ICERS' Impact on Marine Engineering Training

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ABSTRACT
This paper presents the impact of *International Conferences on Engine Room Simulators (ICERS)* on marine engineering training over the last 20 years. Several most inspiring and most valuable ideas raised and promoted at all ICERS will be presented. Some of them – like the classification of engine room simulators for example – have been incorporated into classification rules and international conventions. Others – like the use of checklists and an automated assessment – have become de-facto standard within maritime training. Different simulator technologies, such as full mission with hardware consoles, PC-based part task trainers or the latest virtual reality products, will be outlined. Finally, some possible simulator development ideas will be presented.

Keywords: *engine room simulators, ICERS, STCW, maritime training*

1. Introduction

The author of this paper has had the pleasure of participating in all International Conferences on Engine Room Simulators (ICERS) except the first one, and on account of his personal involvement in the development of engine room simulators, he has examined in more depth the influence of ICERS on engine room simulator training. "Training" means not only the training programs and methods but also the equipment (simulators) and legislative rules influencing this kind of maritime activity. STCW and DNV simulator standards for simulator certification are the most important documents, having great impact on maritime training as a whole.

These conferences always constituted a place where different groups involved in maritime training used to meet: the simulator users, the simulator developers, the researchers, the classification societies and the maritime authorities from all over the world. Even if some people do mean that the internet made ICERS less necessary today, the author is convinced that such conferences should be continued in the future as an important meeting point and as an engine room simulator technology "boost".

2. Overview of Engine Room Simulator Development

This paper is not intended to be a history of engine room simulators, but it is worth taking a closer look at the simulator "Genealogy Tree" (Fig. 1).

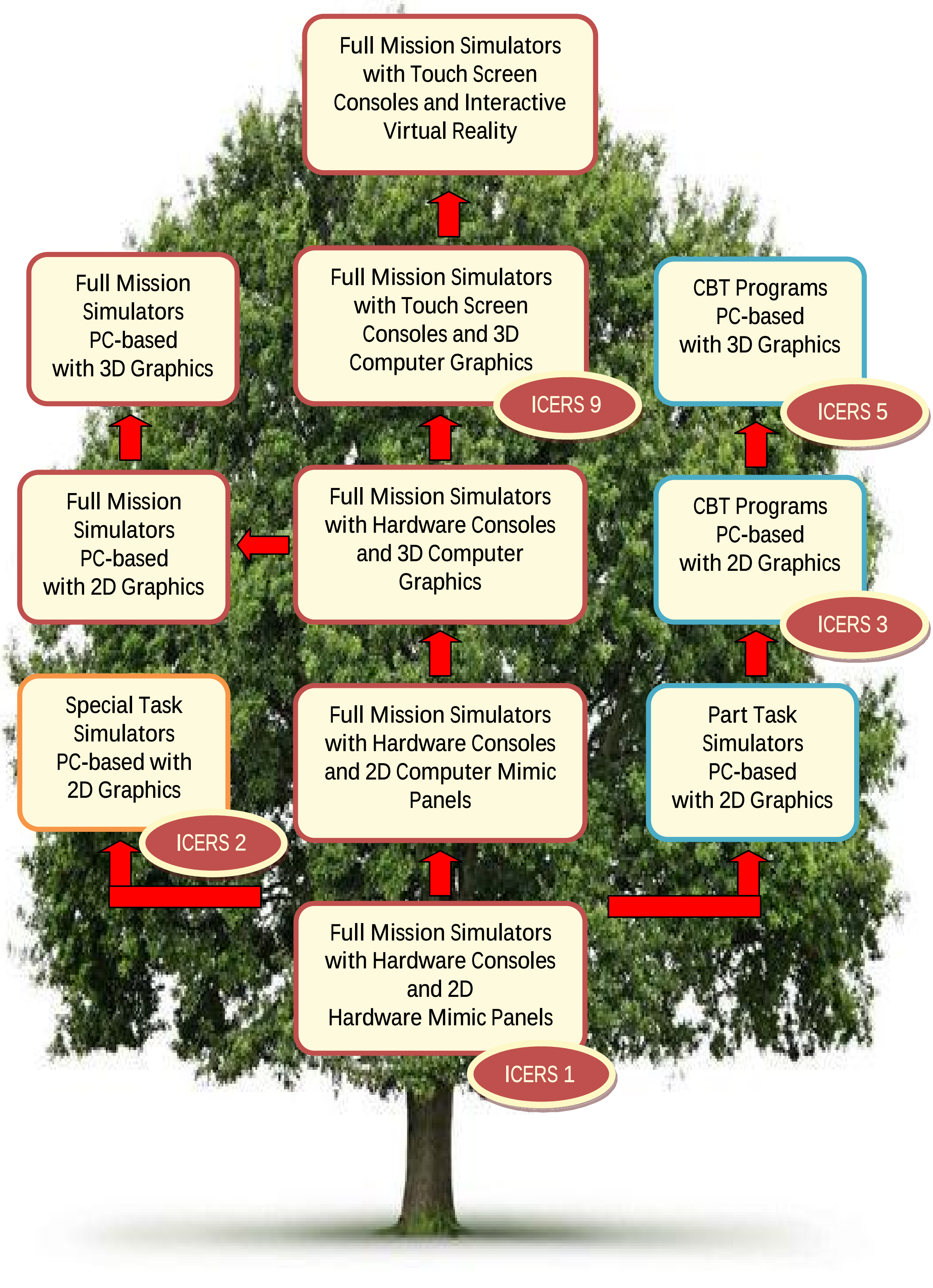


Fig. 1 Engine Room Simulator "Genealogy Tree"

It is hard to say that ICERS was a place where the new simulator types have been invented, but it is certainly the place where some new engine room simulator types have been presented for the first time (see Fig. 1).

On the other hand ICERS was always a good place to observe the "boost" in simulator technology (Fig. 2). Many people believe that the acceleration in simulator development is mainly a result of the rapid advancement in computer technology. This is true of course, but one should not forget that the cumulative experience gained by thousands of simulator users was converted first into progress in engine room simulator technology and later into legislative progress (IMO, classification societies and maritime authorities).

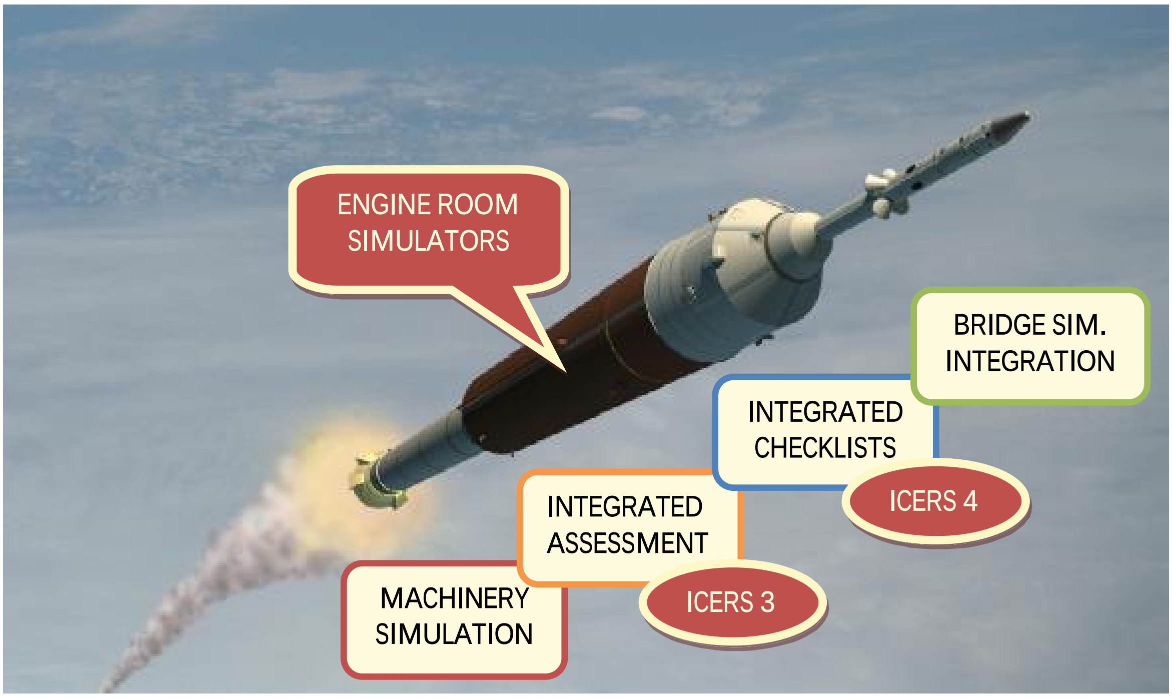


Fig. 2 Engine room simulator technology "boost"

For simulator users, the main outcomes from ICERS were:

- the opportunity to learn new simulator technologies;
- the opportunity to get some 'hands on' experience with the new products presented at ICERS exhibitions;
- the opportunity to share their training experience with other users and the simulator developers;
- the opportunity to build interpersonal relations with other users and the simulator developers.

3. The influence of ICERS on Legislation

An overview of ICERS topics is presented in Table 1. It is evident that certain topics (like new simulators and new training methods) have been presented at every ICERS conference [1-10]. However, many new topics have also been introduced at these conferences, which later became industrial standards.

Table 1. Overview of ICERS topics (original new topics in bold type) [1-10]

No	Year	Place	Main Topics
1	1993	Nantes France	New simulators, Simulator training methodology, Modeling methodology
2	1995	Rimouski Canada	New simulators, Simulator standards and classification , Simulator certification, Simulator interface, Occupational health aspects of simulators, Simulator training methodology, Assessment methodology
3	1997	Svendborg Denmark	New simulators, STCW, CBT, Simulator training methodology, Assessment methodology, Human factors, Computer Aided Assessment
4	1999	Vallejo USA	New simulators, STCW, CBT, Simulator training methodology, Assessment methodology, Use of simulators for crew resources management, Training material for simulators, Integrated checklists
5	2001	Singapore Singapore	New simulators, Simulator training methodology, Assessment methodology, Modeling methodology, Relation between learning objectives and appropriate simulator type, 3D Visualization, Human errors and simulators
6	2004	Wuhan China	New simulators, Specialized simulators, CBT, Simulator training methodology, Assessment methodology, Modeling methodology
7	2005	Portoroz Slovenia	New simulators, Assessment methodology, Specialized simulators, Integration between bridge and engine room simulator, 3D Visualization, Part task simulators, Simulators with real machinery, Specialized simulators, Modeling methodology, Scenarios, Checklists
8	2007	Manila Philippines	New simulators, Simulator training methodology, Assessment methodology, Modeling methodology, Speech synthesis application, Scenario development, 3D Visualization
9	2009	Kings Point USA	New simulators, STCW, Modeling methodology, Simulator training methodology, Assessment methodology, Integration between bridge and engine room simulators, Touch screen applications, 3D Visualization, Simulation of electronically controlled engines
10	2011	Sankt Petersburg Russia	New simulators, STCW, Total ship simulation, Touch screen use, Environment protection, Simulator training methodology, CBT
11	2013	Busan South Korea	To be seen.

It is worth noting that the participation of classification societies, the maritime authorities and other maritime institutions (like IMarEST for example) has been very important in promoting the value of ICERS at maritime training. The need for recognition of the complexity of engine rooms has been discussed since the first conferences and, as a result, the latest version of STCW 2010 (with Manila Amendments) [12] has included a wider scope of machinery used in maritime training involving simulators (Table 2). This new trend increases the need for part task simulators and CBT programs – also a topic of many ICERS.

Table 2. A comparison of selected STCW operational-level standards [11, 12]

STCW 1995	STCW 2010
Operate main and auxiliary machinery and associated control systems Main and auxiliary machinery: .1 preparation of main machinery and preparation of auxiliary machinery for operation .2 operation of steam boilers, including	Operate main and auxiliary machinery and associated control systems Basic construction and operation principles of machinery systems, including: .1 marine diesel engine .2 marine steam turbine .3 marine gas turbine

combustion systems .3 methods of checking water level in steam boilers and action necessary if water level is abnormal .4 location of common faults in machinery and plant in engine and boiler rooms and action necessary to prevent damage	.4 marine boiler .5 shafting installations, including propeller .6 other auxiliaries, including various pumps, air compressor, purifier, fresh water generator, heat exchanger, refrigeration, air-conditioning and ventilation systems .7 steering gear .8 automatic control systems .9 fluid flow and characteristics of lubricating oil, fuel oil and cooling systems

The need for recognition of several separate engine room simulator types (diesel, steam turbine, gas turbine and diesel electric) has been discussed since 1995 in Rimouski. As a result, even the fishing schools or navy academies had to have low-speed engine room simulators, even if they were not fit for purpose. The left column of Table 3 shows the DNV 2.14 standards for engine room simulators in 2000 [13], compared with the 2011 version of the same standards (right column) [14]. The author had the pleasure of taking part in the development of these standards as a member of the international expert group, many of whom were ICERS participants.

Table 3. The comparison of selected DNV standards for machinery simulator certification

DNV 2.14 (2000)	DNV 2.14 (2011)
The simulated engine room shall consist of a typical machinery found on merchant ships. The following main components shall be simulated and all necessary sub-systems are to be included: *(The detailed description follows in the original text)* The simulated main engine shall replicate a system, working according to one of the following principles: — diesel combustion — steam turbine — gas turbine	Low-Speed Engines The simulated engine room shall, as a minimum, reflect typical machinery found on merchant ships. The following main components shall be simulated and all necessary sub-systems included for a low-speed engine: *(The detailed description follows in the original text)* Medium- and High-Speed Engines The simulated engine room shall consist of typical machinery found on merchant ships. The following main components shall be simulated and all necessary sub-systems included for a medium and high speed engine: *(The detailed description follows in the original text)* Steam Propulsion The simulation model should reflect main steam related subsystems of an actual ship: *(The detailed description follows in the original text)* Electric Propulsion Motors (Diesel and/or Gas) The simulated engine room shall reflect typical machinery found on merchant or passenger ships. The following main components shall, as a minimum, be simulated and all necessary sub-systems included for a diesel and/or gas turbine electric propulsion plant: *(The detailed description follows in the original text)*

The changes in MARPOL (Tier 3) [15] and the increasing interest in environmental protection have also been observed at ICERS 10 in Sankt Petersburg. These problems have also been specifically addressed in the latest version of the management level simulator Turbo Diesel 5, developed by this author [16].

4. Turbo Diesel 5 - New Trend in Simulators

This model simulates the engine operation under selected initial conditions (for example: torque, revolution speed, ambient air pressure) and a variable technical state (Table 4). It will react naturally under almost any combination of factors, but sometimes the engine operation will be impossible. Faults introduced by the user or by the computer will lead to a progressive deterioration in system conditions if maintenance action is not taken at an appropriate stage.

Table 4. Diesel engine fault simulations available in Turbo Diesel 5

Simulation Name	Unit	Min. Value	Max. Value
Injection advance angle change	deg	10	26
Fuel effective quantity decrease	%	0	20
Gas leak through the piston rings or valves	%	0	20
Injector nozzle cross section change	%	80	120
Decrease of the air filter cross section	%	0	40
Air blower - decrease of air flow efficiency	%	0	4,5
Air cooler - decrease of the cross section at air side	%	0	40
Decrease of the exhaust duct cross section	%	0	40
Gas turbine - decrease of the cross section at gas side	%	0	4,5
Decrease of the water flow in the air cooler	%	0	20
Decrease of combustion chamber cooling efficiency	%	0	20
Cooling water temp. change at inlet to the engine	°C	40	80
Engine friction coefficient increase	%	0	40
Increase in the pressure drop at the oil filter	MPa	0	0.2
Lub. oil temp change at inlet to the engine	°C	30	70
Ambient air temperature change	°C	20	60
Ambient air pressure change	hPa	950	1050

There has been considerable focus on the mathematical modeling of the fuel injection and combustion process (Fig. 3) [5]. In general, the technique is to solve the governing equations of state and of conservation of energy and mass on a step-by-step basis, using small (2°) crank angle increments. The calculation sequence invariably divides itself into two major parts, for closed and open period, starting with assumed trapped conditions of the cylinder charge at the beginning of compression. The stable values of these conditions are obtained only after several successive cycles have been evaluated.

Focus has also been directed towards the digital simulation of an exhaust gas emission, including the concentration of O_2, CO_2, CO, SO_2 and NO_x (Fig. 4) [1, 2, 3]. The mathematical model was validated during tests on the actual diesel engine in the laboratory, but the model illustrates how both single faults and multiple mixed faults influence exhaust emission. The numerous additional combustion parameters, such as the maximum combustion temperature, air/fuel ratio and even the thermal load, can be presented on request in order to make the relation between engine technical state and the caused environmental pollution more readable und understandable.

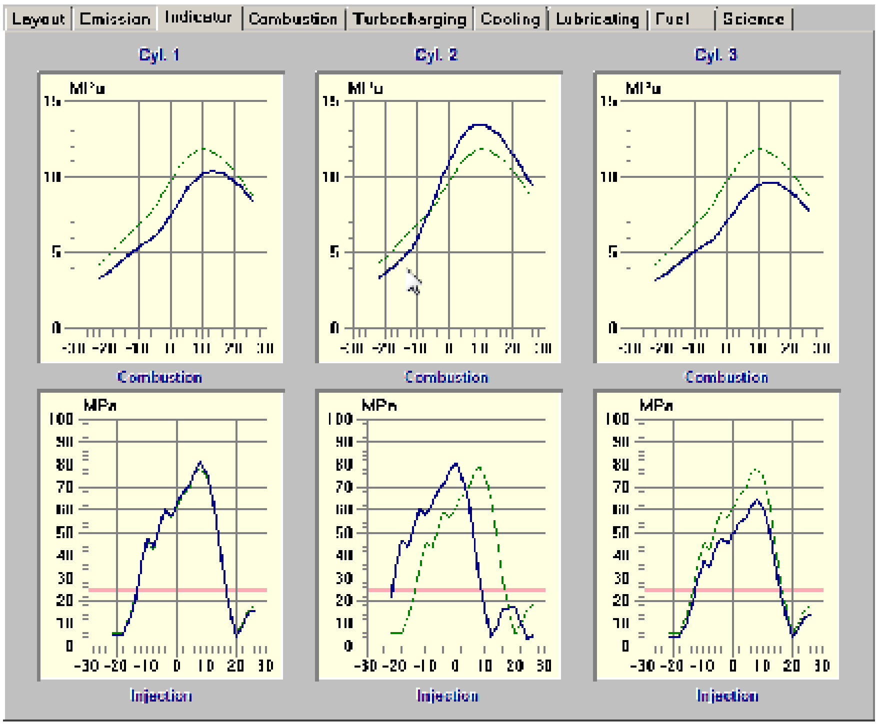


Fig. 3. Combustion and injection diagrams calculated for different faults (medium speed diesel engine Sulzer3AL25)

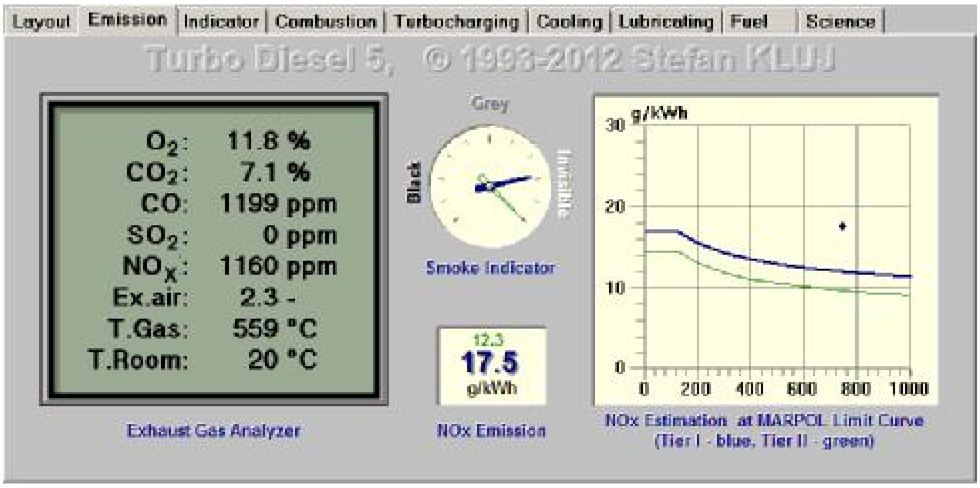
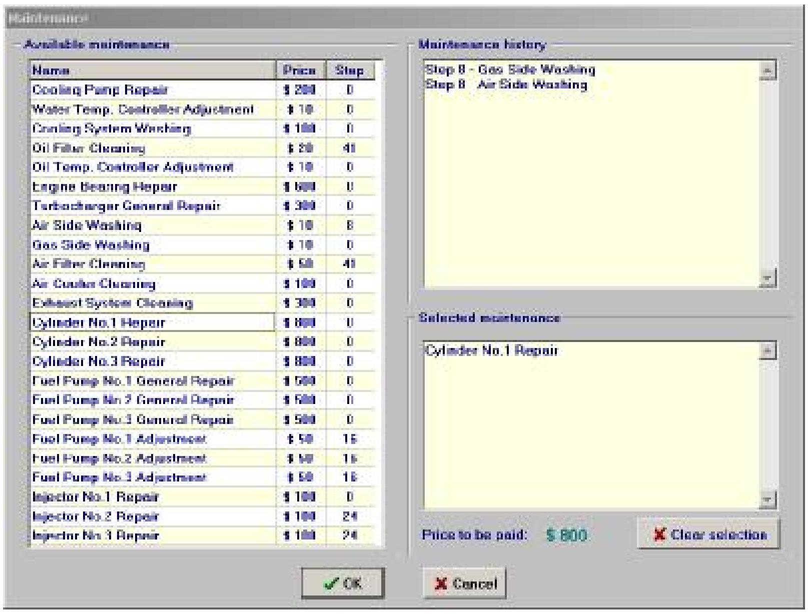


Fig. 4. Exhaust gas content simulation and its immediate evaluation in reference to MARPOL

Turbo Diesel 5 has three operation modes: Evaluation mode (default), Live Run mode and Replay Run mode.

The Live Run mode is the most interesting in terms of maritime training because the operator has to act as the qualified user against the computer with its dangerous situations, faults, etc. The trainee can freely inspect all the available engine parameters, perform maintenance and repair, and change the engine speed. Each maintenance and repair has its specific price (in US $) which the engineer has 'to pay' and which has to be deducted from the total income (Fig. 6).



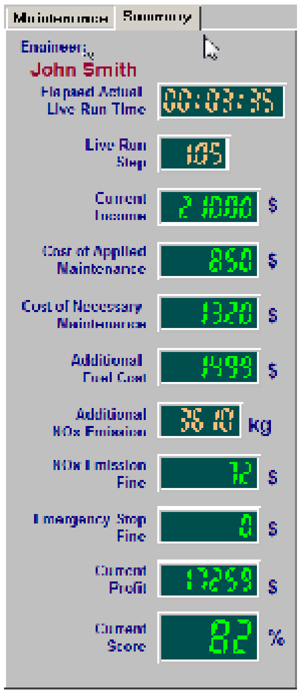


Fig. 5. The choice of available maintenance and repair with their prices

Fig. 6. Example of a Live Run current status

The present status of the Live Run can be seen in the Summary tab where the following information (Fig. 6) is presented, together with other data:

Current Income field shows Live Run Step number multiplied by an Income in a single Live Run Step, which is by default $200/day but can be changed at any time by a person with full rights (instructor) in the Options | Preferences dialog window. Increasing Step Income means that all Live Runs will be easier; decreasing it means that they will be more difficult (not recommended).

Cost of Applied Maintenance is the sum of the applied maintenance cost until the present. This cost depends only on the kind of applied maintenance (and its quantity). The cost of each maintenance cannot be changed.

Cost of Necessary Maintenance shows the cost of all maintenance that should be applied immediately and depends only on the current technical state.

Additional Fuel Cost is a cost of the additional fuel (i.e. over the normal consumption) burned since the beginning of a Live Run. This value depends on the MDO Fuel Cost, which can be changed in the Options | Preferences dialog window.

Additional NOx Emission displays the additional NOx in kg caused only by an improper engine technical state since the beginning of a Live Run. This value cannot be changed.

NOx Emission Fine is calculated by multiplying the Additional NOx Emission (in tons) by NOx Emission Fine in $/t. The NOx Emission Fine per ton can be customized in the Options | Preferences dialog window.

Emergency Stop Fine is calculated by multiplying the number of emergency stops (since the beginning of a Live Run) by the Emergency Stop Fine per single stop, which can be customized in the Options | Preferences dialog window.

Current Profit is calculated as follows: Current Income minus Cost of Applied Maintenance minus Cost of Additional Maintenance minus NOx Emission Fine minus Emergency Stop Fine.

Current Score shows the relation of the Current Profit to Current Income, shown in %. The Current Score must be higher than 60% in order to pass the assessment.

The current Live Run results (Fig. 7) will be saved automatically in the file and can be viewed or printed on request. The result also shows the evaluation of completed (premature or unnecessary) maintenance and required maintenance. This feature enables very precise debriefing of the Live Run and learning about proper engine operation, depending on its technical state.

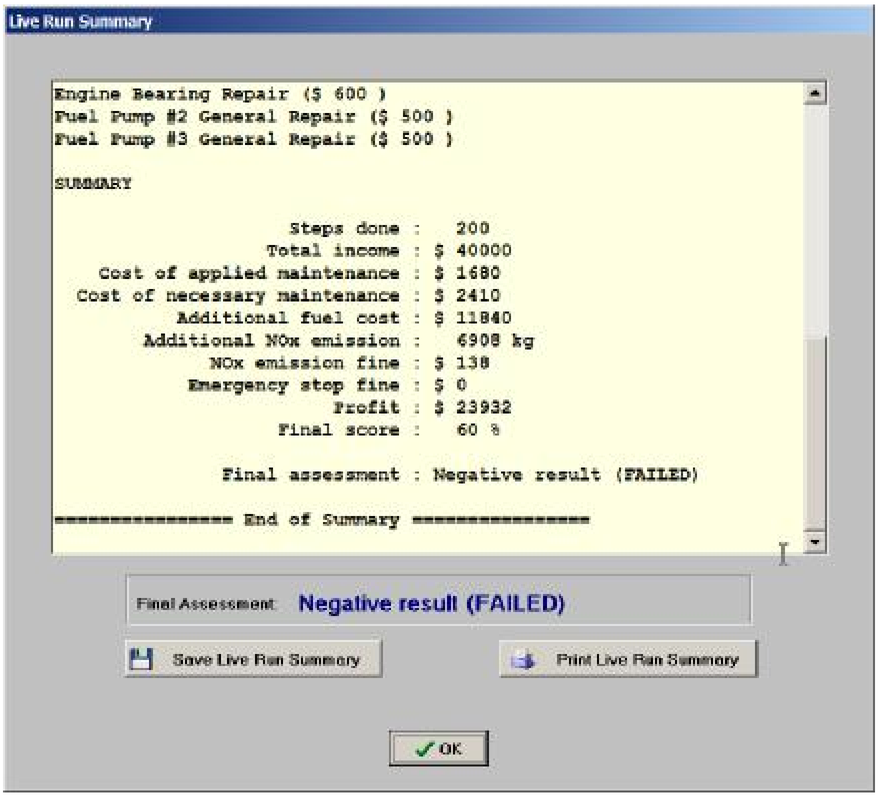


Fig. 7. Example of Live Run results

Turbo Diesel 5 can be considered as the new trend in engine room simulators. This means that operational accuracy will be enhanced but also that cost optimization and environment protection can be incorporated into training, which is especially important at management level.

5. Conclusions

Twenty years' presence of the engine room simulator market at ICERS is a good opportunity to summarize what was done in the past and what can be done in the future. It seems possible that future engine room simulators will be characterized not only by their high fidelity but also by providing the opportunity to try many different engine room operation strategies. Such analysis has been commonplace for those involved in research but now it may become a vital part of maritime training, especially at management level.

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