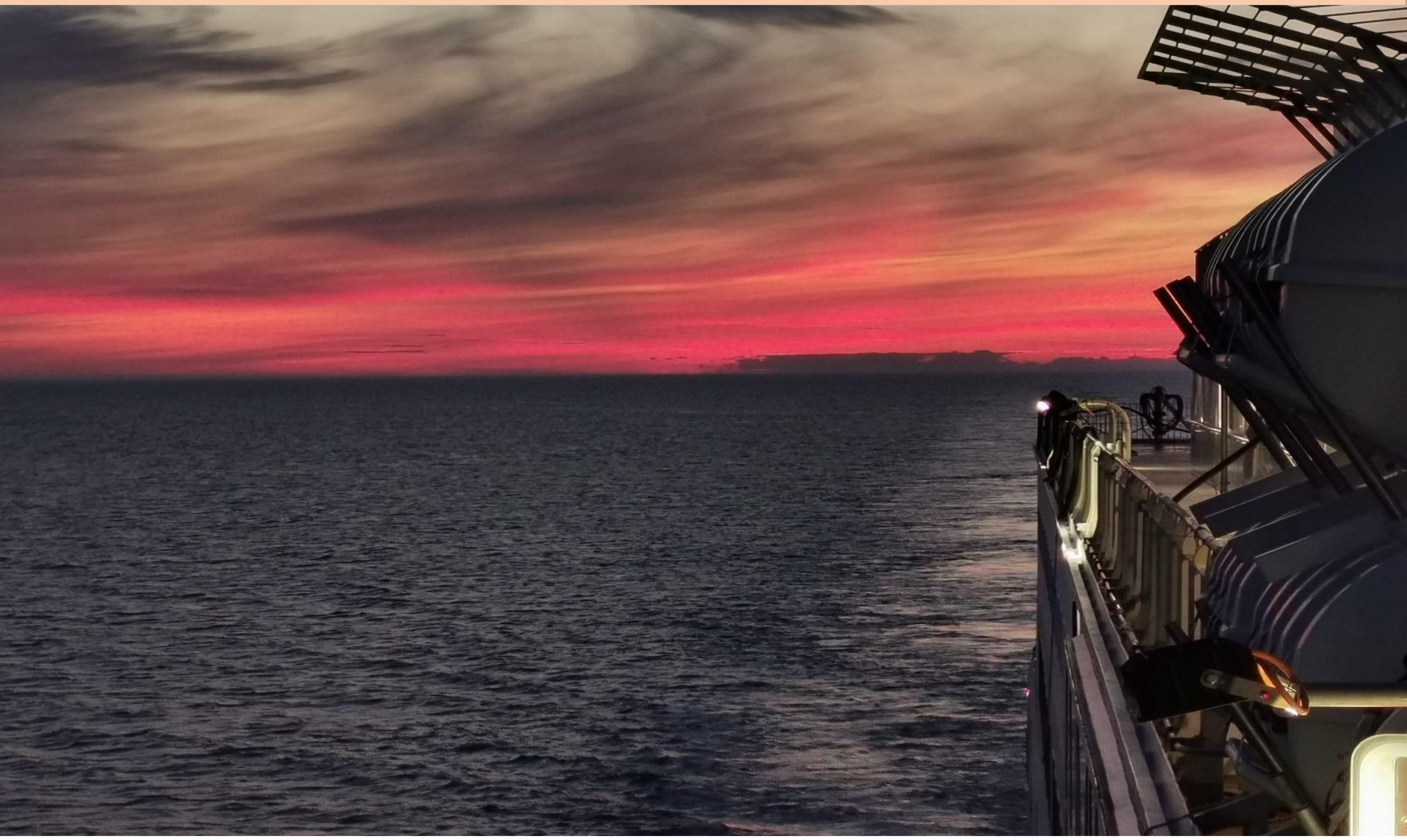
Co-funded by the Erasmus+ Programme of the European Union

MERSol

Maritime Engine Room Simulator on-line



CONTENT

INTRODUCTION

The shipping industry had been significantly affected by the COVID-19 pandemic, and whilst the biggest challenge is seen to be crew changes, the impacts of the COVID-19 pandemic on maritime education and training and the supply of qualified and certificated seafarers is a growing area of concern for the industry. Shipowners and operators need to pursue a close relationship with Maritime Education and Training (MET) institutions, and this would also be crucial when working towards the next comprehensive revision of the STCW Convention and Code.

The MERSol – project (Maritime Engine Room Simulator online) was invented due to Covid-19 that made face-to-face simulator lessons mostly impossible. It is a two-year ERASMUS+ project started at 1st June 2021 and lasting to 31st May 2023.

This proposal focuses mainly on the horizontal priorities of supporting individuals in the maritime sector to acquire and develop key competences. This will ensure them being more relevant to the labour market needs in terms of updating their education and training. MERSol study modules, assessment modules and specific software, ERS, will be provided not only as training for new Cadets but also as part of continuing education for already qualified seafarers; however, these are not the only priorities the proposal addresses, as the environmental priorities are addressed as well, respecting the novel global requirements. Furthermore, additional to the chosen priorities, gender equality and any kind of non-discrimination will be promoted, as the online simulation environment will make no differentiation between the genders, the age of users or any other identity or features related to a person.

The MERSol project is supporting the uptake of innovative approaches and digital technologies for teaching and learning. Taking into consideration the special conditions of the work at sea and the fact that many seafarers pass a lot of time far from the provision of training ashore, the MERSol project has been designed to provide all results on-line, using digital technologies. Although it is due more to a necessity than to a choice, it fully coincides with the Digital Education Action Plan, initiated by the European Commission.

1. AIMS AND OBJECTIVES OF THE ENGINE ROOM SIMULATOR TRAINING

Aims and objectives of this document are to introduce the main operations of Research Vessel MERSol Engine room, familiarize the Engine Room Instructor with engine room functions and the simulator, which imitates the ship's engine room facilities, control panels, valves and switches (illustration 1).

Illustration 1. Research Vessel MERSol is a deep-sea fisheries research vessel

The Research Vessel MERSol Engine Room Simulator (ERS) can be installed to a reasonably powerful Windows 10 computer. Windows 10 operating systems must be original and legal versions with latest updates installed.

Research Vessel MERSol ERS can be interconnected with Image Soft Full Mission Bridge Simulator enabling comprehensive ship maneuvering exercises. A classroom version with e.g. six student work stations and one instructor workstation is also configurable.

Generally, in Engine Room Simulator training following universal objectives can be listed:

1. Engine room equipment familiarization:

– familiarization with engine room systems, associated equipment and controls and simulation equipment;

– understanding the interdependency of the various machinery.

2. System layout and flow diagrams:

– understanding the operations and intricacies of machineries;

– preliminary theoretical knowledge of day-to-day operations and piping systems.

3. Monitoring and control systems:

– use of steering, controlling, and measuring systems in operation.

4. Automation:

– introduction to remote control, alarm and monitoring systems;

– practices for energy consumption and sustainable operations.

5. Emergency operations

– common safety practices and preparing for emergency situations.

6. Watchkeeping and troubleshooting:

– providing knowledge and skills to operate and monitor the safe operation and control of a ship's machinery installation.

7. Vessel resource management

– achieving safe engineering operations by managing personnel, equipment, and information by reviewing the team roles, human factors, and situational awareness.

However, to get started with the ERS training, following Research Vessel MERSol specific training objectives are to be implemented in the first phase. The scope of Research Vessel MERSol functions is defined with Engine Room Simulator Development tools.

2. RESEARCH VESSEL MERSOL SPECIFIC ERS FUNCTIONS

2.1. Propulsion plant. Main engines, Reduction Gear and CPP

Research Vessel MERSol propulsion plant is a twin medium-speed, Wärtsilä W20 1600kW, diesel engines with reduction gear and two controllable pitch propeller (CPP). Main engines are set to run in default rpm, and reduction gear acts as a switch to transmit the power to shaft & propeller at desired rpm. CPP further enables to finetune propeller blade pitches to reach a desired speed. To keep the ship positioned in changing wind and current Dynamic Positioning (DP) system takes over the control of reduction gear and CPP.

2.2. Seawater Cooling System

Fresh seawater is used as a cooling agent, within large cooled heat exchangers, the sea water is processed directly within the machinery, thereby cooling the system.

Research Vessel MERSol is equipped with a sea water cooling system with three pumps for the two main engines' central cooler and two pumps for the two auxiliary engines' central cooler.

2.3. Freshwater Cooling System

Research Vessel MERSol is supplied with two combined LT/HT cooling systems. Both main engine cooling systems consists of separate high temperature (HT) and low temperature (LT) circuits, which are cooled by sea water in the central cooler.

2.4. Fuel System

Research Vessel MERSol is equipped with fuel oil system with three feed pumps that feed marine diesel oil (MDO) for the main engines, and auxiliary diesel generators with built-in circulation pump and filter. There are two MDO day tanks. The fuel oil transfer system is designed to pump MDO fuel onboard from storage tanks to storage tanks and day tanks, or pumped ashore from storage and overflow tanks. One MDO separator is installed. The separation system is intended for constant flow single stage purification and connected for working alone in the fuel oil system.

2.5. Lubricating Oil Storage and Transfer

Lubricating oil (LO) storage and transfer system consists of bunkering, storage, transfer and separation of LO. At start the inlet and outlet side valves shall be opened and pumps started.

Filling the LO's of the main diesels is done by clean LO hand pump. Emptying of LO from main engines is provided by sludge oil pump. Both of the main engines have an independent LO separator that is automated, self-cleaning type.

2.6. Air Conditioning System

The model ship has three separate air conditioning systems. One system controls the freezer and cold room cooling and the other two systems maintain the temperature at the technical spaces such as engine control room and wheelhouse.

The system is now simulated as heat producing load, which is connected to seawater cooling system of auxiliary equipment. The basic operation is to switch it to on and off modes.

2.6.1. Refrigeration System

ERS simulates the freezer and cold room system by imitating the automated vapor-liquid compression cycle at the refrigeration plant's compressor, condenser, and evaporator. The refrigeration plant's compressor unit has a control panel that is located at engine room's second level at tween deck (illustration 2.1).

Illustration 2.1. Refrigeration plant control panel

2.7. Ventilation, Operating Fans and Dampers

Ventilation of Main Engine rooms: Two axial type supply fans are provided for ME-room, 11 m3/h each, 1500 rpm and with frequency converters. Fans are flexible mounted.

Damper must be open in normal operation to avoid vacuum in ME room.

Ventilation of other machinery spaces are thermostat driven and adjustable as such, however Research Vessel MERSol ERS focuses on operating on/off modes of ventilation only. Since machinery compartments have independent ventilation, opening / closing doors plays a role on the sea.

2.8. Start Air, Working Air and Instrument Air Systems

Research Vessel MERSol is equipped with two fully automatic compressors that deliver compressed air of 30 bar to the two starting air receivers, which serve both main engines and auxiliary diesel generators. Oil and water separators are built-on.

One working air compressor (9 bar) and one working air receiver (9 bar) are installed.

One instrument air dryer and one emergency air vessel for remote controlled valves are installed in engine room. Supply of instrument air-to-air dryer is provided from working air system. The air used must be cleaned, dry and oil-free to ensure that small lines, restrictions and nozzles will not be plugged by dirt, oil or water.

2.9. Quick Closing Valve System

The ship is equipped with a quick closing valve system. The purpose of the system is to quickly close critical valves on the ship's fuel and lubrication oil lines in case of an emergency. The quick closing valves are closed by releasing compressed air to the pipelines leading to quick closing valve pistons. The quick closing valves retain position after the actuation and must be opened manually.

The emergency actuation of the release groups is controlled using the quick closing valve control cabinet on the ship's engine control room (illustration 2.2.).

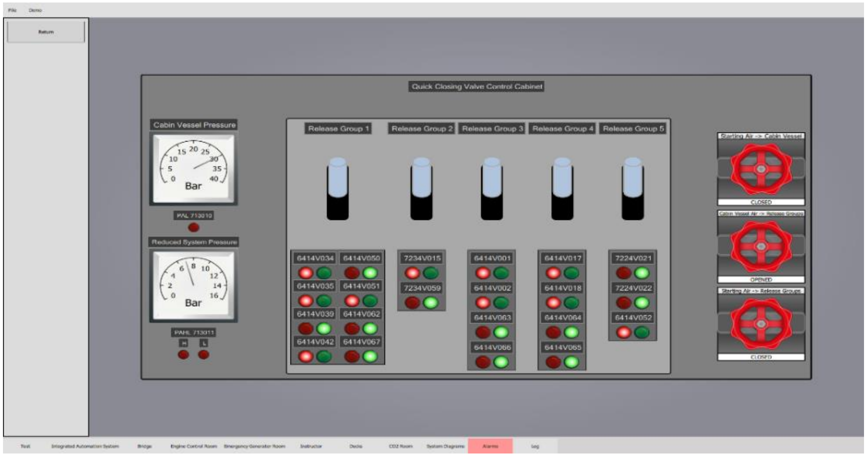


Illustration 2.2. Quick closing valve cabinet

2.10. Preheating of Engines

The starting procedure of marine engines requires several points related to electricity, air pressure and pumps that need to be taken into consideration in enabling a safe and sound start. One of them, preheating of engines, relates to fuel oil, cooling water and lubricating oil cycles, which all must be set to required temperatures before start in order to avoid possible malfunctions and damages to engines.

2.11. Electricity

Electricity is generated by generators on ships on the sea. On Research Vessel MERSol diesel operated auxiliary engines and shaft generator are in charge of electricity generation that is fed to all electricity circuits onboard, both technical and utility purposes.

2.12. Shore Power and Emergency Generator

Shore power is the source for electricity when the ship is docked, reducing air emissions and improving local air quality, but also saving fuel costs.

Energy on the sea is generated by auxiliary engines and shaft generators. In case the main power generation system on the ship fails, an emergency power system or a standby system is also present. Research Vessel MERSol hosts a diesel operated emergency power generator.

2.12.1. Main and Emergency Switchboard including fuses

Main switchboard (MSB) is an assembled unit of electrotechnical components. It is used for receiving, measuring and distribution of electrical energy, and protects the network from overload, short-circuit and current leak.

2.12.2. Auxiliary Engines

Auxiliary engines' function is to drive generators that generate electricity to engine room and to all electricity driven functions on the ship (deck machinery, navigation equipment, along with daily life demands of the crew onboard. Two auxiliary engines MAN D 2842 LE 301, with rated power of 532 kW at 1500 rpm. The generators connected to auxiliary engines are Leroy Somer, type LSAM 49.1 M 6, with output of 489 kW., 440 V, 1000 A, 50 Hz.

2.12.3. Shaft Generator

Shaft generator is by definition attached to main engine shaft to generate electricity without a dedicated auxiliary diesel engine. As such, it is an environmentally friendly technique to produce electricity, provided that the main engine(s) is running. In Research Vessel MERSol the two shaft generators supply power to the ship's network or bow thruster motor (driven by electricity only). The shaft generators are of type SF400L4(PTO) with rated power 969 kW at 1500 rpm. Shaft generators are connected to the main engines trough the reduction gear boxes.

2.12.4. Earth Fault

Earth fault is considered very critical on board a ship. Research Vessel MERSol features 24, 230 and 440V distribution circuits. At high 440 voltages earth faults are potentially highly dangerous to the crew, so they must be dealt with high priority. The source of the leakage must be identified, located and isolated, to which the ship's IAS (Integrated Automation System) system offers tools. The ship's IAS also helps manage situations, where critical maneuvering units must stay operational to avoid emergencies on the sea.

2.13. Bow Thruster

Research Vessel MERSol is equipped with one 450kW bow thruster with controllable pitch propeller (CPP). This controllable pitch propeller installation consists of a hub, propeller blades hydraulics and a remote-control system. Electrically driven hydraulic pump adjusts the propeller blade pitches by oil pressure. Bow thruster must be started with pitches at zero position (lever is in neutral position) and shifting the pitch shall be done gradually avoiding sudden changes in BT movement.

2.14. Alarm Log

Alarm log displays the alarm information emitted through the ship to the integrated automation system. Alarm log has layouts for active, acknowledged and resolved alarms.

2.14.1. Active Alarms

Alarms become active if the alarm's abnormal state is triggered. The number of active alarms is displayed in the simulator's header menu, and they are logged on the alarm menu. The alarm menu displays the alarm's name, description, threshold, date, and time.

2.14.2. Acknowledged Alarms

Active alarms can be acknowledged using the icon on the active alarm layout. Acknowledged alarms are not treated as active alarms on the header menu or action log. The time of alarm acknowledgement is logged in the alarm log.

2.14.3. Resolved Alarms

Active and acknowledged alarms become resolved if the alarm's abnormal state returns to normal. The time when abnormality returns to normal is logged in the alarm log. Resolved alarms are removed from the log if they become active again.

2.14.4. Alarm Names

Alarm name is a combination of a code and an identifier number.

Some alarm codes depend on context. The alarm description in the alarm log will clarify the meaning in these cases.

3. USING THE ONLINE ENGINE ROOM SIMULATOR

3.1. Installing the simulator

The installation package for this Simulator is provided as a self-extracting installation package. The package can be installed by double clicking on it in any modern Windows environment.

After clicking the installation is presented as below (illustration 3.1):

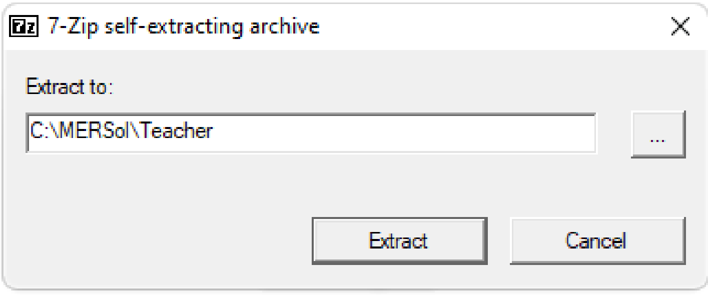


Illustration 3.1. Installation dialog

By selecting a folder for example C:\MERSol\Teacher as presented in the figure, the software will be installed into that folder.

3.2. Running the Simulator

To start the simulator, navigate to the folder that you installed the simulator using the file explorer.

Start the simulator by selecting the MERSol ERS.bat file and double clicking on it.

3.3. Activating the Simulator

First time a new installation of simulator is opened the program must be activated by Image Soft Oy staff.

To get the correct Activation Code for the installation. Copy the Site code and MID to an email and send it to *sami.ketola@imagesoft.fi* with the information that you have installed either teacher or student ERS client to your machine.

3.4. Logging in

After clicking on the file, you'll be presented with the following dialogue (Illustration 3.2):

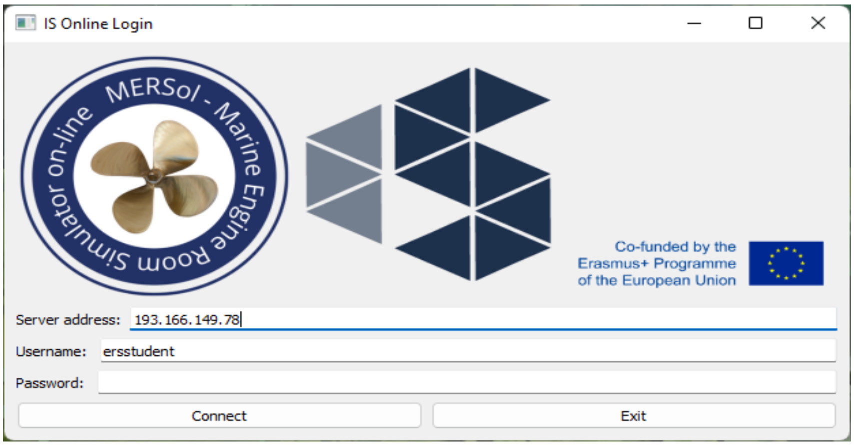


Illustration 3.2. Online Login dialogue for logging in to the simulator

Here you need to fill the Server address, username and password that have been given to you by the training organization or use the defaults if they're provided automatically by your custom installation package.

After giving the correct information to the form you should be ready to participate in the simulation exercise.

4. STUDY AND ASSESSMENT MODULES

The MERSol-project has developed new ship related, high class and up-to-date study modules followed with assessment study modules.

Modules are set in the Moodle-platform. For the testing purposes only one server is used so that all partners are using the same exercise, especially developed by project partners. When online technology is steady then there is a possibility to test usage of several servers simultaneously.

Modules are as following (table 1).

Table 1

List of study modules (Maritime Engine Room Simulator on-line application)

Study module	Topics	Develop	Check
Electricity	Electric motors (electric propulsion), electric power plant, diesel generator, emergency generator, shaft generator, shore connection, batteries, and fuel cells	KSMA	LMA
Steam, thermal oil, ventilation of machinery systems, air conditioning	Steam, thermal oil, ventilation of machinery spaces	PRU	LMA
Auxiliary systems 1	Fuel- and lubrication oil (bunkering, storage, transfer, purifying, feeding), exhaust gas scrubbers- cooling (sea water, LT & HT), starting air, air pressure systems	LMA	KSMA
Auxiliary systems 2	Bilge (main bilge, oily bilge), ballast water treatment, fire protection systems (water fire extinguishing, CO2)	LMA	PRU
Operations of engine	Monitoring, controlling, automation	PRU	SAMK
Water systems	Fresh water, technical water, water production	KSMA	PRU
Connection to deck systems and bridge connection	M/S MERSol connections to deck and bridge through classification notations.	SAMK	SPIN
Vocabulary (with explanation)	Vocabulary from modules 1-7	ALL	

Designing and developing the study modules and assessment modules on a specific e-learning delivery platform allows cadets and seafarers to access the training programme and learning materials over the Internet at any time and any place. This is particularly relevant in the Maritime sector where seafarers are highly mobile and have less opportunity to take long face-to-face training courses whilst they are working.

During the application phase topics of the modules were set and at the beginning of the project only small adjustment was done but all main topics kept unchanged. In the beginning of the project study and assessment roles were agreed among the project taking the best expertise into consideration and the first commenting partner set.

Totally 35 online partner meetings took place concerning these modules and partners in question of each module had several of their own several online meetings. UPC was the final approver of each module.

When material was transferred into the Moodle-platform some photos and figures had to be reloaded as the quality was not at acceptable level so original photos and figures were used. Also typing was checked. Feedback was collected in multiplier events arranged in Klaipeda, Barcelona, Portoroz, Rauma and Helsinki.

Due to the Russian attack on Ukraine on 24th of February 2022 project on-line meetings became very sensitive and other partners could only show their full support to the brave Ukrainian partners. One multiplier event was planned in Kherson but due to the situation in Ukraine it was firstly planned to arrange in Odessa but soon found out that also impossible so agreed with the financer, Finnish National Agency of Education (Opetushallitus, (OPH)), that this multiplier event will be shared with all the other partners.

Terrible earthquake in Turkey was the following accident changing the final conference from Istanbul to Helsinki, approved by OPH. Multiplier event was planned to take place during major maritime expo, Expomaritt Exposhipping İstanbul – 17. International Fair’ ensuring hundreds of participants due the expo.

5. PROCESS FLOW-CHART

The development of the online engine room simulator followed a structured process flow, which can be broken down into the following key stages:

1. *Conceptualization and planning.* Identifying the objectives, scope, and requirements of the online engine room simulator, and creating a high-level project plan.

2. *Collaborative design.* Engaging with maritime schools, subject matter experts, and stakeholders to design the simulator's features, functionality, and learning content.

3. *Technical development.* Building the cloud-based software and user interface for the online engine room simulator.

4. *Testing and refinement.* Conducting rigorous testing and refinements of the simulator, incorporating feedback from users and stakeholders to ensure optimal performance and reliability.

5. *Implementation and integration.* Working closely with maritime schools to integrate the simulator into their training curricula and providing support for user onboarding and training.

6. *Evaluation and continuous improvement.* Collecting and analyzing data on the effectiveness of the simulator, identifying areas for improvement, and implementing enhancements based on user feedback and industry best practices.

Development stages

The development of the online engine room simulator can be further divided into the following stages:

1. *Requirements gathering.* Engaging with stakeholders to understand their needs, expectations, and the desired outcomes for the simulator. This stage involved in-depth discussions with maritime schools, subject matter experts, and industry representatives to identify the key requirements and constraints for the project.

2. *Content development.* Collaborating with subject matter experts to develop the learning content and scenarios for the simulator, ensuring that the material aligns with

industry standards and regulations, and addresses the unique needs of maritime training.

3. *Software and infrastructure development*. Creating the cloud-based infrastructure, as well as developing the software and user interface for the simulator. This stage involved selecting the appropriate technologies, tools, and platforms to support the project's objectives and ensure scalability, reliability, and ease of use.

4. *Quality assurance and testing*. Conducting extensive testing of the simulator to identify and address any technical or performance issues, as well as soliciting feedback from stakeholders and users to refine the learning content and functionality.

5. *Deployment and integration*. Collaborating with maritime schools to deploy the simulator and integrate it into their training programs, providing support for user onboarding, training, and ongoing maintenance.

6. *Monitoring, evaluation, and improvement.* Collecting data on the simulator's performance and user outcomes, analyzing the results to identify areas for improvement, and implementing changes based on feedback and industry best practices.

Technology and software

The development of the online engine room simulator involved the use of a variety of technologies, software, and tools, including:

1. *Cloud-based infrastructure*. To support the scalable, accessible, and reliable delivery of the simulator, a cloud-based infrastructure was utilized. The cloud-based infrastructure supports simulation software, user identification and communication.

2. *Simulation software*. Specialized software was used to create high-fidelity, physics-based simulations of engine room operations, ensuring a realistic model of the simulated ship. The simulation software also handles the training scenarios.

3. *User identification software*. The software for identifying the simulator users was created. Each trainee is assigned with a unique identifier and simulator station on connecting the cloud-based simulation server. The responses from the cloud-based server are arranged using the above-mentioned credentials.

4. User interface. User interfaces were created for both trainees and instructors. Instructor interfaces contain the modules for controlling the simulation. Instructor interfaces display the online trainees and offer functions for controlling the simulator usage. Trainee interfaces contain the essential controls for operating the simulated ship systems.

5. Communication. Communication between simulator users and cloud-based server was established. Cloud-based simulation software sends simulation status changes to online users. User interfaces that visualize the simulated ship constantly listen to and display the attributes evaluated by the physic-based model of the simulated ship.

6. Low-latency data transmission protocols. To ensure real-time interaction and responsiveness in the simulator, low-latency protocols were implemented for data transmission between the user's device and the cloud-based server.

6. RECOGNIZED CHALLENGES

The MERSol project is designed to provide realistic training for marine engineering students and professionals. Some recognized challenges that this project may face include:

Technical challenges

1. Ensuring stable and reliable connectivity for all users. This issue was exacerbated by the fact that maritime trainees are often located in remote areas with limited Internet infrastructure. To address this, we implemented better connectivity handling and saved the state of the simulation on the server and also optimized the simulator's bandwidth usage.

2. Latency. The migration to the cloud introduced additional latency due to the increased distance between users and the server hosting the simulation. To minimize latency, we suggest using Content Delivery Networks (CDNs) to distribute the simulator's resources closer to the users and implemented low-latency protocols for data transmission.

3. Ensuring consistent server reliability. Frequent server downtime or performance issues could have severe consequences for training schedules and user satisfaction. To address this issue, we suggest adopting a multi-server architecture with automatic failover mechanisms, which would ensure that if one server encountered issues, the system would automatically switch to another server, maintaining the simulator's availability. Geographic issues arose due to the diverse locations of users and institutions participating in the online engine room simulator training.

Pedagogical challenges

1. Finding the right balance between theoretical knowledge and practical skills.

Although the online simulator provides an interactive environment for learning engine room operations, it is essential to ensure that trainees also gain a strong theoretical foundation. To address this challenge, we worked closely with maritime school partners to integrate the simulator into a comprehensive curriculum that combined theoretical lessons with practical exercises in the simulated environment.

This allowed trainees to apply their theoretical knowledge in real time, enhancing their understanding of the subject matter and developing their practical skills simultaneously.

2. *Maintaining trainee engagement and promoting active learning was another challenge we faced.* The online nature of the simulator could potentially lead to trainees becoming passive observers rather than active participants. To overcome this, we collaborated with our maritime school partners to design engaging learning activities and scenarios within the simulator.

3. *Accounting for the diverse learning needs and preferences of trainees*. To address this, we worked with our maritime school partners to develop a flexible and customizable learning environment that could cater to individual trainee needs. By incorporating a range of learning resources the trainees can focus on the areas where they needed the most improvement.

4. *The ability to assess trainee progress and provide meaningful feedback.* This was another challenge we faced, as traditional assessment methods may not be easily applicable in an online simulation environment.

Industry-specific challenges

1. *Ensuring that the online simulation provided an accurate and realistic representation of actual engine room operations.* This required close collaboration of the maritime school experts and engineers to develop a simulator that captured the nuances and intricacies of real-world engine room operations. In the end we succeeded at refining the simulations based on the feedback to ensure that the experience closely mimicked the behavior of actual equipment.

2. *The need to provide trainees with hands-on experience in operating engine room equipment.* Although the online simulator offered an immersive environment, it could not fully replicate the tactile sensations associated with physically manipulating machinery. This would need to be mitigated in the future by having the online training supplemented by the hands-on training on the actual equipment.

3. *The need to comply with stringent industry standards and regulations*. To meet

these requirements, the simulator must follow the established guidelines, such as the IMO's Standards of Training, Certification, and Watchkeeping (STCW).

4. The integration of our online simulation with existing maritime training curricula. This close collaboration with maritime schools is required to identify possibilities in their current programs, as well as different opportunities to enhance learning outcomes through the use of our online engine room simulator.

7. SWOT-ANALYSIS OF THE MERSol PROJECT

To comprehensively analyze the work of the Engine Room Simulator and to clarify how the changes in physical lectures, workshops, simulators and other practical classes that arose amidst COVID-19 pandemic would affect the evolution in the long term, a strengths, weaknesses, opportunities, and threats (SWOT) analysis was performed in this project discussions as well as related research results.

Strengths, weaknesses, opportunities, and threats of the MERSol project are listed in the table 7.1.

Table 7.1

SWOT-analysis of the MERSol project

Strengths	***Weaknesses***
1. Flexibility and accessibility	1. Limited Tactile Experience
2. Cost-effectiveness	2. Dependence on Stable Internet Connectivity
3. Scalability	3. Technological Learning Curve
4. Customizable Learning Experiences	4. Integration with Existing Curricula
5. Realistic Simulation Environment	
Opportunities	***Threats***
1. Expansion into New Markets	1. Traditional Training Heritage
2. Technological Advancements	2. Regulatory Challenges
3. Collaborations and Partnerships	3. Technological Obsolescence
4. Increasing Adoption of Online Learning	4. Cybersecurity Risks
5. Innovative and attractive training solution	5. Economic Uncertainties

Strengths of the MERSol project:

1. Flexibility and accessibility. The engine room simulator is flexible enough to accommodate different training needs and scenarios. It allows instructors to customize training programs and scenarios to suit different training requirements. The online nature of the engine room simulator allows trainees and maritime schools to access the training platform from anywhere, at any time, providing unparalleled flexibility and convenience.

2. Cost-effectiveness. The simulator helps reduce the costs associated with traditional maritime training, such as travel expenses, accommodation, and physical training facilities, making it an attractive option for schools and trainees alike.

3. Scalability. The cloud-based infrastructure of the simulator enables it to accommodate a large number of trainees simultaneously, allowing for easy expansion and adaptation to meet the growing demands of the maritime industry.

4. *Customizable learning experiences.* The simulator offers a range of learning resources, adjustable difficulty levels, and personalized learning paths, catering to the diverse needs and preferences of trainees.

5. *Realistic simulation environment.* The high-fidelity physics-based simulations provide trainees with an immersive and authentic learning experience, closely replicating real-world engine room operations.

Weaknesses of the MERSol project:

1. *Limited tactile experience.* The online simulator cannot fully replicate the hands-on experience of physically interacting with engine room machinery, which may affect the development of practical skills.

2. *Dependence on stable internet connectivity.* The effectiveness of the simulator relies on stable internet connectivity, which may pose challenges for trainees in remote areas or with limited infrastructure.

3. *Technological learning curve.* The simulator requires trainees to be proficient in using digital technology, which may present a learning curve for some individuals, particularly those with limited experience in using online learning platforms.

4. *Integration with existing curricula.* Seamlessly integrating the online simulator with existing maritime training curricula may be challenging for some institutions, requiring close collaboration and adaptation.

Opportunities of the MERSol project:

1. *Expansion into New Markets.* The online engine room simulator has the potential to be utilized not only in the maritime industry but also in other sectors, such as electricity engineering, environmental fields, civil engineering, healthcare, and social services.

2. *Technological Advancements.* As technology continues to evolve, there are opportunities to further enhance the simulator's features and capabilities, such as integrating virtual reality (VR) or augmented reality (AR) components to create even

more immersive learning experiences.

3. *Collaborations and partnerships.* By forming strategic partnerships with maritime schools, industry stakeholders, and technology providers, the simulator can continue to evolve and address the changing needs of the maritime training landscape.

4. *Increasing adoption of online learning.* As more educational institutions recognize the benefits of online learning, there is a growing opportunity for the online engine room simulator to become an integral part of maritime training programs worldwide.

5. *Innovative and attractive training solution*. Gamification is a popular technique used in online learning to engage learners and motivate them to participate actively in the learning process. In an engine room simulator online project, gamification can be used to create interactive scenarios, leaderboards, rewards, and badges that encourage learners to complete training modules and assessments.

Threats of the MERSol project:

1. Traditional training heritage. Traditional maritime training providers may view the online engine room simulator as too novel learning tool, leading to resistance or reluctance to adopt the new technology.

2. Regulatory Challenges. Ensuring compliance with stringent industry standards and regulations, such as those set by the International Maritime Organization (IMO) and various classification societies, may present ongoing challenges for the simulator.

3. Technological Obsolescence. Rapid advancements in technology may require constant updates and improvements to the simulator to ensure it remains relevant and effective in the fast-paced digital landscape.

4. Cybersecurity Risks. As an online platform, the engine room simulator may be susceptible to cybersecurity risks, requiring robust security measures to protect user data and the integrity of the system.

5. Economic Uncertainties. Fluctuations in the global economy or changes in the maritime industry could impact the demand for maritime training, affecting the adoption and success of the online engine room simulator. By understanding our project's strengths, weaknesses, opportunities, and threats, we can make informed decisions about the future development of the simulator, address existing challenges, and capitalize on emerging opportunities. This will enable us to continue providing a high-quality, engaging, and effective learning tool for the maritime industry and beyond.

By conducting a SWOT analysis, we have identified the key strengths, weaknesses, opportunities, and threats associated with our online engine room simulator. This analysis provides valuable insights into the areas where we excel, areas that need improvement, and potential avenues for growth and development.

8. BEST PRACTICES

This chapter discusses the best practices employed in the development and implementation of the online engine room simulator, focusing on consortium; curriculum design, collaboration between institutions and subject matter experts (SMEs), assessment and feedback mechanisms, and the importance of continual improvement and adaptation.

1. Consortium

Consortium in MERSol project is a group of organizations working together to develop and implement the simulator. There are several advantages to using a consortium for MERSOl project. These include:

➢ *Shared resources*. By pooling their resources, consortium members can share the costs and workload of developing the simulator. This makes the project more affordable and allows for more extensive testing and development.

➢ *Access to expertise*. A consortium brings together experts from different fields, such as software development, maritime training, and engine room operations. This gives a result in a more comprehensive and effective simulator.

➢ *Increased credibility*. By having multiple organizations involved in the project, the simulator gains increased credibility and recognition in the industry.

➢ *Collaboration*. A consortium encourages collaboration and cooperation among its members, which can lead to better communication and more efficient development processes.

➢ *Flexibility*. Consortium is designed to allow for flexibility in the development process, which are useful when dealing with unexpected challenges or changes in the project scope.

2. Curriculum design

A crucial aspect of the online engine room simulator's success is its integration into a comprehensive maritime training curriculum. The following best practices were followed in the design process:

➢ *Aligning with industry standards and regulations*. Ensuring that the software meets curriculum requirements set by the International Maritime Organization (IMO), the Standards of Training, Certification, and Watchkeeping (STCW), and other relevant authorities.

➢ *Balancing theoretical knowledge and practical skills*. Integrating the simulator into a curriculum that combines theoretical lessons with practical exercises, allowing trainees to apply their knowledge in real-time and develop their practical skills simultaneously.

➢ *Customizing learning experiences*. Creating a flexible and adaptable learning environment that caters to the diverse needs and preferences of trainees, offering various learning resources, adjustable difficulty levels, and personalized learning paths.

3. Collaboration between institutions and SMEs

The development and implementation of the online engine room simulator relied heavily on the collaboration between maritime schools, subject matter experts, and industry stakeholders. The following best practices were employed:

➢ *Engaging stakeholders early in the development process*. Involving key stakeholders from the conceptualization stage ensured that their insights and expertise were considered throughout the design and development process.

➢ *Establishing clear communication channels*. Maintaining open and transparent communication with all partners facilitated the sharing of ideas, feedback, and concerns, leading to better software design outcomes.

➢ *Fostering a culture of collaboration*. Encouraging teamwork, knowledge sharing, and mutual support among all parties involved in the project created a positive working environment that contributed to the overall success of the simulator.

4. Assessment and feedback mechanisms

Effective assessment and feedback mechanisms are essential for evaluating trainee progress and providing meaningful guidance to enhance their learning experience. The following best practices were followed:

➢ *Regularly reviewing and updating learning content*. Ensuring that the learning content remains current and relevant by incorporating new developments, regulations, and industry best practices.

- *Embracing technological advancements*. Adopting emerging technologies to enhance the simulator's features and capabilities and create more immersive learning experiences.
- *Encouraging user feedback and participation*. Actively seeking input from trainees, instructors, and stakeholders to identify areas for improvement and implement changes that enhance the user experience and the simulator's effectiveness.

By following these best practices in curriculum design, collaboration, assessment, and continuous improvement, the online engine room simulator can provide a high-quality, engaging, and effective learning experience for trainees and support the maritime industry's ongoing training needs.

ABOUT THE AUTHORS

The project involves five relevant HEIs (Higher Education Institutions) and two SMEs across EU and in Ukraine, each bringing expertise required to implement the work programme. Skills, expertise, and management support from each partner are clearly identified in the proposal. The role of the SMEs is vital in the technical expertise and development of the online version of the simulator Associated partners include stakeholders relevant to the field.

Satakunta University of Applied Sciences (SAMK) from Finland had the leading role to set the consortium, as this project application was sent to Finnish National Agency for Education, Opetushallitus. SAMK invited maritime training partners from Lithuania, Lietuvos aukstoji jureivystes mokykla (Lithuanian Maritime Academy, Klaipeda), Spain, Universitat Politecnica de Catalunya (Nautical Studies of Barcelona) Turkey, T. C. Piri Reis Universitesi (Maritime University of Piri Reis, Istanbul) and Ukraine (Kherson State Maritime Academy, Kherson) to join as marine engineering specialist. Two SMEs were invited as well; simulator manufacturer Image Soft Ltd. from Finland, and online teaching tool specialist Spinaker proizvodnha trgovina in trzenje doo from Slovenia. Some of the project partners have already shared ERASMUS+ projects for nearly 20 years, and some had had previous bilateral cooperation, but also new partners in ERASMUS+ were in the consortium, which was then found strong to prepare the actual application.

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