Application

Maritime Research

Selection of subcategory:

☐ Management, finance & governance

☐ Operational optimisation

☐ Climate & environment

☒ **Health & safety**

Brief description of applicant (university/institution)

DFDS is a Danish shipping company that operates a shipping and logistics company in XXX. DFDS' route network involves operating more than 75 ships, of which DFDS owns the majority on over 25 routes with over 550 ship journeys per week, as well as owning and operating eight port terminals adjacent to these. At sea, DFDS primarily transports cargo and also transports passengers on selected routes.

Brief descriptive headline for the project

Alarm management practices at sea: existing challenges and possible solutions.

Summary of the essence of the project

The main purpose of the project is to investigate existing challenges in alarm management practices in the maritime sector and screen for possible solutions. Several accident reports have highlighted that the quantity and quality of alarms are often more of a burden than a benefit. With the development of green fuels, this is expected to become an increasing problem. The project will examine how alarm management practices at sea can be improved; in particular how the time response of safety actions can be used as a design criterion in the validation of alarm systems. To this end, the project will use full-mission simulators as an exploratory testing environment.

DFDS LR AAMS FMS ITU

Brief project description (understandable by non-professionals)

Background:
By now there are numerous examples of maritime accident reports in which existing alarm management practices, the quantity of alarms and the quality of alarm systems in particular, are judged to be more of a burden than a benefit (see e.g. the Danish Maritime Accident Investigation Board's accident reports for Stena Scandica 2022 and Emma Maersk 2013). With the development of green fuels, this is expected to become an increasing problem. Due to the chemical nature of the fuels, the latency times and consequences are significantly higher. In adjacent industries, such as nuclear power and the process industry, there are already examples of international standards that set requirements for the quality of alarms, especially the response times associated with them. Although these standards have been used for years with great success, similar standards are still lacking in the maritime industry.

Project:
Based on relevant alarm standards already in place for maritime-adjacent industries, this project will investigate how alarm management practices at sea can be improved; in particular, how the time response of safety actions can be used as a design criterion in the validation of alarm systems. For this purpose, the project will utilise state-of-the-art, full-mission simulators as an exploratory testing environment.

Expected results:
First and foremost, the project is expected to contribute new knowledge regarding current problems and potential solutions in alarm management practices at sea, thereby propelling the maritime industry to move closer to establishing widely recognised technical commonalities and standards. Specifically, the project will seek to assess the extent to which alarm standards from relevant adjacent industries can be used in the maritime industry; full-mission simulators can be used as a scientific method to develop and validate the transferability of adjacent-industry standards to the maritime industry; and the "timeliness" of alarms (timeliness criterion) can be established using scalable methods for predictable safety events at sea.

Detailed project description

What is the purpose of the project?

The main purpose of the project is to examine existing challenges in alarm management practices in the maritime sector and screen for possible solutions by validating a possible ”process transfer” of alarm management practices from relevant adjacent industries to the maritime industry. There will be a specific focus on individual aspects of the alarm rationalisation itself—i.e. what is the rationale behind a given alarm. In addition, the project has sub-purposes to:

A. Examine the extent to which alarm standards from relevant adjacent industries can be used in the maritime industry;
B. Examine the extent to which full-mission simulator testing can be used as a satisfactory approach to the validation of alarm standard(s) in the maritime industry; and
C. Examine the extent to which the time response criteria for safety events can be met under current maritime alarm management practices.

What is the background of the project?

Internal studies by Lloyd’s Register show that seafarers on watch receive a large number of alarms and that many of these alarms are of too poor quality to make a positive difference in the operation. In fact, it is reasonable to deduce that the high number of alarms is a decidedly distracting influence and thus a dangerous risk to the crew, the ship and the environment (Lloyd’s Register found examples of ships with more than 20,000 annunciated alarms in a single day, rates at which watchkeepers cannot even accept or acknowledge all of them (Figure 1) (Figure 2)). There is currently no maritime regulatory framework that sets criteria for how well all these alarms must work collectively on board throughout the lifetime of the ship. While other industries have successfully implemented alarm management for decades, it has yet to be implemented successfully in the maritime industry.

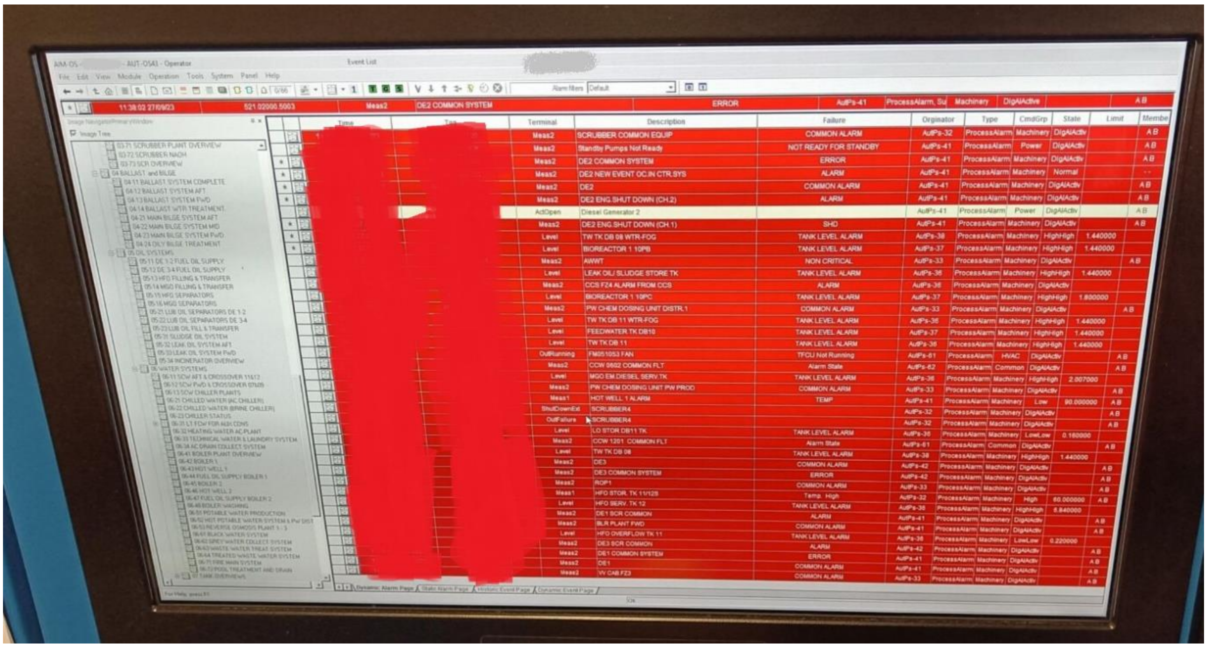

Figure 1. Alarm display on a ship visited by Lloyd's Register in the autumn of 2023.

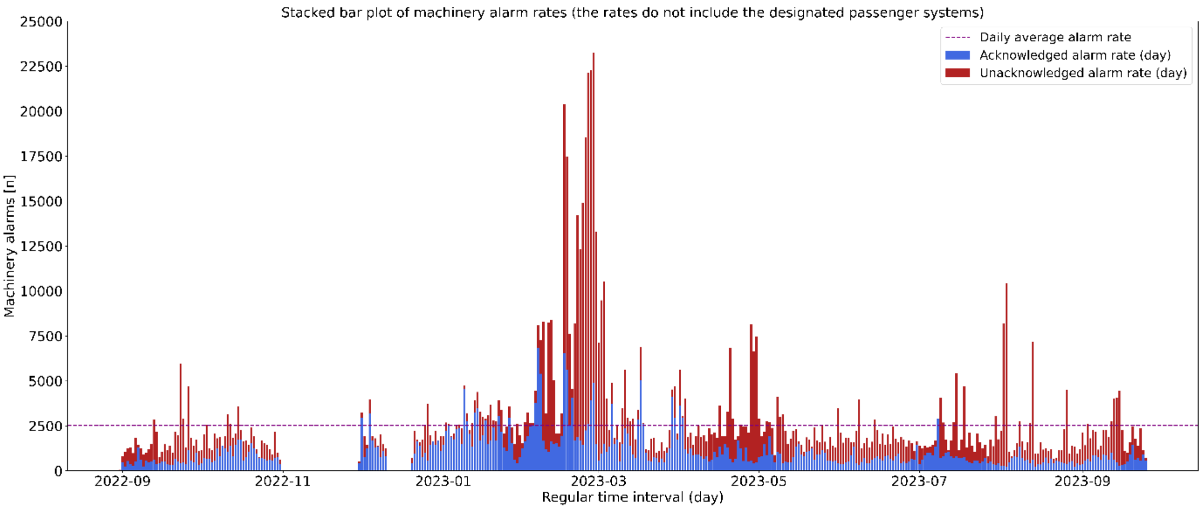

Figure 2. Daily alarm rates for ship engine room from Figure 1. Note that the dates with zero alarms indicate missing data, and not no alarms, on the given day.

A very important element in alarm management is *alarm rationalisation,* which is based on the idea that only real and valuable alarms should be made active. After all, alarms need people to work. Of the quality criteria used during the alarm rationalisation process, the most important and hardest to solve is "*timeliness*"—that the user has enough time to diagnose the problem and perform all necessary actions in time to prevent the problem from escalating into a safety shutdown or an outright accident.

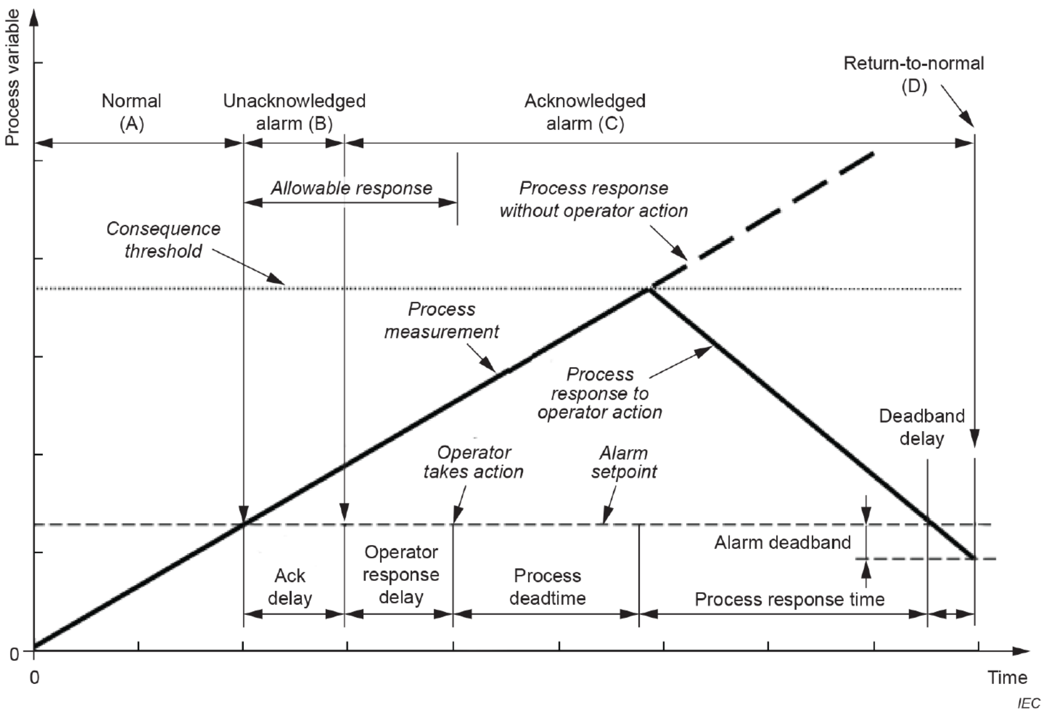

Figure 3. Alarm response time (Source: IEC 62682:2014)

The above timeline from the IEC 62682:2014 standard relates to the management of alarm systems in the process industries and illustrates the issue of the timeliness criterion (Figure 3). The figure represents a process measurement increasing from a normal state to an abnormal state, as well as the two possible outcomes based on whether or not the operator manages to take timely corrective action. In a maritime context, it is feared that the operator may ignore a real and important alarm, due in part to becoming accustomed to being overwhelmed with irrelevant alarms, and as a result, the time window which would otherwise be available to avert the consequences of an inappropriate condition in the machinery is reduced. At present, there is no maritime requirement to validate that the given process has time to stabilise before an unintended consequence occurs—even if the seafarers have taken all necessary actions to mitigate this. In the worst-case scenario, even if the seafarers do everything correctly, the time constants in the process will be the dominant factor as to whether or not the consequence occurs.

It is predicted by Lloyd's Register that the upcoming Viking Sky cruise ship accident report will look towards alarm management as a future requirement for ship engine rooms. In particular, the standards from some of the maritime-adjacent industries (such as ANSI/ISA 18.2, IEC 62682, EEMUA 191 2013, etc.) will serve as the informative standards for the development of a maritime alarm standard for engine rooms. These guidelines describe the rationalisation process in detail, albeit with significant shortcomings regarding the timeliness criterion. It is also predicted that the maritime industry will stall in the rationalisation process for this specific quality criterion due in part to disagreements about the extent to which generalisable solutions can be created for ”wicked problems”. Although the problem is difficult and intractable, the ANSI 58.8 standard has, since 1984, provided the nuclear industry with a set of generalisable guidelines for the timeliness criterion for time-critical operator actions for basic scenarios that occur regularly, as well as for extreme events. Traditional and qualitative methods do not scale to thousands of alarms on ships. Therefore, generalisable guidelines are also needed in the maritime industry, similar to what was accomplished with ANS/ANSI 58.8.

The project aims to investigate whether the same or similar methods, inspired by ANSI 58.8, can be used in a maritime context. In addition, the project will examine the extent to which it is possible to determine various time stamps via test scenarios in full-mission simulators at maritime educational institutions, as well as the extent to which these timestamps can be designed in generalisable timetables for use in a maritime alarm standard. If this is feasible, the method can be used in the rationalisation process for a validation criterion of maritime alarms. Lloyd's Register predicts the latter to be an essential future element of safety throughout the maritime industry.

Despite the existence of internationally recognised good practices for alarm management in several industries, the maritime shipping industry—and its primary risk owner, the ship operators—have yet to effectively implement these into their safety management systems. This is due to a set of interrelated factors that make the problem systematic:

(1) At present, systems are evaluated against performance standards and rules in which the set of requirements are broken down into customised units of equipment, each bringing its own set of alarms. What ship operators can do to influence equipment

design function at such detailed levels is limited. Furthermore, when it comes to risk control options, the majority of vessel operators compete in a global industry where cost-effectiveness is the basis of commercial viability and very few vessel operators can afford the privilege of having customised equipment produced that goes beyond basic compliance.

(2) Neither flag states nor class societies have requirements regarding the total sum of alarms and their management. This is because neither flag states nor class societies can risk being deselected by operators as a result of having a set of requirements stricter than those of their competitors. In a competitive and volatile global market, stricter requirements are regarded as a disadvantage for a business. Ships can be re-flagged from a flag state or moved out of a class society that imposes stricter regulations than their competitors, so ultimately, these regulations will have no effect on the industry. The processes of re-flagging and class transfer are far more agile than scaling resources up or down at the national administrations (flag states) or the respective classification societies.

(3) Maritime policy regulations and rules are the standard instruments that create a level playing field in the maritime industry. Systemic challenges, such as the management of alert (alarm) systems, need to be addressed at an international level. The International Maritime Organisation (IMO) has attempted to address the problem by introducing the revised version of the Code on Alerts and Indicators (CAI) in 2009 and the Bridge Alert Management (BAM) in 2014, but neither has yet demonstrated tangible benefits. Nevertheless, design processes and performance criteria have proven to be crucial to the success of alarm management in the nuclear and process industries, among others, which have historically gone through similar journeys.

To move forward, the maritime industry must take inspiration from the significant efforts and results achieved in relation to this challenge in adjacent industries, and promptly carry out testing and report which of these processes are transferrable. Testing these processes is a matter of interdisciplinary research and stakeholder collaboration and piloting – something that the maritime nation of Denmark in general, and the Danish Maritime Fund specifically, have a proven track record of facilitating.

What specific activities does the project consist of?
The project will consist of the following main activities:

1. **Analysis of alarm standards that can be transferred to the sea,** including:
   1.1. Review of alarm standards in the relevant adjacent industries;
   1.2. Analysis of the extent to which all or parts of the processes in these alarm standards can be transferred to the maritime industry;
   1.3. Review of any additional alarms that are expected to become necessary in the context of autonomy, remote control, and green fuels.

2. **Establishment of scenarios that can be tested in the full-mission simulator,** including:
   2.1. Determining which safety events to use in the simulator tests;
   2.2. Analysis of actual response times from the operator in relation to the designated safety incidents via GEMBA walks on board ships;
   2.3. Analysis of actual latency times from the operator's action until the safety event is over.

3. **Preparation of full-mission simulator tests**, including:
   3.1. Examine how Game Design can be used as a scientific method to support distribution-independent generalisation;
   3.2. Establish the methodology for collecting all relevant data points during the simulator test.
   3.3. Program simulator scenarios with the actual response times and latencies.

4. **Execution of full-mission simulator tests**, including:
   4.1. The logistical planning of the actual simulator tests;
   4.2. Conducting the actual simulator tests with the programmed scenarios;
   4.3. Interviewing the participants after their tests to obtain qualitative information about the operators' experience of the scenario that could not be gained through the quantitative analysis of alarm data.

5. **Analysis of full-mission simulator tests**, including:
   5.1. Evaluation of the extent to which the selected alarm standard processes need to be adapted for use in the maritime industry;
   5.2. Evaluation of the extent to which the methodology can be used as a viable approach for the development and validation of alarm standards in the maritime industry;
   5.3. Evaluation of discrete operator actions and process response and dead times that influence time-critical operator safety actions and how these are reflected in existing alarm management practices.

The project will utilise selected DFDS engineering students and their upcoming professional bachelor's degree projects, as well as DFDS engineers more generally, to provide accurate operational inputs from the frontline regarding actual onboard timeliness criteria (e.g. how long it actually takes to open a valve in a separate room).

What are the project's expected outcomes and success criteria?
The project is expected to culminate in a final public report.

This report will include the following project-specific points:

- Clarification of alarm standards in relevant adjacent industries and the extent to which they can be used in the maritime industry;
- Clarification of the methodology behind the study and the extent to which this can be used for the purpose;
- First iteration of a Time Critical Action (TCA) register of selected security incidents for the maritime industry.

In addition, the report will also include the following general points:

- Status of alarm management practice issues and potential solutions;
- New research knowledge regarding the use of full-mission simulators as an exploratory testing environment;
- Suggestions for future research avenues related to emergency management practices, including the impact of autonomy, remote control and green fuels.

What are the project's biggest barriers to success? *(risk assessment)*
The project has categorised risks and barriers based on the following risk matrix:

Table 1. The risk matrix of the project

Consequences	High	3	5	9
	Medium	2	4	5
	Low	1	2	3
		Low	Medium	High
	Likelihood of occurrence			

Additionally, the project is based on the following risks and risk control measures in relation to the above work:

1. **Unavailability of the full-mission simulator**
   a. Risk score: 3
   b. Risk Control Measure: The project is already planning to schedule the simulator tests either as part of or in direct continuation of the normal training (for inexperienced participants) and as far as possible from the standard training (for experienced participants).

2. **Breakdown of the full-mission simulator**
   a. Risk score: 3
   b. Risk Control Measure: The simulators undergo regular inspections and maintenance to ensure that they are fit for purpose as part of the STCW conventions' requirements for the training of seafarers. The project partners are already in dialogue with the equipment manufacturer (Kongsberg) regarding technical support for the project.

3. **Issues related to programming scenarios for use in the simulator**
   a. Risk score: 4
   b. Risk Control Measure: The project will dedicate a senior trainer to lead the work on the programming of scenarios in the simulator and enter into close dialogue with the equipment manufacturer (Kongsberg), including possibly getting them out to train additional staff.

4. **Unavailability of necessary personnel**
   a. Risk score: 2
   b. Risk Control Measure: It is anticipated that the project will receive funding so that the parties involved can dedicate staff critical to the project activities. In addition, the project will set up a project structure so that there is full transparency and knowledge sharing between project activities, thus avoiding dependency on individual staff members (should they become unavailable at some point).

5. **Issues at sea that will limit Gemba walks, etc.**
   a. Risk score: 2
   b. Risk Control Measure: Close dialogue with the ships and students involved will ensure that the project team has the opportunity to adapt the project activities if unforeseen issues arise on a given ship. DFDS will also arrange for the involvement of multiple ships so that the project is not dependent on a single ship.

UN's Global Goals

Primary objective:
GOAL 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE:
The goal involves developing reliable infrastructure, promoting sustainable industry and investing in scientific research and innovation.

Secondary objectives:
GOAL 3: GOOD HEALTH AND WELL-BEING
GOAL 7: AFFORDABLE AND CLEAN ENERGY
GOAL 8: DECENT WORK AND ECONOMIC GROWTH
GOAL 14: LIFE BELOW WATER

Documentation for supporting sustainable development:
By improving alarm management practices, the project contributes to UN Goal #9 by avoiding more accidents at sea today and Goal #7 regarding the future use of sustainable energy. This will also contribute to Goals #3 and #8 by improving the safety of personnel and passengers on board, and will have a direct impact on Goal #14 by avoiding marine pollution.

Measuring impact

At the beginning of the project, a set of relevant impact KPIs will be established, which will include articles published in relevant journals/news magazines, presentations at relevant events/conferences and participation in the development of an international alarm standard for ships via Lloyd's Register's technical committee.

Declarations of interest and cooperation and more

Lloyd's Register (LR) is one of the leading providers of classifications and compliance services to the marine and offshore industry.

DFDS is a Danish international shipping and logistics company that owns and operates ships and employs associated personnel.

Aarhus School of Marine and Technical Engineering (AAMS) is one of Denmark's leading engineering schools. It educates marine engineers and conducts research on related subjects.

Fredericia College of Marine and Technical Engineering (FMS) is one of Denmark's leading engineering schools that educates marine engineers and researches related subjects.

Maritime HUB at IT University of Copenhagen (MHUB) is the maritime research centre at one of Denmark's leading universities focusing on IT.

In addition, the project has received expressions of interest from Maersk Line, Stena Line, Copenhagen School of Marine Engineering and Technology Management (MSK), Svendborg International Maritime Academy (SIMAC), and the University of Southern Denmark (SDU).

Time schedule

Specify expected start and end dates.

Start: **01.04.2024**

End: **31.03.2025**

The specified time schedule can be seen in the Gantt chart below. (A more detailed version can be found in the attached Excel spreadsheet.)

	2024												2025		
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Application deadline(s)	■														
Official project start				■											
Preparation of simulator tests				■	■	■	■	■	■	■					
Simulator test 1 (students)					■	■				■	■	■			
Simulator test 2 (on-duty staff)						■				■					
Analysis of simulator tests						■	■	■	■	■	■	■	■		
Preparation of final report													■	■	■ X
Master's project (SDU)		■	■	■	■	■ X									
Bachelor project (FMS/DFDS)		■	■	■	■	■ X									
Bachelor project (SIMAC/DFDS)		■	■	■	■	■ X									
Bachelor project (MARTEC/DFDS)								■	■	■	■	■ X			

X Report

Finances

Amount applied for

The following section describes the project finances, including the amount applied for, the total project budget, cash flow and residual financing.

We are applying for a grant of… **1,997,500 DKK**
Out of a total project budget of… **4,875,500 DKK**
Corresponding to a percentage of… **41% of the project**

Project budget

The total project budget is as follows:

Budget line	Total Expenses	Comments
Internal time consumption	4,860,000 DKK	Equivalent to 600 DKK per hour cf. Danish Maritime Fund maximum rate
External consultancy services	0 DKK	
TAP Personnel, etc.	0 DKK	
Purchasing	0 DKK	
Travelling expenses	10,000 DKK	Equivalent to two trips of 5,000 DKK per trip
Auditor's statement	7,500 DKK	
Total project budget	**4,875,500 DKK**	

Of the budget items, support is sought for the items as follows:

Budget item	Requested Funding	Comments
Internal time consumption	1,980,000 DKK	Equivalent to partial wage subsidy
Travelling expenses	10,000 DKK	Equivalent to partial travel subsidy in connection with full-mission simulator tests
Auditor's statement	7,500 DKK	Equivalent to the total amount
Amount applied for	**1,997,500 DKK**	

Cash flow budget

The projected cash flow budget with inflows and outflows for the project, broken down by the specified schedule, is as follows:

Month	Flows	Comments	Balance
April 2024	+1,997,500 DKK +240,000 DKK -405,000 DKK -2,500 DKK	Danish Maritime Fund [1] Self-financing [2] Time spent [2] Travelling expenses	+1,830,000 DKK
May 2024	+240,000 DKK -405,000 DKK	Self-financing [2] Time spent [2]	+1,665,000 DKK
June 2024	+240,000 DKK -405,000 DKK -2,500 DKK	Self-financing [2] Time spent [2] Travelling expenses	+1,497,000 DKK
July 2024	+240,000 DKK -405,000 DKK	Self-financing [2] Time spent [2]	+1,332,500 DKK
August 2024	+240,000 DKK -405,000 DKK	Self-financing [2] Time spent [2]	+1,167,500 DKK
September 2024	+240,000 DKK -405,000 DKK	Self-financing [2] Time spent [2]	+1,002,500 DKK
October 2024	+240,000 DKK -405,000 DKK -2,500 DKK	Self-financing [2] Time spent [2] Travel expenses	+835,000 DKK
November 2024	+240,000 DKK -405,000 DKK	Self-financing [2] Time spent [2]	+670,000 DKK
December 2024	+240,000 DKK -405,000 DKK	Self-financing [2] Time spent [2]	+505,000 DKK
January 2025	+240,000 DKK -405,000 DKK	Self-financing [2] Time spent [2]	+340,000 DKK
February 2025	+240,000 DKK -405,000 DKK	Self-financing [2] Time spent [2]	+175,000 DKK
March 2025	+240,000 DKK -405,000 DKK -2,500 DKK -7,500 DKK	Self-financing [2] Time spent [2] Travelling expenses Audit costs	0 DKK

[1] The funds from the Danish Maritime Fund may be distributed semi-annually/quarterly
[2] Self-financing and hourly time spent are calculated as a linear relationship

Residual funding

The remaining funding will come from the partners involved in the form of self-financing of activities. This applies to subsidies for internal time consumption as well as travelling expenses in addition to those stated and payment for the publication of reports (depending on where the project partners choose to publish them). In addition, the partners involved have agreed on residual funding for any technical support in connection with the programming of full-mission simulator scenarios.