Institute of Machine Components and Methods of Development

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Application of the Arcadia Method on a Bulk Carrier with Siemens Teamcenter PLM Integration

Capella Days Online 2024 by IME @TU Graz

CapellaDays









Agenda

- Introduction | Research at IME
- Context | Decarbonization & Digitalization of the Maritime Industry
- Example | Bulk Carrier System Model
 Integration Into Siemens Teamcenter
- Summary Outlook



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Introduction | Research at IME

Workshop Presenters

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- University assistant at Institute of Machine Components and Methods of Development
- Project engineer at ANTEMIA GmbH
- Experience in automotive industry
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Matthias Bajzek Dipl. Ing. Dr.-techn.



- PhD researcher at Institute of Machine Components and Methods of Development
- Head of R&D and Product Development at ANTEMIA GmbH
- Experience in automotive industry, SE, MBSE
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Introduction | Research at IME Institute of Machine Components and Methods of Development (IME)



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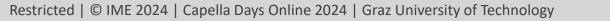


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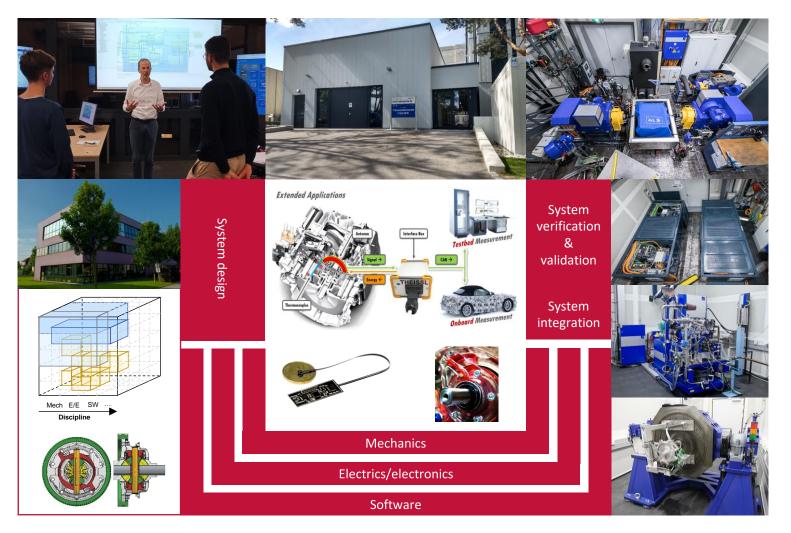


Mathias Dreier BSc mathias.dreier@tugraz.at





Introduction | Research at IME Institute of Machine Components and Methods of Development (IME)



Powertrain Series Editor: Helmut List PERENCE Hannes Hick Klaus Küpper Helfried Sorger Editors Systems Engineering for Automotive Powertrain Development

🖄 Springer



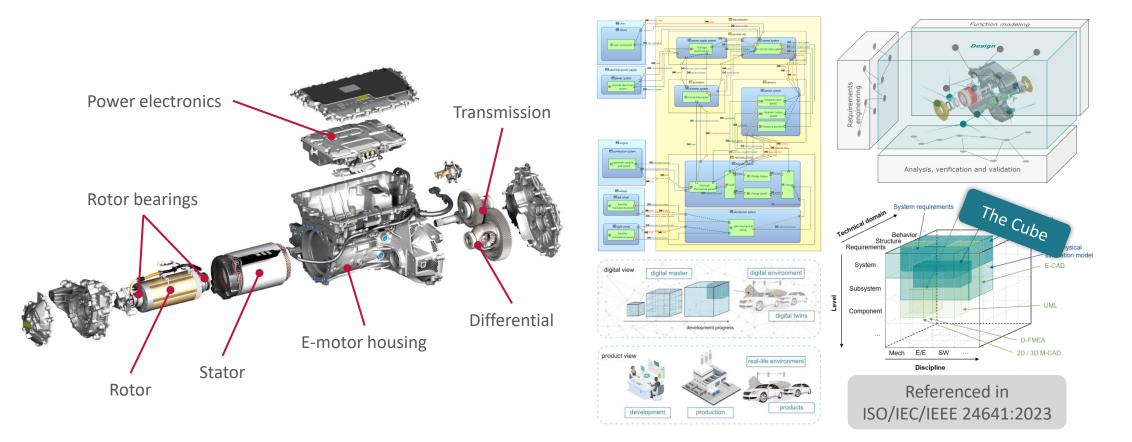


Introduction | Research at IME

Research at IME

Machine components

Methods of development

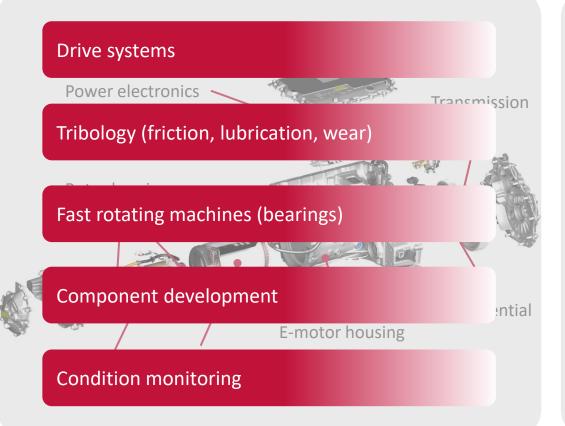




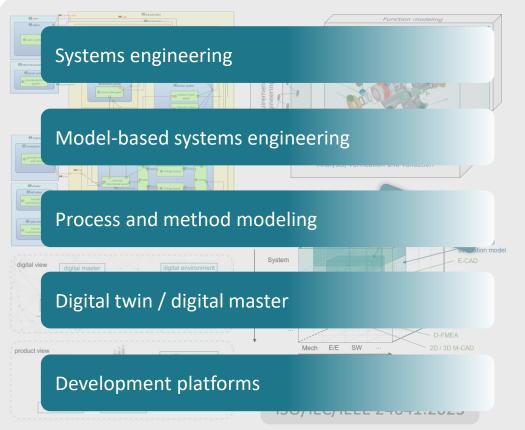
Introduction | Research at IME

Research at IME

Machine components



Methods of development





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Context | Decarbonization & Digitalization of the Maritime Industry

The Maritime Industry

Container ship

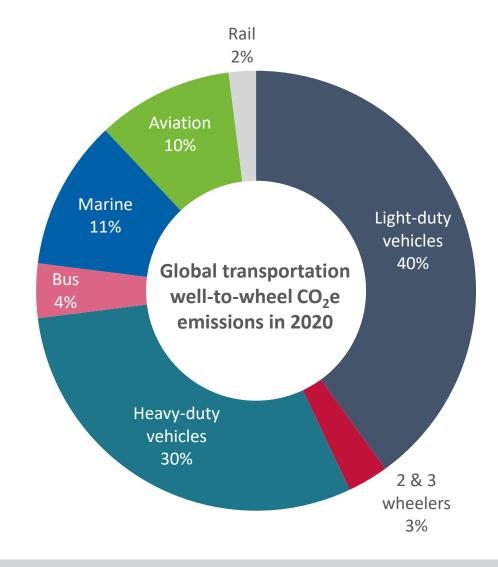


Bulk carrier



Wheat transport in bulk







Context | Decarbonization & Digitalization of the Maritime Industry

The MBSE Industry in Numbers

Represented Industries or Products

50% 45% 40% 35% 30% 25% 20% 15% 10% 5% 0% Medical Aircraft Space Systems Defense IT Automotive Other

What about **MBSE** in the **maritime industry**?

Industries represented in a 2018 MBSE Survey



Context | Decarbonization & Digitalization of the Maritime Industry



Challenge of Marine Shipping

On-time VS. environment VS. market demands



Decarbonization VS. legislation VS. cost

Transportation of **goods**, **resources**, **passengers**

ource: International Maritime Organization (IMO). (2023). 2023 IMO Strategy on Reduction of GHG Emissions from hips ource: Comer, B., & Carvalho, F. (2023). IMO's Newly Revised GHG Strategy: What It Means for Shipping and the Pai

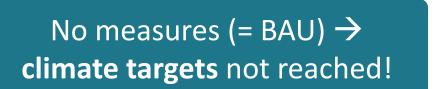


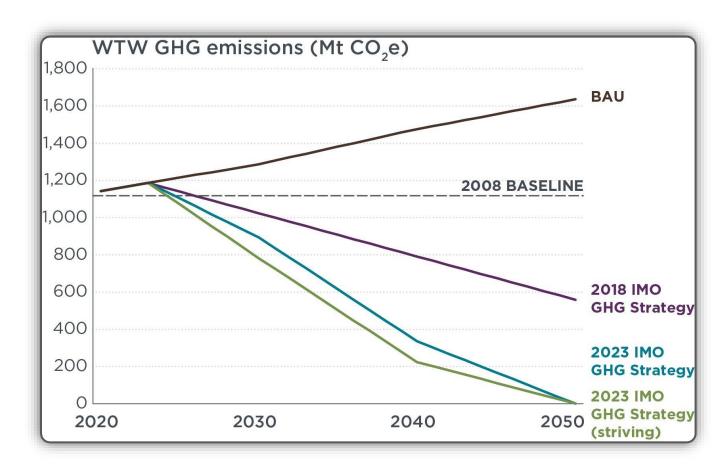
Context | Decarbonization & Digitalization of the Maritime Industry 2023 IMO GHG Strategy

 Reduce the total annual GHG emissions from international shipping

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2050: Net-zero GHG emissions





Context | Decarbonization & Digitalization of the Maritime Industry

goods & services

 research funds – - money IMO Researcher technology etwor knowledge classification & surveys information money classification & surveys regulation -Marine equipment Classification 🗕 money money society money company Ζ knowledge / money regulation information regulation subsidy regulation classification machine & & surveys maintenance information Government money subsidy subsidy equipment Seafarer workforce regulation regulation regulation taxes opinion opinion – money — Shipbuilding port & cargo workforce money Shipping company handling company ship & repair Port regulation shipping policy / regulation / rule money money knowledge / information money Shipper (trading monetary value **Public** company)

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Value

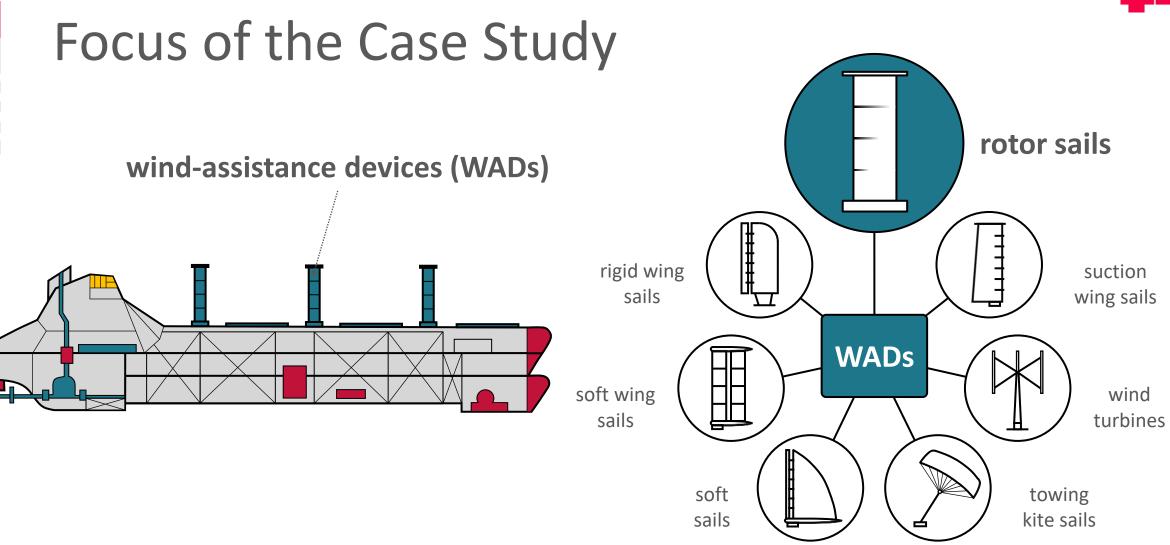
Stakeholde

goods / services



Context | Decarbonization & Digitalization of the Maritime Industry **Technical Solutions** Low- and zero-emission alternative fuels and propulsion technologies Energy-saving technologies control system wind-assistance solar **Operational measures** optimized routing and navigation devices (WADs) power optimized cargo loading/unloading onboard CO₂ slow steaming energy-efficient vessel type capture wind resistance reduction highly efficient bow shape waste heat recovery power generation highly efficient engine and alternative fuels propulsion improving devices (PID) highly efficient gate rudder cargo handling low friction air lubrication energy saving ducts battery system paint system highly efficient propeller



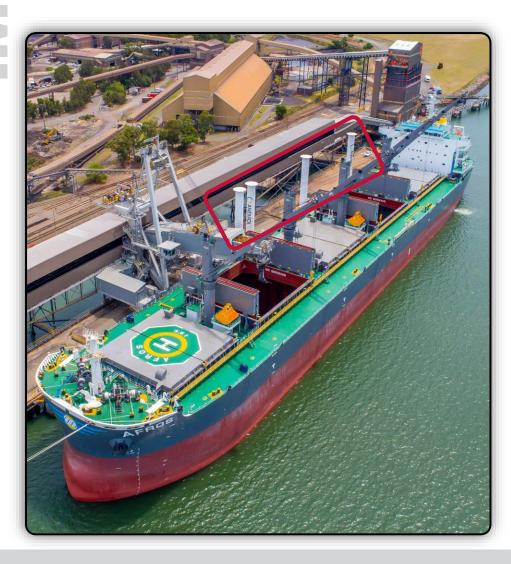


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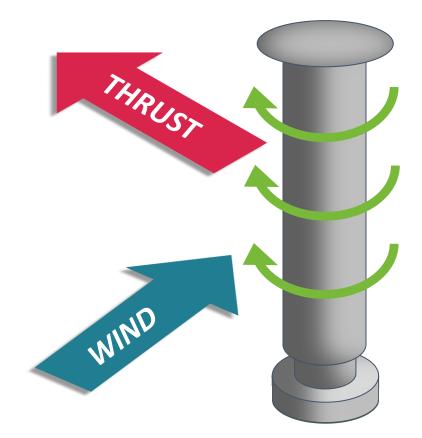
Context | Decarbonization & Digitalization of the Maritime Industry



Bulk Carrier With Flettner Rotor Sails



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Forward thrust generated through the Magnus effect!

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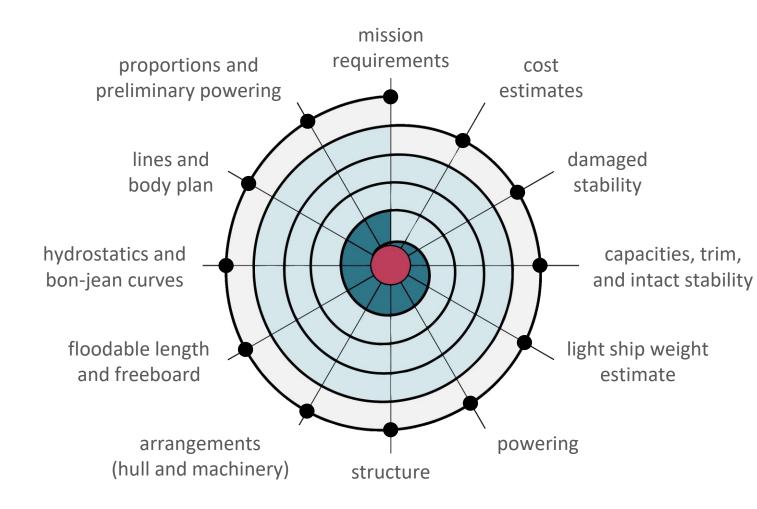


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Ship Development Process – Design Spiral



Concept design

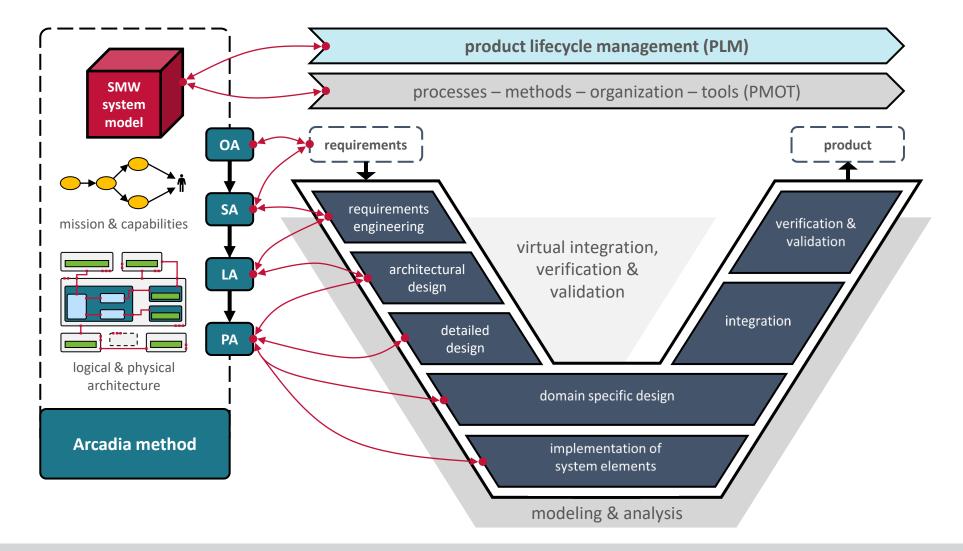
- Preliminary design
- Contract design
- Detail design

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Source: Dreier, M. (2024). MBSE in the Maritime Industry: Enabling Digital Transformation for CO₂ Reduction through Wind-assisted Ship Propulsion

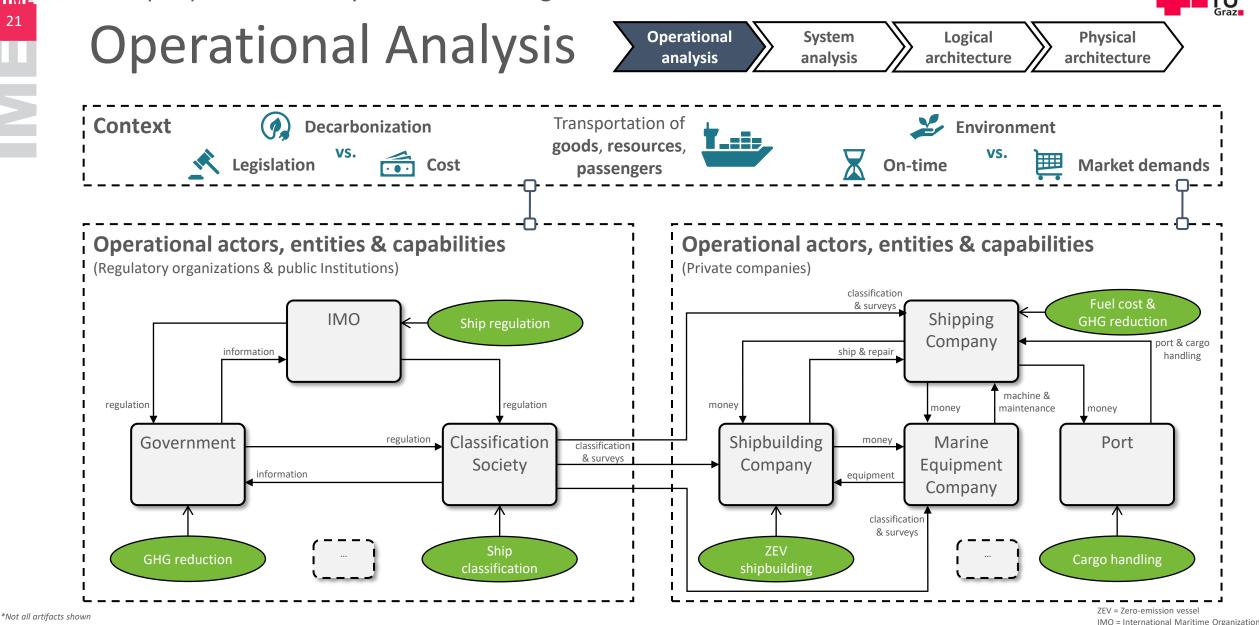
Example | Bulk Carrier System Model Integration Into Siemens Teamcenter MBSE With Arcadia/Capella

Integration of the Arcadia method and the SMW system model into the V-model, PLM and PMOT



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Source: Dreier, M. (2024). MBSE in the Maritime Industry: Enabling Digital Transformation for CO₂ Reduction through Wind-assisted Ship Propulsion

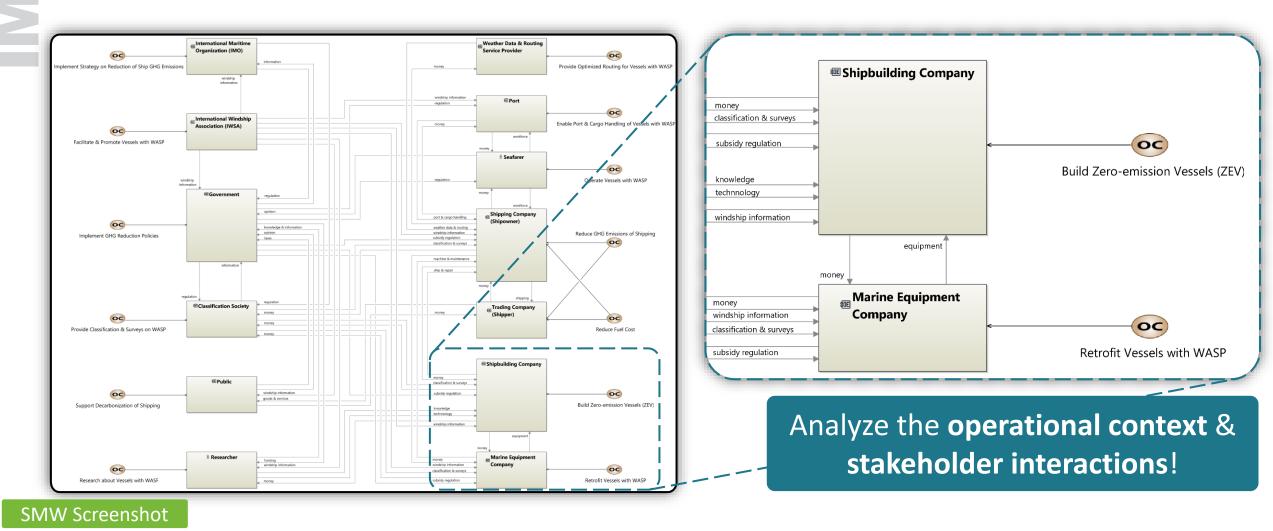
Example | Bulk Carrier System Model Integration Into Siemens Teamcenter



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System Analysis Operational System Logical **Physical** analysis analysis architecture architecture System actors, functions, interfaces, Environment Port exchanges & Sol environmental condition Cause environmenta Load & unload cargo IMO **Bulk Carrier System** Handle operational information cargo management cargo handling ᢇᡣ᠇ **Shipping Company** shipping Enable shipping port & cargo handling management Government service Carry out shipping service information Implement policies regulation **Provide shipping** shipping machine & maintenance Improve environmental & service **Provide funding** economic efficiency ship & classification Use optimized routing & surveys repair Marine Equipment regulation regulation $\cap \cap \cap$ classification & surveys Company Classification Shipbuilding equipment Society Company classification Provide maintenance Provide classification & surveys Other System Build & repair ship equipment service & surveys Actors $\neg \cap \cap$ *Not all artifacts shown Sol = System-of-Interest

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Source: Dreier, M. (2024). MBSE in the Maritime Industry: Enabling Digital Transformation for CO₂ Reduction through Wind-assisted Ship Propulsion

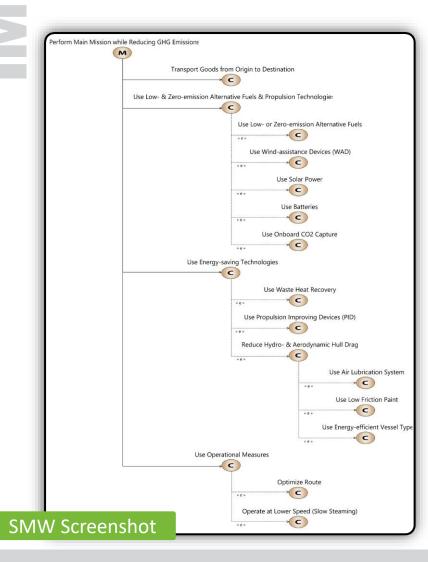
Example | Bulk Carrier System Model Integration Into Siemens Teamcenter

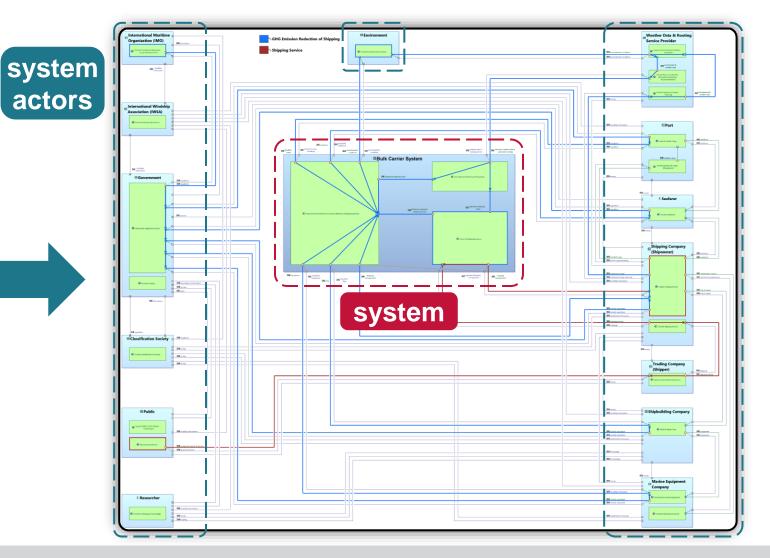
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System Analysis

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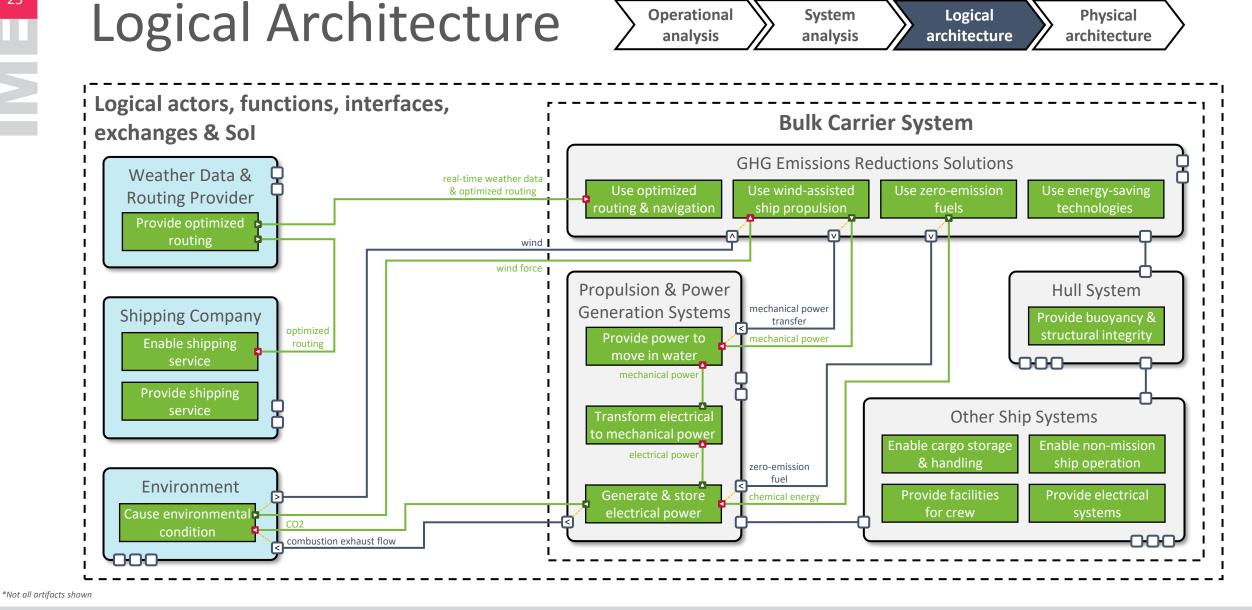


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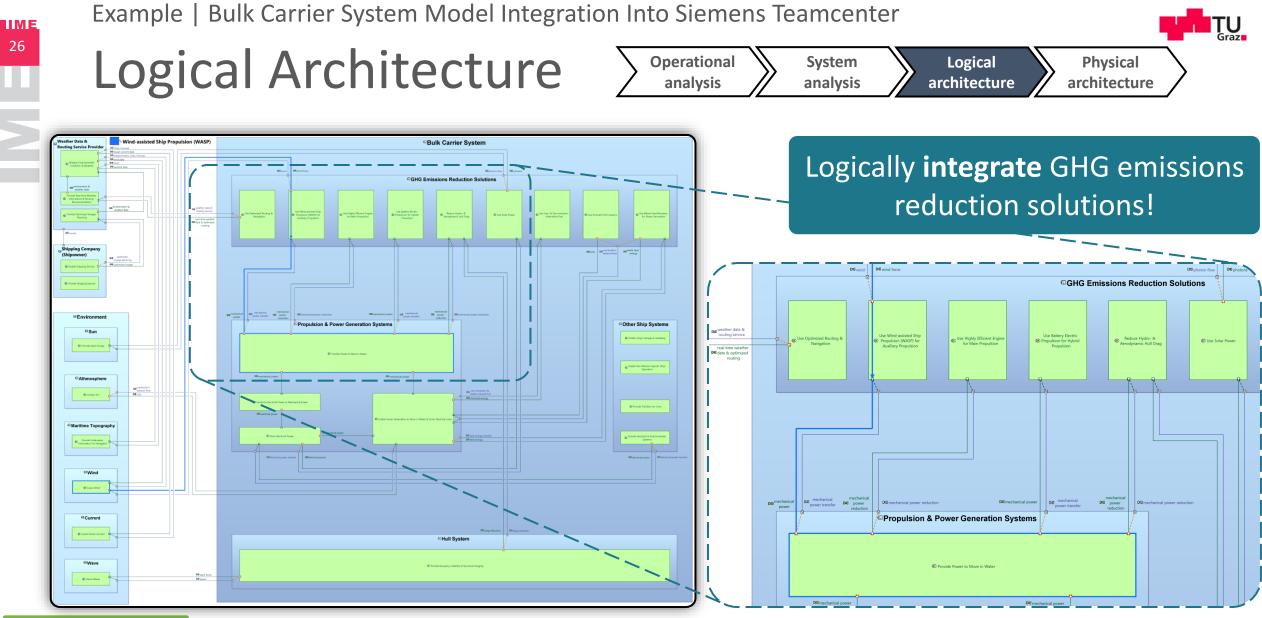
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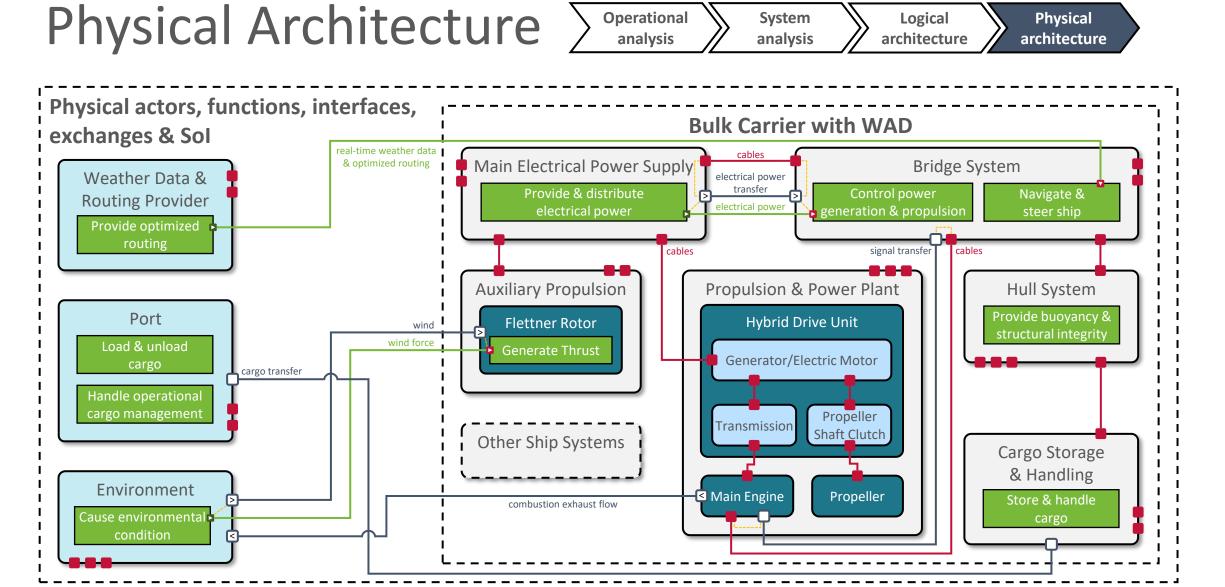
Source: Dreier, M. (2024). MBSE in the Maritime Industry: Enabling Digital Transformation for CO₂ Reduction through Wind-assisted Ship Propulsion



SMW Screenshot







*Not all artifacts shown

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WAD = Wind-assistance device

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Source: Dreier, M. (2024). MBSE in the Maritime Industry: Enabling Digital Transformation for CO₂ Reduction through Wind-assisted Ship Propulsion

Physical

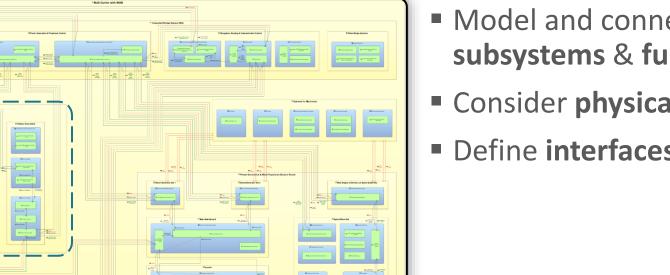
architecture

Example | Bulk Carrier System Model Integration Into Siemens Teamcenter

Physical Architecture

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SMW Screenshot



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Operational

analysis

System

analysis

- Model and connect all relevant subsystems & functions
- Consider physical actors

Logical

architecture

Define interfaces & exchanges

The essential step for further discipline development!

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Source: Dreier, M. (2024). MBSE in the Maritime Industry: Enabling Digital Transformation for CO₂ Reduction through Wind-assisted Ship Propulsion

Physical

architecture

Example | Bulk Carrier System Model Integration Into Siemens Teamcenter

Operational

analysis

System

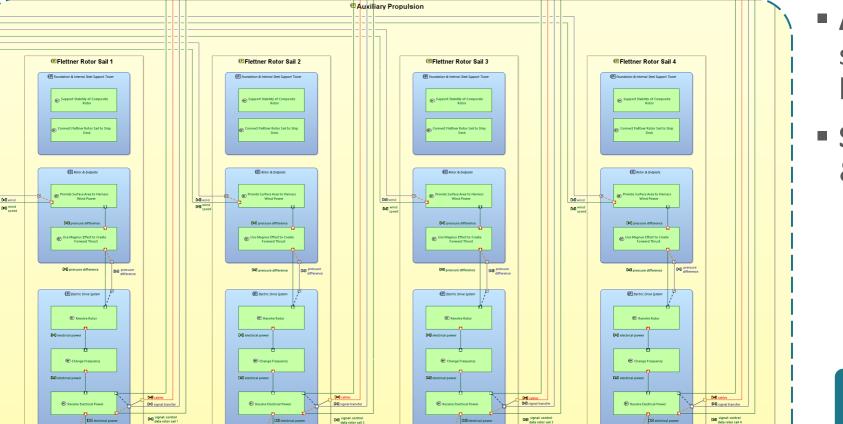
analysis

Physical Architecture

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D-El win

SMW Screenshot



Auxiliary propulsion subsystem integrated in bulk carrier system

Logical

architecture

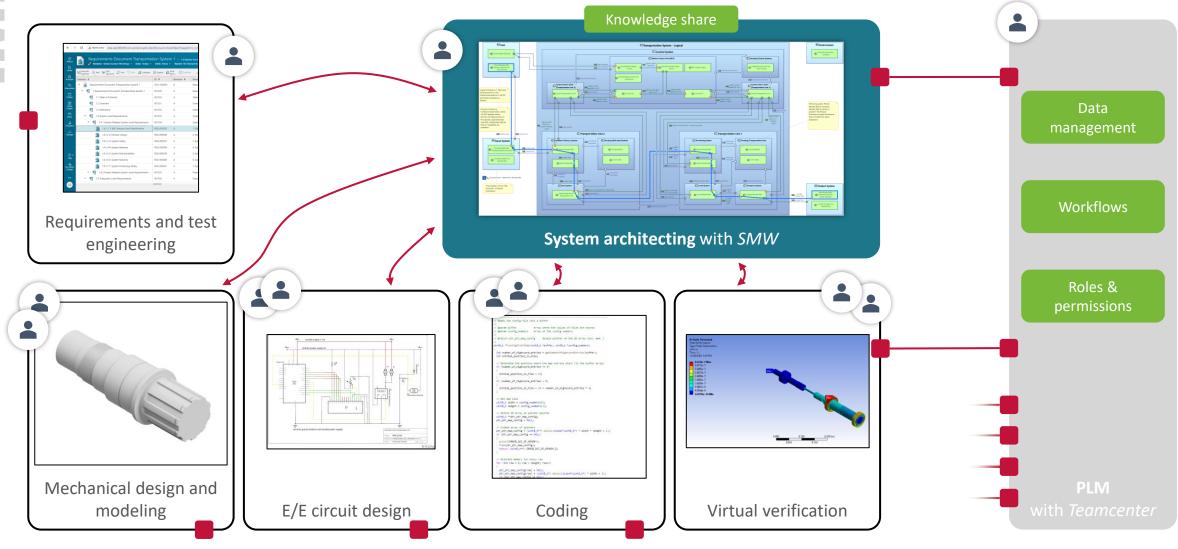
Structural, hierarchical, & functional view

The basis for integration, V&V!





Product Development With MBSE and PLM



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SMW Architecture Workflow

1. SMW architecture creation

- Operational analysis
- System analysis
- Logical architecture
- Physical architecture

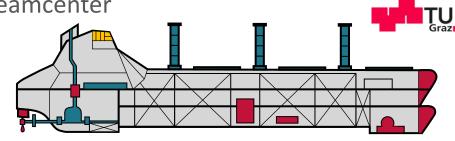
2. Architecture upload to Teamcenter

- 3. Review of architecture
- 4. Release of architecture
- 5. Requirements and test cases creation

Creation of requirements and test cases in the maritime context

6. Linking of system artifacts

 System architecture components linked with requirements and test cases in Teamcenter













Create your **RQs**

and test cases

and link them

with **system**

artifacts!

Requirements & Test Cases

N	avigate Overview				
Ŀ[]	free with Excel Selection Select	🖉 Edit	Overview Classification	Documentation Diagrams Parameters Attachments	History Relations Requirements Reports
Nar	ne 🗢	Description 🗘 😳			- DEFUSIV
	05_SW development		* PROPERTIES	REQ-000314	▼ PREVIEW
	04_E/E development		ID: Revision:	REQ-000314 A	Checkout Concel Checkout Checko
	03_M development		Name:	Cargo Type	
	02_System architecture		Description:	The vessel must be able to carry dry cargo Bdit such as ore, coal or grain.	REQ-000314-Cargo Type
	01_Requirements	Requirements categories derived from: Book "Ship Design and Construction: Volumes 1-2 (2003)" by Thomas Laml	Туре:	Requirement Revision	
	20_Classification and Regulatory Requirements	and any activitient construction, round in a reason by months Lam	Release Status:		Cargo Type
	 10_Mission and Owner's Requirements 		Date Released:		
	 40_Shipbuilding Contract Price and Total Proj 		Owner:	Systems_Engineer (systems_engineer)	
	30_Ownership and Operating Arrangements		Group ID:	dba	
	20_Other Owner's Technical Requirements		Last Modifying User: Checked-Out:	Systems_Engineer (systems_engineer)	
	10_Top Level Mission Requirements		Checked-Out By:		
	90_Vessel Design Life				
	80_Design Environmental Conditions		► PROJECTS		
	T0_Endurance				
	60_Service Speed				
	50_Rules and Regulations				
	40_Additional Port Requirements				
	30_Principal Characteristics				
	Rotor Sails Dimensions and Placement	The vessel's Flettner rotor sails must be positioned on the deck to minimize			
	Hull Type	The vessel must have a single-hull design optimized for dry bulk cargo.			
	Ballast System	The vessel must incorporate a ballast water management system in compli			
	20_Cargo Type and Cargo Capacity				
	Deadweight Tonnage (DWT)	The vessel must have a deadweight tonnage (DWT) of 61,000 metric tonne			
	Cargo Type	The vessel must be able to carry dry cargo such as ore, coal or grain.			

Teamcenter

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Screenshot



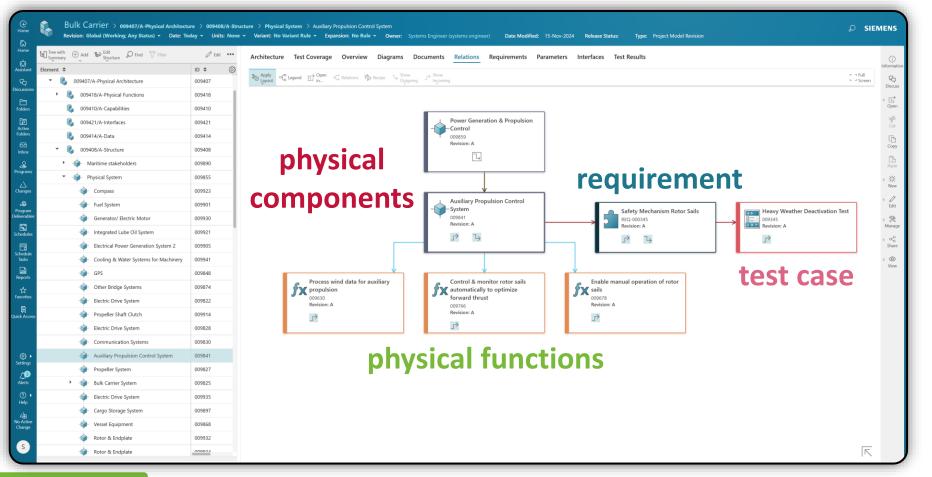
Manage your

artifacts

traceability in

Teamcenter!

Requirements & Test Cases



Teamcenter

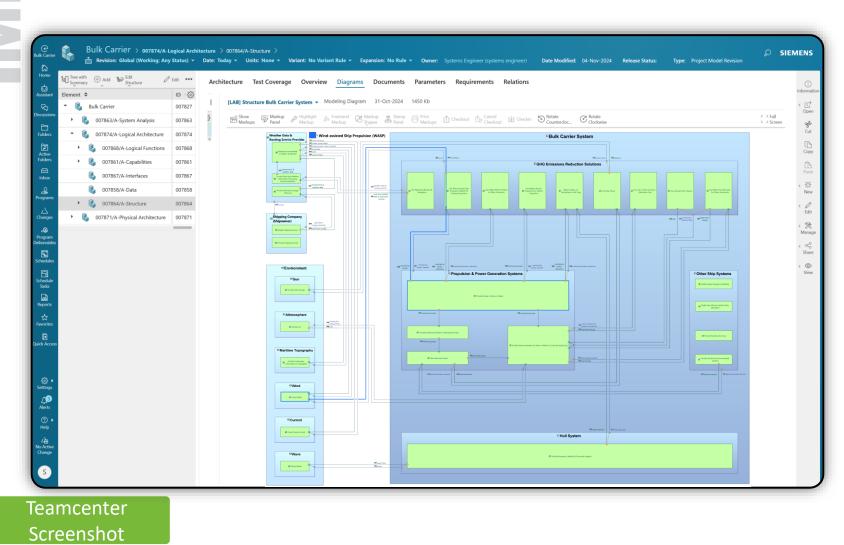
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Screenshot



Architecture in Teamcenter

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- Bringing the disciplines together early in development using the system architecture
- Realized by an comprehensive PLM approach
- Do not just "document" what has already been built!

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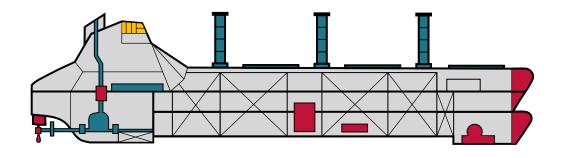
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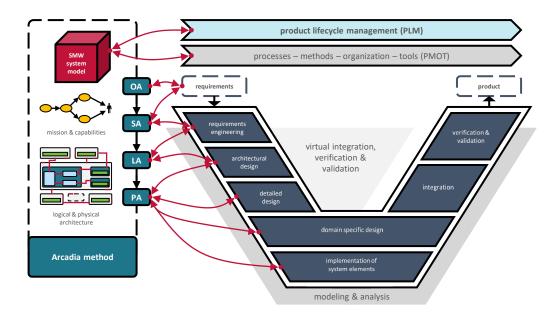




Summary | Outlook

- Outlook
- International shipping must reduce its GHG emissions (IMO 2023 strategy)
- Retrofit the existing fleet with GHG reduction solutions e.g., WADs
- New methodologies needed for developing zero-emission vessels (ZEVs)
- Modernized development approach in ship design with Arcadia and the V-model
- MBSE in the maritime industry is a must!







Thank you!



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