3. Exploring the Capacity Limits of Estuarine Access Channels, A Case Study of the Western Scheldt and the Port of Antwerp

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The increase in demand in maritime traffic leads to changes in ship size, charge and draft, leading to more challenging operational conditions of maritime ports, particularly more inland situated ports such as Antwerp. Real time nautical simulations have been developed and used to study the nautical accessibility and to study the conditions for manoeuvring to and in the ports. Such models are limited to the study of the behaviour of one ship and its interaction with other ships and the shallow water conditions in the port basin and the access channel. Useful and necessary information for pilots is deduced from such simulations to improve the safety of the port entry. However, other instruments are required to deduce information on the capacity of the access channel and port basin to accommodate larger vessels in a context of increasing traffic. As in all traffic situations, the increase in traffic density (number of vessels), will at first lead to an increase in traffic flow (cargo), which will at first reach a maximum, and finally decrease to zero (standing still) if traffic density continues to increase. Plans to increase port capacity related to the expected traffic increase, led to a prior demand to investigate traffic flow. IMDC developed a new traffic model capable of investigating the flow and potential saturation point of the access channel and port basin. The existing IMDC Waterways model (Adams et al., 2014) developed for inland navigation, was adopted to take into account the specific requirements for operating a maritime port. The model was developed, tested and calibrated using: detailed navigation data coming from the AIS-based dataset of the Port of Antwerp; the nautical experience from the Knowledge Centre Manoeuvring in Shallow and Confined Water, of University of Ghent and Flanders Hydraulics, deduced from tests on their simulators; hydro meteorological conditions (tide and current) from the detailed 3D hydrodynamic model of the Scheldt constructed by Flanders Hydraulics.

The existing traffic generator was modified to take draft and ship speed into account, as well as destination terminal and the residence time at the port terminal.

A planning tool was developed to check available time slots for generated ships at terminals and for the (6) maritime locks, taking into account tidal windows for tidal bound ships. The tidal window check is performed for newly generated up sailing ships and checked again before leaving the port (after the specified residence time).

The generated ships are then sent on the network. On the network, ship movement is defined by the defined ship speed and simulated current velocity. The speed is altered in case of interaction with other ships (overtaking). The possibility for ship encounters is checked using geometrical rules, taking into account geometrical requirements in bends, drift caused by currents, a safety distance between ships, both in width and length, calibrated on the basis of indications by pilots. In the port basin, ship encounter is complicated by the manoeuvring towards the docks, the terminals and the lock entrances. Specific algorithms have been defined to simulate the turning, and the impact on the possibility of ship encounter and need to adopt the ship's velocity.

The model can be considered as a hybrid traffic model combining theory from both microscopic and macroscopic traffic models, which allow to accelerate the calculations compared to pure microscopic models. The handling of ships is on an individual level (microscopic), checking the interaction ship by ship. It is macroscopic in the sense that links are defined by the most critical section.

After a warming up period an image of the traffic is built. Allowing to evaluate traffic capacity of the access channel and port basin. Calibration is done for ship speed and manoeuvring (number of encounters). Calibration of the different components: the traffic (or ship) generator, the tidal window model, the planning tool, as well as the network model is satisfactory, showing that the model is capable of simulating the development of traffic in estuarine channels and port basins with complex connections to tidal terminals and dock and port basins connected with locks. The model was tested to explore the limits of the capacity of the fairway and port basin. Traffic was finally studied for a future port planning scenario, to check whether this is adopted to the expected future traffic (characterized by a shift from smaller to larger and higher draft vessels).

The model provides a tool for the analysis of ship encounters, and may contribute to the analysis of probability of ship impact.

The presentation will elaborate on the ways criticism of nautical experts was taken into account to improve the modelling approach, and will introduce several concepts for presenting the capacity of access channels and ports.