

## Summary

Due to a growing world population, upcoming economies and increasing wealth, the demands for materials and goods increase. These materials and goods must be transported and for many goods, the transport costs must be low to keep the price of the goods as low as possible. A cheap transport mode, compared to rail, road and air transport, is transport over water. This transport mode has the disadvantage that it has a low reliability: the ability to perform and maintain the agreements made between shipper, transporter and buyer of the cargo during normal circumstances, as well as during unexpected circumstances. In this report we will look at inland waterway transport and how water dynamics, caused by climate changes, influence the reliability.

Characteristics of inland waterway infrastructures, like slopes and curves, and artificial structures in and around the waterways, like sluices, ports and bridges, have an influence on the types of vessels that navigate on the waterways. On some waterways the vessels are built in such way, that they can maximize cargo transport per trip while still be able to fit in sluice chambers. When there are small changes in the characteristics of a waterway, like a decrease in water level, the vessels must decrease the amount of cargo on board, so that the vessel is still able to navigate on the waterways and to avoid grounding with the river bottom. This decrease in cargo makes the vessel become less efficient in transportation, with higher prices per ton of cargo as a result.

Due to climate changes, extreme water level, both high and low, will occur more often. The climate changes cause changes in temperature, precipitation and evaporation, and these changes will cause higher water levels during autumn and winter, and lower water levels during spring and summer. Extreme water levels will cause congestions, because vessels cannot pass bridges, due to height problems during high water levels, and sluices, due to a restricted water flow through the sluice during low water levels. High water levels are less harmful than low water levels, because high water levels only occur for several days, while low water levels can continue for months. To provide information about levels and currents of the waterways, several systems, like radar and optical measurement systems, are used. These systems can provide real-time data, but also predictions of the water dynamics for the next 96 hours. The systems are used by shippers, ports and governmental authorities. Together with information from vessels, like position, speed, destination and route, shippers can plan their trip more precise, and Vessel Traffic Service centers can observe the waterways and act when unexpected events occur, like extreme water levels and accidents. Both water dynamics and traffic information is collected and is shown on electronic charts for navigation, which give an accurate and clear overview of the waterways, vessels and artificial structures in and around the waterways.

To decrease the chance of congestions and blockage of waterways, measures are needed. The measures that can be taken are management systems for sluices and pump systems, which can help to remain a water level which is navigable. Another measure is to shut off less important waterways, to ensure the main waterways will remain enough water to maintain a certain minimum water level, so that waterway transport will not have restrictions, caused by extreme water levels.