2nd COB seminar
February 6, Ostend, Belgium

SHIP MODEL TESTING IN THE TOWING TANK FOR MANOEUVRES IN SHALLOW WATER AND BEYOND

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Guillaume DELEFORTRIE

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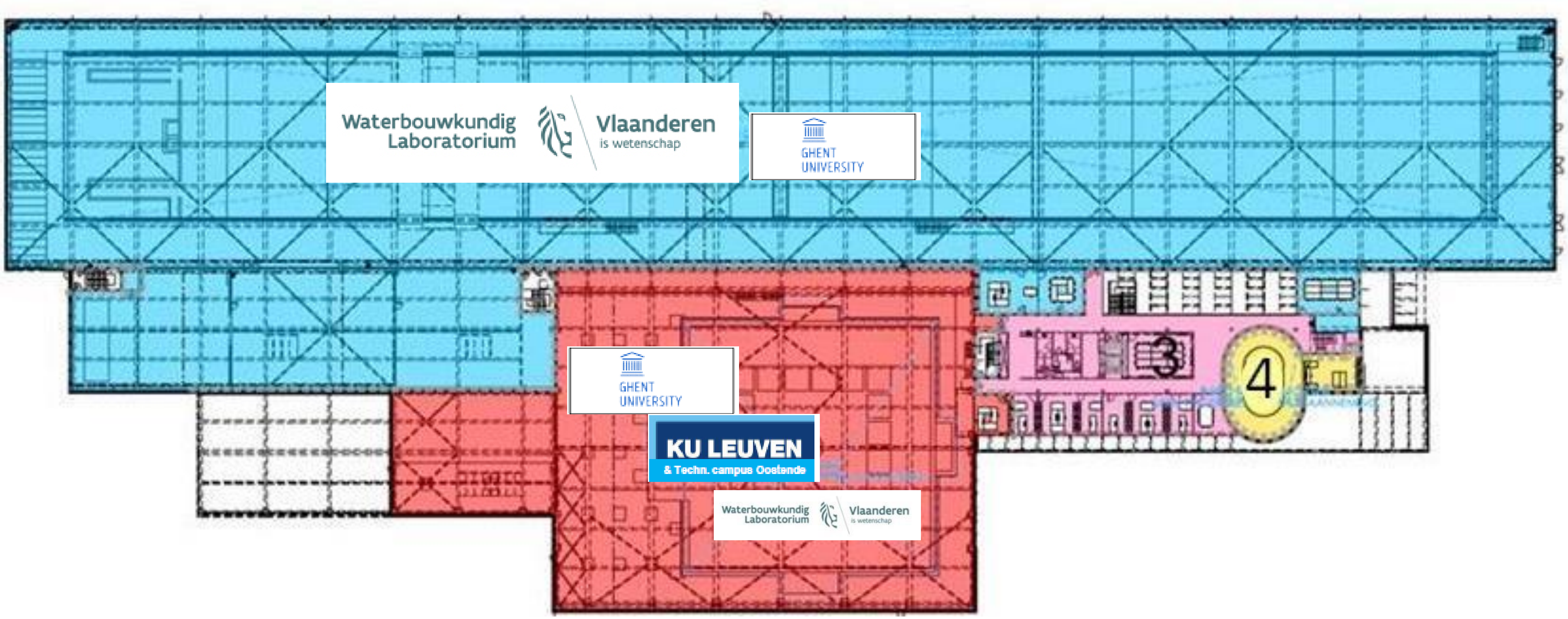
1. Flanders Maritime Laboratory

Flanders Maritime Laboratory:
a brand of a house of brands



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Business plan towing tank 2

2011

Gen4Wave project

2013

2019

Opening FML

2020

Design towing carriage

2022

Start commercial exploitation

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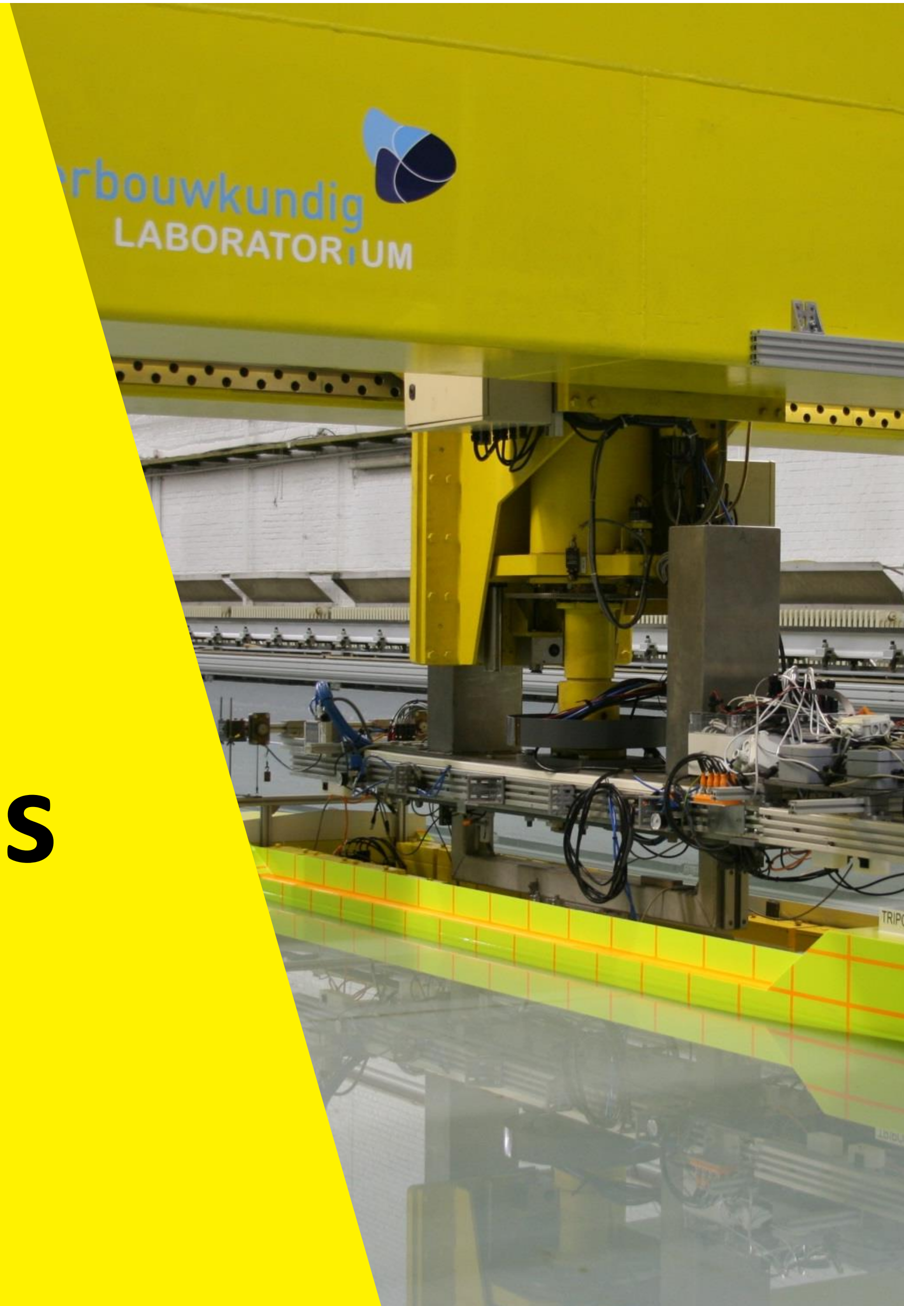
2. Towing Tank for Manoeuvres in Shallow Water



Flanders Maritime Laboratory: towing tank

- **scale factor 95 -> 55**
- **fully automated, unmanned operation**

		Antwerp	Ostend	Ratio
year		1992	2020	-
Length	m	87.5	174	2
Width	m	7.0	20	**3**
max. water depth	m	0.50	1.0	2
ship model length	m	3.5-4.5	3.5-8.0	1-2

Flanders Maritime Laboratory: towing tank

- **New benefits:**
  - → Observation tunnel and windows
  - → Minimal steering in 4 DOF (horizontal plane + roll), preferably 6 DOF (hexapod)
  - → Ship sizes
  - → State of the art wave maker
  - → Commercial availability on short term
  - → Application for ITTC Advisory Council

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3. Manoeuvring of ships

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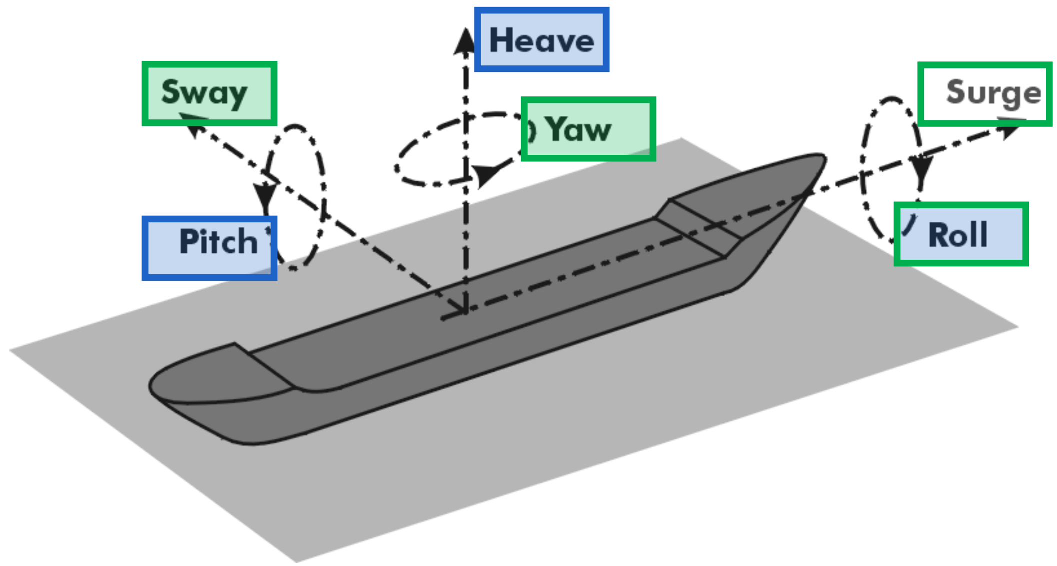
Forces:

- Surge X
- Sway Y
- Heave Z

Moments:

- Roll K
- Pitch M
- Yaw N

MANOEUVRABILITY = the ease to change a course



Sway velocity v, sway acceleration v

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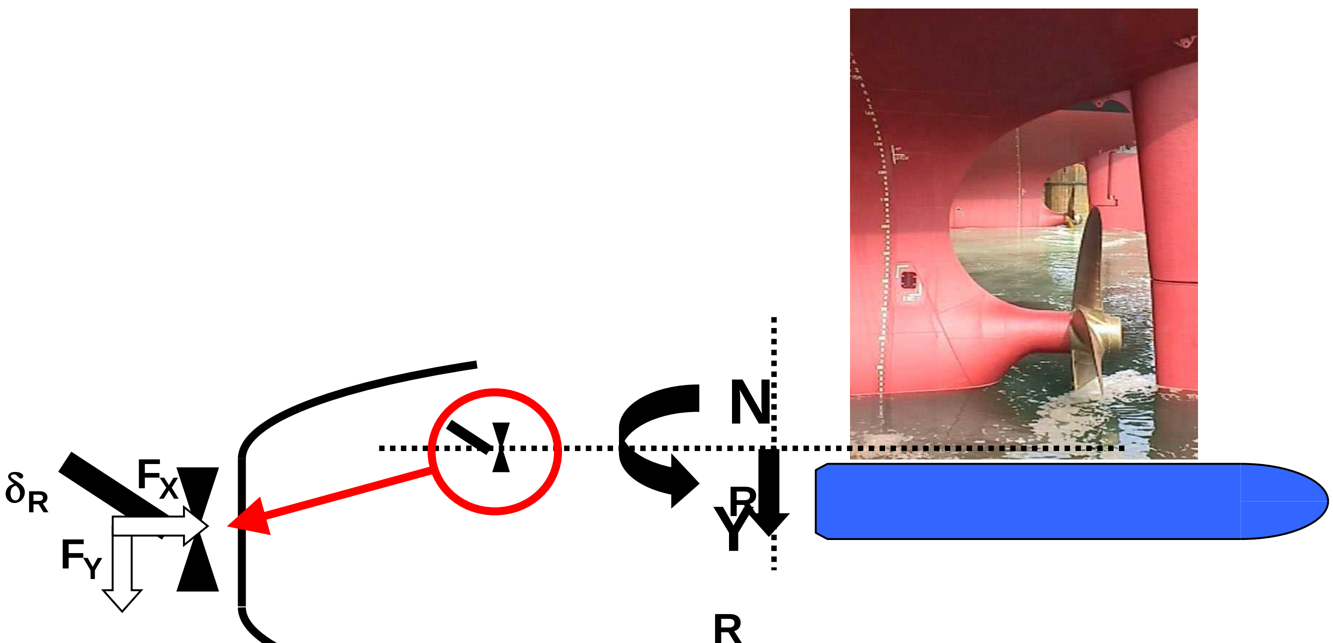
$$-Y_{\delta}\delta_R = Y_v v + (Y_{\dot{v}} - m)\dot{v} + (Y_r - mu)r + (Y_{\dot{r}} - mx_G)\dot{r}$$

$$-N_{\delta}\delta_R = N_v v + (N_{\dot{v}} - mx_G)\dot{v} + (N_r - mx_G u)r + (N_{\dot{r}} - I_{zz})\dot{r}$$



$$Y_R = Y_{\delta}\delta_R$$

$$N_R = N_{\delta}\delta_R$$

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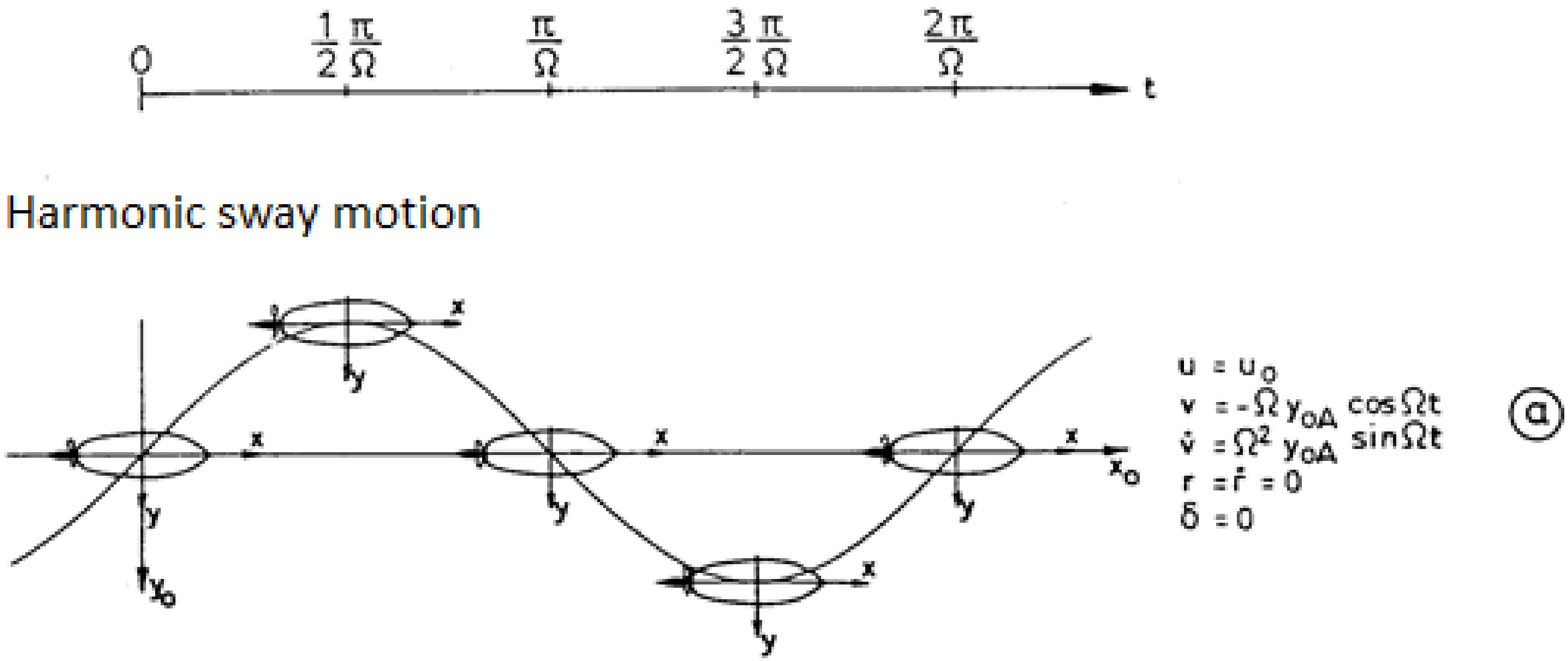
- **Harmonic sway**



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Harmonic sway

$$v = v_A \cos \omega t$$

$$\dot{v} = \frac{dv}{dt} = -\omega v_A \sin \omega t$$

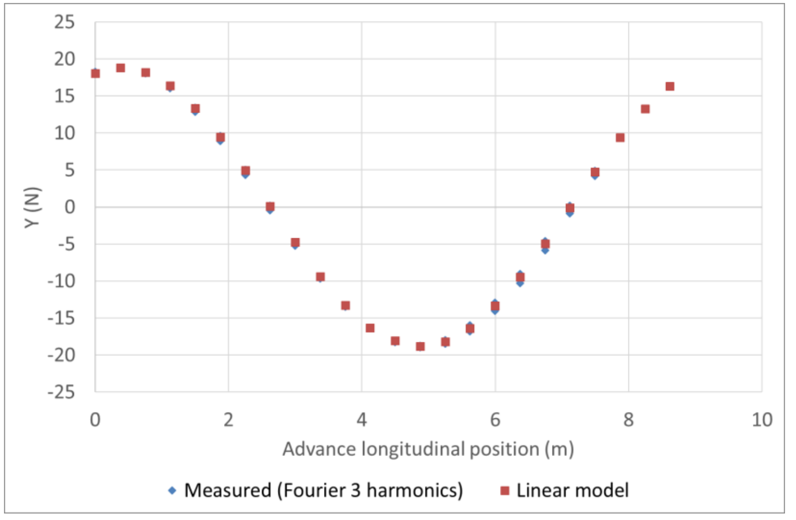
$$Y = Y_v v_A \cos \omega t - (Y_{\dot{v}} - m)\omega v_A \sin \omega t$$

$$N = N_v v_A \cos \omega t - N_{\dot{v}} \omega v_A \sin \omega t$$

Fourier Analysis

$$Y = Y_a \cos \omega t + Y_b \sin \omega t$$

$$N = N_a \cos \omega t + N_b \sin \omega t$$



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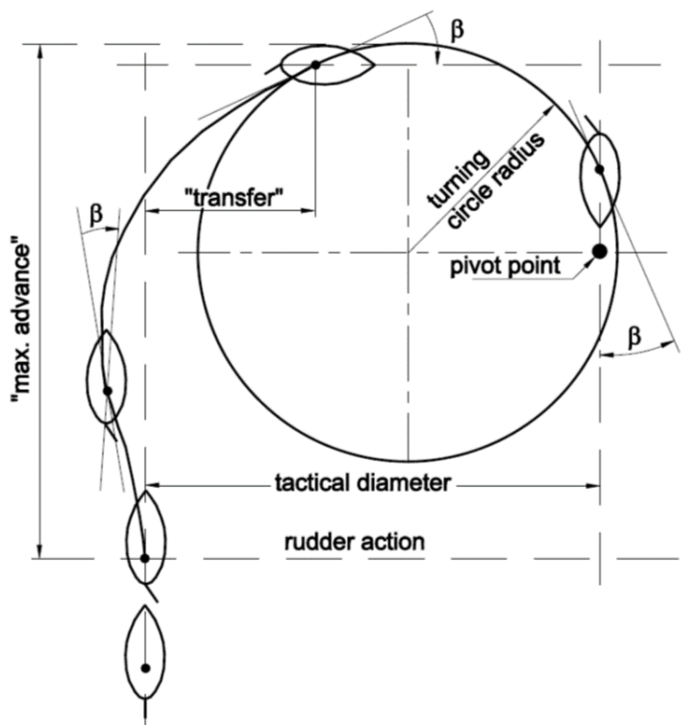
- **Simulation of manoeuvres**

$$R = \frac{L}{r'} = \frac{Y'_v(N'_r - m'x'_G) - N'_v(Y'_r - m')}{Y'_\delta N'_v - N'_\delta Y'_v} \frac{L}{\delta_R}$$



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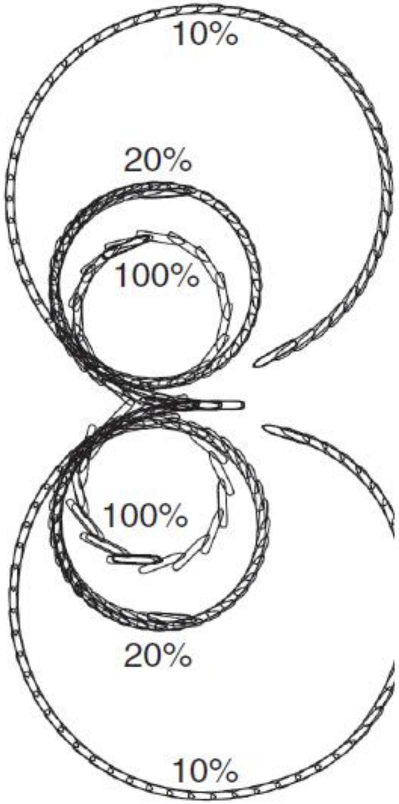
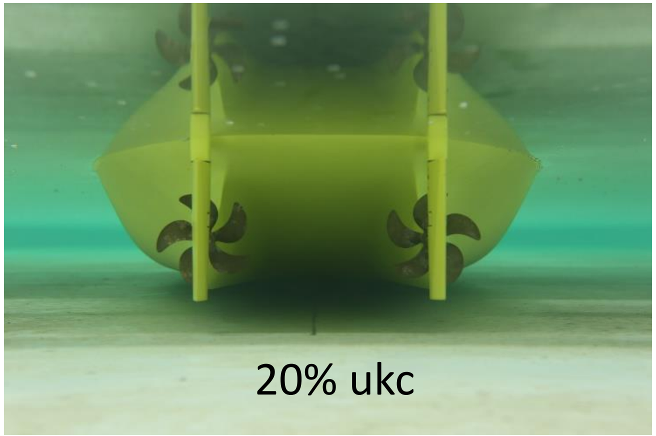
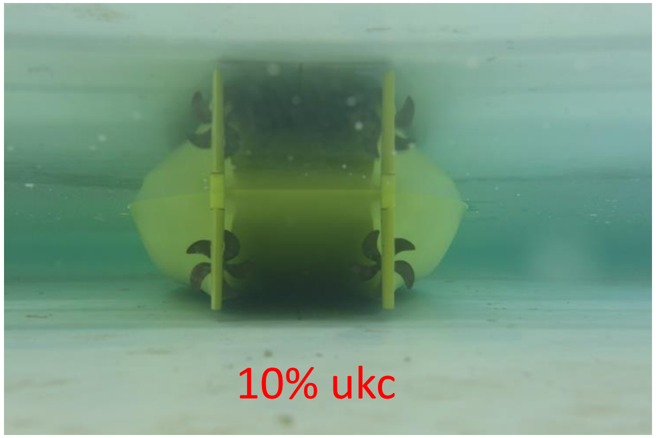
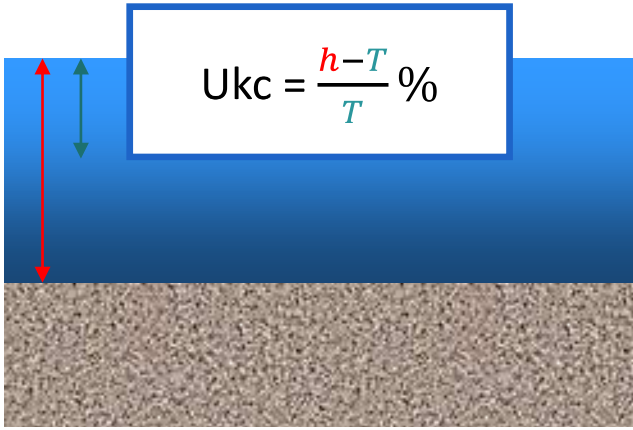
▸ Simulation of shallow manoeuvres









$$\text{Ukc} = \frac{h - T}{T}\,\%$$

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4. Alternative methods

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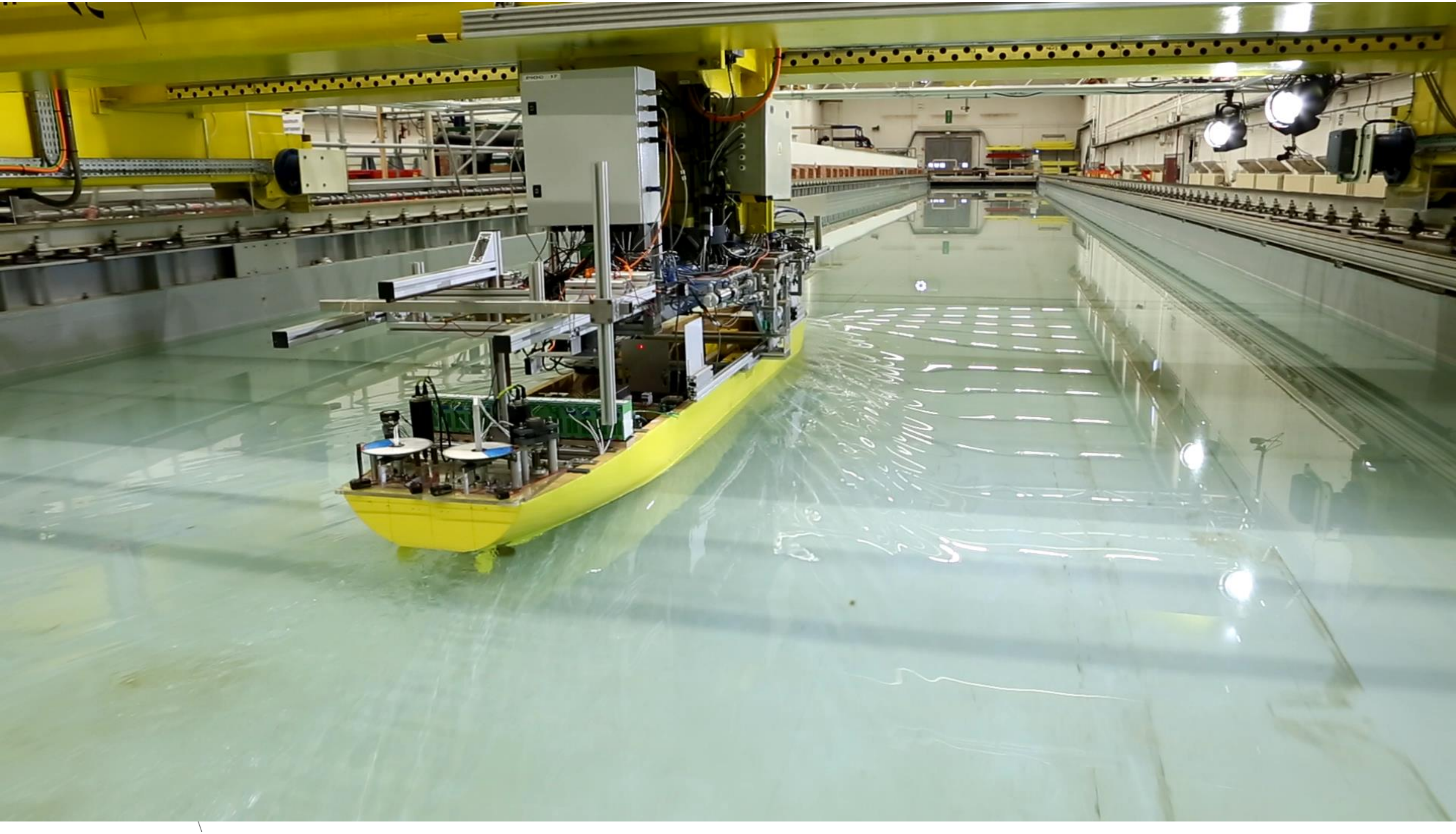
- **Free running model tests**



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- **Free running model tests**
  → In waves

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5. and beyond

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- **Free running model tests**
  - → In waves
  - → In wind
  - → In current

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Validation of numerical tools

132 P.M. Carrica et al. / Ocean Engineering 112 (2016) 117–133

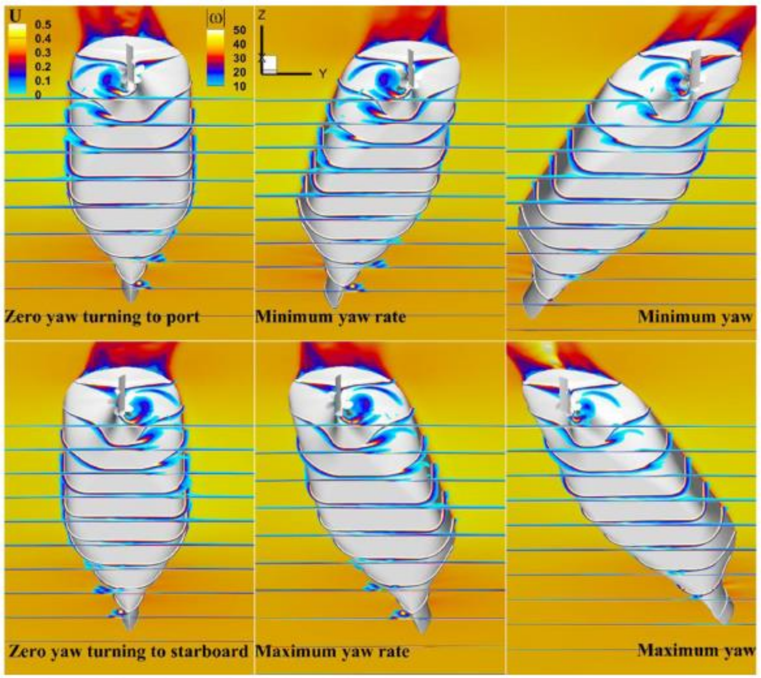

Fig. 18. Cross sections colored with vorticity magnitude showing the boundary layer at instantaneous points of zero yaw turning to port, minimum yaw rate, minimum yaw, zero yaw turning to starboard, maximum yaw rate and maximum yaw. Free surface colored with velocity.

130 P.M. Carrica et al. / Ocean Engineering 112 (2016) 117–133

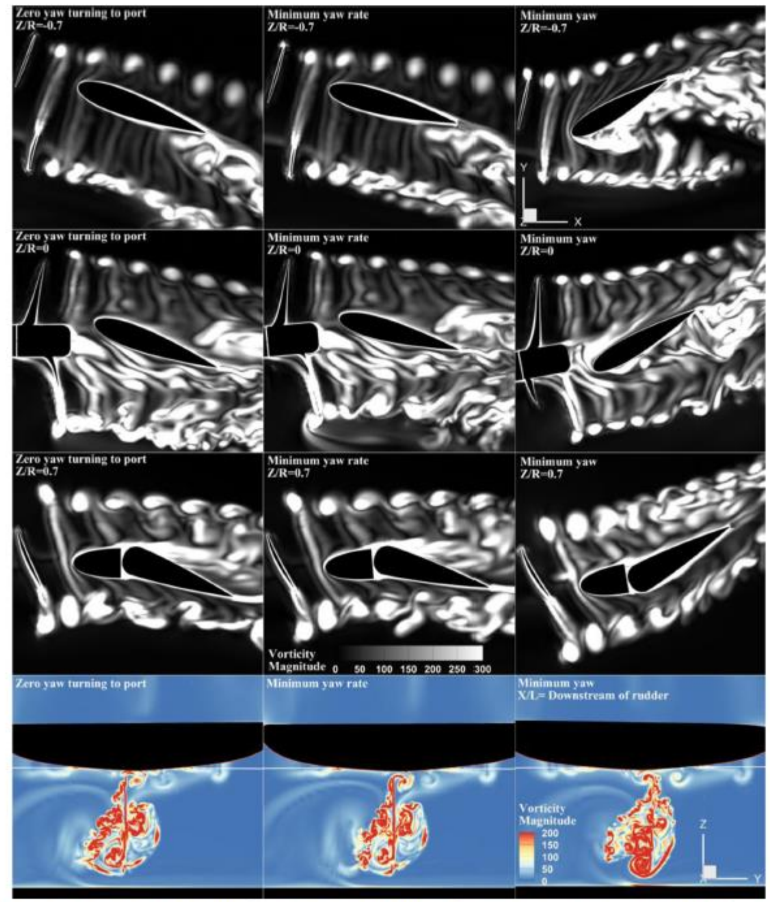

Fig. 16. Horizontal sections 0.7*R* below the propeller axis ($\frac{z}{R}=-0.7$, top row), at the propeller axis ($\frac{z}{R}=0$, second row), and 0.7*R* above the propeller axis ($\frac{z}{R}=0.7$, third row), and axial cross section at the trailing edge of the rudder (bottom row), showing vorticity magnitude at instantaneous points of zero yaw turning to port, minimum yaw rate and minimum yaw.

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6. Q&A