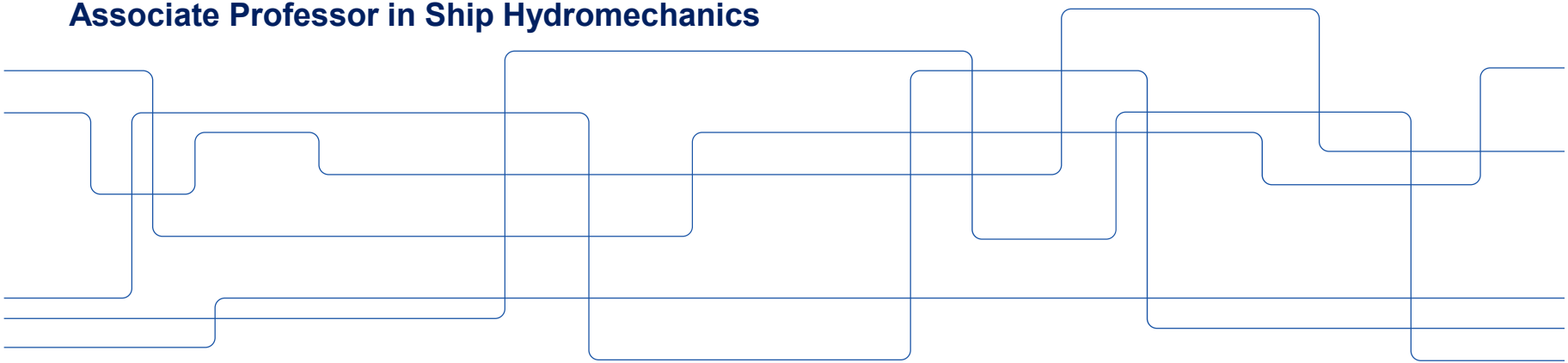
KTH ROYAL INSTITUTE OF TECHNOLOGY

Rethinking Hull Design for a More Sustainable Marine Industry

Abbas Dashtimanesh, abbasda@kth.se

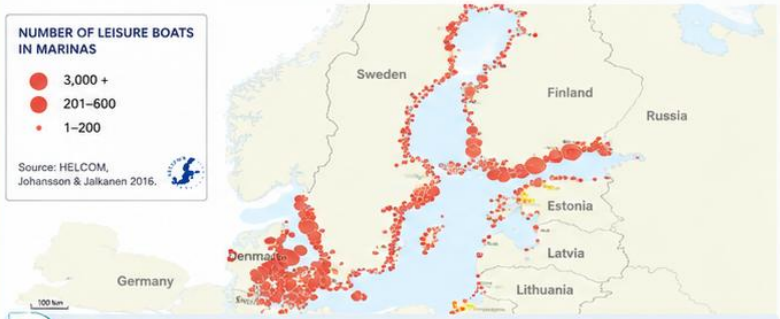
Associate Professor in Ship Hydromechanics



Background

Leisure-boat marinas in the Baltic Sea

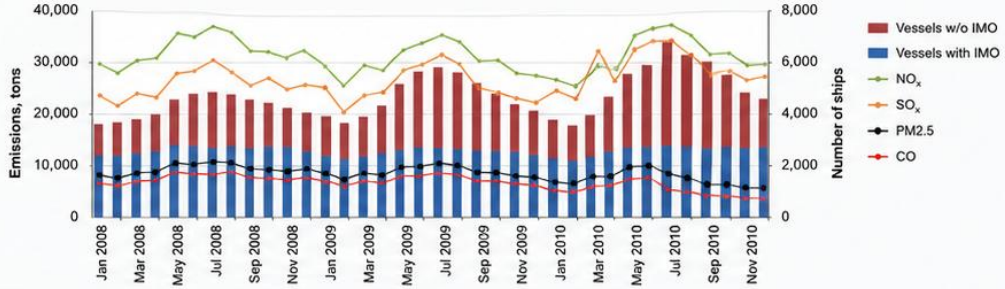
Size of marinas (number of leisure boats, 2016)



Marinas and leisure-boat activity are concentrated along Baltic coasts.

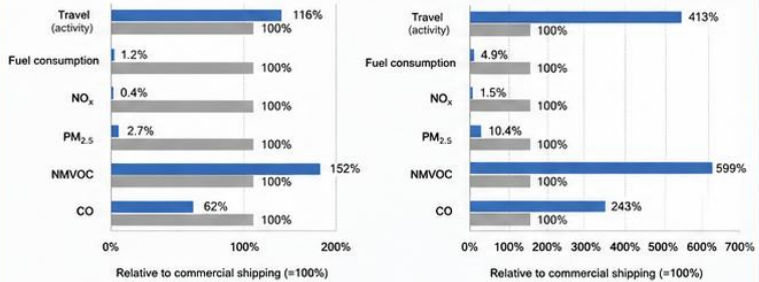
Registered commercial shipping in the Baltic Sea (2008–2010)

Monthly emissions (tons) and number of ships



Commercial-shipping activity is relatively steady over the year.

Annual comparison (2014)

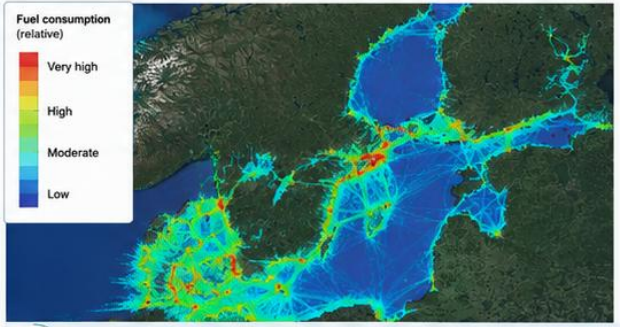


July comparison (2014)

Annually, leisure boats emit less fuel, NO_x and $PM_{2.5}$ but much more NMVOC; in summer, NMVOC and CO from leisure boats are especially high.

- Sweden, Finland, and Denmark have among the world's **highest per-capita boat ownership**.
- More than **900,000** recreational boats in Sweden (2021); about **3.5 million** in the Baltic Sea region.
- Leisure-boat emissions are strongly concentrated in **summer** and near **populated coastal areas**.
- Annual totals are **lower** than commercial shipping for fuel, NO_x and $PM_{2.5}$, but **NMVOC** emissions are much higher and CO becomes especially important in summer.

Summer (July) activity from AIS-based fuel consumption



Activity is concentrated in summer and in coastal waters close to populated areas and marinas.

The Baltic Sea is highly sensitive; water exchange takes about 25 years.

Source: Johansson et al., Model for leisure boat activities and emissions – implementation for the Baltic Sea, Ocean Science, 16(5), 2020.

Building the Green Small Craft Consortium

From consortium formation to EU-funded research focus in the Baltic Sea Region

1

Need identified

Greener high-speed small craft in the Baltic Sea

2

Consortium shaped

Academic + industrial + regional partners

3

Funding secured

European Commission / Interreg Baltic Sea Region

PROJECT

Green Cruising for High-Speed Small Craft in the Baltic Sea (Green Small Craft)

EU-supported collaboration targeting cleaner, safer, and smarter leisure craft



Why it matters for the Baltic Sea

- CO_2 Lower CO_2 and pollutant emissions
- Protect coastal and marine ecosystems
- Safer and more sustainable boating

A Hydrodynamic Design



Hull-form development for lower resistance, improved efficiency, and safer performance

B Propeller and Propulsion System Design



Cleaner propulsion concepts and efficient power delivery

C Automation and Digitalization



Smart monitoring, decision support, and digital tools for operation and design

European Commission

Interreg Baltic Sea Region

Turning a regional environmental challenge into **EU-funded innovation** for a **cleaner Baltic Sea.**

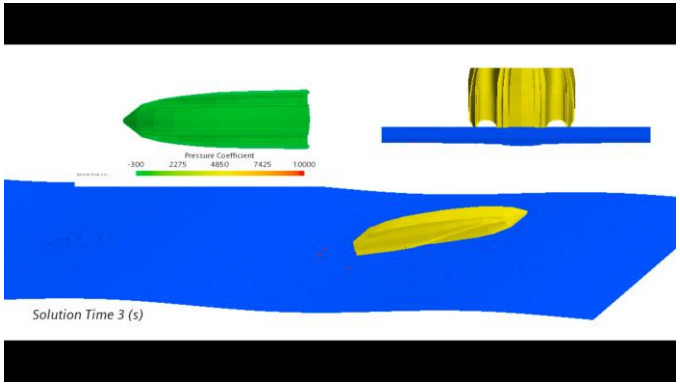
Different Hulls Need Different Engineering Judgement!



Stepped planing hulls



Catamarans



Tunnel hulls



Hydrofoil craft

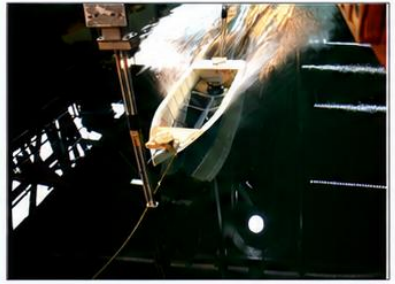
Stepped Hull Systematic Series and Experimental Campaign

1. SYSTEMATIC SERIES – DIMENSIONAL COMPARISON

Model	Unit	Taunton model A	Taunton Model B	Taunton model C	Taunton model D	VMV Stepped Series (present study)
L	[m]	2.00	2.00	2.00	2.00	0.91
B	[m]	0.32	0.39	0.46	0.53	0.268
Δ	[N]	119.25	175.83	243.4	321.95	30.71
$L/\nabla^{1/3}$	[-]	8.7	7.64	6.86	6.25	6.24
L/B	[-]	6.25	5.13	4.35	3.77	3.41
β	[deg]	22.5	22.5	22.5	22.5	23
LCG	[%L]	0.33	0.33	0.33	0.33	from 0.30 to 0.34

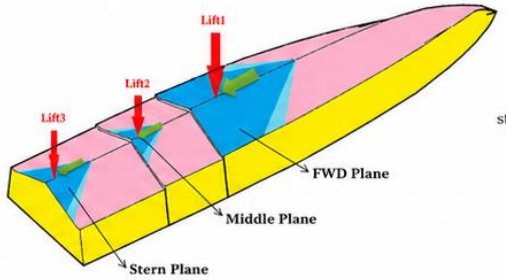
2. LITERATURE / SYSTEMATIC-SERIES COMPARISON

Series	L/B range	⊽ range	B_{TC}/B_C
Clement and Blount (1963)	2.00 7.00	2.97 8.46	0.66
Keuning and Gerritsma (1982)	1.95 6.82	2.99 8.36	0.66
Keuning et al. (1993)	3.41 7.00	3.29 8.25	0.66
Hubble – A (1974)	3.20 9.26	4.0 10.0	0.35
Hubble – B (1974)	2.32 9.28	4.0 10.0	1.00
Kowalyshyn and Metcalf (2006)	3.24 4.50	4.98 0.87	0.96
Taunton et al. (2010)	3.77 6.25	6.25 8.70	1.00
Grigoropoulos and Loukakis (2002)	4.00 7.00	6.18 10.00	–
NSS De Luca and Pensa (2017)	3.24 5.86	4.83 7.49	0.95
VMV Stepped Series (present study)	3.41	6.24	1.00

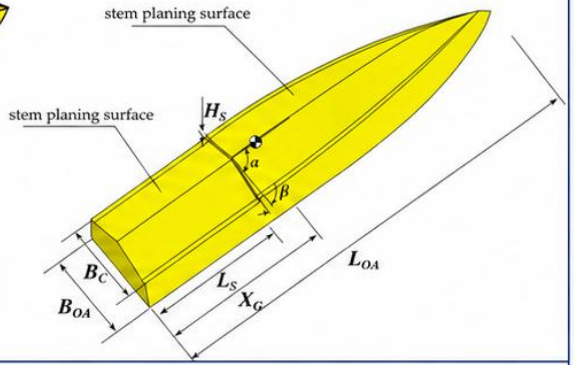




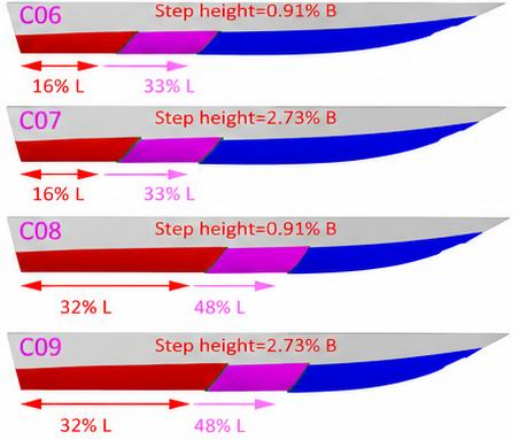
3. STEPPED HULL CONCEPT



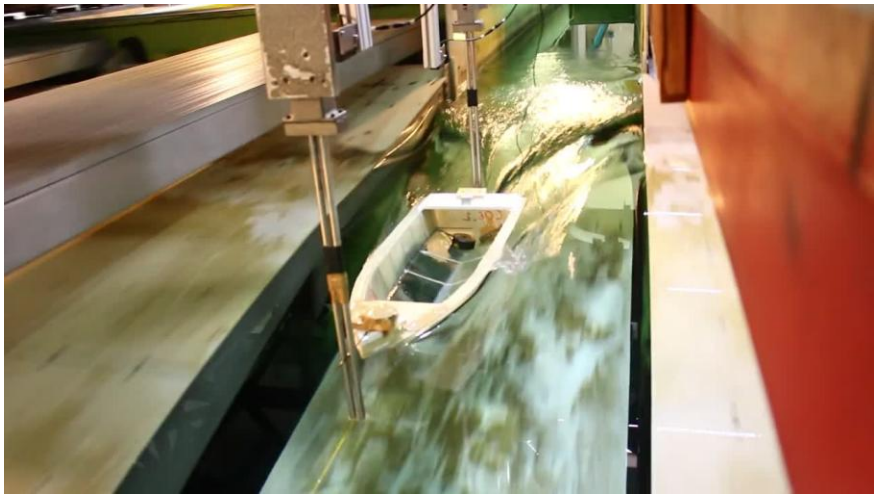
4. GEOMETRY AND SYMBOLS

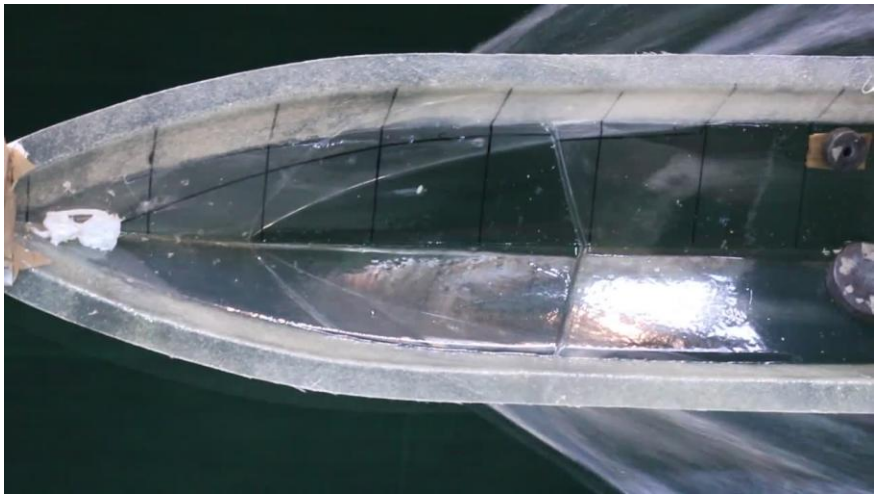






Towing Tank Experiments





Towing-tank measurements

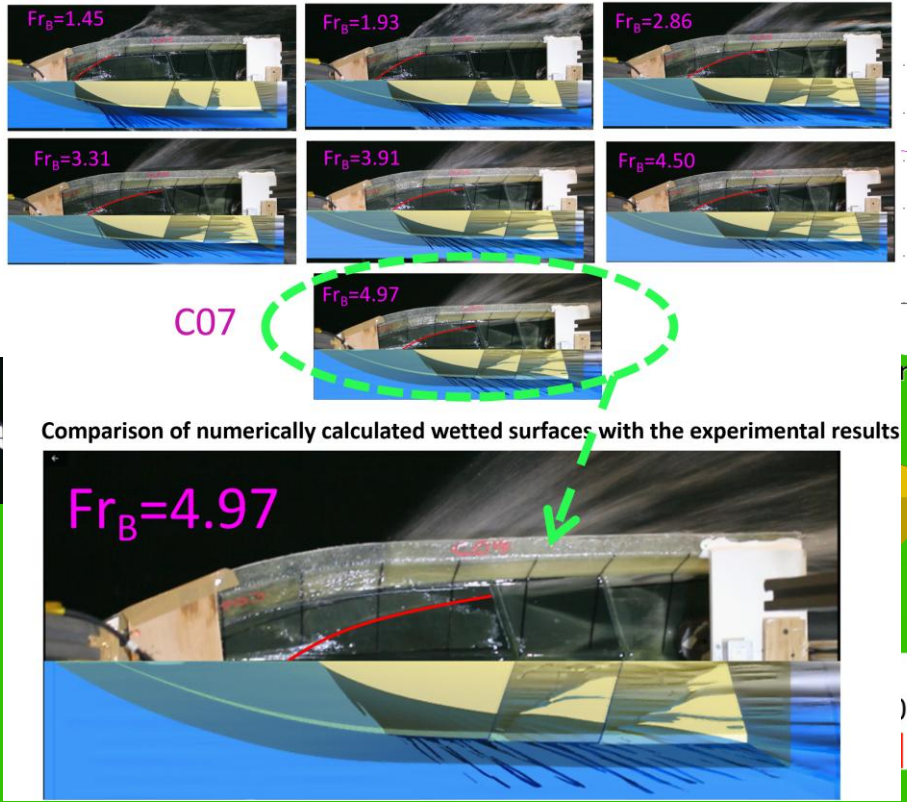
Flow beneath a transparent hull

Napoli Fedrico II University's towing tank – Transparent hull model

Vitiello et al. (2022), A comprehensive stepped planing hull systematic series: Part 1 – resistance test, Ocean Engineering 266, 112242.

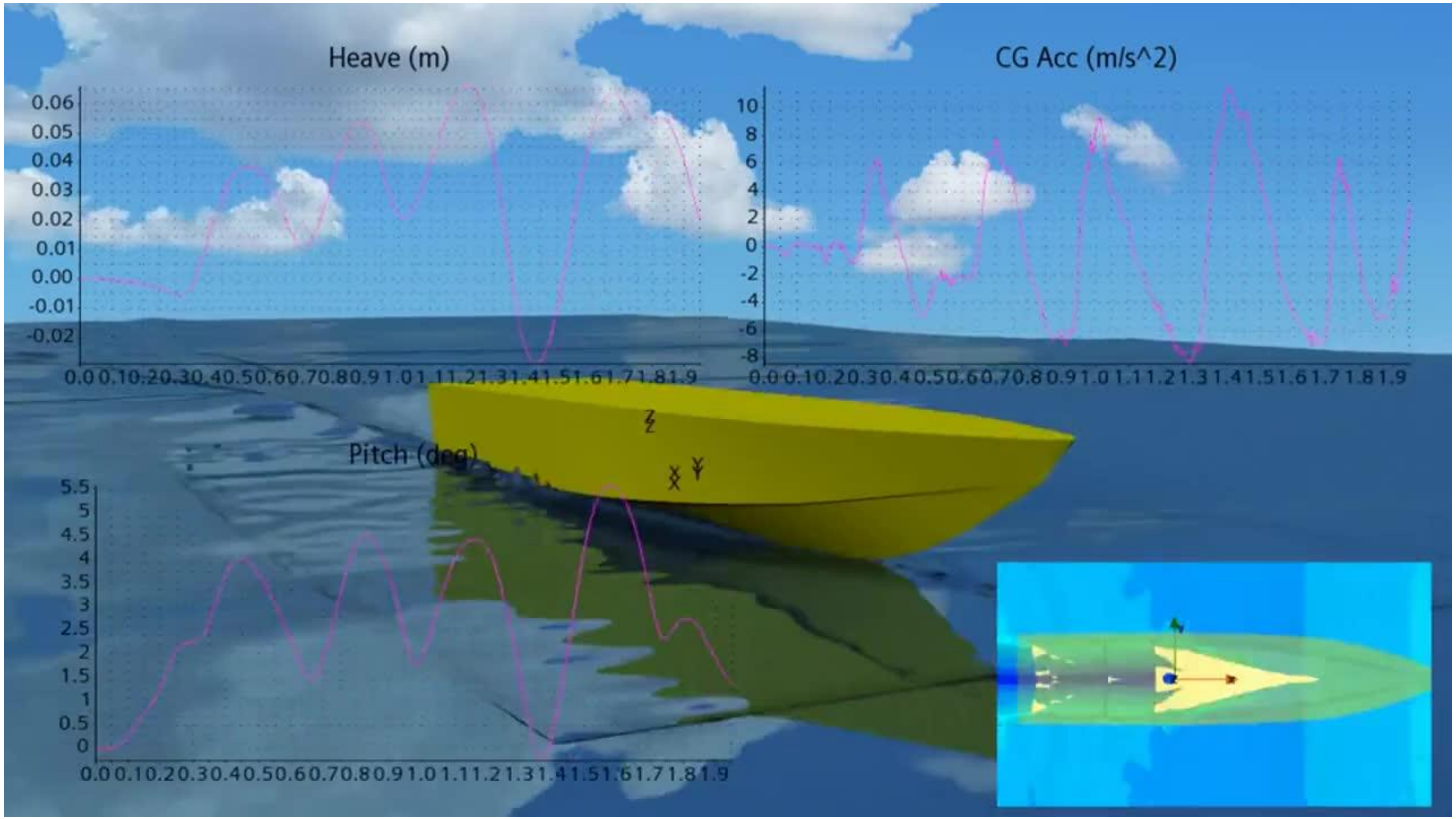
CFD Simulations

EXP



Niazmand Bilandi, R., Dashtimanesh, A., Mancini, S. & Vitiello, L. (2023). Comparative study of experimental and CFD results for stepped planing hulls. Ocean Engineering, 280, 114887-114887.

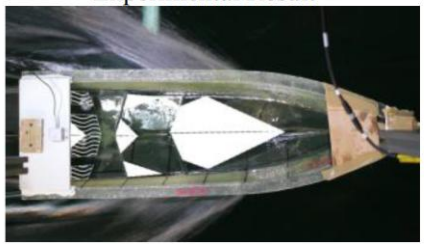
CFD simulations



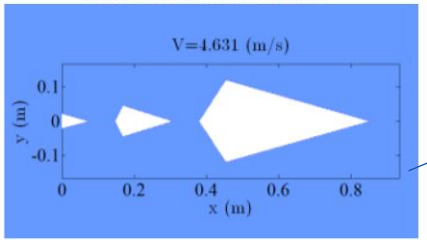
Bilandi, R. N., Tavakoli, S., Mancini, S. & Dashtimanesh, A. (2024). Dynamic motion analysis of stepless and stepped planing hulls in random waves: A CFD model perspective. Applied Ocean Research, 149.

Mathematical Modelling (2D+t)

Experimental Result



Mathematical Method



Niazmand Bilandi, R., Tavakoli, S. & Dashtimanesh, A. (2021). Seakeeping of double-stepped planing hulls. Ocean Engineering, 236, 109475-109475.

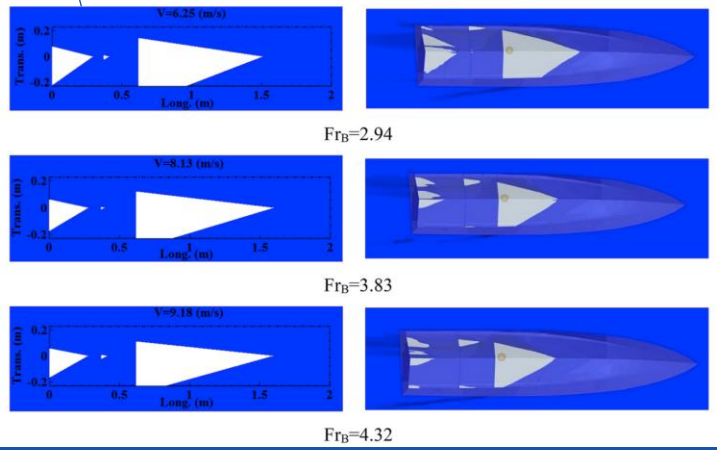
Calm Water

Regular Waves

Manoeuvring

Heel angle of 10°

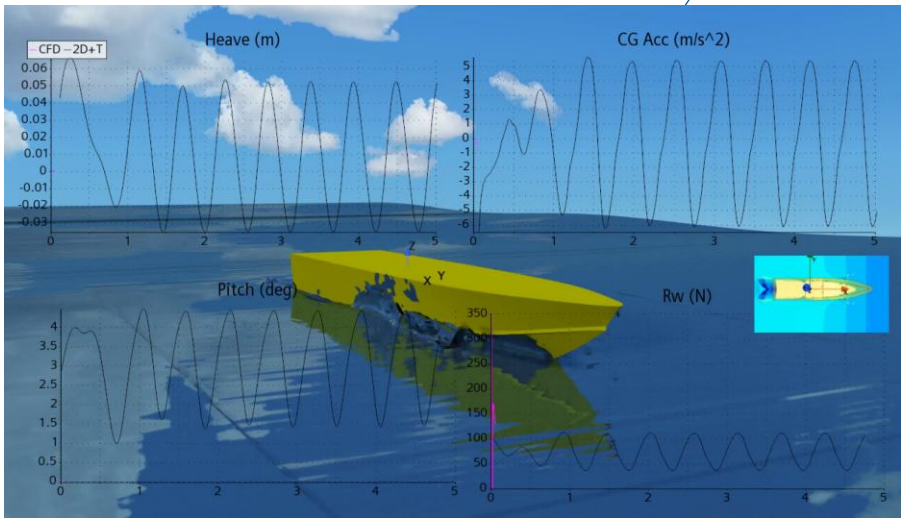
2D+T method | CFD



Fr_B=2.94

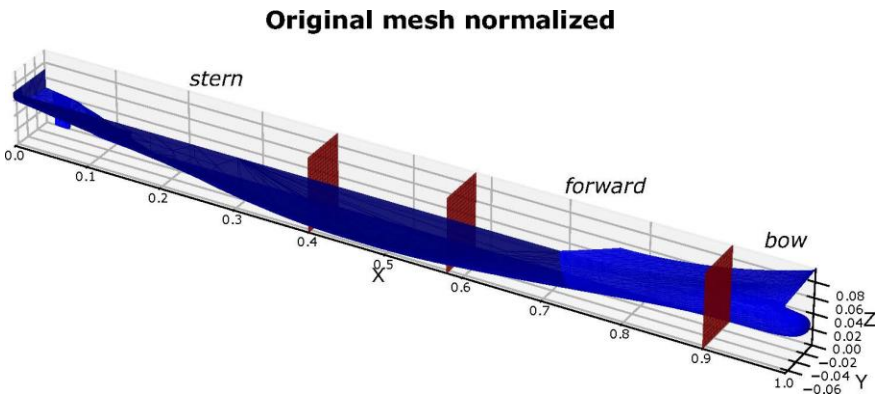
Fr_B=3.83

Fr_B=4.32

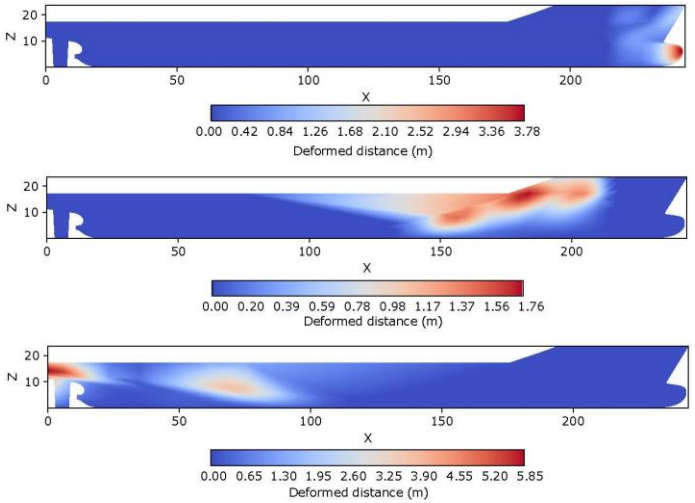


Generative AI for Hull Design

Starting geometry

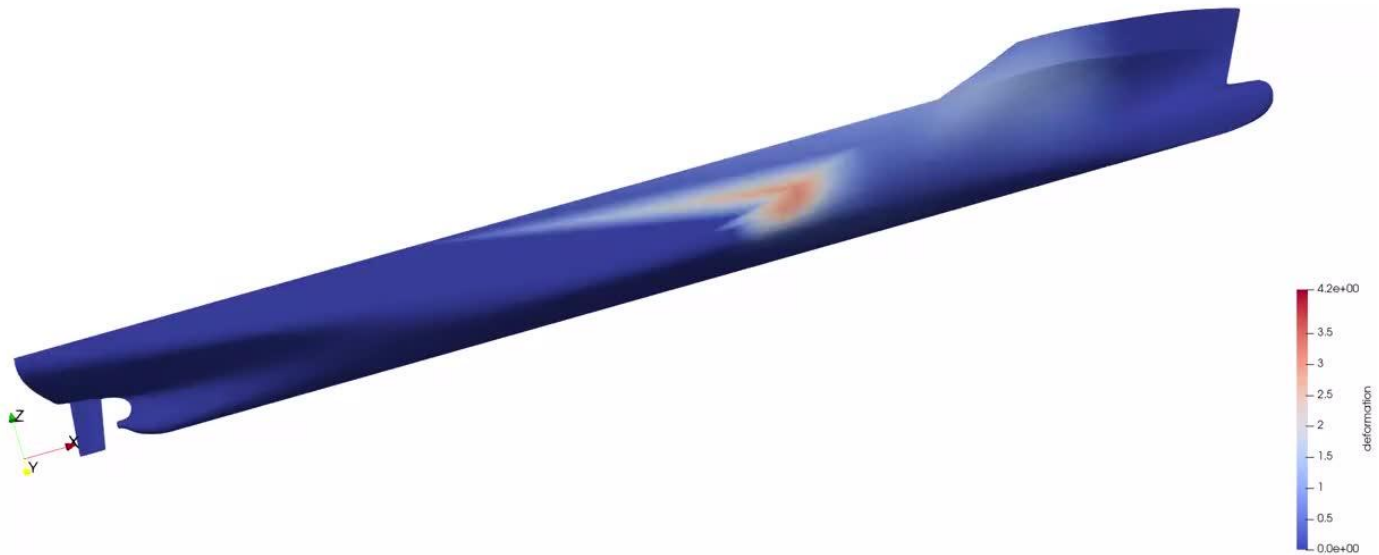


Examples from the hull dataset



Generative AI can generate and explore more candidate hull forms!

Hull variation for AI-based design



Concluding remark

Generative AI can widen the search.
Hydrodynamic knowledge guides the choices.

Current development

Commercial-ship hulls.

The next application

Small craft, supported by our hydrodynamic experience.



Boat-specific hull data and performance requirements

KTH ROYAL INSTITUTE OF TECHNOLOGY

Rethinking Hull Design for a More Sustainable Marine Industry

Abbas Dashtimanesh, abbasda@kth.se

Associate Professor in Ship Hydromechanics

