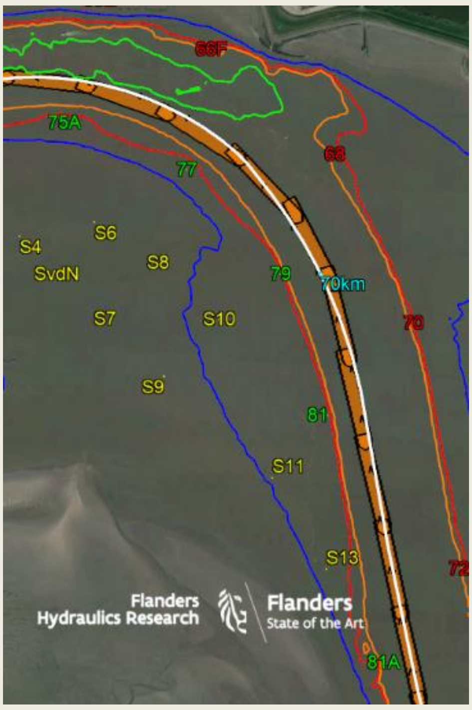
This is the 46th newsletter of the *Knowledge Centre Manoeuvring in Shallow and Confined Water*, which aims to consolidate, extend and disseminate knowledge on the behaviour of ships in shallow and confined water. In this newsletter, we present an item on a study where fast-time simulations were used as an assessment tool for fairway navigability, we mention the incident in the Suez Canal and we discuss the updates that have been made to a software package that has been developed in-house to study the motion characteristics of floating structures moored to the seabed.

Over the last year, Flanders Hydraulics Research (FHR) developed a tool to evaluate the navigability of the Western Scheldt in different tidal and morphological conditions. The project was ordered by the Flemish-Dutch Scheldt Commission (VNSC) as an update of the global evaluation methodology of the Scheldt estuary. The evaluation methodology aims to monitor periodically (ca. every six years) on the main functions of the Scheldt estuary, such as safety against flooding, ecology and nautical accessibility.

The Western Scheldt is a shallow and confined river characterised by sharp bends and important tidal conditions. The largest port along the Western Scheldt is the Port of Antwerp located 40 miles inward. The so-called marginal ships calling the Port of Antwerp concern Ultra Large Container Ships.

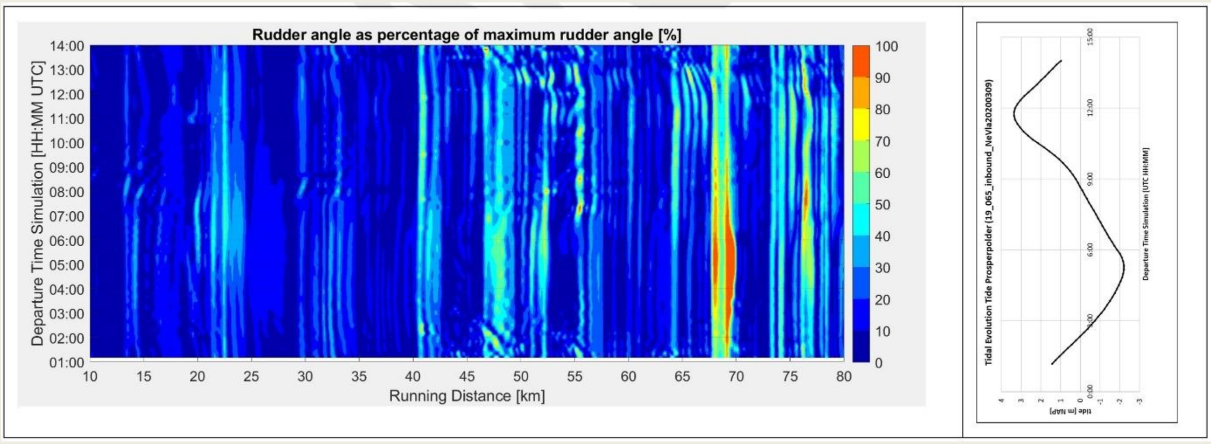
The navigability of the river is highly influenced by shallow water effects such as small under keel clearances (up to 12.5% UKC) and bank effects. Furthermore the tidal currents result in important cross currents (up to 1.3 knots) and the highly curved river bends require large values for the rate of turn. In order to evaluate the navigability of the river, taking into account all the above mentioned effects, ship manoeuvring simulations were considered as the most reliable tool. Track-controlled fast-time simulations not only simulate the ship behaviour, but also aid with the decision making of rudder and propeller application in order to follow a given track and speed. The project could take advantage of the newly developed track controllers, allowing for much shorter execution times of the simulations compared to the former track controllers.



The track-controlled simulations were performed with a 400 m long and 54 m wide container vessel at a draft of 13.5 m, which may be considered as a tide independent draft. Both inbound and outbound manoeuvres were considered between the mouth of the Western Scheldt (Flushing) and the Port of Antwerp, covering a distance of 70 km (38 nm). The reference trajectories were defined at one third of the fairway width (at starboard side) and the requested speeds through water were chosen as the mean values obtained from an AIS analysis. A full tidal cycle of 13 hours was evaluated by initiating simulations every 10 minutes, leading to 78 simulations.

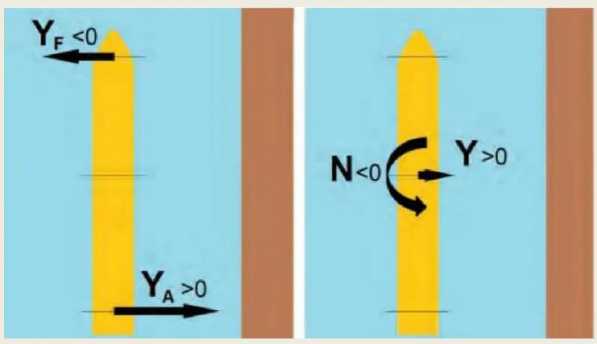
The methodology was applied on 2019 conditions for bathymetry, tidal water levels and currents. Wind effects or interaction with other shipping traffic were not considered so far.

78 simulations of 70 km in length provide a large amount of data, from which the rudder application and the cross track error proved to be a measure for the navigability of the river. These parameters could be visualised in a 2D colour plot with running distance on the horizontal axis and tidal evolution on the vertical axis. The colour plot for rudder application for inbound simulations is provided as an example. The application of rudder reveals an important variation, both along the trajectory and during the tidal cycle. The most important rudder applications are applied at the Bend of Bath (69 km) at low tide (05:00), illustrating the important influence of shallow water on manoeuvrability.

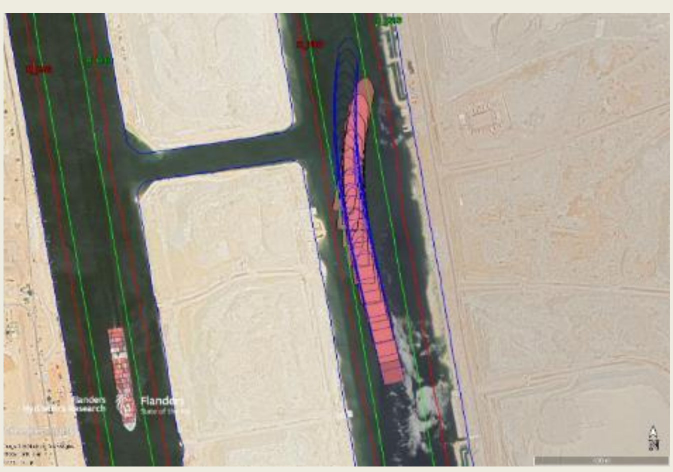


The methodology was also applied on historical conditions for the years 2011 and 2015. The corresponding results of rudder application and cross track error could illustrate the effect of evolutions in morphology and current conditions on the navigability of the fairway. The developed methodology was considered as a valuable tool for evaluating the navigability of the Western Scheldt and it is decided to include the track-controlled fast-time simulations in the evaluation methodology of the Scheldt estuary.

The tool for navigability on the Western Scheldt could be of interest for waterways and channels worldwide. After the grounding of the Ever Given in the Suez Canal, Prof. Evert Lataire, head of the Maritime Technology Division at Ghent University, was contacted for interviews by media all over the world, including television and radio stations and international newspapers and press agencies, such as the Financial Times, the Wall Street Journal and Bloomberg.

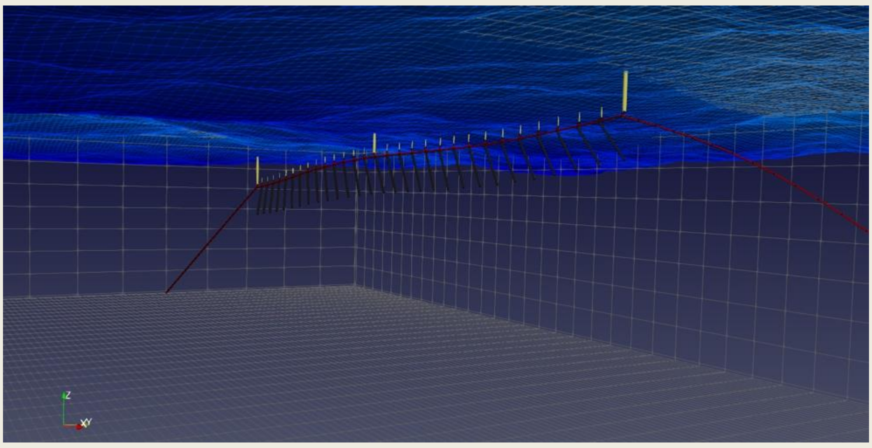


Before the grounding, the Ever Given sailed close to the western bank, which could have induced large bank effects with a strong bow away moment. More than 14,000 different model tests have been carried out in the Towing Tank for Manoeuvres in Confined Water to study bank effects. The experiments were carried out with many different ships and bank configurations. Using advanced regression analysis, a mathematical model was developed that properly takes bank effects into account.

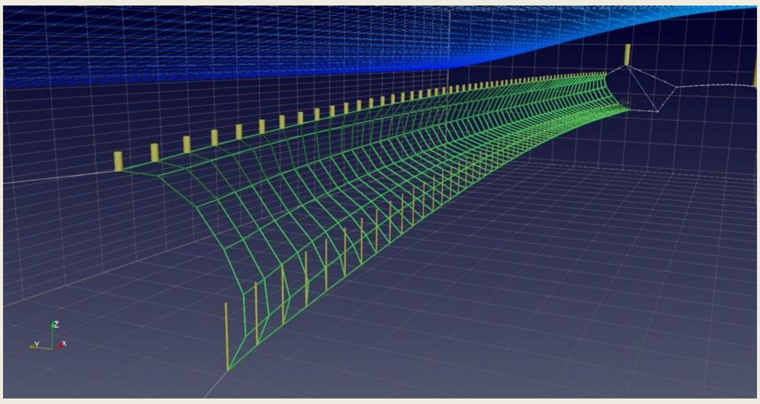


This mathematical model is one of the key parts behind the simulators at Flanders Hydraulics Research. For illustration of the speed effect on ship hydrodynamics and bank effects in particular, two simulations were executed in another stretch of the Suez Canal with a 400 m long and 61.5 m wide container ship (draft 15.5 m) at 13 (red) and 8 (blue) knots. Mathematical models and simulation tools are important to understand the physics and in order to set up an admittance policy for waterways.

MoorDyn-UGent is a mooring line solver based on the lumped-mass approach to simulate the behaviour of moored systems in the time domain. The original MoorDyn code was developed by Matthew Hall and made available through the GitHub platform. Using this version as a starting point, the Maritime Technology Division at Ghent University has adapted the software to cope with elements present in offshore aquaculture mooring configurations, specifically seaweed net structures and oyster/mussel longline systems. The newly adapted software is capable to function as a stand-alone tool in which one can model



environmental loads induced by waves and current as well horizontal seabed interactions. By modelling the hydrodynamic interactions using the Morison Equation, 3-degrees-of-freedom buoys



and clump weights are added as an extension of the nodes. The latest addition to the code is the inclusion of a large moored floating object. The hydrodynamic response of the moored rigid body is solved in advance using a Boundary Element Method (BEM) solver to obtain the wave excitation force, the infinite added mass and the Impulse Response Functions. These frequency domain results are transformed into the time domain using the Cummin's equation of motion. In terms of visualization, a Graphical User Interface (GUI) is available that allows to setup an input file, preview the configuration and run the solver. Simulation results are post-processed utilising VTK files that can be viewed in an open-source tool, namely ParaView.

The software has been used in several projects, including applications for aquaculture (Edulis, Wier en Wind and UNITED) and other types of floating structures, such as floating solar panels (MPVAQUA).

MUDNET 2021 took place from 29 to 30 March 2021. Prof. Marc Vantorre and Prof. Guillaume Delefortrie presented a keynote speech entitled "Manoeuvring behaviour of vessels in muddy waters - Nautical bottom related research at Flanders Hydraulics Research & Ghent University". In addition, Marco Salvador Sotelo Zorrilla presented a poster entitled "Experimental and numerical study of a cylinder passing through fluidized natural mud".

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