The International Maritime Forum “Sustainable seas shaping the future through knowledge, partnership and innovation Empowering Blue and Smart Transformation of the Black Sea”

22.10.2025 г.
Varna, Bulgaria

STARTUP CONCEPT

NEXT-GENERATION CARGO & STABILITY INTELLIGENCE FOR SIMULATORS

Prepared by :
Capt. GEORGI PARVANOV

Naval Academy
”Nikola Yonkov Vaptsarov”
NVNA

1. Cargo & Ballast Simulator (In Development)

The Cargo & Ballast Simulator is designed to reproduce loading, unloading, and ballast operations, with a strong focus on dynamic stability and safety awareness. Unlike conventional loading computers, the simulator emphasizes the physical phenomena that often remain hidden:

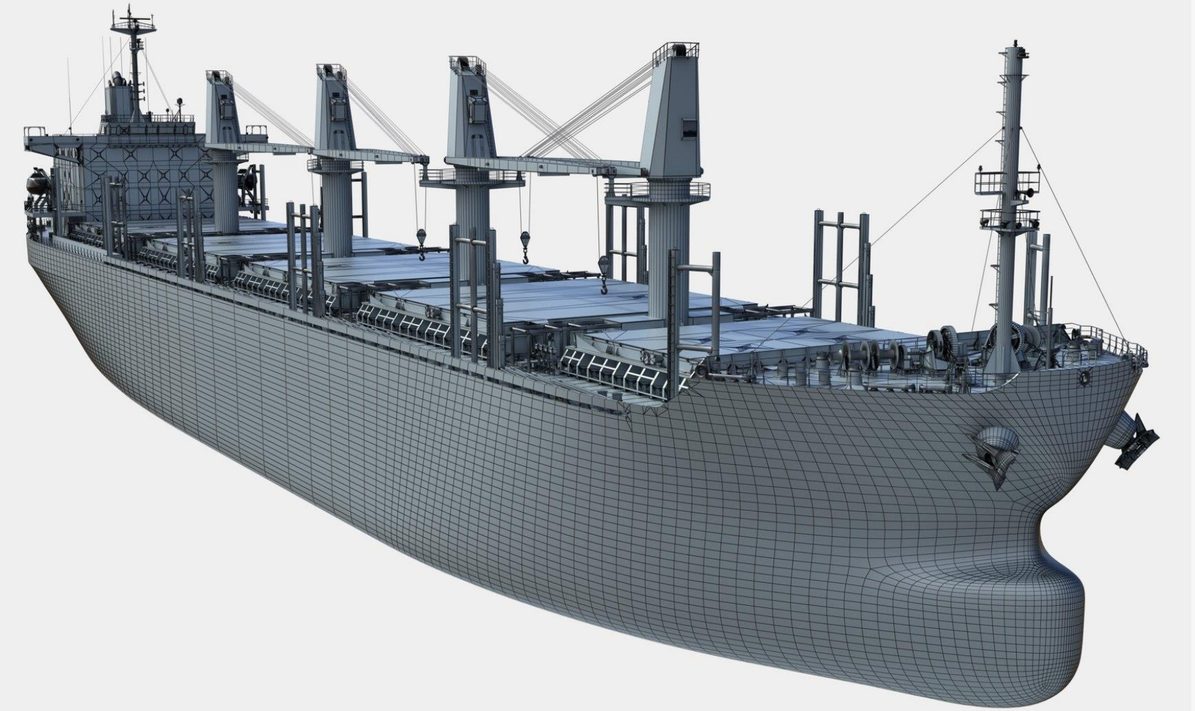
- *Statistical stability analysis (GM, GZ curves, trim, list).*
- *Free surface effect visualization – how partially filled tanks reduce stability.*
- *Shifting cargo simulation – heeling surfaces and moments from bulk cargo movement.*
- *Dynamic ship response under irregular wave excitation, depending on loading condition (Strength analysis for BM, SF, Deflection and local shear)*
- *Ballast transfer operations – highlighting consequences for trim and stability.*
- *Custom features and alarms*


AI
AI
ai

2. AI-GENERATED HULL MODEL (NEXT STAGE)

Once hydrostatic curves and a theoretical drawing are available, we can construct an AI-generated 3D hull model. This model:

- *Represents the vessel in a digital twin, independent of the ship's loading computer.*
- *Allows direct calculation of submerged volume under trim, list, hogging, or sagging.*
- *Uses discretization methods to provide high-fidelity hydrostatics (displacement, LCB/LCF, GM, FSM, GHM, LCG, TCG, VCG, TPC).*
- *Forms the backbone for real-time integration with sensor data.*

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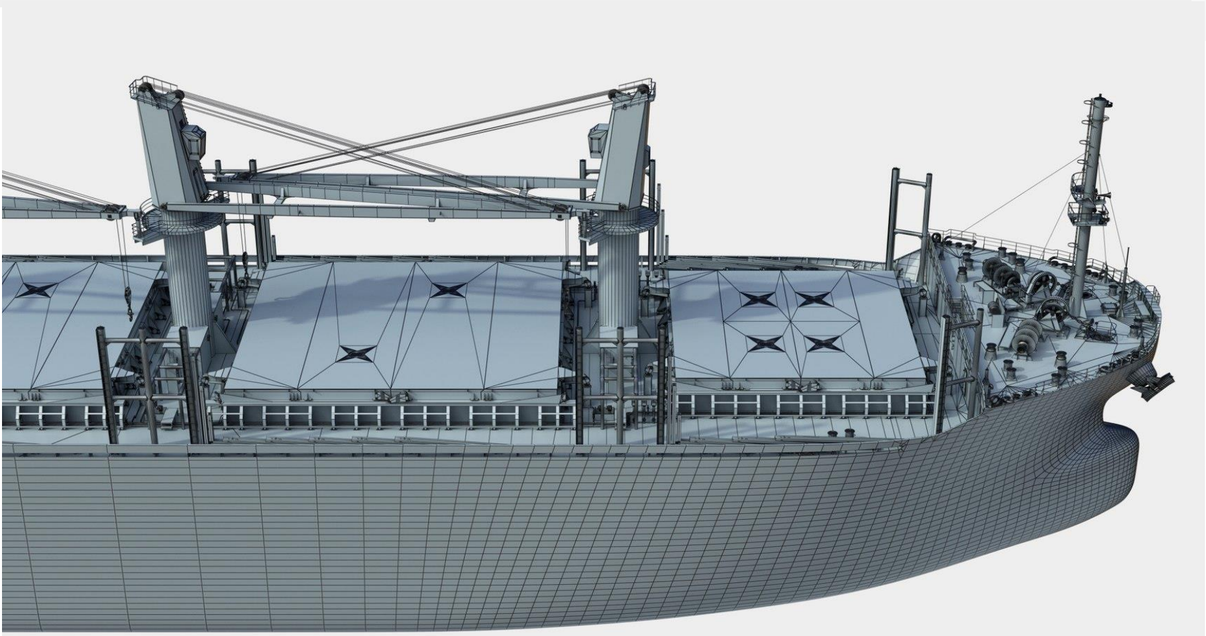


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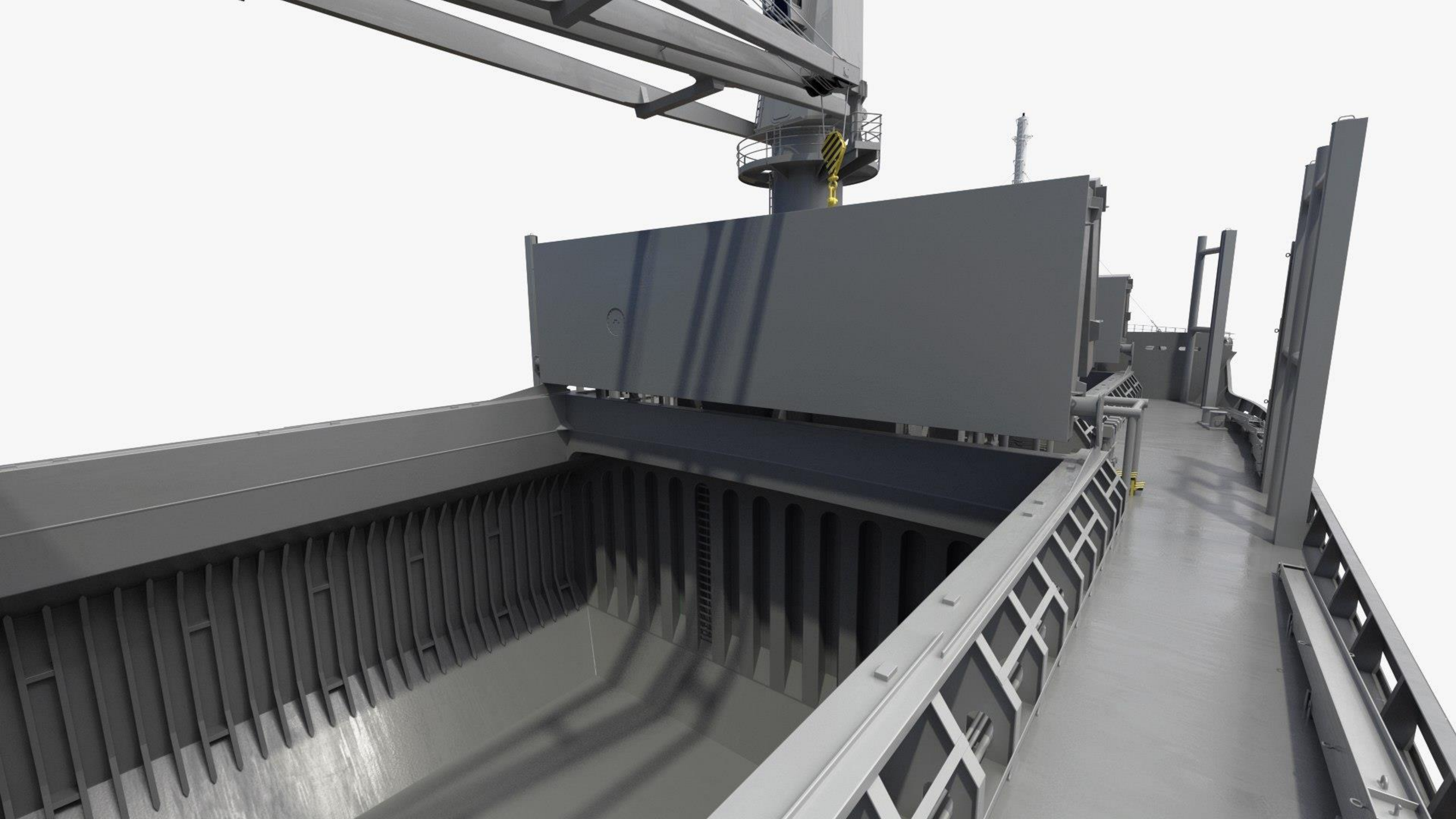

3. DRAUGHT & SEAWATER PROPERTIES (CORE MEASUREMENT TECHNOLOGY – R&D)

A new multi-sensor system is under development to precisely measure:

- *Draught – by replacing manual draught mark reading with automated level sensors, optical references, and inertial corrections.*
- *Trim & heel – via Micro-Electro-Mechanical Systems (MEMS) inclinometers and accelerometers*
- *Salinity and water density (ρ) – using inline CTD (Conductivity, Temperature, Depth) or densimeters for exact buoyancy correction.*

This system aims to deliver objective, repeatable measurements, enabling continuous draught control with ever-decreasing error margins.

4. DYNAMIC ROLL PERIOD & STABILITY MONITORING (IN DEVELOPMENT)

By combining:

- *Precise draught changes (from the sensor system), and*
- *Inertial motion data (Motion Reference Unit-MRU /Inertial Measurement Unit-IMU),*

we can dynamically determine the ship's roll period in real time.

This unlocks:

- *Parametric roll detection (head/following seas, 2:1 resonance).*
- *Resonant roll detection (beam seas, 1:1 resonance).*
- *Early-warning signs of decreasing stability (e.g., due to free-surface effect, cargo liquefaction, or improper securing).*


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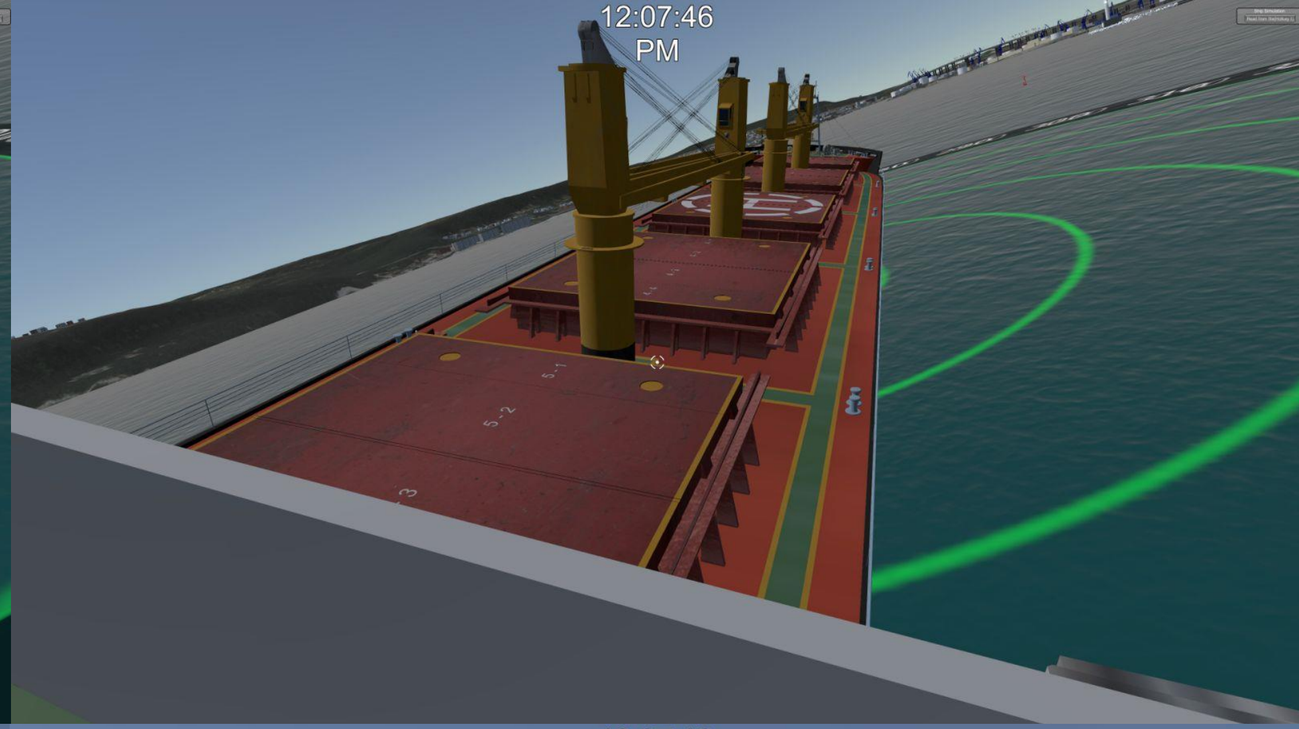
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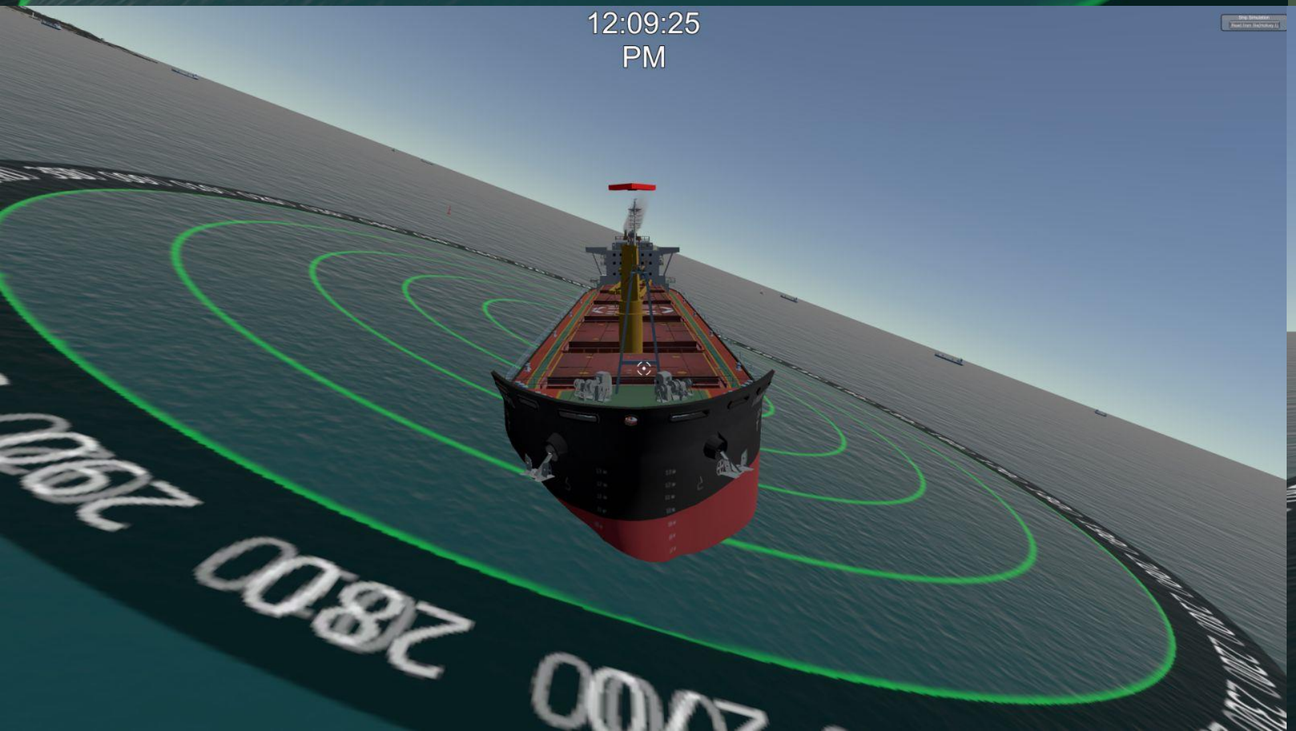
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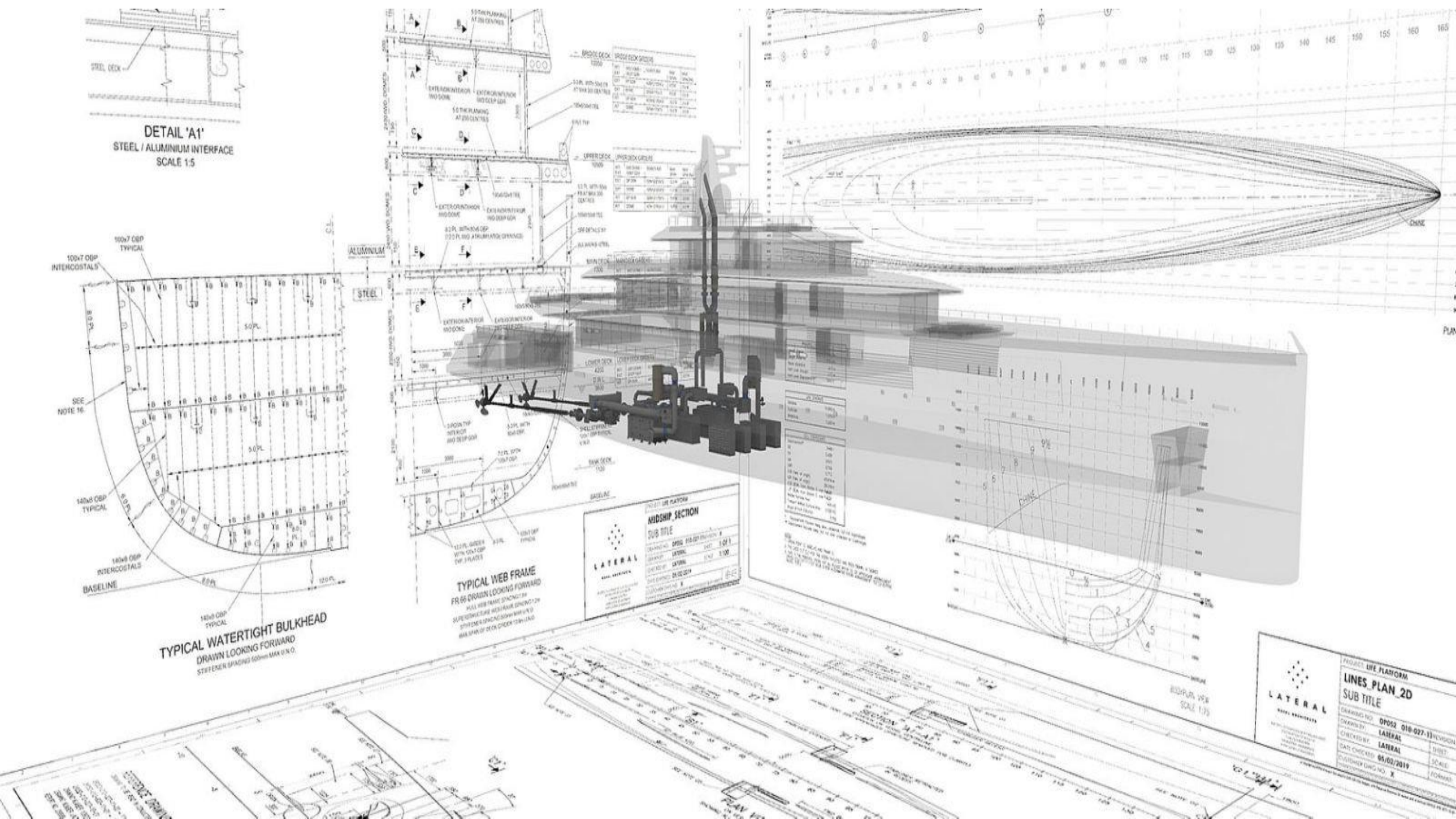
5. FINAL OBJECTIVE – STABILITY & CARGO INTELLIGENCE TOOL

The ultimate goal is a bridge-deployed advisory system that provides:

- ***Exact cargo weight on board in real time – a live figure on the bridge, continuously updated.***
- ***Early prediction of stability reduction – proactive alarms when GM is trending down or FSE is increasing.***
- ***Prediction of resonance risks – based on current loading + forecast sea state.***
- ***Decision-support advisor – suggests course and speed adjustments (e.g., "Alter course by 15° to starboard" or "Reduce speed by 2 knots") to mitigate roll risks.***


DETAIL 'A1'
STEEL / ALUMINIUM INTERFACE
SCALE 1:5
TYPICAL WATERTIGHT BULKHEAD
DRAWN LOOKING FORWARD
TYPICAL WEB FRAME
FR.66 DRAWN LOOKING FORWARD
MIDSHIP SECTION
SUB TITLE
LINES_PLAN_2D
SUB TITLE
LATERAL

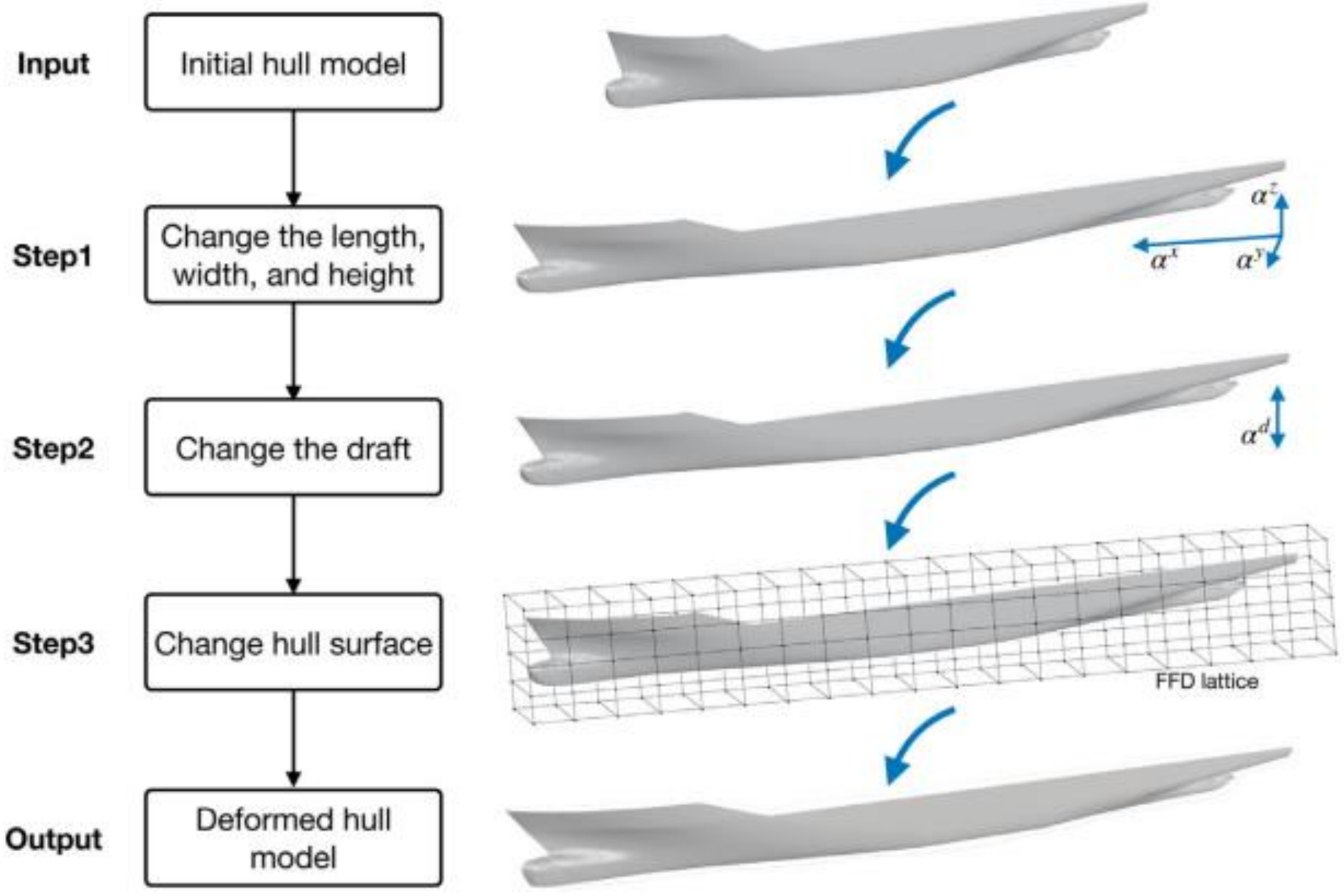
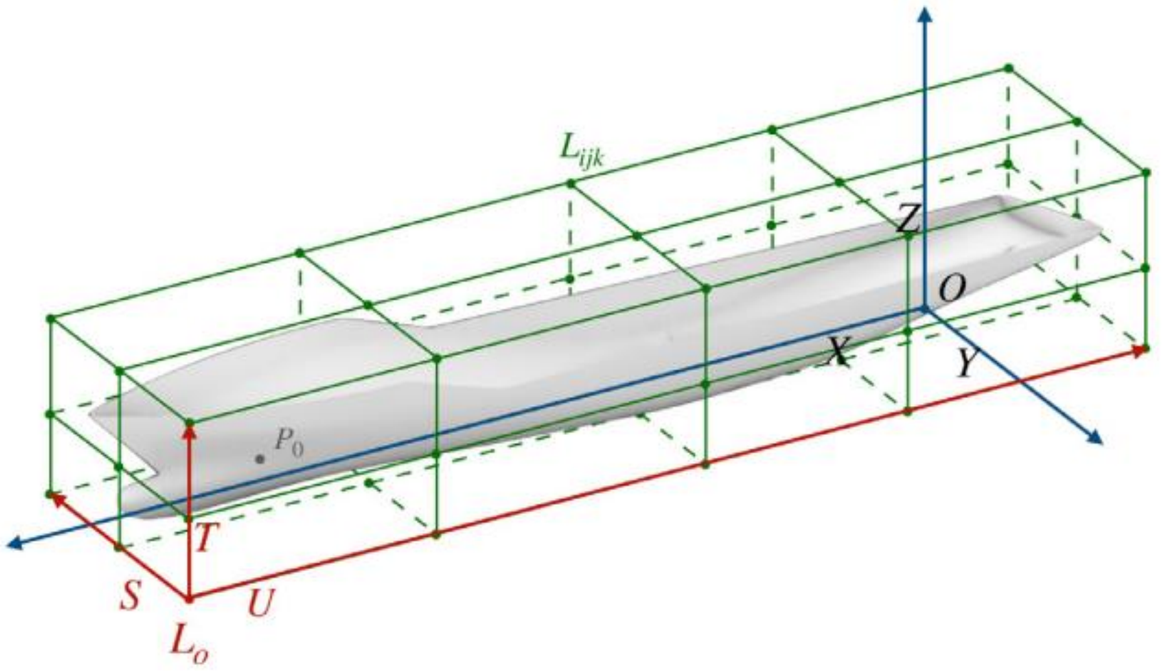
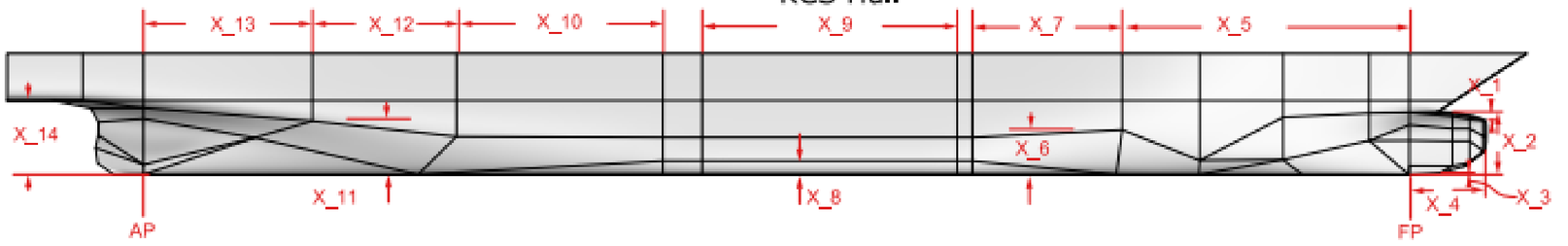


Fig. 2. Entire geometry modification process of the hull form.

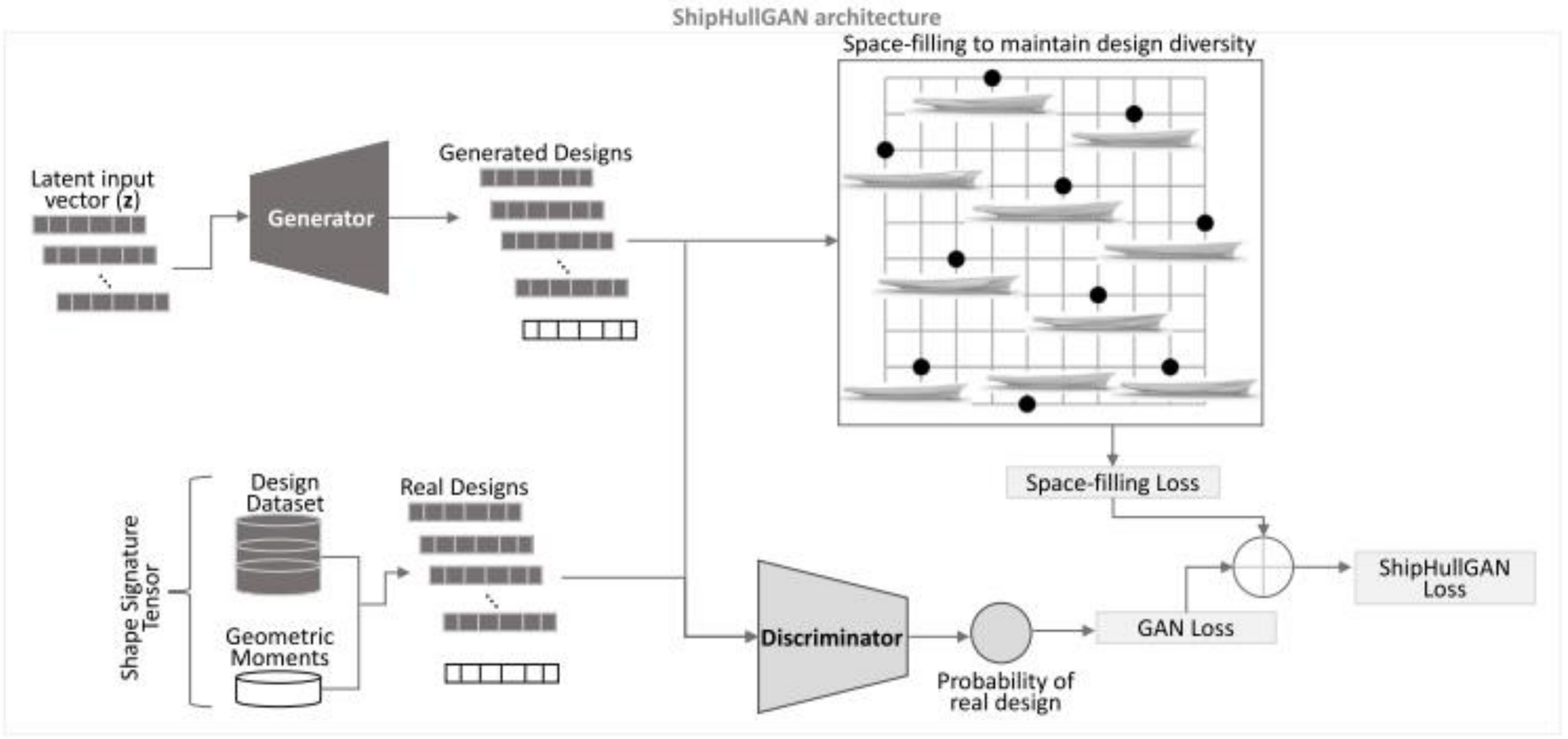


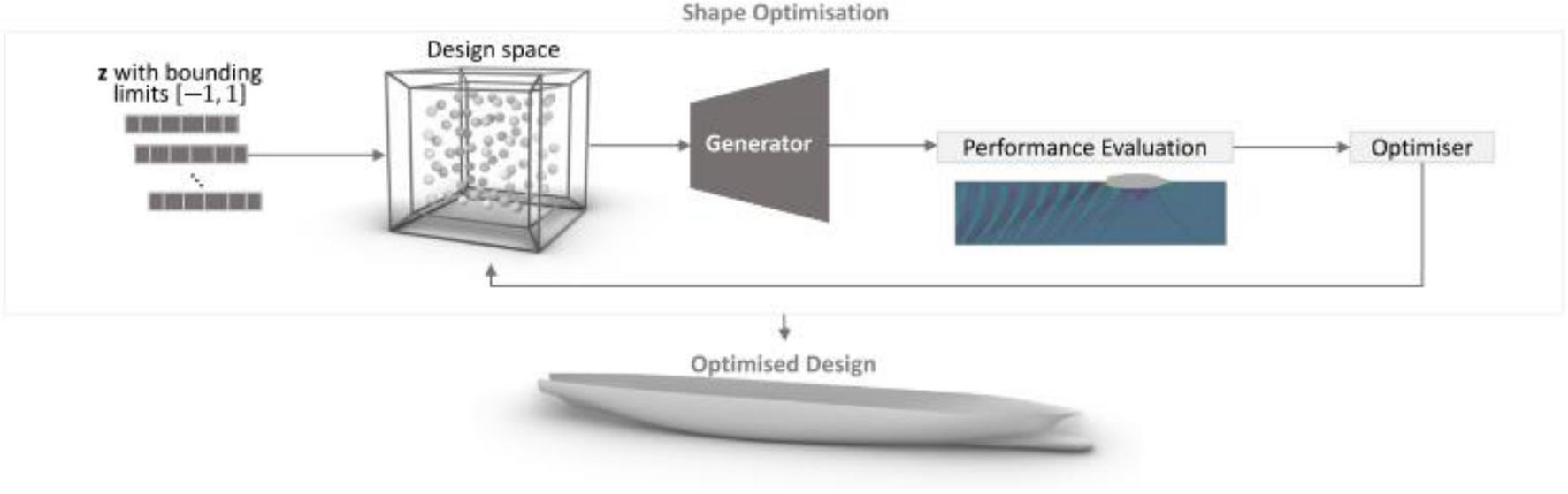
KCS Hull

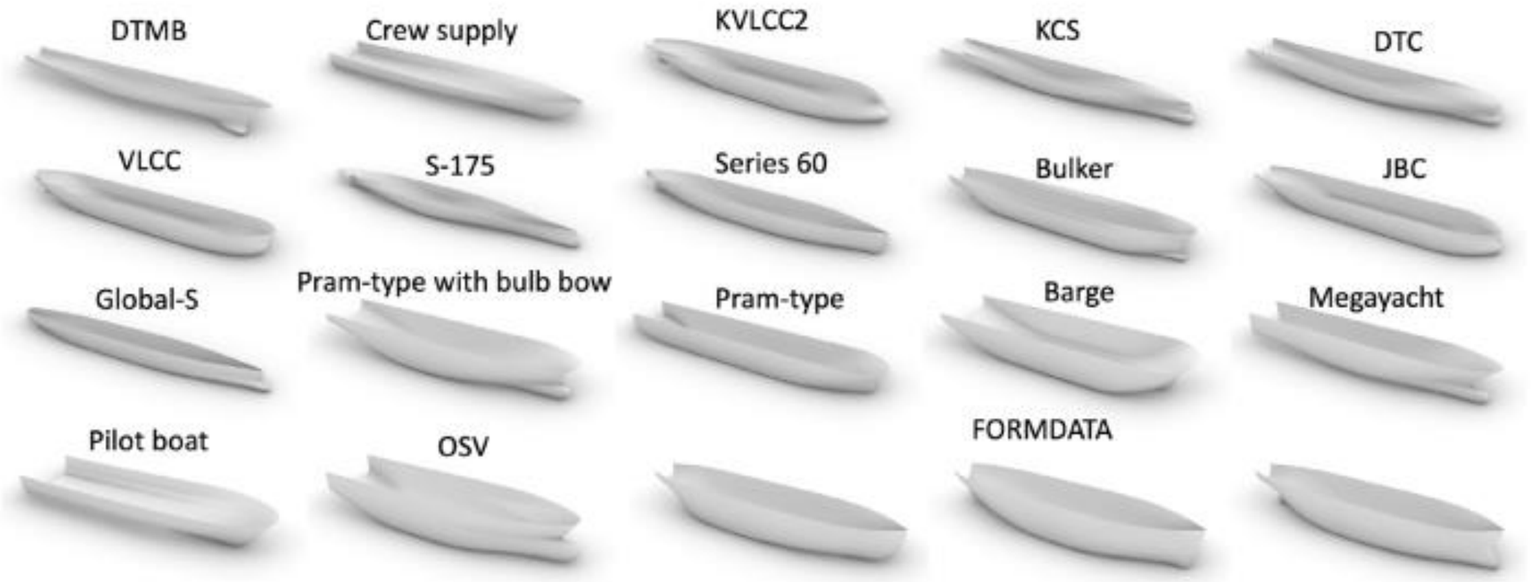


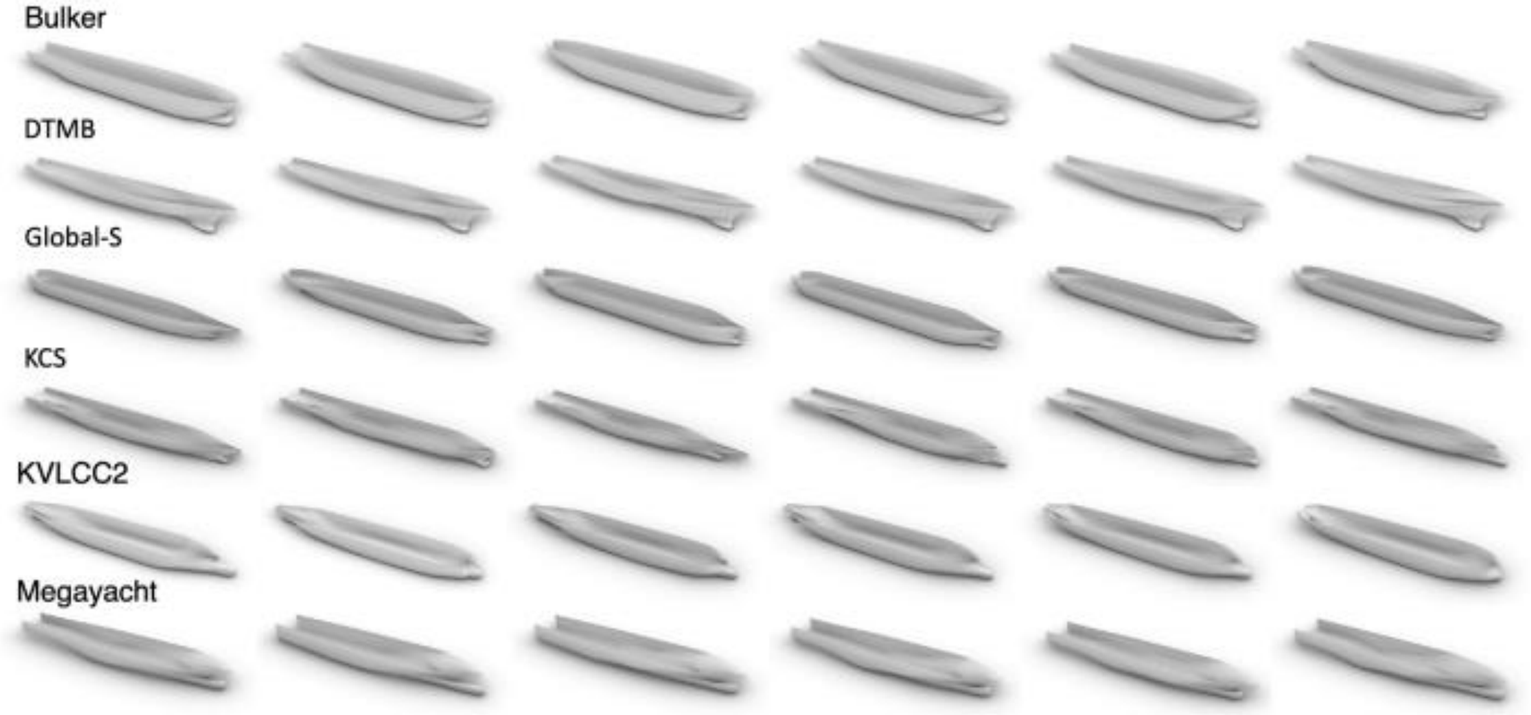
How to map parameterisation?

DTMB Hull


ShipHullGAN architecture
Space-filling to maintain design diversity
Latent input vector (z)
Generator
Generated Designs
Space-filling Loss
Design Dataset
Real Designs
Shape Signature Tensor
Geometric Moments
Discriminator
GAN Loss
ShipHullGAN Loss
Probability of real design


Shape Optimisation
z with bounding limits [−1, 1]
Design space
Generator
Performance Evaluation
Optimiser
Optimised Design


DTMB
Crew supply
KVLCC2
KCS
DTC
VLCC
S-175
Series 60
Bulker
JBC
Global-S
Pram-type with bulb bow
Pram-type
Barge
Megayacht
Pilot boat
OSV
FORMDATA


Bulker
DTMB
Global-S
KCS
KVLCC2
Megayacht

6. VISION & IMPACT

This system represents a paradigm shift:

- *From "static loading computers"* → ***to dynamic AI-driven stability monitoring.***
- *From after-the-fact incident analysis* → ***to real-time prevention.***
- *From dependence on human judgment alone* → ***to objective, sensor-based decision support.***

By integrating cargo simulation, AI hull modeling, precision draught measurement, and dynamic stability intelligence, we aim to:

- ***Reduce accidents caused by improper loading and hidden stability losses.***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FURUNO

7. INTERNATIONAL LEGISLATION THAT WILL TAKE INTO ACCOUNT WHEN CONFIGURING AND CREATING THE CARGO HANDLING SIMULATOR

- *International Convention for the Safety of Life at Sea (SOLAS), 1974*
- *The International Code for the Safe Carriage of Grain in Bulk (International Grain Code) IG CODE*
- *The International Code on Intact Stability (IS Code) IMO*
- *International Convention for the Prevention of Pollution from Ships (MARPOL)*
- *International Maritime Solid Bulk Cargoes (IMSBC) Code*
- *The International Safety Management (ISM) Code*
- *Code of Safe Practice for Cargo Stowage and Securing (CSS Code)*
- *The Code of Practice for the Safe Loading and Unloading of Bulk Carriers (BLU Code) & (BLU Manual)*
- *The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)*
- *The International Maritime Dangerous Goods (IMDG) Code*

8. UPDATED FINAL OBJECTIVE (SUMMARY)

The system integrates:

Accurate determination of cargo weight at any given moment.

Early prediction of stability changes (GM, GZ, free surface effect, liquefaction).

Forecasting of resonant and parametric rolling, including recommendations for course and speed adjustments.

Prevention of excessive shear forces and bending moments through dynamic SF/BM monitoring.

Thank you for your attention

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Capt. Georgi Parvanov

+359 883 46 42 06

georgi.parvanov@marad.bg