

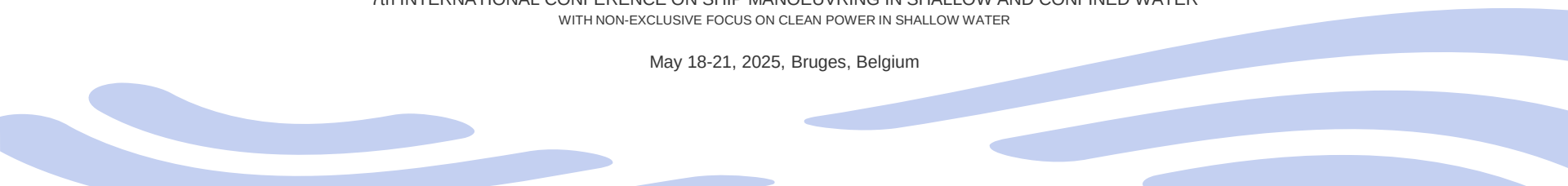
Exploring the hydrodynamic effects at high rudder angles on inland vessels

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7th INTERNATIONAL CONFERENCE ON SHIP MANOEUVRING IN SHALLOW AND CONFINED WATER
WITH NON-EXCLUSIVE FOCUS ON CLEAN POWER IN SHALLOW WATER

May 18-21, 2025, Bruges, Belgium

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1. Introduction
2. Experimental campaign
3. Results and discussion
4. Concluding remarks

Why?

Manoeuvring simulation involving inland vessels in initial design stage

Many of the existing formulations and assumptions used to predict inland vessel manoeuvrability are derived from maritime studies.

MMG models developed under deep-water conditions, further limiting their applicability to inland vessels.

Current state neglects asymmetries that may arise between port and starboard side in manoeuvring.

What is this work about?

This study investigates how rudder deflections influence the thrust, and therefore the wake, generated by the propulsion system of a TPQR inland vessel in straight-moving conditions across various scenarios.

2. Experimental campaign

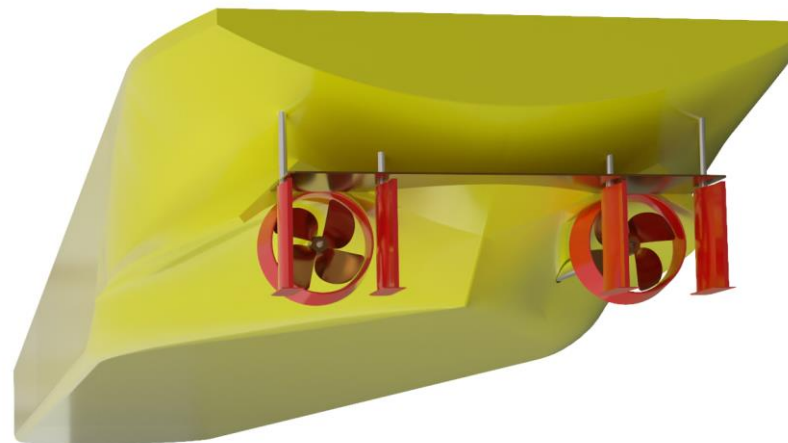
The experimental campaign aimed to gather data on propulsion system thrust under varying loading conditions, water depths, speeds, and rudder angles during steady-straight motion.

SAMPLE INLAND MODEL

Large vessel operating on the Rhine
Twin-propeller quadruple-rudder (TPQR)

L_{PP} [m]	B [m]	T [m]	C_B [-]	A_R [m ²]	Λ_R [m ²]	D [m]
110	11.40	2.8	0.901	2.372	1.256	1.6

Table in FULL SCALE

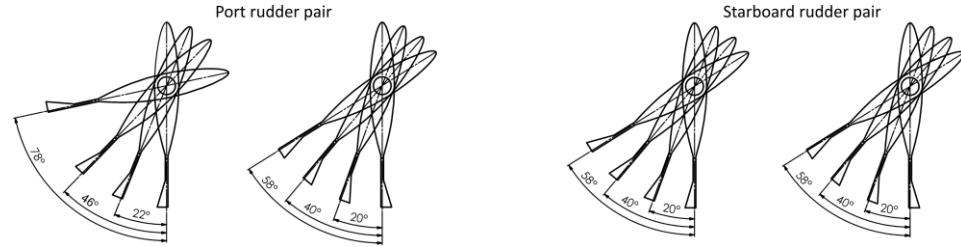


2. Experimental campaign

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TYPE OF TESTS

1. Self-propulsion tests with rudders (neutral position)
2. Propulsion tests with deflected rudders (same propeller revolution rates of the ship self-propulsion points)



RESULTS

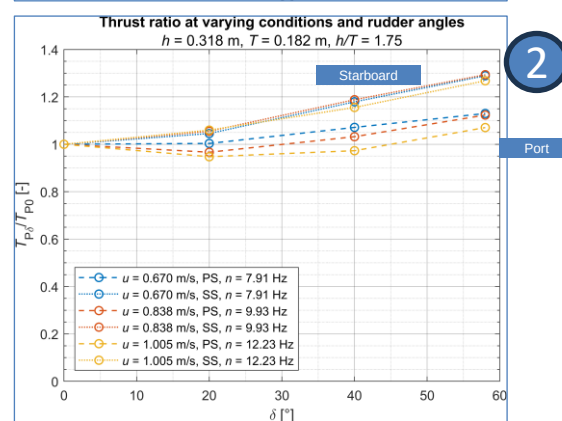
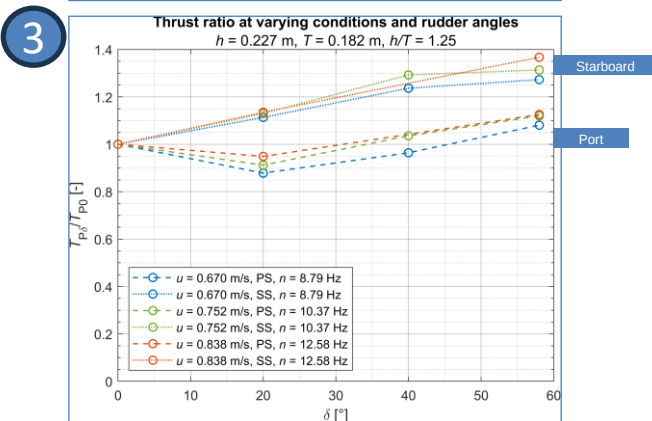
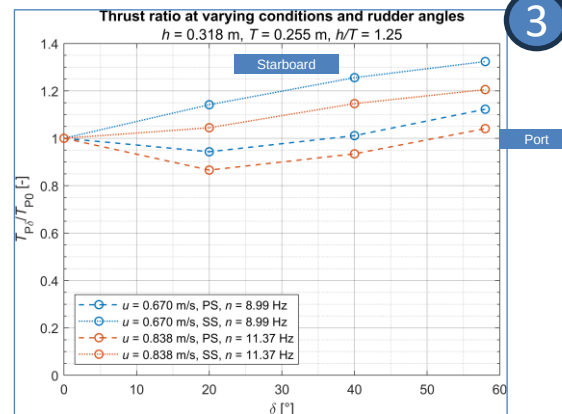
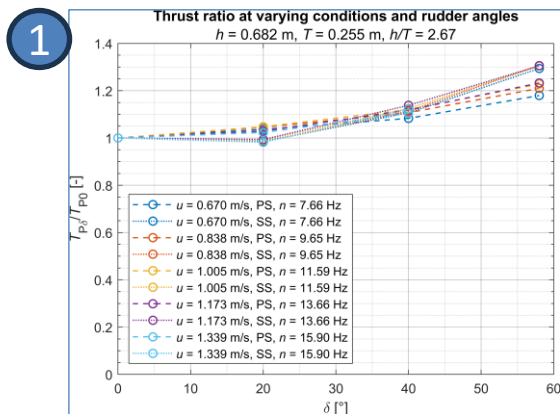
Presented in form of:

1. Thrust of the propulsion system
2. Wake fractions (using the thrust identity method)

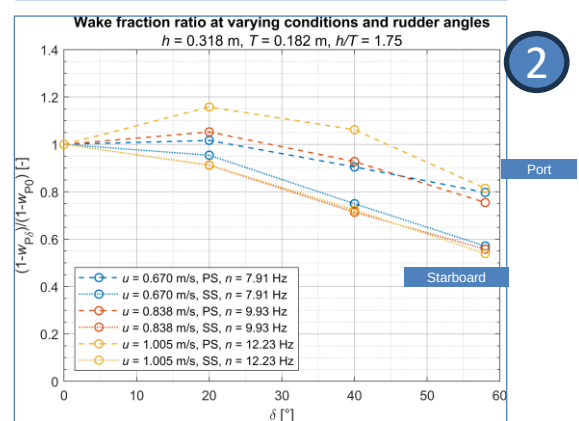
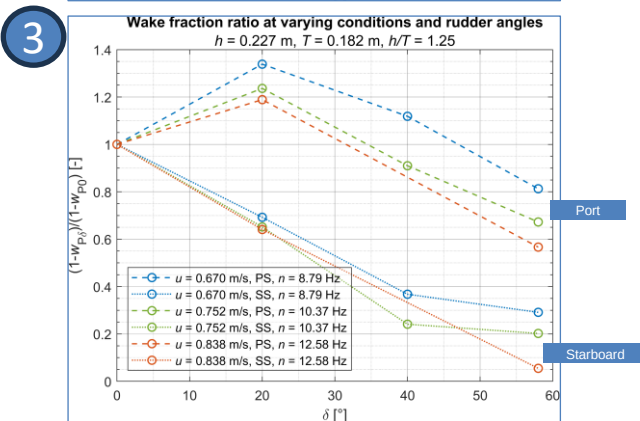
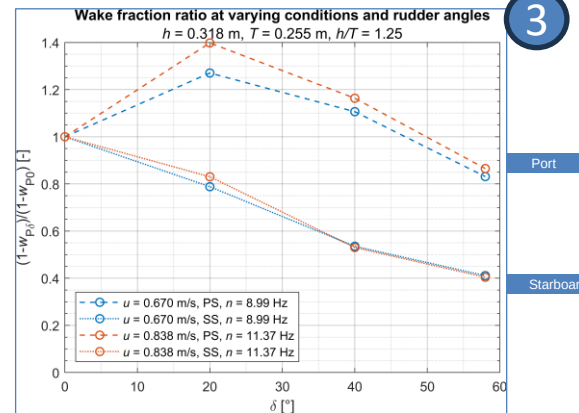
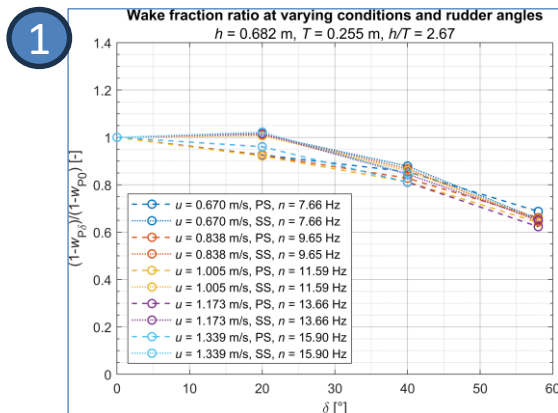
across all scenarios.

↓ T [m] / h [m] →	7.5	3.5	2.5
2.8 (even keel)	✓ (h/T = 2.67)	✓ (h/T = 1.25)	
2.0 (even keel)		✓ (h/T = 1.75)	✓ (h/T = 1.25)
Speeds from 8 to 16 km/h Table in FULL SCALE			

3. Results and discussion



3. Results and discussion



Wake fraction
from thrust
identity

4. Concluding remarks

Key findings

High rudder deflections lead to:

1. Increased thrust (up to about 35%) and reduced flow (up to about 95%)
2. Asymmetries between the port and starboard sides becoming more pronounced as the h/T ratio decreases (up to about 25% in thrust and 70% in wake)

Furthermore:

1. Starboard side exhibits a more pronounced increase in thrust ratio and decrease in wake ratio at lower h/T ratios compared to the port side (rudder deflections occur to the port side)
2. The velocity, together with the corresponding self-propulsion point n , plays a more significant role in terms of thrust and wake variation at low h/T ratios.

The present study highlights the need to reassess traditional maritime-derived approaches and promote the development of methodologies that better account for the differences between inland and seagoing vessels and environments.

Thank you for your attention!

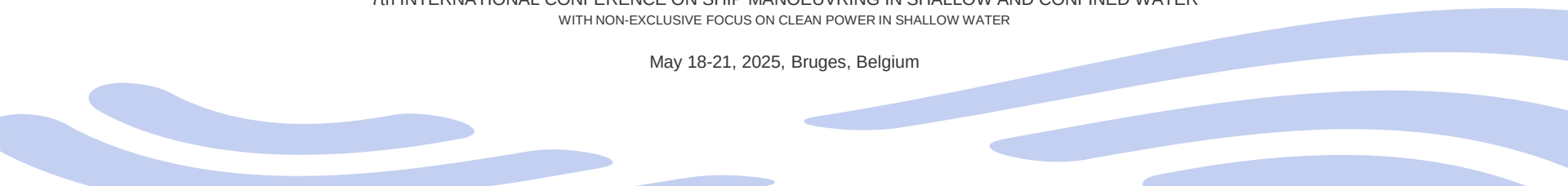
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