Photos: Sam Rentmeester

Dr.ir. Lex Keuning at the K&M Yachtbuilders wharf in Makkum.

Bible for boats

After nearly forty years researching yacht hulls in the Delft towing tank, boat expert Dr Lex Keuning has decided to share his life's work with yacht builders and researchers. The Delft Systematic Yacht Hull Series is available online.

Jos Wassink

Due to an unfortunate combination of events, Dr Keuning was unable to personally attend the presentation of his systematic series at the Hiswa Symposium – the annual symposium on yacht design and yacht construction. TU Delft researcher Michiel Katgert did the honours. He explained that the full measurement data of seventy hull shapes over the last 39 years, as well as the forty publications based on these data, are now publicly available to anyone who takes the trouble to request a login (at dsyhs.tudelft.nl). According to Katgert, these measurement data can then be used to develop software that will predict the performance of ships during the design stage (the so-called velocity prediction programmes or VPPs). The Delft data can also be used to validate numerical approaches to a ship's resistance, for example. Katgert asked designers at the symposium to post on the website discussion forum to let them know how they use the data. "We invite you to participate in our research." That sounded very open-source and contemporary, but a little later Katgert had to admit that expanding the series was no longer an option in Delft.

Mathematical aid

Yacht designer and ocean yachtsman Gerard Dijkstra made a name for himself with the 'Stad Amsterdam' (which featured in the VPRO series 'Beagle'), the mysterious three-master 'Maltese Falcon' and Greenpeace's new mother ship: the motor yacht 'Rainbow Warrior III'. When performing design calculations, Dijkstra prefers to use 'the Delft series' or 'Sysser' (systematic series). During the coffee break at the Hiswa symposium he said: "I have been familiar with the series from day one and witnessed its development. That inspires confidence."

'There are forces above and under water which together form a complex balance'

Keuning (62) witnessed the beginning of the series as a student. That was in 1973 when Professor Jelle Gerritsma, Professor of Ship Hydromechanics, wanted to start generating comparative measurements of yacht hulls. He did this together with two colleagues from Massachusetts Institute of Technology who shared his passion for yachts and sailing. The two men concerned were Nick Newman, Professor of Ship Hydromechanics, and Justin Kerwin, Professor of Hydromechanics. The objective was twofold: to create a mathematical aid to enable yacht designers to determine the sailing properties of their design and to develop a method of calculating the handicaps of the various yachts in a yachting race.

"It is much more difficult to predict the velocity of sailing yachts than that of motor yachts", explains Keuning (3mE faculty) in his office next to the towing tank. His aged dog is lying near the door. "There are forces above and under water which together form a complex balance. This is difficult to calculate by hand. A programme was needed that could approximate a ship's performance based on its length, breadth, depth and water displacement."

The research needed to be systematic. This means using adjustments on the basis of a standard-model ship. The ship chosen as standard was Frans Maas' 'Standfast 43', a 13-metre sailing yacht of which a 1:6.25 scale model was built. Keuning explains the adjustment process: "Taking the mother ship as starting point, we increased and reduced the width slightly. This resulted in three models, which were all dragged. Any differences in resistance that you measure are consequently attributable to the difference in width. You can do the same with the length, draught and displacement. That

Yacht designer Gerard Dijkstra: "The series inspire confidence."

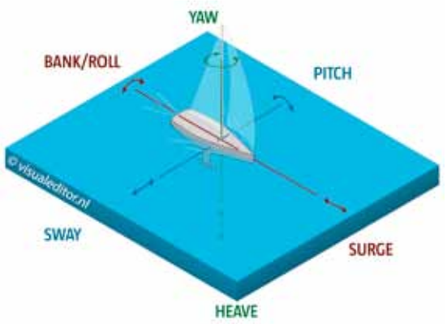
sounds simple but adjusting the width also changes the displacement. There are many interdependencies."
The first systematic series consisted of nine models.

Towing tank

The measurements were performed in the large TU Delft towing tank: 142 metres long, 4 metres wide and 2.5 metres deep. As all the measurements were performed using the same method and the same equipment, they are not only comparable with each other but also with the measurements of later models.
Drag tests involve a 4-ton aluminium carriage travelling along rails on either side of the tank at a maximum speed of nearly 30 km/h. Below a hull model, fully lit, cuts through the waves. The hull is hinged – only the angle between the heading and the track (the drift angle) is registered and the angle with respect to the vertical (slope). This is where we encounter nautical terminology such as pitching, heaving and yawing (see more in the box on ship movements).
The measurements take at least a week for each hull. Just consider: besides the upright measurements with and without out a keel, measurements are performed at four different speeds, four different slopes (angle with respect to the vertical) and four different drift angles (angle with respect to direction). That's at least 64 measurements and after each measurement it takes a quarter of an hour for the water in the tank to settle sufficiently for the next test.
Among others, each test produces values for the resistance (the tractive force exerted on the model in the direction of displacement), the lateral forces, the fore-and-aft angle of the yacht (trim) and how far the hull sinks (immersion). Asked how often a test is repeated, Katgert answers with a smile and the maritime adage: "Thou shall never measure twice." In this field, absolute measured values (and the applicable margins) are less important than the differences between them. It's all about serial comparisons. The reproducibility of the measurements is always verified. In the case of the series, for example, the models were dragged again after twenty years and the differences were within one to two percent.

Largest measurement series in the world

After those nine models the Delft group wanted to continue, but the Americans pulled out: the money had run out. The research could continue in Delft as long as the researchers were still motivated enough and yacht builders were interested in the results.
A new measurement series consequently followed in 1982, based on a design by Van der Stad & Partners; in 1993 there was a series based on a model by Sparkman & Stephens and in 2007 a model by Judel & Vrolijk was the last mother ship for the time being. The Delft Systematic Yacht Hull Series (DSYHS) comprises a total of seventy systematically varying and mutually comparable hulls, which makes it the largest systematic series in the world.
"Whether a boat is 4 or 140 metres long, the series still applies", Dijkstra says. The ship hydromechanics research group has hence written a bible for boats, which will serve as a standard for yacht builders and racing sailors for years to come.
The data from Delft form the basis for the velocity prediction programmes or or VPPs that yacht builders use during the design stage. "The nice thing about the systematic series is that you don´t have to design using a model that has been dragged", Dijkstra explains. "You create your own design based on your experience and the client´s wishes in terms of length, width and draught. This forms the operational profile of the yacht. Using WinDesign (one of the VPPs, ed.) you then calculate the performance and iteratively modify your design until you reach the best compromise that meets the client´s requirements. If you base your performance calculations on this series, you´ll always know that your ship will sail properly."
In fact, Dijkstra doesn´t take the velocities that WinDesign specifies for the various directions all too seriously. Due to the structure of the atmosphere and the wave pattern of the water the actual velocity will often deviate from the theoretical prediction. You´d be lucky to get a match within five percent. But, once again, it´s all about the mutual comparisons.



SHIP MOVEMENTS

	TRANSLATION	ROTATION
X-axis (fore-and-aft)	slacking (change)	rolling
Y-axis (transverse)	driven off course (dynamic)	pitching
Z-axis (mast direction)	heaving (dynamic)	yawing

It is much more difficult to predict the velocity of sailing yachts than that of motor yachts.

Handicaps

The same applies when using the systematic series to determine handicaps. As a researcher, Keuning is a member of the International Technical Committee of the Offshore Racing Congress. In this competitive world, the handicaps of the various yachts are determined using VPPs based on the Delft systematic series. "This enables us to apply a correction for the length or weight of the ship and establish who sailed best of all", Keuning tells us.
Asked whether the series is to be extended, he answers with a sigh. Followed by:
"There's no money left for that." Keuning would like to add lightweight, plane sailing yachts to the series. Dijkstra sometimes comes on to drag an extremely long, slimline model. "A twelve-metre yacht used to be quite spacious; nowadays a hundred metres is perfectly normal", he explains. While these data are added to the series, clients prefer to keep racing yacht data to themselves. Contrary to what they were used to, the group now has to wait to see what they are offered in the way of drag testing.
And Keuning? He is working on a good handover. He will spend the last two years up to his retirement passing on his knowledge and experience of sailing yachts and fast motor ships to his successor as well as possible. He also plans to go sailing more often, with his twin brother for example. Not around the world, but to Britain and the Baltic would be nice enough.

'If you base your performance calculations on this series, you´ll always know that your ship will sail properly.'