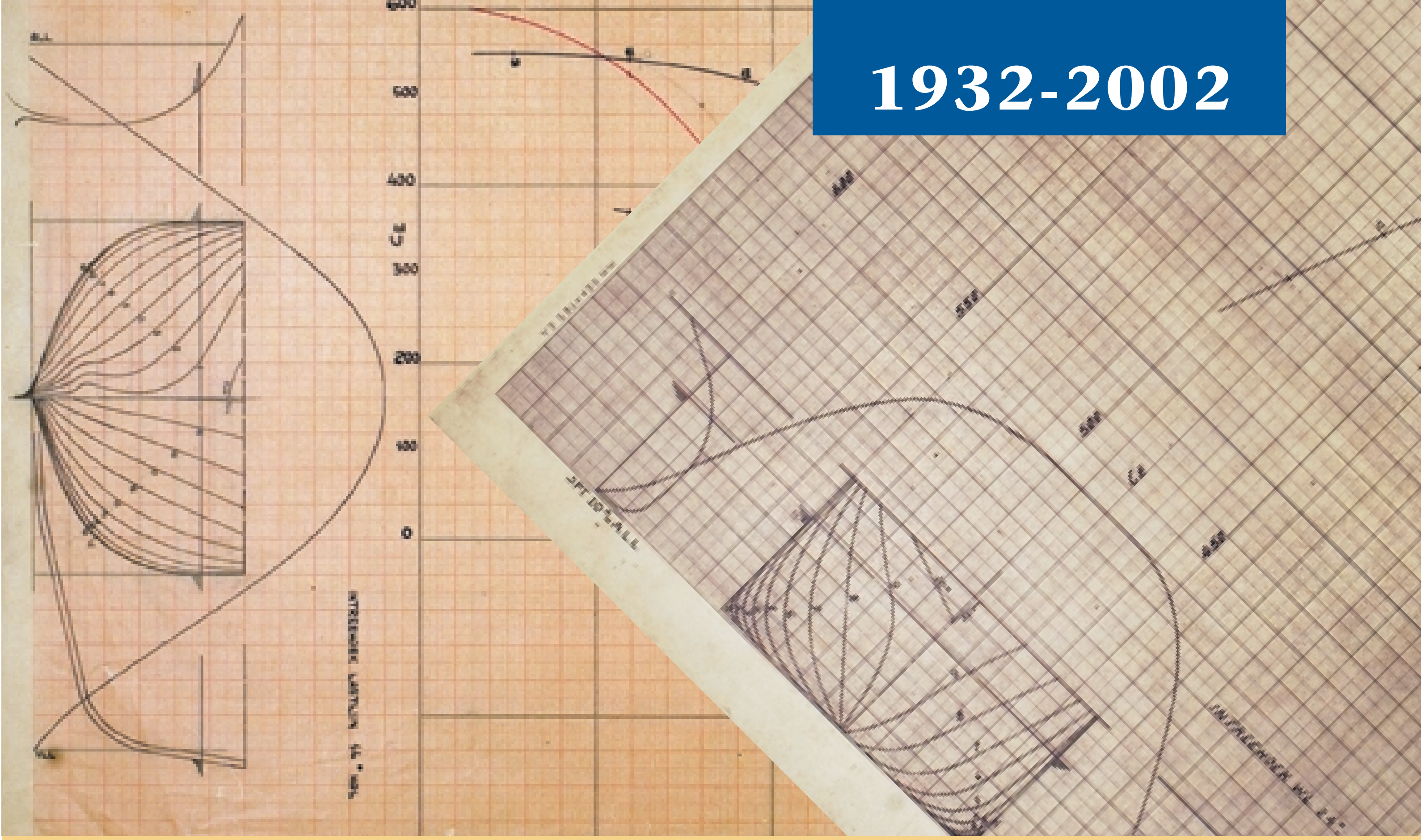


1932-2002

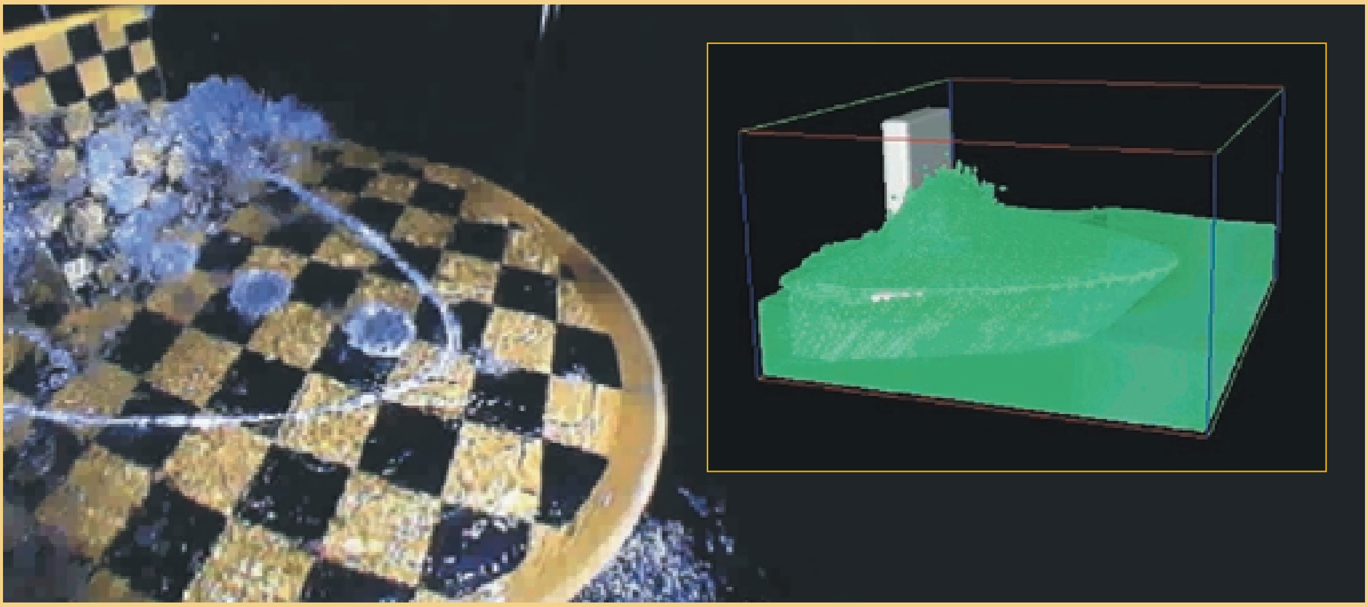
One of the first statistical sheets, for a model tested 70 years ago.

MARIN ensures industry has right tools for the job

Seven decades of tool development at MARIN and in the wider ship hydrodynamic community, have brought great advances in terms of realism, accuracy and in the capabilities of prediction tools. Here Report examines these developments.

MARIN's role has often been to translate progress in applied sciences into practical tools, which are then developed and refined in its integrated experimental and theoretical work. Today, the integrated procedure of computational predictions, careful analysis and model experiments, means a vast improvement in designs effectivity compared with the early days. Through the years MARIN has responded to the growing need of the shipbuilding and shipping industry for design tools for hull forms and propellers. Of course, at the start of MARIN's activities in 1932, the design of hull forms was mostly based on sound judgement and experiences from the sea.

However, as several towing tanks had started operation, large amounts of new experimental data came available. To be used effectively this data had to be categorised and represented systematically. At MARIN, the basis was laid for the now, vast collection of 'statistical sheets', a compact representation of the hull form, test results and a quality judgement for all vessels



Calculation and measurement of greenwater on deck.

tested. Design diagrams were produced that enabled MARIN to make performance estimates for certain hull forms or propeller designs. To provide design data, systematic series were set up at some towing tanks. Between 1936 and 1970, MARIN contributed the widely known B- and Ka-series propellers.

Progressing insight in ship hydrodynamics had permitted the semi-empirical methods to move forward to become very practical tools, such as the Holtrop-Mennen method, which is again a MARIN tool used world-wide. Besides the more empirical approach, much research has been done on the entirely theoretical prediction of aspects of ship hydrodynamics. Initially, simplified potential-flow methods suitable for analytical solution were developed. The usefulness of these analytical tools differed strongly between the different fields of application. For example, Michell's theory for ship wavemaking appeared limited to very slender ships, but in seakeeping strip theory well predicted ship motions and added resistance; and the lifting line and lifting surface theory still play an important role in propeller design, such as in the ANPRO propeller analysis code.

Breakthrough with panel methods

A major breakthrough came with the advent of computers and better numerical techniques and here MARIN took full advantage of the new development. This made it easier to solve realistic problems, without requiring the simplification required for analytical techniques. Actually, an important initial development came from the aircraft industry, in the shape of the Hess and Smith method (1962) for the calculation of the potential flow around a body of arbitrary shape. In the early eighties MARIN's corresponding HESM code was used in practice, providing valuable insight in the pressure distribution and streamline pattern for ship hulls.

As the next step, Gadd at BMT (1976) and Dawson at DTMB (1975) proposed 3D panel methods for predicting the wave pattern. Work on Dawson's method at MARIN started in 1985 and by 1987 the DAWSON code was introduced in practical design work. Soon it was used on a large scale which led to an analysis protocol for the predicted flow fields and wave patterns that helped improve hull form designs. However, Dawson's method still contained a simplification (linearisation) of the treatment of the wave formation. With increasing experience and increasing computer speed, a step towards a fully non-linear solution technique was desired. From 1990, such a code was developed at MARIN, the well-known RAPID code, which since 1994 is one of the main workhorses for practical ship hull form design. Also in propeller analysis, 3D panel codes are finding application and are now being incorporated in the propeller analysis package.

With the upcoming offshore industry in the late 60's, the calculation of the motions of non-slender moored constructions in waves became important. The need to describe the diffraction of waves and the determination of the motions in waves resulted in a panel programme DIFFRAC using the full 3-D geometry and complex Green's functions. The calculation of the non-linear wave excitation at the natural period of the mooring system and subsequently, the low frequency motions, were crucial for the design of mooring systems of FPSOs.

CFD tools help solve viscous flow problems

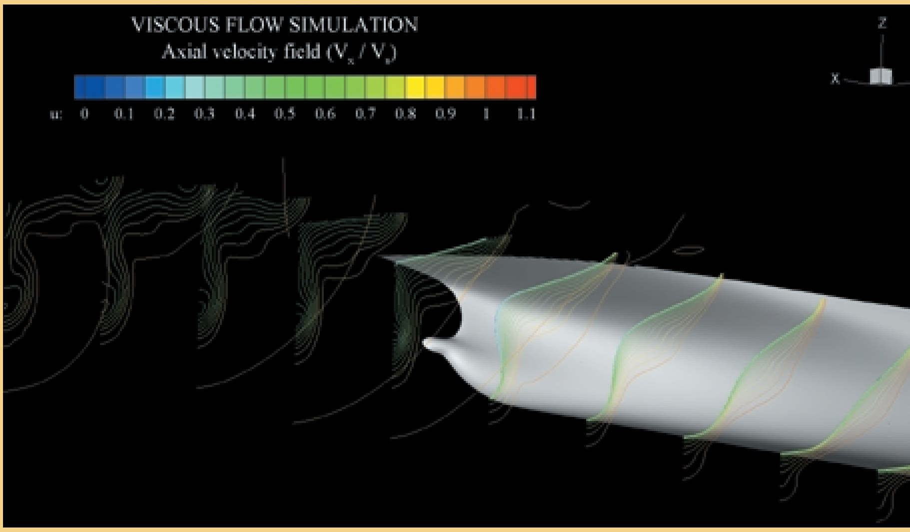
The problem of computing a turbulent viscous flow past a ship hull is less tractable by analytical techniques and the first attempts could only be made once computers were available. In the seventies, a code BLSHIP was developed at MARIN based on the assumption of a thin boundary layer. Some applications were made, but it was soon discovered that the boundary layer assumption was too inaccurate in the region where it really matters - propeller inflow. Therefore, the development of a tool based on the RANS equations was undertaken at MARIN which represented a brave move at that time (1981).

In 1985, this resulted in one of the first RANS tools world-wide able to compute the viscous flow around a ship hull - the early version of the PARNASSOS code. Today, the new PARNASSOS is an advanced, accurate and practical tool to predict wake fields, flow separations, streamline directions, and is applied routinely in ship design.

Also in offshore technology RANS tools are being applied. The requirement of detailed safety studies for offshore green water protection barriers on FPSOs led to the development of a CFD code named COMFLOW which was developed along with the University of Groningen. This involves an unsteady Navier-Stokes solver with non-linear free-surface treatment based on Volume of Fluid techniques. The method essentially treats violent free surface movements including breaking waves, slapping or slamming of waves against structures on deck. The capabilities of the code were extended to the determination of the internal flow in anti-roll tanks in ships in waves. This has led to a better understanding of the reduced roll behaviour in the design of anti-roll tanks.

Simulation tools tackle complex designs

The study of complex design and operational aspects of ships and offshore constructions requires trustworthy and robust simulation tools. Several of these tools have been developed at MARIN, here, just a few are highlighted. The simulation of complex mooring and offloading operations in waves became feasible using the basic hydrodynamic results in the frequency domain, together with their transformation into the time domain. The programmes DYNFLOAT and LIFSIM are based on this. Several designs of side-by-side offloading operations could be simulated efficiently before doing final design model tests. The determination of the efficiency of dynamic positioning algorithms required the integration of thruster performance, thruster allocation and the positioning accuracy and this was all incorporated in the code DPSIM. For naval applications the assessment of the dynamic stability of vessels in following



Today's viscous flow computations provide unprecedented possibilities for hull form design - an example of isolines of the longitudinal velocity component for a container-ship, predicted using the Parnassos code.

sea conditions is essential. Using the exact integration of the undisturbed wave pressures over the wetted hull of the vessel, broaching and capsize predictions became feasible. The simulation programme for this purpose, FREDYN, has been used in the safety analysis of future designs of frigates. The simulation programme SURSIM, assesses the manoeuvring characteristics, such as zigzag tests and turning circles, in an early design stage.

Undoubtedly, the future will bring methods with increasingly comprehensive modelling and to bring a more complete, precise and more efficient optimisation of the design of ships and offshore structures within reach.

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