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Free Running Model tests s hed light on the elusive world of the submarine

Free Running Model tests have always been in common use at MARIN, given that they offer the most accurate picture of a ship's behaviour. However, this technique is also important for submarines. But until now, little has been reported on the usually hidden activities of submarines. Report takes this opportunity to reveal some of the latest developments in this underwater world.

Frans Quadvlieg & Bas Overpelt
f.quadvlieg@marin.nl

For submarine model testing, particularly when it concerns manoeuvring and seakeeping, two techniques are in principle possible: captive tests and Free Running tests. Captive tests consist of a range of activities, including model design, a matrix of test conditions, an analysis of test results, fitting of derivatives and performing simulations. Free Running tests require fewer stages and therefore, the results are much more quickly available. In addition to that, the results give the most complete picture of the behaviour of the boat but without the schematisations of a mathematical model.

New approach

The first Free Running model of a submarine actually sailed at MARIN back in the 1960s. At that time, Free Running turning circle manoeuvres were carried out in the Wind Wave and Current Basin. Since that time, the techniques of data acquisition and modelling have increased significantly. But more importantly, the time projects take has speeded up dramatically over the years.

A new century calls for a new approach, which has led to a redesign of the test set-up for Free Running submarines. The core of the submarine model is a re-usable, watertight container (WTC) completely filled with measuring and control equipment. A new hull shape can be placed around the WTC for investigations into any type of submarine. The implementation of measurement techniques in the Seakeeping and Manoeuvring Basin using an on-line position measurement system, gives submarine designers and users the possibility to asses the qualities of their submarine design in a fast and reliable way. MARIN has been involved in captive model testing for submarines many times but Free Running Model tests have only recently been added to the toolbox of the submariner.

Ideal size

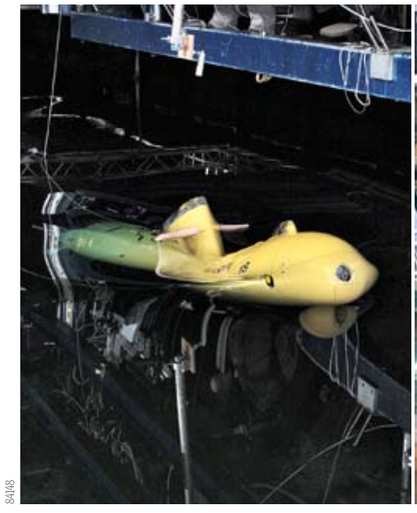
MARIN's Seakeeping and Manoeuvring Basin is ideal to perform a range of manoeuvring and seakeeping tests. At 170 m by 40 m, the basin is a good size for testing manoeuvres in calm water and in waves. The long length of the basin facilitates acceleration and deceleration phase testing and with the width at 40 m, the basin can comfortably accommodate a submarine making a range of turning circle tests.

In addition, the versatile wave-makers of the Seakeeping and Manoeuvring Basin makes it possible to judge the submarine's behaviour while sailing just under the waves, in snorting or submerged conditions. The ability to combine an assessment of the submarine's behaviour in calm water and in waves, means Free Running Model tests have the advantage of giving a complete picture in a short time frame, which is especially important for submarine designers.

For the model of the submarine, there are three important enablers:
- Underwater power of up to 14 hours, meaning that the basin can operate its usual double shifts, without delays for recharging the submarine power.
- An accurate underwater position measurement system.
- The model-following capabilities of the carriage of the Seakeeping and Manoeuvring Basin. This facilitates wireless, two-way communication between the carriage and model, and as such, online control over the submarine.

Free Running manoeuvring tests for the Royal Netherlands Navy, comprising amongst other things, near bottom sailing, have recently been carried out. Results are being used to improve mathematical modelling of the simulation code of the Walrus-class submarine. This is used for failure mode and effect analysis, as well as for crew training.

During manoeuvres, propeller thrust and torque and also rudder forces are measured and registered. This data is gathered with the motion data of the submarines. Together they form a basis to be able to compare the results of fast time or real time computer predictions, against the results of the Free Running Model tests.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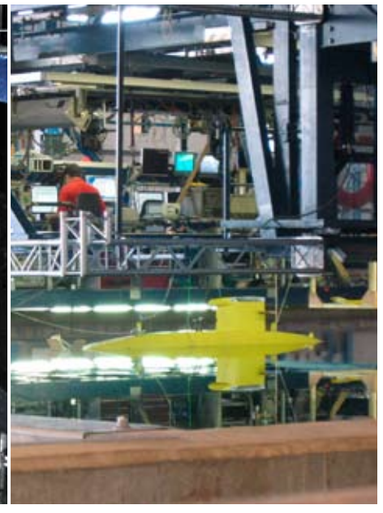
Submarine model performing emergency manoeuvre



Surfaced submarine in Seakeeping and Manoeuvring Basin