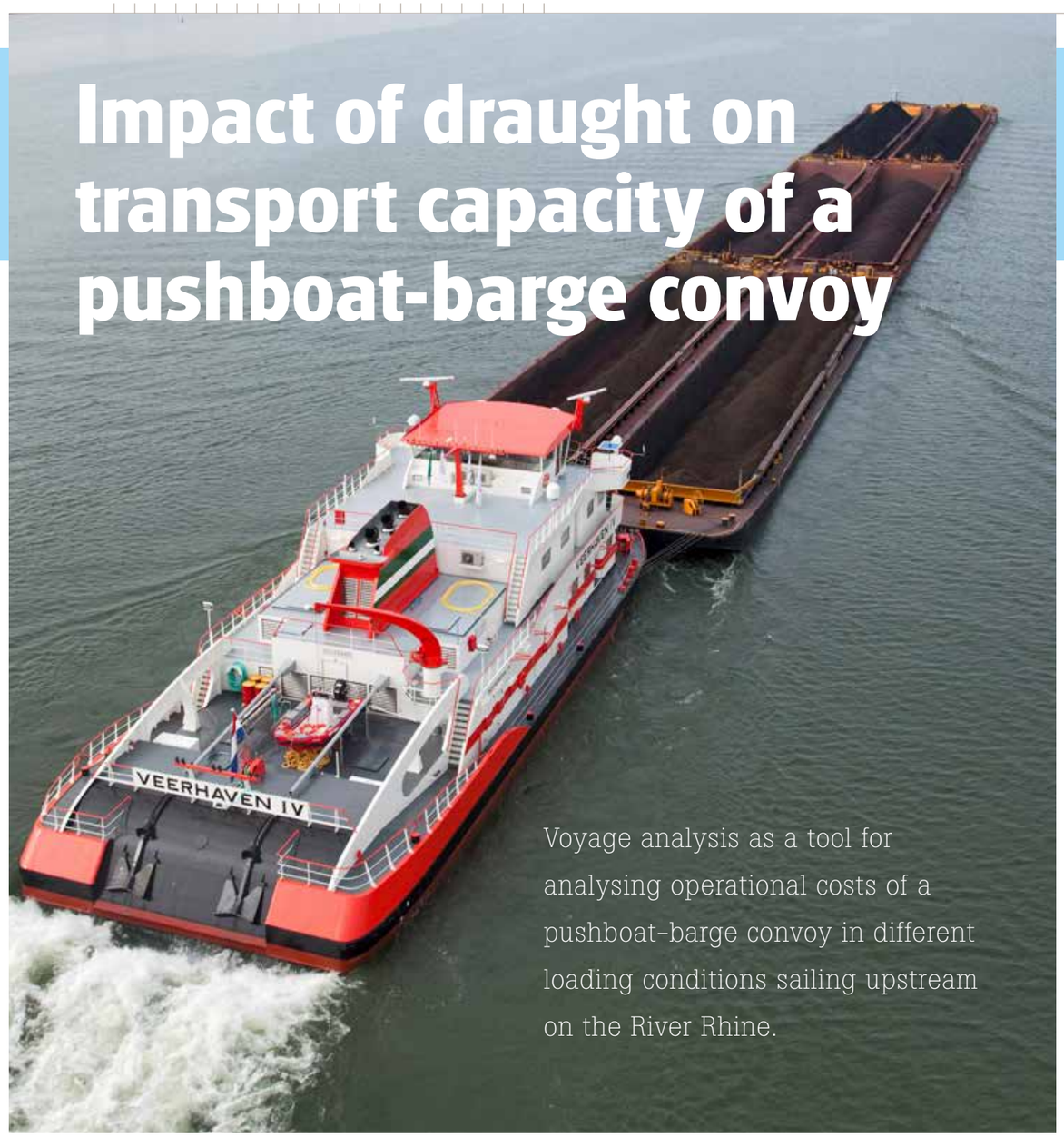
Impact of draught on transport capacity of a pushboat-barge convoy



Voyage analysis as a tool for analysing operational costs of a pushboat–barge convoy in different loading conditions sailing upstream on the River Rhine.

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MARIN extended the voyage simulation tool 'Gulliver' for seagoing ships to inland waterway conditions. This tool was validated in close cooperation with pushboat and barge operator Veerhaven and was subsequently applied for an operational analysis.

Veerhaven operates seven pushboats and more than 100 barges. The pushboats operate 24/7, and a convoy with six barges carries about 15,000 tonnes of ore/coal.

Veerhaven is one of the companies that participates in the CoVadem network, which MARIN helped develop (see www.covadem.org). This is an important network which delivers the actual water depth along the route, based on the depth measurements of the participating ships. The availability of these depth measurements was a key element in this project.

CoVadem network CoVadem continuously provides up-to-date water depth information by combining a 'sailing data collection network' of inland ships with state-of-the-art Big Data technology. It collects and processes depth information readings providing a growing range of services for the members. At present over 80 ships participate, but CoVadem aims to grow to a network of about 250.

The recent project started after a discussion with Veerhaven about using CoVadem data to analyse transport capacity. In the case of draught restrictions caused by lower water levels, captains wondered whether loading the barges at maximum draught was the most efficient in terms of fuel consumption per tonne. This resulted in two research questions:

1. Could MARIN realise a sensitivity analysis with respect to fuel costs per tonne based on voyage simulations of a convoy with six barges on the route Dintelhaven – Duisburg with different draughts?

2. Given the optimal draught, how to compare costs of hiring additional capacity versus sailing at higher speeds?

Voyage simulation model Firstly, the voyage simulation model was aligned to this situation. The speed-resistance characteristics of the pushboat-barge convoy were modelled for different draughts and water depths and compared with full-scale trials. Additionally, the effect of the restricted width and the gradient (or slope) of the river on the resistance of the pushboat-barge convoy was modelled and the relevant data of the fairway was collected.

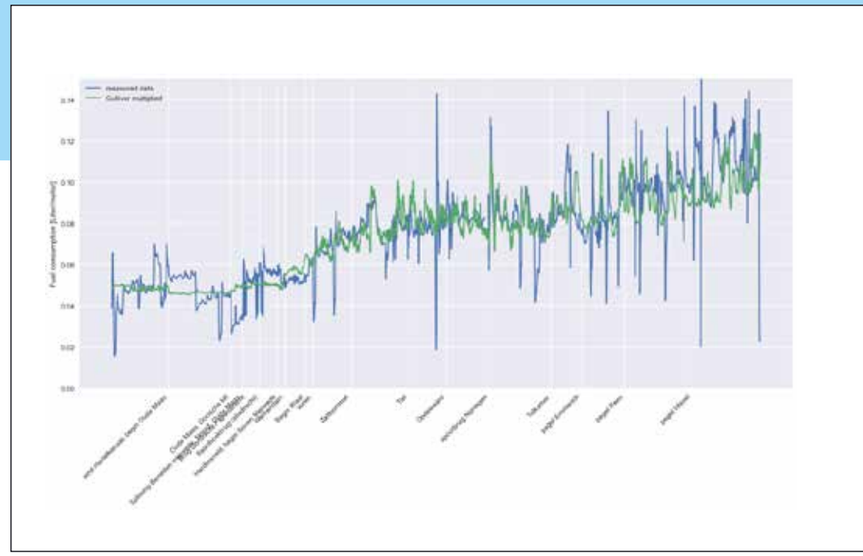
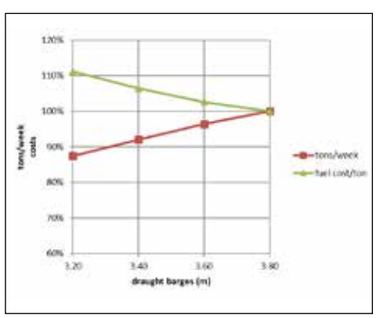


Figure 1: Comparison of the course in fuel consumption over the trajectory: blue (reality) versus green (simulation)



One of the pushboats is equipped with a fuel consumption meter. The figure shows the comparison of a fuel consumption registration, versus the fuel consumption in a simulation.

Fuel consumption & sailing conditions For the condition under consideration, four draughts were taken into account: 3.8 m, 3.6 m, 3.4 m and 3.2 m. Voyage simulations were realised for the pushboat-barge convoys with these draughts and the transport capacity per week was calculated (see graph). A lower draught reduces transport capacity and increases fuel costs per tonne. Based on these simulations and the fairway characteristics, sailing at smaller draughts is not beneficial.

The pushboat-barge convoy sails only a short part of the trajectory with very small keel clearances. Thus the impact of sailing with less draught is small. To verify this, simulations were made assuming a flat bottom and a water depth of 4.60 m on the entire trajectory. The same power setting was used for a convoy with a draught of 3.8 m and a convoy with a draught of 3.6 m. These simulations found that the transport performance of both convoys was about equal and fuel costs/tonne were approximately the same.

Sailing with higher speeds With respect to the second research question, hiring extra capacity or sailing with a higher speed, it should be noted that the possibilities are limited. Both the power of the pushboat and the effect of applying a higher power on the ship speed are limited. The applied power setting was based on operational practices. The simulations were performed for one draught and demonstrated that applying a higher speed increases transport capacity. The extra costs of sailing at a higher speed are dependent on fuel prices and the 'breakeven fuel price' was estimated. If actual fuel prices rise to a higher level than the breakeven fuel price, then the advantage turns into a disadvantage.

By applying the trip simulation model Gulliver, the impact of different loading conditions, waterway conditions and fuel prices can be analysed to improve insight and determine more effective sailing strategies. This is a typical project focusing on the operational assessment, and it fits well with MARIN's ambition to gain on both sides – on the design (for operation) and on the actual operation itself.