Progress on the Pilot Project 1 until 31.12.2023. (M7-M12)

Improved fire evacuation VR model of a ship engine room

CHALLENGE! To provide an improved, more realistic, albeit safer environment for onboard firefighting training.

HOW? By building a fire scenario in a virtual reality (VR) environment of a ship engine room (ER) based on fire spread results obtained by computational fluid dynamics (CFD) analysis.

WHY? The problem with the current VR models is that the fire is modelled rudimentary, i.e. as a concentrated flame that does not spread, making users less susceptible to the stimulus.

FINAL RESULT→ Functional VR model of fire spread in ship ER, reaching TRL4/TRL5.

GOALS FOR INNO2MARE PROJECT: To advance maritime fire safety and to digitalize the maritime education and training (MET) process.

PROGRESS ON ACTIONS:

Action	Start-End	Accomplished
1. State-of-the-art literature review, existing solutions analysis, mapping research gaps solutions	M1-M3	Yes
2. Selection and design of a representative ship ER	M1-M3	Yes
3. Building a VR model of ER	M4-M6	Yes
4. Developing and defining fire scenarios	M7-M9	Yes
5. CFD modelling of fire spread in ER	M10-M12	Yes
6. Implementing CFD analysis results in VR model	M12-M18	Not started
7. Testing of improved VR model	M19-M30	Not started
8. Equipment procurement & subcontracting	M3-M6	Yes
9. Dissemination	M1-M48	Ongoing

In the following, more details are given on every action performed.

1. <u>State-of-the-art literature review, existing solutions analysis, mapping research gaps solutions</u>

Please see Progress on Pilot Project 1 until 30.06.2023 (M1-M6).

2. <u>Selection and design of a representative ship ER</u>

Please see Progress on Pilot Project 1 until 30.06.2023 (M1-M6).

3. <u>Building a VR model of ER</u>

Please see Progress on Pilot Project 1 until 30.06.2023 (M1-M6).

4. <u>Developing and defining fire scenarios</u>

Previous studies on ship engine room fires focused on pool fires, while leaked liquid fuel tends to form dynamically evolving spill fires, which are scarcely investigated. To enter the simulation procedure, a fire on the main engine fuel oil pipeline is chosen for the first scenario. The origin of the fire is placed on the boundary of one of the two main engines, with dimensions of 0.76x0.75x0.33 meters, which is represented in Figure 1 as a red block. The origin of the fire is also given in Figure 3.1.1. It should be noted that the software limitations prevent the fire from being located inside the 3D object that represents the engine, so this solution was chosen to place it at the very boundary of the object. Fire is defined as a simple fire and fuel generation is calculated by expression $P = Ct^2$, with constant $C = 6e^{-7}$, and scenario being run for a period of $t = 600$ s. The other two scenarios involve common cases of fires on the fuel oil purifiers and in a bucket containing oily rags.

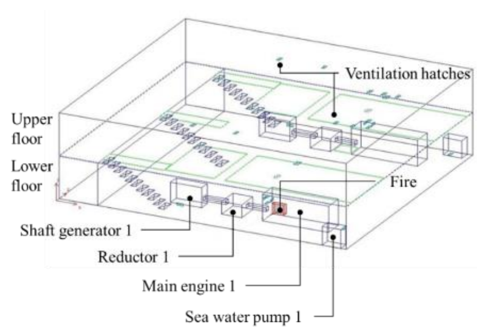
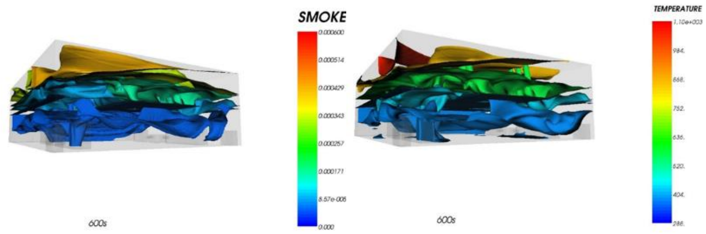


Figure 1: 3D model of the ER.

5. <u>CFD modelling of fire spread in ER</u>

For CFD modelling, the layout of the engine room was slightly simplified. The changes make less than a 1% difference in overall area but contribute significantly to the cell economy of the CFD simulation. All the machinery is replaced with cuboids of similar size, Figure 2. Ventilation inlets/outlets are added across the room according to the technical specifications. Creation of geometry, meshing with finite volumes and fluid dynamics analysis were all performed in the CFD software Smartfire, specifically designed for the modelling and simulation of fire. Interactive meshing procedure within the software resulted in a refined mesh of 607.600 “brick” type cells. During the procedure, several mesh sizes were tested, from 200.000 cells up to 2.000.000 cells being used. Simulation with 200.000 cells ran for six hours, while the one with 2.000.000 cells ran for 50 hours. Mesh size of 200.000 cells resulted in rough final images that were hard to comprehend. Mesh size was gradually refined, but no further change in the results was noticed after the mesh size of 607.600 cells. It was, hence, chosen as optimal regarding required process time and the accuracy of results. This simulation ran for about 30 hours using a multi-core processor of 3.00 GHz with 128GB of RAM.



a) b)

Figure 2: CFD analysis results presented at the last time step (600 s) in the form of iso surfaces representing: a) smoke, b) temperature.

6. <u>Implementing CFD analysis results in VR model</u>

Not yet started.

7. <u>Testing of improved VR model</u>

Not yet started.

8. <u>Equipment procurement & subcontracting</u>

Please see Progress on Pilot Project 1 until 30.06.2023 (M1-M6).

9. <u>Dissemination</u>

The following papers have been published in international scientific journals or conference proceedings:

1. Vukelić, Ogrizović, Bernečić, Glujić, Vizentin. Application of VR Technology for Maritime Firefighting and Evacuation Training-A Review, *Journal of marine science and engineering*, 2023.
2. Glujić, Bernečić, Vizentin, Vukelić, Orović. CFD fire modelling in a virtual ship engine room, *3rd International Conference of Maritime Science & Technology,* Dubrovnik, 2023.
3. Vizentin, Glujić, Vukelić; Bernečić, Ogrizović. Coupling CFD and VR for Advanced Fire Training in Ship Engine Room, *International Association of Maritime Universities (IAMU) Conference,* Helsinki, 2023.