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Long-period passing vessel forces on ships moored in a port

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Highlights

In a previous contribution to this workshop comparisons were made between the results of measurements and computations of ship-induced long waves and current variations in a port. In this contribution passing vessel forces on a moored ship will be treated for the same set of conditions as in Ref.(1). A novel aspect of the computations lies in the use of a GPU to accelerate 3-d diffraction computations.

Introduction

In this contribution results of model tests and computations of passing vessel forces on a container vessel are presented. The model test program was part of the Joint Industry Project (JIP) ROPES, acronym for Research On Passing Effects of Ships. The objective of the ROPES JIP was to increase insight in the factors influencing forces on ships moored in ports caused by passing vessels. A review of this project may be found in Ref. (2). The objective of a part of the scale model tests carried out by Deltares was to investigate and to better understand the hydrodynamic forces on a moored ship due to a passing ship, especially related to the influence of (complex) harbour geometries. In complex harbour geometries, a large passing vessel will generate long waves consisting of so-called 'draw-down' which travel with the passing vessel and transient long period oscillatory waves in the form of standing waves or seiches with a wave length and period that is related to the typical main dimensions of a harbour basin. Such oscillatory wave effects may also be of influence on the forces on moored ships especially since these standing waves may lead to amplification of water level slopes around the moored vessel, and consequently lead to increased forces acting on the moored vessel. By ignoring such free surface effects in complex harbour geometries, passing vessel effects may therefore be underestimated. Furthermore, natural periods of standing waves in harbour basins can be of the same order as the natural period of the moored ship and its mooring system, making these effects also relevant considering the dynamic response of the moored vessel. The objective of the model tests carried out by Deltares was to produce a high-quality dataset, which included the effects of currents and the influence of harbour geometries on mooring forces , transient long waves and current effects.

Set-up of the model tests

The model tests were carried out in the Atlantic Basin at Deltares. An overview of these tests excluding comparisons with computed results is given in Ref. (3). The basin has a total length of 74.7 m which included , among others ,a dissipative beach at both ends. The effective length of the test section is 43.9 m with a width of 8.7 m. For the model tests , the basin was fitted with a towing carriage to which the a model of a Post-Panamax container vessel was connected. The vessel was captive in the surge, sway, roll and yaw directions while it was able to squat and trim freely. The model scale amounted to 1: 100. Several lay-outs of a straight channel with a width of 270 m with different basins to one side of the channel were modeled. The water depth in the channel and the basins amounted to 18 m full scale.

The vessels

The main dimensions of the passing Post-Panamax and the moored Panamax vessels are given below:

	Units	Post-Panamax	Panamax
Lpp	m	331.5	255.0
Beam	m	42.9	32.26
Draft	m	14.5	12.0
Displacement	m^3	127037	58660

Measurement equipment

Forces on the passing vessel have not been measured, since these tests primarily focus on the forces on the moored vessel. A partially captive measurement frame is used to measure the forces on the moored ship. The horizontal motions of moored ship were restricted (surge, sway, and yaw), but the moored ship was free to move in the other degrees of freedom (heave, pitch, and roll). The transverse forces in sway direction are measured by transducers F01 and F02, at two different longitudinal positions near the forward perpendicular and aft perpendicular of the vessel. The force in surge direction is measured by transducer F03. By combining F01 and F02 the total sway force and yaw moment (around midship) is determined.

Test program

In this contribution some results of passing vessel forces are shown for three port layouts. For all three cases the passing speed of the Post-Panamax vessel corresponded with 10.4 kn and the centerline of the vessel was 107 m from the bank nearest the side-basin. The centerline of the moored Panamax vessel was 19.0 m from the channel side. In the model tests the passing vessel started from X= +3000 m and slowly accelerated up to the required speed in order to minimize additional transient waves due to the start-up. Measurements were carried out with the vessel at a constant speed. At the end of the run the vessel was decelerated and stopped at about X= -1000m. The vessel was at 10.4 kn for the part of the channel shown in the layouts. In the computations a similar procedure was followed regarding the speed of the vessel.

Computations

The computations are based on potential flow which are solved using zero-order panel methods. The procedure is carried out in four phases : firstly the time-dependent flow due to the passing vessel is solved assuming double-body flow i.e. no free-surface effects. At each time-step the strengths of the sources on the passing vessel are solved based on the near-field assumption i.e. both vessels and the fairway are modeled and included in the solution process. Secondly , the thus derived time-dependent source strengths on the passing vessel are used to compute the time-dependent velocity and pressure disturbances at the fairway boundaries and the moored vessel i.e. 'undisturbed' velocity components and pressure due only to the sources on the passing vessel. These time-dependent disturbances are transformed to frequency-domain vectors (FFT) which form the input to the third phase which consists of solving a zero-speed frequency-domain 3-d diffraction problem involving the fairway and the moored vessel but which excludes the passing vessel. Based on the frequency-domain solutions, RAOs of fluid velocity components , wave elevations and forces on the moored vessel are computed. Finally, the RAOs are transformed to transient time-domain results using Inverse FFT methods. These records are directly comparable with the measured time-records of velocity components and wave elevation. A new aspect of the computations is the use of a GPU. The original code was rewritten to account for the reduced memory available on a GPU. An important result of the use of a GPU is the significant reduction in compute time. Some details of the application of the GPU will be presented.

Results

In fig. 1 through fig. 6 the layout and comparisons of computed and measured results for three selected cases are shown. All data are for full scale. Computed results are given in red.

The results for Layout 1 show force variations comparable to open water interaction effects with little apparent effects from long period wave oscillations. The results for Layout 2 clearly show the effects of strong seiching in the side basin on the forces on the moored vessel. Layout 7 shows more effects of seiching on the forces than Layout 1 but clearly significantly less than Layout 2. Effects of secondary waves are almost indiscernible in the measured forces.

References

1. Pinkster, J.A.,and van der Hout, A.:" Long-period waves and current variations in a port due to a passing vessel", 30th IWWWFB, April 2015, Bristol and Bath, UK

2. van den Boom, H.J.J, Pluijm, M. and Pauw, W. :" Ropes; Joint Industry Project on Effect of Passing Ships on Moored Vessels" , PIANC , San Francisco, USA, 1-5 June 2014.

3. Hout, A.J. van der, M.P.C de Jong and S.P. Reijmerink, "Passing-ship effects in complex geometries and currents", PIANC, San Francisco, USA, 1-5 June 2014.4. Pinkster, J.A. ,"The Influence of a Free Surface on Passing Ship Effects," Int. Shipbuilding Progress, 51, No. 4, 2004.

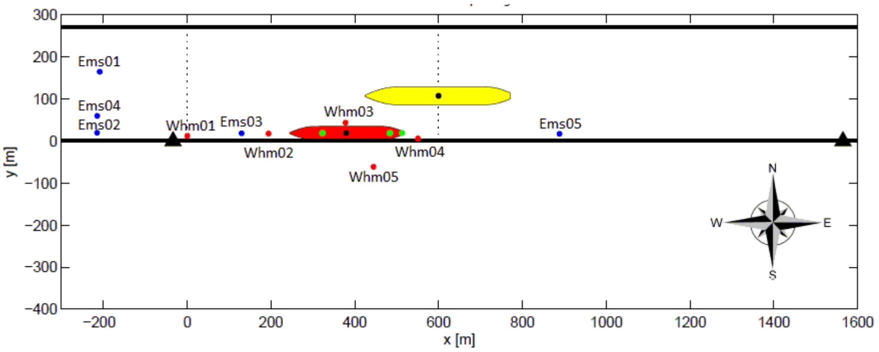

Figure 1 Layout 1 ; Straight channel , width 270 m, waterdepth 18 m.

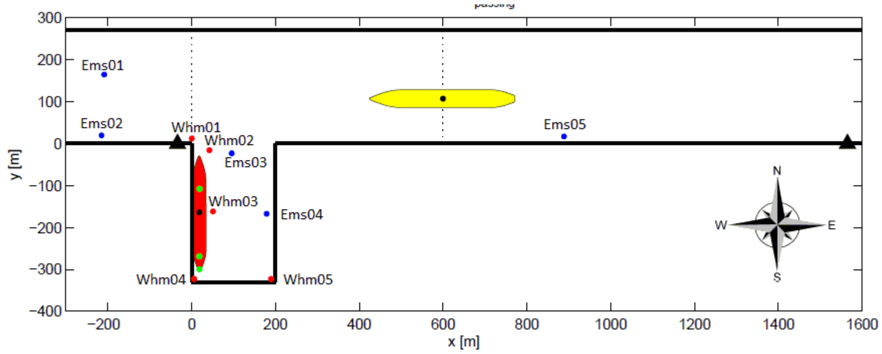

Figure 2 Layout 2 ; Narrow basin at right-angle to channel axis.

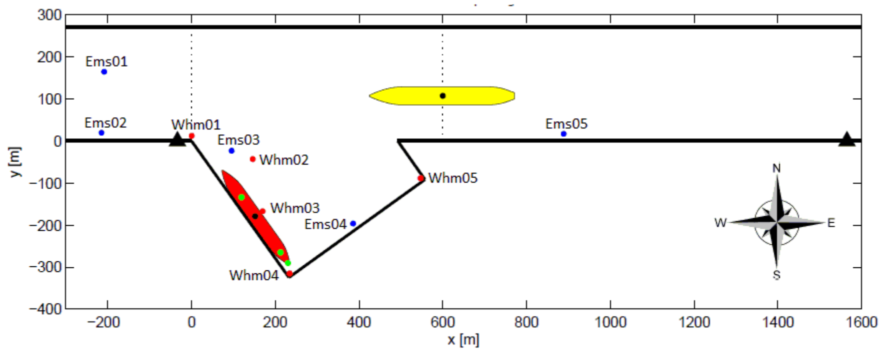

Figure 3 Layout 7; Basin at angle to the channel axis

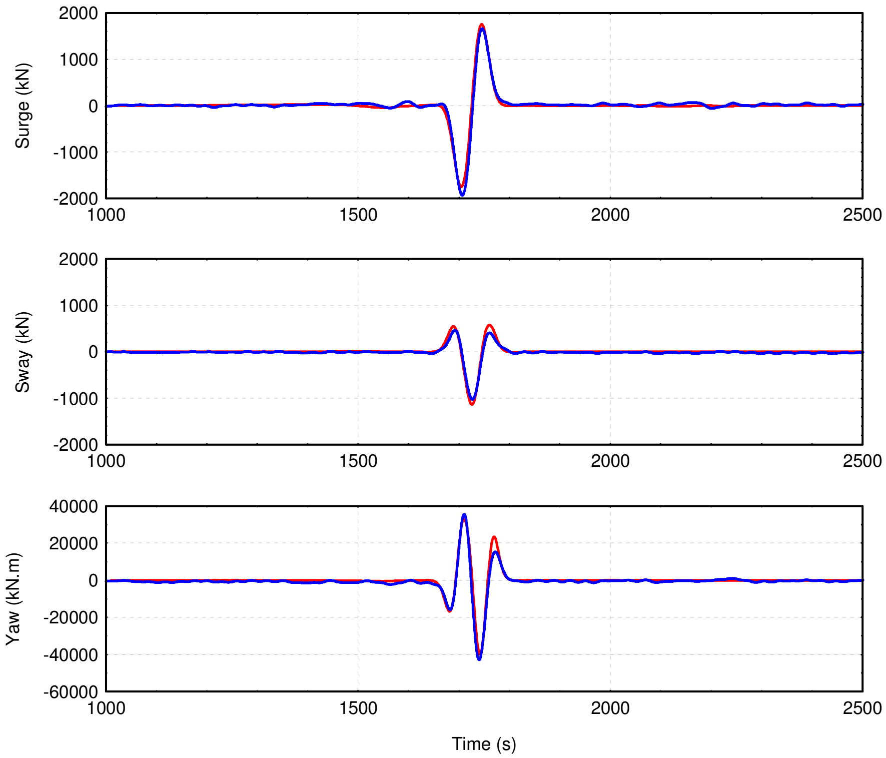

Figure 4 Layout 1; Surge force, sway force yaw moment

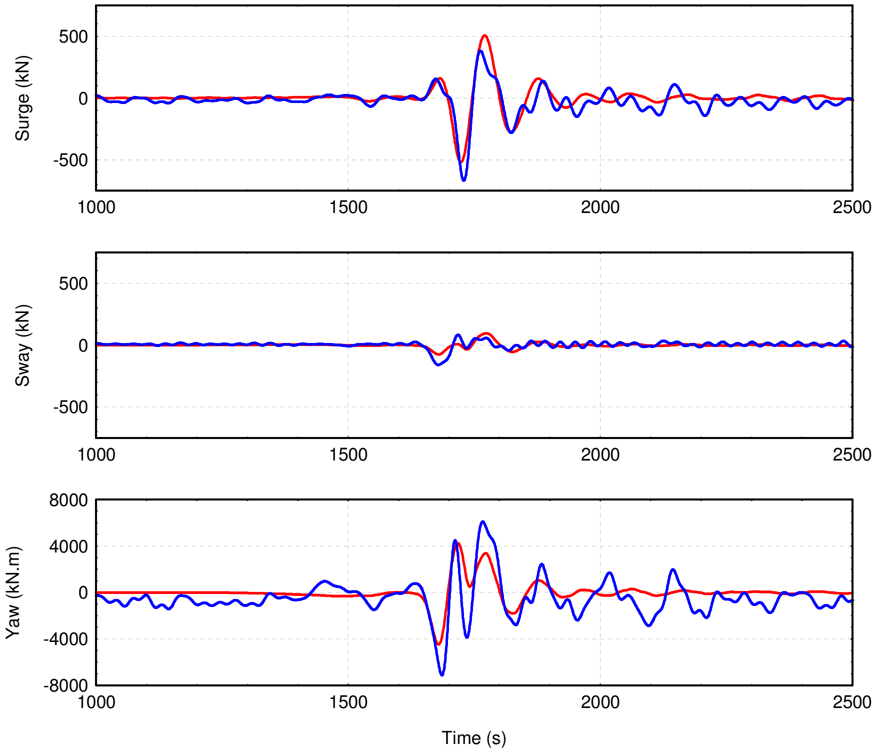

Figure 5 Layout 2; Surge force, sway force and yaw moment

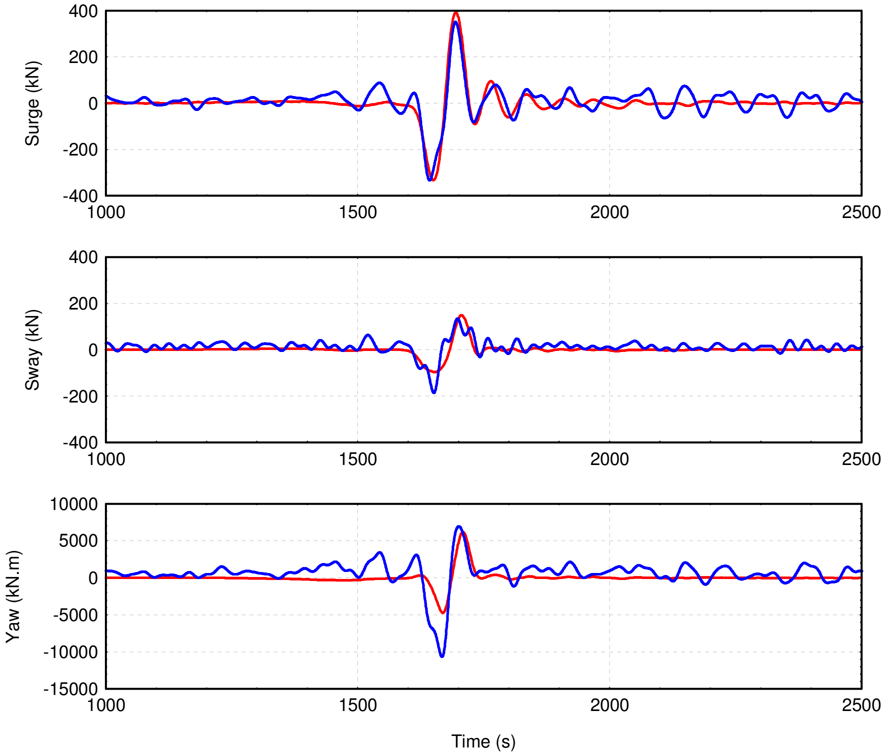

Figure 6 Layout 7; Surge force, sway force and yaw moment