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Application of the ARCADIA Method on a Bulk Carrier Vessel Equipped with a Wind-assistance Device

Presenters & Authors

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Dipl.-Ing. Nico Michels
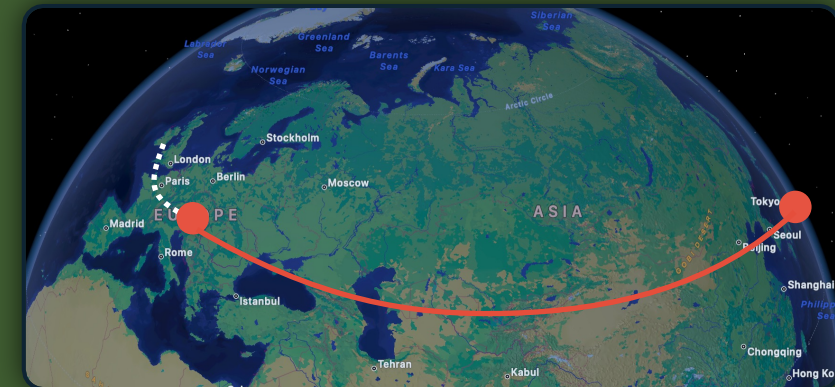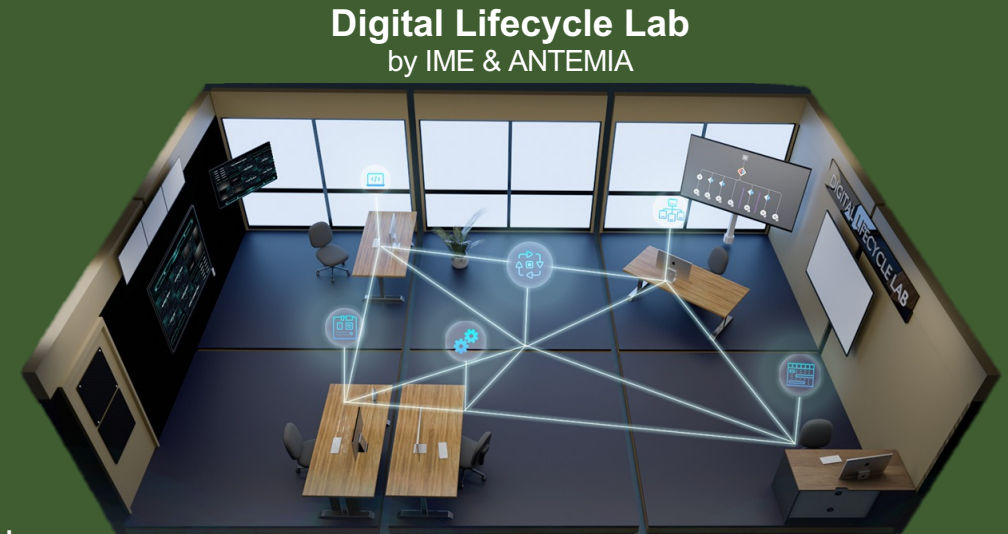 – Head of Digital Enterprise at Siemens Industry Software GmbH

Prof. Dr.-Ing. Carsten Burchardt
  – Head of Science at Siemens Industry Software GmbH

Prof. Kazuhiro Aoyama
  – Professor at University of Tokyo

Digital Lifecycle Lab
by IME & ANTEMIA

Agenda

01 Maritime stakeholders & technological options
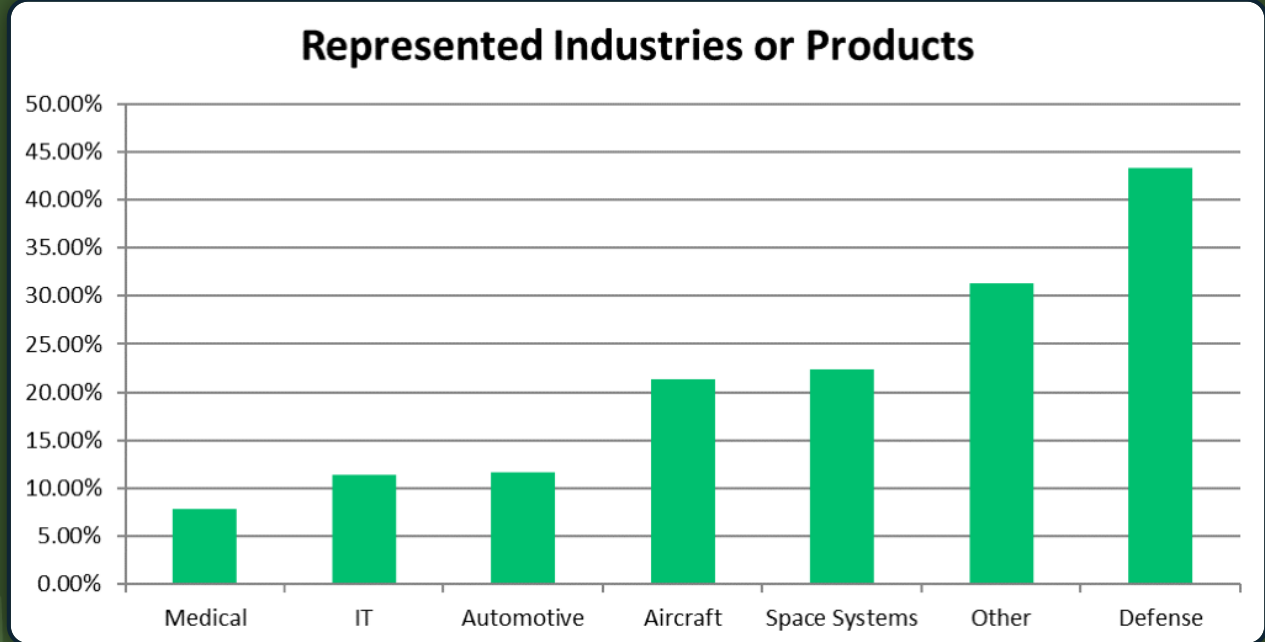
Decarbonization of marine shipping

02

04

03

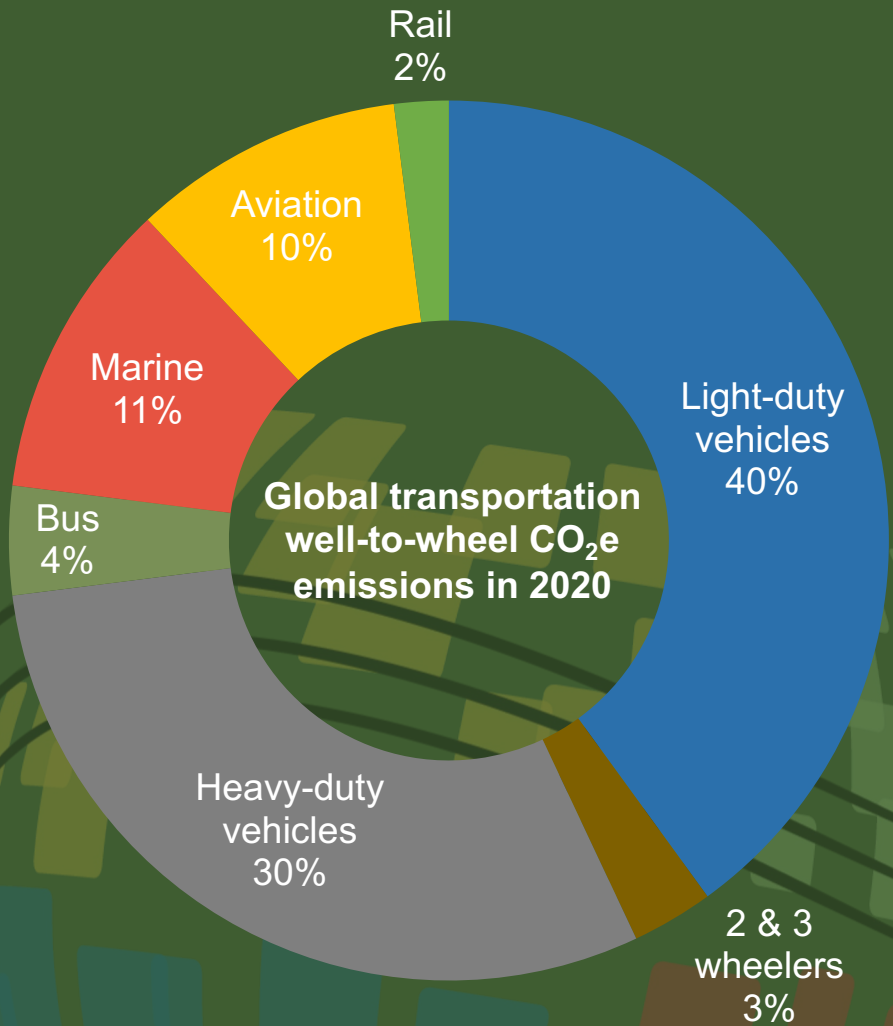ARCADIA method case study

PLM integration

The MBSE industry in numbers

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

Global transportation well-to-wheel CO_2e emissions in 2020

- Rail 2%
- Aviation 10%
- Marine 11%
- Bus 4%
- Heavy-duty vehicles 30%
- Light-duty vehicles 40%
- 2 & 3 wheelers 3%

Represented Industries or Products

Industries represented in the 2018 MBSE Survey

Challenge of marine shipping

On-time
vs.
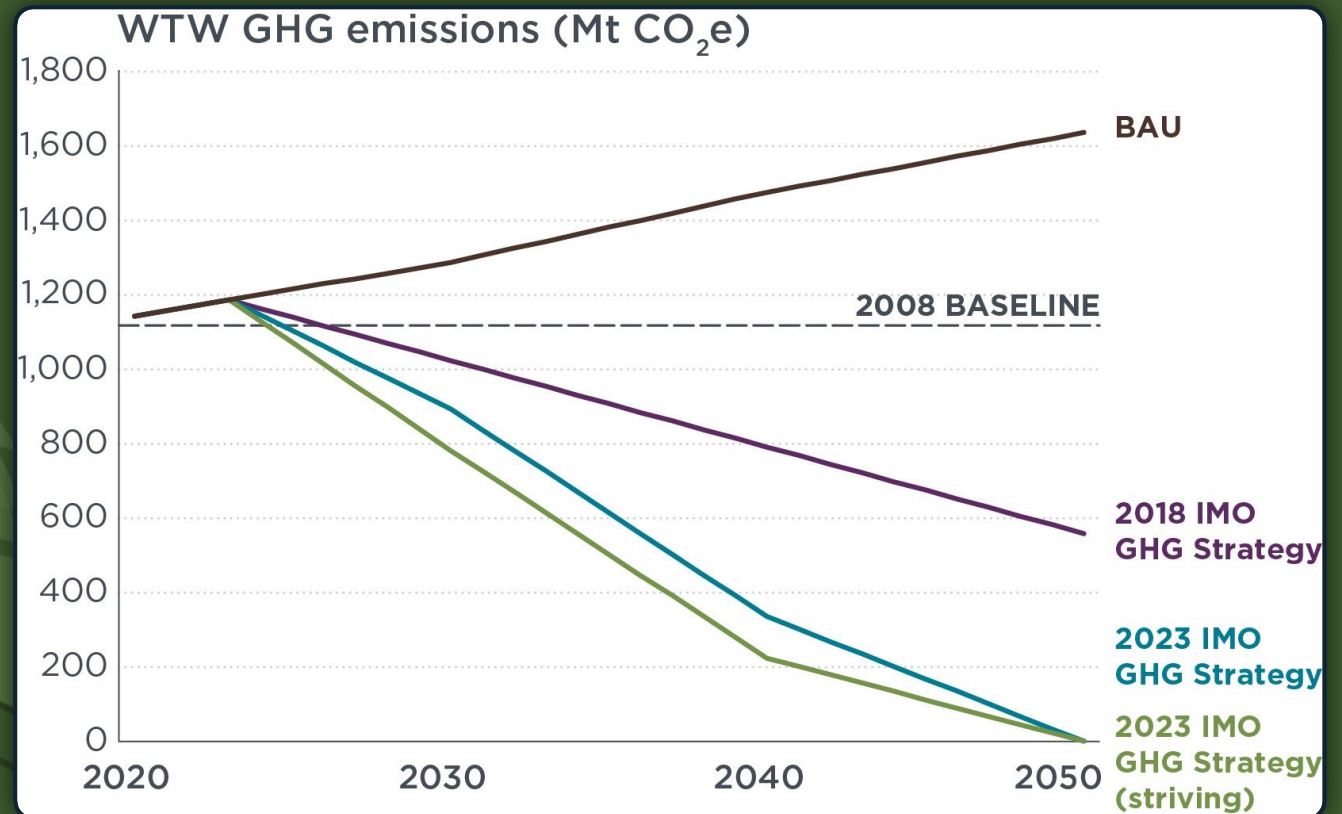**environment**
vs.
market demands

Decarbonization
vs.
legislation
vs.
cost

Transportation of **goods**, **resources**, **passengers**
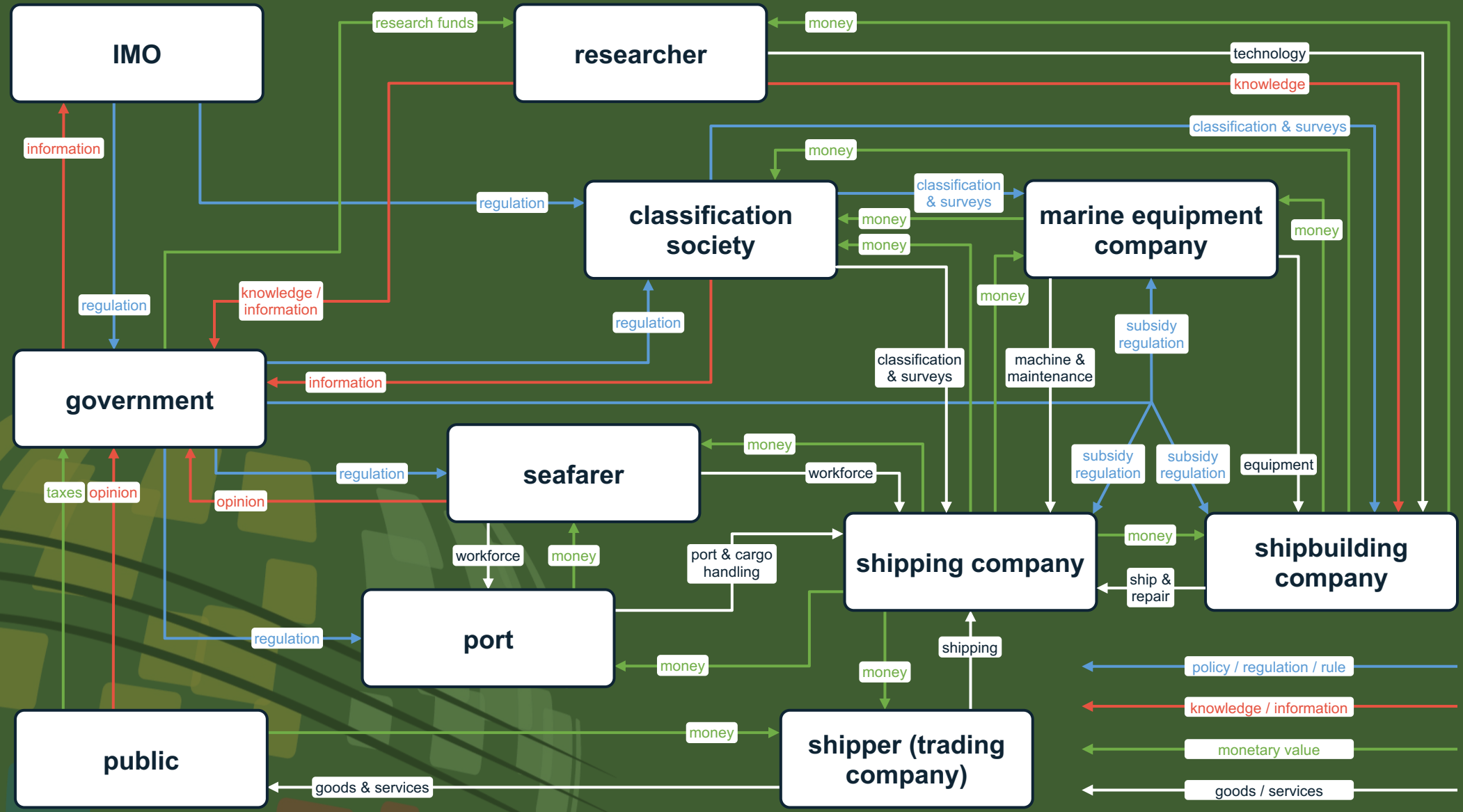
2023 IMO GHG strategy

- Reduce the total annual GHG emissions from international shipping
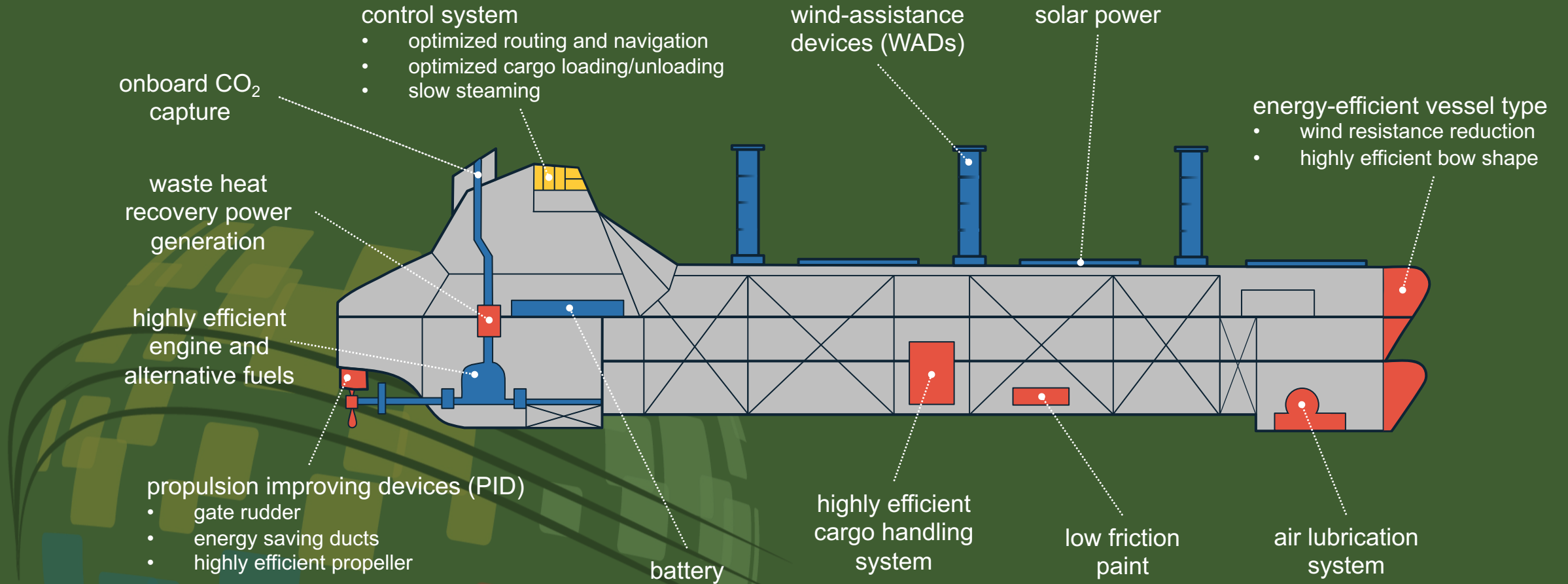
- **2050:** Net-zero GHG emissions

No measures (= BAU) →
climate targets not reached!

WTW GHG emissions (Mt CO_2e)

Stakeholder value network

IMO

researcher

research funds
money
technology
knowledge
classification & surveys

classification society

money
classification & surveys
money
money

marine equipment company

information
regulation
knowledge / information
regulation

government

information
classification & surveys
machine & maintenance
subsidy regulation
money

taxes opinion
opinion
regulation

seafarer

money
workforce
subsidy regulation
subsidy regulation
equipment

workforce
money

port

port & cargo handling

shipping company

money

shipbuilding company

ship & repair
shipping

regulation
money

money

public

money

shipper (trading company)

goods & services

policy / regulation / rule
knowledge / information
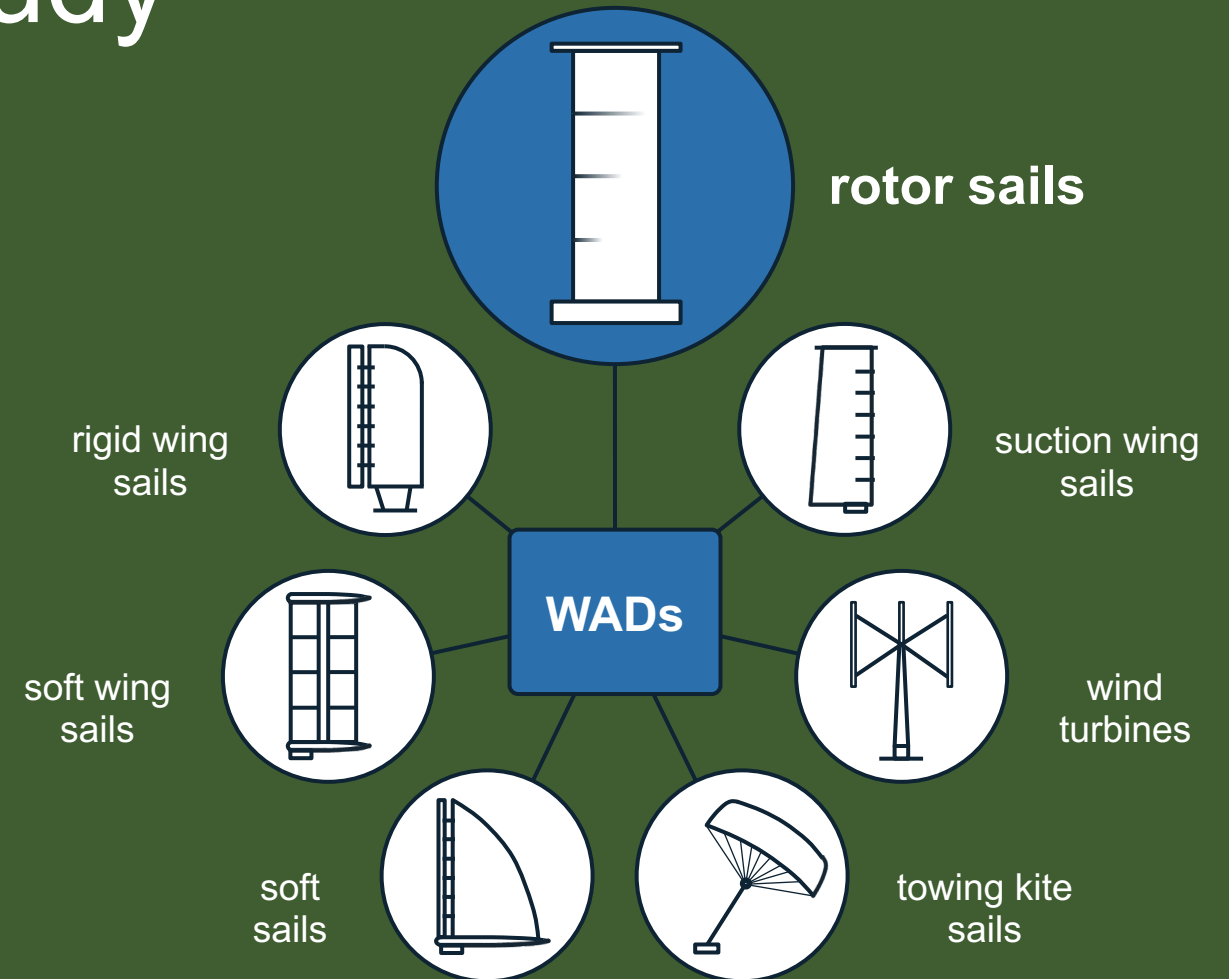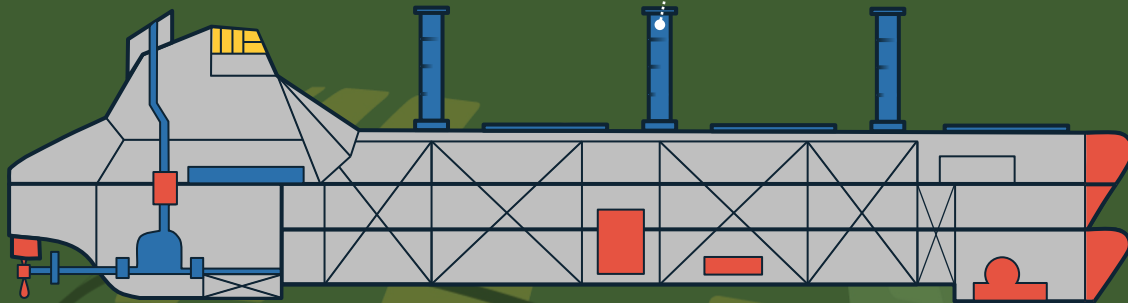monetary value
goods / services

Technical solutions

Legend:
- Low- and zero-emission alternative fuels and propulsion technologies
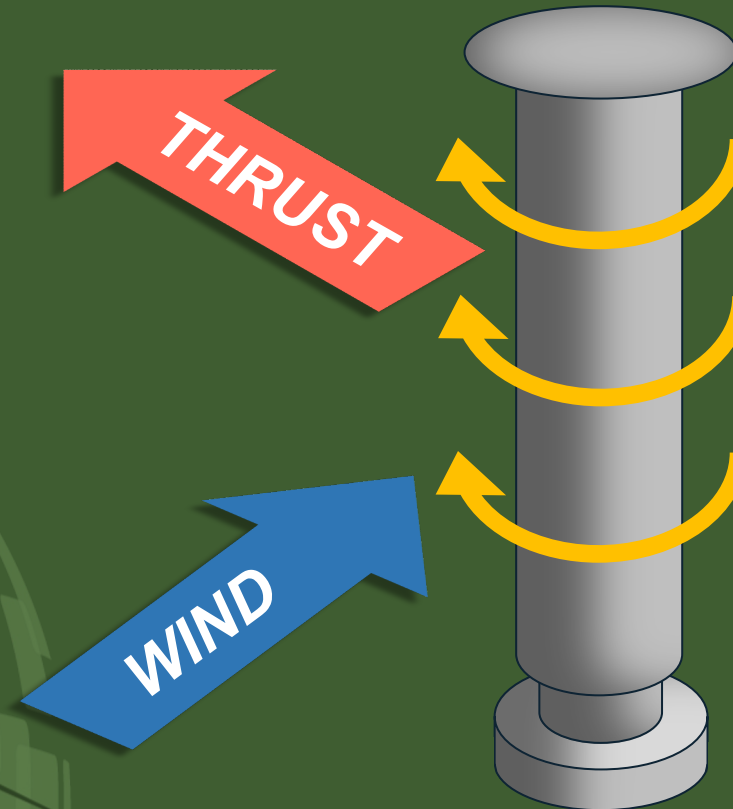- Energy-saving technologies
- Operational measures

control system
- optimized routing and navigation
- optimized cargo loading/unloading
- slow steaming

wind-assistance devices (WADs)

solar power

onboard CO$_2$ capture

energy-efficient vessel type
- wind resistance reduction
- highly efficient bow shape

waste heat recovery power generation

highly efficient engine and alternative fuels

propulsion improving devices (PID)
- gate rudder
- energy saving ducts
- highly efficient propeller

battery

highly efficient cargo handling system

low friction paint

air lubrication system

Focus of the case study

wind-assistance devices (WADs)

rotor sails

rigid wing sails

suction wing sails

WADs

soft wing sails

wind turbines

soft sails

towing kite sails

Bulk carrier with Flettner rotor sails

THRUST

WIND

Forward thrust generated through the **Magnus effect!**

Routing options

Route
Long-range

Near-port

Port A

Port B

Wind

Current

Weather

other

The **shipping route** needs to be **optimized!**

Virtual means models (ideally)

Cube of models

system architecture model

Capella/SMW with ARCADIA

FEA structural strength model

FEA thermal model

control system model

M-CAD geometry model

DMU model

E-CAD model

…

system models

technical domain

behavior
structure
capabilities

marine transportation

bulk carrier

propulsion system

engine

level

mechanics   electrics/elec.   software   …

discipline

specific models

ARCADIA method for solution development

operational analysis → system analysis → logical architecture → physical architecture

Capella/SMW model

mode and state diagrams

capability diagrams

scenario diagrams

data flow diagrams

breakdown diagrams

architecture diagrams
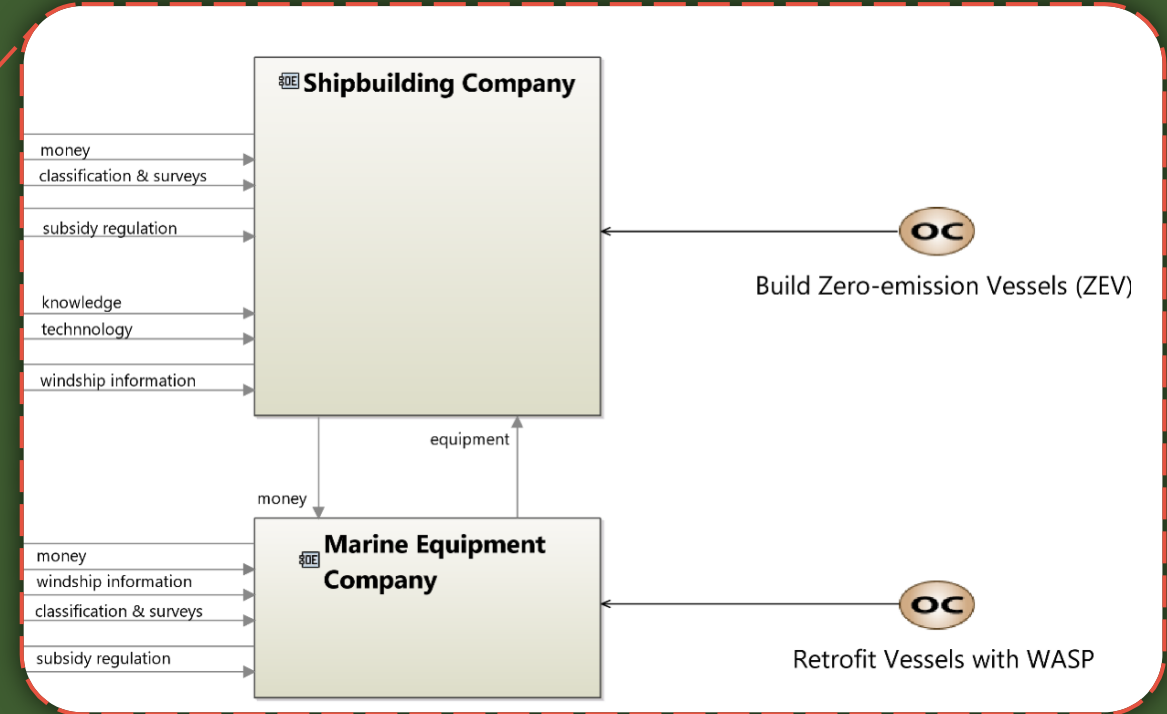
class diagrams
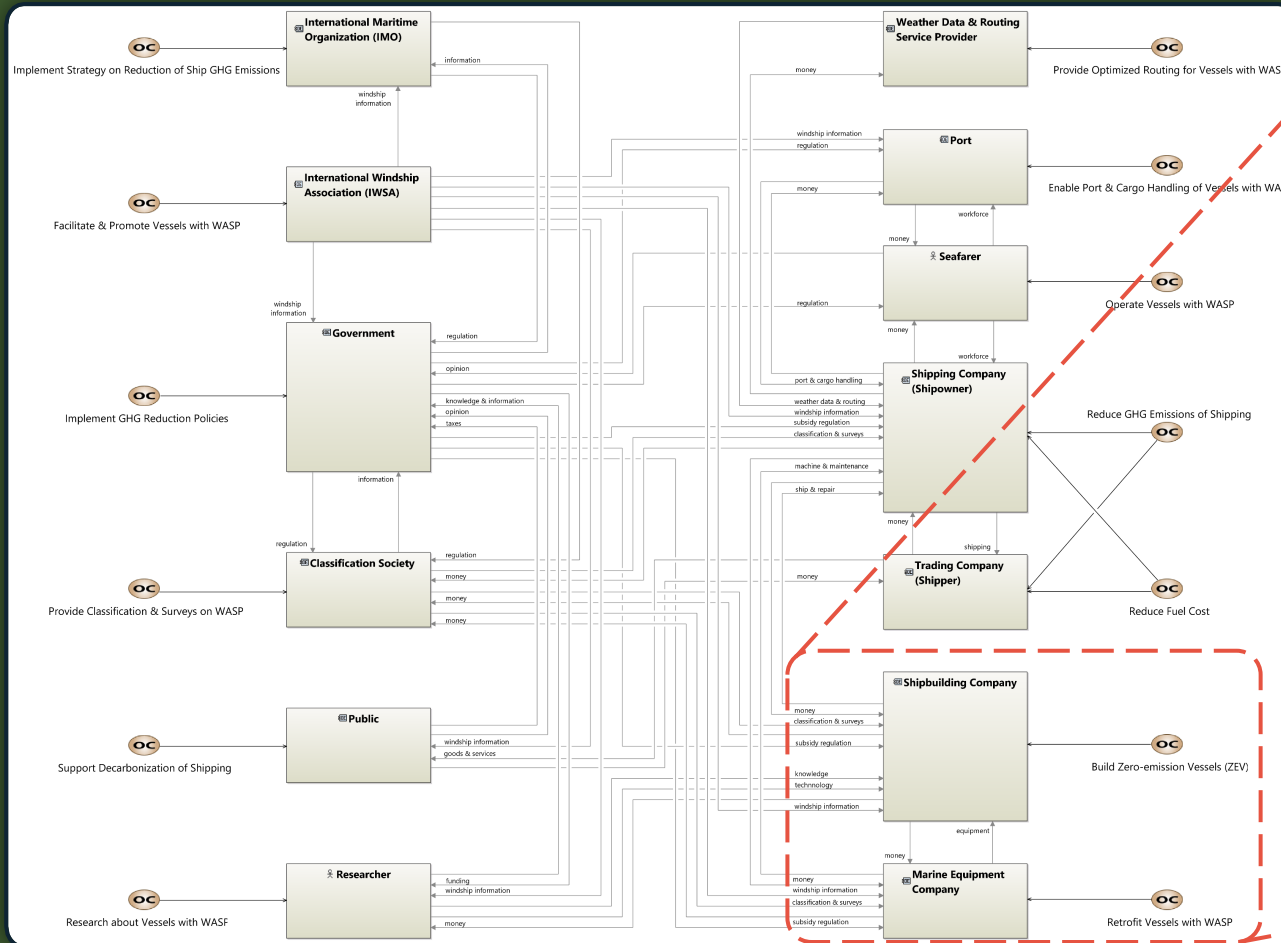
Why ARCADIA & Capella/SMW?

- **Tool** with integrated **method**
- Steep **learning curve**
- Made for **architecting**
  - Architecture diagrams
  - Combined views
  - "Modeling experience"
  - Excellent reuse
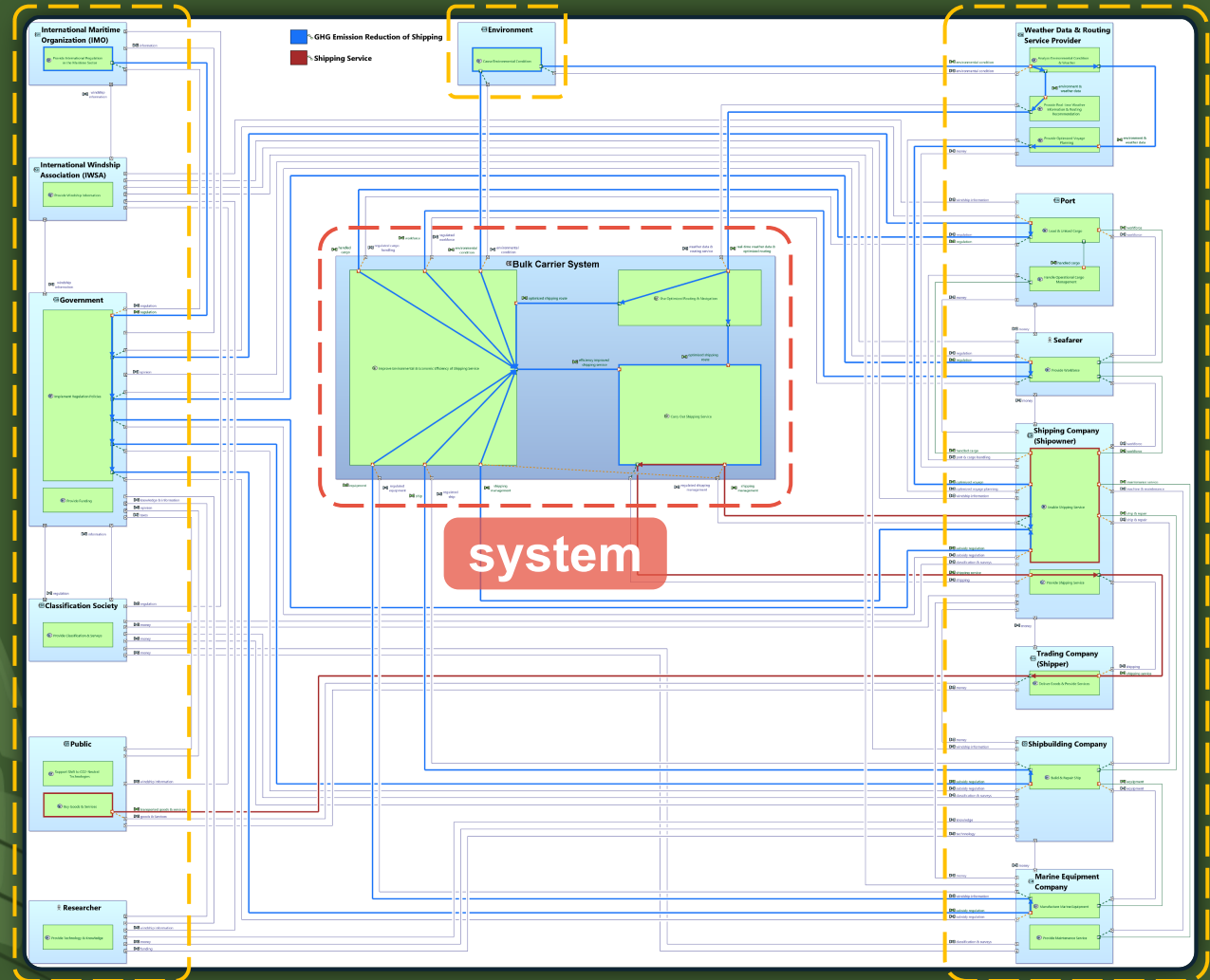 - And much more …

Going from the *need* …

↓

… to the *solution*!
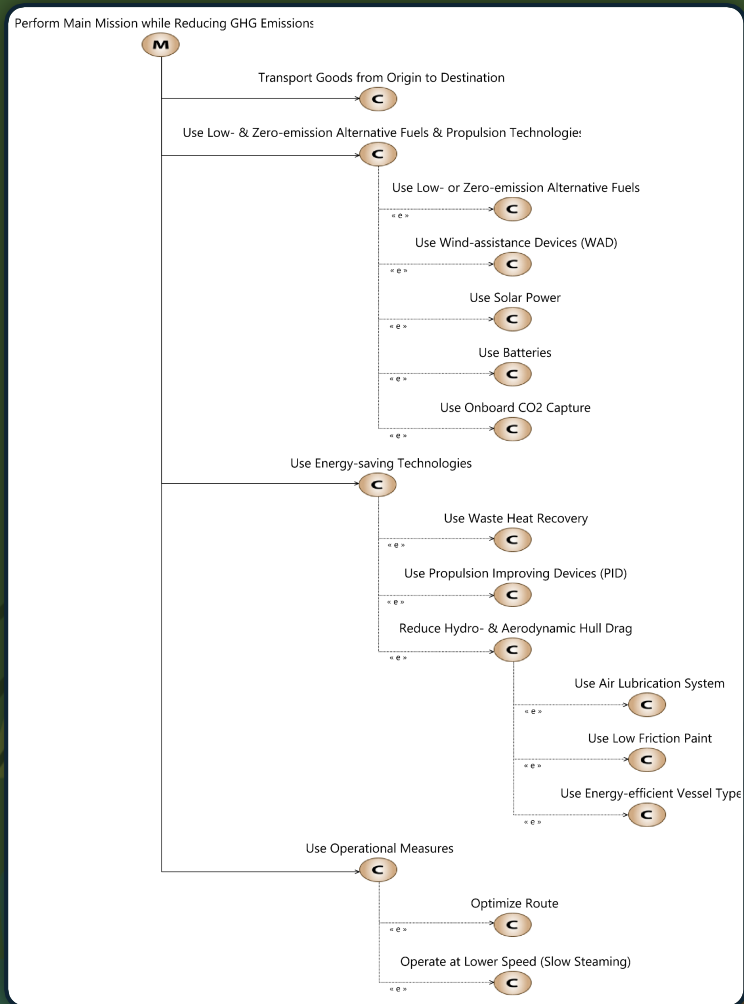
Operational situation as-is

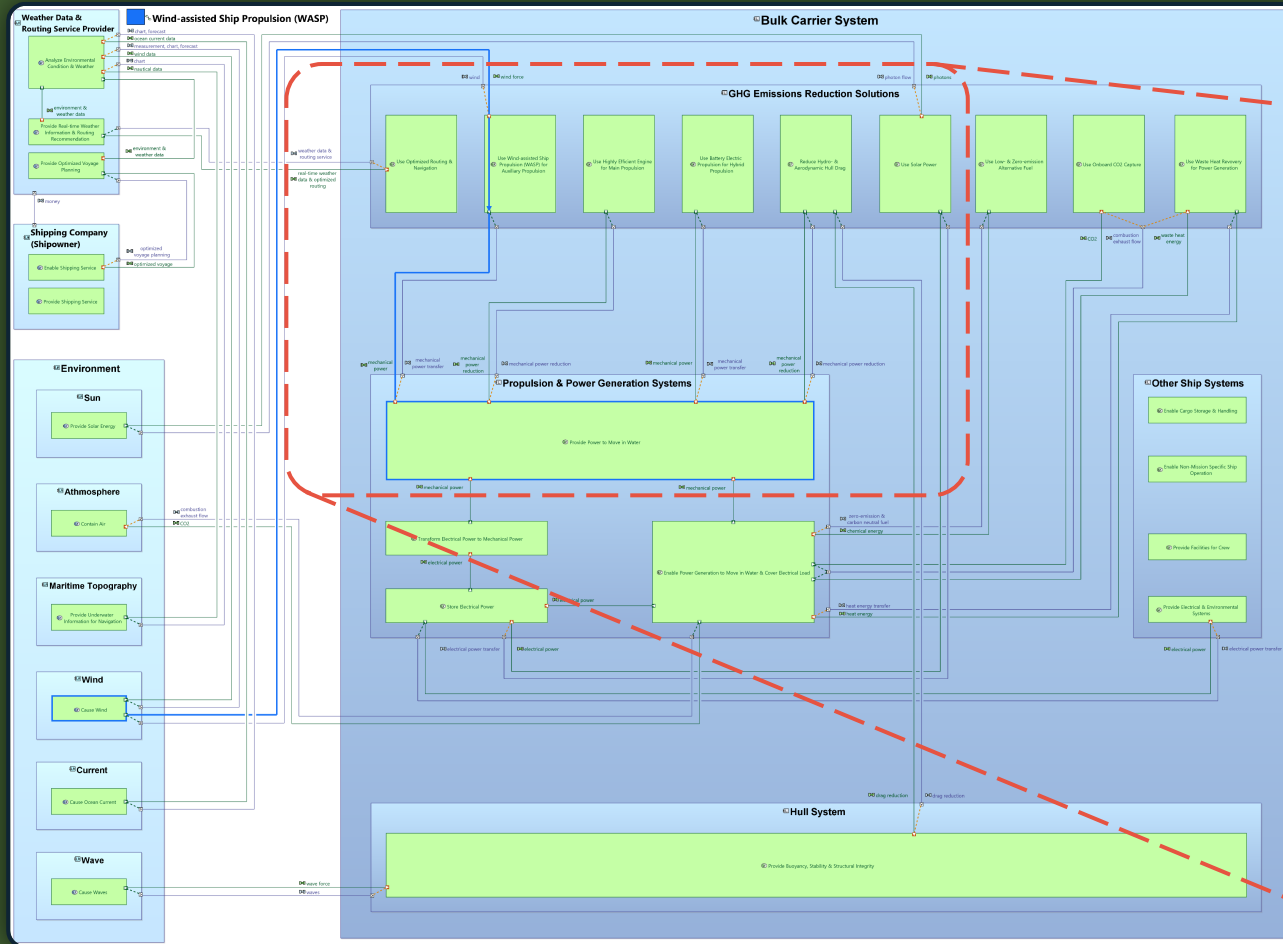Analyze the **operational context** & **stakeholder interactions**!
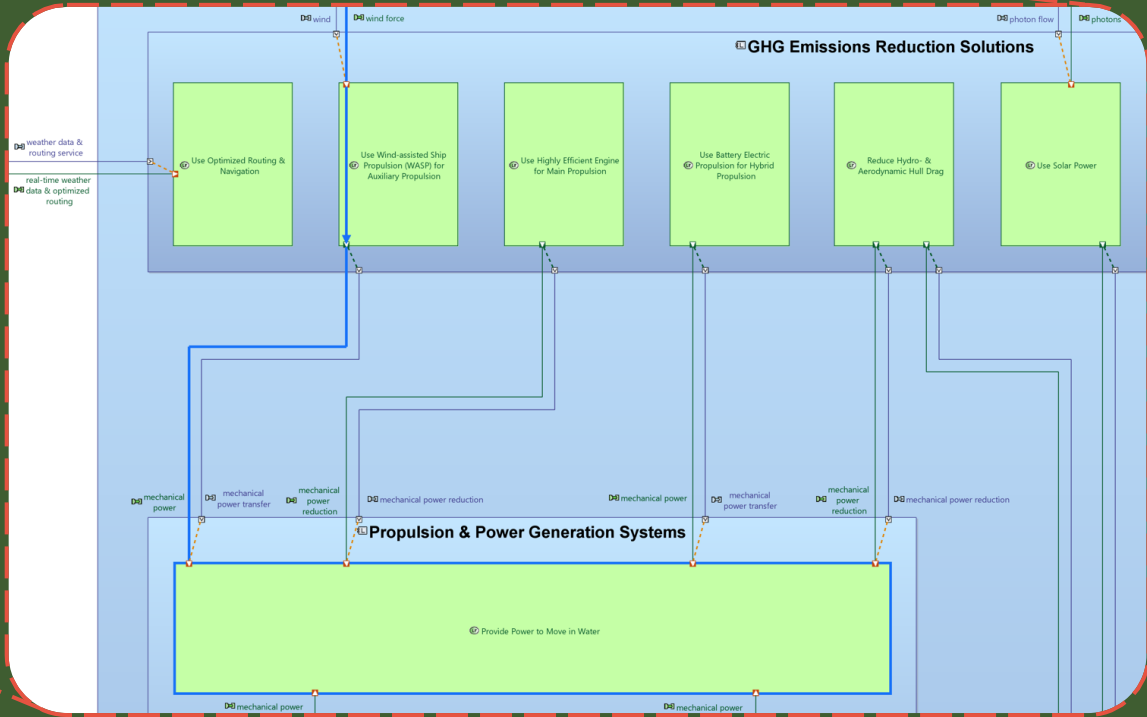
System-to-be-defined

Deriving the logical architecture

Logically **integrate** GHG emissions reduction solutions!

The physical architecture of the bulk carrier

- Model and connect all relevant **subsystems** & **functions**
- Consider **physical actors**
- Define **interfaces** & **exchanges**

The essential step for further **discipline** development!

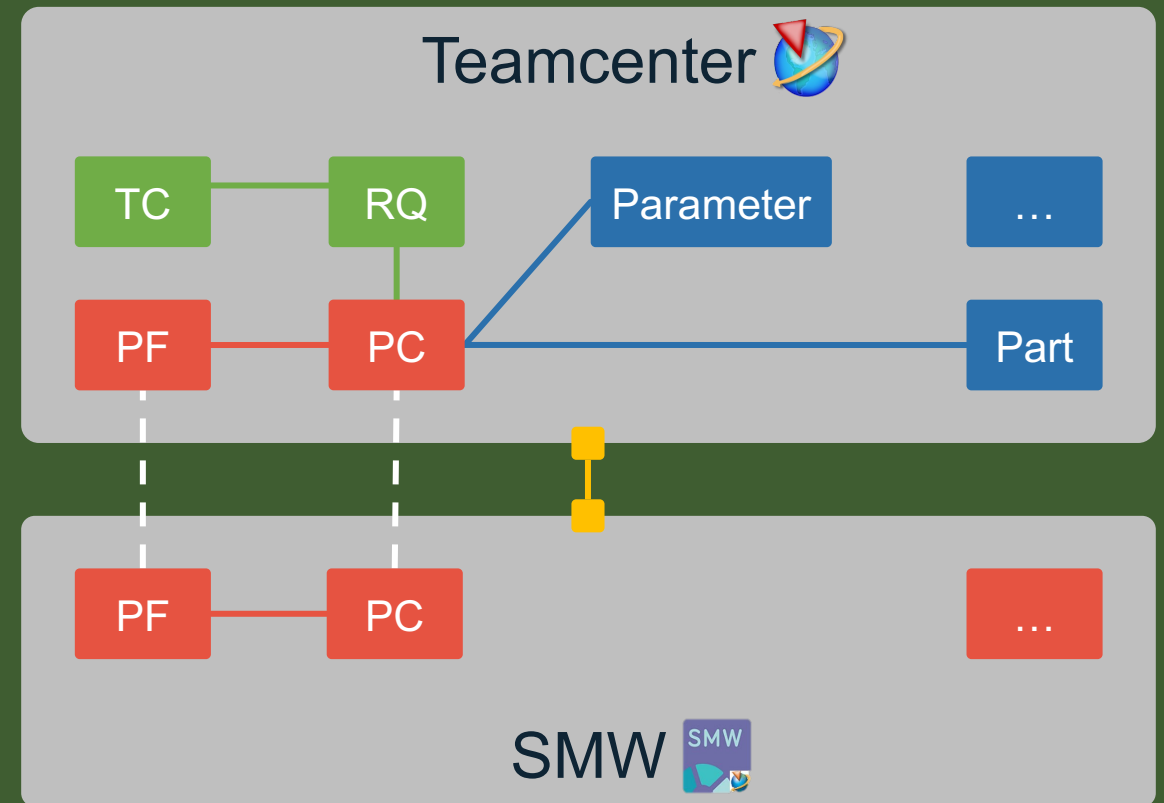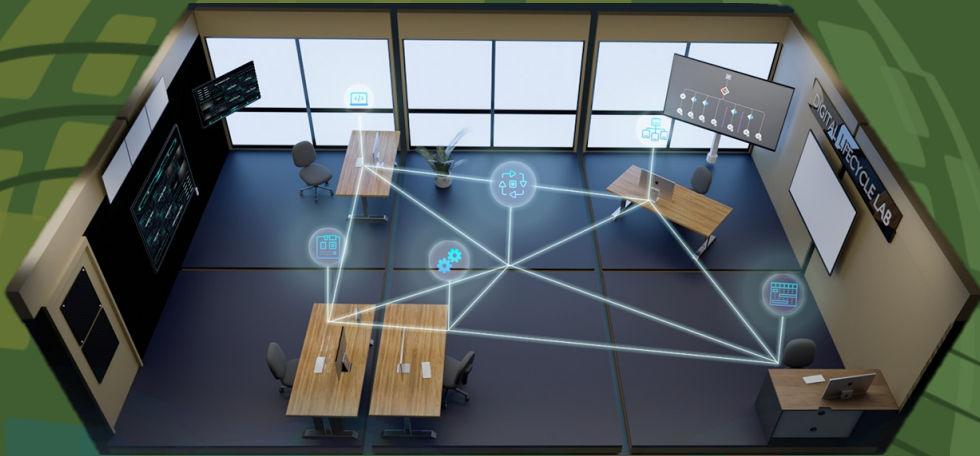# The physical architecture of the bulk carrier

- **Auxiliary propulsion** subsystem integrated in bulk carrier system
- **Structural**, **hierarchical**, & **functional** view

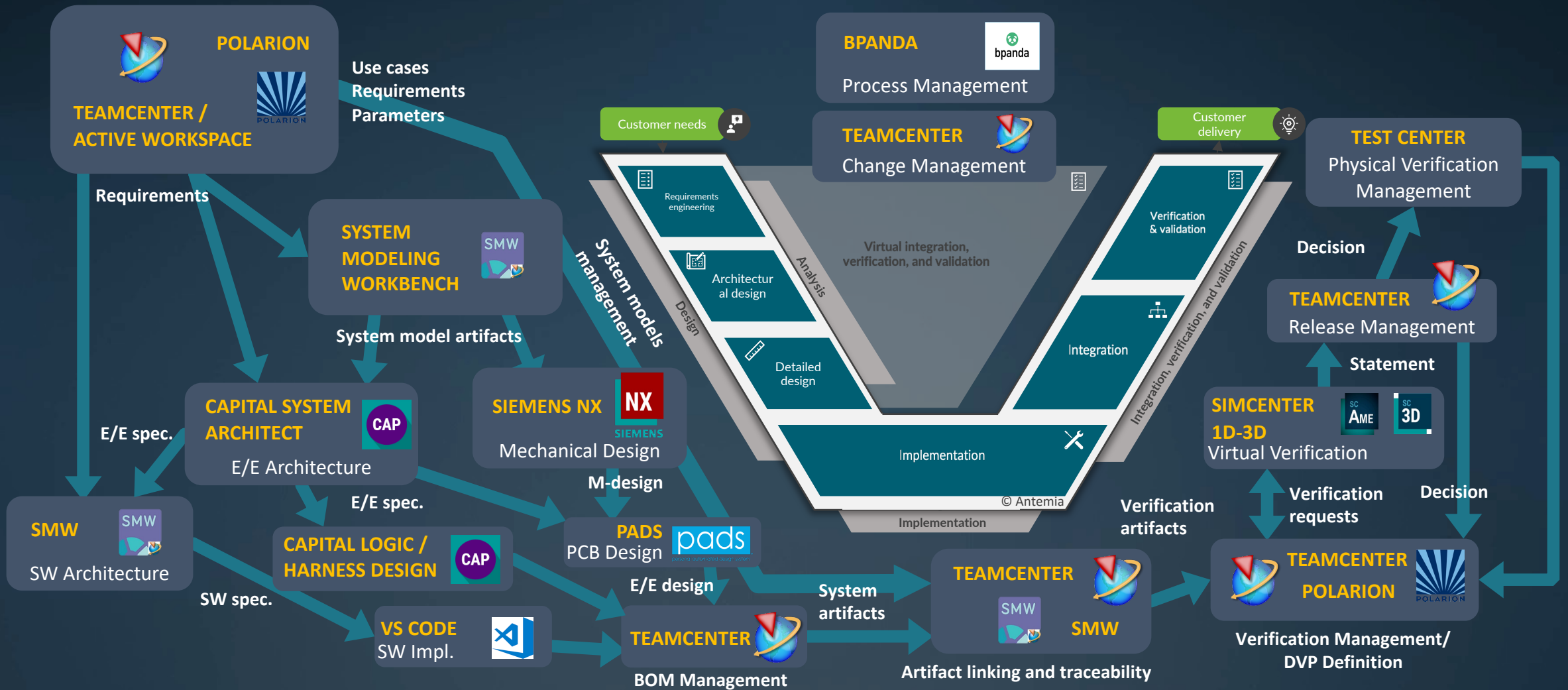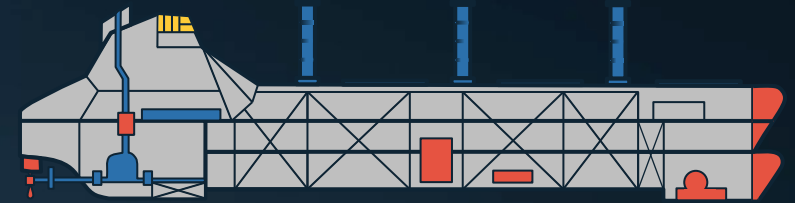The basis for **integration, V&V!**

Integration to PLM

- **Link artifacts** from different models & tools

- Defined **workflows** with underlying **methods**

- Realized in the **Digital Lifecycle Lab** by IME & ANTEMIA

SMW with ARCADIA into PLM

POLARION

TEAMCENTER / ACTIVE WORKSPACE

Use cases
Requirements
Parameters

Requirements

SYSTEM MODELING WORKBENCH
SMW

System model artifacts

System models management

CAPITAL SYSTEM ARCHITECT
CAP
E/E Architecture

E/E spec.

E/E spec.

SIEMENS NX
NX
SIEMENS
Mechanical Design

M-design

SMW
SW Architecture

SW spec.

CAPITAL LOGIC / HARNESS DESIGN
CAP

PADS
pads
PCB Design

E/E design

VS CODE
SW Impl.

TEAMCENTER
SMW
BOM Management

System artifacts

BPANDA
bpanda
Process Management

TEAMCENTER
Change Management

Customer needs

Requirements engineering

Analysis

Architectural design

Design

Detailed design

Implementation

Virtual integration, verification, and validation

© Antemia

Implementation

Customer delivery

Verification & validation

Integration

Integration, verification, and validation

TEAMCENTER
SMW
Artifact linking and traceability

Verification artifacts

TEST CENTER
Physical Verification Management

Decision

TEAMCENTER
Release Management

Statement

SIMCENTER 1D-3D
SC AME
SC 3D
Virtual Verification

Verification requests

Decision

TEAMCENTER POLARION
POLARION
Verification Management/ DVP Definition

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