacher/instructor. In the above mentioned paragraphs we talked only about routine navigation. Regarding the training for navigation emergency situations there is no doubt that it can be performed using only a simulated environment (J S Habberley, et al., 2001).

Without any reliable statistical evidence we could only make the following logical assumptions concerning the on board training period:

- in 80% of the cases, a cadet did not spend more than 200 days on the bridge, performing watchkeeping duties;
- because cadets will be embarked on all types of merchant ships, we could consider that from the above mentioned 200 days, only 70% of this period (140 days) could be considered as near coastal voyages;
- a near coastal voyage implies also port arrival and port operations. As a result, a 15% ratio of time spent in ports (21 days) could be applied. Lets also assume that on these near coastal voyages, 40% of the transit time is represented by passing maritime areas with high traffic, confined waters, dangers for navigation, high risk areas;

In conclusion, in a 12-month compulsory sea time period, the cadet carries on watchkeeping duties for 200 days. The ship in this period will perform 140 days of near coastal voyages, including 21 days of port operations. From the remaining 116 days, 47 days will be considered as ship passages through areas dangerous for navigation, meaning that during the 1-year on board training, only 12.8% of that time will be spend by the cadet in a really challenging environment.

In contrast with the real opportunities offered by ship's voyages, all the FMBS scenarios are designed for near coastal navigation and most of the simulated areas are maritime areas difficult for navigation.

The necessity of simulators and simulations as complement of the on board training is also recognized by the big shipping companies. Many of them had different CBT (Computer Based Training) programs implemented on their onboard PCs. For example, in 2001, A.P. Møller installed 16 SimFlex On-board Training Systems on their vessels that are used for training cadets and deck officers in rules-of-the-road and general ship handling.

5. Conclusions

We think that for original licenses issued to Third deck officers, the 6 to 1 sea service equivalency ratio applied by the USCG is fair enough, but with a well structured and balanced training program that uses all the capabilities offered by the new generation of FMBS, this ratio could be increased to an 8 to 1 ratio. This ratio means that 1 watchkeeping hour performed on a Class A FMBS is the equivalent of 8 watchkeeping hours carried out by a cadet during the compulsory 12 months on board training period. Transforming this possible 8 to 1 remission of sea time ratio into days, it means that one hour of FMBS training could be the equivalent of 1 day spent on board the ship.

Considering that IMO STCW 95 requirements for the practical training of cadets are well justified, we propose the following alternative to the 12-month on board training rule:

"Every candidate for certification as deck watch officer has to prove that he completed:

- 6 months of seagoing service (at least 4 months of this period the cadet must perform bridge watchkeeping duties);
- 180 hours of simulated training on a Full Mission Bridge Simulator (FMBS) Class A."

In accordance with the Constantza Maritime University curricula, the Navigation Department had prepared for its students a training program that guarantees for each student 168 hours of training using FMBS environment. These 168 hours are accumulated during the last 2.5 years of study, using the lab hours of various courses related to navigation, shiphandling, communication and watchkeeping procedures.

If the on board service time for cadets can be reduced to 6 months, we will have the practical opportunity to increase the FMBS training period with another 28 -32 hours, in the first semester of the fifth year of study.

We also propose that in 2005, the IAMU Steering Board (with the participation of all IAMU members) undertakes a full study regarding:

- the practical skills that could be achieved by students and cadets using the capabilities of the new generation of full mission bridge simulators;
- the realities of the on board training periods for cadets;
- the main problems of ensuring and monitoring the efficiency of the on board training programs.

The results of this study and an official request regarding the implementation of the sea service equivalency ratio concept should be forwarded to the IMO MSC Sub-Committee on Standards of Training and Watchkeeping.

We think that at the beginning of the 21st century, IMO MSC will have to admit the importance and benefits of simulators, and the achievements of training in simulated maritime environment.

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BIOGRAPHY

Sea Service Equivalency for Full Mission Simulators training

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