Associated with document Ref.
Ares(2024)8827656 - 10/12/2024

SEASTARS

DATE: July 1, 2025

SUSTAINABLE EMISSION ABATEMENT STRATEGIES & TECHNOLOGIES
FOR ADVANCED REVOLUTION SHIPS

D1.1

Report on the Systems Engineering Methodology for the Modularization

Project Acronym	SEASTARS
Project Name	SUSTAINABLE EMISSION ABATEMENT STRATEGIES & TECHNOLOGIES FOR ADVANCED REVOLUTION SHIPS
Project Number	101192901
Type of Action	HORIZON-CL5-2024-D5-01
Project Coordinator	University of Strathclyde (UoS)
Project Duration	January 2025 - December 2027 (36 Months)
Website	https://seastars-project.eu
Deliverable No.	D1.1
Deliverable Title	Report on System Engineering Methodology for the Modularization
Work Package	WP1 Model-based system engineering in vessel design
Deliverable Leader	University of Strathclyde, DG Twin
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Reviewed by	MARIN, MERCURIUS
Due Date	30/06/2025
Submission Date	27/06/2025
File Name	DGT_D8.1_v0.6
Version	0.x for draft version 0.6 for final version 1.0 for revised version (if requested)
Status	Final
Dissemination Level	PU

REVISION HISTORY

Date	Version	Description	Edited by
06/03/2025	0.1	Table of Contents presented within WP1 call	Michela Costa (DGT)
15/05/2025	0.2	First draft discussed within call with UoS	Michela Costa (DGT)
08/06/2025	0.3	Version for WP1 and Peer Review	Michela Costa (DGT)
21/06/2025	0.4	Review	Panos Louvros (UoS) Cornelis van Dorrser (MERCURIUS)
26/06/2025	0.6	Final version submitted to coordinator for submission to ECAS	Michela Costa (DGT)

DISCLAIMER:

The project has received funding from the European Union's Horizon Innovation Actions programme under grant agreement No 101192901. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor CINEA can be held responsible for them.

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Abbreviations and Terminology

Partners - Abbreviations	
AMC	ALFA MARIN TECHNIKH SYMVOULEYTIKH MELETON KAI ERGON EPE
ATHINA	ATHINA KENTRO NAFTIKIS KATARTISIS KAI EXELIXIS ANONYMI ETAIREIA
AURELIA	AURELIA DESIGN B.V.
Bound4Blue	BOUND 4 BLUE SL
COMPOSITE RECYCLING	COMPOSITE RECYCLING SA
DG TWIN	DG TWIN SRL
Erma First	ERMA FIRST ESK ENGINEERING SOLUTIONS SA
HEMEXPO	ELLINES KATASKEVASTES NAFTILIAKOU EXOPLISMOU ASTIKI MI KERDOSKOPIKI ETAIREIA (HEMEXPO)
QUADRISE	QUADRISE INTERNATIONAL LIMITED
MARIN	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND
MERCURIUS	MERCURIUS SHIPBUILDING BV
METACON	METACON MONOPROSOPI ANONYMI ETAIREIA
MINERVA	MINERVA MARINE INC. TRUST COMPANY COMPLEX,
NEPTUNE LINES	NEPTUNE LINES SHIPPING AND MANAGING ENTERPRISES S.A.
RINA	RINA HELLAS ETAIRIA PERIORISMENIS EVTHINIS NIOGNOMONAS
UoB	THE UNIVERSITY OF BIRMINGHAM
UOS	UNIVERSITY OF STRATHCLYDE
VERTORO	VERTORO BV
Voyex	Voyex B.V.

Abbreviations	
CAD	Computer aided Design
CAPEX	CAPital Expenditure
CCS	Carbon Capture and Storage
CFD	Computational Fluid Dynamics
CII	Carbon Intensity Indicator
CINEA	European Climate, Infrastructure and Environment Executive Agency
CSRD	Corporate Sustainability Reporting Directive
CTUe	Comparative Toxic Units for ecosystems
CTUh	Comparative Toxic Units for humans
DCF	Discounted Cash Flow
DMP	Data Management Plan
DP	Data Platform
DPP	Discounted Payback Period
DSCR	Debt Service Coverage Ratio
DT	Digital Twin
EEDI	Energy Efficiency Design Index
EFRAG	European Financial Reporting Advisory Group
EROEI	Energy Return on Energy Invested
ESG	E nvironmental, Social, and Governance
ETS	Emissions Trading System
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LCOE	Levelised Cost of electricity
LOHC	Liquid Organic Hydrogen Carriers
MBSE	Model-Based Systems Engineering
MDO	Marine Diesel Oil
MEPC	Marine Environment Protection Committee
MGO	Marine Gas Oil
MRV	Monitoring, Reporting, and Verification
NAI	Net Annual Income
NFRD	Non-Financial Reporting Directive
OFB	Oil-Fired Boiler
OPEX	OPerational EXpenditure

OPS	Onshore Power Supply
POCP	Photochemical Ozone Creation Potential
RFNBOs	Renewable Fuels of Non-Biological Origin
RMSE	Root Mean Square Error
ROI	Return on Investment
SDG	Sustainable Development Goals
SFOC	Specific Fuel Oil Consumption
SOC	State of Charge
TCO	Total Cost of Ownership
TRUST	Transparency, Responsibility, User focus, Sustainability, and Technology
WMO	World Meteorological Organization
WTT	Well-to-Tank
TTW	Tank-to-Wake
WTW	Well-to-Wake

Terminology	
Digital Twin	A digital replica of a physical asset, process or system that can be used for various purposes including monitoring, simulation and optimization.
MBSE	A methodological approach that uses digital models as the primary means of information exchange and system development

Executive Summary

By **combining innovative decarbonization technologies for shipping applications**, the SEASTARS project has the main objective of **demonstrating a well-to-wake GHG emissions reduction of minimum 30% by 2030 (compared to 2008) as well as a 20% energy efficiency improvement (compared to 2022 reference performance) on 8 market-ready vessel designs (4 retrofits and 4 newbuilds)** operated over inland, short and high-seas routes. Emission reduction measures and efficiency enhancement are considered at different levels, both **directly related to the vessel's hydrodynamics**, through propeller-hull optimization and air lubrication implementation, **and to the energy conversion and use onboard**. In this respect, technologies such as fuel cells, electric motors, integrated solar panels, sails and electrochemical storage systems are contemplated, as well as alternative fuels such as biofuels, hydrogen, methanol, LNG, ammonia and energy treatment systems like fuel preparation, fuel reforming, cold ironing and Carbone Capture Storage (CCS).

The final project outcome is a **smart design tool suitable to support shipowners in achieving a concrete future-proof efficiency enhancement of their fleets while reducing operational costs and acknowledging capital expenditure**, thus providing a robust decision-making instrument for integrated sustainability and profitability purposes.

Shipowners' needs and modular technology integration are seamlessly aligned by the project, so as to ensure that every retrofit or new build delivers measurable efficiency gains, **finally accelerating the uptake of new technologies and the reduction of the environmental impact of the shipping industry**.

The most innovative aspect of SEASTARS lies in **the adopted approach**, which **fully accounts for the growing complexity of modern ship systems, as coupled with amplified industry demands** for cost-effectiveness, environmental sustainability and accelerated market entry.

Model-Based Systems Engineering (MBSE) is proposed by the Consortium as a methodology to be applied, a pivotal evolution from traditional document-centric methods towards a model-driven engineering paradigm. By establishing comprehensive system representations alongside domain-specific models, MBSE facilitates improved collaboration between multi-disciplinary Partners and the information exchange throughout the engineering lifecycle. It enhances various systems engineering functions, including requirements specification, architectural design, and downstream development activities, by centralizing system models as the primary engineering artifacts. **Models, indeed, play a crucial role as they not only provide structured system information and specifications but also serve to build a cross-disciplinary communication framework**.

The present **Deliverable examines the MBSE methodology and especially the adopted practices by the Consortium**, as defined in Work Package 1, to establish a strong foundation for the SEASTARS project's activities and provide a smart guideline to Partners for a collaborative and effective R&D action.