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Ship Lifecycle Software Solutions (SHIPLYS)

Project Deliverable Report

D2.1 Selected scenarios and the rationale for such selection

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Author: E. Bilalis (NTUA), N. Tsouvalis (NTUA), U. Bharadwaj (TWI)

Contributors: T. Koch and K. Kreutzer (AES), D. Frank (AS2CON), L. Herrera (ATD), C. Volbeda (FERG), Y. Garbatov (IST), S. Hirdaris (LR), F. del Castillo (SOERMAR), B. Jeong, E. Oguz, H. Wang and P. Zhou (SU), I. Atanasova (VARNA)

Internal reviewers: G. Katsaounis (NTUA)

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EXECUTIVE SUMMARY

Early on in the project and in the context of WP2, SHIPLYS participants have developed several different scenarios (case studies), each of them aiming at different challenges that European SME shipyards face today, which could potentially be dealt with by the software tool that will be developed within the project. This is with a view to understanding end users' requirements and targeting the development of the SHIPLYS software activity towards such needs, thereby maximising the impact of the project to the intended audience.

Scenario 1 aims to optimise the design of a short-route ferry (domestic voyages) using a novel hybrid propulsion system, which combines internal combustion engines and battery cells. Carrying out an analysis for this scenario will cover the whole life cycle of the ferry, including design and production, operation and maintenance and scrapping and recycle stages. Scenario 1-A covers a shipyard already building new hybrid ships wanting to investigate the optimum mix of operation modes within the hybrid system. Scenario 1-B aims to design and plan the retrofitting of a conventionally powered short route ferry with a hybrid propulsion system. The retrofitting can be treated as new design requiring new building processes, but also including the disassembling process analysis of the existing conventional system. The hybrid system design and optimisation is the same as in Scenario 1-A.

Scenario 2 deals with the conceptual design of a new Multi Purpose Vessel (MPV), which is assumed to be carried out within the environment of an SME shipyard, accounting for the shipyard's constraints and using the SHIPLYS software tool to be developed. The procedure involves an optimization of the design and production on the basis of a risk-based LCA, including features like risk-based structural design, production operation and maintenance optimisation, greener design for environmental impact, retrofitting options and end-of-life decommissioning.

Scenario 3 aims at supporting a repair shipyard during the bid stage to optimise retrofitting design and production and to arrive at realistic costs. The proposed retrofitting is the installation of scrubbers to cut funnel emissions or the installation of a ballast management plant. The improvement of retrofitting/repair of ships is of particular interest in SME shipyards. The scenario includes the calculation of Life Cycle Cost (LCC), performance of Life Cycle Assessment (LCA) and Risk Assessment (RA), which will quantify the overall cost and impact of the retrofit/repair works during the project implementation.

Scenario 4 focuses on production optimization in response to changing demand. Production optimization will lead to more competitive offers by the shipyards which are essential in the growth of their cycle of operations' and profits. Production planning and simulation as well as the various solutions proposed in the scenarios like laser cutting, laser welding, laser-scanning quality controls, the use of new structural concepts like sandwich panels and the introduction of standardised assemblies, are to be investigated and included within the scope of the SHIPLYS software.

SHIPLYS

CONTENTS

Abbreviations/Glossary of terms

CoF	Consequences of a Failure or an adverse event, as used in some Risk Assessments (RA).
CAPEX	Capital expenditure Funds used by a company to acquire or upgrade physical assets, i.e. initial investment.
Circular Economy	Unlike a traditional linear economy in which a product is made, used and then disposed, in a circular economy a product is used as long as possible, maximum value is extracted from its use, and, at the end of the product's service life, products or materials are recovered and regenerated to the extent possible.
D-E	Diesel-Electric propulsion system
D-M	Diesel-Mechanical propulsion system
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
EI	Environmental impact Possible adverse effects caused by a development, industrial, or infrastructural project or by the release of a substance in the environment.
Failure	The loss of function of a system, structure, asset or component to perform its required or intended purpose(s).
LCCA	Life Cycle Cost Assessment; alternative terminology for Life Cycle Costs (LCC).
LCC	Life Cycle Costs It includes the costs of design, production, operation and maintenance, retrofitting/ life-extension and end-of-life costs.
LCA	Life Cycle Assessment It is a process-level approach for assessing EI associated with all the stages of a product's life from cradle to grave. Such assessments are usually quantitative in nature, but in the context of SHIPLYS, EI assessments can be quantitative, qualitative or may have mixed attributes.
LCT	Life Cycle Tools LCT is a term specific to SHIPLYS. SHIPLYS LCT means the suite of tools enabling LCCA, environmental impact assessment, risk assessment and decision support functionalities such as MCDA.
MCDA	Multi-Criteria Decision Analysis A sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision-making.
MPV	Multi Purpose Vessel(s)
O&M	Operation and Maintenance

OPEX	Operating expenditure An on going cost for running a product, business, or system, i.e. operational cost collected during the entire service life and accounting for the cost related to the failures.
PoF	The likelihood or probability of failure or an adverse event occurring
Risk	The combination of the probability of an event and its consequence. In some situations, risk is a deviation from the expected. Risk is the product of the probability of failure and its consequence when probability and consequence are expressed numerically.
RA	Risk Assessment Systematic use of information to identify sources and to estimate the risk. Risk Assessment provides a basis for risk evaluation, risk mitigation and risk acceptance. Information can include historical data, theoretical analysis, informed opinions and concerns of stakeholders.
ROI	Return on Investment

1 Introduction

The SHIPLYS (Ship Life Cycle Software Solutions) project is in response to needs of SME naval architects, shipbuilders and ship-owners. It is aimed at helping them improve their capability to reduce the time and costs of design and production, develop the ability to reliably produce better ship concepts through rapid virtual design and production simulation, and meet the requirements for undertaking a life cycle perspective at the early ship design stage itself. In the project, LCCA (Life Cycle Cost Analysis), environmental impact assessments, and risk assessments are included as features of the life cycle perspective.

Early on in the project and in the context of WP2, SHIPLYS participants have developed several different scenarios (case studies), each of them aiming at different challenges that European SME shipyards face today, which could potentially be dealt with the software tool that will be developed within the project. This is with a view to understanding end users' requirements and targeting the development of the SHIPLYS software activity towards such needs, thereby maximising the impact of the project to the intended audience.

This report collates and summarises the information regarding the scenarios considered within SHIPLYS. This is with a view to confirm the scenarios to be taken forward, using the evaluation criteria mentioned in the SHIPLYS proposal. The rationale for the selection of these scenarios is also presented.

It is acknowledged that although the initial activities in the project are scenario-specific, the end-result (SHIPLYS software) will have functionality that will be beneficial in other types of scenarios faced by SME shipyards. If more types of scenarios are considered at this stage than those envisaged in the proposal, some of the scenarios may be taken up at the demonstration/validation stage of the project.

The aims and objectives of the present report are:

- To describe in detail and collate the scenarios considered in SHIPLYS
- To conduct a quick evaluation of the scenarios based on various criteria including those mentioned in the proposal
- To highlight specific matters relating to the scenarios, as mentioned by SHIPLYS participants
- To confirm the scenarios to be taken forward for the purpose of software development and, potentially, for demonstration/validation activities

The assessment criteria, on the basis of which the final selection of the scenarios was made, are as follows:

- The scope for considering through life stages
- The inclusion of interests of diverse stakeholders apart from SME shipyards such as shipowners, regulators and environmentalists
- Potential environmental and regulatory aspects involved
- Potential for impact on circular economy
- The challenges in developing solutions taking cognisance of competing solutions
- The feasibility of implementing solutions to optimise early design within SHIPLYS resources

2 Description and evaluation of scenarios

For each scenario to be considered within SHIPLYS, information that could help in the evaluation of the scenario on the criteria mentioned was requested. Corresponding to the scenarios, examples of early design/conceptual design that shipyards typically receive were requested; this is important as a starting point in terms of understanding the functionality envisaged in the SHIPLYS software by the end-users.

Information for the various scenarios considered is presented in the following sections. A brief summary of each scenario and the rationale for its proposal are presented here, whereas a detailed description of the scenario is given in the corresponding Appendix.

2.1 Scenario 1: Optimisation of the design of a novel hybrid propulsion system used in a short-route ferry

2.1.1 Scenario 1-A: Hybrid propulsion system in a new built short route ferry

Proposers: Ferguson Marine (FERG) and University of Strathclyde (USTRATH)

Objective: To design an optimized hybrid propulsion system for a new-built short route ferry.

Summary: This scenario aims to optimise the design of a short-route ferry (domestic voyages) using a novel hybrid propulsion system, which combines internal combustion engines and battery cells. A hybrid propulsion system is Diesel-Electric (D-E) as opposed to the conventional Diesel-Mechanical (D-M). Carrying out an analysis for this scenario will cover the whole life cycle of the ferry, including design and production, operation and maintenance and scrapping and recycle stages. In each stage, cost analysis, environmental impacts and risk assessments will be considered.

Scenario 1-A covers a shipyard already building new hybrid ships wanting to investigate the optimum mix of operation modes within the hybrid system. Four modes of the hybrid ship operation will be investigated, i.e. Generator; Generator + Battery; Battery; Battery charging. The scenario consists of four parts: design; production; in-service; end-of-life. A comparison of hybrid with conventional systems will be done within the framework of this scenario. A detailed description of this scenario can be found in Appendix A (together with that of scenario 1-B).

Rationale behind scenario 1-A: There is an already existing and evolving market for hybrid ships. Ferguson Marine is already delivering orders for hybrid ships and their design, production and operation optimisation would be very beneficial and of particular interest not only for Ferguson Marine but also for all European SME shipyards. Using LCC methods, the flow of energy, emissions, cost, etc. from the ship's production to scrapping will be tracked. As the cost reduction heavily depends on how ships' crew operates the ship, the focus for this scenario will be placed on investigating the most optimum operating practices under proposed voyage conditions. Potentially, hybrid ships will have comparatively more CAPEX with reduced OPEX and reduced environmental impact in comparison to conventional designs. Additionally, unlike machineries, electric systems including batteries are basically maintenance free. Using batteries will reduce the operating hours of diesel generators, thereby it is expected that the maintenance interval will be longer and the cost will be reduced. It is expected that the saving of operating cost with optimized energy management will compensate for the relatively high initial capital expenditure in the long run.

2.1.2 Scenario 1-B: Retrofit of a short route ferry with a hybrid propulsion system

Proposers: Ferguson Marine (FERG) and University of Strathclyde (USTRATH)

Objective: To support planning of a hybrid system to be installed in lieu of a conventional system

Summary: This scenario aims to design and plan the retrofitting of a conventionally powered short route ferry with a hybrid propulsion system which combines internal combustion engines and battery cells. The retrofitting can be treated as new design requiring new building processes, but also including the disassembling process analysis of the existing conventional system. The hybrid system design and optimisation is the same as in Scenario 1-A. However, scenario 1-B has the constraint that the engine room can't be enlarged since it is already built. A detailed description of this scenario is given in Appendix A.

Rationale behind Scenario 1-B: Fuel consumption between D-M and D-E propulsion systems have been compared by Ferguson Marine. The results are very promising and similar analyses can be done for hybrid systems. This supports the view that a retrofitting of a hybrid system would be beneficial in the long term life of the ship. However, since remaining life expectancy is a key factor for retrofitting, cost analyses are also needed to evaluate the feasibility of retrofitting by analysing the capital expenditures and operational savings during the remaining service period of the vessel. SHIPLYS software, encompassing LCCA, aims to support decision making concerning retrofitting, as well as production planning of the retrofitting process, and in this point of view, scenario 1-B is of particular interest.

2.2 Scenario 2: Conceptual ship design accounting for risk-based LCA

Proposers: Varna Maritime (VARNA), Instituto Superior Tecnico (IST) and Atlantec Enterprise Solutions (AES)

Objectives: To carry out the conceptual design of a newbuilding accounting for a risk-based life cycle assessment.

Summary: A conceptual design of a new Multi Purpose Vessel (MPV) is assumed to be carried out within the environment of an SME shipyard like Varna Maritime, accounting for the shipyard's constraints and using the SHIPLYS software tool to be developed. The procedure involves an optimization of the design on the basis of a risk-based LCA, including features like risk-based structural design, production optimization, Operation and Maintenance (O&M) optimisation, greener design for environmental impact, retrofitting options and end-of-life decommissioning. It approaches the shift of an SME shipyard from a mainly repair functionality to a new-construction functionality, with a capacity to build new ships. A detailed description of this scenario can be found in Appendix B.

Rationale behind Scenario 2: Scenario 2 deals with the development of a software tool for conceptual ship design, based entirely on the SHIPLYS criteria, covering life cycle cost and environmental and risk assessments. A special focus is attributed to the shipbuilding limitations of an SME shipyard in terms of engineering specifications, as well as to construction, operational, maintenance and end life costs in the life cycle optimization. In this scope, scenario 2 offers a full overview of the basic abilities and introduces risk analysis that the SHIPLYS software tool should offer. Such a scenario is beneficial in both the development and the verification phase of this tool. In cooperation with Varna Maritime shipyard, the scenario proposed will be applied to an MPV. The partners of SHIPLYS project have experience with this ship type and have already collected information that can be used to calibrate the developed applications. Although the market for MPV is currently not very good, the use of this scenario will result in a software tool that can be employed to design also other types of ships.

2.3 Scenario 3: Ship retrofitting accounting for Life Cycle Cost Assessment

Proposers: Astilleros de Santander (ATD) and SOERMAR

Objectives: To support a repair shipyard during the bid-stage to optimise retrofitting design and production and to arrive at realistic costs.

Summary: The proposed retrofitting works are:

a) Installation of scrubbers in an existing ROPAX ferry to cut funnel emissions

b) Installation of a ballast management plant (potentially)

The scenario includes the calculation of Life Cycle Cost (LCC), performance of Life Cycle Assessment (LCA) and Risk Assessment (RA), which will quantify the overall cost and impact of the retrofit/repair works during the project implementation. A detailed description of scenario 3 can be found in Appendix C.

Rationale behind Scenario 3: Scenario 3 focuses on the improvement of retrofitting/repair of ships which is of particular interest for SME shipyards. It indicates that the SHIPLYS software should have virtual modelling tools that will enable optimal retrofitting/repair, working in parallel with LCCA, environmental assessment and RA. The design and production planning of the installation of scrubbers and ballast management plants are among the most common retrofitting activities that European SME shipyards would face. Therefore, a scenario addressing these activities would demonstrate the effectiveness of the SHIPLYS software tool to integrate modelling and lifecycle analysis abilities.

2.4 Scenario 4: Optimising shipyard production systems

Proposers: Atlantec Enterprise Solutions (AES)

Objective: To optimise the shipyard's production system in response to changing demands

Summary: Production optimisation will include transforming to a new vessel type portfolio, which for example necessitates use of thin sheet materials, which in turn need new or updated methods for cutting and welding. An additional consideration will be that where the shipyard moves to a modular construction concept, where as much as possible standard assemblies of the ship are manufactured. Return of Investment (ROI) will be calculated, given forecasts relating to future applications of this scenario. Production optimisation is a strand that is potentially part of the other scenarios too. This is understandable as production is included in life cycle costs. A description of two possible changes in the production system of a shipyard can be found in Appendix D.

Rationale behind Scenario 4: Lowering production cost while simultaneously reducing production time is a key point of interest for European SME shipyards. Production optimization will lead to more competitive offers by the shipyards which is essential in the growth of their cycle of operations and profits. Production planning and simulation as well as the various solutions proposed in the scenarios like laser cutting, laser welding, laser-scanning quality controls, the use of new structural concepts like sandwich panels and the introduction of standardised assemblies, are considered beneficial and should be investigated and included within the scope of the SHIPLYS software.

2.5 Scenarios at a glance

Table 1 shows how the scenarios directly or indirectly measure in terms of the assessment criteria cited in section 1. Some attributes indirectly and/or collectively relate to the criteria mentioned. For example, a scenario that includes design, production, operation and maintenance and end-of-life considers 'through-life stages' which is mentioned as one of the criteria.

3 Conclusions and recommendations

It is recommended that the following Scenarios (or variants) be considered within the SHIPLYS project.

Scenario 1
It is suggested that the project focuses on Scenario 1-A and then, should the time and resources are available, scenario 1-B would be assessed or used towards the later stages of the project, to explore the generic features of the SHIPLYS software.

Scenario 2
Scenario 2 is ideal and it is proposed to be considered in the project, as it can show the optimisation of early design of a ship based on life cycle performance, and also the production system required. Thus, it has the potential to showcase the full functionality of SHIPLYS life cycle tools.

Scenario 3
Scenario 3 is focussed on the optimisation of shipyard design and production planning systems for retrofitting/repair activities and it is proposed to be considered in the project. Here the optimisation is more about reducing costs, identifying risks and environmental impact in a shipyard that is mostly performing retrofitting and repair works.

Scenario 4

Providing support to optimise shipyard production systems is a recurring theme in all scenarios. Optimising shipyard production systems are crucial activites included in scenarios 1, 2 and 3. Therefore, rather than treat production system optimisation as a separate scenario 4, it was envisaged this functionality to be developed using, in varying extent, scenarios 1, 2 and 3, particularly using those scenarios where relevant data for software development is made available. Therefore, scenario 4 will not be considered separately but within the framework of the previous three scenarios.

Table 1: Summary of scenarios evaluation.

Assessment criteria	**Scenarios 1-A & 1-B** Hybrid propulsion of a short route ferry	**Scenario 2** Conceptual ship design accounting for risk-based LCA	**Scenario 3** Retrofit or repair works	**Scenario 4** Optimising shipyard production systems
Early design	Partially	Yes	Yes	N-A
Retrofitting	Yes	Yes	Yes	Yes
Production optimisation	Yes	Yes	Yes	Yes
Operation and maintenance	Yes	Yes	Yes	Yes
End-of-life / decommissioning	Yes	Yes	Yes	Yes
Environmental impact	Yes	Yes	Yes	Yes
Impact on circular economy	Yes	Yes	Yes	Yes
Feasibility of developing solutions	Yes	Yes	Yes	Yes
Overall risk assessment of the scenario and its mitigation	Focus is on optimising the hybrid system, but other aspects showcasing SHIPLYS functionality can be developed	Scenario 2 will result in software that can be applied for different types of ships and any SME shipyard	Focus is on specific retrofitting, but other aspects showcasing SHIPLYS functionality can be developed.	Focus is on specific production procedures changes, but other aspects showcasing SHIPLYS functionality can be developed.

N-A: Not applicable

Two flowcharts have been developed and are shown in Figures 1 and 2, the first referring to a complete new ship design and corresponding to scenario 2 and the second referring to a pure retrofitting work and corresponding to scenario 1. Both flowcharts were developed in order to visualise the various tasks that the SHIPLYS software should be able to deal with. Each particular box corresponds to a different module of the software. Additionally, the various required databases are also presented in the flowcharts.

Appendix E contains a summary of each one of the above scenarios which are going to be sent to the SHIPLYS Stakeholders' Advisory Committee for the purpose of informing its members about these scenarios and ask for their views as to how the problems that SHIPLYS seeks to address relate to their own businesses, thus collecting valuable feedback.

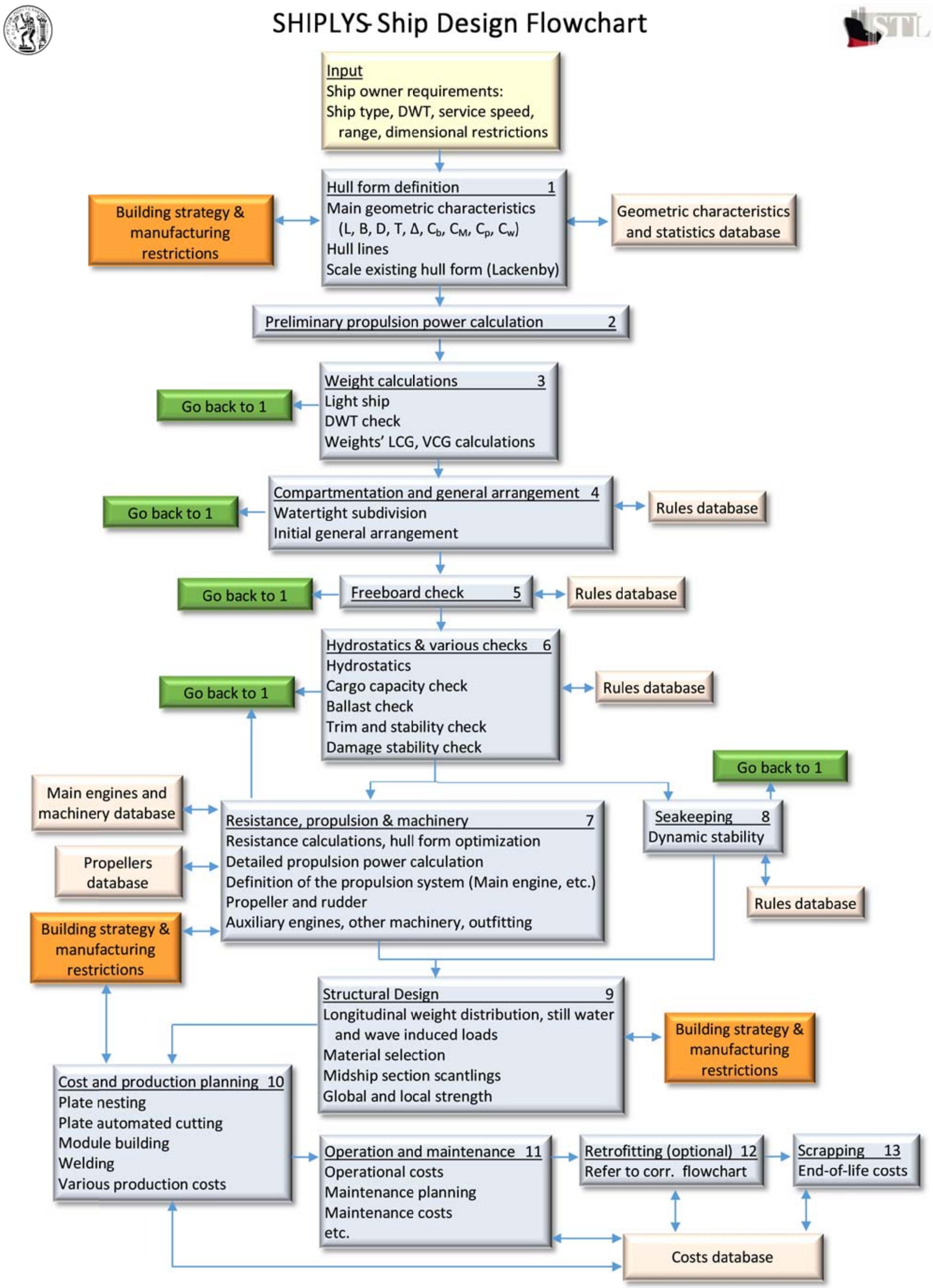

Figure 1: Ship design flowchart.

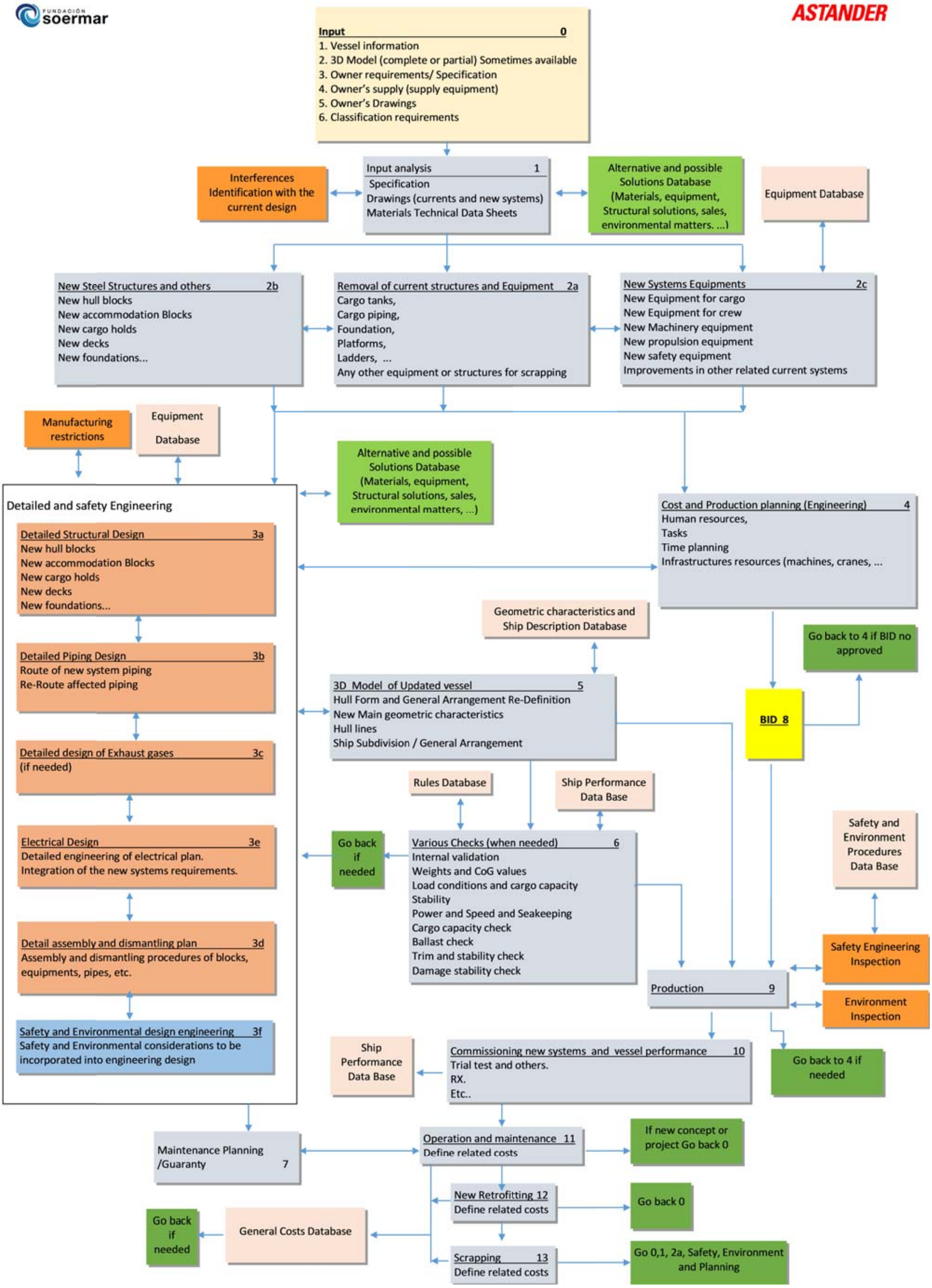

Figure 2: Ship retrofitting flowchart.

Appendix A

Scenarios 1-A and 1-B

Optimisation of the design of a novel hybrid propulsion system used in a short-route ferry

Ferguson Marine and University of Strathclyde

A.1 Introduction

One of the objectives of the SHIPLYS project is to offer a toolkit to the shipowners, shipyards, as well as researchers in order to provide a detailed life cycle view of their products and research targets. Scenario (1-A) aims to optimise the design of a short-route ferry (domestic voyages) using a novel hybrid propulsion system, which combines internal combustion engines and battery cells. Carrying out an analysis for this scenario will cover the whole life cycle of the ferry, including design and production, operation and maintenance and scrapping and recycle stages. In each stage, cost analysis, environmental impacts and risk assessments will be considered. Furthermore, this scenario could include a branch for retrofitting of a hybrid propulsion system (scenario 1-B). The retrofitting can be regarded as a new design and building processes, including the disassembling process analysis.

The basic idea is to conduct a Life Cycle Assessment (LCA) for a selected case ship with different types of propulsion systems. For the selected ship, the costs, environment and risk impacts will be analysed and they will be compared under different circumstances: Diesel-Mechanical (D-M), Diesel-Electric (D-E) and hybrid. The main difference will be due to the fuel costs: D-M system will propel the ship directly; D-E system will convert fuel into electricity and drive motor to propel the ship; hybrid system will distribute the loads to generators and batteries based on specific route. The advantage of D-E compared to D-M system has been calculated by Ferguson Marine. One potential advantage of the hybrid system is to save energy costs because the batteries are charged during night tariff.

It must be noted that scenarios 1-A and 1-B do not include hull form optimisation and machinery arrangement. One parameter which may be taken into account is the size of the engine room for scenario 1-A only (it is given for scenario 1-B). The detailed arrangement of the engine room will not be investigated.

A.2 Sample hybrid ship

MV Hallaig (Figure A.1) is the world's first seagoing hybrid Ro-Pax ferry. She was entered service in November 2013 and she can be used as a target ship for scenarios 1-A or 1-B. The design route is between Sconser to Raasay and the total voyage duration is 30-45 minutes (Transit Time: 20 mins, Manoeuvring Time: 2 mins, At Slip: 8-23 mins). The aim of this scenario is to find out optimized operational practice for the hybrid propulsion system, as well as the preferred propulsion system based on the proposed voyage plan. The specifications of this ferry are given in Table A.1.

Figure A.1: MV Hallaig.

Table A.1: Specifications of MV Hallaig.

MV Hallaig		
LOA	43.50	m
LBP	39.99	m
Breadth	12.2	m
Draught	1.73	m
Deadweight	100	ton
Top Speed	9	knot
Max Beam Wind	37	knot
Total Propulsion Power	2*375	kW
Total Power for 9 knots Service Speed	265.5	kW

A sister ship to MV Hallaig, MV Catriona, was launched in December 2015.

A.3 Hybrid propulsion system

The hybrid propulsion system uses D-E system instead of D-M system. The following tables A.2 and A.3 indicate the fuel calculation for these two different propulsion systems.

D-M propulsion system includes two engines connected with two shafts and two propeller units. There are also two generators in D-M system, which can be used for electricity supply.

There are three diesel generators in the D-E system, linked to the switchboard which can distribute the energy as demanded. Like D-M system, two propeller units are applied but driven by two electric motors. Two variable speed drives are applied to convert between DC and AC electricity.

For a hybrid propulsion system, two battery banks are connected with the D-E system to help supply electricity. When the power required is low, battery banks can be used as main power source. Under some circumstances, running two generators is not efficient and battery banks could be applied as a replacement for one generator. As the battery banks could be charged by onshore power grid at night tariff, it is potential to decrease the fuel consumption during the ship operation. However, environmental impacts should be considered in detail, such as the emissions from onshore power generation.

Table A.2: Fuel consumption of D-M propulsion system.

Diesel-Mechanical: 2 x 450kW Engines					
	Max propulsion power	9 knots	Maneuvering	In port	Overnight
Daily hours		25%	3%	16%	57%
		6	0.6	3.72	13.68
Shaft power (kW)	750	267.5	120	72	
MCR (kW)	450	450	450	450	
Number of engines connected	2	2	2	2	
Total installed ME power (MCR in kW)	900	900	900	900	
Total ME power demand (kW)	840	291	130	78	
Main engine load	93%	32%	14%	9%	
Fuel consumption (litres/day)		441	22	85	
Estimated total fuel consumption (litres/day)		548			

Table A.3: Fuel consumption of D-E propulsion system.

Diesel-Electric 3 x 360kW Engines					
	Max propulsion power	9 knots	Maneuvering	In port	Overnight
Daily hours		25%	3%	16%	57%
		6	0.6	3.72	13.68
Shaft power (kW)	750	267.5	120	72	
MCR (kW)	360	360	360	360	
Number of engines connected	3	1	1	1	
Total installed ME power (MCR in kW)	1080	360	360	360	
Total ME power demand (kW)	848	322	144	87	
Main engine load	79%	89%	40%	24%	
Fuel consumption (litres/day)		434	19	85	
Estimated total fuel consumption (litres/day)			538		

Another purpose of this scenario is to investigate the four operation modes of the hybrid system shown below, thereby resulting in an optimised design and operation of the hybrid system.

1. Generator
2. Generator + Battery
3. Battery
4. Battery charging

According to FMEL, the batteries are charged during night tariff so the scenario will consider and optimize the operation phase with changing batteries by generators on board. One example of a serial hybrid system layout is presented in Figure A.2.

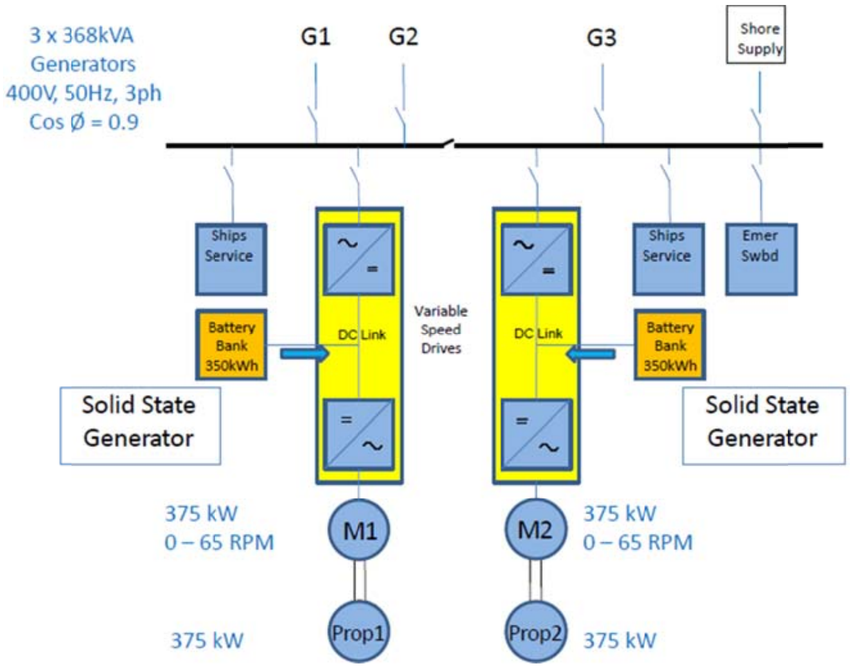

Figure A.2: Layout example of serial hybrid system.

In order to explore the potential advantages of the hybrid propulsion concept, the results of the analysis will be compared to corresponding D-M and D-E systems. An example of such a comparison is shown in Table A.4.

Table A.4: Comparison of fuel consumptions

	Diesel-Mechanical	Diesel-Electric	Hybrid
Daily Fuel Consumption (litres/day)	548	538	To be analysed
Engine load at 9 knots	32%	89%	To be analysed
Engine load during maneuvering	14%	40%	To be analysed
Engine load at port	9%	24%	To be analysed

Based on the information received from Ferguson Marine, the benefit of the hybrid system is that it uses less fuel at full load and during maneuvering. Some other potential advantages are listed below:

- Greater redundancy
- Reduced fuel consumption
- Reduced impact of CO2 emissions and other pollutants
- Uncertainty of future fuel costs
- Insurance against increasing environmental regulation
- Noise reduction
- Possibility to operate in zero emission mode when vessel is at port
- Lower life cycle costs (such as lower maintenance for batteries)
- Flexibility of operating modes
- Propulsive performance at lower power conditions when diesel engines are not efficient (<50% MCR)

Many considerations can be made following the installation of batteries, such as changing the engine room and disposal of batteries. As suggested by FMEL, the locations (spaces) for batteries in a hybrid ship were void in D-M and D-E propulsion ferries. Therefore the sensitivity of engine rooms changing is not so significant. The process for batteries disposal will be recommended by battery manufacturers which should be considered in detail on its costs, environmental impact and potential risks.

A.4 Attributes

This scenario aims to optimise the design for a short-route ferry using hybrid propulsion. The scenario consists of three parts. First, the ship building processes should be optimised including the costs analysis, environment assessment, risk assessment and decision making. Then while in service, the target is to determine the optimal distribution of operation and maintenance on the hybrid propulsion system. It is essential to take into account financial, environmental and risk aspects. At the end of life stage, the ferry will be scrapped and recycled. All the investment, emissions and possible hazards will be considered. Table A.5 illustrates a general view on stages of optimisation for this scenario and the main contents.

The optimisation will consider the whole life cycle including design and production stage, operation stage and the end life of the ferry (scenario 1-A). If the performance of the hybrid system is promising, the retrofitting of the new hybrid propulsion system for an existing ship can be also considered (Scenario 1-B). Therefore, the optimisation approaches of Scenario 1-A can be also applied to Scenario 1-B (Table A.5). The only difference is to consider retrofitting as a new construction process which will dismantle conventional system and install the new hybrid system.

Table A.5: Stages and contents of hybrid propelled ferry optimization

Stages	Main contents		
Design and production stage (include disassembling for scenario 1-B)	Cost analysis	Environmental assessment	Risk assessment
Operation and maintenance stage	Cost analysis	Environmental assessment	Risk assessment
End life scrapping and recycle stage	Cost analysis	Environmental assessment	Risk assessment

The cost analysis for each stage will be derived and utilised for life cycle cost analysis using Table A.5. All the impacts on environment will be assessed based on current rules and regulations and the results will be used for the development of the SHIPLYS software. The risks during the whole life cycle will be determined by building a database and they will be rated and analysed so that a virtual risk assessment can be delivered. The risk assessment will apply a model similar to that developed for scenario 2. Since the target ships are different in these two scenarios, additional risks should be considered.

A.5 Methodology

In a previous project (ECO-REFITEC), the analysis of different painting candidates was carried out. The methodologies applied in ECO-REFITEC will be considered for this project too.

CAPEX can be calculated by applying breakdowns in construction phases to determine their costs and demonstrate the initial expenses of a product. The costs for each breakdown should be listed for calculation, such as steel plate and machinery.

OPEX can be calculated using the same idea for the operation and maintenance costs. The operation costs for each year should include fuel and energy costs, repair and maintenance costs and so on.

To analyse and evaluate the costs of these different circumstances, Net Present Value (PV) will be applied. The Net Present Value formula is presented as following:

$$PV=PV_0+FV\cdot(1-(1+i)^{-n})/i$$

where:

PV_0 CAPEX: amount spent initially for the implementation;

FV OPEX: cost of operative expenses, for any given year;

i Interest rate;

n Lifetime of vessel (years).

Figure A.3 shows schematically the flowchart of the proposed LCA procedure.

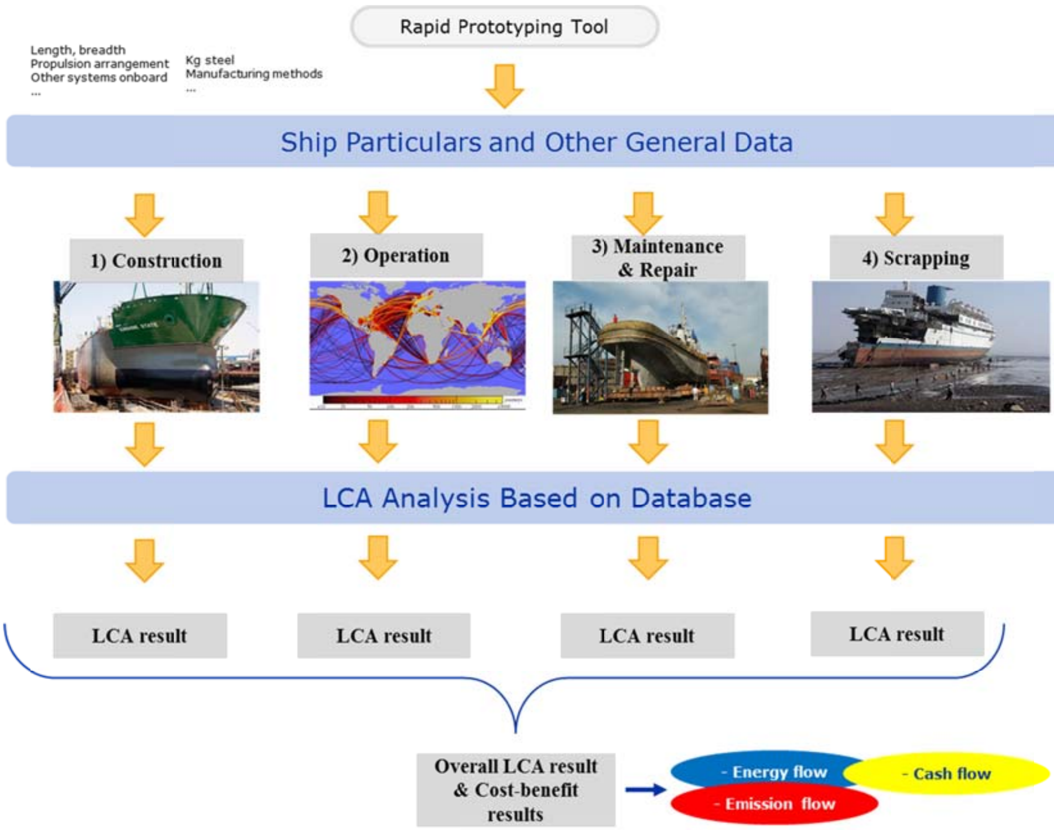

Figure A.3: Flowchart of ship LCA model.

A characterisation method will be selected and applied for the environmental impact analysis. A flowchart of the principle is presented in the following figure.

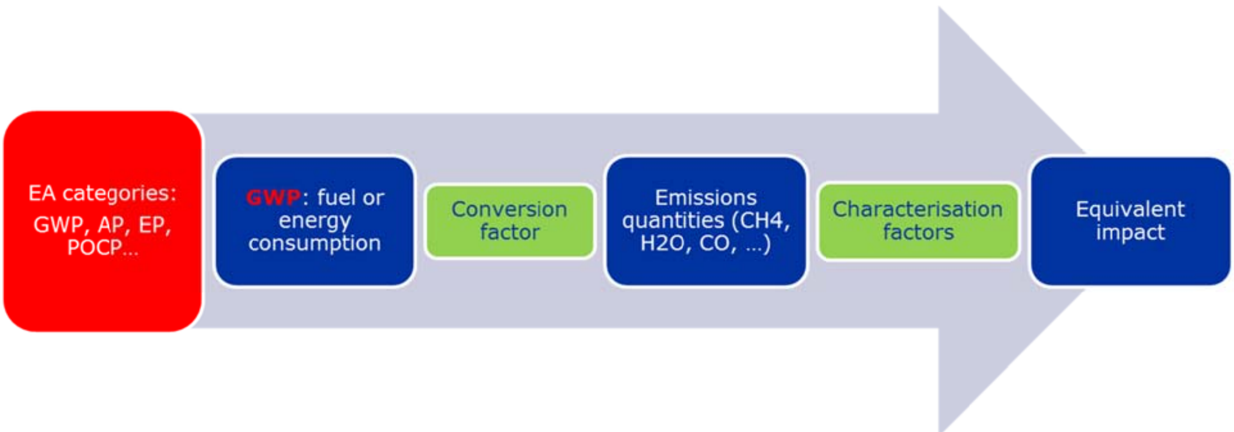

Figure A.4: Flowchart of characterisation method principle.

To comply with current regulations, the Energy Efficiency Design Index (EEDI) and the Energy Efficiency Operational Indicator (EEOI) will be considered in the environment impact. To combine the characterisation method with EEDI/EEOI, a new LCA score is designed and its equation is presented below:

$$LCA_{effGWP} = \frac{\sum_i gGWP_i}{\sum_i (m_{cargo,i} \times D_i)}$$

where,

D	Distance (nautical miles) corresponding to the cargo carried or work done;
gGWP	LCA CO_2 inventory aggregate in grams comprising classification and characterisation of releases analogous to CO_2;
LCA_{effGWP}	LCA energy efficiency GWP score in g CO_2/tonne-nm;
m_{cargo}	Cargo carried (tonnes) or work done (number of TEU or passengers) or gross tonnes for passenger ships;
i	Index of summation.

A.6 Conclusions

This scenario aims to investigate and verify the many potential advantages of the hybrid D-E propulsion system compared to the conventional D-M and D-E systems. The hybrid system could consider the operation conditions during the service life of the vessel and make the best use of main engine power so that the fuel consumption is reduced. As this hybrid propulsion system is promising, the LCA analysis of the system will provide more details in design, production, operation and recycle stages, especially on the perspective of costs, environment and risk. In order to make hybrid propulsion a possible option for existing ships, the retrofitting of the system will be also analysed through this LCA analysis, considering the additional disassembling in the design stage.

Appendix B
Scenario 2
Conceptual ship design accounting for risk-based LCA

Varna Maritime, Instituto Superior Tecnico and Atlantec Enterprise Solutions

B.1 Introduction

A jointly developed scenario by AES, IST and VARNA is presented here, where a new design of a Multi Purpose Vessel (MPV) is assumed to be built within the environment of an SME shipyard and satisfying the principal objectives of the SHIPLYS project. VARNA is accounting for the shipyard constraints.

B.2 General description of the MPVs

The target of this scenario is the conceptual design of an MPV, a small handy vessel in the range of 7000 to 14000 DWT with predominantly two large cargo holds and a cargo tank. The multi purpose vessels are non-cellular vessels designed to carry different types of cargo, including nearly all types of dry cargo: general, bulk and heavy over dimensional and/or containerized cargo.

Typical features of this type of vessel are box-type holds, cranes with a minimum lifting capacity of 60 tons, movable bulkheads and tween decks. Some statistics about the current exploration of different types of ships in short sea shipping of goods in EU in 2014 is given in Figure B.1. Goods for short sea shipping in the Mediterranean Sea are shown in Figure B.2 and goods for short sea shipping in the Black sea is given in Figure B.3.

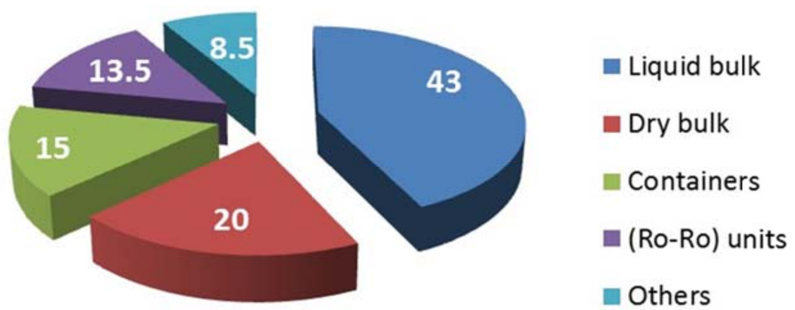

Figure B.1: Short sea shipping of goods in EU (2014).

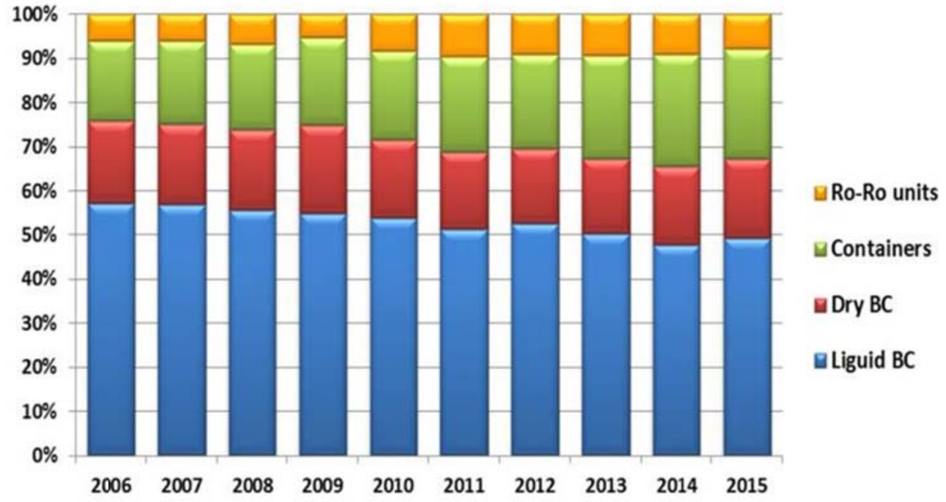

Figure B.2: Goods for short sea shipping in the Mediterranean Sea.
(Source: http://ec.europa.eu/eurostat/ web/transport/data/ database)

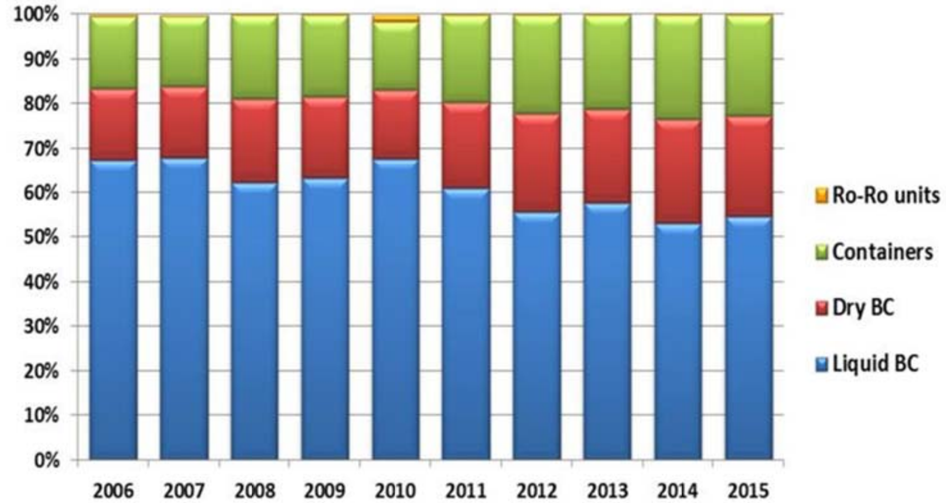

Figure B.3: Goods for short sea shipping in the Black Sea.
(Source: http://ec.europa.eu/eurostat/ web/transport/data/ database)

Figure B.4 indicates that MPVs are one of the aging ship types (www.equasis.org), which can be a reason to expect more orders to be seen in the coming years. However, MPVs are not facing a lack of cargoes, but strong competition from other vessel types.

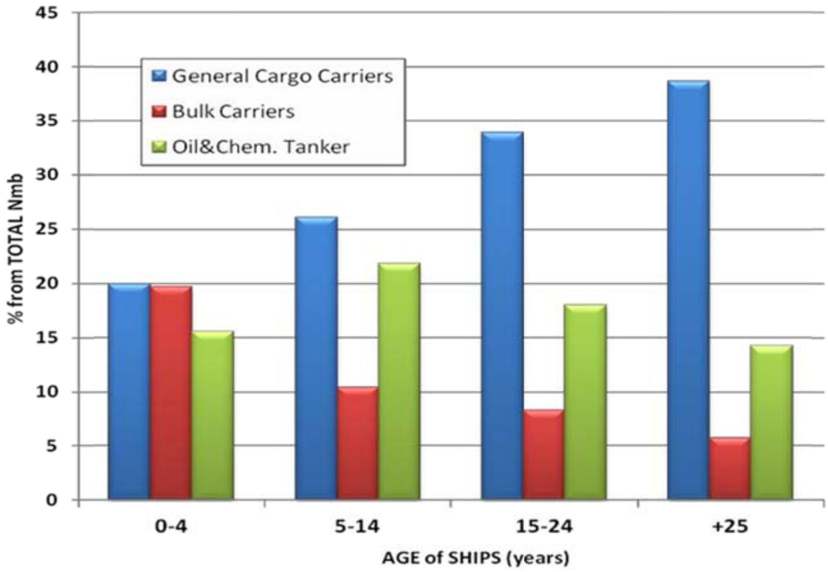

Figure B.4: Age of existing ship types.
(Source: The world merchant fleet in 2014)

Positive trends in MPV fleet seen in Figure B.5 have been registered by the DNV Trend Report "Business area maritime – business development", February 2015.

Figure B.5: MPVs worldwide contracts, mDWT.

B.3 Target shipyard

This proposed scenario is targeting the environment of a small and medium shipyard, and VARNA MARITIME LTD shipyard, as a partner of the SHIPLYS project, is a good candidate. The objective of scenario 2 is to design and build new MPVs at a shipyard similar to that of VARNA MARITIME LTD.

Scenario B will also examine and trace corrective measures to move from mainly ship repair activities to designing and building new ships, by implementing new production technologies and materials and by introducing higher quality requirements and better life-cycle performance. On the production side, this includes the identification of required product capacities for all trades involved, facilities to be installed or upgraded, configuration of the supply chain, as well as resource levelling.

Implementing new technologies and building new ships in a shipyard without historical experience in this environment will generate higher uncertainties concerning the technological requirements, personnel qualification, schedule, material flows and supplies and involved cost. Furthermore, as the new design may involve recent state-of-the- art equipment for propulsion, manoeuvring or charging/discharging, specific requirements may evolve requiring particular attention.

The descriptors of the new environmental conditions that are going to be imposed to the small and medium shipyard, including the uncertainties related to them, will be included in the risk-based design framework to be carried out within the framework of this scenario.

B.4 Prototype ship - MPV 9800 DWT

The ship that is going to serve as a prototype is an MPV with the following characteristics:

- Length overall L_{OA} = 126.08 m
- Length b/w perpendiculars L_{PP} = 113.75 m
- Breadth, moulded, B = 20.00 m
- Depth, moulded, D = 10.40 m
- Draft summer, d = 8.29 m
- Deadweight DWT = ab. 9800 t
- Speed: 14 knots

The midship section of the prototype ship is shown in Figure B.6, whereas a longitudinal profile and a general view of the ship are shown in Figures B.7 and B.8, respectively.

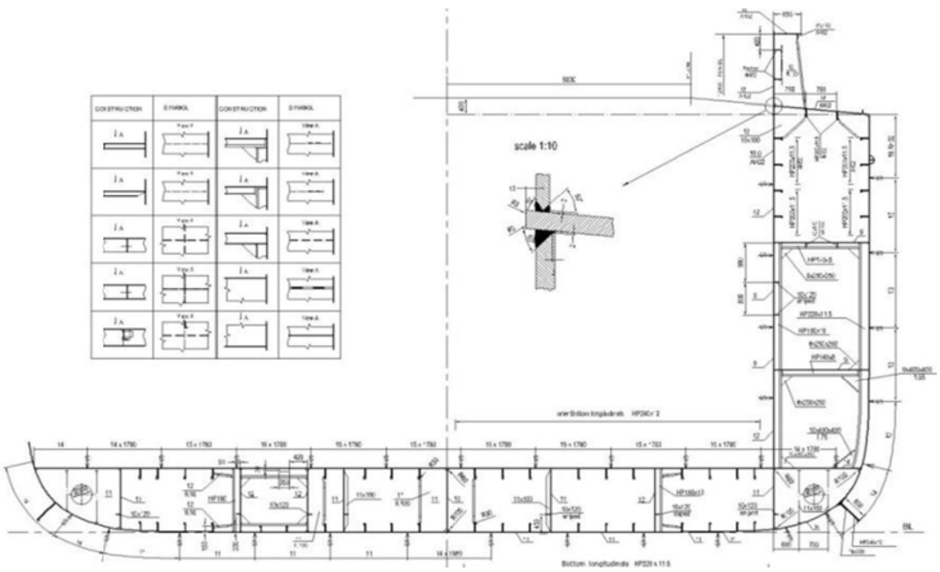

Figure B.6: Midship section of the prototype ship.

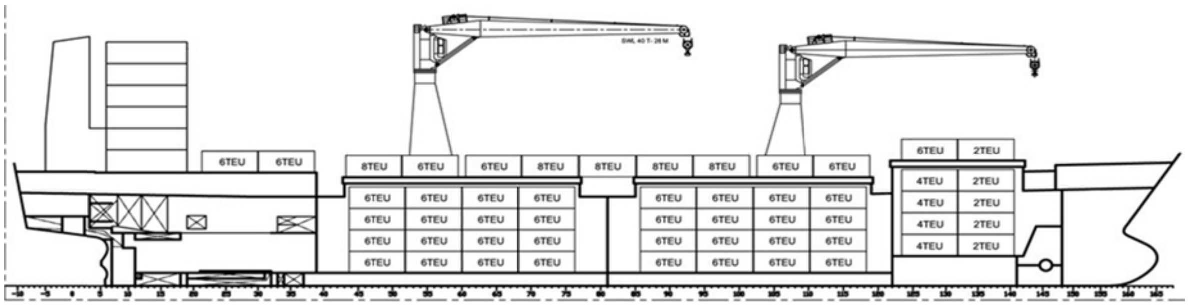

Figure B.7: Longitudinal profile of the prototype ship.

Figure B.8: General view of the prototype ship.

B.5 Conclusions

A conceptual ship design optimization of a Multi Purpose Vessel and her systems' characteristics is proposed to be employed within scenario 2, accounting for the constructional limitations of an SME shipyard and including constructional, operational and failure cost assessment. The scenario approaches also the shift of an SME shipyard from a mainly repair functionality to a new-construction functionality, with a capacity to build new ships.

A risk based approach for the structural design of the vessel will be performed, involving the ultimate strength of the ship's hull girder, reliability, consequences of structural failure and optimum safety levels, based on a cost-benefit analysis.

Recent developments of risk based approaches in the design of ship structures, as well as the work carried out by IMO on the Formal Safety Assessment (FSA) and Goal-Based Standards (GBS) are going to be accounted for.

The assessment of hull girder reliability and probability of structural failure will be performed using a limit state function based on the IACS progressive collapse analysis to estimate the ultimate capacity of ship hull, employing First Order Reliability Methods.

The effects of the shipyard manufacturing processes, of the use of new materials and advanced equipment and of the scantlings of the ship hull on the probability of failure of the ship hull girder and, consequently, the effect of the risk of the expected cost of failure will be analysed, accounting for ageing, environmental impact and cost of loss of human life.

A special focus is attributed to the shipbuilding limitations of an SME shipyard in terms of engineering specification, construction, operational, maintenance and end life (scrap) costs in the life cycle optimization.

Retrofitting options can be also considered for decommissioning. The greener design accounting for the environmental impact is taken into consideration in defining the target structural reliability level.

Scenario 2 is going to be used as a generic scenario to test the developed models and tools in different tasks in the SHIPLYS project, including integration of rapid virtual prototyping and life cycle tools, database development, models for LCCA, environmental assessment, risk assessment and multi-criteria decision making and implement rapid virtual design and production process prototyping generators.

The proposed scenario is flexible enough and can be adapted to any small and medium shipyard. The proposed prototype MPV is used as an example to demonstrate the developed interactive intelligent conceptual design framework of the SHPLYS project, which can be employed to design any other type of ship with a conventional diesel or hybrid electric propulsion, using advanced new technologies for shipbuilding.

As Figure B.9 schematically shows, the scenario will be organized in three consecutive tasks related to conceptual ship design (Task 1), risk-based structural assessment (Task 2), risk-based maintenance (Task 3) and fast hull geometry prototyping (Task 4). Task 4 will be carried out in parallel with Task 1.

Figure B.9: Schematic organization of scenario 2.

Appendix C
SCENARIO 3
Ship retrofitting accounting for Life Cycle Cost Assessment

Astilleros de Santander, Fundación del Centro Tecnológico Soermar

C.1 Introduction

A jointly developed scenario by ASTANDER (ATD) and SOERMAR is presented here, where the optimisation/assessment of either one or two different types of retrofitting will be addressed, namely a scrubber system and/or a water ballast management plant, both of them assumed to be carried out within the environment of a small and medium shipyard like ATD, accounting for the shipyard constraints. This scenario is aiming at satisfying the objectives of the SHIPLYS project, as follows:

- Demonstrate the effectiveness of the SHIPLYS integrated modelling and lifecycle approach.
- Develop a Virtual Prototyping system to incorporate LCCA, environmental and risk assessment criteria, for fast and cost effective evaluation of alternatives.
- Carry out concept-stage design 3D CAD modelling with the detail required for product construction at the shipyard, and use these to establish a data set suitable to determine work load, processes, resource needs and build a more complete analysis model.
- Be able to keep the bid-stage technical information and pass it through into the detailed design stages.
- Introduce a reliable modelling method for lifecycle analyses (costs, environmental, risk) for designs both at the early design stage (supporting bid decisions) and at later stages for detailed design.
- Assess the through life impact of changes at various stages in order to arrive at optimum configurations.

C.2 Description of the ship repair/retrofitting bidding process

The nature of repair and retrofitting projects differs substantially from long term new building projects. Bidding and preparation time is very short in comparison, and a lot of facts can only be determined on board the vessel or in close interaction with the ship operator. The work specification is commonly provided by the ship operator. Along the same line, the ship operator is also often driving the engineering design activities in preparation for a repair, conversion or retrofitting project.

The main challenge for shipyards is to establish realistic estimates of work activities and their work volumes, and to develop an overall project schedule.

The dynamics of the repair and retrofitting process is complex. Typically, there is a large number of ad-hoc decisions that will have to be made as work progresses. The state of different systems is investigated during the course of the project, potentially revealing issues that were previously unforeseen. This creates a challenge, both in planning and logistics operations.

It´s also important to underline that repair shipyards usually face inconsistency issues between the 2D project drawings provided sometimes by the owner and reality. This incosistencies cause interferences, delays and extra cost for the retrofitting.

In a timely manner, before a shipyard accepts a contract for a repair or retrofitting project, a series of analyses and preparations have to be made. Review and preparation of appropriate entities documentation and internal procedures, play an important role to achieve the required level of scope of the project, in order to reduce the threats of occurrence of extra costs.

Additionally, for LCCA, LCC and RA purposes, it is necessary to estimate and quantify the overall cost and impact in terms of resource consumptions and environmental emissions, hazards and risks occurring during the project implementation.

C.3 Target shipyard

Astilleros de Santander is a shipyard focused on repairs and transformations of already existing vessels. Their contribution to SHIPLYS project are examples of this kind of works and activities. The main objective of Astilleros de Santander is to increase their production efficiency and reduce energy consumption, environmental impacts and production costs not only of the shipyard but also of the vessels in operation.

C.4 Description of the proposed scenario

The first scenario study proposed here focuses on the holistic assessment and optimization (through the SHIPLYS tools) of some retrofitting activities recently addressed by the shipyard, related to the installation of scrubbers in existing ROPAX ferries to cut funnel emissions and to protect the environment.

The French company Brittany Ferries has completed in Astilleros de Santander the installation of scrubbers in five of their vessels, namely “Normandie”, “Cap Finistere”, “Barfleur”, “Mont St. Michel” and “Armonique”. As these ferries regularly operate in SECA areas and in order to comply with the newly updated MARPOL VI Regulation, an extensive program to update the fleet has been performed, based on maintaining the use of the cost-effective heavy fuel oil, and, consequently, installing scrubbers.

- In October 2014, the M/V “Normandie” was docked in Astilleros de Santander for a less than two months project, consisting of:
  - Removal of the existing exhaust systems and replacement of the silencers by the new scrubbers.
  - Installation of the new seven scrubbers (four for the M/E and three for the A/E).
  - Rerouting of the existing pipe network in the casing.
  - Installation of new pump rooms.
  - Installation of the new exhausts and water system piping.
  - Fabrication and mounting of new enlarged funnel.
  - Installation of new electrical systems, control systems, insulation, structural modifications and other auxiliary jobs.

Due to the limited space available in the casings and the important interference of piping and structural systems, the tight delivery time was achieved by means of a correct planning and strategy of the removal/mounting process (Figure C.1).

- In January 2015, the “Cap Finistere” arrived to Astilleros de Santander for a similar project.
- In March 2015, the M/V “Barfleur” also experienced the same type of open loop scrubber conversion at Astilleros de Santander.
- In September 2015 commenced the installation of scrubbers in the M/V “Mont St. Michel”. This scrubber installation was, unlike in the other members of the fleet, of a close loop type and housed in a new upper deck structure between her two existing funnels.
- In April 2016, scrubbers were installed in the M/V “Armonique”.

Note: All the vessels are currently operating making Brittany Ferries a much more environmentally friendly fleet. The overall process could be assessed/optimised in the light of the outcome of the SHIPLYS evaluations.

The modifications in M/V “Normandie” (the first of the series) are roughly shown in Figures C.2 and C.3.

Figure C.1: M/V Normandie before (up) and after (down) retrofitting (© BRITTANY FERRIES).

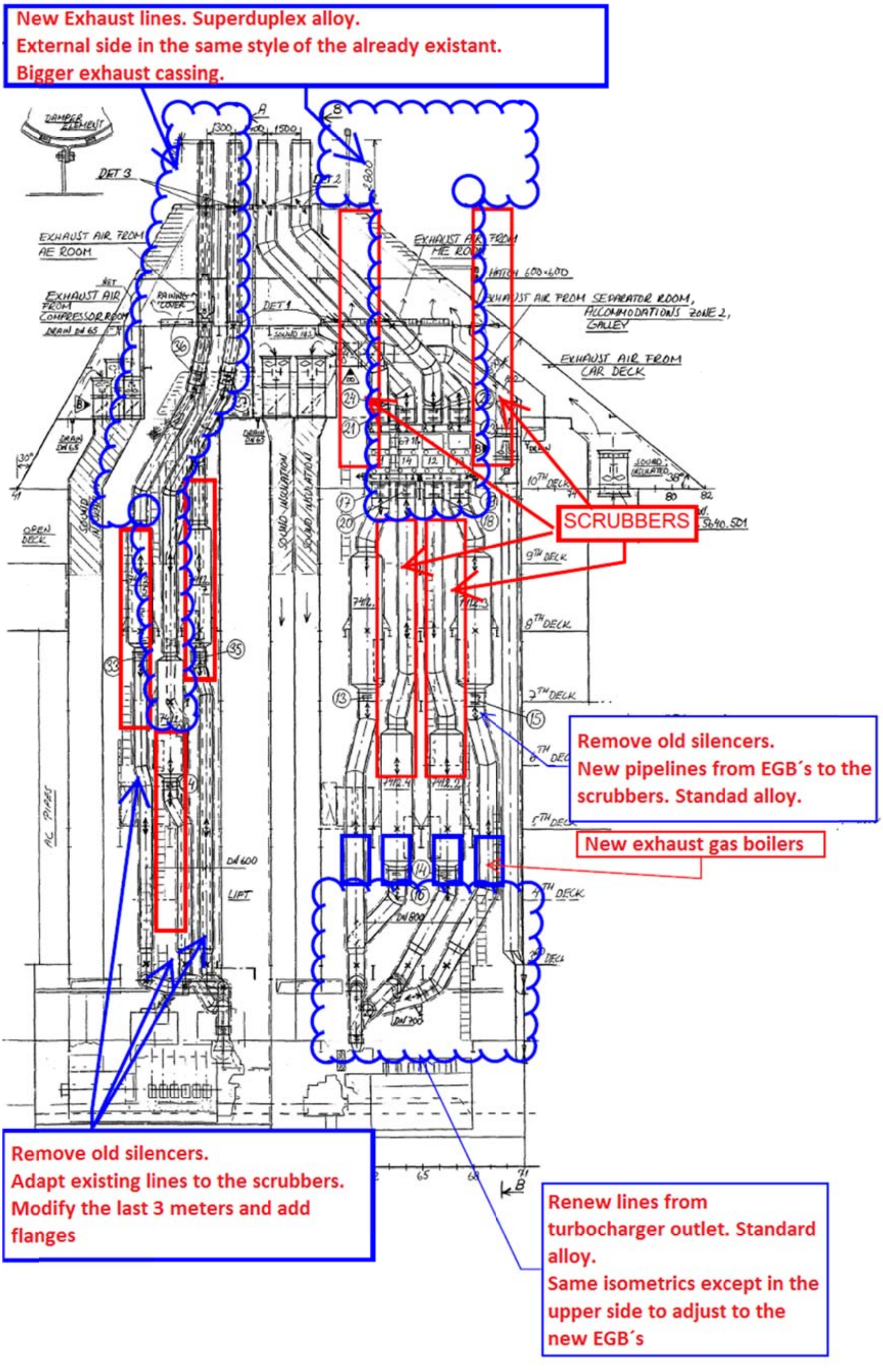

Figure C.2: Scrubber installation modifications in M/V Normandie.

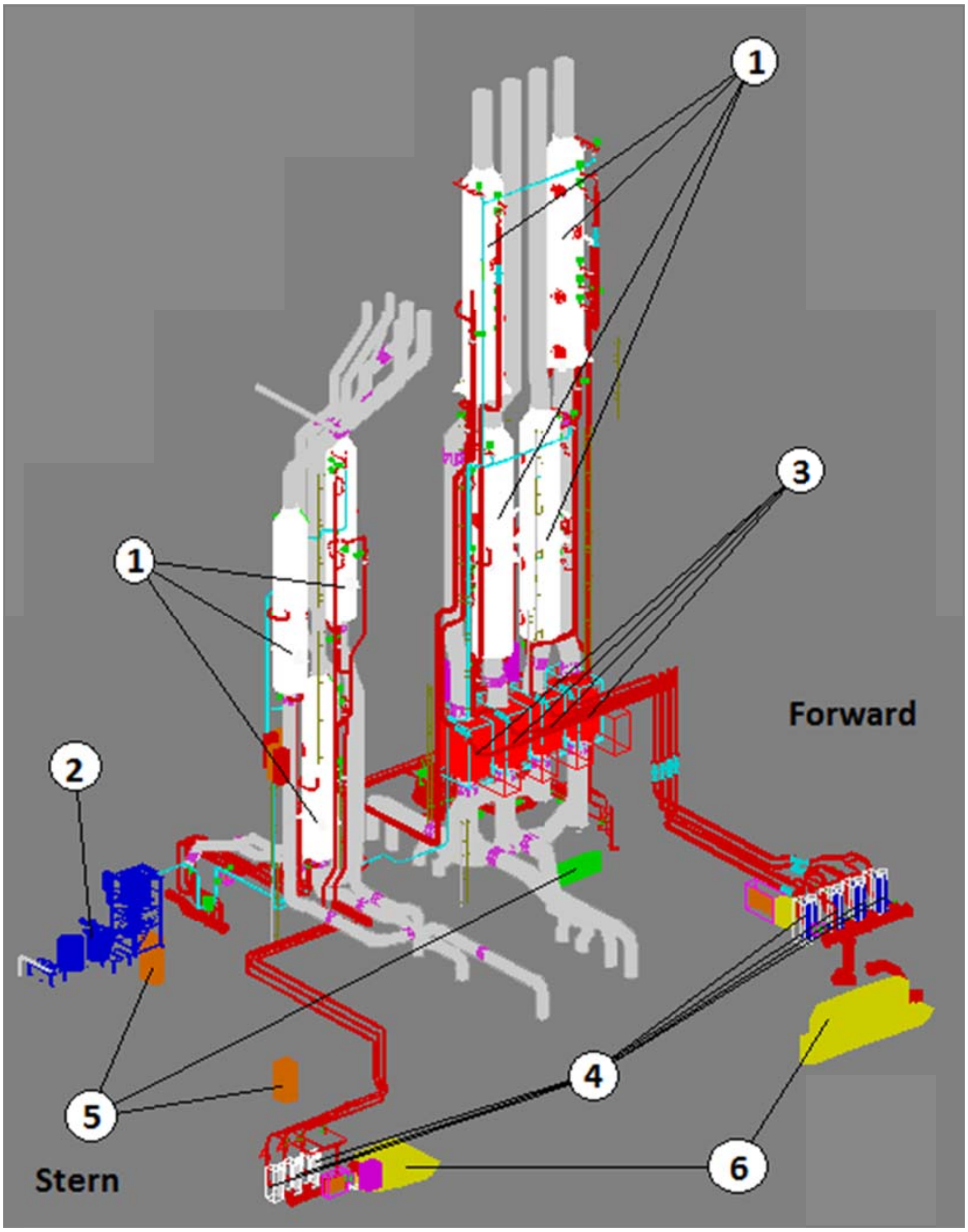

Figure C.3: Complete scrubber system in M/V Normandie.

Although there were similarities among the various scrubber systems installed, the actual installations and solutions were different from vessel to vessel. Equipment and materials used were not the same, providing thus additional information that could be used for the scenario simulation and the SHIPLYS tool evaluation.

The ROPAX ferry on which the proposed scenario will be first applied has the basic characteristics shown in Table C.1 and the sample general arrangement shown in Figure C.4. Typical similar vessels for applying the same scenario are shown in Table C.2.

Table C.1: Main characteristics of sample ship.

Type of vessel	Ro-Ro passenger ship
Year of built	1999 - 2003
Length Overall (L_{OA})	Around 200 m
Length Between Perpendiculars (L_{BP})	Around 175 m
Breadth	Around 25 m
Displacement	Around 20000 tonnes
Dead-weight (DWT)	6500 tonnes
Gross Tonnage (GT)	Around 30000 tonnes
Power:	Around 35.000 kW

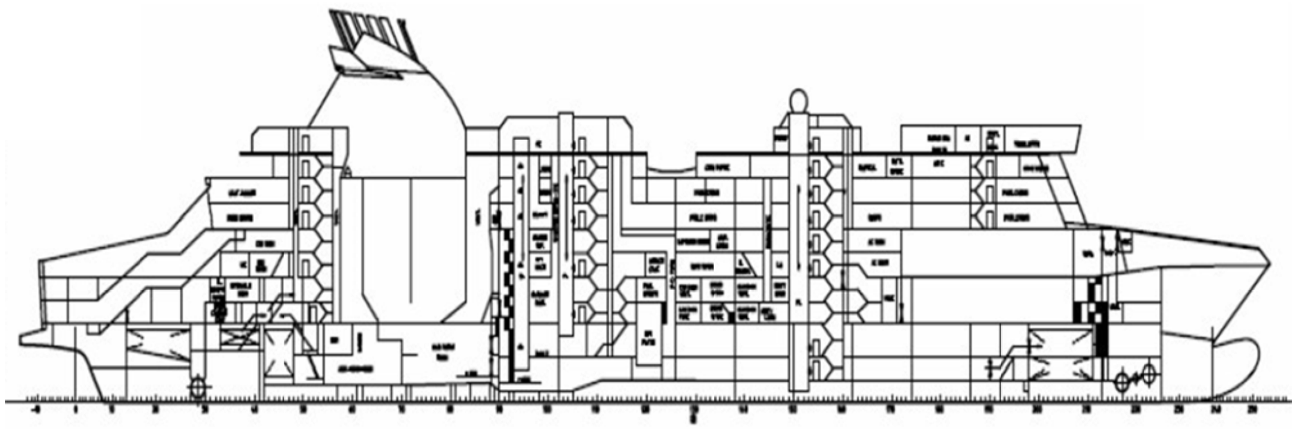

Figure C.4: General arrangement of the representative ROPAX ferry.

Table C.2: Similar vessels data.

Year of built	# of Ships	Average length in meters (L_{BP})	Avg. Main engine Total kW
1999	7	170.17	25180
2000	10	167.96	37459
2001	26	179.74	41252
2002	17	178.91	37973
2003	12	177.38	34375
TOTAL	72	174.83	35247

It can be noticed at this point that the series of existing ships shown in Table C.2 can be a reason to expect more orders to be seen in the coming years.

Among the three solutions to the emissions control area fuel sulphur limit question (distillate fuel, exhaust gas cleaning and LNG) the favoured option for ships spending all or most of their sea time within ECAs seems to be the exhaust gas scrubbers.

As mentioned previously , it´s a very common risk that the information from documentation provided by the ship-owner (drawings, specifications, etc.) and the real ship do not match. This fact causes large deviations in terms of cost and it´s necessary to perform new data collection and new “drafts”, affecting therefore the cycle of repair.

C.5 Organisation of the proposed scenario

Scenario 3 will be first applied for assessing the retrofitting of the MV “Mont St. Michel”, a Ro-Ro passenger vessel (Figure C.5) which has been equipped with an exhaust gas cleaning system (SOx scrubber) in order to comply with MARPOL. ASTANDER shipyard has experience with this ship type and has collected information that will be used to calibrate the developed applications. Notwithstanding, the scenario could be adapted to other ship types and works.

Figure C.5: M/V “Mont St. Michel”.

The following remarks should be made regarding the proposed case study:

- MV “Mont St. Michel” is a ROPAX ferry fitted with four main Diesel engines, MAK 6 M 43 type, used for propulsion and located in two engine rooms.
- The ship is also equipped with three Diesel generating sets located in the auxiliary engine room and powered by Wärtsilä 9L20 auxiliary engines.
- The ship is operated in SECA area continuously.
- The EGC system installed, of the hybrid type, treat the main engines and the auxiliary engines exhaust gases.
- The installation was made by installing one scrubber system with by-pass on the exhaust lines.
- A new network was also installed to feed scrubber system with sea water and to discharge effluent overboard during the operation in open loop and to run the scrubber system with cooled alkali treated water during operation in closed loop.

Along the lines of SHIPLYS project, this scenario covers retroffiting design and optimization in terms of planning and production cost. The scenario will use technologies embedded in existing software applications which will be integrated with software able to perform LCCA (Life Cycle Cost Analysis) and Risk Assessment from the conceptual retroffiting design stage (see Figure C.6).

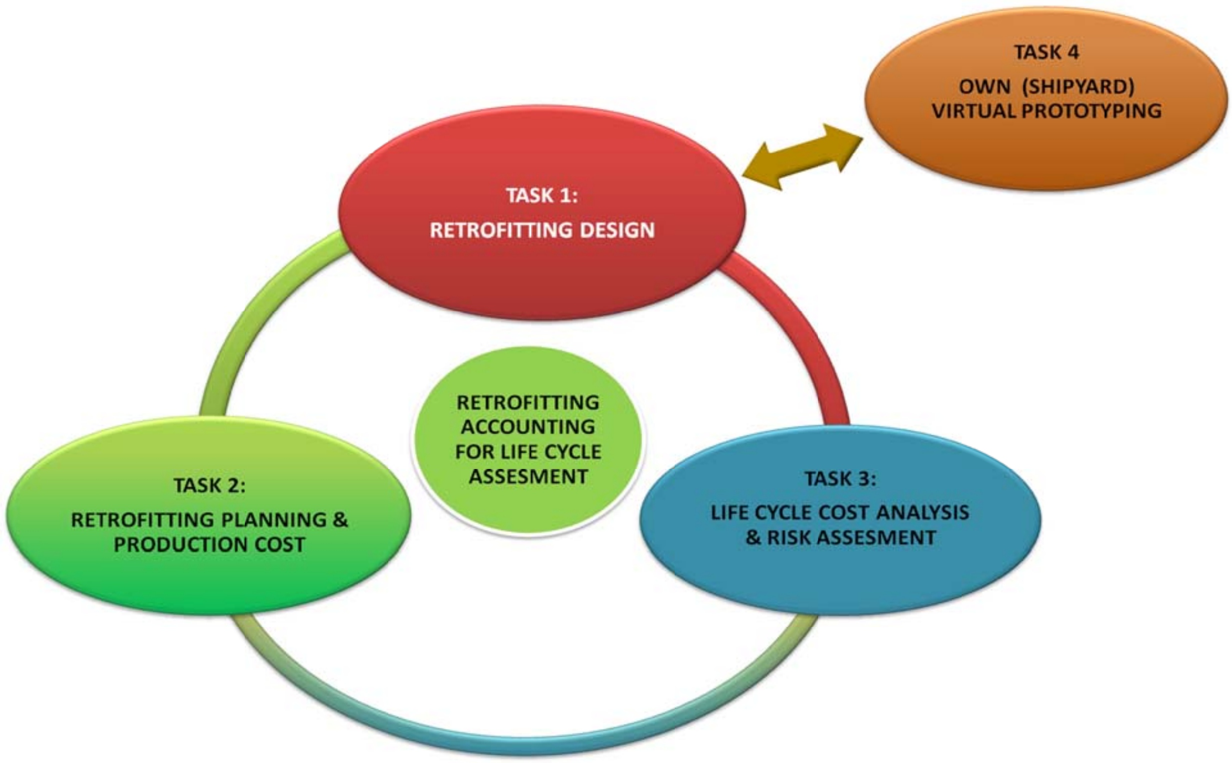

Figure C.6: Schematic organisation of Scenario 3.

As Figure C.6 schematically shows, the scenario will be organized in four tasks related to retroffiting design (Task 1), retrofitting planning and production cost (Task 2), LCCA and risk assesment (Task 3) and 3D virtual prototyping (Task 4).

C.6 Conclusions

Astilleros de Santander considers that the software tool to be developed within SHIPLYS project will be useful for retrofitting and repair works if it has the following basic characteristics and meets , at least, the following requirements:

<u>*Budget estimation based on the complete quantification of the needed materials and labour hours*</u>

Building on the detailed engineering provided by the owner, the program should display a complete quantification of the materials needed. This should include raw materials (plates, profiles, pipes, cables, etc.), as well as complete hardware (pumps, engines, scrubbers, etc.).

Since a budget should include not only materials but also labour hours, introducing the quantity of the shipyard personel grouped in sectors is essential. In this way, considering the different works to be completed by each group (not only type, but also clearance), an estimation of the number of personel should be provided by the tool, for each sector and each operation. The consequence of this is adequate planning of the works. In addition, labour hours could be easily calculated.

Allow to optimize the use of shipyard´s own machinery

The software tool should include a model of the shipyard with its dry-docks (or tiers), as well as its infrastructure (cranes, ashore connections, etc.). In this way, an adequate coordination of the means of the dry-dock (or tier) could be planned.

It allows "high" detailed engineering

The vessel´s model made with the SHIPLYS tool must not include only generalities about the ship or individual models of different systems. It should contain also models of every pipeline, cable line, steel, and equipment. This information should be grouped by layers and be dealt with as a single whole thing, so that there is almost no difference between the model and the real vessel. This will allow easier planning of the installation or removal of the equipment, and will reduce non desired interactions among them.

Allows the determination of the most adequate dates for material and equipment reception

Once the material and equipment list is completed, logistical planning of acquirement and fabrication would be easier. Definition of the most adequate dates for material and equipment reception could be possible. This improves competitiveness of shipyards (Just in Time).

The above requirements will allow Astilleros de Santander to increase its production efficiency and reduce energy consumption, environmental impact and production costs. The scenario proposed has the advantage of being based on real retrofitting carried out in the shipyard. A lot of information is already available and could be useful to develop a Virtual Prototyping system to incorporate LCCA, environmental and risk assessment criteria, for fast and cost effective evaluation of alternatives.

Appendix D
SCENARIO 4
Optimising shipyard production systems

Atlantec Enterprise Solutions

D.1 Initial conditions

The shipyard plans to modify its production procedure (typical block erection and zone outfitting) aiming at a new future portfolio. As an example, production of plate and profile parts (cutting and small assemblies) is targeting typical medium thickness material. Processes used include:

- Oxy-fuel and (optional) plasma cutting,
- Manual and semi-automatic shielded arc welding (including some variations) and comparable production technology.
- A certain sequence of assembly stages primarily dictated by production facility limitations such as workplace dimensions, crane capacity, welding technology etc.

D.2 New Requirements

Due to change of vessel type portfolio, a substantial amount of material will be thin sheet material, which is far more sensitive to heat-induced distortion and related quality issues. A search for better production methods is initiated[1].

As an alternative investigation and in order to achieve lower production cost while simultaneously reducing production time, a study can be initiated to find a new approach based on standardised assemblies (modular production). Standardised assemblies are intended to be parameterised structural solutions for specific purposes (e.g. based on compartment function, location, structure loads etc.).

D.3 Potential solutions

Depending on the actual conditions (e.g. production volume, supply chain organisation, cost), potential solutions for including thin sheet material may include:

- Use of laser cutting equipment
- Use of laser welding station for small panels
- Use of new structural concepts like sandwich panels which require specific modifications to the flow of production, including effects on resources
- Use of advanced quality control tools such as laser-scanning for dimensional control

Once more depending on the actual conditions (e.g. production volume, supply chain organisation, cost), potential solutions for introducing the standardised assemblies concept may include:

- Design of a catalogue of parameterised assemblies built from standardised parts
- Reconfiguration/upgrading of existing production facilities to enable optimised production of these standardised assemblies

[1] A variation of this topic may be switching to vessel modifications to make them capable of polar shipping operations, resulting in other types of material and more uses of higher thickness.

D.4 Scenario

As regards the introduction of thin sheet material in production, the basic scenario characteristics may be the following:

- Create an innovative design (e.g. ruggedized battery powered ferry with substantial weight reduction requirements) that involves use of new production techniques
- Perform a production planning for one up to a larger series of ships
- Simulate production and compare different solutions, determine ROI of production technology investments and cost effects for vessels

As regards the introduction of the standardised assemblies concept in production, the basic scenario characteristics may be the following

- Select an existing or new ship design for identification of structural patterns
- Develop assembly standards catalogue, possibly by applying system engineering methods
- Verify structural performance of redesign
- Perform a production planning for a single vessel up to larger series of ships
- Simulate production and compare different solutions, determine feasibility of approach and ROI of production technology investments and cost effects for vessels

Appendix E

Summary of SHIPLYS scenarios for the purpose of informing the SHIPLYS Stakeholders' Advisory Committee and inviting feedback

SCENARIO 1: Optimisation of the design of a novel hybrid propulsion system used in a short-route ferry

- Shipyard proposing the Scenario: Ferguson Marine

Ferguson Marine Engineering Limited, a member of the SHIPLYS consortium, is a commercial shipbuilding and marine engineering company based on the River Clyde in Port Glasgow. It specialises in building commercial ships up to 115 metres in length and other marine and industrial fabrication. Ferguson Marine is a proven innovator, having built the world's first hybrid ferries, and it continues to collaborate with international partners on the development of alternative, energy-efficient propulsion and the next generation of greener vessels. In addition, the company has completed numerous civil engineering and marine fabrication contracts and is developing marine and offshore wind energy as a key business area. More details of the company can be found at http://www.fergusonmarine.com/.

- Objectives of the Scenario

This scenario proposed by Ferguson Marine, together with the University of Strathclyde (another member of the SHIPYLYS consortium), is aimed at optimising the design of a novel hybrid propulsion system used in a short-route ferry.

The hybrid propulsion system combines internal combustion engines and battery cells. The scenario will cover the whole life cycle of the ferry, including operation and maintenance, scrapping and recycling stages. Potentially, implications of optimising the propulsion system on the design and production of the short route ferry will also be considered using the generic functionality of the suite of software created. In each stage, cost analysis, environmental impacts and risk assessments will be considered for thorough evaluations of the hybrid propulsion system.

This scenario will determine the benefits of applying hybrid propulsion compared with applying diesel-mechanical (D-M) and diesel-electric (D-E) propulsion. The comparison will be carried out in the perspective of ship life cycle, including the cost, environment and risk assessment. Work done by the University of Strathclyde and others in a previous European Union project, Eco-REFITEC, showed that the LCA (life cycle assessment) approach is a feasible way to evaluate the environmental impacts from the ship operation phase. The SHIPLYS project will enhance and extend the application of LCA from environmental assessment to cost and risk assessments and from operation phase to the whole life cycle.

The basic idea is to conduct LCA for a selected case ship with different types of propulsion systems. For the selected ship, the costs, environment and risk impacts will be analysed and they will be compared under different circumstances: D-M, D-E and hybrid. The difference will be mainly derived from fuel consumption: D-M system will propel the ship directly; D-E system will convert fuel into electricity and drive motor to propel the ship; hybrid system will distribute the electric loads to generators and batteries based on the specific route undertaken. The advantage of D-E compared to D-M system has been calculated by Ferguson Marine and, potentially, the former can save about 2% of diesel fuel. Compared with D-E propulsion system, the hybrid system is to save fuel because the batteries are charged from the onshore power grids during night tariff. This project will investigate and evaluate the life cycle cost, environmental and risk impact of these systems in order to determine the optimal propulsion system and its operation.

Ferguson Marine Engineering Limited expects that the development of this scenario will enable SMEs to make more reliable predictions on operational optimization.

SCENARIO 2: Conceptual ship design accounting for risk-based life cycle assessment

- Shipyard proposing the Scenario: VARNA MARITIME LTD

VARNA MARITIME LTD, a member of the SHIPLYS consortium, is an SME ship repair and engineering service provider specialized in class/special survey repairs of different types of vessels. The yard combines technological knowledge and experience in ship repair for more than 25 years that provides a good basis for the company's management to look into expanding the production portfolio. One of the focuses is shipbuilding, which will allow for more efficient use of the technological capacity and workforce, optimization of technological and organizational structure, utilization of new technologies, and expansion of market positions. More information regarding the shipyard can be obtained from http://www.varnamaritime.com/en/.

A key aspect to offering advance solutions to clients is the ability to assess and present options from a life cycle perspective at the concept ship design stage by rapid prototyping, assessment of production requirements and risk assessments.

- Objectives of the Scenario

The objective of this scenario is to develop a software tool for conceptual ship design accounting for risk-based life cycle assessment. The scenario is organized in three consecutive tasks related to (Task 1) conceptual ship design, (Task 2) a risk-based structural assessment and (Task 3) risk-based maintenance. Task 4 is focused on fast hull geometry prototyping and Task 5 is related to production assessment. Tasks 4 and 5 will be carried out in parallel with Task 1.

This scenario covers conceptual ship design and optimization in terms of naval architecture (main ship dimensions) and marine engineering systems. Special focus is given to shipbuilding limitations of an SME shipyard in terms of engineering specification, construction and operational costs. For this scenario, some applications will be developed within SHIPLYS, whilst those that already exist will be made use of. These applications will have the attributes of being integrated using a software platform developed within the project in order to provide the functionalities mentioned (Figure E.1).

This scenario, in the first instance, will be applied to a Multi-Purpose-Vessel. VARNA MARITIME LTD will be involved in the development and testing of the final product resulting from this scenario. The developers have experience with this ship type and collected information will be used to calibrate the developed applications.

- Expected benefits to the shipyard from SHIPLYS

Particularly in recent times, most shipyards are required to take a cautious approach to their business models, factoring in market trends and the risks of new specific requirements, efficient production and processing costs, and the lack of historical experience. Under such circumstances, the ability provided by the project to make realistic assessments at the ship conceptual design stage is much valued.

VARNA MARITIME LTD expects that the development of this scenario will enable SMEs shipyards to make more reliable estimates, given the client requirements in the early stage of inquiry and the shipyard`s existing production capacity. At the same time, the possibility to study the implementation of alternative production and technological solutions, the evaluation of their effectiveness, the environmental impact and the projection of the risk based maintenance in the early planning phase will be highly appreciated. This scenario and the software developed can be adapted to other ship types apart from Multi-Purpose-Vessel, and to other shipyards in addition to VARNA MARITIME LTD.

Figure E.1: Conceptual Ship Design accounting for Risk-based Life Cycle Assessment.

SCENARIO 3: Ship retrofitting accounting for Life Cycle Cost Assessment

- Shipyard proposing the Scenario: ASTANDER

ASTANDER is a shipyard focused on repairs and transformations of vessels. More information is available at the website http://www.astander.es/.

- Goal and scope of the proposed scenario

The ship retrofit process is a reengineering process of the vessel which in many cases can involve fundamental changes in the architecture, functionality or operation of the vessel, but the nature of repair and retrofitting projects differs substantially from long term new building projects.

For ship repair and retrofitting processes, the SHIPLYS goal is to develop software that, given sufficient information of a repair or a retrofit, can be used to assess the optimum cost and time for the retrofitting and to perform LCCA, LCA and Risk analysis. In summary: To support a repair shipyard during the bid-stage to optimise retrofitting design and production and to arrive at realistic costs.

The scenario will be focussed on the optimisation of shipyard design, planning and production systems for retrofitting/repair activities where the optimisation is more about reducing costs, identifying risks, safety and environmental impact in a shipyard that is mostly performing retrofitting and repair works.

For this purpose, a ship retrofitting recently carried out in ASTANDER (related to the installation of scrubbers in an existing ROPAX ship), is proposed as a case study.

The scenario will serve two important purposes – firstly it will promote a high level of discussion around the important issues and information requirements, which SHIPLYS will use to gain strong insights into developing the optimal data structuring, uncertainty measures, and user interfaces for the models. Secondly, this case study and other similar projects will provide a wide ranging and robust test of the effectiveness of the SHIPLYS models once developed.

- Business and technical issues to be addressed within SHIPLYS

ASTANDER's key objectives are increasing production efficiency; reducing energy consumption and environmental impact; increasing safety; and, reducing production costs in shipyards and vessels in operation.

ASTANDER requires integrated virtual modelling tools which enable improved Retrofitting/ Conversion, particularly in SME shipyards, and optimal Retrofitting/ Conversion with life cycle cost assessment (LCCA), environmental assessment and risk assessment.

ASTANDER recognise that to be able to serve the ship retrofitting development process, a product model is required that includes all the necessary information for the complete process.

Four consecutive tasks in the development of SHIPLYS tools for a holistic assessment and optimisation of retrofitting are envisaged:

- Retrofitting design
- Retrofitting planning & production cost
- Life cycle cost analysis & risk assessment
- Own (shipyard) virtual prototyping.

To highlight that although sometimes a detailed 3D model is delivery as technical documentation by the owner for the retrofit, usually the traceability between the documentation provided by the ship-owner (drawing, specifications, 3D model, etc.) and the reality ship do not match. To avoid large deviations in terms of cost affecting in the cycle of repair, the shipyard need to perform its own 3D model based on data collection on board which enables a quick retrofitting design, procurement and planning phase.

A cost breakdown structure should be implemented aligned with work specification and owner requirements. Necessary codes for follow-up material quantity, subcontracting cost and hours should be considered as well.

Since retrofitting projects are characterized by short planning periods and highly dynamic decision making processes, a powerful validation method like simulation will be further developed towards an LCCA package that is integrated within the SHIPLYS framework. Simulation of planned production processes of a ship must become a general and relevant part of production preparation planning activities in order to support a repair shipyard during the bid-stage to optimise retrofitting design and production and to arrive at realistic life cycle costs and environmental impacts.

- Other relevant information

Although this scenario could be adapted to any ship type and works, the first study proposed focuses on the holistic assessment and optimization (through the SHIPLYS tools) of some retrofitting activities recently addressed by ASTANDER which are related to the installation of scrubbers in existing ROPAX ferries to cut funnel emissions and to protect the environment.

The French company Brittany Ferries has completed in Astilleros de Santander the installation of scrubbers in five of their vessels, namely “Normandie”, “Cap Finistere”, “Barfleur”, “Mont St. Michel” and “Armonique”, so ASTANDER can count on experience and useful information that may be used to develop and calibrate the SHIPLYS applications.