# AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

# D.3.1: Concept designs for one RoCoPax and two SSS small feeder vessels

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# List of Acronyms

| Abbreviation / acronym | Description |
|---|---|
| B | Maximum breadth moulded at or below still waterline |
| B/T | Breadth-Draught ratio |
| CAPEX | CAPital EXpenditure |
| Cb | Block coefficient |
| CI-ICE | Compression Ignition Internal Combustion Engine |
| CNG | Compressed Natural Gas |
| ConOps | Concept of Operations |
| D | Propeller diameter |
| D1.1 | Deliverable number 1 belonging to WP 1 |
| DAC | Direct Air Capture |
| DESP | DEsign Ship Powering |
| DF-CI-ICE | Dual Fuel Compression Ignition Internal Combustion Engine |
| DISM | Displacement mass in seawater |
| DISV | Displacement volume moulded |
| DOC | Diesel Oxidation Catalyst |
| EC | European Commission |
| ECHA | European Chemicals Agency |
| EGR | Exhaust Gas Recirculation |
| ETA-D | Propulsive efficiency |
| ETA-H | Hull efficiency |
| ETA-O | Propeller efficiency in open water |
| E&S | Equilibrium and Speed |
| FB | LCB position fwd of 1/2FP |
| FEU | Forty-foot Equivalent Unit |
| FI | Frequency index |
| FN | Froude number |
| GT | Gross Tonnage |
| HFO | Heavy Fuel Oil |

| Abbreviation / acronym | Description |
|---|---|
| ICE | Internal Combustion Engine |
| IMO | International Maritime Organization |
| LNG | Liquid Natural Gas |
| LPP | Length between perpendiculars |
| Lpp/B | Length-Breadth ratio |
| LWL | Length on still waterline |
| N | Rate of revolution |
| NOx | Nitro Oxides |
| OPEX | OPerational EXpense |
| PE | Effective power |
| PHA | Preliminary Hazard Analysis |
| PM | Particulate Matter |
| PS | Shaft power |
| R | Resistance in general |
| RI | Risk index |
| S | Wetted surface area hull |
| SCR | Selective Catalytic Reduction |
| SDS | Safety Data Sheets |
| SI | Severity index |
| SI-ICE | Spark Ignition Internal Combustion Engine |
| SOLAS | International Convention for the Safety of Life at Sea |
| SOx | Sulphur Oxides |
| SPEC | Ship Power Energy Concepts |
| SWL | Safe Working Load |
| TA | Moulded draught at aft perpendicular |
| TEU | Twenty-foot Equivalent Unit |
| TF | Moulded draught at forward perpendicular |
| THDF | Thrust deduction fraction |
| V | Speed of ship |
| W | Effective wake fraction on thrust identity |

| Abbreviation / acronym | Description |
|---|---|
| WP | Work Package |

# Executive Summary

The MOSES project has expressed the ambition to design innovative feeder vessels. The innovations for the vessels are concentrated on two different directions, in which the innovations for the maritime industry are being developed and demanded by society. The first one is the ambition to reduce or eliminate harmful emissions by designing environmentally friendly vessels. The second one is the ambition to design a highly autonomous feeder vessel, that is able to sail large part of its route without human intervention. Main drive here is to reduce the number of accidents due to human errors followed by a reduction in cost.

The design of both zero emission and autonomous vessels of this size is beyond the current state of the art of technology. Especially for seagoing vessels the steps that are made in this field are very small. Up to now most zero emission and/or autonomous vessels are operated in a small and coastal area or at inland waters. The design of larger seagoing vessels with a capacity of 100 or more than 600 TEU (Twenty-foot Equivalent Unit) and an increased autonomy range, has not been done before.

In addition, the vessels will be equipped with an autonomous robotic crane, which will be developed in T3.3, T3.4 and T3.5. Finally, the vessels should be able to facilitate the transport of passengers in selected legs of their round trip, which is worked out in T3.6.

Concept designs were made using information from a Greek and Spanish business case (D2.3) in combination with the concept of operation and requirements that were drafted up in D2.4.

In the design of the vessels, partly autonomous operation of the vessels has been considered. This was done in the selection of the equipment but also considering the effects autonomous operations might have on the potential safety of the vessel. The autonomous operation of the feeder vessel concepts described in D3.1 will be further explored within T3.2.

With the first ship parameters, the route and cargo volumes, a so called "trip simulation" was done. In this simulation, the sailing and logistic operations are calculated for a period of two years. From the results of these simulations, it was concluded that the presented logistic ambitions could be fulfilled with a smaller vessel, which lead to the introduction of a second Greek case for which the design process was repeated. The design studies for the Greek case showed that it is technically possible to design a hybrid powered solution, consisting of a methanol fuelled ICE in combination with a battery, which enables partly zero emission operation of the feeder vessel. The operational cost of the hybrid methanol solution is found to be

about 15% more than those for a conventional feeder vessel. This is attributed to the higher price of the selected energy carriers for the innovative feeders.

For the Spanish case both a methanol hybrid powered solution and a battery electric solution were found to be feasible from a technical and operational point of view. The operational cost of the methanol hybrid solution is about 10% lower than those of a conventional design. The cost reduction is derived via the increased autonomy and manoeuvrability of the vessel, which results into lower cost for pilotage and tug assistance.

The preliminary hazard analysis (PHA) for the innovative feeder concepts has resulted in a non-exhaustive list of twelve (12) hazards that are the sources of specific hazardous events. The identified events relate to the following system components, focusing on innovative aspects of the feeder: propulsion machinery, fuel/energy/storage system, cargo space, superstructures and hull.

The main result of the analysis is the identification of five (5) high-risk events, from the total twelve (12), from which further design requirements and risk analysis have been derived. These five events have the following hazards as their source: system complexity, extreme weather conditions, the operation of the on-board crane, and situation awareness with respect to monitoring the cargo space.

Summarizing, the designs of the innovative feeder vessels prove in concept the feasibility for a zero emission and autonomous operational feeder vessel for routes that are not or occasionally being served at this moment. The concepts are in this way not only new, but the various evaluations that were done for the selected hybrid concepts, which are beyond current design practice, show that the realisation of these concepts is possible.

Finally, it must be noted that the future costs of the innovative vessels will be lower in than those of the conventional ones, once a tax related with CO2 emissions is introduced.