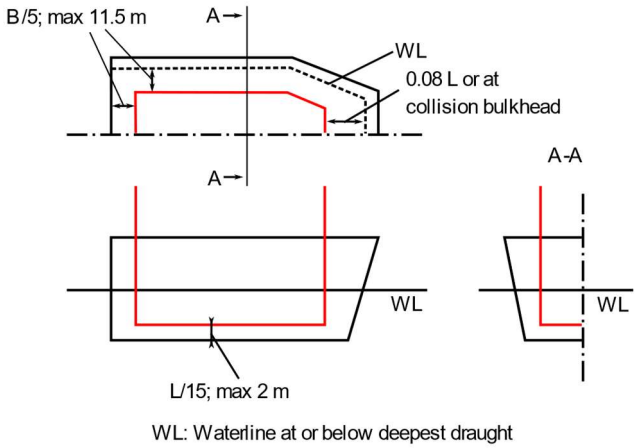
Quasi-static strength analysis of a ship retrofit with LNG-Tank

As part of work package 3.2: “Preparation of analysis presenting types of small-ships in use for conversion to LNG usage”, the University of Rostock developed and published several topics on the conversion of small ships to LNG. The students then had the opportunity to choose one of these topics for their study or even bachelor thesis. One of these topics was the retrofitting of a pilot ship with LNG tanks. Here, the University of Rostock was supported by the Lotsbetriebsverein e.V. (Kiel branch office). They provided the technical document of their Swedish pilot boat and declared their interest in the result of this study work. The author of the work is Mr. Joachim Foedtke, a student from University of Rostock.

Picture of one of the Swedish pilot boats in the fleet (Source: Joachim Foedtke)

Due to the characteristics of LNG, there are several risks for ships. The low temperature can cause brittleness, vaporization and thus expansion due to heat, and lastly, the gases can form an explosive atmosphere if they mix with air. Therefore, it is important to ensure the safety of the entire LNG storage system. One of the most important regulations for LNG on ships is the IGF Code for ships using gases or other low-flashpoint fuels. This specifies the types of tanks that may be used on ships, the minimum distances that must be maintained from the ship’s hull and how to categorize the spaces in which parts of the fuel system are located.

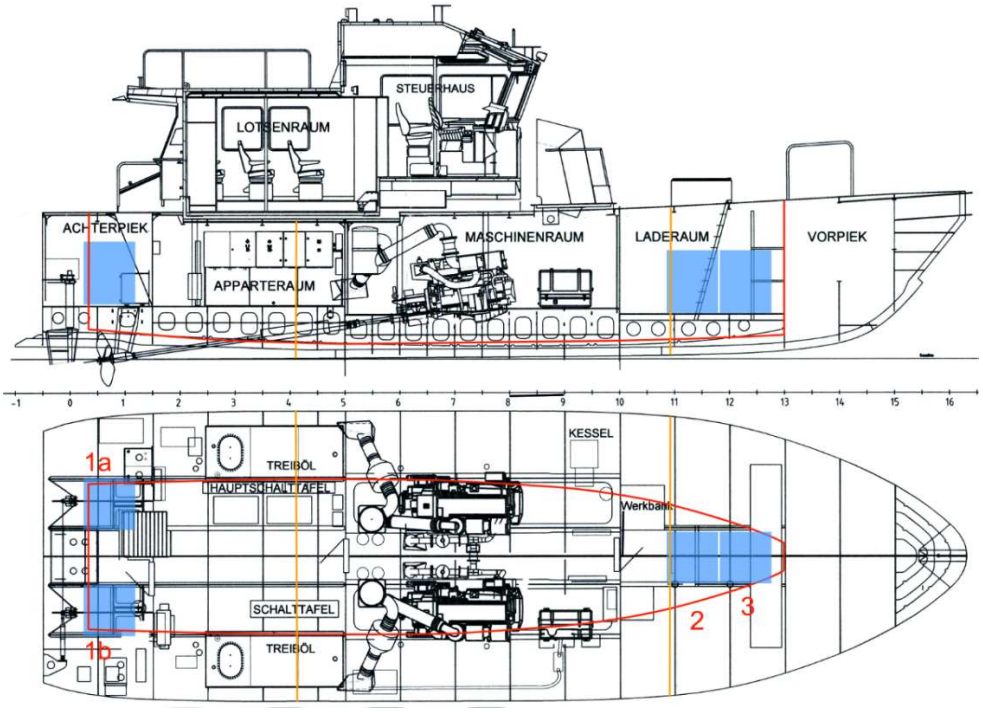
Furthermore, it is important which type of tank is used, since the different types require different approaches. In this work, type C tanks were used because they are decoupled from the ship’s structure and can be freely placed. Nevertheless, they must comply with the regulations of the IGF Code, which defines specific spaces in the ship. Since type C tanks can be classified as cofferdams, only the tank connections and the surrounding space must comply with the strict regulations.



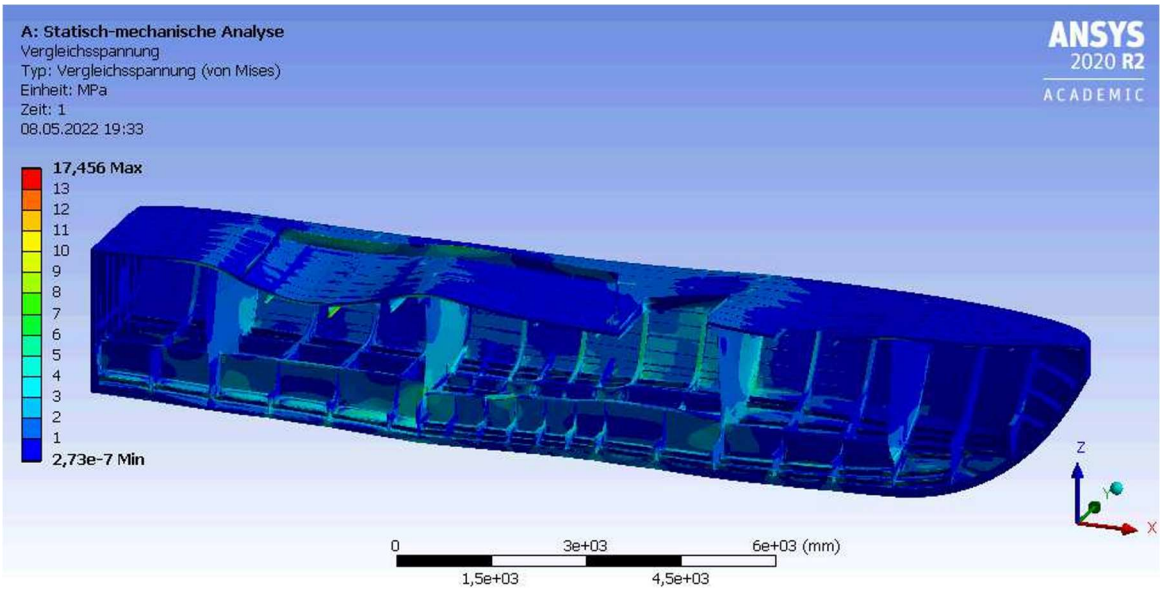
Distances between tank and hull according to the IGF Code (Source: Joachim Foedtke)

Based on these regulations, a lot of spaces on the vessel cannot be used for additional tanks. Thus, only two spaces can accommodate additional tanks. These are the aft peak and the cargo hold. In consideration of the existing equipment, it was determined that each possible space can accommodate up to two tanks, allowing for four tank positions. Afterwards, it was investigated whether they have an impact on the floating position. The result is that they change the draught by 6 mm when they are full and, in relation to position, cause a change in trim of about 30 mm when full.

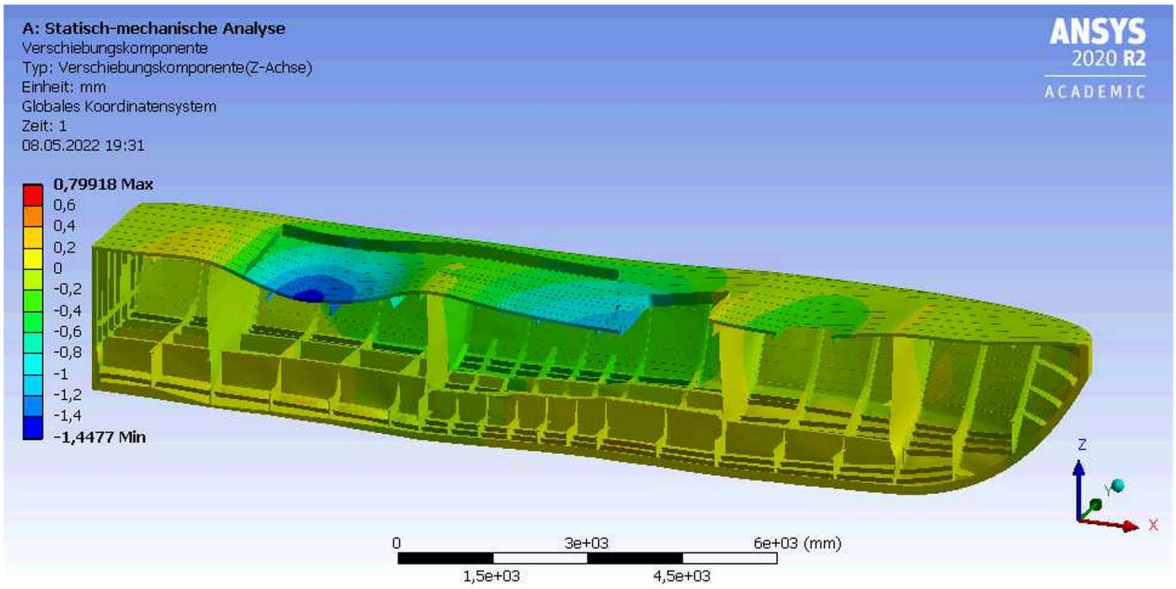
In order to investigate any changes in the structural behaviour of the hull, a static FEA was performed. For this purpose, a highly simplified 3D model was used, which was created based on the technical documentation of the Lotsbetriebsverein e.V. (Kiel branch office). Boundary conditions were then defined, including hydrostatic pressure on the hull, gravitational loading on the entire structure, load cases for the tanks and a load distribution representing the current equipment. The resulting analysis shows that the structural stresses and displacements of the structure are almost negligible compared to the overall ship structure. Even if all four positions contain tanks, only the floating position of the ship experiences a visible change.



Tank positions including the red distance indicator line (Source: Joachim Foedtke)



Von Mises stress of the structure with all four positions holding a tank (Source: Joachim Foedtke)



Displacement of the ship structure along the z-axis (Source: Joachim Foedtke)