SEUS

Smart European Shipbuilding

Funded by European Union

D6.2 - CUSTOMER-ORIENTED COMMERCIAL MATERIAL FROM SOFTWARE SUPPLIERS

This project has received funding from the Horizon Europe Framework Programme (HORIZON) EU programme under grant agreement No 101096224.

Project no.	101096224
Project acronym:	SEUS
Project title:	Smart European Shipbuilding
Topic:	HORIZON-CL5-2022-D5-01-06
Start date of project:	01.01.2023
Duration:	48 months
Deliverable title:	Customer-oriented commercial material from software suppliers
Deliverable No.:	D6.2
Document Version:	02 (M30)
Due date of deliverable:	30 June 2025
Actual date of submission:	30 June 2025
Deliverable Lead Partner:	Partner No. 5, CADMATIC OY
Work Package:	6
No of Pages:	84
Keywords:	Customer-oriented commercial material from software suppliers

Name	Organization
Evgenii Egorov	Partner No. 5, CADMATIC OY

Dissemination level

PUB	Public

History

Version	Date	Reason	Revised by
1	01 June 2025	Report	Evgenii (CADMATIC)
2	26 June	Final Report	Henrique & Magnhild (NTNU)

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Executive Summary

To support the platform's adoption and public visibility, SEUS partners (CADMATIC, CONTACT Software, and SARC) have developed a comprehensive suite of **customer-oriented materials**, aligning with the dissemination strategy (Task 6.2, M30). These materials aim to raise awareness, educate stakeholders, build trust, and enable market readiness. Key formats include:

- **Webpages** – Dedicated online hubs detailing the SEUS project, its stakeholders, and supporting software ecosystems.
- **Brochures** – Visually engaging documents tailored for industry events, webinars, and stakeholder outreach.
- **White Papers** – In-depth publications that position partners as thought leaders and demonstrate technical depth on topics like PLM, digital twins, and regulatory compliance.
- **Videos** – Short, dynamic explainer content that showcases real-world use cases and the collaborative value of the SEUS platform.
- **Social Media Posts** – Regular updates via LinkedIn and other platforms to maintain engagement, communicate milestones, and promote innovation leadership.

Commercial Significance

The SEUS project is not only a technical endeavour but also a commercial innovation strategy. All materials developed aim to bridge the gap between software development and practical, scalable solutions for the shipbuilding industry. By integrating stakeholder input from across shipyards, academia, and software vendors, SEUS is positioned as a leading force in the digital transformation of European shipbuilding.

The materials will be available via our repository (https://seus-project.eu/ - June 2025 release: https://zenodo.org/records/15748013).

Table of Contents

This project has received funding from the Horizon Europe Framework Programme (HORIZON)
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1. SEUS Project Overview and Visual Roadmap

Developing a smart platform for the digitalization of shipbuilding is the core ambition of the SEUS project. In this context, software development and integration of existing commercial tools are central to the project, summarized in the tasks from work packages (WPs) 2 and 3. Figure 1 presents and overview of the project. A detailed description of how all tasks are managed was provided in D7.1 – Management and Quality Plan, delivered in M6. Risk Management measures were described in D7.2 – Risk Management Plan.

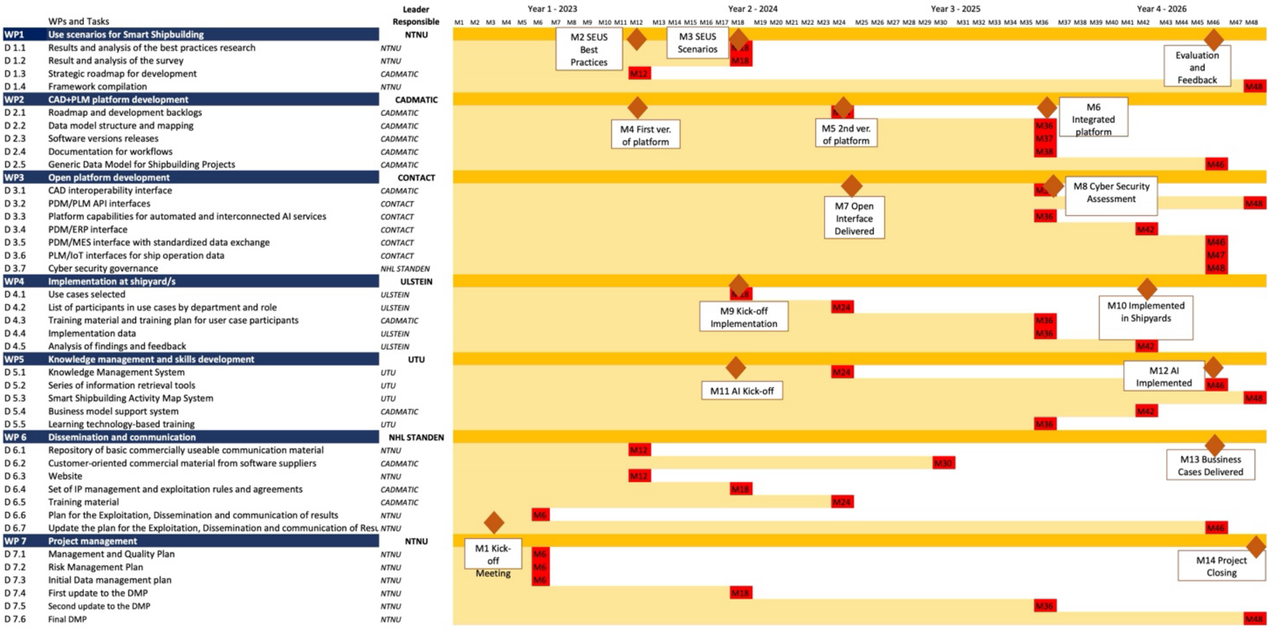

Figure 1 - SEUS Project Overview

A more visual overview of the tasks and WPs towards the common goal of the SEUS platform is observed in Figure 2. The sun diagram there combines the logic behind the WPs (1-6) towards the development of the platform, emphasizing the nature of the parallel tracks in the WPs, leading to the goal of the SEUS Platform: a computational tool to enhance shipbuilding practices. WP7, as project management, oversees the efficient flow of the project and was not included in this roadmap by design.

This roadmap overviews the main outcomes of the project, organized by a matrix WPs (1-6) and project years (2023-2026). In this sense, it allows a simplified but useful understanding of the overall tasks that will be necessary for the development of the digital platform, detailed in Section 3 and 4. This is also useful to communicate coherence and consensus among all involved in the project, internally and externally, as well as to present a comprehensive compilation of the aims and the role that each individual topic has towards the project's main objective.

Such visual representations introduce the context for the tasks detailed in the rest of this report and justify the gates and milestones used as a basis for the releases described in Section 3.

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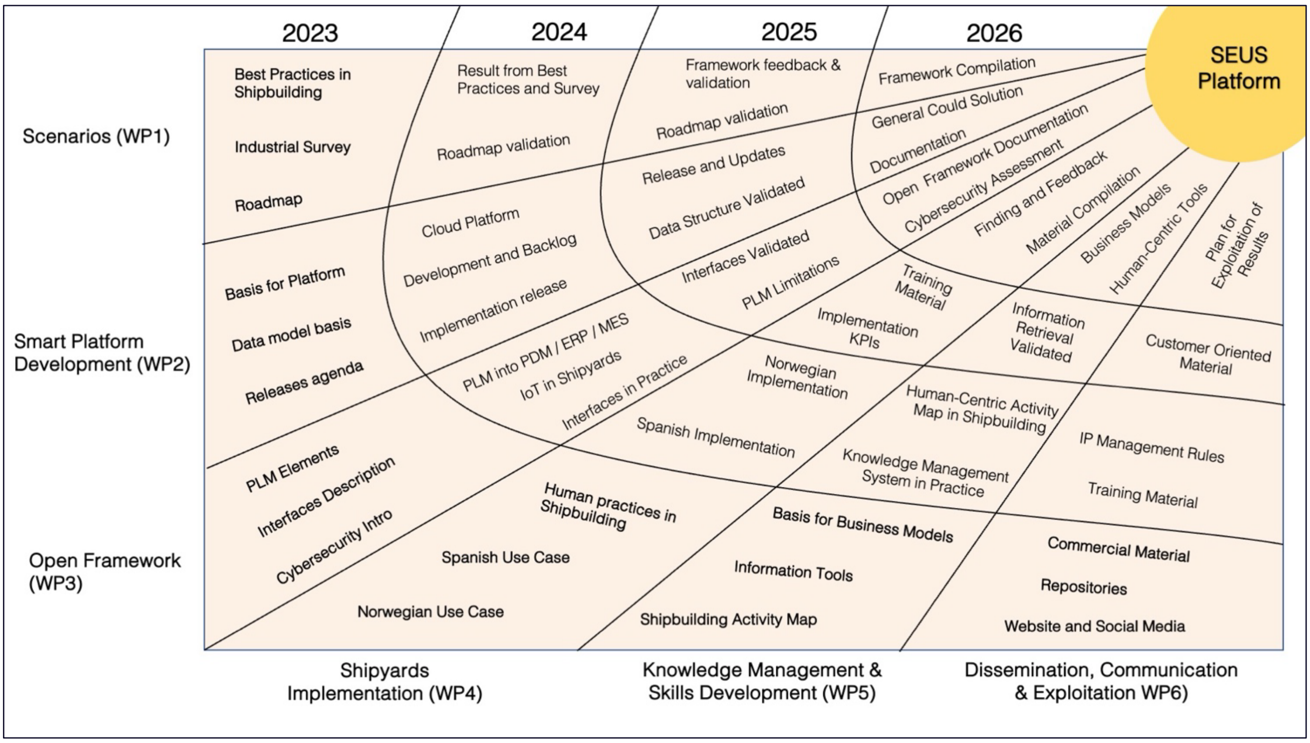

Figure 2 - Sun diagram with a visual roadmap of the SEUS Project

2. Overview of the development project tasks

2.1 WPs and Activities Connections and Alignment

The primary outcome of the SEUS project is a software platform that incorporates several parts of the existing software solutions and embedded knowledge. Each software development partner has its own development management process, while Cadmatic is responsible for the overall integration and the SEUS platform solution.

The project encapsulates several parts: research, software development, implementation at shipyards, knowledge and skills management, continuous project management, and dissemination and communication processes (see D7.1 for more details).

While most of the activities are carried out in parallel tracks, it is important to identify and highlight the interconnections between the parts and alignment with the project timeline. The following Figure 3 visualizes these main parts and main connection between them, aligned with the project timeline at the bottom of the image. It consists of research, input and evaluation, software development, implementation at shipyards, knowledge management and skills development The timeline is presented as years and milestones, identified as months of the project (M6-M48).

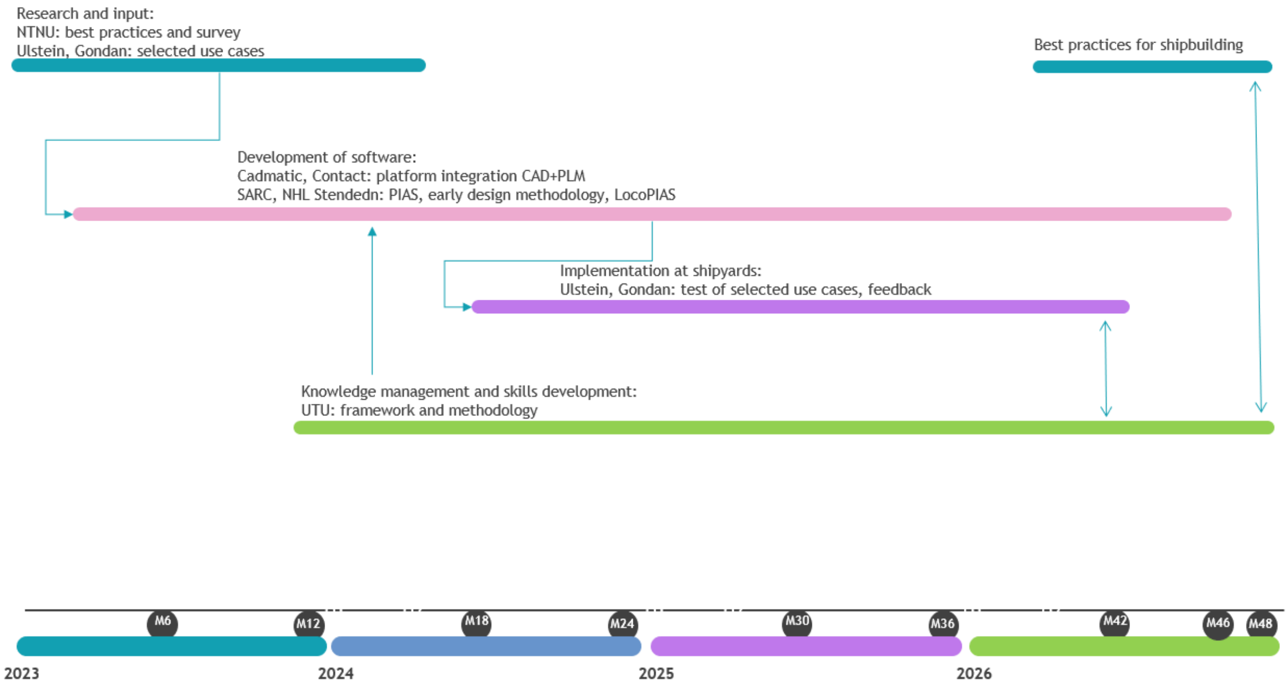

Figure 3 SEUS project summary and split of the main activities along the timeline

The division of the total work into WPs and the alignment of these with the timeline are presented in Figure 4. The arrows on the figure show the connection between the work packages and are placed on the timeline only for indication purposes to complement the logic presented in Figures 2 and 3.

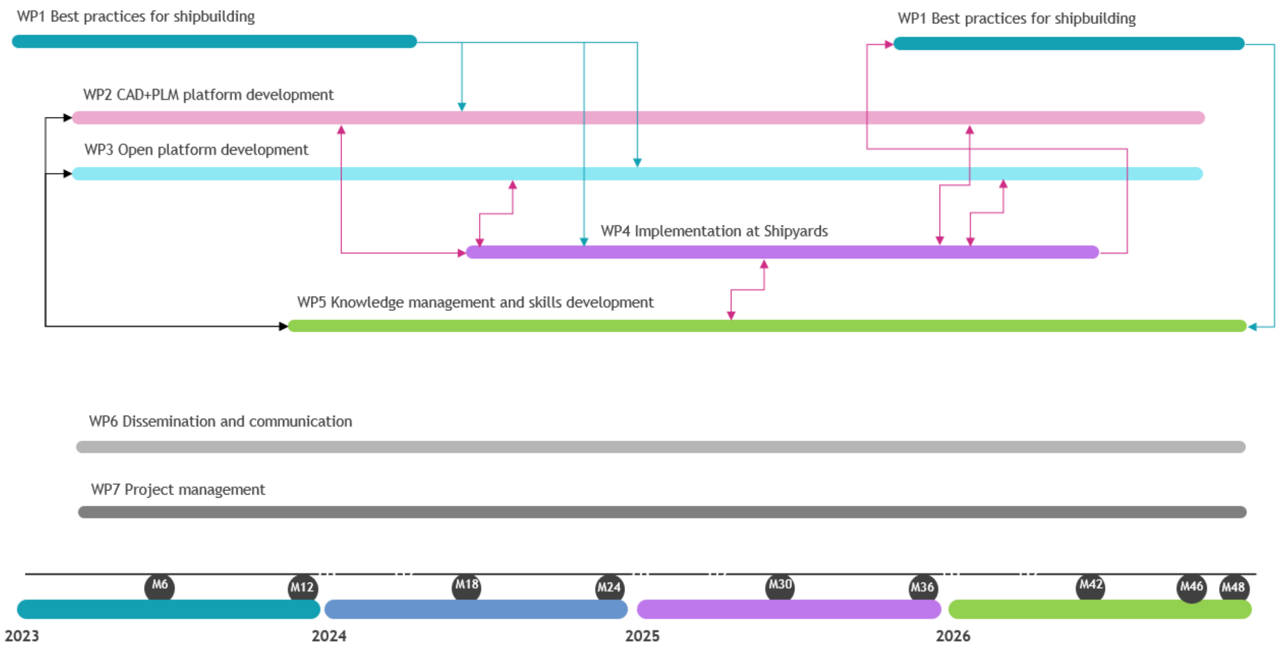

Figure 4 Project WPs, interconnections, and alignment with project timeline

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2.2 Status of the Project Tool – RACI

A comprehensive *Status of the Project* tool was developed as part of the roadmap to follow the status of the project among all WP coordinators and main project coordinators. The tool is a live document in the project's internal repository (see D6.1), a spreadsheet containing information about deliverables, milestones and tasks from each WPs.

The tool also goes in line with the proposed critical risks mitigation measures described in the Risk Management Plan (D7.2 – M6).

Training material adapting the model to SEUS project particularities was developed (Appendix A) for use by all partners. A screenshot of the material's thumbnails is presented in Figure 5.

Figure 5 - RACI model training material, adapted to the SEUS project (Appendix A)

The RACI model was selected to detail the level of interaction of the concurrent tasks (Figure 2 and 4), connecting each task to the level of responsibility required from each partner. This simple matrix defines roles and responsibilities for tasks or decisions, with four key roles: *Responsible, Accountable, Consulted, and Informed* (RACI). It suits the project's needs well, providing stakeholders - which range between academia, shipbuilding, and software development - with a proper structure to follow up on the workload and deadlines and clarity regarding the roles of the partners involved in the project.

Figure 6 exemplifies it, with the WP6 (Dissemination and Communication) description inside the status of the project tool according to the RACI model. The left column presents the tasks (T 6.1-T 6.5), the header includes the partners, plus additional metadata for each task. Such effort exemplifies how the roadmap of all tasks is considered in the project, as well as useful for communication and interaction between all partners.

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						Plan of Action (RACI: Responsible/Accountable/Consulted/Informed)							
WP6-Dissemination and communication	The purpose of WP6 will be to assure the project's visibility, NHL Stenden spread pertinent information on its goals, activities and results to the relevant stakeholders and scientific communities, thereby fostering the engagement of the target in the SEUS activities. Specifically: Distributing knowledge about the project to the wider maritime world. Distributing knowledge that is or can be made publicly available to the world of academics and software developers. Distributing user knowledge on SEUS to present and future designers, engineers, and their managers. Identifying and managing the Intellectual Property Rights as developed in this project. The task in this WP is to spread the word about SEUS, not only from a commercial perspective, but also about the core underlying methods or algorithms. The latter as an invitation to other parties also to connect to SEUS A second aim is to familiarize ship designers, engineers with the tools and strengths of SEUS. A related task is to set up an IP strategy, in particular for the case that other parties are interested to connect with SEUS, during or after the project. This work package is led by NHL Stenden, while all participants will contribute with their specific knowledge, and supply relevant materials. Contribute, upon invitation by the CINEA, to common information and dissemination activities to increase the visibility and synergies between HE/H2020 supported												
WP Leader: Welmoed van der Velde / welmoed.van.der.velde@nhlstenden.c													
		Lead	Main Contacts	Deadline	Connected to	NTNU	CONTACT	NHL Ster	UTU	CADMAT	SARC	Ulstein	Gondan
T6.1 Communication in industry events and publications	The purpose of this task is to compile commercially useful material that can be used as a basis by the SEUS partners in their commercial communication at trade fairs, leaflets and professional journals. The same material will be used for some articles of a technical, yet not scientific nature, by this consortium in professional magazines.	NTNU	**Contact:** Name / Email		D6.1, D6.6, D6.7	R	I	A	I	I	I	I	I
T6.2 Reach through customers, partners and prospect networks	CADMATIC, Contact and SARC are mature software companies with an established user base, and an existing framework of customer communications, such as newsletters and user events. These companies will use the material as developed in task 6.1 in these channels, and as such disseminate the project results to their customers and prospects.	CADMATIC	**Contact:** Evgenii Egorov / evgenii.egorov@cadmatic.com	30.6.2025	D6.2	I	C	I	I	A	I	I	I
T6.3 Promotion	During the project a public website will be maintained which includes summaries of the deliverables and achieved results, as well as practical results on the test vessel. After the duration of the project, the website will exist for two more years, although frozen.	NHL Stenden	**Contact:** Name / Email		D6.3	I	I	R\A	I	C	I	I	I
T6.4 Analyse options for IP protection and different models of licences	At the start of the SEUS development a consortium agreement will be drawn up, which will include clauses on IP rights. This will, therefore, not be a matter of further elaboration or research. However, additional question will arise if third parties are interested in IP developed within the project or after the finalization of the project. These can be either software users that utilize a binary version of the IP while using SEUS, or other software developers either wishing to connect with SEUS or with an interest in its independent use.	NHL Stenden	**Contact:** Name / Email		D6.4, D6.7	I	I	A	I	C	C	I	I
T6.5 Connecting project outcomes to university and vocational teaching	Teaching and training material on the background and use of SEUS software will be developed. This material is aimed at all levels of professional education – Technical University, University of Applied Science and vocational education – and includes: Elucidation on the background of the system, its merits, and limitations. A course outline on Product Data Technology, and the position of SEUS within this framework. An outline for a hands-on course on the application of open channels to connect to and collaborate with the SEUS system.	NHL Stenden	**Contact:** Name / Email		D6.5, D6.7	A	I	C	C	I	I	I	I

Figure 6 – WP6 exemplifying the RACI model in the project status tool

3. Types of Customer-oriented commercial materials

To ensure effective communication with potential customers and stakeholders, software suppliers - CADMATIC, CONTACT Software, and SARC have developed a broad range of customer-oriented commercial materials. These materials are designed to promote their solutions, raise awareness of their unique value propositions, and support market adoption, following the guidelines outlined in Task 6.2 (M30) of the dissemination and commercial exploitation plan.

These materials are made publicly accessible and aligned with the overall dissemination strategy, contributing to awareness, lead generation, and long-term commercial success.

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3.1. Webpages

Each supplier maintains **dedicated webpages** that serve as central information hubs. These pages highlight core software capabilities, application areas, technical specifications, and customer success stories.

- **CADMATIC** features product-specific landing pages with downloadable content, use case examples, and integration details.
- **CONTACT Software** offers interactive product portfolios with embedded multimedia, customer references, and technology insights.
- **SARC** provides clear explanations of their naval architecture tools, such as PIAS, with technical overviews and update announcements.

These webpages are optimized for SEO and user experience, ensuring accessibility for both technical users and business decision-makers.

3.2. Brochures

Printable and digital brochures are crafted to give concise, visually appealing overviews of the companies' offerings.

- They include key features, benefits, and target industries.
- Infographics and visuals simplify complex information for non-technical stakeholders.
- Brochures are distributed at industry events, during webinars, via email campaigns, and available for download on the vendors' websites.

3.3. White Papers

White papers serve as in-depth documents that discuss market challenges, software solutions, and the technical or business rationale behind them.

- CADMATIC, CONTACT Software, and SARC publish white papers that position their products as thought-leading and innovative.
- Topics include digital twin applications, lifecycle integration, simulation-driven design, and regulatory compliance.
- These papers support technical evaluation and justify investments to procurement and IT teams.

3.4. Videos

Video content is a powerful format used to demonstrate software in action and build brand trust.

- **Demo videos** show real-world use cases and workflows.
- **Explainer videos** make complex concepts accessible to broader audiences, including management and procurement.

YouTube video player on websites is a typical distribution channel.

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3.5. Social Media Posts

To maintain visibility and engagement, the three companies actively use **social media platforms** (LinkedIn).

- Posts include news about software updates, upcoming webinars, project highlights, and industry trends.
- Hashtags and tagging enhance discoverability among professionals in marine engineering, shipbuilding, and industrial design.
- Interactive campaigns (e.g., polls, Q&A sessions, live demos) increase outreach and feedback collection.

4. Purpose of customer-oriented commercial materials

The purpose of customer-oriented commercial materials from software suppliers like CADMATIC, CONTACT Software, and SARC is to communicate value, generate interest, and support decision-making for potential and existing customers. Specifically, these materials aim to:

Raise Awareness

- Introduce the company and its software solutions to new audiences.
- Make the brand visible in relevant industries such as shipbuilding, engineering, and product lifecycle management (PLM).

Educate Customers

- Explain the features, benefits, and applications of their software in a clear and accessible way.
- Help both technical users (e.g., engineers) and non-technical stakeholders (e.g., managers) understand the software's capabilities.

Build Credibility and Trust

- Use case studies, testimonials, and white papers to show real-world success and industry expertise.
- Demonstrate how the software meets industry standards and solves practical challenges.

Differentiate from Competitors

- Highlight what makes their products unique or superior (e.g., ease of use, integration, support).
- Clarify their positioning in the market with tailored messaging for different customer segments.

Facilitate Commercial Exploitation

- Help turn research, development, and innovation into commercial value.
- Translate technical achievements into marketable content that supports revenue growth.

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Support the Dissemination Plan (per Task 6.2 M30)

- Ensure that project results and innovations are shared widely and transparently.
- Make materials publicly accessible to fulfill project communication and exploitation obligations.

In short, these materials bridge the gap between **technical innovation** and **market adoption**, ensuring that stakeholders not only understand the product but are also motivated to use it.

5. Customer-oriented commercial materials in the SEUS Project

Since M12, SEUS software vendors have been producing materials that support future commercial use and ongoing software improvements. Their expertise has also contributed to effectively showcasing the current progress of software development and implementation at shipyards to a broader audience.

Brochures and Whitepapers listed in this document can be found on the SEUS Cadmatic website, replicated at SEUS Open repository at June 2025 release: https://zenodo.org/records/15748013.

5.1. Webpages

https://www.cadmatic.com/en/marine/seus/, also accessed via open and FAIR principles at ZENODO: June 2025 release: https://zenodo.org/records/15748013.

Purpose: To inform stakeholders about the SEUS initiative, its objectives, consortium partners, and the envisioned impact on European shipbuilding through the development of an integrated digital platform.

Commercial Relevance:
This webpage serves as a thought leadership and awareness-building resource, ideal for:

- Industry Professionals: Providing insights into collaborative efforts to digitize shipbuilding.
- Potential Partners: Highlighting opportunities for collaboration and innovation in maritime technology.
- Policy Makers and Funders: Demonstrating the project's alignment with Industry 5.0 principles and its potential economic impact.

https://www.cadmatic.com/en/marine/shipbuilding/

Purpose: To present CADMATIC's comprehensive digital solutions tailored for the shipbuilding industry, addressing current challenges and promoting efficiency, sustainability, and collaboration through advanced technologies.

Commercial Relevance:
This webpage serves as a solution overview and educational resource, ideal for:

- Industry Professionals: Providing insights into the challenges and solutions in modern shipbuilding.
- Potential Clients: Demonstrating the value proposition of CADMATIC's digital tools.

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- Stakeholders: Highlighting the importance of embracing digitalization for a sustainable future.

https://www.sarc.nl/news/the-smart-european-shipbuilding-project-seus/

Purpose: To inform stakeholders about the SEUS initiative, its objectives, consortium partners, and the envisioned impact on European shipbuilding through the development of an integrated digital platform.

Commercial Relevance:
This webpage serves as a thought leadership and awareness-building resource, ideal for:

- Industry Professionals: Providing insights into collaborative efforts to digitize shipbuilding.
- Potential Partners: Highlighting opportunities for collaboration and innovation in maritime technology.
- Policy Makers and Funders: Demonstrating the project's alignment with Industry 5.0 principles and its potential economic impact.

https://www.sarc.nl/

Purpose: To provide a comprehensive overview of SARC's offerings in ship design and maritime software solutions, highlighting their expertise, products, and services tailored for the maritime industry.

Commercial Relevance:
This homepage acts as a central hub for clients and stakeholders, offering:

- Comprehensive Product Information: Detailed insights into SARC's software and hardware solutions.
- Service Offerings: An overview of the consultancy and support services available to clients.
- Resource Access: Easy navigation to manuals, downloads, and support materials.
- Engagement Opportunities: Information on training, job opportunities, and company news to foster community and client engagement.

https://www.contact-software.com/en/contact-research/research-projects/seus/

Purpose: To present the objectives, structure, and anticipated impact of the SEUS (Smart European Shipbuilding) project, an EU-funded initiative aimed at enhancing the competitiveness of European shipyards through digital transformation.

Commercial Relevance:
This webpage serves as a thought leadership and awareness-building resource, ideal for:

- Industry Professionals: Providing insights into collaborative efforts to digitize shipbuilding.
- Potential Partners: Highlighting opportunities for collaboration and innovation in maritime technology.
- Policy Makers and Funders: Demonstrating the project's alignment with Industry 5.0 principles and its potential economic impact.

https://www.contact-software.com/en/

Purpose: To present CONTACT Software's comprehensive suite of digital solutions designed to enhance product development, project management, and industrial operations through integrated platforms and innovative technologies.

This project has received funding from the Horizon Europe Framework Programme (HORIZON) EU programme under grant agreement No 101096224.

Commercial Relevance:
This homepage acts as a central hub for clients and stakeholders, offering:

- Comprehensive Product Information: Detailed insights into CONTACT's software solutions, including PLM, IoT, project management, and integration platforms.
- Service Offerings: An overview of consultancy and support services available to clients, ensuring software solutions that work in the real world of day-to-day business.
- Resource Access: Easy navigation to manuals, downloads, and support materials to assist clients with their software and hardware needs.
- Engagement Opportunities: Information on training, job opportunities, and company news to foster community and client engagement.

5.2. Brochures

Early Ship Design Developments by SARC (Appendix A)

Purpose: This slide deck presents recent developments in early ship design tools, particularly within the PIAS software. It details new capabilities like internal layout configuration via "chunks" and propulsion modeling.
Commercial Relevance: This qualifies as a product deep dive or technical explainer, aiming to educate technical users (e.g., naval architects) and show innovation in engineering tools. It indirectly promotes adoption by highlighting software maturity and problem-solving capabilities.

Large Area Hull Shape Modification (Appendix B)

Purpose: This file introduces novel hull shape manipulation techniques within the Fairway module. It explains the flexibility of point- and curve-based deformation and visualizes how these methods enhance design agility.
Commercial Relevance: This serves as a demonstration aid or training material that both educates users and reinforces brand credibility by showcasing unique and advanced functionality, thereby contributing to differentiation.

CADMATIC Wave with Change Management (Appendix C)

Purpose: This document presents a detailed explanation of how the CADMATIC Wave platform integrates Change Management functionalities using CONTACT Software's PLM backbone. It outlines system architecture, user roles, workflows, and specific use cases in a real-world context.

Commercial Relevance:
This file acts as a high-value educational and trust-building resource, ideal for:

- Technical decision-makers evaluating software capabilities.
- Stakeholder education, especially for engineering and compliance teams.
- Demonstrating real-world workflows and practical efficiency gains.
  It also functions as a visual explainer or sales support material in commercial presentations or consultations.

SEUS – Research Lecture Presentation (Appendix D)

Purpose: This lecture-style document summarizes the SEUS (Smart European Shipbuilding) research initiative. It covers the consortium structure, project goals, deliverables, platform architecture, and implementation strategies.

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Commercial Relevance:
This presentation serves as a thought leadership and awareness material. It is useful for:
- Building awareness of emerging solutions tailored for the shipbuilding sector.
- Positioning the SEUS initiative and its stakeholders as innovation leaders.
- Supporting funding, academic, or industrial partnerships by showcasing technical achievements and collaboration models.

5.3. Whitepapers

Can European Shipyards be Smarter? A Proposal from the SEUS Project – Cadmatic (Appendix E)

Purpose: A comprehensive white paper detailing challenges in European shipbuilding and a strategic proposal for digital transformation through a smart platform integrating CAD, CAM, CAE, and PLM systems.
Commercial Relevance: This document acts as a thought leadership piece. It promotes digital thread integration and modern software infrastructure, showcasing strategic vision and technological expertise. It's designed to educate the audience, differentiate the offering, and indirectly generate leads by positioning the authors as innovation leaders.

PLM — Main Information Objects for Shipbuilding _ by Elisabeth Brandenburg _ CONTACT Research (Appendix F)

Purpose: Published article that explains the challenges and approaches for aligning PLM systems with the specific needs of shipbuilding, with a focus on managing complex data structures and lifecycle integration.
Commercial Relevance: Clearly a white paper aimed at thought leadership. It's written to inform stakeholders (especially in shipbuilding IT and management roles) about how PLM tools can be adapted and integrated effectively. It promotes technical credibility, encourages informed decision-making, and serves to position the authoring organization as an expert in PLM adaptation.

5.4. Videos

Wave Digital Platform

Purpose: To capture attention and generate interest among potential customers by presenting a concise, visually engaging overview of a new product that streamlines collaboration across all stakeholders in a shipbuilding project.
Commercial Relevance:
This video acts as a high-impact awareness and lead-generation tool by:
- Creating emotional resonance through fast, sleek visuals and a sense of technological innovation.
- Positioning the product as the enabler of seamless, modern collaboration.
- Triggering curiosity and motivating viewers to explore further — ideal for use on landing pages, LinkedIn ads, trade shows, and executive pitches.

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5.5. Social Media Posts

CADMATIC Data-driven Shipbuilding Newsletter

Purpose: To inform stakeholders about ongoing efforts to integrate early-stage ship design with detailed engineering processes, highlighting the challenges of disparate data models and the potential of graph databases within the SEUS (Smart European Shipbuilding) project.

Commercial Relevance:
This post serves as a thought leadership piece, ideal for:

- Industry Professionals: Providing insights into the integration of design and engineering processes in shipbuilding.
- Potential Partners: Highlighting opportunities for collaboration in developing standardized data models.
- Policy Makers and Funders: Demonstrating ongoing research efforts to enhance efficiency and interoperability in maritime design and engineering.

Contact Software LinkedIn Post

Purpose: To announce CONTACT Software's involvement in the SEUS (Smart European Shipbuilding) project, highlighting the development of an integrated platform that combines CAE, CAD, CAM, and PLM software, aiming to enhance efficiency and collaboration in European shipyards.

Commercial Relevance:
This LinkedIn post serves as a thought leadership and awareness-building resource, ideal for:

- Industry Professionals: Providing insights into collaborative efforts to digitize shipbuilding.
- Potential Partners: Highlighting opportunities for collaboration and innovation in maritime technology.
- Policy Makers and Funders: Demonstrating the project's alignment with Industry 5.0 principles and its potential economic impact.

SARC BV LinkedIn Post

Purpose: To announce SARC BV's contribution to the EU-funded SEUS (Smart European Shipbuilding) project, highlighting the publication of the SEUS 2024 Report and the development of tools within their PIAS software to bridge early-stage design with downstream engineering.

Commercial Relevance:
This LinkedIn post serves as a thought leadership and awareness-building resource, ideal for:

- Industry Professionals: Providing insights into collaborative efforts to digitize shipbuilding.
- Potential Partners: Highlighting opportunities for collaboration and innovation in maritime technology.
- Policy Makers and Funders: Demonstrating the project's alignment with Industry 5.0 principles and its potential economic impact.

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Appendix A – Early Ship Design Developments by SARC

SARC
MARITIME SOFTWARE AND SERVICES

SARC developments on early ship design support in PIAS

Bremen, March 2025

Funded by
the European Union

SARC
MARITIME SOFTWARE AND SERVICES

Background

2

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EU programme under grant agreement No 101096224.

SEUS task 2.4

SARC MARITIME SOFTWARE AND SERVICES

T2.4 Integration for early design stages (SARC)
Parametric early design & variant management, in order to facilitate the quick evaluation of present and future propulsion/power systems. Developed for the selected type of vessels and extrapolated to other types.

3

Proposed in Turku

SARC MARITIME SOFTWARE AND SERVICES

4

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And now the elaboration

SARC
MARITIME SOFTWARE AND SERVICES

- Quick configuration of internal layout (spaces and compartments).
- Propulsion and machinery.
- Running OpenFoam CFD from PIAS.
- Global hull shape modifications.

5

SARC
MARITIME SOFTWARE AND SERVICES

Quick configuration of internal layout (spaces and compartments)

6

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Constituents

SARC
MARITIME SOFTWARE AND SERVICES

- PIAS' Layout module, www.sarc.nl/images/manuals/pias/htmlEN/layout.html
- A library of chuncks.
- A function to assemble chunks.
- Tuning to requirements.

7

Chunks

SARC
MARITIME SOFTWARE AND SERVICES

- 'Chunks' is an optional method to be used instead of, or in combination with PIAS' conventional Layout module.
- A chunk is a 'boxed' portion of the subdivision of a ship. It is scalable and determines the (rough) layout a portion of the ship.
- There is a library of chunks to choose from. From this, a user can choose multiple chunks. With this, and a given hull, the subdivision of the vessel will be easily generated.

8

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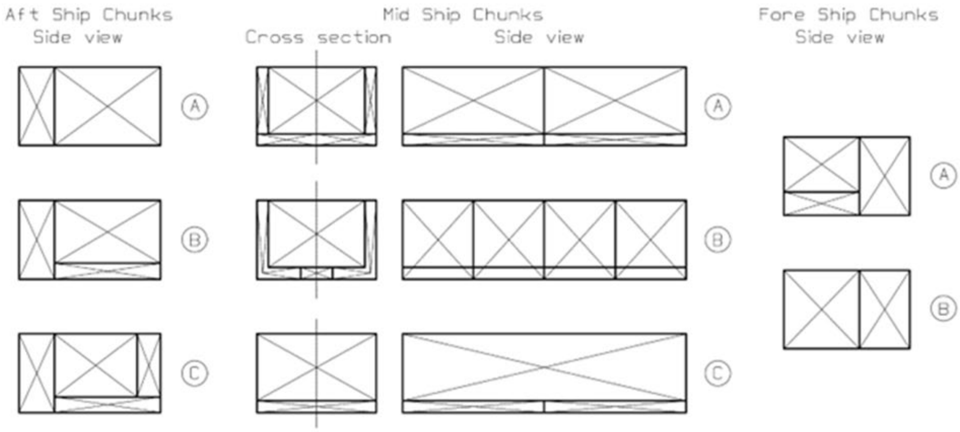
A library of chunks

SARC
MARITIME SOFTWARE AND SERVICES



Extending over full L, B and H. Lateron Boolean *and*ed with the hull form.

9

An assembly of chunks

SARC
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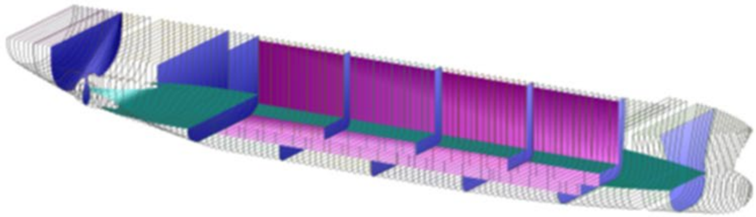

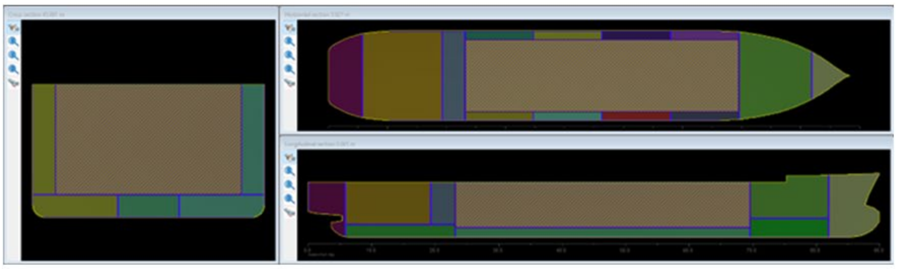

Combination of Chunks (Aft C - Mid B - Fore A)

10

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Tuning to requirements

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- Requirements on volumes, areas or distances.
- Mininimum, maximum or 'range'.
- Available in PIAS under the name 'constraint management', although 'matching to requirement' could be an alternative term.
- White paper: www.sarc.nl/resources/uploads/2022/08/Constraint-Management-paper.pdf.
- Manual:www.sarc.nl/images/manuals/pias/htmlEN/layout.html#layout_constraint_management.

11

Status

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- Design specification of the software is finished.
- Constraint management is available. Yet,perhaps to be refined towards new insights in combination with chunks.

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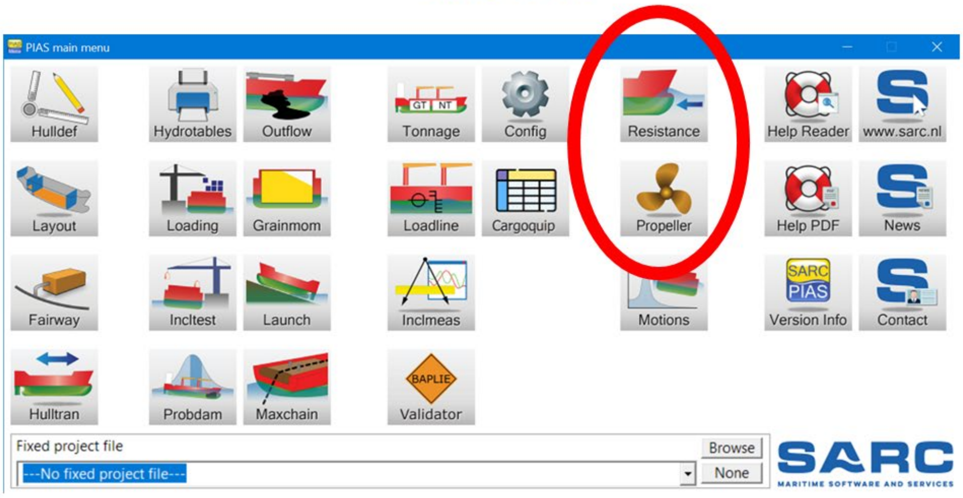
Propulsion and machinery

13

Propulsion and machinery

PIAS now:



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Now under development

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- Resistance.
- Mechanical and/or electrical propulsion.
- Gear boxes.
- Wind propulsion.
- All interfaced by means of:
  - Logical connections (e.g. equality of RPM of (direct drive) engine and propellor).
  - Equality of power (e.g. KW out shaft line = kW in propellor),
- Constructs a set of equations, with unknows that can be solved.

15

Specifics

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- Stationary (= constant ship speed).
- # equations = # unknowns, yet the program will assist in this.
- Most common empirical toolset (on resistance, propulsion) pre-programmed, but others importable through a data set.
- Combustion engine characteristics also to be provided in tabular form (incl. SFOC).
- Resistance importable from CFD (as data set).
- Without ship motion, yet with drift and induced resistance (wind assist).

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Example: CODAE

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- Combined Diesel And Electric.
- Compare Toyota Prius, where the different components were connected by a planetary gear.
- For a ship we could conceive a similar arrangement, with a combustion engine and E-motor jointly, through a planetary gear, driving a propellor (with fixed dimensions and shape).
- With the question which speed will be obtained by an input of 190 KW (at 400 RPM) by the combustion engine and 127 KW of the E-Motor (ignoring wake and thrust deduction).

17

Set of equations

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No.	Equation	Content
1	n3 = f(n1,n2)	The RPM ratio of the gear (depending on the number of teeth)
2	2*pi*n1.M1 + 2*pi*n2.M2 = 2*pi*n3.M3	Equality of powers[10] around the gear
3	M3 = f(n3)	By e.g. Kq from standard propellor series
4	F3 = f(n3)	By e.g. Kt from standard propellor series
5	M1. 2*pi*n1 = 190	190 KW from the combustion engine
6	M2. 2*pi*n2 = 127	127 KW from the E-motor
7	F3 = f(V)	Ship resistance, e.g. by Holtrop & Mennen or CFD
8	n1 = 400/60	Fixed angular velocity (1/sec) of combustion engine

With eight unknowns (n1..n3, M1..M3, V, F3) these eight (non-linear) equations will provide the steady-state solution. And hence solve V (and as side effect the other seven parameters).

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Versatile (1)

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With a small variation --- given speed instead of available power --- this system can be applied to compute required engine power to achieve a ship design speed.

19

Versatile (2): extendable

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Including thrust deduction, wake fraction and the involvement of input voltage and current of the E-motor.

No.	Equation	Content
1	M1*2*pi*n1 = 190 = P1	190 KW from the combustion engine
2	M2*2*pi*n2 = 127 = P2	127 KW from the E-motor
3	n1 = 400/60	Fixed angular velocity (1/sec) of combustion engine
4	D = 4	Propeller diameter
5	ηe = 0.75	Efficiency of electrical motor
6	ηp = 0.9	Efficiency of planetary gear
7	Ui = 400	400 V 3 phase power grid on board of ship
8	I = f(Ui, P2)	Current expressed as a function of the voltage and power of the e-motor
9	M2 = f(Ui, I, ηe)	M2 expressed as a function of current
10	n2 = f(Ui, I, ηe, M2)	n2 expressed as a function of voltage, current, efficiency and M2
11	n3 = f(n1,n2)	The RPM ratio of the gear (depending on the number of teeth)
12	2*pi*n1*M1 + 2*pi*n2*M2 = 2*pi*n3*M3	Equality of powers around the gear
13	Q = f(M3, ηp, n3)	Propeller torque expressed as a function of M3, η, n3, Va
14	kq = f(Q, n3)	Torque coefficient expressed as a function of Q, n3 and Va
15	J = f(10*kq, kt)	Advance ratio expressed as a function of 10*kq , to determine from kt, 10*kq diagram
16	Va = f(J, n3, D)	Advance speed expressed as a function of J, n3 and D
17	ω = f(Cb)	Wake factor, determined with method Holtrop & Mennen
18	1-t = f(ω)	Thrust deduction, determined with method Holtrop & Mennen
19	T = f(kt, n3, D)	Thrust delivered by prop. Determined via kt-10kq diagram of the propeller
20	V = f(Va, ω, 1-t)	Vessel speed
21	Rt = f(V)	Total resistance of moving vessel, determined via Holtrop & Mennen

20

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Ahhh..., and the user?

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- Complex: on the contrary. It all boils down to conservation laws.
- Complicated: neither. With a well-designed user-interface the intricacies of the system of equations/unkowns can be hidden.

21

GUI overall design

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Design variant(s)

Name
Hybrid propulsion with planetary gear

Connection of the components

Name	Type	Connected to
Hull	Hull	Propeller
Combustion engine	Chemical to rotary energy converter	Planetary gear
Electical motor	Electrical energy converter	Planetary gear
Planetary gear	Rotational energy transfer	Propeller
Propeller	Rotational to linear propulsor	Planetary gear, Hull

Characteristics of the components

Determination method:

Holtrop and Mennen

Parameter	Unit	Value	Source
Density	t/m3		
Length waterline	m		
Breadth	m		

Output of user defined case

Select	Name
Y	Speed determination for a given power
N	Delivered power for a given speed

Definition of variables

Name	Characteristics	Value	Link	Ratio
Combustion engine	Output power	190		
Electrical motor	Output power	127		
Combustion engine	Revolutions	400		
Electrical motor	Input voltage	400		
Hull	Speed			

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One integrated UI, containing

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- Design variants, which is simply a collection of varying properties of a single design.
- A set of components, with their properties. Componetns are things you can buy; an engine, a propellor, a gearbox, an E-motor.
- A box where the connections of components can be specified; which input connects to which output. Call it ‘the propulsion plant configuration’.
- Another box where fixed and variable parameters are specified. E.g. fixed power / computable speed, or fixed speed, comptable power. Or fixed speed & fixed engine power, computable wind-assisted power.

23

Further enhacements

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This is all stationary. Additionally, support for ranges or sequences of stationary conditions is being co-designed:

- Optimizations. Automated (yet, limited to sensible optimization tasks).
- Scenarios / operational profiles.

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Data flow

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- This tool is partly founded on data as available in PIAS (hull shape, etcetera).
- The fruits of this tool (such as its results, the logs) remain in PIAS.
- In general, they will be used in design variations (e.g. hull shape modification / adapted engine room space to accomodate other propulsors).
- Through the PIAS – CADMATIC interface the related (shape) design changes will flow downstreams.

25

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Running OpenFoam CFD from PIAS

26

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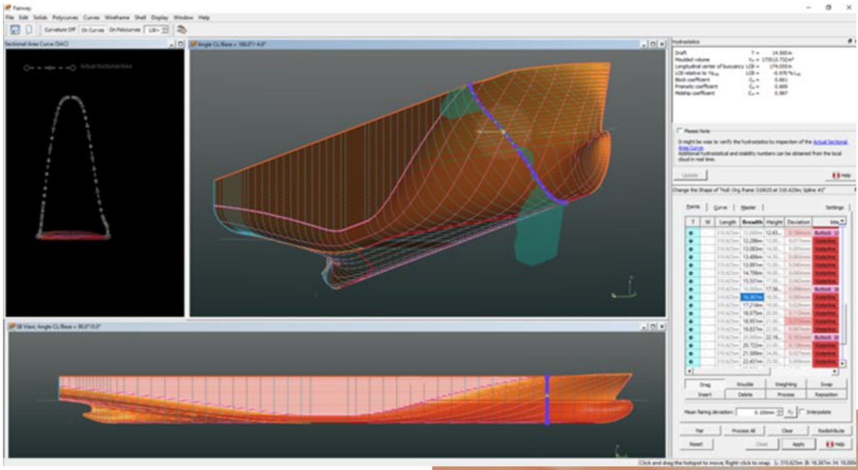

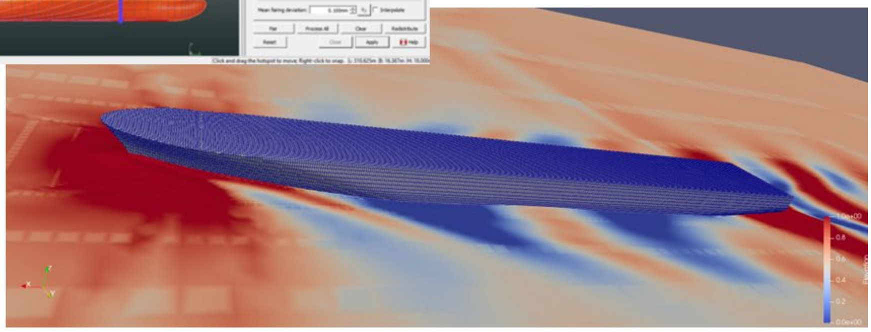

Global hull shape modifications

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Global hull shape modification

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NTNU Open

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Variations of Shape in Industrial Geometric Models

Veelo, Bastiaan Niels

Doctoral thesis

Variations of Shape in Industrial Geometric Models

View/Open

Abstract

This thesis presents an approach to free-form surface manipulations, which conceptually improves an existing CAD system that constructs surfaces by smoothly interpolating a network of intersecting curves. There are no regularity requirements on the network, which already yields superior modelling capabilities compared to systems that are based on industry-standard NURBS surfaces.

Originally, the shape of such a surface can be modified only locally by manipulating a curve in the network. In this process there is an inherent danger that the curve is being pulled away from intersections that it has with other curves. When this happens, the network is invalidated as a surface representation, and many curves may have to be adjusted to restore network consistency and surface quality. This thesis contributes a method that solves these problems by propagating changes that are made in one curve to curves in its vicinity. How and to what extent curves react to changes is controlled by two parameters that can be varied along the curve that is being manipulated. Any curve may be constrained in one or more degrees of freedom. The integrity of the curve network is implicitly conserved, as well as the geometric continuity of the surface.

29

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Appendix B – Large Area Hull Shape Modification

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Large Area
Hull Shape Modification

Bremen, March 2025

Funded by
the European Union

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Fairway is special

Network of curves instead of patchwork of surfaces

1. No topological restrictions
   - Curves can intersect any number of other curves, leaving cells with any number of corners
2. No regularity requirements
   - Curves can run over arbitrary stretches of the hull in arbitrary directions
3. No indirection in surface manipulation
   - Points and curves are *on* the surface
4. Tools for evaluating and improving smoothness (Fairing)

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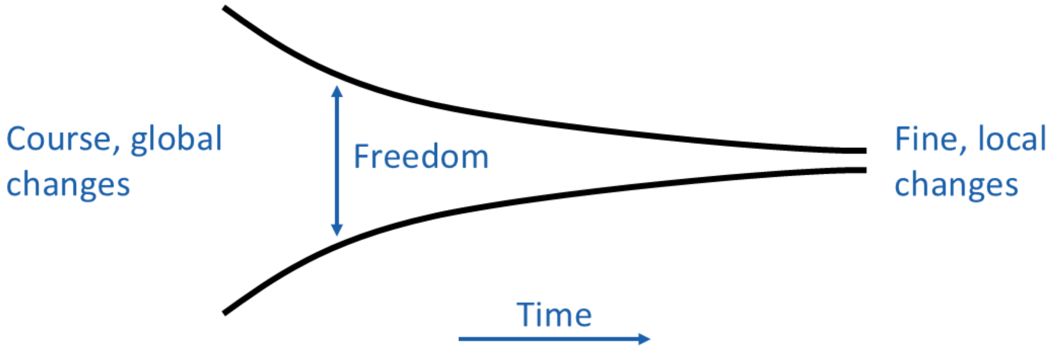
Progressive commitment

The further a design progresses, the more local changes get.



31-5-2025 3

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Spatial Deformation

- Deforming the fabric of space in which the model is defined
- Popular technique in entertainment industry
- Generally only applicable to discrete representations
  - Indirect modelling paradigms cannot maintain continuity across seams
  - CFD, optimizations need to be converted back into continuous representation by reverse engineering
- Thanks to direct surface manipulation: Applicable in Fairway!
- Developed and demonstrated in 2004
  - Point-based (a.k.a. radial basis functions)
  - Curve-based (in theory)
- New variant basis for SARC concept early design
  - Break free from progressive commitment

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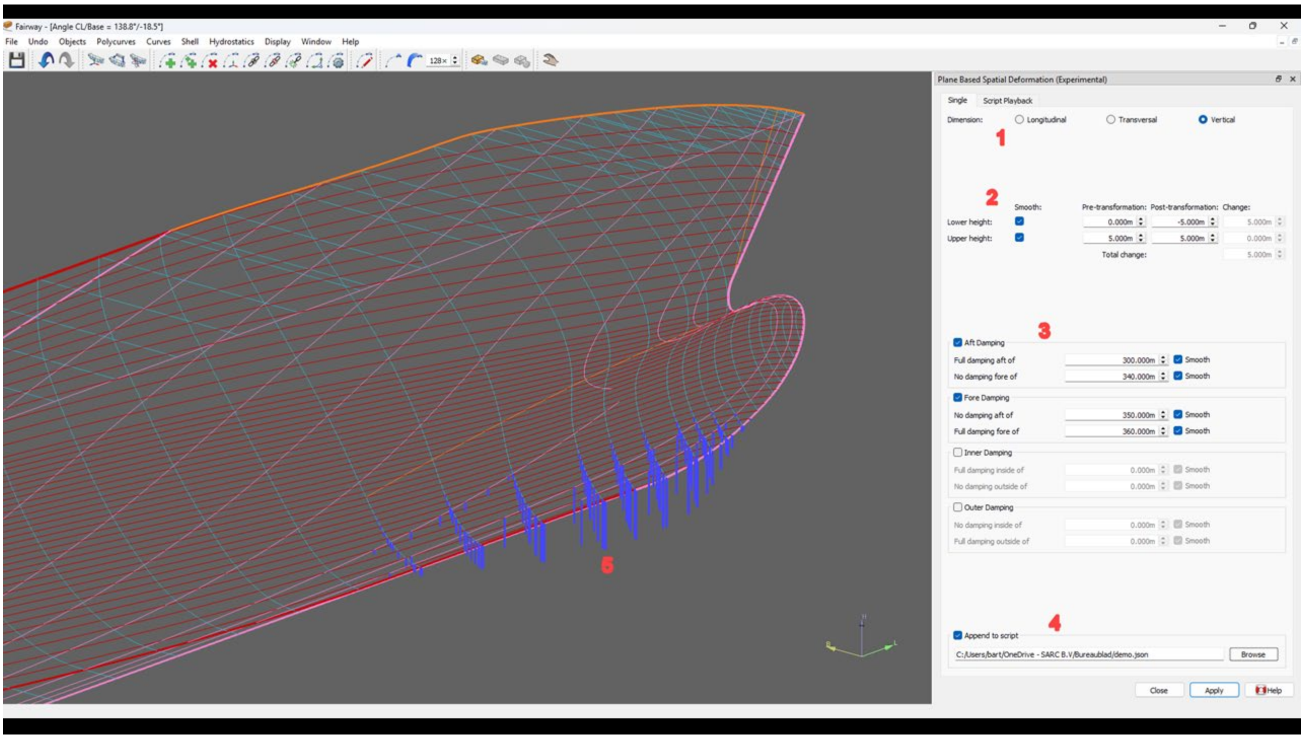

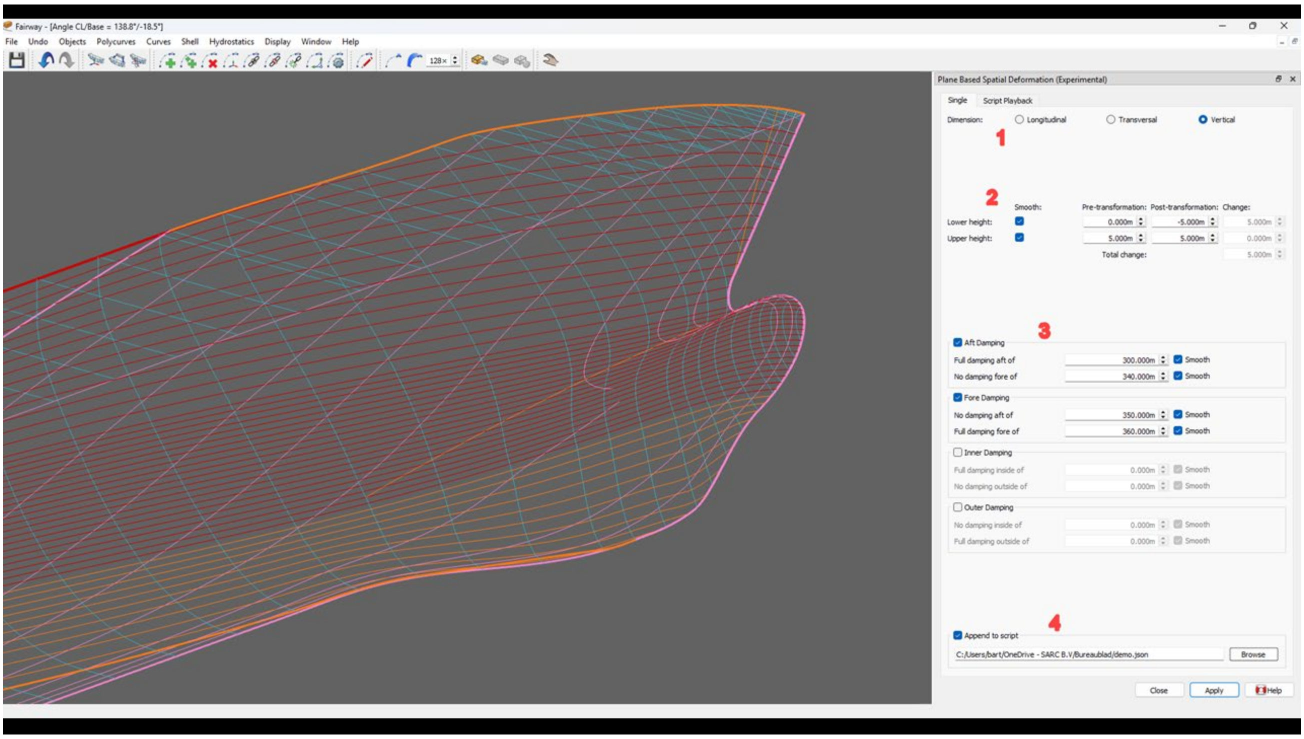

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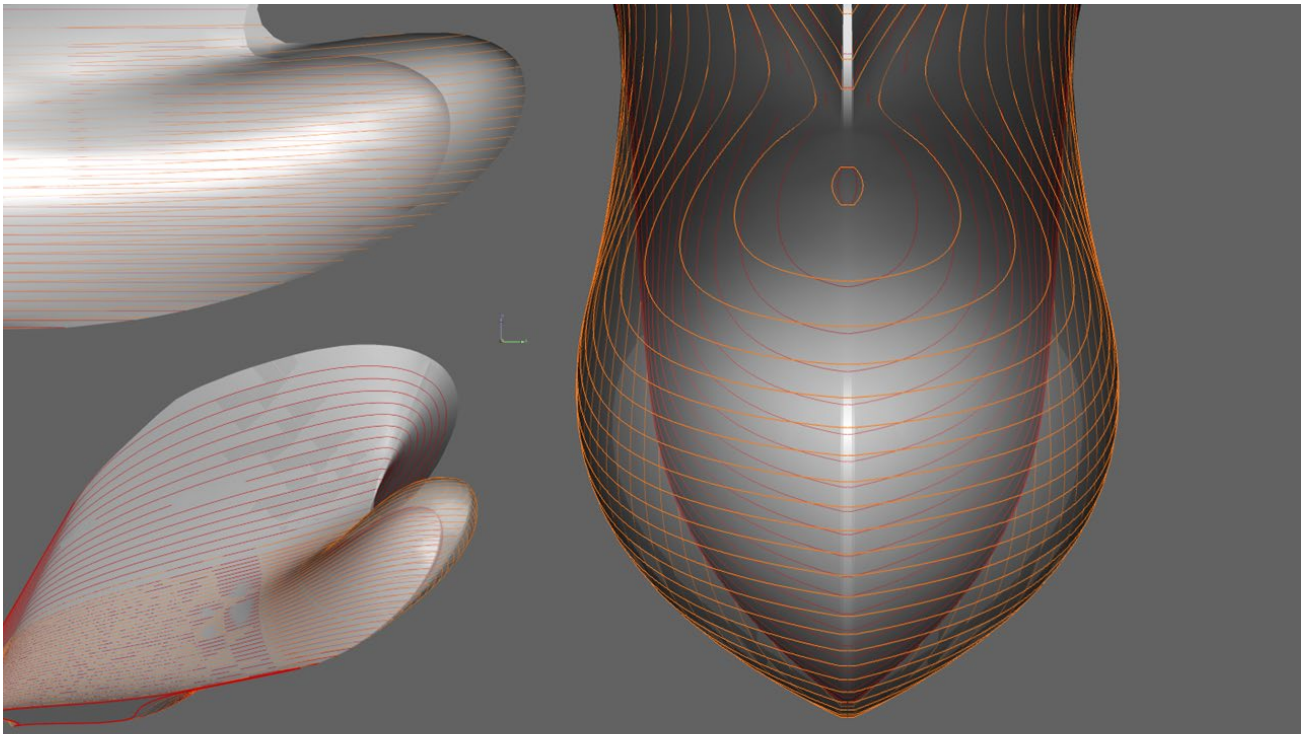

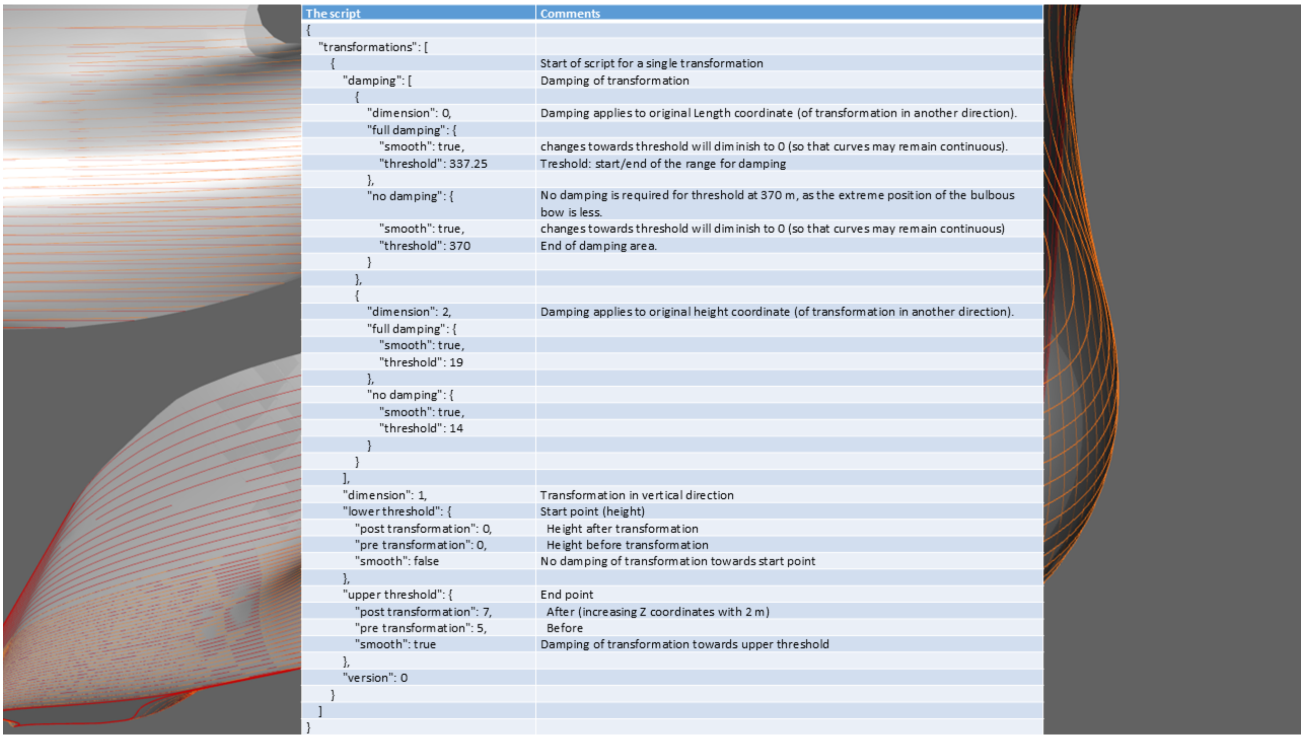

The script	Comments
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"transformations": [	
{	Start of script for a single transformation
"damping": [	Damping of transformation
{	
"dimension": 0,	Damping applies to original Length coordinate (of transformation in another direction).
"full damping": {	
"smooth": true,	changes towards threshold will diminish to 0 (so that curves may remain continuous).
"threshold": 337.25	Treshold: start/end of the range for damping
},	
"no damping": {	No damping is required for threshold at 370 m, as the extreme position of the bulbous bow is less.
"smooth": true,	changes towards threshold will diminish to 0 (so that curves may remain continuous)
"threshold": 370	End of damping area.
}	
},	
{	
"dimension": 2,	Damping applies to original height coordinate (of transformation in another direction).
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"threshold": 19	
},	
"no damping": {	
"smooth": true,	
"threshold": 14	
}	
}	
],	
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"lower threshold": {	Start point (height)
"post transformation": 0,	Height after transformation
"pre transformation": 0,	Height before transformation
"smooth": false	No damping of transformation towards start point
},	
"upper threshold": {	End point
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"pre transformation": 5,	Before
"smooth": true	Damping of transformation towards upper threshold
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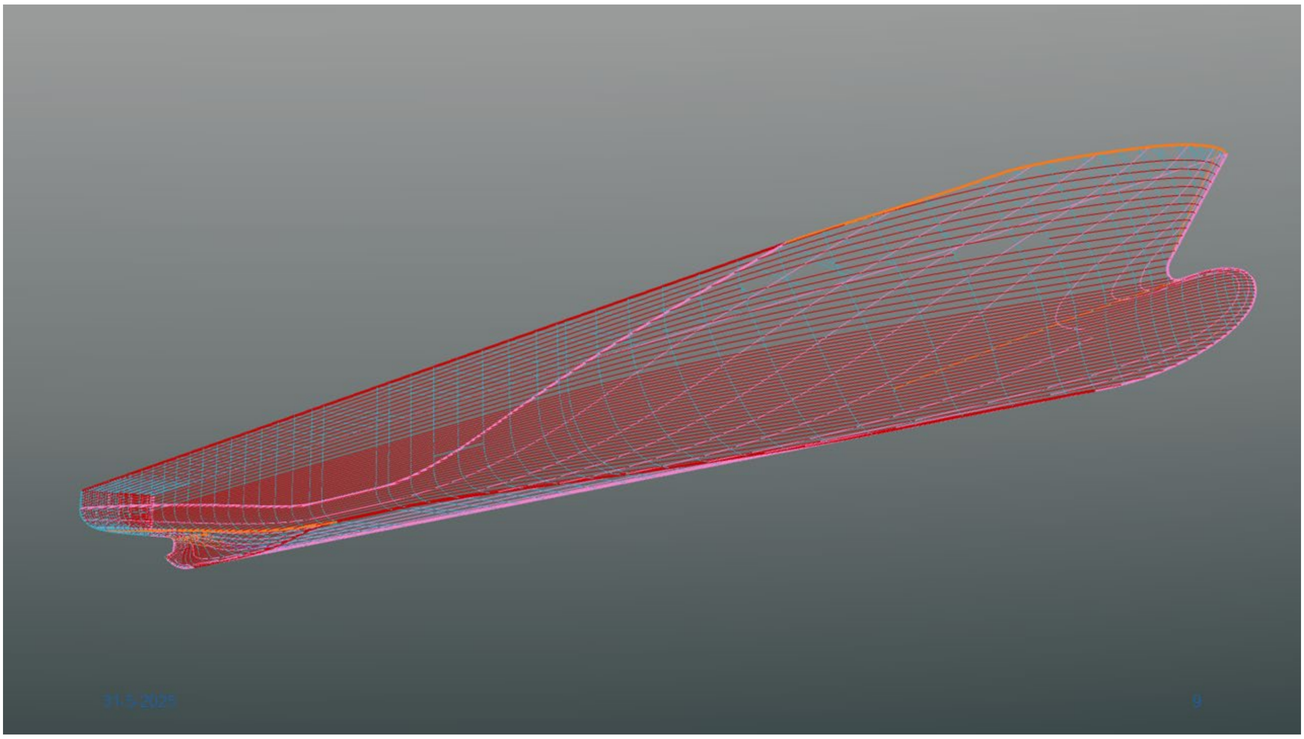

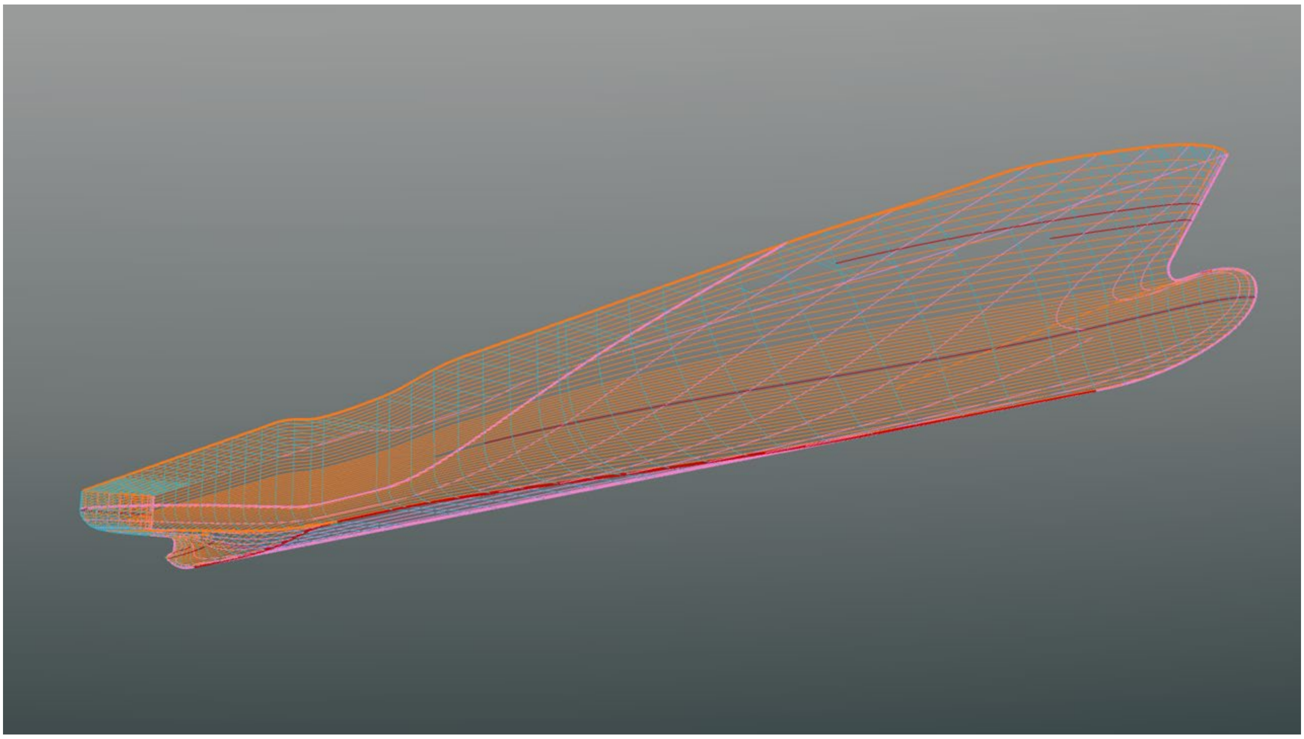

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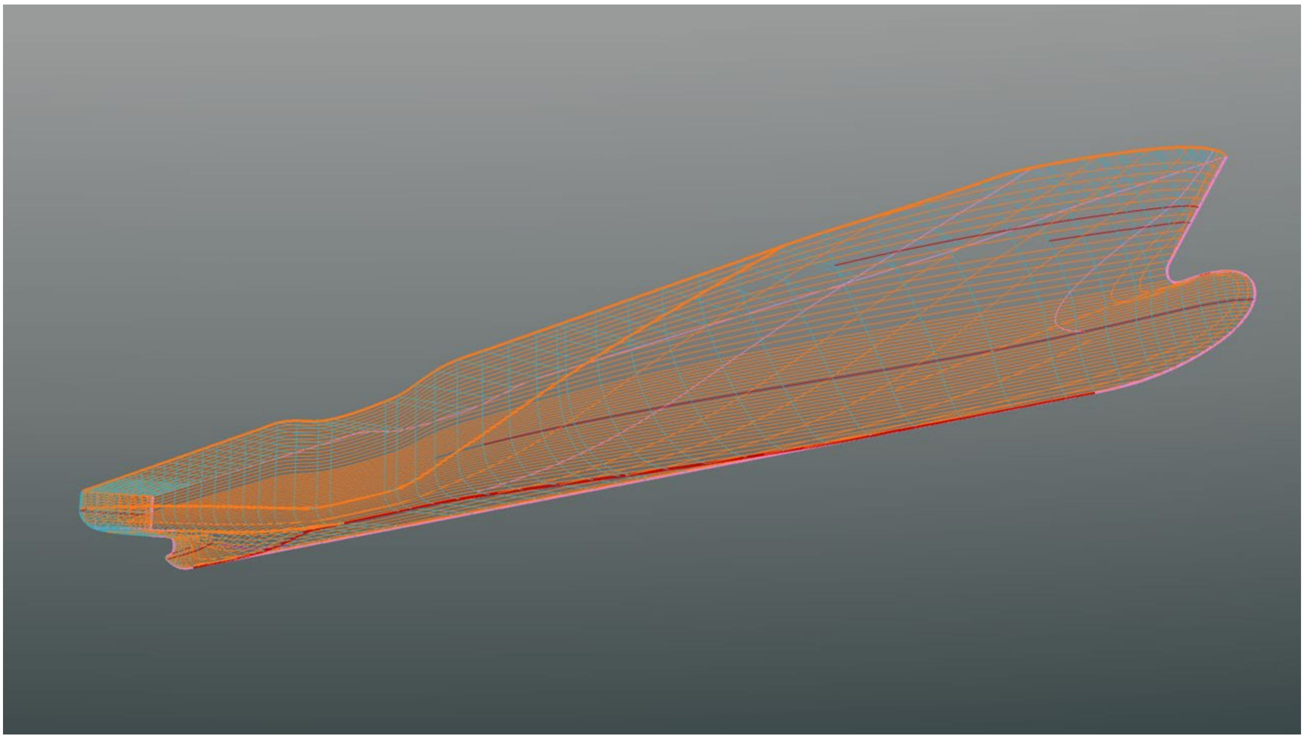

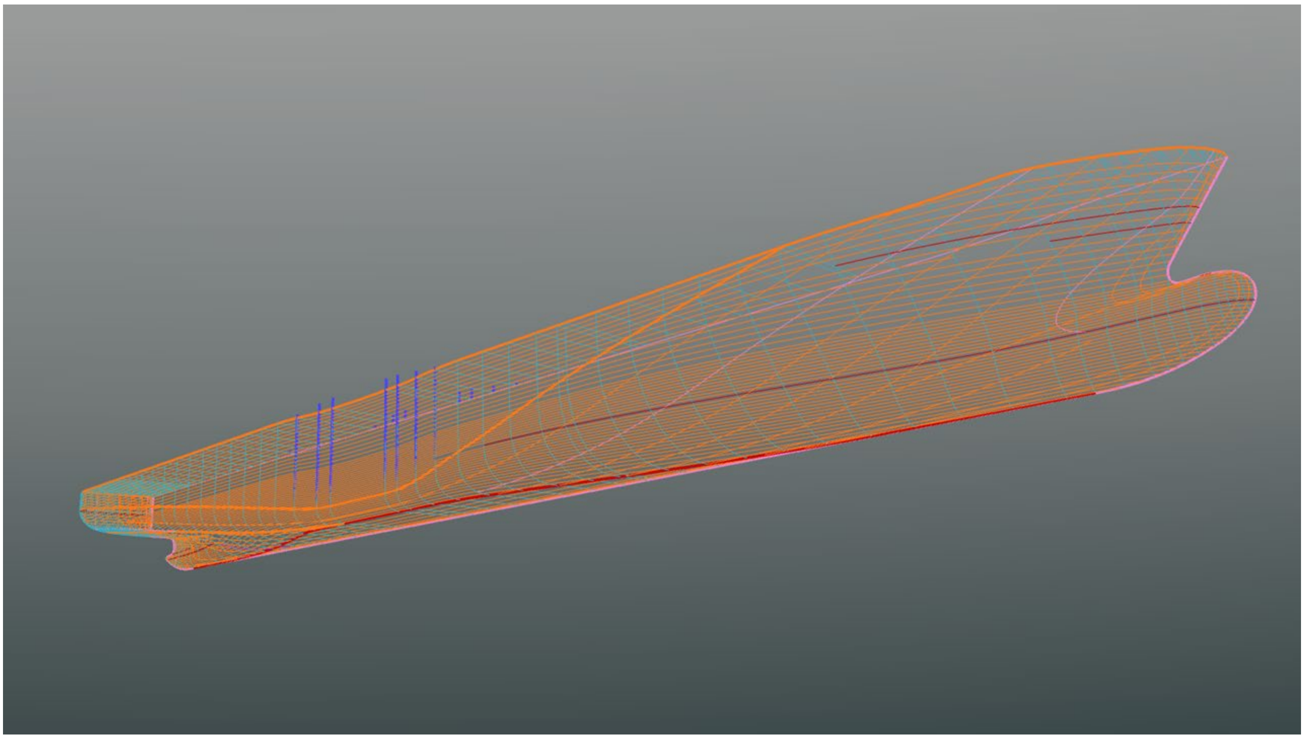

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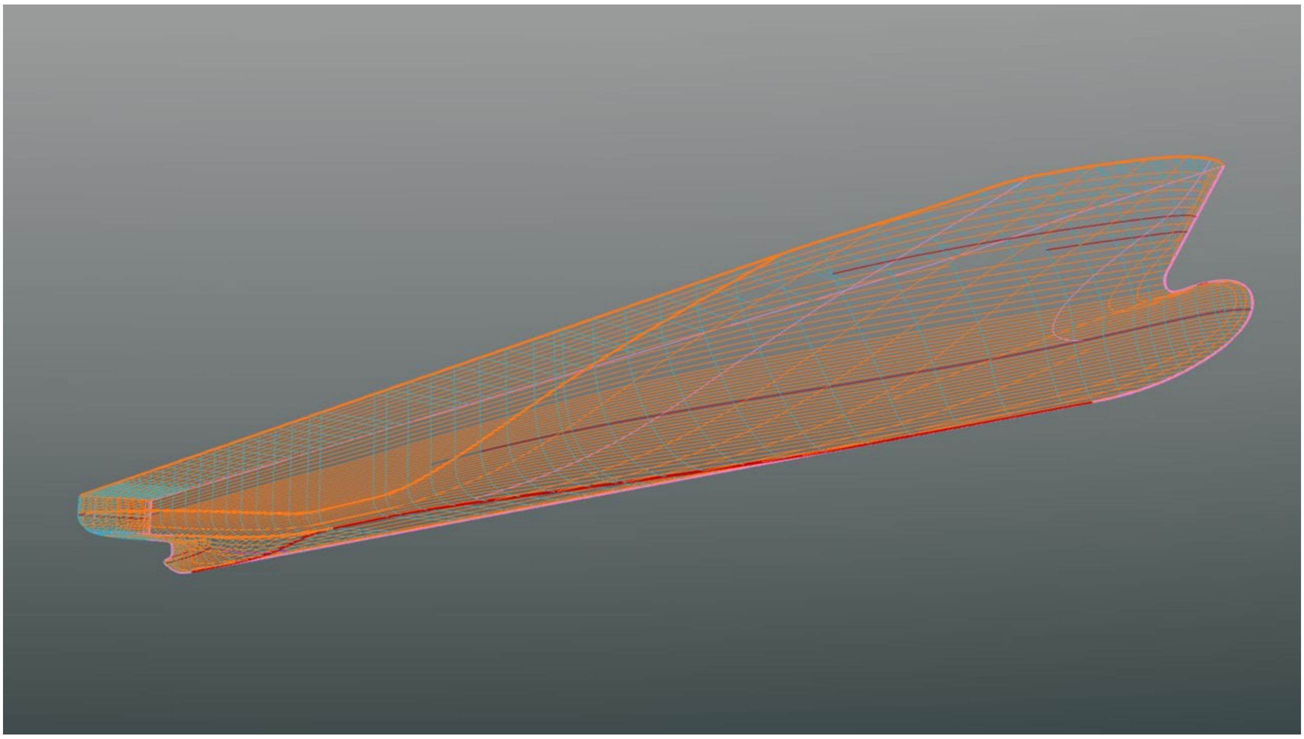

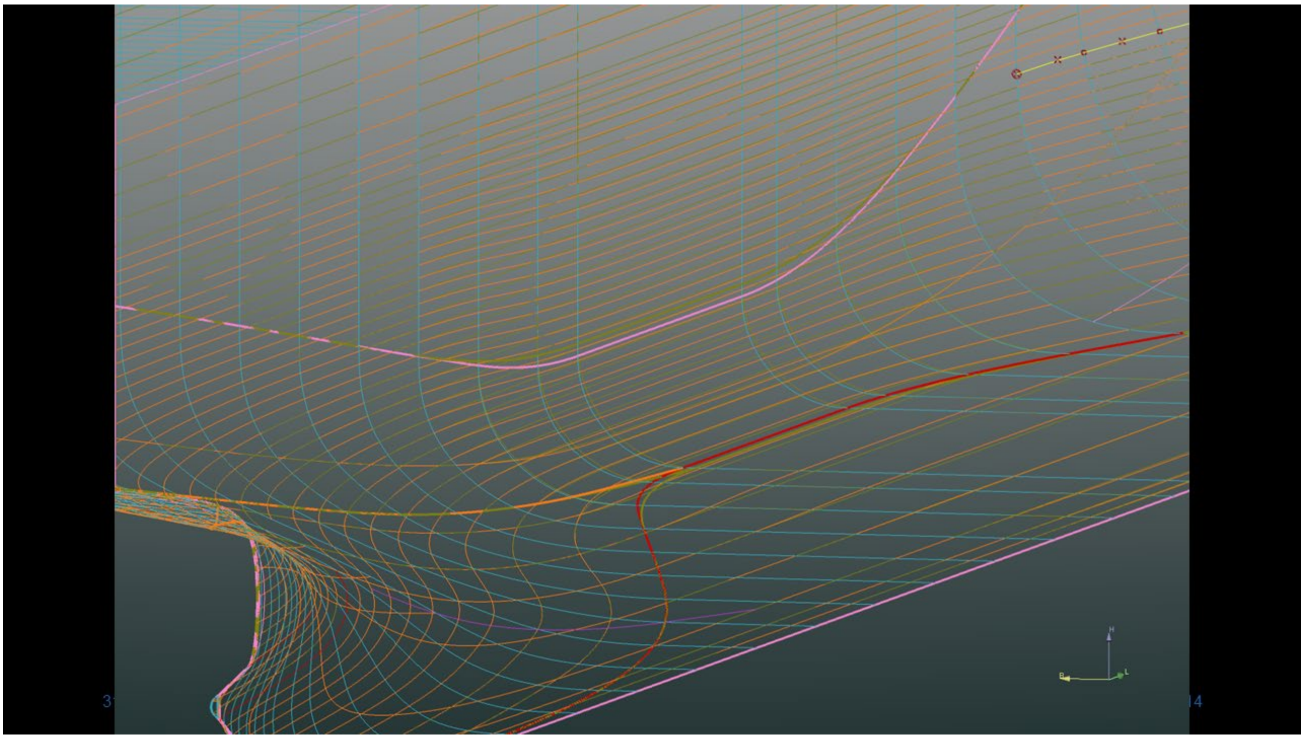

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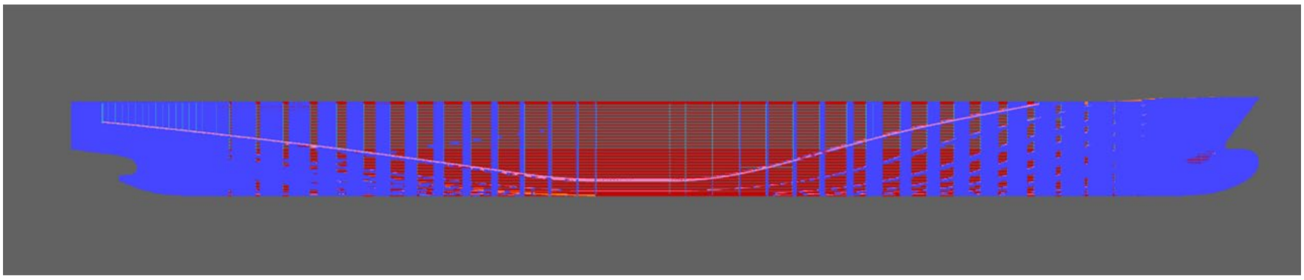
Reduce Cb (displacement)



31-5-2025 15

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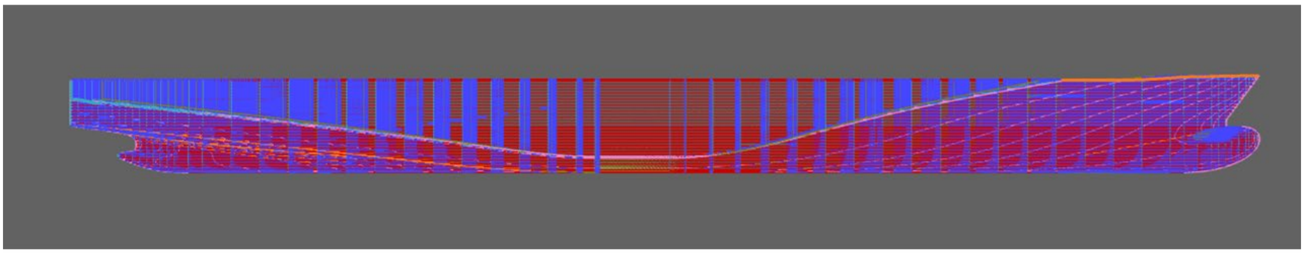
Reduce Cb (displacement)



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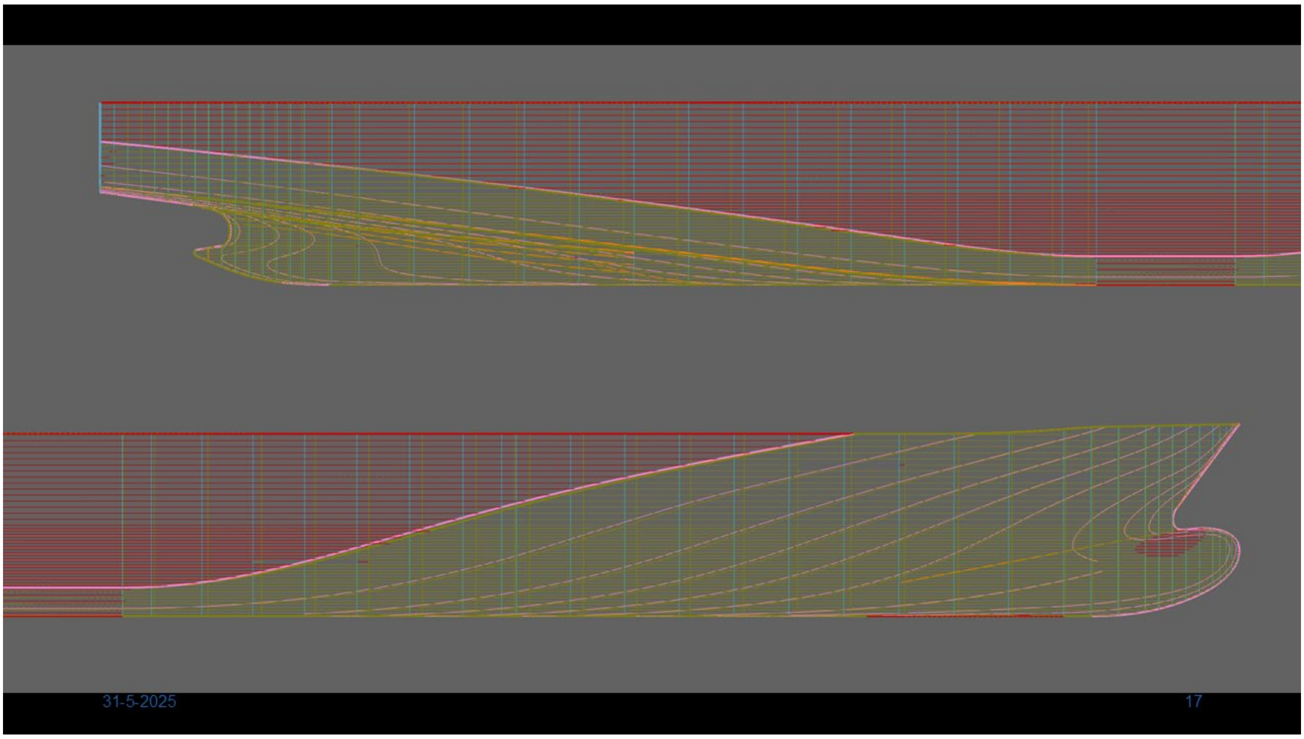

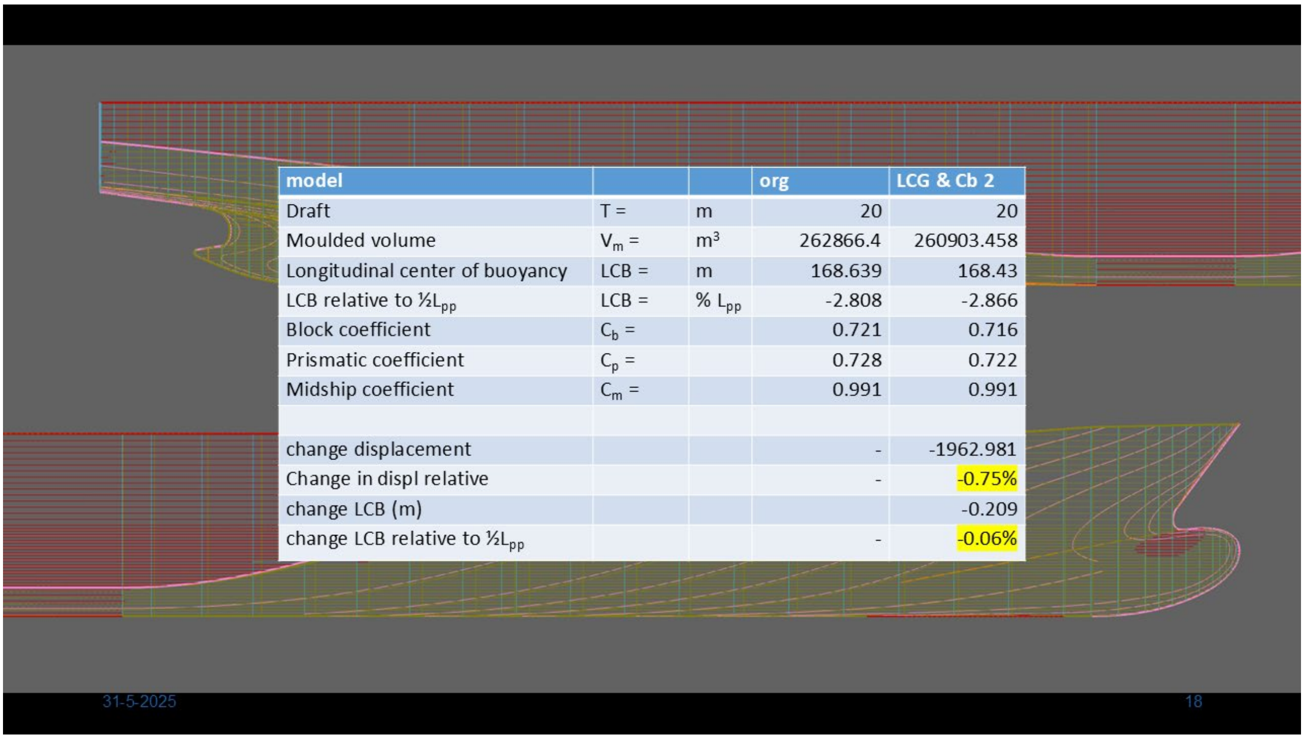

model			org	LCG & Cb 2
Draft	T =	m	20	20
Moulded volume	V_m =	m^3	262866.4	260903.458
Longitudinal center of buoyancy	LCB =	m	168.639	168.43
LCB relative to ½L_{pp}	LCB =	% L_{pp}	-2.808	-2.866
Block coefficient	C_b =		0.721	0.716
Prismatic coefficient	C_p =		0.728	0.722
Midship coefficient	C_m =		0.991	0.991
change displacement			-	-1962.981
Change in displ relative			-	-0.75%
change LCB (m)				-0.209
change LCB relative to ½L_{pp}			-	-0.06%

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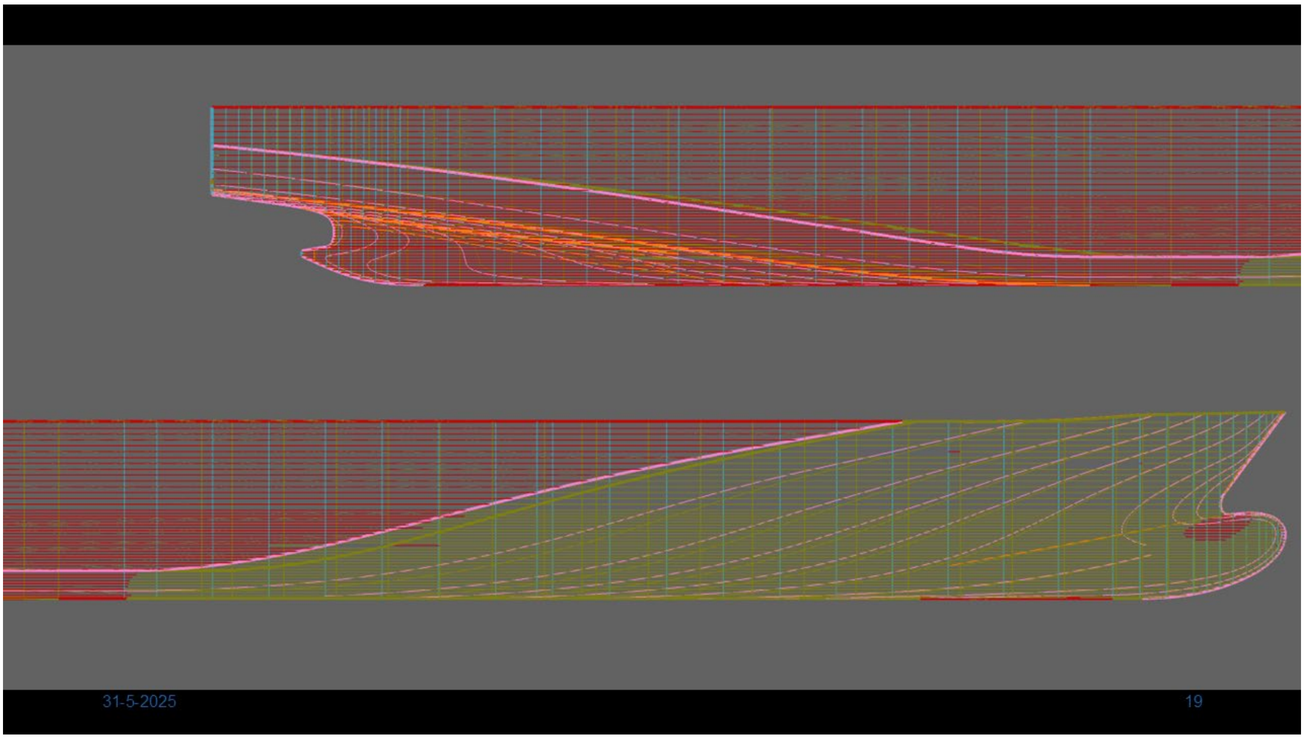

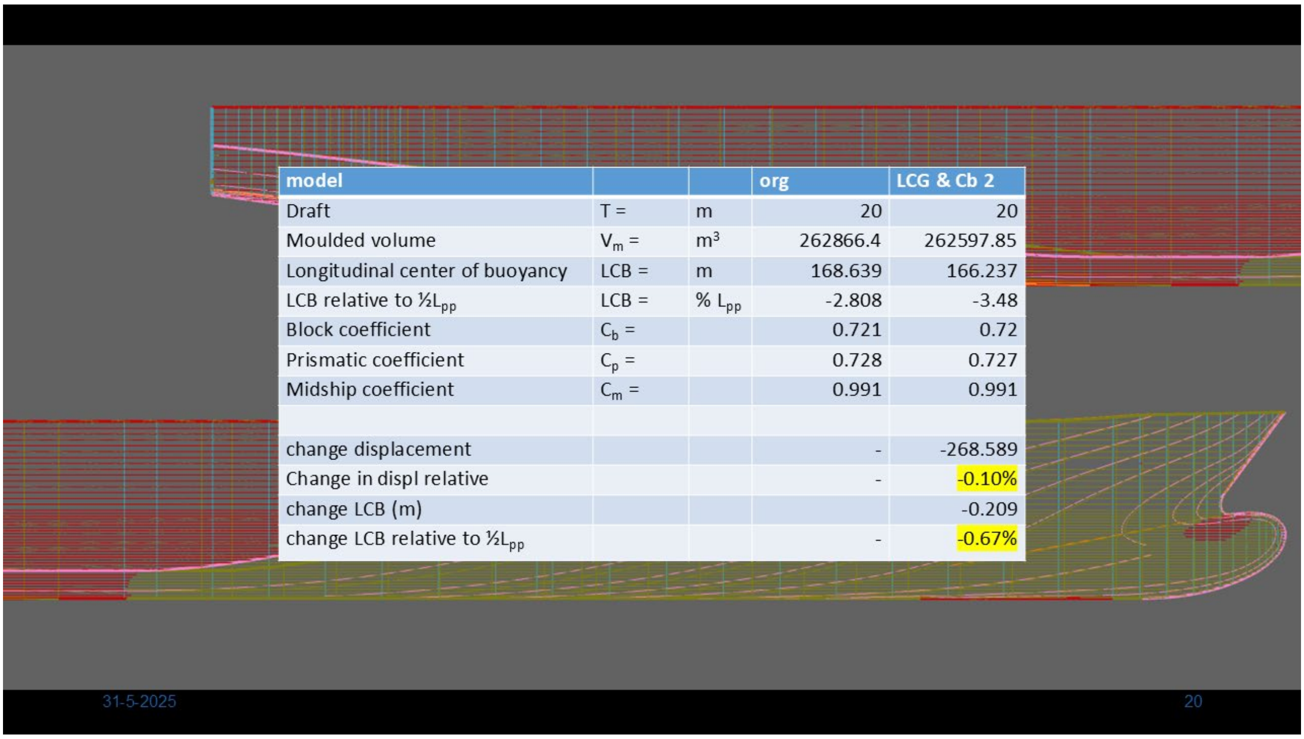

model			org	LCG & Cb 2
Draft	T =	m	20	20
Moulded volume	V_m =	m^3	262866.4	262597.85
Longitudinal center of buoyancy	LCB =	m	168.639	166.237
LCB relative to ½L_{pp}	LCB =	% L_{pp}	-2.808	-3.48
Block coefficient	C_b =		0.721	0.72
Prismatic coefficient	C_p =		0.728	0.727
Midship coefficient	C_m =		0.991	0.991
change displacement			-	-268.589
Change in displ relative			-	-0.10%
change LCB (m)				-0.209
change LCB relative to ½L_{pp}			-	-0.67%

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Key Points

- Break free from progressive commitment
- Simple concept
- Composable
- Replayable
- Variable and expandable

- Can express legacy transformations (Linear scaling, Lackenby)

31-5-2025 21

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Vision

- Ensure sufficient surface points
- Reinterpolate planar curves, build frames
- Dimensionless
- Higher level interfaces, sliders
  - Change bilge radius to *r*
  - Increase the beam to *b* but preserve the bilge radius
  - Raise the propeller shaft by *n*
  - Lift the bulb by %
  - Change LCB to *l*
  - Make more room for the gearbox
  - etc., etc.
- Lower level scriptable (also by capable customers)
- Automated feedback loop with CFD optimization
- Mother shapes (do we even need more than one?)

31-5-2025 22

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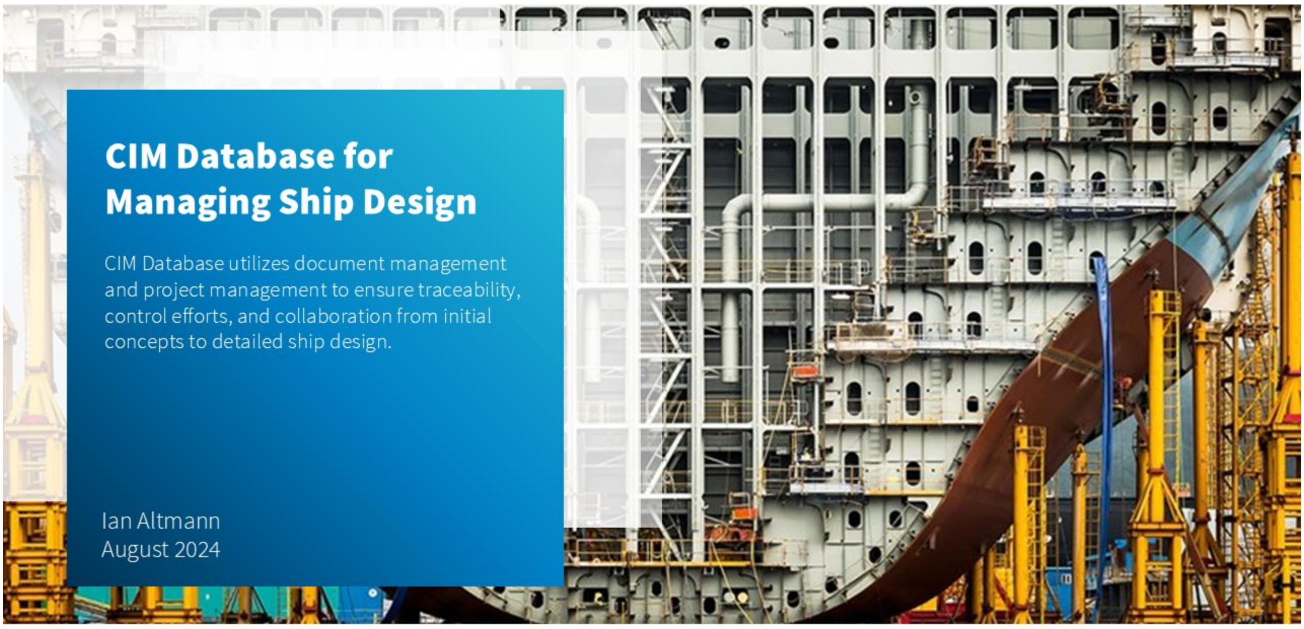
Appendix C – CADMATIC Wave with Change Management



energizing great minds

CONTACT Research

Introduction
Summary, challenges and benefit of Change Management

PLM Concepts
An overview of definitions of terms, concepts and architecture

Users
Detailed description of the personas and user roles

Use Cases
Detailed description of the interaction between users and systems

CONTACT Research

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CADMATIC Wave with Change Management

Introduction

Gaute Gaudestad, Head of PLM at Ulstein:

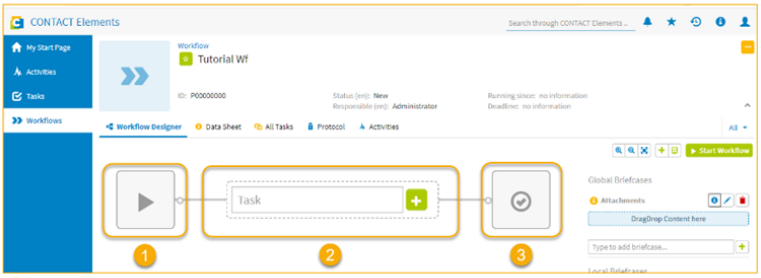
“We need a well-defined way to handle document revisions and its feedback from externals."

CONTACT Research

PLM Concepts

Workflow

- Workflows, however, are computer-readable processes that are executable and deterministic, so there is no room for interpretation.



1 The workflow consists of a start node,

2 a placeholder for its first task to be created and

3 an end node.

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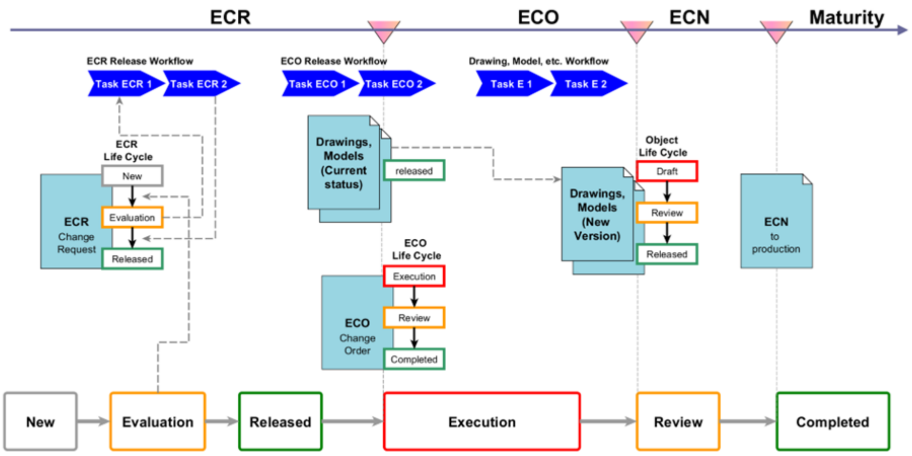
PLM Concepts

Engineering Change



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CONTACT Research

Users

Detailed description of the personas and user roles

Company	Department	Name	Role in Ulstein	Role in CIM	Note:
	Design		Principal Engineer-Lead Naval Architect	Naval Architect	Project managers
	Design		Principal Engineer-Lead Naval Architect	Naval Architect	
	Design		Principal Engineer-Lead Naval Architect	Naval Architect	
	Design		Senior Principal Engineer - Lead Naval Architect	Naval Architect	
	Design		Principal Engineer - Lead Naval Architect	Naval Architect	
	Design		Manager Design	Naval Architect	
	Design		Engineer - System Architect, Electro	Design Engineer	Engineers
	Design		Senior Engineer Hydrodynamics	Design Engineer	
	Design		Senior Engineer - System Architect	Design Engineer	
	Design		Senior Engineer - Stability & Weight	Design Engineer	
	Design		Principal Engineer - Head of Stability & Weight	Design Engineer	
	Design		Principal Engineer - System Architecht	Design Engineer	
	Design		Principal Engineer - Machinery Systems	Design Engineer	
	Design		Senior Engineer - Head of Hydrodynamics	Design Engineer	
	Design		Senior Principal Engineer - Stability & Weight	Design Engineer	
	Design		Senior Principal Engineer - Head of Electrical Systems	Design Engineer	
	Sales and Marketing		Sales manager	Sales	View'er only
	Sales and Marketing		Commercial Director	Sales	
	Sales and Marketing		Sales Manager	Sales	

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CONTACT Research

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Paul Murmann (42)

Required Input

- Person data
- Open issues

Deliverables

- Projects & Project Dashboards
- Project structure plan
- Tasks
- Valuation of open issues
- Schedules
- Reports
- Documents

Project Manager

"I'm the connecting point between the management and project members. The system is supposed to support me in planning, executing and monitoring projects efficiently and furthermore in communicating with stakeholders.

Tasks

Paul is the project manager and is therefore responsible for the planning, implementation and monitoring as well as the completion of projects. During the supervision of the projects, he adheres to process specifications of the company, that puts great emphasis on transparent and sustainable handling of the project.
He works together with various people and groups of people in the projects: from product management and design to manufacturing, procurement and accounting, he continues to be in constant exchange with external stakeholders. He has to send regular reports to the management team in order to document the progress of the projects. Paul must also maintain an overview of deadlines, costs, tasks, associated documents and project progress at all times.

Use of CONTACT Elements

- Works multidisciplinary in the project management application and via task boards with his team
- Uses project tasks for task description and is responsible for the project structure plan
- Evaluates open issues created by project members to record problems and questions
- Keeps his projects up to date, especially the Project Dashboard
- Uses schedules to plan his projects
- Takes advantage of the card view in project result lists for a quick overview of his projects
- Makes use of document management, e.g., to file and distribute relevant documents
- Uses the Activity Stream to communicate with colleagues and other departments

Thilo Preuss (29)

Required Input

- Strategic product approach (specifications, variants, ...)

Deliverables

- Product specific documents
- Technical requirements
- Test/Simulation

Technical Product Manager

"If anyone has any questions about my products, I am the first person to ask.

Tasks

Thilo is a technical product manager and thus responsible for specific products or product lines. He is in close contact with the strategic product management, but in contrast to the strategic product management he rather carries out operational tasks.
Thilo defines and prioritizes the technical requirements of a product. He ensures that these are understood and implemented accordingly by the development department. He regularly tests if products meet the technical requirements and fulfill the requirements of the market.
He plans projects involving his products and sets milestones. In addition, he supports the technical sales department, e.g., he creates sales presentations and holds them at the customer's site or provides support for projects with special requirements. If product-specific documents such as technical articles, manuals or complex data sheets have to be created, he is the right contact person.

Use of CONTACT Elements

- Is involved in the creation of product-specific documents (e.g., technical articles, manuals) and stores these as documents for the product
- Defines and prioritizes technical requirements from requirements of the strategic product management in the specification editor
- Sets milestones in projects involving his product
- Works with his team in the project application
- Uses the Activity Stream to communicate with colleagues and other departments

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Conrad Molski (57)

Compliance Manager

"To ensure that our products meet all regulatory requirements, I have to combine a wide variety of information from different sources – Quite a tricky task!

Tasks

As a compliance manager, Conrad ensures that the company complies with legal and regulatory requirements in the sector. For this, he must not only know the manufacturing BOMs for all products, but also have information on suppliers and on all current standards and guidelines. Using the parts classification, supplier information and other information from the ERP system, he brings together all the necessary information on a product in order to evaluate it. In addition, he must always keep an eye on changing legal regulations and consider the consequences for the products. Furthermore, he prepares all the necessary proof required for the approval of products in the various target markets.

Required Input

- BOMs
- Part classification
- Proof from third parties in the form of documents
- Standards and guidelines
- Specifications

Deliverables

- Product evaluation
- Proofs / Reports
- Proof from third parties in the form of documents

Use of CONTACT Elements

- Views specifications and BOMs of all products
- Maintains and edits classification features that map information on legal requirements
- Requests up-to-date proof and information on products from suppliers, which may be stored in the PLM system
- Evaluates BOMs according to different legal requirements and target markets, for example with the help of the Material Compliance Solution
- Issues documents that serve as proof of regulatory requirements

Elias Cremer (38)

Engineering Change Manager

"I organize and manage changes to our products. It's important to collect all parts, documents, etc. that are affected by changes. And this may be quite a few - the system should support me in the best possible way.

Tasks

Elias gets notified about change requests by tickets or problem reports. Change reasons can be, e.g., problems and requirements from maintenance or production, new laws and norms or cost aspects. He reviews the request and discusses it in regular change meetings with the affected departments (including development, costing, purchasing). If the request is valid, Elias creates an engineering change request. Therefore, he describes the actual change request, assigns affected parts and documents and adds the responsible departments to it. To find parts and documents in the system, he uses, among other things, the link graph. Depending on the maturity of the product in the development process and the complexity of the change, he assigns workflows of varying complexity. He supervises and coordinates engineering changes up to the engineering change notification phase in which all stakeholders are informed about the changes.

Required input

- Semantic links
- Documents to be changed
- Parts to be changed
- Objects to be changed
- Person data

Deliverables

- Engineering change
- Workflows

Use of CONTACT Elements

- Creates engineering change requests
- Supervises all phases of an engineering change (ECR, ECO, ECN)
- Uses the link graph to find all changes of affected objects
- Creates workflow templates for engineering changes
- In the project management application, he works together with project teams that are responsible for changes.
- Uses the Activity Stream to communicate with colleagues and other departments

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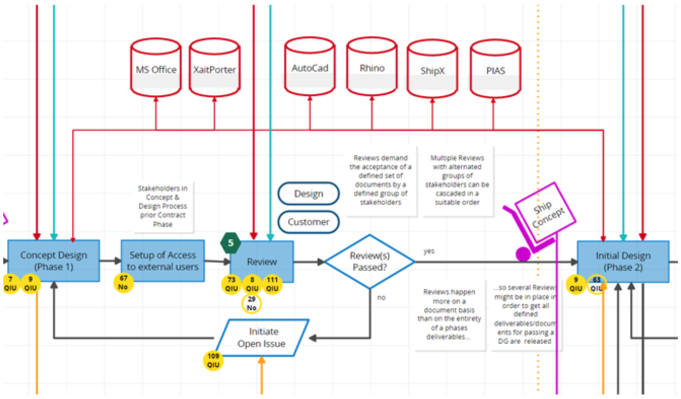
Use Cases

Detailed description of the interaction between users and systems

- **Project Setup**
- **Concept Design**
  The design department collects Documents, Drawings, Files and Mails. Documents need to be reviewed by internal and external Stakeholders. Updated Documents design data will be hosted in PLM system
- **Initial Design**
  The design department shall be able to amend Design Concept with documents and files regarding vessels general design, etc. Updated design data will be hosted in PLM system

Initial Concept Design & Review

Initiate an Engineering Change by an internal Task



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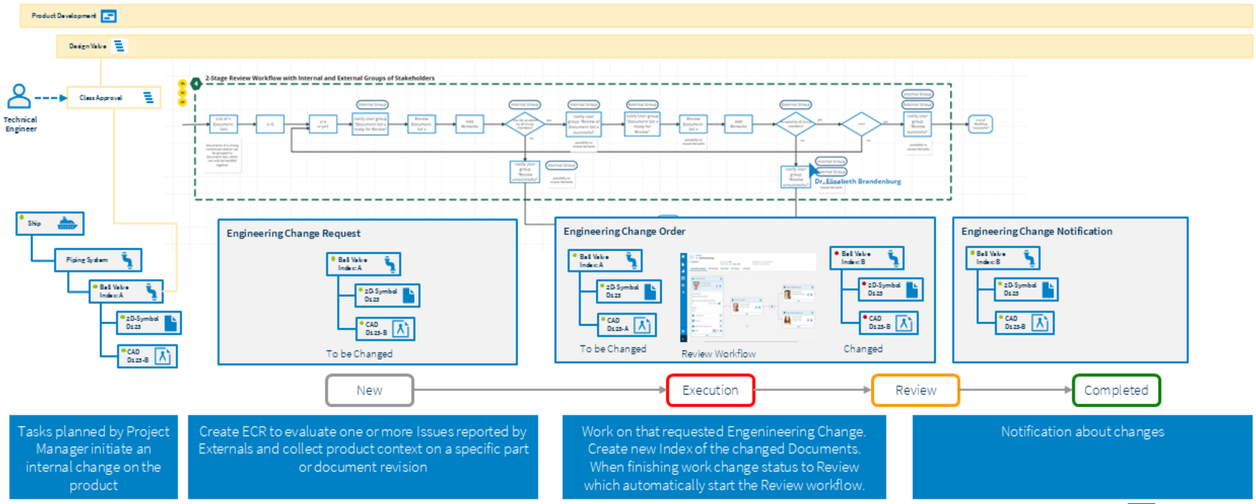
Change Management

Initiate an Engineering Change by an internal Task



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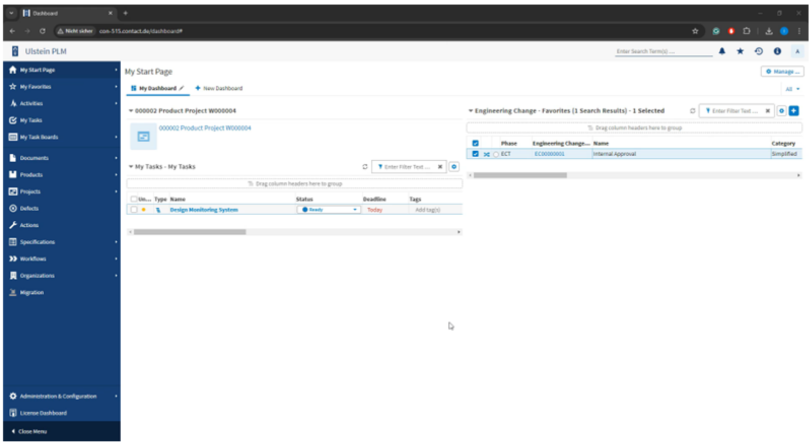
Change Management

Initiate an Engineering Change Request by an internal Task



1. Start from Start Page where current Tasks are listed
2. Begin work by changing status of my assigned task
3. Start Engineering Change from Template
4. Collect relevant Documents for Engineering Change
5. Make status change to execute on the Engineering Change

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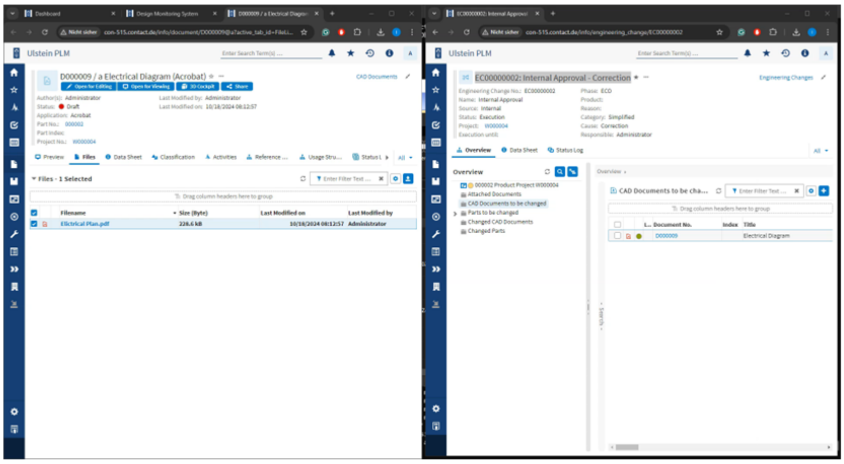
Change Management

Execute and Approve the Engineering Change



1. Change the new Revison of the CAD-Document by creating a new File
2. Do a status change on the engineering change to “Execute” to start the review process
3. Get a notification about an Approval Task
4. Have all information in place for approve the engineering change.
5. Review work by having all information in place

15

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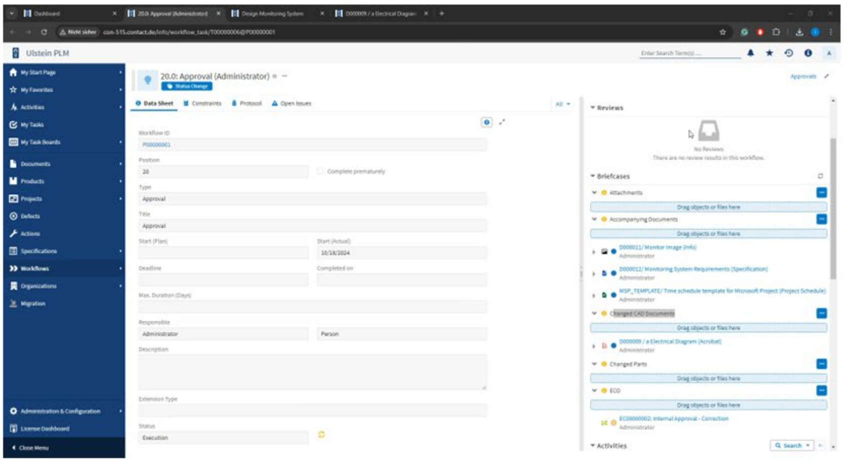
Change Management

Approve the Engineering Change



1. Approve work by the status change of the Approval Task and
2. Add a Comment to document Approval

16

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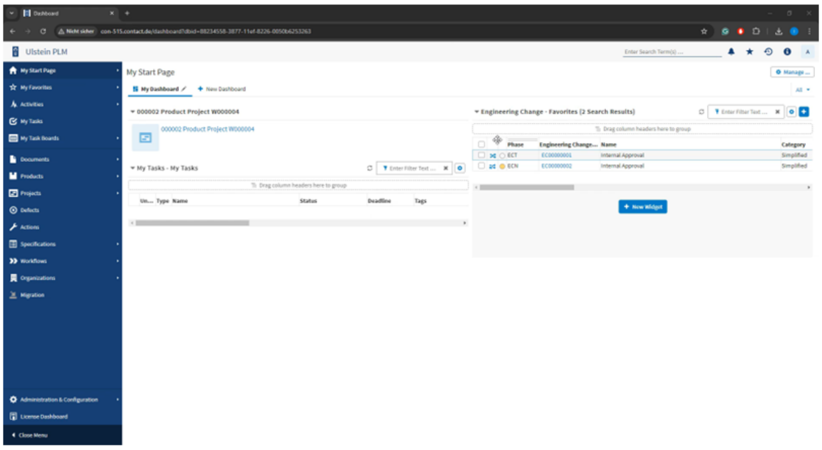
Change Management
Change History



1. Starting from Landing Page to navigate to the Product Project

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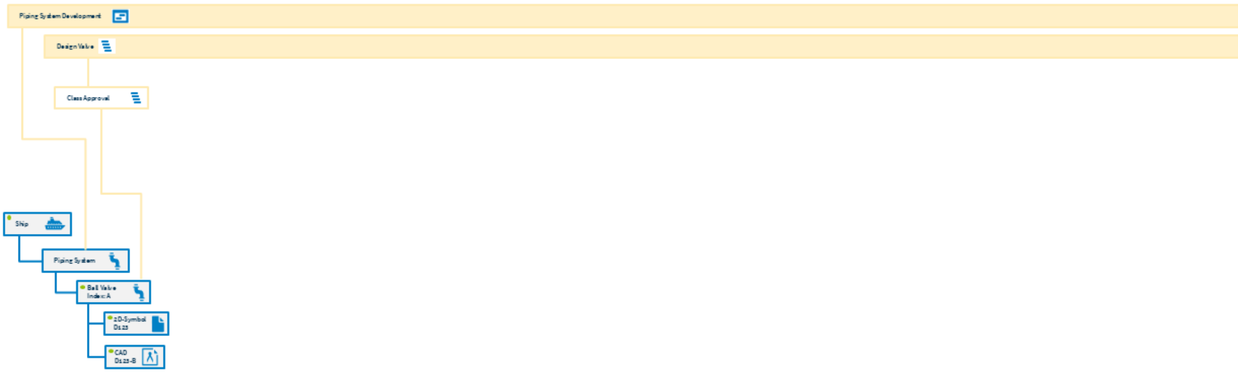
Change Management
Initiate an Engineering Change by an internal Task



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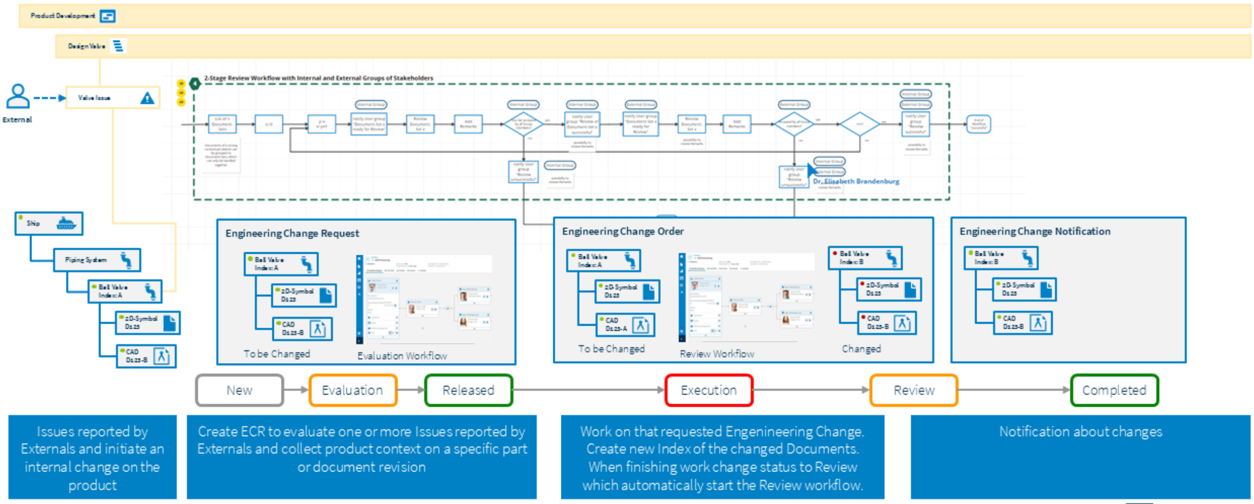
Change Management

Initiate an Engineering Change by an (external) Open Issue



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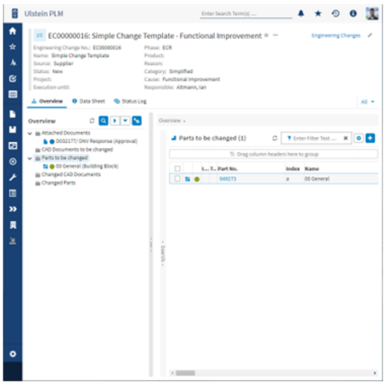
Engineering Change

ECR phase

1. The engineering change is created in the ECR phase from a template (see Work with engineering changes).
2. The work objects (approved models, drawings and accompanying documents) are linked to the engineering change (for example, as a drag-and-drop assignment, see Adding accompanying documents, CAD documents and parts). The engineering change is changed to the Execution status via a status change.



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Comments & Issues within an EC-Workflow

- Comments in Workflow Tasks
  - For Review Tasks: Comments are optional
  - For Approval Tasks: Comments are mandatory
- Creation of Open Issues within ECO Phase
- Activity Stream

Engineering Change

- What CAD models are affected by a change?
- Have all departments and locations evaluated the change?
- Have the specified tests and trials been carried out?
- What were the results?
- Which development status was the last design review based on?
- Which status was the current tool design based on?

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Change Management

- To summarize, the planning, analysis and tracking of engineering changes is indispensable. They must be systematically documented and communicated if various processes are in progress simultaneously, such as design engineering, simulation, toolmaking, prototyping or production scheduling.

Engineering Change

- Engineering Change Lifecycle: Request (ECR), Order (ECO) and Notification (ECN).
- Template management for various change scenarios: Fast Track, Standard etc., depending on the product maturity, for example.
- Direct access to the work objects changed or to be changed, such as parts, documents, and models.
- Significant acceleration compared to paper-based circulation procedures.
- High level of clarity due to briefcases for all relevant work objects, test results, modification notes, order documents and other accompanying documents, such as cost calculations.
- Automation and assistance, e.g. using automatic notifications or collective release of the relevant parts, documents and models.
- Ensuring consistency in a rule-based manner. Example: Completing all changes before full EC release.

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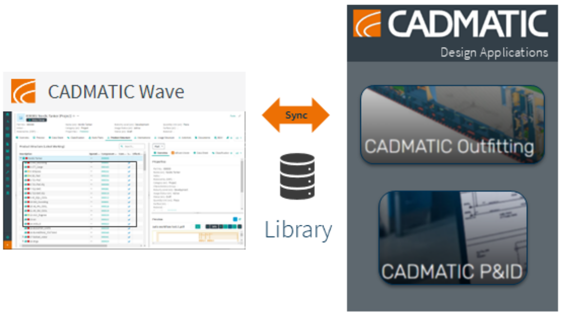
Integrated Library Management

Summary and benefit

CADMATIC Wave, based on CONTACT Elements, uses library management in early ship design to centrally manage standardized components and materials in the modelling and procurement processes by integrating CADMATIC Design Applications. It enhances collaboration between Engineers and Designers, reduces errors, and contributes to the successful delivery of high-quality vessels while ensuring regulatory compliance, and optimizing the use, costs and sustainability of ship designs.



CONTACT Research

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Appendix D – SEUS – Research Lecture Presentation

This project has received funding from the Horizon Europe Framework Programme (HORIZON)
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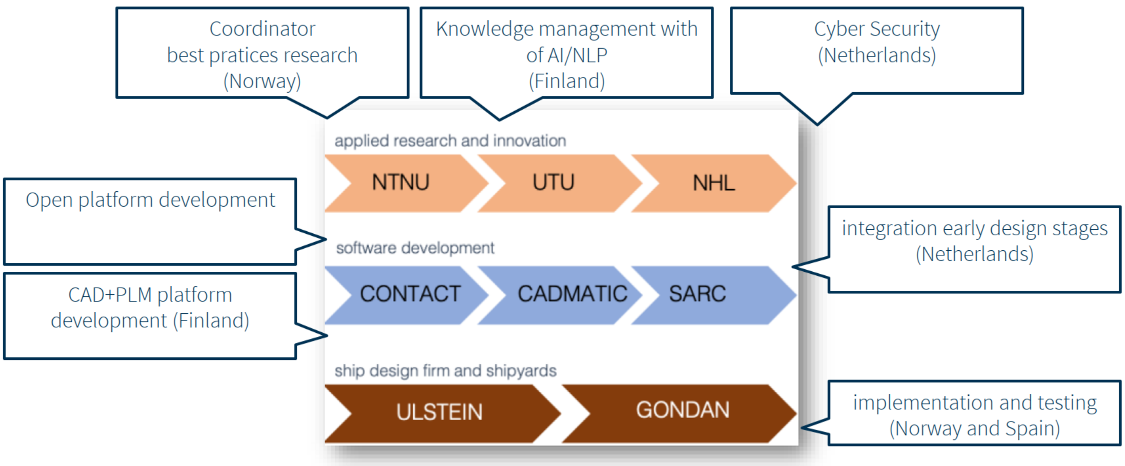
EU resrach project SEUS

create a “framework” for European shipyards

architecting and developing an **integrated platform** for a combined solution incorporating **CAE, CAD, CAM, and PDM** software and testing it at shipyards

3

SEUS: Participants and Roles



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Partnership CADMATIC
lead: Nam Nguyen

Hull and Structural Design | Outfitting and Piping Design | Electrical & Automation | Information Management

- Goal: integrated CAD + PLM solution for shipbuilding

=> CADMATIC WAVE

Ulstein customer project
lead: Markus Feldmann

- PLM Strategy
- Project Management
- Document Management
- ERP-Integration
- Go-Live in November

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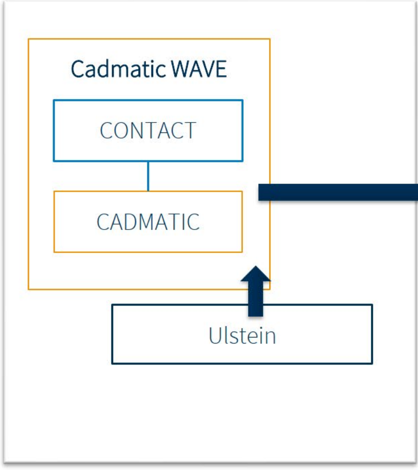
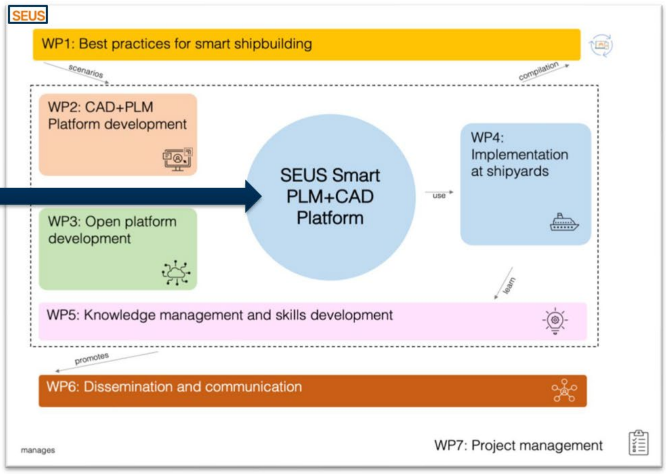
SEUS deliverable





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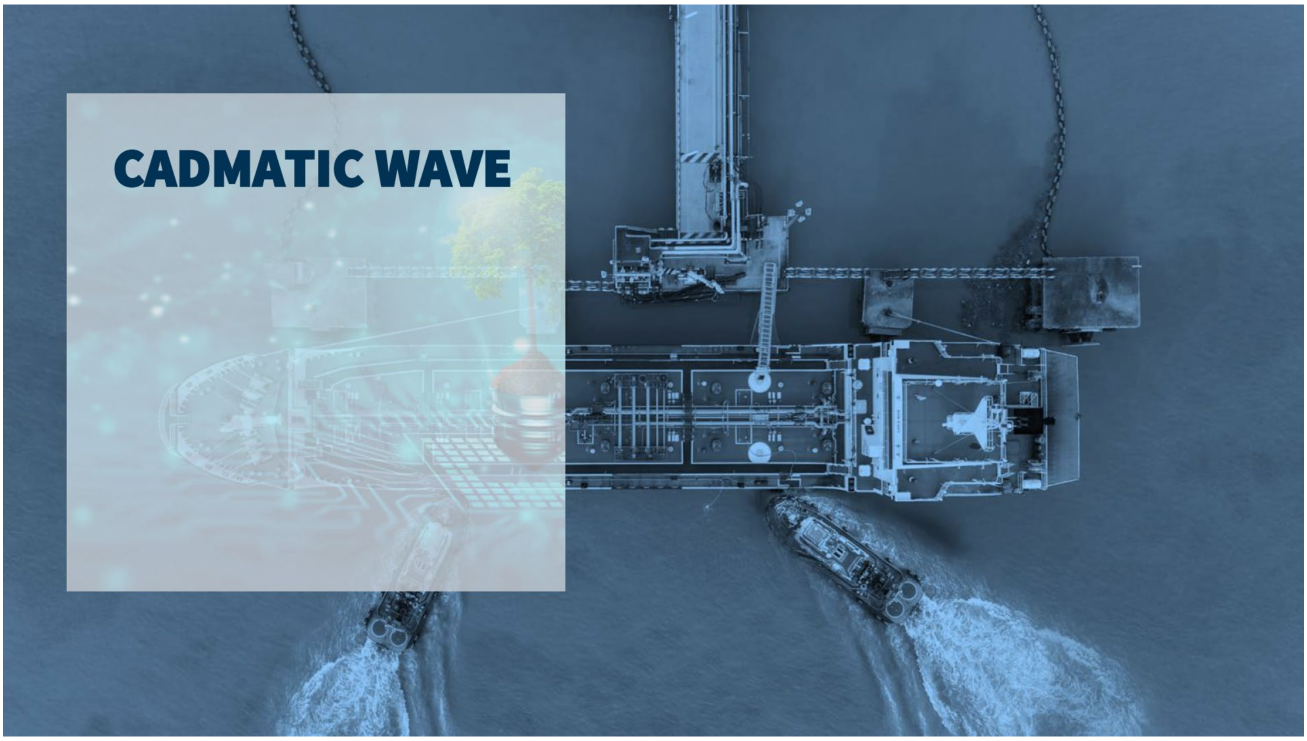

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WAVE PRODUCT

- Technology behind the CADMATIC Wave is using existing modules from our partner CONTACT Software
- Examples of out of the box functionality with CONTACT modules:
  - Document management
  - Project management
  - Workflows
  - Collaboration
- WAVE development focuses on:
  - CAD integrations
  - PLM usability and use cases in shipbuilding
  - Making the standard configuration for shipbuilders
  - Enabling shipbuilders a quick start with PLM

CADMATIC

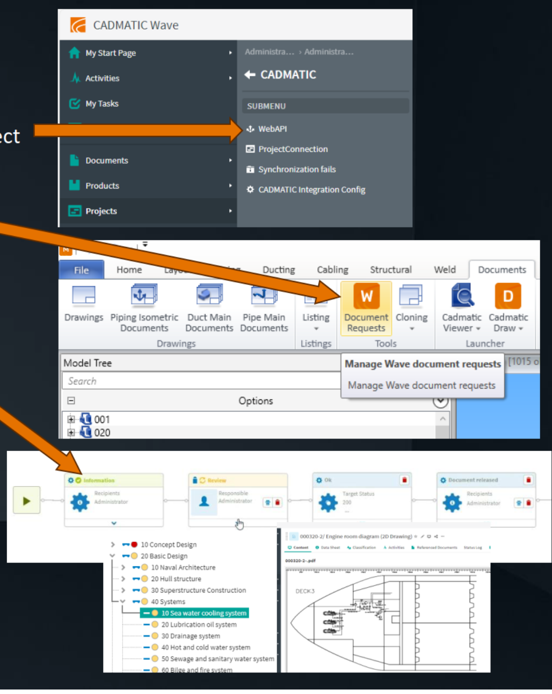
10

Wave first release

- Integration classes and configuration objects created to connect Wave with COS (CADMATIC object storage)
- CADMATIC Document integration with document reply and request functionality
  - CADMATIC Outfitting documents
  - CADMATIC P&ID documents
- Ready to use shipbuilding specific workflows
- CADMATIC Integrated document management
- CADMATIC Integrated project management

After first release

- Document requests from Hull and Electrical
- Embedding eShare as file viewer
- Integrating eShare markups with Open Issues objects in Wave
- Product/Part integration
- Embedding eShare as product structure viewer



CADMATIC

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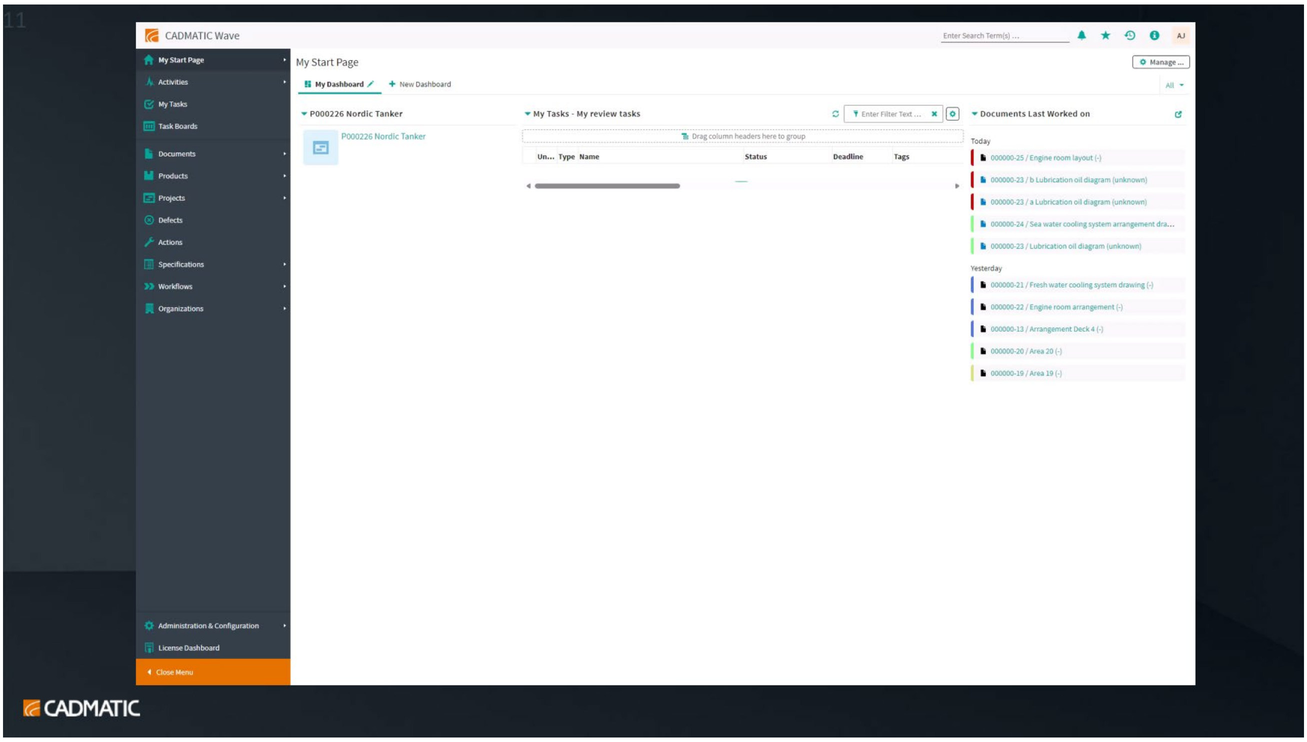

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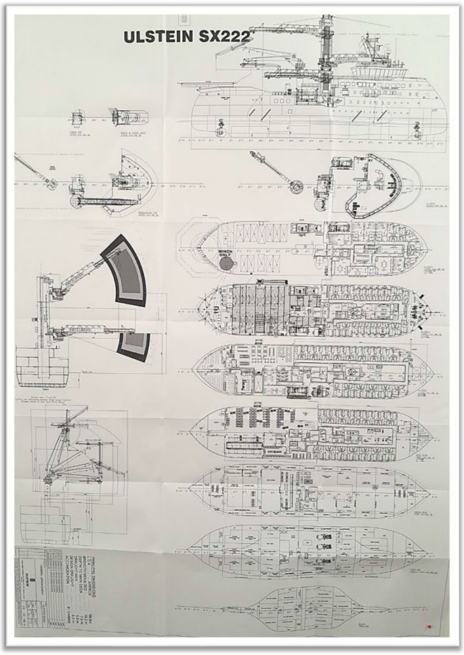
Shipbuilding Characteristics

- Document based working
  - 28,700 documents for the design phase only
  - Multiple files per document
  - Up to 45 filter for documents
  - With external and internal processing and approval steps
  - Simultaneous work on different versions of a document

45 working structures
-> Distinguished by the view of the product in relation to the process



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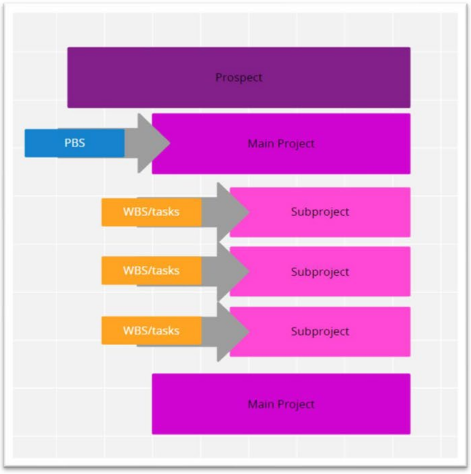
Project Structure (templates)

- Prospect Projects:
  - collects all projects for one client
- Main Project:
  - created on request
  - connected with product
- Subproject
  - projects with task and document (templates) needed (related to the request)



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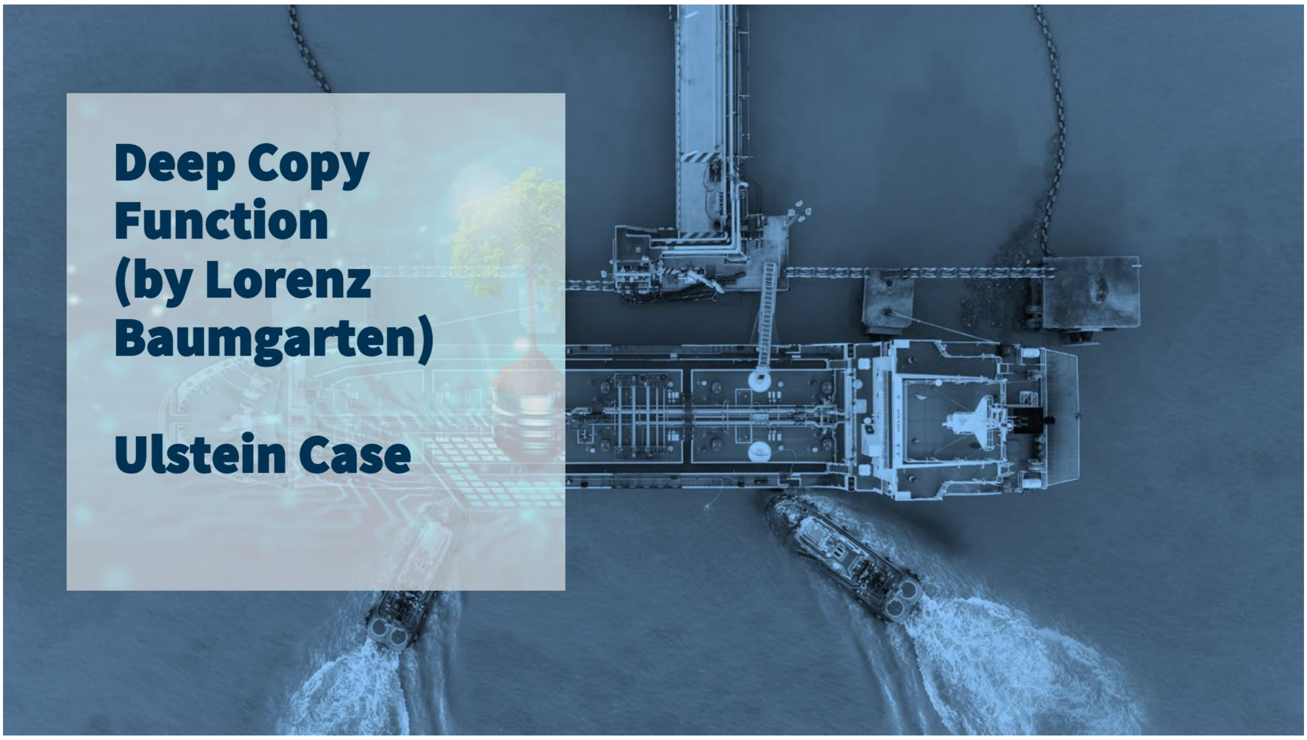
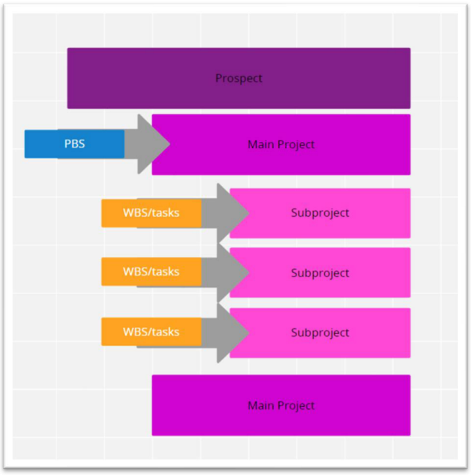


new „deep copy“ function

- Main project kopieren, mit Übernahme der entsprechenden parts und documents
  - parts in der BOM werden kopiert statt referenziert => (noch) keine Wiederverwendbarkeit
- Sub-projects zu bestehenden projects hinzufügen
  - beim Zufügen von Subprojekten werden die neuen Tasks/Documents mit den schon bestehenden Parts im Main Project verbunden
  - Sind documents im main project/bestehendem sub project schon vorhanden, werden nur die Relationen zu den neuen tasks erstellt



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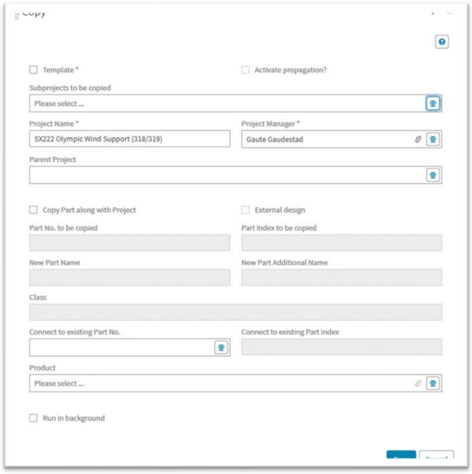
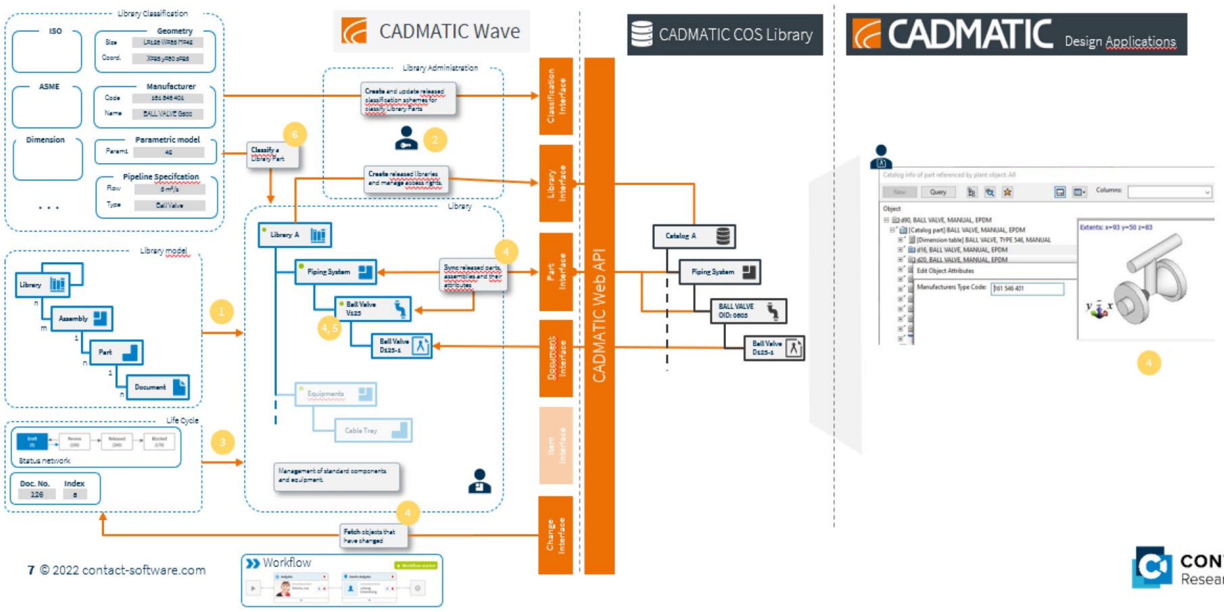
- Standard: Kopier-Funktion langsam, weil konfigurierbar, vieles gecheckt werden muss (Signale) und Objekte iterativ kopiert werden
- für komplexe Projekte mit Ship 1 Woche warten
- Custom sql querys stattdessen (jetzt 20 min zum Kopieren)



Manage Library Parts



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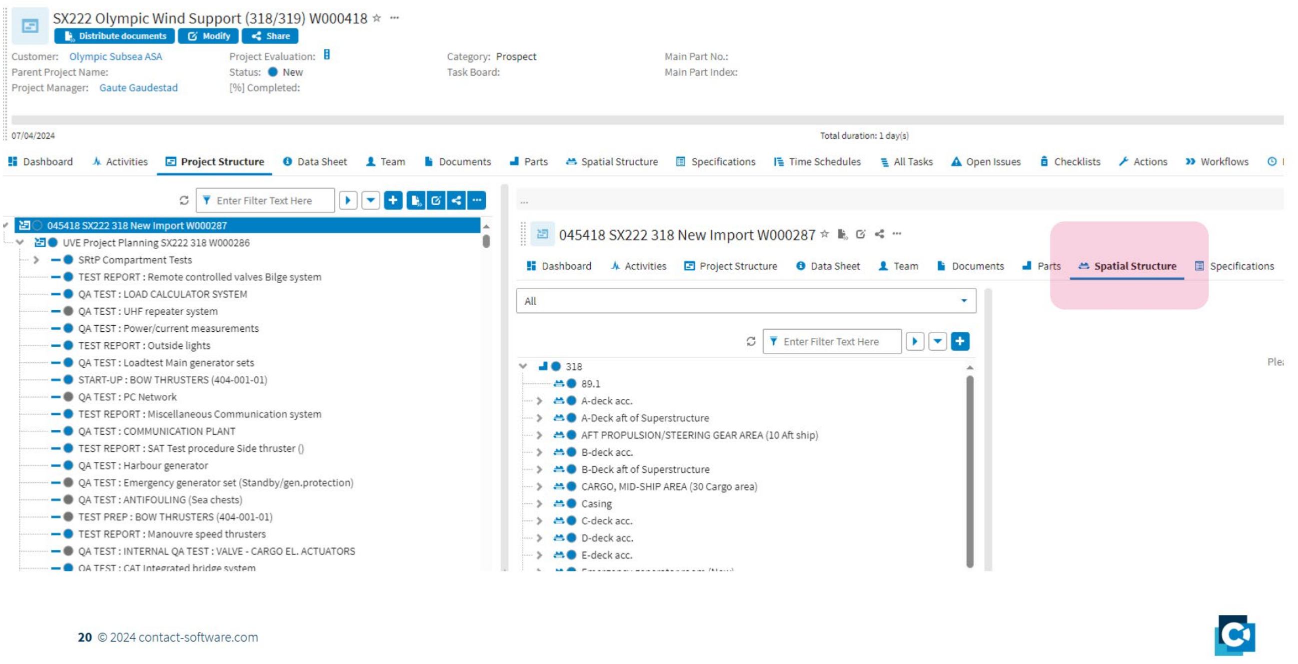

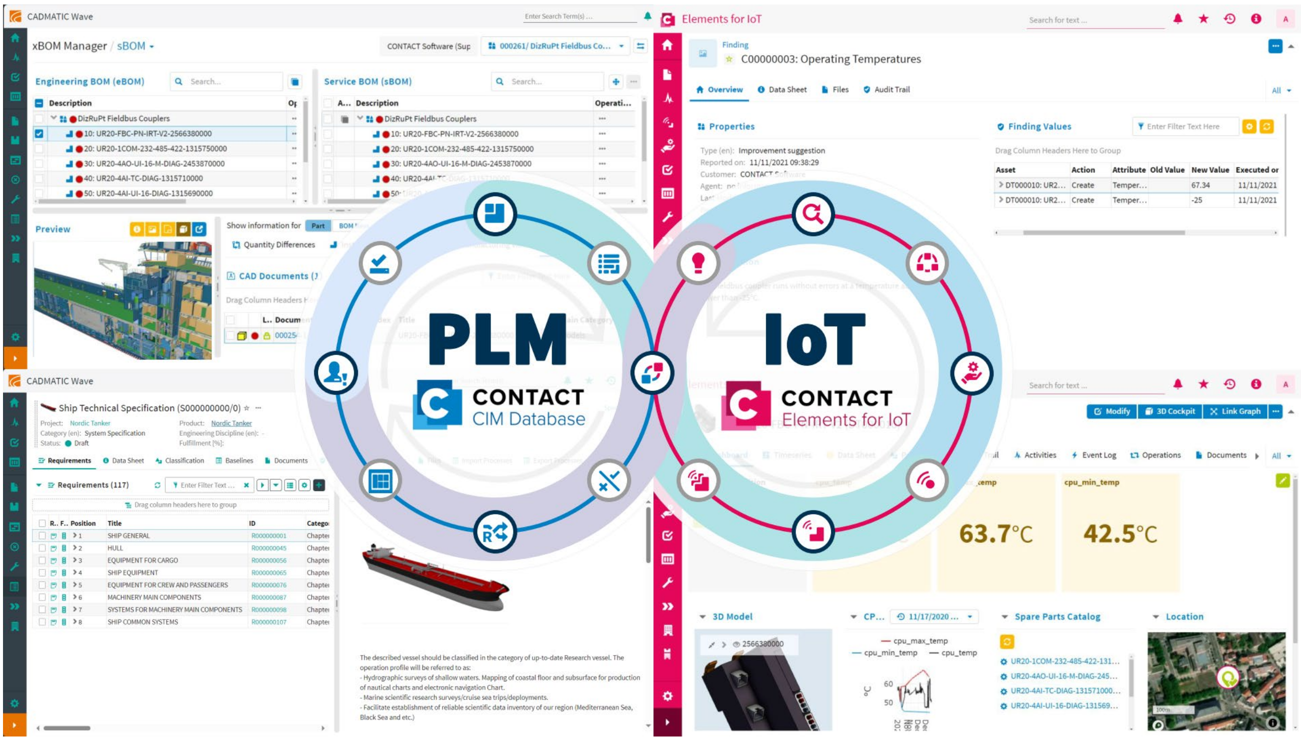

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Appendix E – Can European Shipyards be Smarter? A Proposal from the SEUS Project

Can European Shipyards be Smarter? A Proposal from the SEUS Project

Posted on **September 13, 2023**

This paper was presented for the first time at the annual Conference on Computer Applications and Information Technology in the Maritime Industries (COMPIT) held in Drübeck, Germany, from 23-25 May 2023. The abstract has been redacted.

Authors: Ludmila Seppälä, Cadmatic; Henrique Gaspar, NTNU; Herbert Koelman, SARC; and José Jorge Garcia Agis, Ulstein Group

1. European Shipbuilding and the Need for a Digital Thread

The European shipbuilding industry faces many challenges, including increased competition from Asia, economic uncertainty, and a growing demand for more sustainable vessels. However, despite these obstacles, the industry remains an essential player in the global maritime sector.

A white paper published by the European Maritime Safety Agency (EMSA) in 2021 emphasized the importance of investing in new technologies and innovation to maintain the competitiveness of European shipyards. One of the most notable trends in the industry is the increasing importance of digitalization and automation in the shipbuilding industry. Digital technologies such as artificial intelligence, the Internet of Things (IoT), and blockchain have the potential to improve efficiency, reduce costs, and enhance safety in the industry, *EMSA (2021)*.

Diverse commercial, societal and academic actors emphasized the need for European shipyards to focus on innovation and sustainability to remain competitive in the global market, *Ulstein and Brett (2012)*. The main

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argument is that adopting digital technologies is a key factor that will determine the future success of European shipyards. As the industry continues to evolve, the collaboration between stakeholders and the development of new technologies will be critical for success. *Diaz et al. (2023)*.

A vast and increasing amount of data is generated during the shipbuilding life cycle, *Seppälä (2019)*. There is considerable scope to use this data more effectively across the shipbuilding network value chain, *Gaspar (2018)*. Digitalization and computational tools have great potential to generate value for stakeholders in the form of cyber-physical systems or digital twins. It requires a significant reshaping of existing tools and practices to be exploited successfully by the European shipbuilding industry. The gains come in the form of increased quality and reduced time required for design, virtual prototyping, estimations of impacts for the use of greening innovative technologies, modularization, flexible data management, interoperability across proprietary tools, cyber security, efficient support for modern robotized fabrication and openness for integration with operational platforms.

To achieve these gains, a digital thread needs to be facilitated to enable data use and management to support the life cycle of complex engineering systems effectively, focusing on the shipyard as the core of the value chain as it converges the tasks of design, engineering, construction, and maintenance. By establishing a single source of truth for ship data, the digital thread facilitates data fusion for CAE/CAD/CAM/PDM systems, which can improve the organizing, managing, and contextualizing of shipbuilding data. It has the potential to provide virtual prototypes, enhance consistency and compliance with technical standards, use AI and ML, and NLP technology to assist and evaluate technological innovations, enable iterative learning, and significantly enhance communication and access to data for all stakeholders.

However, much of the productivity gain to be achieved during the early stages of ship design is constrained by the many different CAE/CAD/PLM/PDM/ERP tools and models used to create, combine, and evaluate each of the modules that a ship consists of. Consequently, the design of a modularized and standardized work system (enabling reuse of design models and drawings), or even a new design approach configuration, lacks an effective and agile common evaluation framework that can combine standard (traditional) and customized (innovative) solutions through the ship design, engineering, and fabrication processes. A successful smart framework should consider the detailed balance of these elements, especially regarding effective documentation towards clients and third-party partners, including activities beyond the design/delivery process, such as maintenance and repair, retrofit, operation, and scrapping

2. Being Smart: Challenges and Opportunities in Digitalization

The current situation in the shipbuilding industry is characterized by high competition, low-profit margins, high complexity and scale of products, conservative processes, limited use of data and disconnected data streams, and the scattered priorities of a variety of stakeholders in the life cycle. *ECORYS (2009)*. As a result, the European shipbuilding industry has experienced a major capacity reduction in the past 5 years. Over 15 shipyards have ceased operations in this period due to bankruptcy - miscalculated project risks or lack of contracts – in other words, lack of competitiveness.

Typically, ship design, engineering, and fabrication in Europe follow fairly traditional approaches, not keeping the same pace of development observed in the automotive, discrete manufacturing, and aerospace industry. Current shipbuilding approaches are partly fragmented, discontinuous, time-consuming, and laborious. The rationalization of business and work processes (e.g., PLM, PDM, modularization, parameterization, and other data-based techniques) have so far only been tested and implemented successfully in the daily tasks of yards to a limited extent. The marine industry is a traditional and conservative business when it comes to changing its value chain, which is complex and comprised of many globally distributed actors. Ship fabrication methods vary from shipyard to shipyard and the standard by which ship design drawing packages are prepared and communicated varies greatly. Novel and state-of-the-art knowledge and technology (smart) are used only to a limited extent to streamline and improve the efficiency of such work processes and collaboration. The high-cost levels in Europe compared to emerging

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and gradually more competitive low-cost firms and partly large and fully integrated yards in Asia dictates that high effectiveness yields need to be achieved at European shipyards.

Moreover, ship design, class approval, and maintenance include many documents managed over extended life cycles. The digital downstream to operations phase is challenging as 2D, 3D, and simulation models contain a vast amount of model elements. A typical vessel model of only one design project may contain up to 2-3 million model elements or parts. The approach is significantly different from a mechanical CAD model, as shipbuilding uses high levels of topological connections between parts to make it possible for fast modifications, such as the rearrangement of equipment and piping or changes to hull structures. Another element specific to the industry is the use of materials such as steel plates of pipes that require fabrication into panels or pipe spools before the construction process. This pre-fabrication can be done by external subcontractors or workshops where access to design and procurement data as well as the construction particularities, plays a critical role and can significantly impact the quality and schedule of the project. Based on data from Ulstein shipyard, up to 8% of total production time is used for coordination activities by foremen and up to 3% on project management. These are primary areas targeted for improving the process where digital data and information access can significantly impact the total costs and time used for production, *Agis (2020)*.

Discrete manufacturing industries maintain so-called maturity management for all used parts. This highly demanded approach, which supports functional safety, traceability, and compliance, is not practiced in the shipbuilding industry. This is because the check and approval processes would get stuck due to the vast number of parts, limited design speed, and rise in complexity. However, one of the main reasons lie in the lack of computational tools that can support the digital tread and the life cycle process of shipbuilding. Staged maturity management and traceability are desirable for the shipbuilding industry and should derive from the life cycle approach to data usage. Literature suggests that the application of AI will benefit ship design, although few working systems are yet available.

The SEUS project aims to address these topics, making a step in this direction for a data-assisted method to support early ship design. While each of the pitfalls listed above can significantly slow down or improve the overall process, having a holistic view of shipbuilding is a prerequisite. This views, with suggested room for improvements via process innovation, is illustrated in Fig.1.

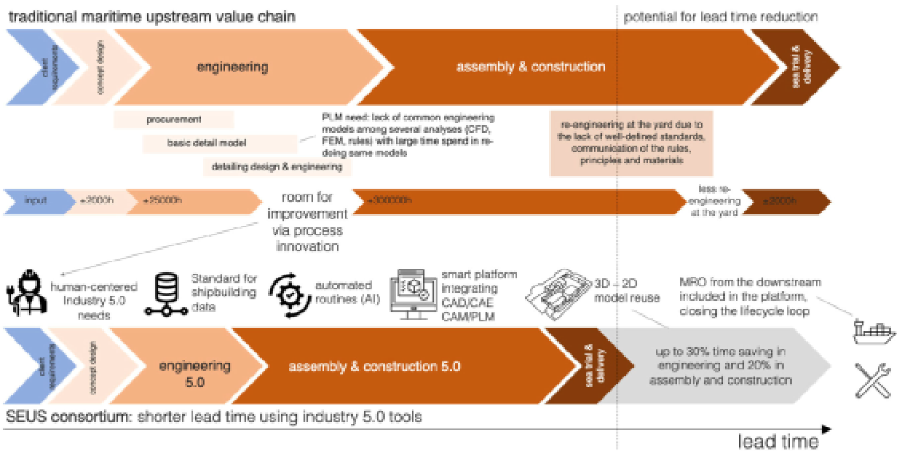

Fig.1: Potential for lead time reduction in the upstream maritime value chain

In this context, we summarize seven challenges for enhancing the current status of European Shipbuilding:

- Facilitate rapid early-stage design to support lower-risk bid development, particularly when integrating innovative new technologies

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- Provide better capital cost estimations and performance predictions, particularly showing the improvements expected from the inclusion of new technologies
- Tools to be integrated with ship construction and production and consider supply chain management and future maintenance and repair of vessels.
- Address and quantify the competitiveness gains provided by the tool(s) in the context of the wider European shipbuilding sector.
- Ensure that the tool is robust and resilient against cyber threats.
- Identify and address the development of the necessary skills needed to achieve the maximum benefit from innovative advanced computational shipbuilding tools.
- Develop business cases to quantify the added value from the developed tool to the shipbuilder concerned and within the context of the wider European shipbuilding sector.

3. Smart European Shipbuilding (SEUS) Proposal

The main ambition of the Smart European Shipbuilding project (SEUS) is to tackle the mentioned challenges, by developing a smart platform dedicated to shipbuilding and its downstream and upstream lifecycle phases. This will be achieved by architecting an integrated platform for a combined and open solution incorporating CAE, CAD, CAM, and PDM software and testing it at shipyards. The new platform solution will be built with state-of-the-art European shipbuilding expertise provided by academic and industrial consortium participants. It intends to develop novel practices for human-centric knowledge management in shipbuilding, the use of NLP, and data-driven AI design elements in the current consensus or intelligent technologies and Industry 5.0, *EU (2021)*.

The SEUS project will develop, implement, test, and qualify software solutions with an Industry 5.0 mindset for the European shipbuilding market. Smart technology, in terms of digitalization and cyber-physical systems, including humans, are concepts that have never been built from a shipbuilding perspective. Current solutions used by shipyards include significant parts of manual data handling and are prone to a high level of human error or a fragmented adaptation of PLM from other industries, such as aerospace, automotive, or other discrete manufacturing. The shipbuilding industry uses many computational tools to plan, design, simulate, and build vessels and other marine products, such as offshore platforms or other floating constructions. Consequently, the digital information chains of shipbuilding are more weakly integrated than in discrete manufacturing industries and thus lack support for a digital thread: digital continuity, digital lifecycle management, and digital ship operation support. This is an obstacle to gaining efficiency and to implementing new business models based on digital innovations and the development of IT technology. We have set up seven objectives towards a stepwise progress over 4 years:

- Create workflow activity map and use cases applying smart technology and Industry 5.0 concept, specific to European shipbuilding
- Enhance the human-centric competitiveness of shipbuilding and reflect diverse values of stakeholders, including shipyard workers, shipowners, operators, users/passengers, and shipbuilders in general
- Build a shipbuilding-specific PLM platform comprising defined data models and the selected elements of CAE/CAD/CAM and PDM solutions
- Develop a flexible platform that supports multiple instances of workflows to facilitate rapid early designs, and is fit to support AI tools and virtual prototyping
- Ensure openness and interoperability of the platform while keeping it cyber secure
- Test and implement in an industrial environment – developing the concept of the digital shipyard.
- Quantify added value gains provided by the developed platform, creating a business model of exploitation, and dissemination of project results

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The technology readiness level (TRL) targeted by the project is 8-9, corresponding to the maturity level of a completed and qualified (tested in a large-scale pilot installation) platform, ready for a commercially competitive operational environment. The aimed shipbuilding platform will integrate existing computational tools with TRL 9, commercially exploited in shipbuilding. It will incorporate Industry 5.0 concepts (human-centricity, sustainability, and circular economy) and progress through the process of maturing TRL from level 4 (initial technology validated by combining existing software parts, including AI and ML) to level 7-9 (integrated platform with developed use cases, tested in shipyards).

4. Methodology and Expected Impact

4.1 SEUS Methodology Overview

The overall platform developed by the SEUS project aims to connect existing high-end solutions, specialized in selected areas of the shipbuilding life cycle, and unite data handling for the shipbuilding projects through life stages and disciplines based on expertise in shipbuilding use scenarios. This approach challenges both the prevailing CAD-centric approach in shipbuilding (historically CAD model is used in most shipyards for generating production data) and the PDM-centric approach, where data as such is managed, with an interface connected to the CAD model and focuses on project and change management.

Fundamental to the SEUS approach is that the current toolbox for shipbuilding can be more efficient if properly integrated into a human-centered environment, including Industry 5.0 aspects. The SEUS methodology is focused on developing a smart platform for CAD/CAE/CAM in shipbuilding based on the industrial and academic experience of its consortium members.

The SEUS approach revolves around the fulfillment of the seven mentioned objectives. It consists of four main steps, represented in Fig.2, namely:

- Shipbuilding Best Practices;
- Smart Shipbuilding PLM Platform;
- Shipyard Implementation;
- Business and Innovation.

Each main step contains the sub-process itemized below and is described as follows.

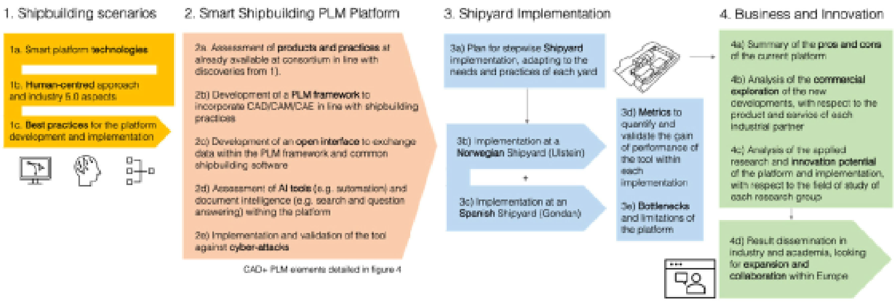

Fig.2: SEUS Methodology Overview

SEUS approach starts with the evaluation of the European shipbuilding scenario concerning the current state of digital tools and the potential to incorporate smart technologies. Parallel to it a deep study of what means a human-centered approach in shipbuilding will be developed, in line with the needs and aspects of Industry 5.0, aiming at the balance between cyber-physical systems and societal challenges. its

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technologies, potential for human-centered, and Industry 5.0 technologies. As a result, a body of knowledge with best practices for the implementation of the smart platform will be developed, feeding the next step.

The second part of the methodology converges the core of the project, with the development of a smart PLM platform incorporating CAD/CAM/CAE elements in line with shipbuilding practices. It consists of the assessment of products and practices already available in the consortium about the needs and standards compiled in the previous phase. Extensive software development will enhance existing toolsets and implement digital support for the use cases and scenarios, representing the computational tools for shipbuilding development stressed in the call. A detail of the desired elements in this development is observed in Fig.3.

The SEUS Smart CAD+PLM platform integrates the following main elements: CAE modules, CAD/CAM modules, PDM/PLM selected applications and features, and embedded shipbuilding expertise.

CAE modules address functionality related to initial and early design stages, such as hull shape form calculations, stability, weight estimations, and interfaces for CFD and FEM calculations, incorporating AI and a data-driven approach to design.

CAD/CAM modules include specialized applications for functional ship design (P&IDs, Electrical schematics), 3D detailed, and production design. It incorporates the reuse of initial design models, 3D modeling, and arrangement (Hull, Piping, Outfitting, HVAC, Cable 3D design, and other outfitting elements) and provides an automated output of fabrication data in a traditional format of 2D documentation along with the direct output for CNC-controlled equipment and robotized manufacturing, all ready for an integrated virtual prototype environment.

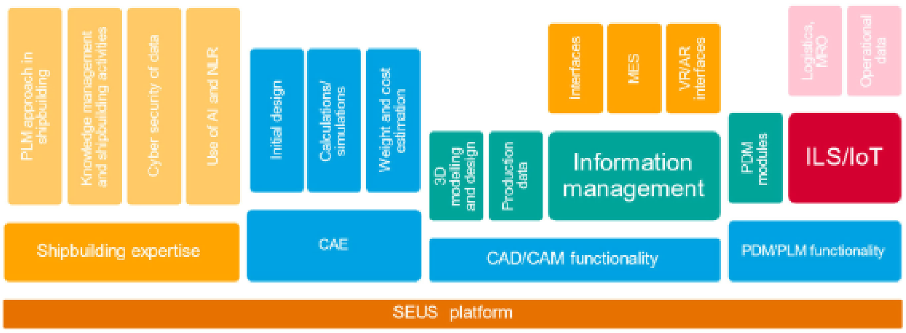

Fig.3: SEUS Smart Platform Desired Elements

PDM/PLM elements consist of selected modules for data management and product life cycle support, including project and change management, document management, Bill of Materials management, IoT integration, and ILS support. This sets a solid basis for the maturity management-based PLM concept that would enable support for functional safety, traceability, and compliance for the shipbuilding industry.

Shipbuilding expertise embraces knowledge of the PLM approach in shipbuilding and other industries' best practices, developed shipbuilding human-centric activity map and knowledge management, embedded cyber security practices, and the use of AI and NLP for ship project data. Added to all the elements, an open interface will connect the software toward efficient data flow, aiming at a common standard that can be used by different shipyards.

As part of the broader cyber security solution for the project, a series of cyber security workshops will be conducted with project team members and support teams. Those workshops will address issues of cyber threat awareness (including threats to AI apps), secure programming practices, active cyber security countermeasures, cyber security hygiene, and the development of the project's Information Security Management System (ISMS).

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A dedicated challenge is the standardization of domain knowledge to speed-up design tasks, especially in early design phases when many new items need to be born quickly and when master data maintenance is typically hindering the ease of designs although needed for efficient downstream work. Attempts to realize PDM-based master data management by so-called orthogonal classification were successful. An analysis of given standards such as ISO 10303, SFI, and German Marine/Ship Assembly Register indicated that such kind of domain knowledge applies to PDM-based MDM and classification schemata, covering technical properties, property values, etc. to classify design documents, work tasks, ship items, equipment or any other PDM information object.

Mechanical CAD systems are used in the marine industry for outfitting and detailed designs of ship components and equipment. *Fonseca and Gaspar (2022)*. These systems are well integrated with PLM elements and approved conversion pipelines. The way of modelling vessels (e.g. steel and parametric hulls, equipment and piping materials) down to production differs for shipbuilding intent-driven CAD systems. This typically leads to a mismatch of the level of details in the 3D model and manageable ship product structures. A concept to interlink and inter-visualize CAD content from both worlds is targeted including the implementation of an integrated conversion pipeline, product structure management, and interactive visualization augmented with master data.

Integration between the PLM elements platform and CAD/CAE authoring application includes several layers of data management, data model alignment, 3D visualization technology, and the development of the user interface to cover various use cases. it will be executed by architectural the integrated platform solution, user stories, and iterative system design process. Various applications: Hull 3D design, Piping and Outfitting 3D design, HVAC, Electrical, etc, need to share data with data management shell and ensure transfer and synchronization with defined accuracy, 3D visualization, and embedded workflows to assist users in everyday design, project management, and production tasks.

4.2 Expected Impact

The impact of SEUS is based on primarily increasing the level of digitalization in European Shipyards, facilitating the transformation of this industry towards competitiveness with a human-centric mindset. A compilation of seven key impacts is presented in Fig.4 and explained as follows.

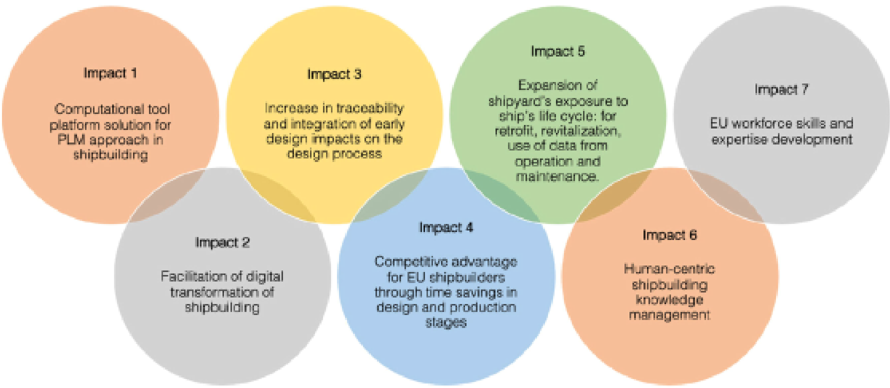

Fig.4: Expected Impacts

Impact 1: Computational platform solution for PLM in shipbuilding
The development of a platform with a PLM approach specific to shipbuilding would be a pioneering addition to the existing landscape of computational tools for shipbuilding in Europe and globally. Like CAD/CAM tools that provided a breakthrough by using computing and 3D modelling some 30 years ago, the PLM platform is a leap forward in digitalization. With interoperability, a standardized data model, and process management tools our initiative will impact European shipbuilding competitiveness with shorter lead times and the capability to adapt to design and production time changes. It will add to the currently unutilized potential for the end customer by reducing lifetime costs during ship maintenance. Since the data model and specialized application landscape during ship design are fragmented, the information disappears between the different design phases, from the initial design to the basic design to construction.

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Impact 2: Facilitation of digital transformation of shipbuilding
Increasing the shipbuilding industry's digitalization levels dramatically will affect how the marine industry works and profits from information consistency and control. Industry 4.0 outlines the benefits of digitalization in the manufacturing industry, such as improved productivity, collaborative working ways, flexibility, agility, reduced costs, and innovation opportunities. Taking this concept further and augmenting it with knowledge and skills in management and circular production models would allow shipbuilding to catch up with other industries and pioneer the use of digital tools to serve society's goals. The expectations are to support resource-efficient designs and provide tools for the evaluation of design impacts at the virtual prototyping stage, develop a human-centric approach for digital shipbuilding processes, and up-skill European shipbuilders.

Impact 3: Traceability and integration of early design impact the design process
The EU targets for the decarbonization of shipbuilding require the possibility to integrate innovative technologies in the early stages of design to evaluate the effectiveness of alternatives and their impacts on the project. In shipbuilding practice, this means experimentation with hull shapes (Ulstein X-bow is an example of such innovation to significantly impact the stability of sea-going vessels), propulsion design, and power or fuelling alternatives (LPG/LNG, ammonia, or hydrogen, etc). The potential impact of these technical solutions on the project will be evaluated at the earliest possible design stages and will be linked with historical data (whenever possible) and downstream detailed design and construction data. The platform aims to integrate all these data streams into the interconnected digital thread to provide traceability of decisions and impacts and significantly simplify working processes for the early design stages for all participants – naval architects, designers, engineers, shipyards, and shipowners.

Impact 4: Competitive advantage for EU shipbuilders through time savings in design and production stages
Communication presents one of the biggest hurdles in shipbuilding projects. Inconsistent, incomplete, and unclear information generates uncertainty in projects that lowers the quality of project decisions resulting in delays, higher costs, and poorer project realization. The SEUS platform aims to provide the next level of communication and information transfer among participants in the shipbuilding project. By eliminating the need for manual data transfer and providing access control tools, it aims to provide information dynamically extracted on demand, as well as supplementing it with 3D data and other relevant information. The primary focus will be on the communication between ship designers and shipbuilders. The involvement of third parties such as equipment suppliers, subcontractors, classification societies and flag status, or shipping companies will, however, also be considered in the case studies. The use of such a platform will significantly reduce the time searching for information at all phases from different tools and sources and especially impact the design to production data transfer. Additional NLP-based conversational search models based on AI and neural networks are expected to provide additional support for information search and communication.

Impact 5: Expansion of shipyard's exposure to ship's life cycle: for retrofit, revitalization, use of data from operation and maintenance
The SEUS platform aims to enhance the exposure of shipyards and ship design offices to the life cycle of the vessels they designed and built to provide insights from the operation stage and historical data for comparisons and evaluation of the design solutions used. It also empowers shipyards by retaining communication with their customers and expanding service offerings toward the operational stage. Both sides can gain from this connection: shipyards can expand their service offering in the post-delivery stages, while operators can get accurate engineering and design models and avoid remodeling while using the digital twin approach.

Impact 6: Human-centric shipbuilding knowledge management
Human-centric shipbuilding knowledge management can be presented as a customizable shipbuilding activity modeling framework for associating typical shipbuilding activities, shipbuilding expertise, and the data thread through the shipbuilding life cycle. The framework includes values, interaction, collaboration, and shipbuilding actors' skill development and training. Identifying these elements of the framework and devising evaluation methods that exploit the association between human subjectivity and context data would be a part of the novel research of the SEUS project. This will impact the effectiveness and productivity of a highly skilled workforce and sustainable knowledge management practices. An additional aspect presents lifecycle-integrated training and learning programs for diverse shipbuilding stakeholders.

Impact 7: EU workforce skills and expertise development
Historically, European shipbuilders lead the industry as the most innovative and technologically advanced. In the last decades, European shipbuilding has focused almost exclusively on high-value vessels that formed the core of the expertise. Executing projects of this complexity scale requires advanced project management skills, technological and industrial skills, procurement, building and construction, and many other areas of expertise. The platform aims to provide a single source of truth for almost all people involved in every shipbuilding project, with a UX designed for each target audience that reflects their characteristics and controlled access to data. It would provide a context for everyday tasks and boost creativity and workers' digital skills, keeping the EU leadership position in the area.

5. Concluding Remarks: A Call from Peers to Join the Smart Approach

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A strong point of SEUS is its consortium, a balanced partnership composed of academics, software developers, and shipbuilding partners representing 5 countries from Europe, which is fully dedicated to bridging the knowledge in its communities and facilitating the uptake of the main results. SEUS's partners are experienced in customer implementation, dissemination, and communication activities in their home countries and internationally, and this experience will be enormously beneficial for achieving the objectives here proposed. Therefore, the consortium is committed to disseminating SEUS's approaches and outcomes, while simultaneously staying focused on the identified target groups and reaching the objectives of development, dissemination, and exploitation.

In this context, peer and stakeholder engagement support is an imperative set of activities to be integrated with the SEUS communication strategy. Besides sharing the results and findings of the project with a broad audience, the consortium welcomes external collaboration. With the ultimate target of supporting European shipbuilding, many projects can benefit from joining efforts and sharing findings in the industry's best interests.

We close this paper with call for peers to contribute and interact with the consortium. In a short term, to develop and publish their own understanding of the smart concepts here discussed, such as industry 5.0, digital thread, PDM/PLM incorporation. In a middle term, the evaluation of the pros and cons of their approaches with our proposal, and the investigation on how to combine features in a way that is beneficial to the majority of European partners. The project considers part of the development for an open standard to connect to the commercial tools, allowing other commercial partners to interact with the tools.

Acknowledgments

The SEUS project has received funding from the Horizon Europe Framework Programme (HORIZON) EU program under grant agreement No 101096224. Consortium members include the software companies Contact Software (Germany), Cadmatic Oy (Finland), SARC BV (The Netherlands), the two shipyards Ulstein Group (Norway) and Astilleros Gondan SA (Spain), and the research from Turku University (Finland), the Norwegian University of Science and Technology (Norway), and NHL Stenden University of Applied Sciences (The Netherlands). Info is updated at http://seus-project.eu/.

This article reflects only the authors' views, and the European Commission is not responsible for any use that may be made of the information it contains.

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Want to know more?

CONTACT US

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Appendix F – Main Information Objects for Shipbuilding

CONTACT Research

PLM — Main Information Objects for Shipbuilding

Elisabeth Brandenburg · Follow
Published in CONTACT Research · 8 min read · Sep 4, 2024

Shipbuilding & PLM | AI-generated by Dall-E

Complex information situation in shipbuilding

It's tricky to combine the product lifecycle management (PLM) domain with the shipbuilding industry. PLM operates on a limited set of information objects, including products, projects, and documents, and offers a multitude of sophisticated functionalities. In contrast, shipbuilders work with a vast array of complex information objects, such as work process-related structures and document structures and use a relatively limited set of functionalities.

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I am engaged in a research project, SEUS, which is funded by the European

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through digitalisation. A consortium of nine partners from Spain, Germany, the Netherlands, Norway and Finland will proceed to implement a comprehensive CAD-PLM software solution, specifically designed to address the unique requirements of the shipbuilding industry. Further information on this innovation action can be found here .

The development and construction of a ship requires the collaboration and digital consistency of complex information throughout its entire ship life cycle. This information is frequently highly interrelated and must be considered from a variety of perspectives and viewpoints in order to meet the necessary requirements (Bronson et al., 2024). The process begins with the initial conceptualisation and design phase and extends through the procurement of materials, construction and integration of systems, and finally to the outfitting of the ship.

What we have and what shipbuilding want

CADMATIC offers CAD design applications for shipbuilding that has been established over years. It covers mainly design phases of detailed planning and outfitting, is customizable and has integrations to other design and production applications. Additionally, CONTACT Software offers a flexible and comprehensive PLM system that is not exclusively tailored to shipbuilding. It is capable of handling large data products and provides comprehensive functionality across the entire product lifecycle.

· PLM for shipbuilding needs to be adapted to ship specific information objects

· PLM must offer processes or best practices for ship design

· PLM must be integrated into ship design tools to collaborate designs and construction

By combining a PLM system with a CAD system and then specialising it for shipbuilding, it presents a significant opportunity to enhance the productivity of every shipyard.

SEUS partners and their data

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CADMATIC and CONTACT are decribed before. As shown in the figure, for the initial design of ships, SARC offers as a CAx application for 2D Hull designs, CAE/simulation and analyses. SARC supports engineers and designers to meet customer requirements in the early design phase and can be used by following basic designs in 3D with CADMATIC design applications.

The PLM system following the single source of truth paradigm stores and maintains the master data of theses design applications in a generic product data model. Partners from universities in Finland, Norway and Netherlands research approaches for analysis and data manipulations of shipbuilding data. The goal is to handle complexity in in shipbuilding projects and support the user with valuable insights of high amounts of data. In summary, we have the following main systems for generating, processing and managing information.

1. Primary Data Generation Authoring System

2. Primary Data Management System

3. And Experimental Data Manipulation research

In the SEUS project, additionally to software vendors the shipyards Ulstein and Gondan apply developed shipbuilding integrations, evaluate their functionalities and contribute with best practices in shipbuilding processes. These two users are engaged to provide use cases, thereby facilitating continuous feedback on concepts and the testing of solutions within their daily work routines. The objective of this project is to ensure customer satisfaction. Furthermore, the combination of customisation and research will result in the development of optimal solutions. It is anticipated that these best practices for shipbuilding in the deep will facilitate the transition to the PLM domain for the European shipbuilding market.

First impressions of integrating PLM and shipbuilding

It is evident that the design of a ship requires a significant amount of data beyond that which can be created using CAD tools. In the initial

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conceptualisation phase, the predominantly two-dimensional computer
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quantity of models. The creation of an intended geometry design and the subsequent calculation of associated parameters is essential for providing the customer with a comprehensive understanding of the proposed design, including its visual appeal, financial implications and potential avenues for optimisation.

In the initial analysis, the primary PLM data objects are contrasted with the actual information generation within a ship design department. The discussion commences with an examination of the conventional PLM objects and subsequently transitions to an investigation of their parallels in the shipbuilding domain.

PLM standard information objects to work on products

In essence of working with PLM, the creation of a project is triggered by the order, which in turn contains the tasks that will deliver the product. The completion of tasks within the project is indicative of an increase in the maturity level of the product.

A **project** is defined as a discrete entity created for the purpose of managing a specific product. It is not necessary for the product in question to be a unique entity; indeed, different variants of a product may also be created within the context of a single project. In the context of product lifecycle management (PLM), project work entails the delineation of sub-projects, tasks, sub-tasks, or work packages. Such elements are characterised by a temporal sequence and interdependencies, as well as the identification of responsible personnel and the delineation of delivery units. The aggregation of these planning elements typically yields a hierarchical structure, which is known as the work breakdown structure.

Products are composed of individual parts that are related to each other and can therefore be mapped in a hierarchical structure, creating the product structure. Each of these individual parts (BOM items) has its own properties.

The term **document** is employed to designate a container that may contain any type of file. This may include, for example, files created in Microsoft Office, computer-aided design (CAD) documents, or other file formats.

Each of these entities can be hierarchically ordered to form a distinct structure. Furthermore, each structure element can be linked to an object in another structure.

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PLM main information object relations

Structures for designing and building ships

In the context of discussing the product and its associated structure within the realm of product lifecycle management (PLM), and in the specific context of seeking a solution within the domain of shipbuilding, it is not feasible to identify a product structure that aligns with the aforementioned definition (Pal, 2015). However, it does offer insights into the various operational structures that are employed in shipbuilding. One notable example is the Ulstein Company, a member of SEUS, which is engaged in the definition of 45 WBS (work breakdown structure) perspectives pertaining to its shipbuilding process. These 45 perspectives provide a personalised view of the 30,000+ design activities. Each activity is specified in more detail by the following properties: Firstly, each activity is assigned to a type: *Task*, *Drawing*, *CompletionCriteria* or *TechDoc*. Depending on the type, mandatory properties are specified: It is essential that each of these activity types is assigned a unique identifier and a brief description, or title. Furthermore, activities, tasks, drawings and TechDocs are consistently allocated to a WBS perspective.

It is evident that a methodology for the decomposition of a product of such complexity as a ship does indeed exist. These decompositions are employed in a manner analogous to that of product structures; however, they serve as placeholders for subsequent, tangible physical components. This product decompositions can be understood as PBS (product breakdown structures). (*ISO 10303–215, Industrial automation systems and integration — Product data representation and exchange Part 215: Application protocol: Ship arrangement*, o. J.)

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The commonality among these PBS is that the attribute pertains to spatial considerations. The requisite functions for these spaces are defined and fulfilled by a multitude of systems. Consequently, the system structure is also a crucial PBS.

Solutions for main information object in shipbuilding

The principal information objects of Product Lifecycle Management (PLM), namely project tasks, document types and product structures, have also been identified in the context of shipbuilding. The following challenges and solutions have been identified:

1. **Project** tasks: In the context of PLM CONTACT Project Management, the term "project" encompasses not only the primary project itself, but also any sub-projects, tasks, and sub-tasks that may be associated with it. Furthermore, the utilisation of checklists and open points facilitates the planning, management and control of a project. Therefore, it was necessary to transform the task list into a more complex, hierarchical structure. The challenge was that not every project task was associated with a group, phase, or sub-project. The aforementioned entity had reference up to 19 WBS perspectives. To address this issue, the Universal Classification was employed, for instance, in the context of the SFI perspective.

2. **Documents:** The CONTACT document management functionality is based on three fundamental principles: the categorisation of documents, their assignment to a specific task within a project, and the utilisation of search functionality with document metadata. Similarly, the documents, in this case drawings, are originally grouped to 19 WBS perspectives. However, a new structure of customer-specific document types will facilitate greater organisation and clarity.

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3. the **Product** structure: In order to be able to use the entire Contact Virtual

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have found a large number of product breakdowns into different process phases or work areas. We will solve this by using attributing classes that can be developed individually according to the customer's needs.

These attributing classes can extend the product structure (which in this case will only consist of the system structure, as this contains real physical components and thus corresponds to a BOM item) and thus generate the required perspectives as required. Overall ship design is an interdisciplinary development with complex products. Product structure must be multi-dimensional and integrated in work break down structures.

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This project has received funding from the Horizon Europe Framework Programme (HORIZON)
EU programme under grant agreement No 101096224.

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