THE RELATION BETWEEN LEARNING OBJECTIVES AND THE APPROPRIATE SIMULATOR TYPE

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Abstract

This paper presents the proposal of the engine room simulator classification. The relation between proposed simulator types and the learning objectives specified in STCW is the main subject of the paper. It has also been proved that the full mission simulator is not always the best tool for the specific training tasks. Finally, the problem of the simulator STCW compliance has been discussed as well.

INTRODUCTION

STCW 95 defines three levels of competency (management, operational and support) and lists the corresponding competencies. Each level of skills implies the set of learning objectives and the objectives identification is the key point in the organisation of the marine engineer education. The point is, that the more complex skills include the simpler ones. This hierarchical growth of skill levels places a heavy burden on the course designer and the simulator instructor. The simulation exercise has to be designed to achieve specific competencies, which have been built upon previous training and knowledge.

SIMULATOR TYPES

It is hard to expect that one simulator (even very sophisticated and very realistic one) will be able to fulfil all the above mentioned expectations. Higher requirements of a user, provoke the growing complexity of the engine room simulators, their higher cost and longer development time. On the other hand, the rapid changes in the engine room equipment and control techniques require a lot of flexibility in the simulator architecture.

The need for the different simulator type can be very well illustrated, when using the map choice problem as an example. Let's assume that one wants to travel by car from the hotel in Braunschweig to the Expo 2000 in Hannover (both towns are in Germany). In order to plan the route not only the road map of Germany will be needed but the city plans of both towns as well (see Figures1 and 2).

Figure 1: The Analogy Between The Country Road Map And Full Mission Simulator.

Transferring this example to the marine training world; we can say that the country road map is like a full mission simulator – most complex, most comprehensive and covering the full scope of the engine room systems. However, due to its complexity this kind of a map (and also a corresponding simulator type) cannot be very precise and go deeply into details. By the way, if too many details are put into the country road map (or full mission simulator) it will become huge in size and not convenient for use. In the case of an engine room simulator its extreme complexity and detailed architecture means very high cost what is also very important.

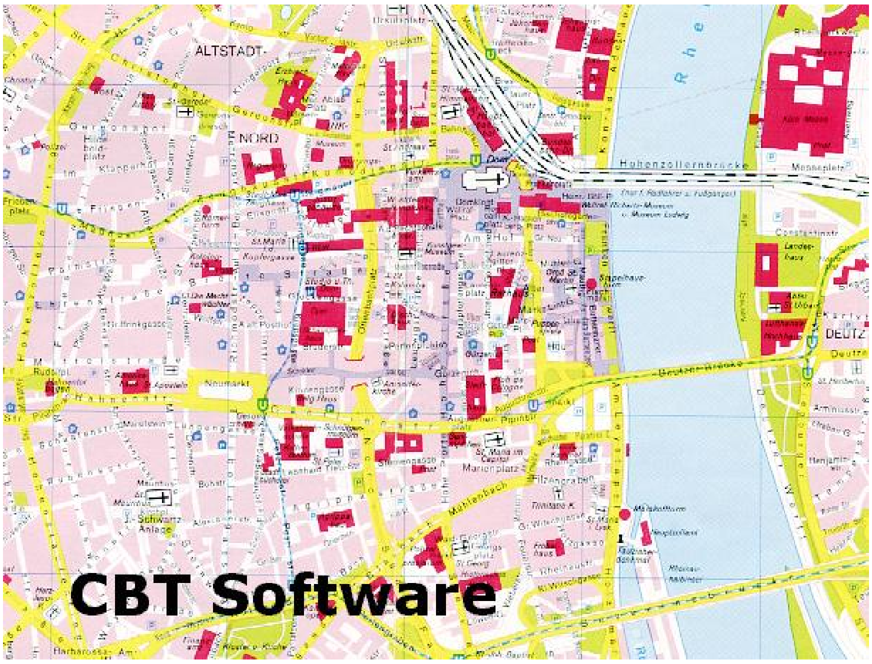

Figure 2: The Analogy Between The City Plan And CBT Software.

The city plan on the other hand, should be very detailed (sometimes it includes also the house numbers) but covers only a very limited area. The same description can be applied to CBT software. Such a software package covers usually only one engine room system or a machinery type, but this coverage is very detailed and includes the following issues:

- The operation principle,
- The detailed construction description.
- The operational procedures for different situations.
- The mini simulator of the system being the CBT main subject.
- The assessment tests.

Let's try to identify two other simulator types using our cartographic example. The specialised simulators are like specialised maps – the tourist maps or the hotel maps for example. This kind of a map (see Figure 3) contains a lot of specialised information (say places of interest, bike roads, tourist paths or hotels) but sometimes other pieces of information are completely omitted – the size of cities or highway connections for example. The specialised simulators can have higher accuracy of simulation in certain aspects but they will be probably very limited in the scope of the simulated systems.

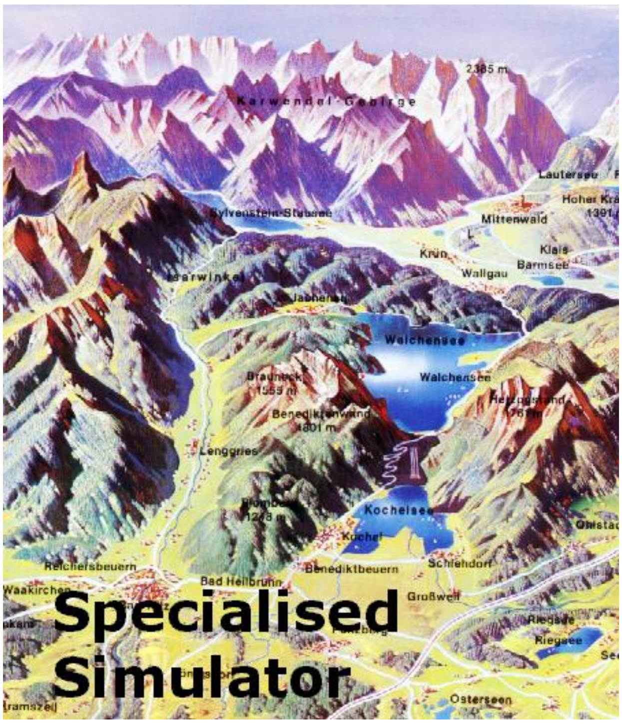

Figure 3: The Analogy Between The Tourist Map and The Specialised Simulator.

It is not so easy to find the right analogy for the PC based simulator, but maybe it can compared to the map on CD. The map on CD can be used only in personal computers and offers several unique features like route planning, distance calculation, zooming etc. The PC based simulator has also several features, which are not typical for full mission simulators: integrated checklists, integrated assessment etc.

The complete list of analogies between the maps and simulators has been presented in Table I. However, the key problem when dealing with different map (or simulator) types is the question: which type is to be used in certain situations.

Maps	Simulators
City maps	CBT software
Maps on CD	PC based
Country road map	Full mission
Specialised maps (tourist maps, hotel maps etc.)	Specialised (diagnostic, cargo handling etc)

Table I: The Analogy Between Different Map And Simulator Types.

SIMULATOR CLASSIFICATION

The long expected, frequently discussed and still missing simulator classification is a serious problem in discussing the issue of the simulator application. The realism and the engine room type cannot be the only criteria of the simulator classification, although this approach seems to be very popular (see: full mission, hybrid and part task simulator type). Also the outside look classification (mock up, desktop, PC based) is a bit obsolete now. The Author would like to propose the following simulator classification, which is based on the ICERS 4 workshop outcome:

- **B** (like Basic) **Class simulators** – include CBT Software and Basic Machinery Simulators like Auxiliary Boiler, Separator, Biological Sewage Treatment, Steering Gear etc. This family of simulators has a form of computer software to be run on a single, multimedia PC. Despite the simulation module, this kind of a simulator includes usually also the theoretical background, operation instruction and competency test. The user interface is based on the simple computer animation and simulated technical sounds. The absence of any specialised hardware consoles and the moderate cost are also typical for this simulator class. The Unitest CBT package which includes several B Class simulators can be an example of this simulator type [9].
- **P** (like Personal) **Class simulators** – include Hybrid and Part Task simulators mainly and are designated for a single person training: both in a stand-alone and in a supervised mode. The P Class simulator should model the specific engine room type and the simulator software can be run on a single PC or on the set of several networked PCs co-operating in the real time. The instructor facility is to be expected in the networked version as well. The user interface is like in B Class simulators but a limited number of hardware consoles (usually of a desktop type) is sometimes offered. The simulator cost is usually higher than in B Class but still

remain far below the level of F Class simulators. Virtual Engine Room is an example of the P Class software-only simulator and Engine Room Console is a P Class simulator with a specialised hardware console [7].

- **F** (like Full) **Class simulators** – include highly realistic and very expensive Full Mission Simulators. The set of hardware consoles equipped with gauges, switches, lamps and pushbuttons and many simulated sounds are obligatory for this simulator class. The requirement for the high realism of the engine room environment causes that even the single machinery mock-ups are sometimes used, in the control room outer space. The high and very high investment and operation costs are the main disadvantage of this simulator type. The team training possibility is on the other hand, a very important advantage of the F Class simulators. The ER-SIM can be considered as a typical example of the F Class simulator [4].
- **S** (like Special) **Class Simulators** – include specialised simulators, which are usually computer programs to be run on a single PC. However, when compared to B Class simulators they have different (rather more complicated) tasks and rarely offer any theoretical background or operational instructions. The example of this simulator class can be Turbo Diesel, which is a diagnostic and maintenance simulator [3].

It is worth mentioning that there are other interesting proposals of the engine simulator classification. For example Det Norske Veritas Standard for Certification of Maritime Simulator Systems [1] proposes the following classification (see also Table II):

- **Class A (ENG)** - A full mission simulator capable of simulating all machinery operations in the engine control room and machinery spaces, by the use of operational stations in machinery spaces.

- **Class B (ENG)** - A multi task simulator capable of simulating several machinery operations in the engine control room and machinery spaces, but with the limited use of operational stations in machinery spaces.
- **Class C (ENG)** - A limited task simulator capable of simulating some machinery operations in the engine control room for procedural training.
- **Class X (ENG)** - A special tasks simulator capable of simulating an operation and/or maintenance of particular machinery equipment, and/or defined engineering scenarios.

At first glance this classification looks very similar to the above described Author's classification, but the closer look shows that only two classes are almost identical:

- **F Class** is identical with the **Class A** (ENG) from DNV classification.
- **S Class** is identical with the **Class X** (ENG) from DNV classification.
- **P Class** is very similar to the **Class B** (ENG) from DNV classification.
- **B Class** is similar (but not identical) to the **Class C** (ENG) from DNV classification.

Despite the fine differences in the definition and the different terminology it should be stressed that the need for the simulator classification is growing fast in the community of the engine room simulator users. The similarity of the two different and independent proposals, means that the approach to the simulator classification seems to be reasonable and experience based.

STCW-95 Reference:	**Competence**	**Class A (ENG)**	**Class B (ENG)**	**Class C (ENG)**	**Class X (ENG)**
Table A-III/1.4	Maintain a safe engineering watch	A	B		(X)
Table A-III/1.6	Operate main and auxiliary machinery and associated control systems	A	B	C	(X)
Table A-III/1.7	Operate pumping systems and associated control systems	A	B	C	(X)
Table A-III/1.8	Operate alternators, generators and control systems	A	B	C	(X)
Table A-III/1.9	Maintain marine engineering systems including control systems	A			(X)
Table A-III/1.11	Maintain seaworthiness of the ship	A	B		(X)

Table A-III/2.1	Plan and schedule of operations	A	B		(X)
Table A-III/2.2	Start up and shut down of main propulsion and auxiliary machinery, including associated systems	A	B		(X)
Table A-III/2.3	Operate, monitor and evaluate engine performance and capacity	A	B		(X)
Table A-III/2.5	Manage fuel and ballast operations	A	B	C	(X)
Table A-III/2.6	Use internal communication systems	A	B	C	(X)
Table A-III/2.7	Operate electrical and electronic control equipment	A	B	C	(X)
Table A-III/2.8	Test, detect faults and maintain and restore electrical and electronic control equipment in operating conditions	A			(X)
Table A-III/2.10	Detect and identify the cause of machinery malfunctions and correct faults	A			(X)
Table A-III/2.12	Control trim, stability and stress	A	B		(X)
Table A-III/2.1	Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea and protection of the marine environment.	A	B		(X)

Table II: Competencies Addressed By Machinery Operation Simulator Class [1].

The application of different simulator types designed with the specific education task in mind can be a better and more effective solution than trying to build more and more complex simulators able to fulfil almost any educational task. The paper presents the certain number of example learning objectives and the appropriate simulator types. The Table III presents the proposed relations in a compact form.

Learning skills	**B Class simulators**	**P Class simulators**	**F Class Simulators**	**S Class Simulators**
Example Simulator	Unitest CBT	VER2 / ERC2	ER-SIM	Turbo Diesel
Operational level				
Maintain a safe engineering watch.		APPROPRIATE	**VERY** APPROPRIATE	
Operate main and auxiliary machinery and associated control systems.	**VERY** APPROPRIATE	APPROPRIATE	**VERY** APPROPRIATE	
Operate pumping systems and associated control systems.			**VERY** APPROPRIATE	**VERY** APPROPRIATE
Operate alternators, generators and control systems.	**VERY** APPROPRIATE	APPROPRIATE	**VERY** APPROPRIATE	
Maintain marine engineering systems including control systems.			*SOMETIMES* APPROPRIATE	VERY APPROPRIATE

			E	
Management level				
Plan and schedule the operations			**VERY** APPROPRIAT E	
Start up and shut down the main propulsion and auxiliary machinery.		**VERY** APPROPRIATE	**VERY** APPROPRIAT E	
Operate, evaluate and monitor engine performance.		APPROPRIATE	**VERY** APPROPRIAT E	APPROPRIATE
Detect and identify the cause of machinery malfunctions and correct faults.			*SOMETIMES* APPROPRIAT E	**VERY** APPROPRIATE
Control trim stability and stress.		APPROPRIATE	APPROPRIAT E	
Manage fuel and ballast operations		APPROPRIATE	APPROPRIAT E	
Use internal communication systems.		*SOMETIMES* APPROPRIATE	**VERY** APPROPRIAT E	

Table III: The Relation Between Learning Skills And The Simulator Type.

TASKS AND TOOLS

Table III shows that one learning task can be achieved with a use of many simulator types. At first glance, the most sophisticated and most expensive F Class simulator should provide the best quality of the training and the best training results. However, the example presented below shows that this rule does not have to be always true. Let’s compare how the fuel separator operation can be trained using F Class, P Class or B Class simulator.

The Figure 4 shows how the fuel separator is modelled in the full mission engine room simulator ER-SIM. It should be emphasised that the separator modelling is very sophisticated and enables not only automated but also manual operation. However, the controls are rather small, and the number of the animated elements is very limited. For example, it is rather difficult to observe the separator rpm, just because the animated gauge has to be very small due to the lack of the free space on the screen. It is easy to understand what role the separator plays in the whole engine room, and what kind of the external conditions (steam, electrical power and the sanitary water) has to be provided in order to start the separator. On the other hand, it is not so easy to learn how the separator has to be operated in the manual mode,

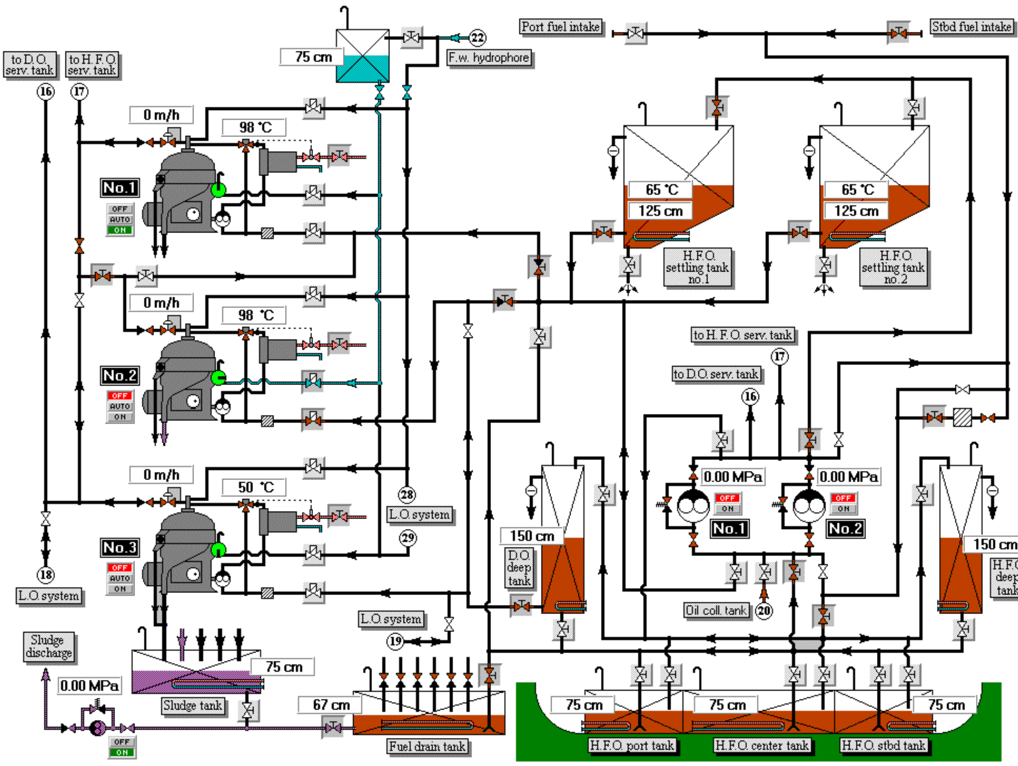

Figure 4: Fuel Oil Separators In F Class Engine Room Simulator (ER-SIM) [4].

The manual operation of the separator can be also mastered in P Class simulator as it has been shown in Figures 4 and 5. In the case of Virtual Engine Room, the user can see not only the external connections of the fuel oil separator, but when he clicks at the red separator symbol, the new window opens and the more detailed separator model is shown.

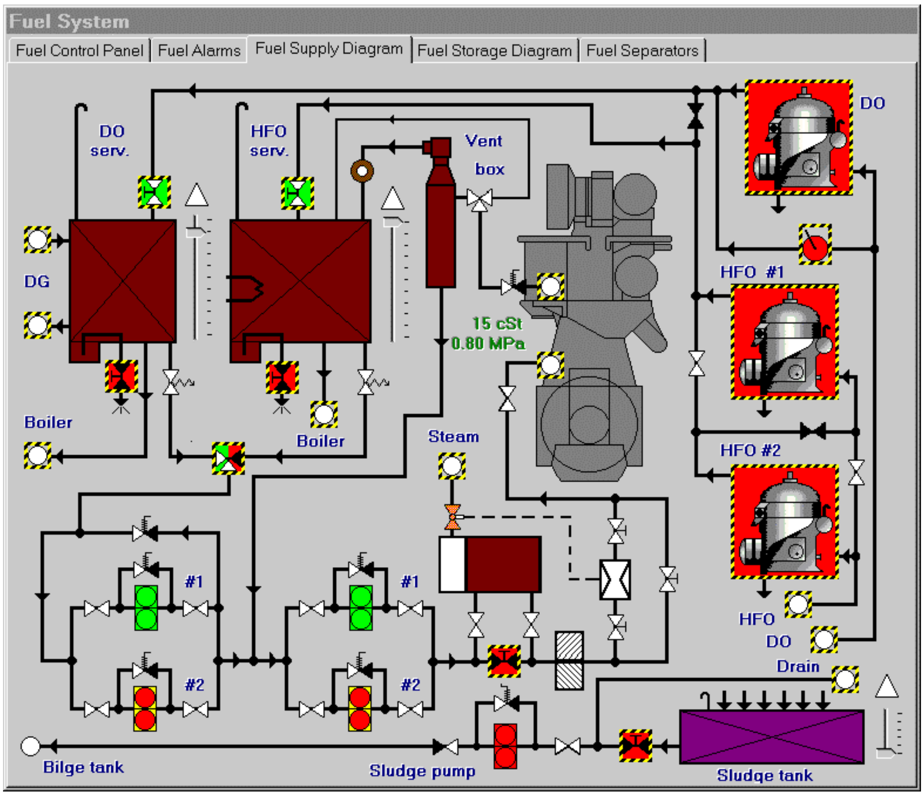

Figure 4: Fuel Oil Separators In P Class Simulator (Virtual Engine Room).

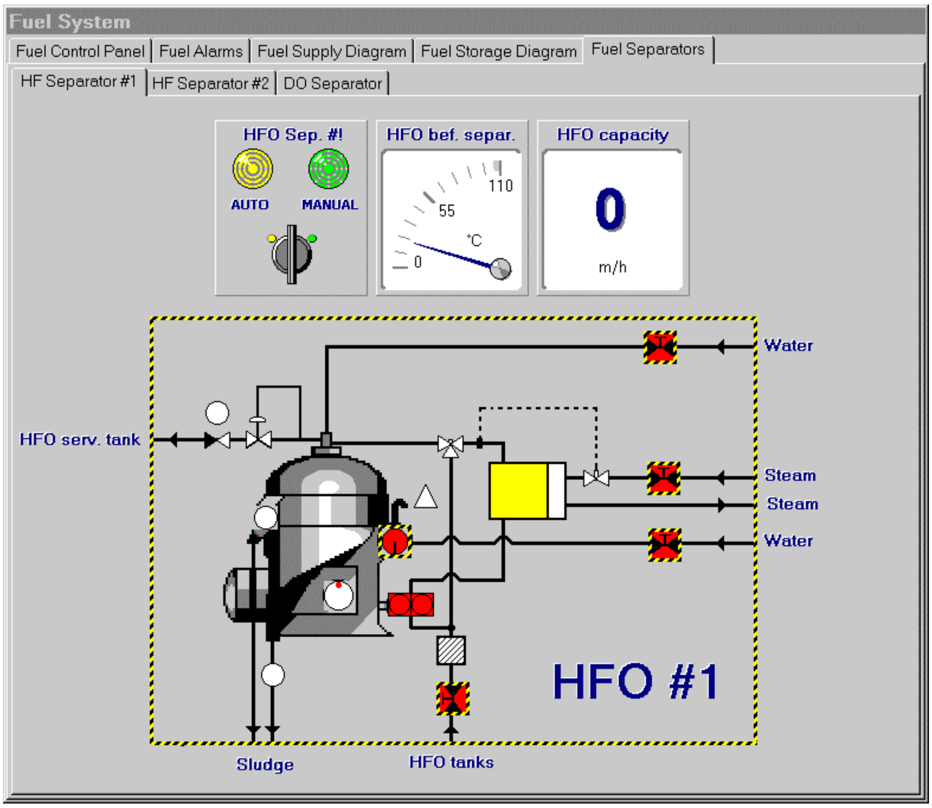

Figure 5: Single Separator Window In P Class Simulator (Virtual Engine Room).

Even if the VER separator model is very similar to ER-SIM model, due to the bigger mimics and virtual controls it is easier to learn how to operate the separator. The VER unique feature, the integrated checklist gives an additional advantage over the F Class simulator: the user will be guided step by step how to fulfil each operational task at the fuel oil separator.

The most detailed modelling and presentation of the fuel oil separator can be found however in the B Class simulator (Unitest CBT for example). Figure 6 shows that the first important difference when compared to P Class simulator is the animated internal view of the separator and the detailed modelling of all valves and automation controls which are typical for this specific separator model. The trainee can learn not only how to operate the separator in the manual mode, but he can also learn how the automated control settings influence the way the separator works (see Figure 7).

The disadvantage of this simulator type in comparison with F and P Class simulators is a fact that in this case it is more difficult to understand how the separator is integrated with the fuel system, steam system and sanitary water system. In other words: to learn almost everything about the fuel oil separator operation more than one simulator type is needed!

STCW 95 COMPLIANCE

It has become common habit that every training centre requires a STCW 95 compliance when ordering a new engine room simulator. This requirement seems to be quite reasonable, however, it would be advisable to analyse what STCW compliance means for the engine simulator specification.

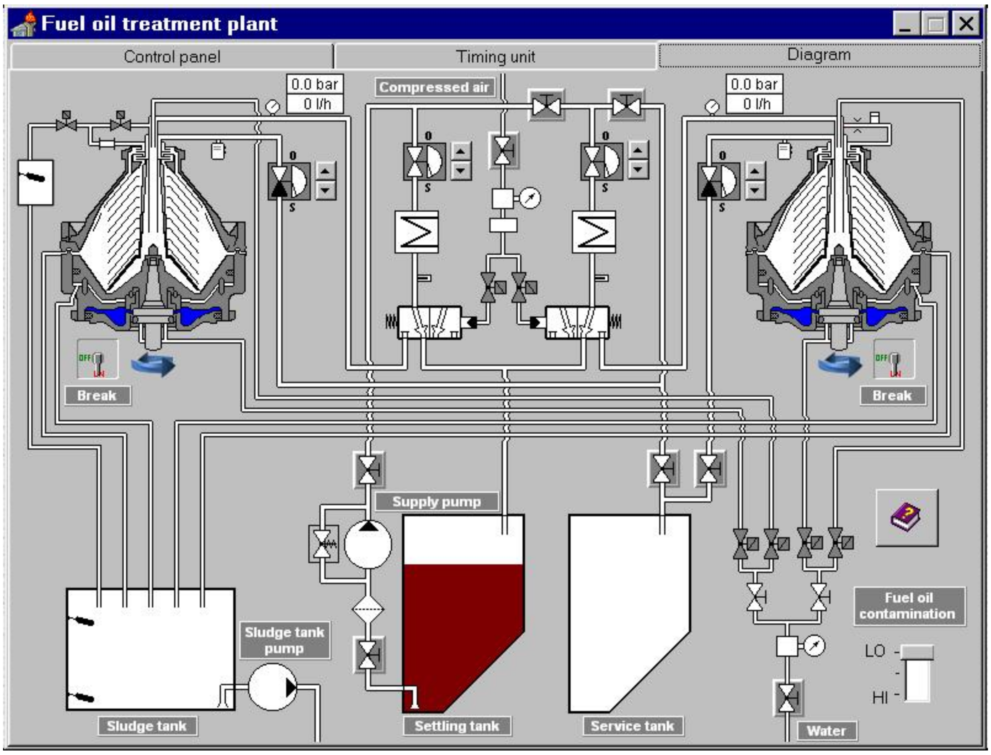

Figure 6: Separator Operation Window in B Class Simulator (Unitest CBT) [9].

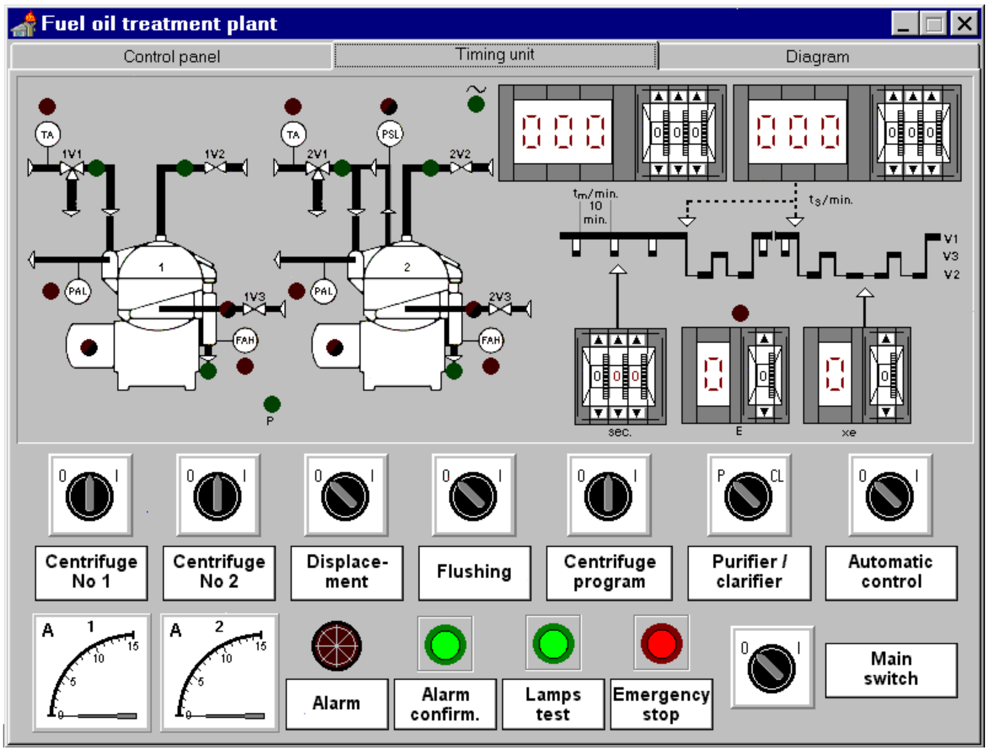

Figure 7: Separator Automation Window in B Class Simulator (Unitest CBT) [9].

Typically, the following parts of the STCW 95 conventions are referred to in the compliance requirements [8]:

(a) Regulation I/12 – *Use of simulators*.

(b) Section A-I/12 – *Standards governing the use of simulators.*

(c) Section B-I/12 – *Guidance regarding the use of simulators.*

(d) Section A-III/1 – *Mandatory minimum requirements for certification of officers in charge of an engineering watch in a manned engine room or as designated duty engineers in a periodically unmanned engine room.*

(e) Section A-III/2 - *Mandatory minimum requirements for certification of chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 3000 kW propulsion power or more.*

The detailed analysis of the above specified regulations shows the following weaknesses and inconsistencies:

- There is no distinction in the requirement in reference to the different simulator classes. *Example: The requested high realism of the operating environment is not so important in the case of B or S Class simulators, so the validity of this requirement should be limited to F class simulators only.*
- There is no distinction in the requirement in reference to the different engine room type. *Example: Please imagine, that somebody wants to order a full mission engine room simulator for the fast patrol boat or ferryboat with water jets. The simulator should comply with STCW 95, but does it mean that the auxiliary boiler or the cargo pumping system (both specified in STCW) should be also included?*
- The basic and important requirements are mixed with sometimes nonsensical and very detailed items. *Example: the deck steam, the accommodation steam and deck air are listed as the factors to be simulated together with the bow thruster and ship*

load. By the way: the same situation is with IMO Model course 2.07 [2] where the main propulsion diesel engine is listed at the same level of detail with steam cargo pumps or steam driven turbo generator.

All that means that it is very hard to fulfil all STCW 95 requirements, especially if the simulator belongs to the other than the full mission class. This means also, that it is necessary to introduce several corrections in the new version of STCW and that the simulator users and experts should take a part in this update. The main changes in STCW should include:

- The acceptance of different simulator types and their standard tasks.
- The requirements for engine room simulators should vary for different simulator classes.
- The list of the simulated engine room systems should depend on the engine room type, thus avoiding non-realistic ‘all-in-one’ simulator specification where for example, a shaft generator can be found together with a steam turbo generator.

CONCLUSION

The discussion at ICERS 4 in Vallejo has confirmed that typical engine room layouts called Reference Engine Rooms (RER) should be developed by a wide spectrum forum consisting of IMO experts, owners, ICERS members and other professional bodies such as the Institute of Marine Engineers for example [6]. It is also necessary to develop the Reference Operation Rules (ROR) in a form of checklists suitable for the specific engine room type but the development of ROR will be only possible if certain standards for engine room types are created. The ROR development should be the next step after setting the standard for different engine room types. Both, RER and ROR standards should be implemented in all newly developed simulators in order to provide STCW compatibility.

On the other hand, the realistic simulator classification should be internationally accepted and taken into consideration in the new version of STCW. The convention should also include the recommendations for the simulator type choice for the specific educational tasks.

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