

Use of Checklists in Engine Room Simulator

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The paper presents the concept of checklists applied to an engine room simulator. Example checklists are included. The author discusses the different aspects of the use of checklists both for training and assessment. The relationship between the checklists and ISM Code is also discussed in this paper.

Introduction

The discussion at ICERS 3 workshop has shown that special checklists should be developed and used during training and assessment with an engine room simulator.

The author has developed a set of checklists for use in an engine room with a 2 stroke, low speed diesel engine and they are based on the original Operation Manual for that type of engine. The checklists are designed to cover the most typical and most important operational situations such as: Preparation for starting the main engine, standby condition, and harbour conditions, etc. The basic form of a checklist is a table with many rows and several columns printed on a sheet of paper. This kind of checklist has been applied and tested in the 'ER-SIM' simulator, developed and installed in Gdynia Maritime Academy. Experience has shown that these traditional checklists can be very useful when used in conjunction with the engine room simulator, but it was soon realised that a better solution would be to integrate the checklist with the simulator software. In other words; the simulator should be able to show the trainee what has to be done in a certain situation. This new approach has been implemented in a new simulator package called Virtual Engine Room (VER).

Checklist Concept

The concept of checklists is well known from aviation and space technology. They have been developed and introduced with the following aims in mind:

- ⇒ They should standardise operation procedures and training, especially for very complicated machines such as aircraft and space vehicles).
- ⇒ They should ensure the avoidance of faults due to improper operating procedures.

Aside from aviation and space technology, the checklists have been also introduced into many other areas where correct operation is very important. The participants of the 3rd International Conference on Engine Room Simulators in Svendborg have decided that checklists should be also introduced into engine room crew training as a valuable teaching tool. The main purpose of checklist introduction is to teach the user proper engine room operating procedures. This will be especially important when VER will be used in stand-alone mode, i.e. without instructor support.

The checklists combined with an objective assessment should create new standards for ship engineers training and competency verification.

Checklist Application

The checklist concept has been implemented in VER in such a way that the whole engine room operation has been divided into many smaller, typical tasks and each of them is covered by a specific checklist. Each checklist is based on the following principles:

- ⇒ The checklist begins with a certain engine room setup, typical for that checklist. This so called entry setup will be loaded automatically each time the checklist will be opened by the user. For example; considering the checklist name 'ME start', the entry setup loaded at the beginning will guarantee that the engine startup is possible.
- ⇒ A checklist properly completed should lead to another specific engine room setup, which is a target of this procedure. Referring to the previous example the running engine should be a target setup.
- ⇒ Clear instruction what to do and how to do it, will be given in every single checklist step. Thus, a user who will follow precisely all the instructions given must be able to obtain the target setup any time the checklist is used. Blinking control lamps and gauges will be displayed alongside the text information in order to simplify a search for specific controls.
- ⇒ The checklists have been linked this way, that in almost every case the target setup of one checklist is an entry setup for the next one.. This means that learning all checklists means learning the whole engine room operation at a rather basic level.

In order to avoid any doubts about checklist sequence, they have not only names but also numbers such as 1.a, 1.b, 1.c, 1.d, 2.a, 2.b, 2c etc.

Smaller checklists are easier to use because an interesting checklist can be repeated many times without the necessity to repeat all preceding actions.

Tab. 6.1 The comparison of entry setup for all readiness levels.

Level	DO	HFO	LO	CO	FW	CA	Voltage	Steam	Cool.	Lubr.	ME
0	no	no	no	no	no	no	no	no	no	no	Stop
1	in Storage Tank	in Storage Tank	in storage tank	in Storage Tank	in storage tank	nc	nc	nc	nc	nc	Stop
2	in service tank	nc	nc	nc	nc	DG ok ME no	nc	nc	nc	nc	Stop
3	nc	nc	nc	nc	nc	nc	Yes 1 DG	nc	nc	nc	Stop
4	nc	nc	in ME sump	nc	AB ok ME no	nc	nc	yes DO	SW ok FW no	nc	Stop
5	nc	in Service Tank	nc	in Service Tank	ME ok	ME ok	nc	yes HFO	yes	yes	Stop
6	nc	nc	nc	nc	nc	nc	yes 2 DG	nc	nc	nc	Man. Slow ahead
7	nc	nc	nc	nc	nc	nc	nc	yes HR	nc	nc	Nav. Full Ahead

(Legend: nc means: 'no change').

Checklist Specification

The whole set of checklists has been grouped into so called *readiness levels* in order to simplify the learning process. The sequence of readiness levels to some extent mimics the time sequence of the engine room operation and represents the increasing requirements for engineer competency.

The following six specified readiness levels have been introduced:

- Level 0. **Empty Tanks.**

Checklists 0.a - 0.d Task: to fill up all storage tanks.

- Level 1. **Filled Tanks.**

Checklists 1.a - 1.b Task: to prepare DG for an operation.

- Level 2. **DG Operational**

Checklists 2.a - 2.c Task: to provide a voltage on busbars.

- Level 3. **Voltage Available**

Checklists 3.a - 3.f Task: to begin starting air compression and to provide heating steam.

- Level 4. **Steam Available**

Checklists 4.a - 4.e Task: to prepare ME systems for an operation

- Level 5. **ME Stopped**

Checklists 5.a - 5.d Task: to start ME

- Level 6. **ME Running**

Checklists 6.a - 6.d Task: to achieve full ahead speed and heat recovery utilisation.

The example checklists can be seen below:

4.d Start ME lubricating

- ✓ ME cylinder oil service tank refilling valve position should be set to OPENED.
- ✓ State of cyl. oil pump switch should be set to ON.
- ✓ Wait until ME cylinder oil service tank will be almost full.
- ✓ State of cyl. oil pump switch should be set to OFF.
- ✓ ME lubricators refilling valve position should be set to OPENED.
- ✓ Lubricating oil pump no. 1 switch position should be set to ON.
- ✓ Lubricating oil pump no. 2 switch position should be set to STANDBY.
- ✓ State of LO pre-heater switch should be set to ON.

5.a Synchronise second DG

- ✓ Diesel generator fuel inlet valve should be OPENED.
- ✓ Diesel generator start air inlet valve should be OPENED.
- ✓ Diesel generators automation reset button should be PRESSED.
- ✓ Diesel generator start mode switch position should be set to MANUAL.
- ✓ Diesel generator start button should be PRESSED.
- ✓ Synchronisation, frequency and load operating mode switch position should be set to AUTO.
- ✓ Automatic generator synchronisation button should be PRESSED.

5.d Start ME

- ✓ Bridge telegraph position should be set to DEAD SLOW AHEAD.
- ✓ ME telegraph position should be set to DEAD SLOW AHEAD.
- ✓ Control lever position should be set to START.
- ✓ Wait until engine shaft speed reaches 40 RPM.
- ✓ Control lever position should be set above 1.5.

6.a Reverse ME

- ✓ Bridge telegraph position should be set to DEAD SLOW ASTERN.
- ✓ M.E. telegraph position should be set to DEAD SLOW ASTERN.
- ✓ Control lever position should be set to STOP.
- ✓ Control lever position should be set to START.
- ✓ Wait until engine shaft speed reaches 40 RPM.
- ✓ Control lever position should be set above 1.5.

6.d Start heat recovery steam system

- ✓ Control lever position should be set to 7.1.
- ✓ Wait until engine shaft speed reaches 85 RPM.
- ✓ HRE circulating pump water inlet valve should be OPENED.
- ✓ HRE steam outlet valve should be OPENED.
- ✓ HRE circulating pump no.1 switch position should be set to AUTO.
- ✓ Auxiliary boiler burner switch position should be set to OFF.

Virtual Engine Room Concept

The author would like to present a new concept in simulators where the checklist and CAA tools have been fully integrated into its structure. Virtual Engine Room is a computer based, full mission simulator that simulates all vital engine room systems like cooling, fuel, lubricating, compressed air and steam but also diesel generators. The main difference when compared to other simulators is the full implementation of checklists as a teaching tool. The user can select a specific task to learn (A main engine start for example) and he will be guided step by step until the task will be successfully completed. At the beginning of the so-called scenario, the appropriate engine room setup has to be loaded or the previous scenarios have to be completed. Later, a set of precise instructions will be shown one by one, and only the fulfilling of the present instruction enables progress to the next instruction. Despite the text information, the appropriate control (i.e. switch, push-button or lever) will blink until it is set in the correct position. Fulfilling the necessary conditions can also include a period of waiting until specific parameters are reached. It is easy to understand that every scenario is based on a hidden checklist but from the students point of view it provides friendly instruction offered by a very patient expert.

This kind of simulator can be especially useful as an entry-level teaching tool used for preliminary preparation prior to exercises with the very expensive hardware based

simulator. Because it offers the same CAA criteria found in a large simulator, the student can be well prepared for both; training and assessment.

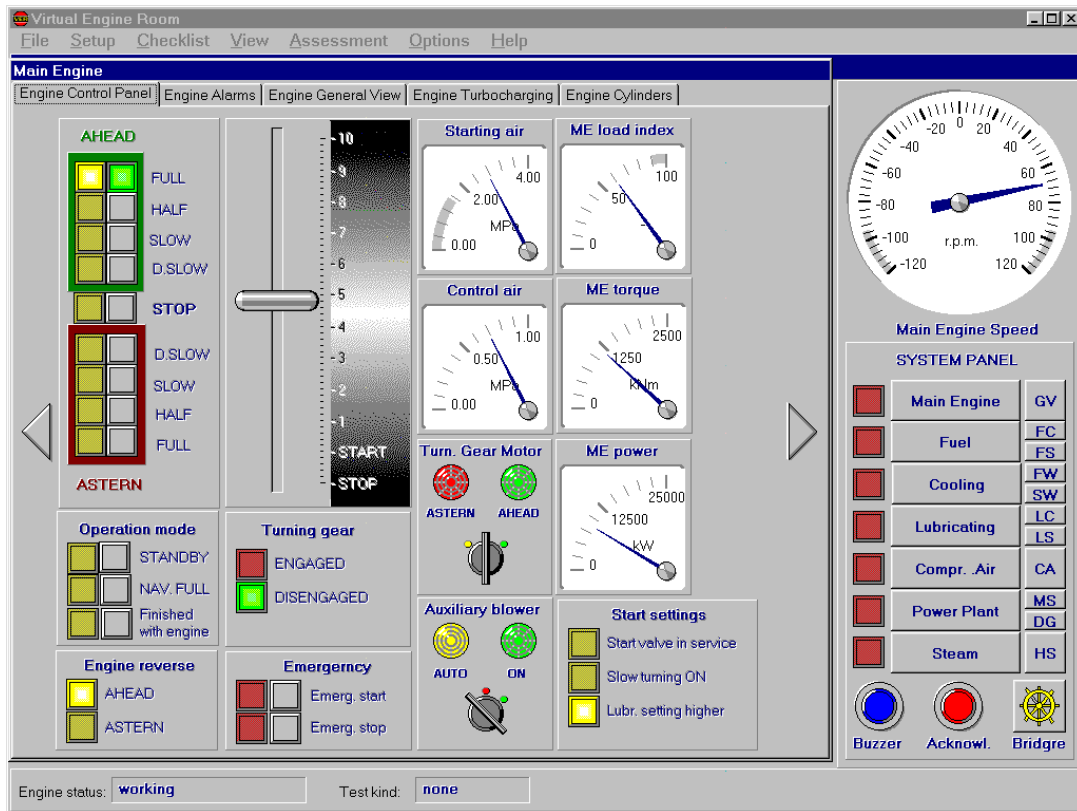


Fig. 1. VER main screen.

Checklist Use

Use of the checklist requires three steps to be executed:

- The selected checklist has to be opened,
- The checklist should be executed (It is recommended that all checklist steps are executed, although the user can quit the execution any time).
- The checklist has to be closed.

Opening the checklist is simply by selecting one of the items from the **Checklist** menu.

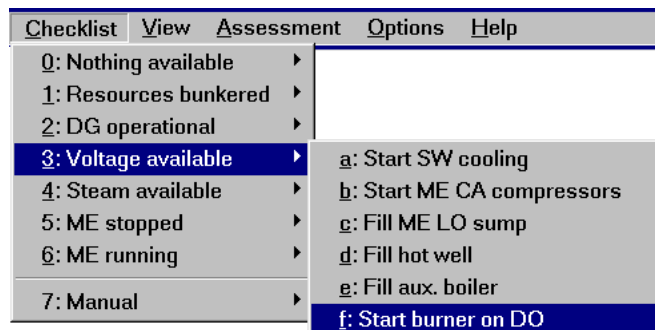


Fig. 2. The checklist selection.

Opening the checklist causes the special checklist window to be open automatically.

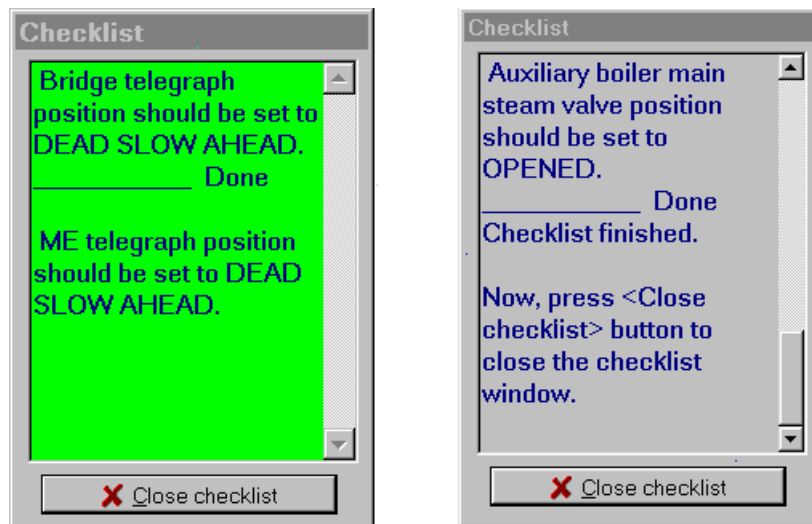


Fig. 3. The checklist window during, and after the checklist execution.

This window has a lime-green background colour when the checklist is not completed and a grey background when the checklist is completed. The word "Done" is used as a checkmark replacement and confirms that the user has completed the checklist step successfully. The appropriate system window will be always opened automatically when a new checklist step is shown in the checklist window, so there is no need actually to use the System Panel when the checklist window is opened.

The control lamp, switch or virtual gauge specified in the checklist step blinks in order to make its identification easier.

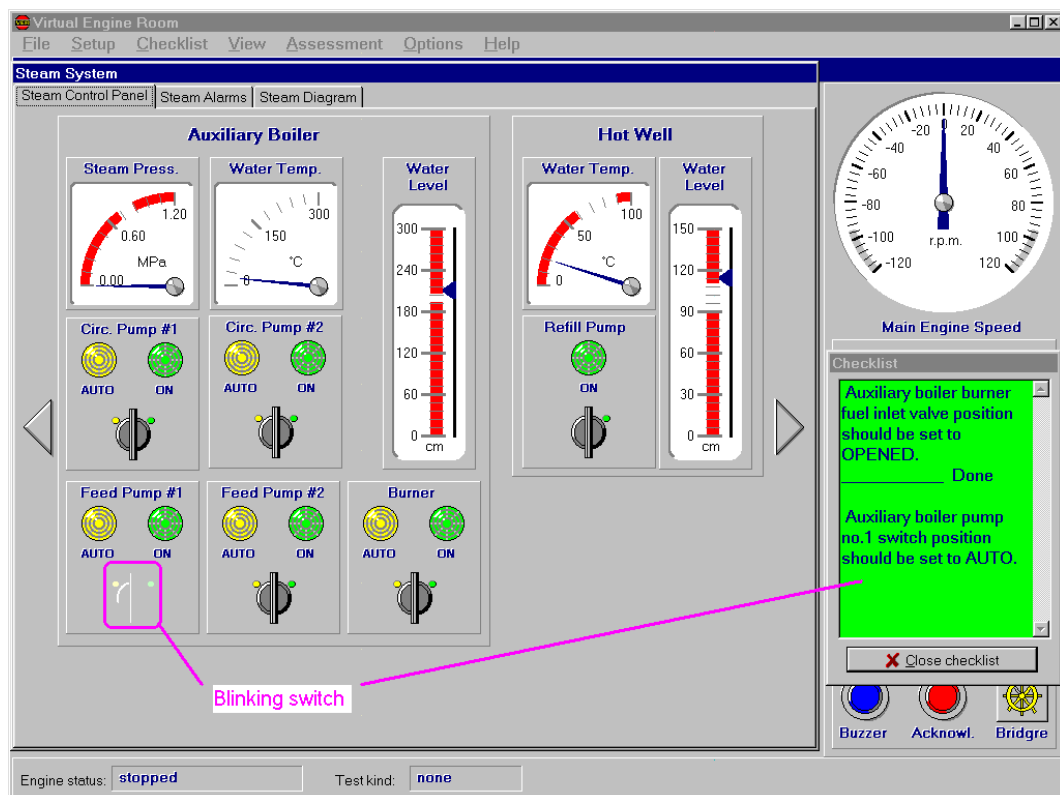


Fig. 4. The example of the checklist instruction (blinking virtual switch).

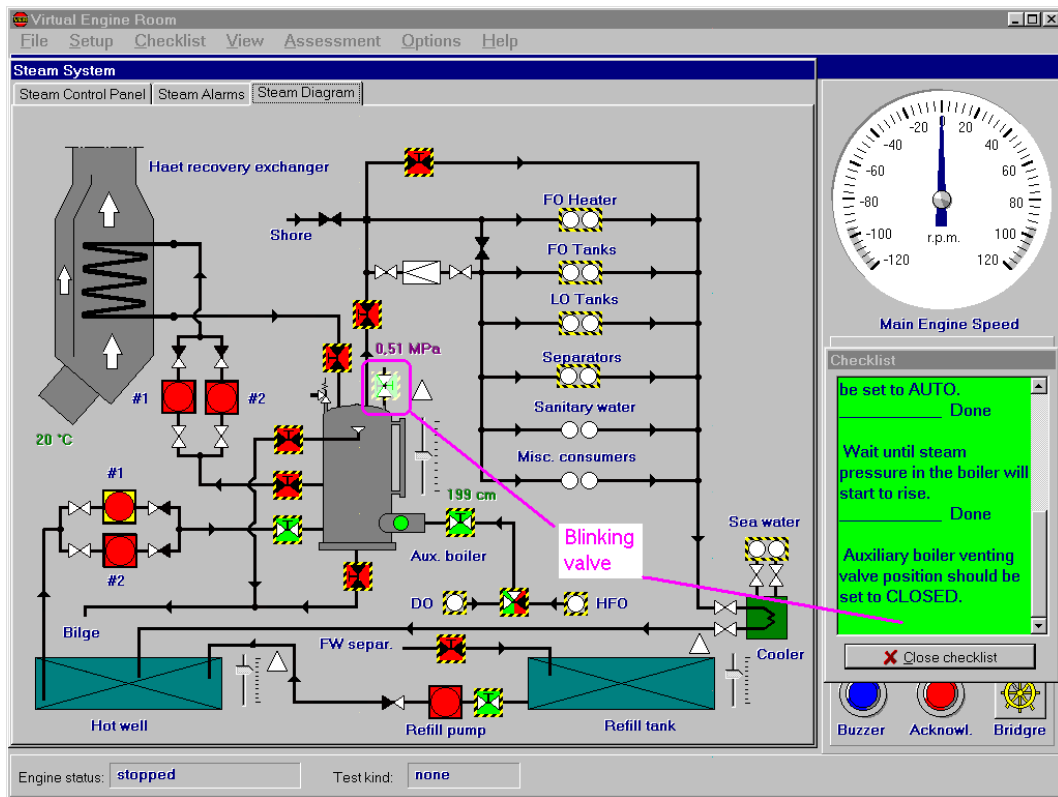


Fig. 5. The example of the checklist instruction (blinking valve symbol).

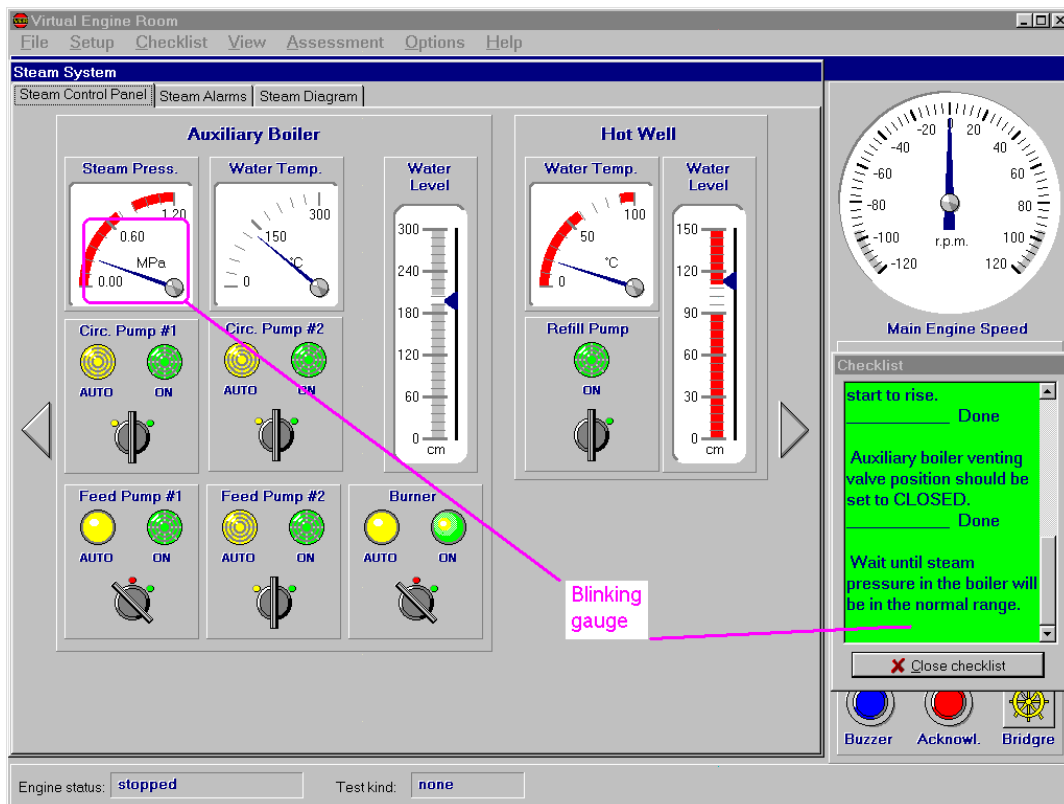


Fig. 6. The example of the checklist instruction (blinking virtual gauge).

Please note, that the completion of the current checklist action is the only way to see the next checklist step. If necessary, the user may scroll back through all completed

checklist steps. He can also close the checklist any time by clicking on the *Close checklist* button.

Checklists and Assessment

Computer Aided Assessment (CAA) means the computer evaluation of data obtained from the engine room simulator where the assessment takes place. The CAA idea has been presented for the first time by an author in Svendborg at ICERS 3 [1] and in Gdynia [2]. The originally introduced assessment tests were based on the 'snap-shot' picture of the engine room systems and the requested engine room status. The purpose of any test is to ascertain whether or not the trainee is able to achieve the requested engine room status, for example: prepare for main engine start.

The checklists introduction provokes the question: "Can checklists be used also for Computer Aided Assessment, and how"? At first glance, the answer looks very simple: "Yes, you can check if the trainee has completed all necessary operations as specified in an appropriate checklist". However, after a while the proposed answer does not look so obvious. Sometimes, the sequence of events specified in a checklist is not the only one that can guarantee the achievement of the desired aim. Usually, the checklist only proposes the recommended sequence of activities and certain changes in this sequence can not be described as a fault. The assessment method should take into consideration not only the differences between the recommended and observed sequence of activities but also it should analyse the possible consequences of these differences. This requires a very sophisticated expert system based on expert knowledge or a computer simulation.

The author's experience shows, that the desired state of the engine room is the real aim of all checklists, and in many cases the more important question is "If the trainee was able to achieve the aim then "how did he do it". This means that assessment tests based on the 'snap-shot' pictures of engine room systems are more suitable for CAA than checklists. Of course, it would be very good to have an assessment method that will be able to combine both approaches in the future. This is one of the objectives in ongoing research.

Checklists and ISM Code

The ISM Code rules create the necessity for checklists to bridge the gap between engine room simulators and the actual engine rooms. The ISM Code states that the owner should establish programs of drills and exercises in order to prepare for emergency actions and should be able to provide response to hazards, accidents and emergency situations involving ships. This is obviously a requirement for checklists for use in the actual engine room, however the best place to develop them is with the use of an engine room simulator. This approach is well known from aviation and space technology. The simulator is a place where the search for proper operational methods can be done. The different checklists are the typical outcome of this search and after the careful validation they are usually implemented into real life situations. The logical consequence of this, is the very important role the simulators play in engine room crew training. If there is a standard for the operation procedures and those procedures have been developed at the simulator, the simulator seems to be the best place also for crew preparation.

One important condition should be mentioned however; this close relation between real environment and simulator is possible only if simulator fidelity is out of question. This is an obvious situation in an aviation or space technology where the number of models

is limited and the operational environment is fairly standardised. The situation is different in the ship engine room technology, at least today. The significant number of engine models, engine room layouts and non-standardised monitoring and control equipment make the situation more complicated.

The engine room simulator with a virtual engine room environment seems an interesting and promising solution to this problem. It is easier and cheaper to adapt the simulator software interface than to build new consoles with different gauges, switches and electrical equipment. It is true that the real hardware based engine room simulator is more realistic than a flat monitor screen, but on the other hand, it is easy to observe the increasing role of computer equipment in modern engine rooms. It happens that actual analogue gauges tend to be replaced by virtual versions of these gauges displayed on the computer screen (See new MaK engines for example). Also many valves, motors and pumps can be remotely controlled by a mouse click on the virtual control symbol.

Conclusions

This paper presents the checklist concept and its application in the engine room simulator. The VER is the first engine room simulator with fully integrated checklists. The checklists are used for learning only and the system 'snap-shots' are used for an assessment. Preliminary experience has shown that this approach is a good entry point for further development of simulator training methods

ISM Code and STCW95 require greater uniformity in the training and assessment with engine room simulators. It is necessary to standardise the several most important engine room types and their operation rules. Today, simulator developers offer a wide choice of engine room layouts. On the other hand there is no common understanding of the term 'proper operation'. It is necessary to develop the Reference Operation Rules (ROR) in a form of checklists suitable for the specific engine room type. The development of ROR will be only possible if certain standards for engine room types will be created. Those typical engine room layouts called Reference Engine Rooms (RER) should be developed by a wide spectrum forum containing IMO experts, owners, ICERS members and other professional bodies such as the Institute of Marine Engineers for example.

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.

References

1. S. Kluj, 'The Computer Aided Assessment for Engine Room Simulator', Proceedings of 3rd International Conference on Engine Room Simulators, Svendborg, 1997.
2. S. Kluj, "The New Method of the Ship Engineer Assessment and its Application for Engine Room Simulators", Proceedings of the International Conference "Safe Navigation Beyond 2000", Gdynia 1998.