Final meeting of Sea Trial Analysis JIP on July 4, 2006.

Full-scale investigations

An Ocean of Knowledge

Full-scale investigations have become essential in research and development and increasingly support operations in shipping and the offshore industry. A few of these developments are outlined.

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Demand for "real world" data, as well as the need for the validation of numerical and experimental models, led MARIN to start the Trials & Monitoring (T&M) Group in 1990. In the past 17 years, research at full-scale has grown into a core service which, often in combination with computational analysis, model testing and simulator training, leads to new insights and solutions.

Today, trials and monitoring activities comprise specialist investigations, giving feedback on design but more and more often, long-term monitoring campaigns are carried out which results in operational support on board ships and offshore structures.

Ship Performance

Traditionally, ships are subjected to speed trials to verify the contract speed-power upon delivery. In 2002, Shell, P&O Nedlloyd, Maersk and MARIN, initiated the Sea Trial Analysis (STA) JIP aiming at transparent and more accurate methods for speed trials.

In close co-operation with twelve leading owners and six major shipyards, rational trial run and measurement procedures were defined and new analysis methods, such as those for wave corrections were developed and documented in Recommended Practice and Recommended Analysis guidelines. "This is the Best Practice we could achieve with our present knowledge and experience today and it will contribute to higher quality ships," says Hans Huisman, Senior Director Newbuilding at ER Schiffahrt and Chairman of the STA-JIP.

The STA group will continue to exchange experiences and is open to new members. The Recommended Practice guidelines are also available to other owners and yards.

Monitoring impacts and hull strains on Victoriaborg.

The recently-launched Service Performance Analysis JIP is aiming at the analysis of speed-power performance in service conditions to reduce increasing fuel costs. A future challenge is to develop a speed-power analysis which can deal with any ship under arbitrary service conditions, only requiring a limited number of input signals and distinguishing the dominant components in the power and fuel consumption.

Validating CFD

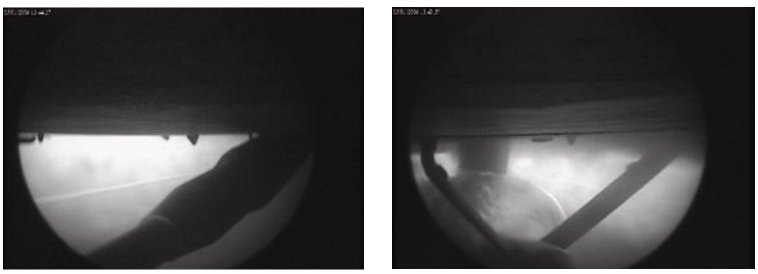
Computational Fluid Dynamics has proven to be a powerful tool in the analysis of flow problems, in the optimisation of hull forms and in the design of propellers. An important step in respect of model testing is that CFD can run at full-scale, thus preventing scale effects.

For the validation of CFD models, full-scale measurements on board actual ships is the most logical approach. For this purpose Laser Doppler Velocimetry (LDV) equipment was acquired and developed at MARIN. In the early nineties the equipment was used on two navy ships. LDV equipment was installed above the propeller and laser beams looked through special windows in the hull. At the crossing of the beams the flow velocity in two components could be measured. A major hurdle at that time was the size of the laser and the cooler capacity required. In 1997, new LDV equipment was obtained with a compact laser and an automatic traversing system to scan a large number of locations in a short period. The system was successfully deployed on the HMS DE RUYTER and the NATO research vessel, ALLIANCE. Results were used for the validation of commercial CFD codes.

Valdation of CFD codes for complex merchant vessels such as trailing suction hopper dredgers was the subject of the EU-sponsored EFFORT project. Obviously, the ultimate challenge for CFD validation is to measure the complete flow in arbitrary conditions. New techniques such as Particle Imaging Velocimetry (PIV) will be used in the coming year to increase the resolution in time and space for full-scale flow measurement.

Flow Observations & Dynamic Pressures

Observation of cavitation phenomenon on propellers has been conducted for several decades. Traditionally, such observations were taken through multiple windows in the hull above the propeller. Stroboscopic light triggered by the propeller shaft revolutions preferably at night-time was used to produce stills. With the availability of light sensitive Hi-8 video recorders in the nineties it became possible to make observation footage in daylight. In early 2000, high-speed video cameras with a sampling of more than 25,000 Hz made it possible to finally frame the dynamic development of cavitation bubbles in all their detail.



Flow observation through boroscope.

At the same time, boroscope technology has improved to apply this through hull penetrations of only 10 mm diameter. The obvious advantage is that no windows are required and these small hull penetrations can be made with the vessel in service. Actually the same hull penetrations can be used for dynamic pressure measurements. Boroscopes also enable a 360-degree view underneath the hull and can therefore, be used to investigate the flow around appendages.

The future challenge is to conduct high-speed observations through boroscopes and to combine these with wireless-distributed dynamic pressure and vibration measurements.

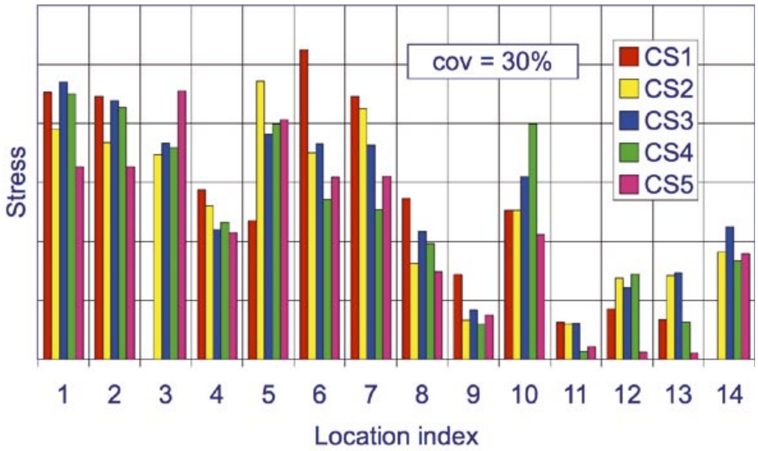
Heavy lift & Lashing

In the early nineties T&M conducted extensive full-scale measurements during heavy lift operations in the North Sea. Motions and hoisting loads measured during the installation of the Gannet Jacket and the 11,000 tonne Piper PUD topsides, were used for the validation of the LIFSIM program.

At the end of the nineties MARIN was already heavily involved in the engineering and operational support of heavy lift transports, among others with the development of SAFETRANS and on board monitoring and advisory systems.

Monitoring motions and loads on Marco Polo TLP in the Gulf of Mexico.

Today the Lashing@Sea JIP is investigating the governing mechanism of lashing loading including the effect of hull deformations and vibrations.



Stress calculations for different locations in FPSO made by class societies.

Lashing@Sea is supported by eight ship operators, five class societies and five suppliers, as well as by the Dutch Ministry of Transport. This campaign comprises three container carriers, two ro-ro vessels and a heavy lift vessel. The challenge here is to combine sea-keeping with mechanical and structural analysis and to obtain an understanding of cargo load mechanisms.

FPSO Fatigue

Although the focus in shipbuilding always has been on the ultimate strength of ships in extreme wave conditions, the actual life-time is increasingly determined by fatigue. The application of high tensile steels in combination with structural optimisation resulted in higher stress levels and consequently, in fatigue cracks which require substantial inspection, repair and maintenance work.

In the FPSO Integrity JIP, fatigue loading on FPSOs was investigated by an extensive monitoring campaign on board FPSO Glass Dowr, a newly converted Aframax tanker operated in the central North Sea by Bluewater. Five major class societies ran their in-house numerical sea-keeping and structural models to predict the fatigue life-time of the FPSO. As illustrated, a large spread of results was found. An important conclusion was that the intermittent wave-loading around the water line is a crucial factor in the fatigue loading.

In the next step, Bluewater, DnV and MARIN, investigated a minimum monitoring system on board an FPSO that could control the fatigue life. With this knowledge and experience, the new MONITAS JIP kicked-off at the recent 18th FPSO JIP Week. The next challenge is to develop an intelligent monitoring system assisting with the inspection, repair and maintenance of FPSOs.

Full-scale investigation has become an essential source of knowledge, although challenges lie ahead. Disciplines traditionally investigating isolated aspects have to be integrated in order to understand the complex reality of structures at sea. On-line, real time monitoring of ships on the Internet through satellite communication is now becoming available and opens up many opportunities. At the same time, this fresh understanding needs to be practically made available to the operators on board which will benefit the safety and economics of the maritime industry.