

VALIDATION OF SLENDERFLOW IN SHIP – SHIP INTERACTION SCENARIOS

7TH MASHCON

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27/05/2025

OUTLINE

1. Introduction
2. Theoretical background
3. Experimental program
4. Comparison of SlenderFlow with experiments

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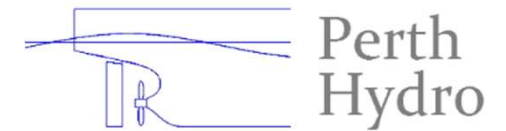




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SLENDERFLOW

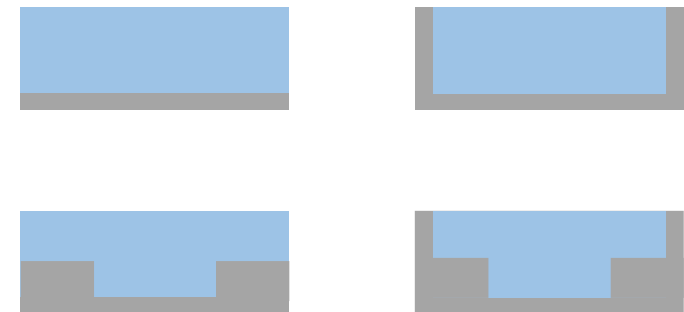
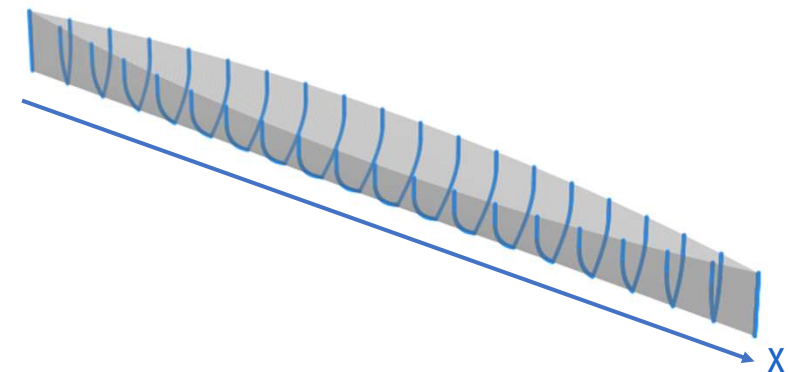


INPUTS

- Hull shape (offsets $B(x)$ and $S(x)$)
- Ship speed
- Channel type
- Channel dimensions

OUTPUTS

- Squat and draft at bow, midships and stern
- Hydrodynamic pressures
- Drawdown on canal banks



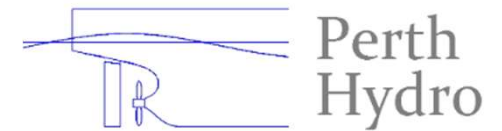
Slide 7

AV0 Logo van Perth Hydro werd toegevoegd, omdat ik hier echt over de code SlenderFlow praat; Goed zo? Weglaten? Op alle slides logo vermelden?

Verbeke Andreas; 2025-05-12T10:38:54.795

SLENDERFLOW

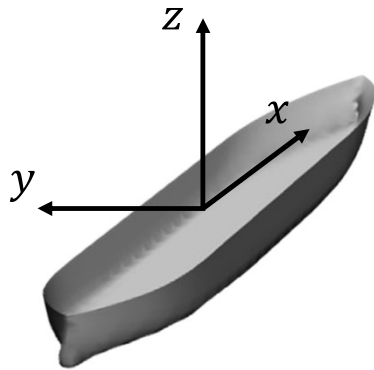
- Boundary value problem



$$(1 - Fr_h^2) \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0$$

$$\frac{\partial \phi}{\partial y} = \pm \frac{U}{2h} S'(x) \text{ on } y = 0_{\pm}$$

Inner (hull) boundary condition (BC)



$$\begin{cases} \frac{\partial \phi}{\partial x}, \frac{\partial \phi}{\partial y} \rightarrow 0 \text{ as } y \rightarrow \pm\infty \\ \frac{\partial \phi}{\partial y} = 0 \text{ on } y = \pm \frac{w}{2} \\ \dots \end{cases}$$

These BCs depend on the bathymetry!

SLENDERFLOW

- Pressure field calculation

$$p(x, y) = -\rho U \frac{\partial \phi}{\partial x}$$

- Calculation of heave force Z and trimming moment M

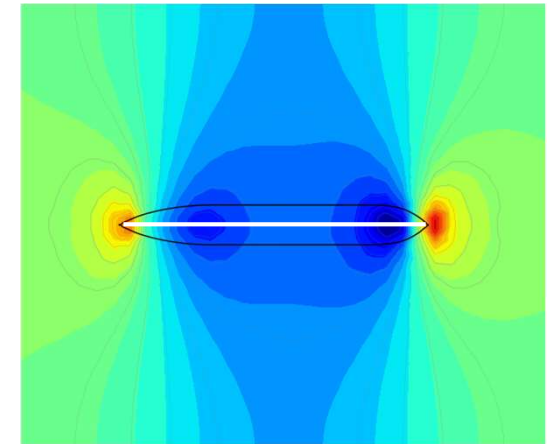
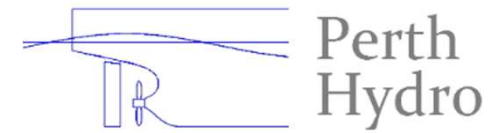
$$Z = \int p(x, 0) B(x) dx$$

$$M = \int p(x, 0) (x - x_{LCF}) B(x) dx$$

- Sinkage and trim (hydrostatic balance)

$$s_{LCF} = -\frac{Z}{\rho g A_W}$$

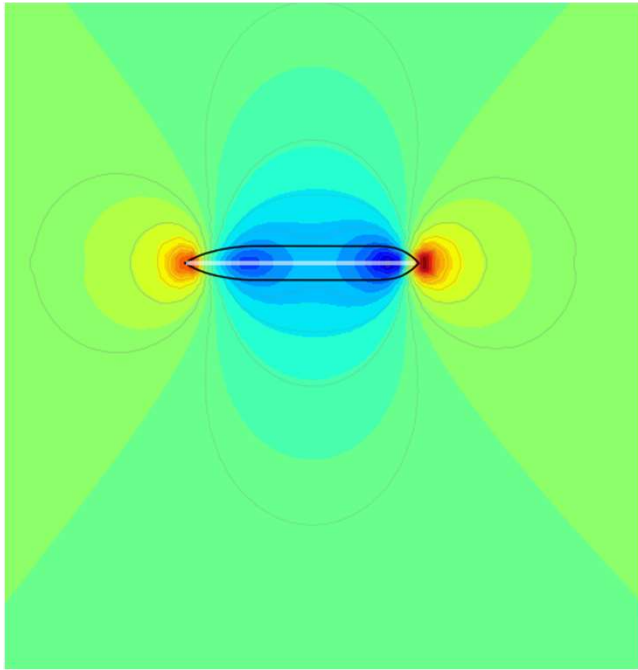
$$\theta_{LCF} = \frac{M}{\rho g I_{LCF}}$$



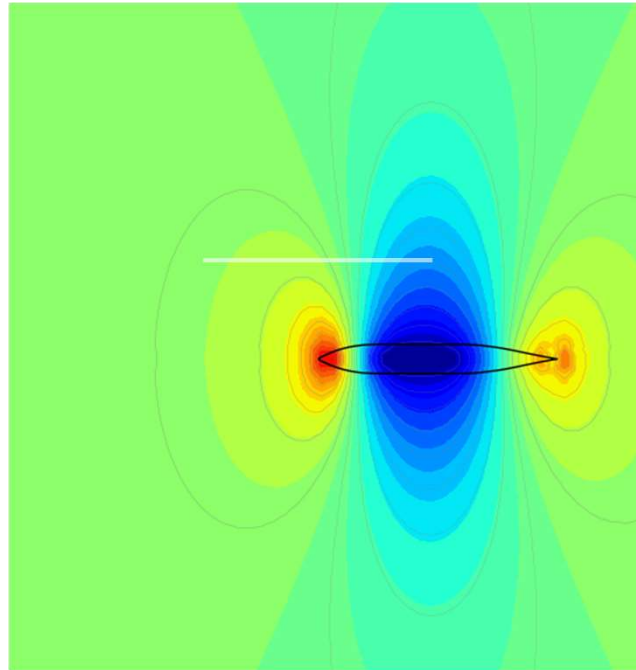
INTERACTION WITH SLENDERFLOW

- Based on Gourlay (2009)*
- Linear superposition of the (steady) pressure fields due to each ship in open water
- Ship-bound reference systems move in time

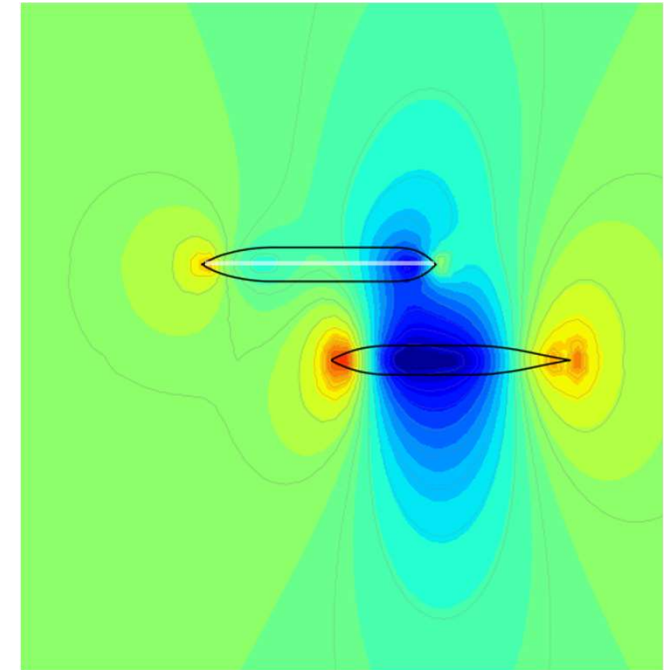
* Gourlay, T. (2009). Sinkage and trim of two ships passing each other on parallel courses. *Ocean Engineering*, 36(14), 1119-1127



$$Z = \int p_{\text{own}}(x, 0)B(x)dx$$



$$Z = \int p_{\text{tar}}(x, 0)B(x)dx$$



$$Z = \int (p_{\text{own}}(x, 0) + p_{\text{tar}}(x, 0))B(x)dx$$

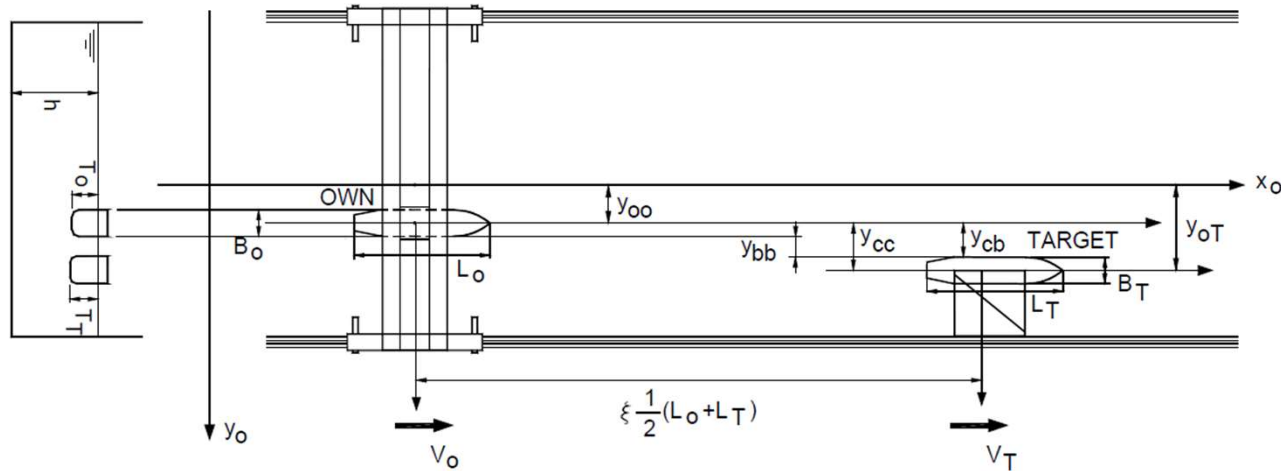
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TOWING TANK DATA FOR VALIDATION

- Systematic towing tank tests at Flanders Hydraulics (2000)**

** Vantorre, M., Verzhbitskaya, E., & Laforce, E. (2002). Model test based formulations of ship-ship interaction forces. *Ship Technology Research*, 49(3), 124-141

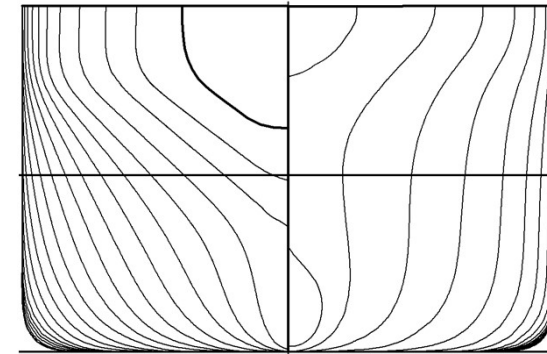
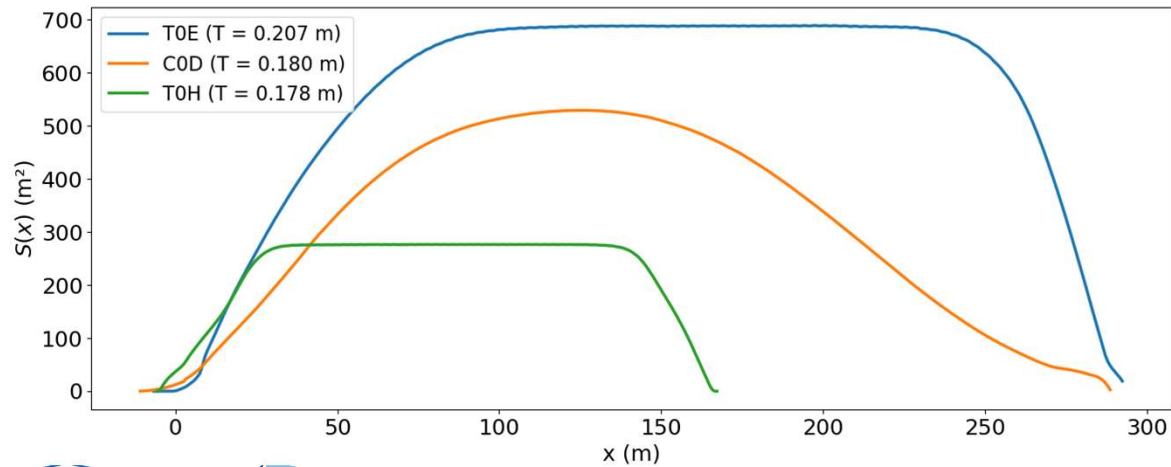
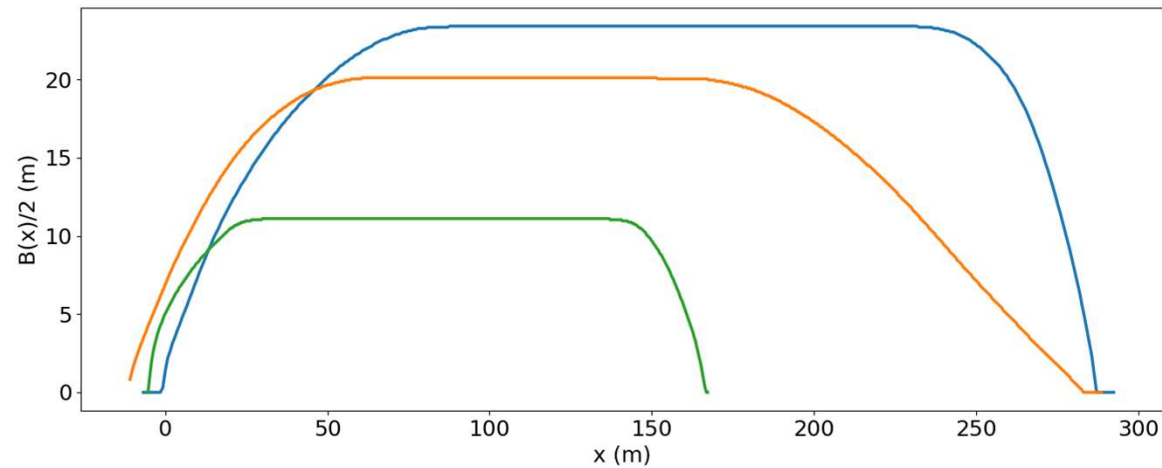


Main carriage (PMM)

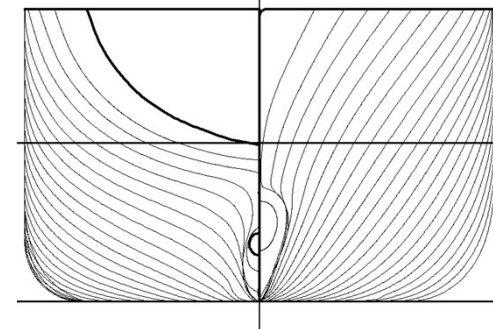


Auxiliary carriage
Fixed distance to wall

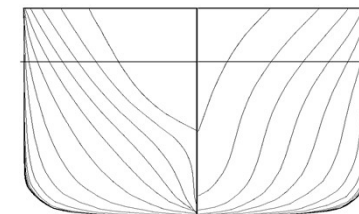
SHIP MODELS AND OFFSETS



T0E
 $L_{pp} = 286.8$
 $T = 15.53$
 $B = 46.80$



COD
 $L_{pp} = 289.8$
 $T = 13.50$
 $B = 40.25$



T0H
 $L_{pp} = 165.8$
 $T = 13.35$
 $B = 22.20$

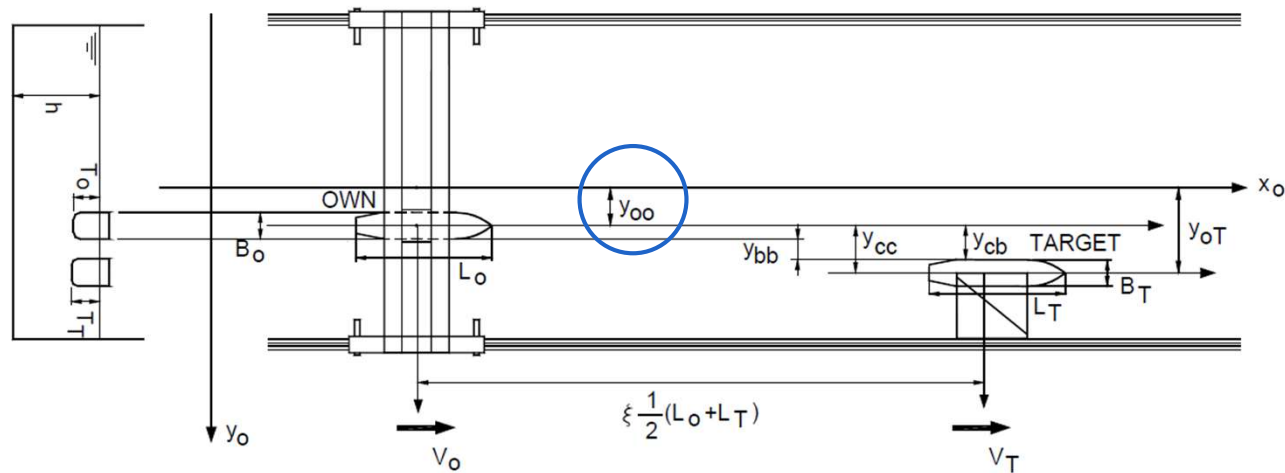
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ELO

ELO Eerder comparison model tests vs slenderflow?
Evert Lataire; 2025-05-14T10:13:05.614

EXPERIMENT VS NUMERICAL SETUP

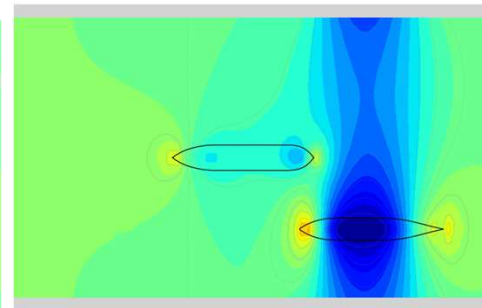
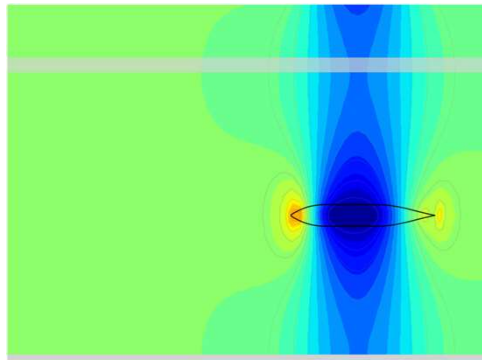
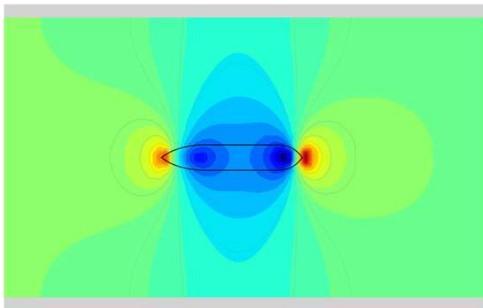


Limitations of SlenderFlow:

- No propeller
- Linear hull boundary condition
- Linear free surface condition
- No viscosity

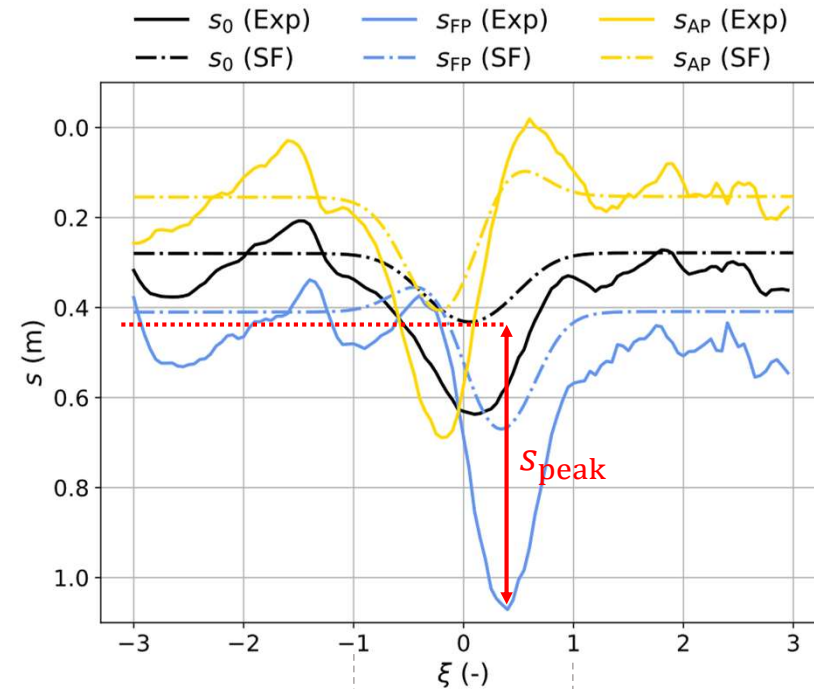
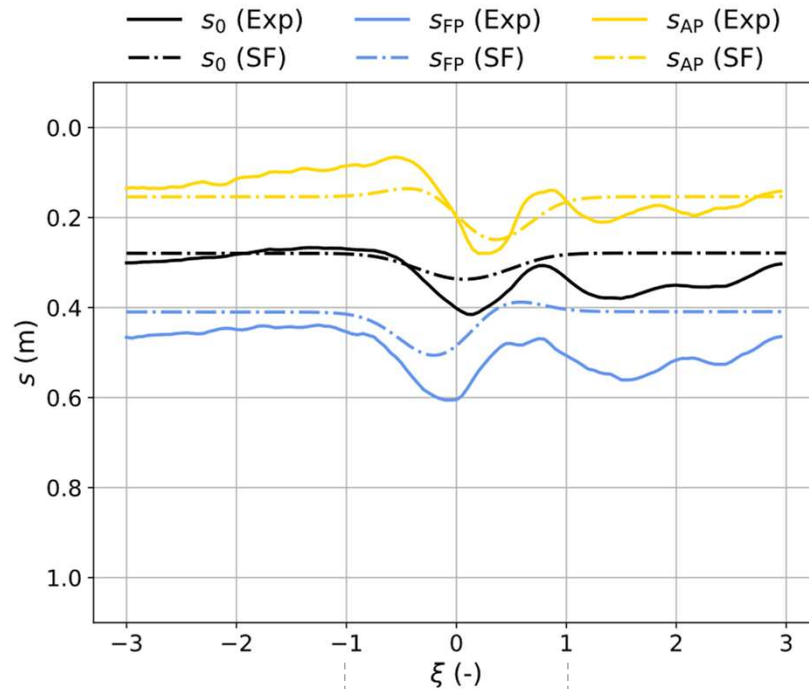
Other approximations:

- Far-field?
- Off-centre sailing ...

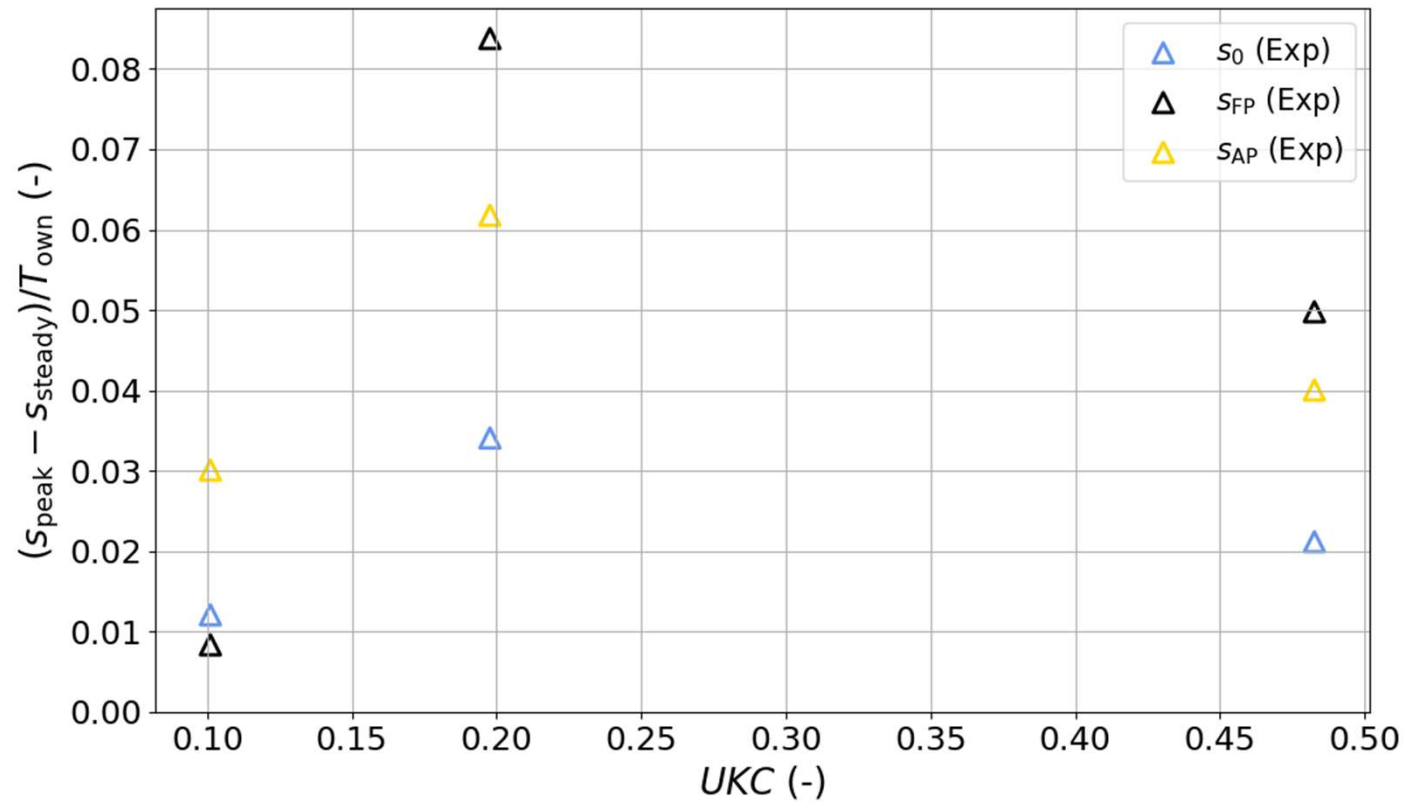


TREND LINES

$$\xi = \frac{x_{cc}}{\frac{1}{2}(L_{own} + L_{tar})}$$

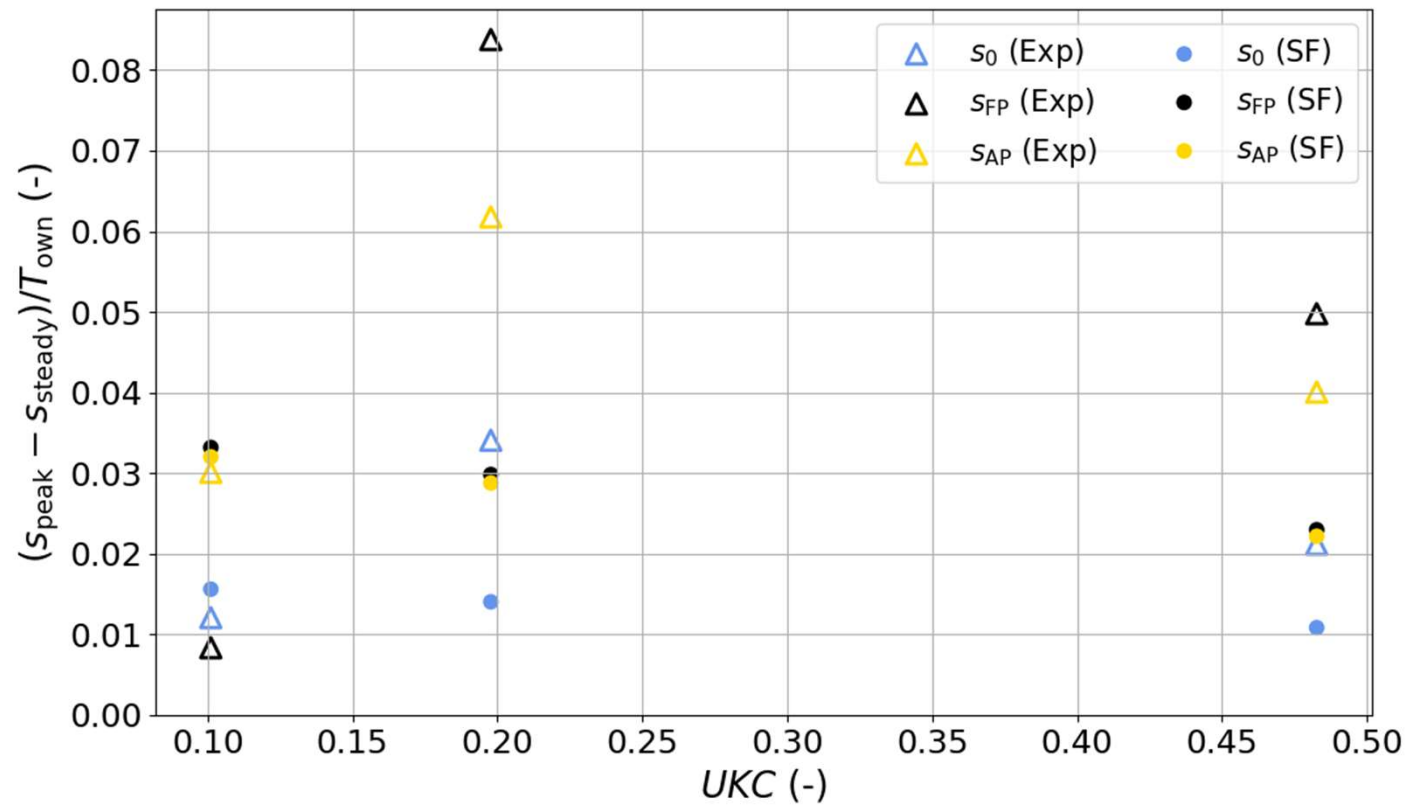


PEAK VALUES (OVERTAKING - UKC)



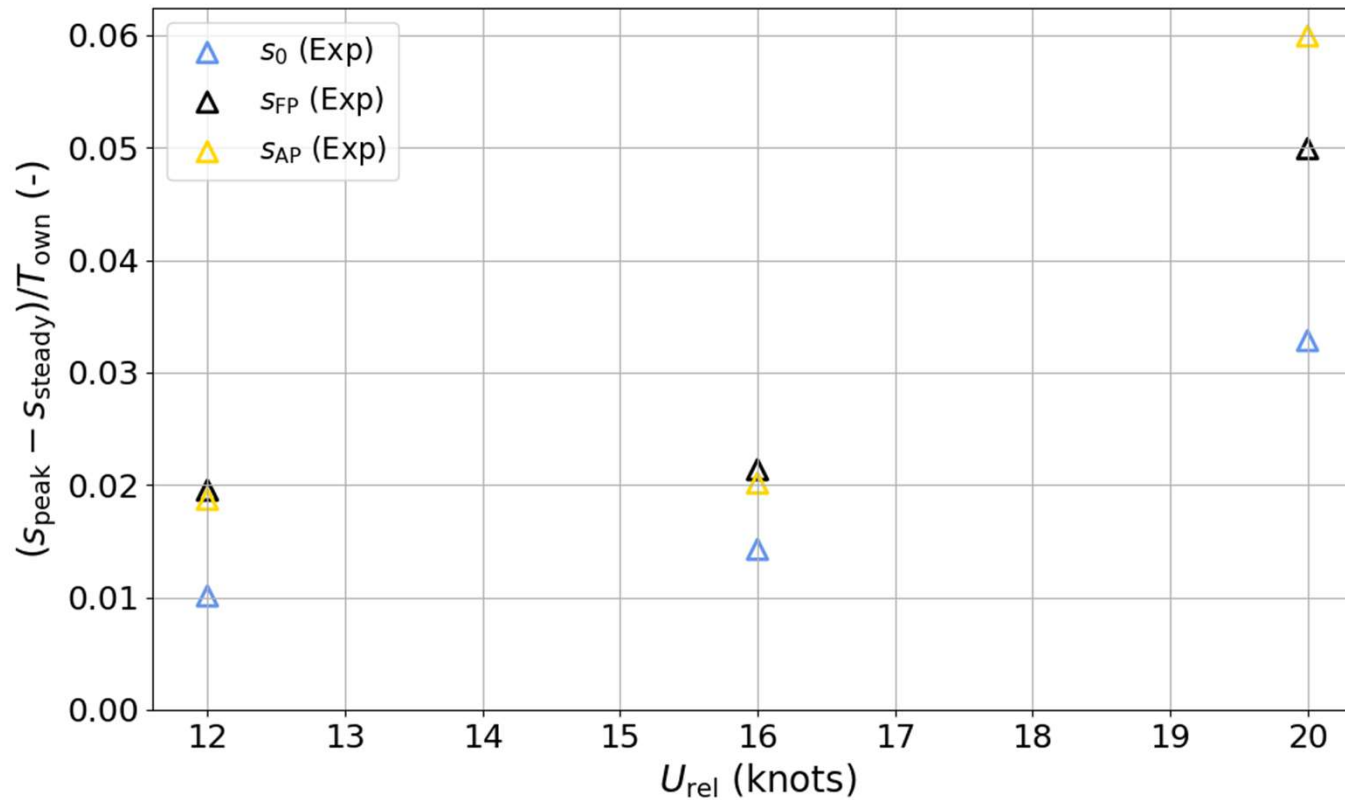
$$UKC = \frac{h - T_{\text{own}}}{T_{\text{own}}}$$

PEAK VALUES (OVERTAKING - UKC)



$$UKC = \frac{h - T_{own}}{T_{own}}$$

PEAK VALUES (ENCOUNTERING – RELATIVE VELOCITY)



$U_{own} = 4$ knots

$U_{tar} = 8$ knots

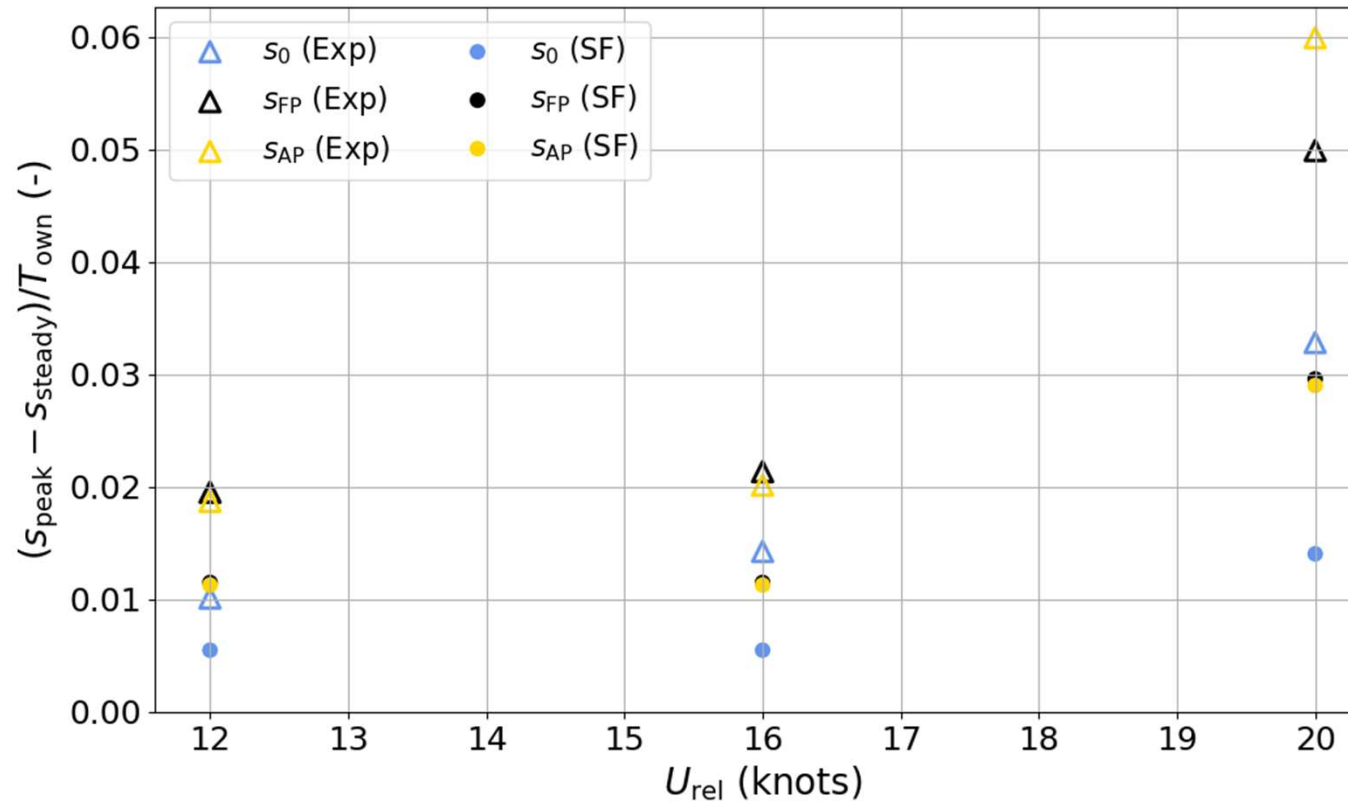
$U_{own} = 8$ knots

$U_{tar} = 8$ knots

$U_{own} = 8$ knots

$U_{tar} = 12$ knots

PEAK VALUES (ENCOUNTERING – RELATIVE VELOCITY)



$U_{own} = 4$ knots

$U_{tar} = 8$ knots

$U_{own} = 8$ knots

$U_{tar} = 8$ knots

$U_{own} = 8$ knots

$U_{tar} = 12$ knots

CONCLUSION

- Trend line shape 
- Peak values 
 - Qualitative trend *okay*, in some cases
 - Underestimated
- Limitations of *SlenderFlow*
- Superposition approach?
 - Unsteady behaviour (Bernoulli)
 - Interaction potential
 - Ship sailing off-centreline

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<http://www.ships.ugent.be/>

<http://www.shallowwater.be/>

