Acceleration turn in Seakeeping and Manoeuvring Basin (MORE project)

Five decades of research into manoeuvrability

In the quest for supertankers 50 years ago, the CRS investigated the effects of ship size on the controllability, and in particular how adequate controllability could be achieved. Today, the ship types and the requirements for manoeuvrability have changed, but the CRS applied research still holds.

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The unique composition of CRS working groups means that the research finds its way into practical applicability. Developed tools and knowledge ensure a competitive advantage in the day-to-day business of shipyards, class societies and shipowners.

Why was the manoeuvrability of large tankers so different from smaller ships? In the 70s, economy of scale pushed to achieve larger and larger ships, allowing the installed power per tonne displacement to reduce. From a manoeuvrability point of view, this had two consequences. Due to the larger ships, the ship reacted much slower and therefore, the stopping distances increased. When the helmsmen gave rudder, the reaction time was longer. The second consequence was related to the Froude number. Due to the increasing length and the same speed, the design Froude number reduced. This means that it was interesting to design ships with larger block coefficients. However, to achieve acceptable added resistance in waves, the bow section became sharp. This has led to fuller aft ships. These fuller aft ships result in less flow over the rudder and hence, less control. Moreover, it resulted into different lift characteristics for the hull and therefore, different directional stability.

Awareness about the impact on directional stability led to investigations concerning the effect of the hull form. In particular, the increasing fullness of the aftbody on the course-keeping ability was a growing concern. Investigations were carried out systematically, both by captive tests in rotating arm basins and free running model tests. This showed which aft body shapes lead to problems. CRS has also merged this knowledge into practical software tools, so that shipyards and designers could use this

Discussing the effect of propeller turning direction on manoeuvring and course keeping (MORE project)

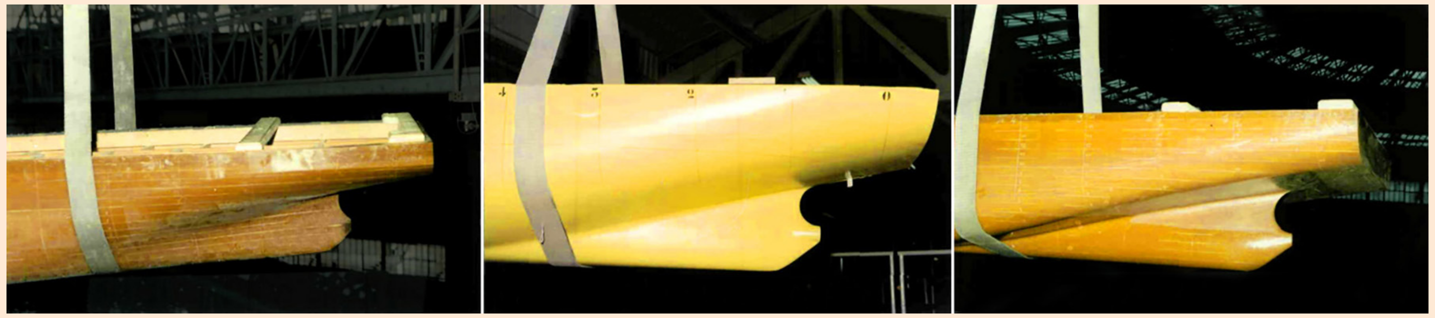
to their advantage and had knowledge that their competitors did not have.

Which applied research did CRS perform?

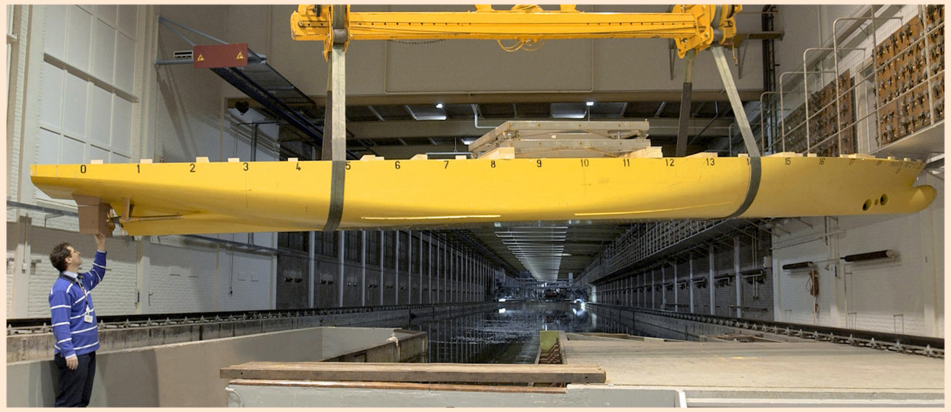
CRS established a working group with a budget to investigate these issues. CRS members needed to know what it would take to reach acceptable stopping distances. The loads that acted on the propeller were very unconventional during stopping manoeuvres. Research took place while measuring the strength of the propellers, and the rapid change of the turning direction of the engine. The Manoeuvring in Early Design Stage working group (1988-1991) and the MAN working groups (1992-1996) focused on the possibility of predicting the cross-flow drag coefficients using segmented model test results. Segmented model tests were carried out to obtain insight into the distribution of manoeuvring forces over the length of a ship. Re-analysis of existing segmented model tests of the so-called 'Todd series' formed the start of the MPP program. Testing of the first version of MPP revealed a good correlation for most ships, except modern tanker forms which had the 'pram' stern. To correct for this, a modern tanker hull was selected to conduct further segmented model tests. This hull form was both lengthened and shortened so that data for different hull forms became available. Hydrodynamicists such as Geert Kapsenberg, Jan Hooft, Ian Dand and Wim Beukelman performed groundbreaking investigations and set-up the cross flow drag method to quantify the non-linear manoeuvring forces. At that time, this was unconventional, but the scientists were convinced that they were on the right track. While somewhat quirky, this has resulted in improvements that otherwise would not have been possible. And it has led to a practical and robust tool for CRS members!

Since 1990, the following working groups have all played a role:

- LB: tankers in light ballast conditions
- MED: manoeuvring in early design
- RUD: rudder design manual
- MAN: manoeuvring predictions
- MANTS: manoeuvring for twin screw vessels
- MAN3: manoeuvring predictions for podded vessels
- COGNAC: low speed manoeuvring (crabbing)
- COGNAC-2: crabbing in the neighbourhood of quays



Three aft body shapes



To measure the crabbing performance, large models need to be used. The model on the photograph was the CRS base model for many crabbing tests in deep and shallow water

- MANWAV and MANWAV-2: methodologies to predict manoeuvring behaviour in waves
- MORE: manoeuvring in operational conditions.

The CRS working groups consist of scientists and practical ship designers. This interesting combination assures that not only fundamental research is carried out: at the end of the day, this always culminates in a software tool or prediction method. The resulting practical prediction method can be applied very rapidly, so that the ship designers can use them to create a manoeuvring prediction within 5 minutes.

What is the key to the CRS success?

The beauty of the CRS model is that the developments are not curiosity-driven, but a direct consequence of developments in ship design. On one hand, designers had a direct need and on the other hand, the quirky scientists had opinions.

The MED project was driven by awareness that a full aft body had a detrimental effect on the course-keeping. The MAN project was a direct consequence of the start of the development of the IMO requirements for ship manoeuvrability. The first non-mandatory A751 requirements became active in 1993, while the mandatory ones became active in 2003.
MANTS occurred at the same time as the development of the larger cruise vessels (end of last century). MAN-3 was established following the introduction of the podded propulsor to the market.
Even the latest developments regarding manoeuvring in waves (the MANWAV working groups) are occurring at the same time as the IMO required investigations related to the minimum power requirements for low powered ships. But also other ships need to demonstrate their ability to have adequate manoeuvring characteristics in waves and in wind nowadays.

The interesting part of the working groups is not only the result, but the way in which the result is achieved. The eclectic nature of the members of the working groups means that there is a good balance between applied research and practical applications in day-to-day work.

Manoeuvring and course keeping in waves

Since 2012, manoeuvring research of the CRS has also focused on special and unconventional manoeuvres such as acceleration turns and turn-on-the-spot manoeuvres. The manoeuvres in waves are of particular interest: course keeping, track keeping and the ability to turn.
First, we developed knowledge and tools in the MANWAV project: insight into the autopilot, propeller loads and ventilation in waves, and the response of the engine to these. A large effort went into the investigation of the best way to quantify the 2nd order wave forces in irregular waves and the methodology to augment it to the manoeuvring simulations. Prior to the now selected solution, a fully coupled theory and de-coupled theory have been developed to investigate which would best suit the needs of the CRS.
At last, the MORE project is applying and validating the simulation methodologies. Practical operational manoeuvres are simulated with the tool and validated with model tests on a ship while manoeuvring in waves (see also cover illustration).