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Comparison of Michlet, phFlow and Rapid with Model Tests for DTMB 5415 Ship Wake

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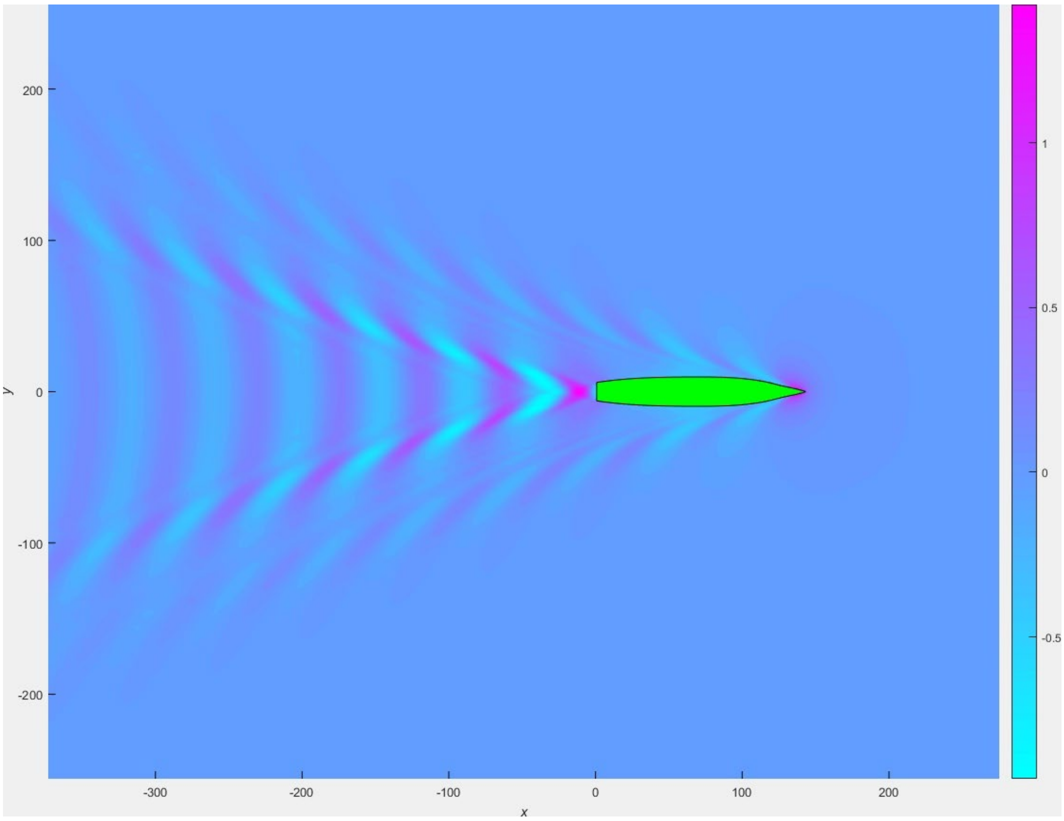

phFlow wave pattern for DTMB hull at 18.1 knots

Document History	
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1. Overview

This report follows on from Perth Hydro report R2019-07 (Gourlay 2019a), which calculated wave patterns for the DTMB 5415 destroyer hull using phFlow software. Here we show a comparison with other ship wavemaking codes, Michlet and Rapid.

2. DTMB 5415 model tests

Particulars of the DTMB 5415 hull are shown in Table 1.

DTMB 5415 destroyer hull	
Length between perpendiculars	142.0 m
Length waterline	142.0 m
Beam waterline	18.9 m
Beam overall	20.5 m
Draft (to keel line)	6.16 m
Sonar dome depth beneath keel line	3.03 m
Displacement	8,425.4 m^3

Table 1: DTMB 5415 particulars at full scale

Test case conditions are as used in Lindenmuth et al. (1991, Table A1) and shown in Table 2.

DTMB 5415 model test conditions		
Speed (knots)	18.1 knots	30.0 knots
Speed (m/s)	9.33 m/s	15.43 m/s
Froude number	0.25	0.41
Water depth	Deep	Deep
Ship vertical position fixed at measured sinkage:	0.25 m forward perpendicular 0.03 m aft perpendicular	-0.06 m forward perpendicular 1.04 m aft perpendicular

Table 2: Test conditions used in this report. Values given at full scale.

3. Michlet software

Michlet is based on the thin-ship theory of Michell (1898), with finite-depth, transom-stern and other improvements as described in Lazauskas (2009) and Cyberiad (2015). It is a linear theory that assumes the ship beam is small compared to the ship length. Wavemaking calculations are "far-field" approximations, which are only intended to be calculated far away from the ship. We have used Michlet version 9.33 for the calculations in this report.

4. Rapid software

Rapid is a nonlinear panel code for calculating wave patterns and wave resistance of ships, described in Raven (1996).

5. Wavemaking results for 18.1 knots ship speed

Comparative results for the DTMB hull at 18.1 knots are shown in Figure 1. Results are as follows:

- Experimental results are from Lindenmuth et al. (1991, Fig. B2).
- Michlet results are calculated for this report.
- phFlow results are from Gourlay (2019a, Fig. 9).
- Rapid results are from Raven (1996, Fig. 9.13).

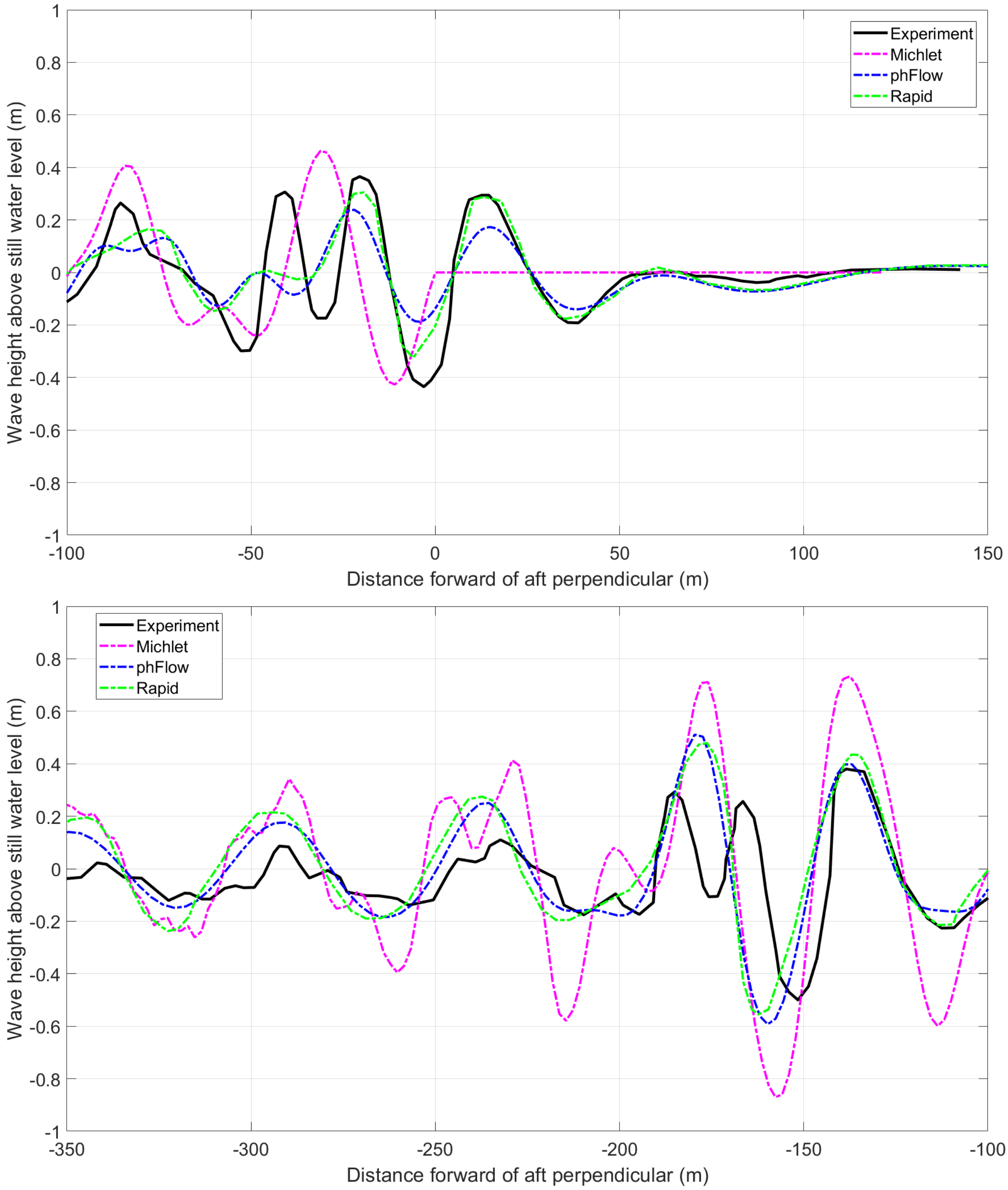

Figure 1: Longitudinal wave cut at distance 46 m from centreline, for DTMB hull at 18.1 knots. Aft perpendicular at *x*=0. All dimensions given at full scale. (Top) Region near ship. (Top) Region behind ship.

6. Wavemaking results for 30.0 knots ship speed

Comparative results for the DTMB hull at 30.0 knots are shown in Figure 1. Results are as follows:

- Experimental results are from Lindenmuth et al. (1991, Fig. B8).
- Michlet results are calculated for this report.
- phFlow results are from Gourlay (2019a, Fig. 12).
- Rapid results are from Raven (1996, Fig. 9.15).

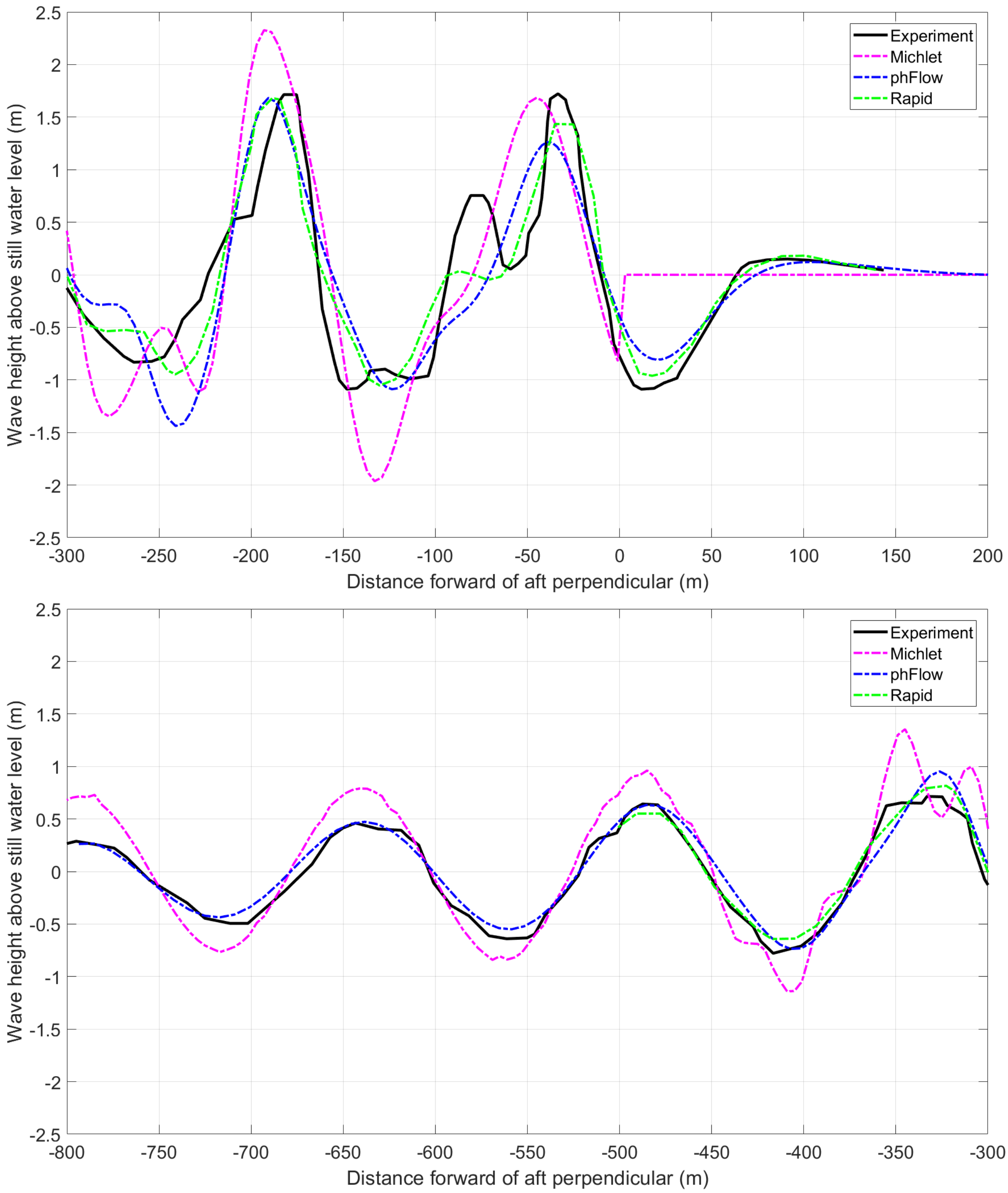

Figure 2: Longitudinal wave cut at distance 46 m from centreline, for DTMB hull at 30.0 knots. Aft perpendicular at *x*=0. All dimensions given at full scale. (Top) Region near ship. (Top) Region behind ship.

7. Wave pattern resistance

Calculated and experimental wave resistance coefficients are shown in Table 3. Results are as follows:

- Experimental results are from Lindenmuth et al. (1991, Table 5).
- Michlet results are calculated for this report.
- phFlow results are from Gourlay (2019a, Table 5).
- Rapid results are from Raven (1996, Table 9.2).

	18.1 knots	**30.0 knots**
Experiment	0.00037	0.00240
Michlet	0.00186	0.00517
phFlow	0.00128	0.00355
Rapid	0.00079	0.00315

Table 3: Wave resistance coefficient

8. Discussion

Michlet wake calculations use a far-field method and, as expected, are not accurate close to the ship. Far behind the ship, at 18.1 knots, Michlet results are similar to the panel code results, though with additional high-frequency components. Far behind the ship, at 30.0 knots, Michlet results are in phase with the experimental results, but slightly over-estimate the wave amplitude.

The two panel codes, phFlow and Rapid, give generally similar results, that are quite close to the experimental results. The theoretical background of the codes is described in Gourlay (2019b) for phFlow and Raven (1996) for Rapid. Both methods use raised free surface panels, together with standard Hess & Smith hull panels. phFlow uses a regular free surface grid with infill panels, whereas Rapid uses a hull-fitted free surface mesh. phFlow's iterative solution focuses on flow velocities, whereas Rapid's iterative solution focuses on free surface height.

9. References

Cyberiad (2015) Michlet 9.33 User Manual. Cyberiad Inc.

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