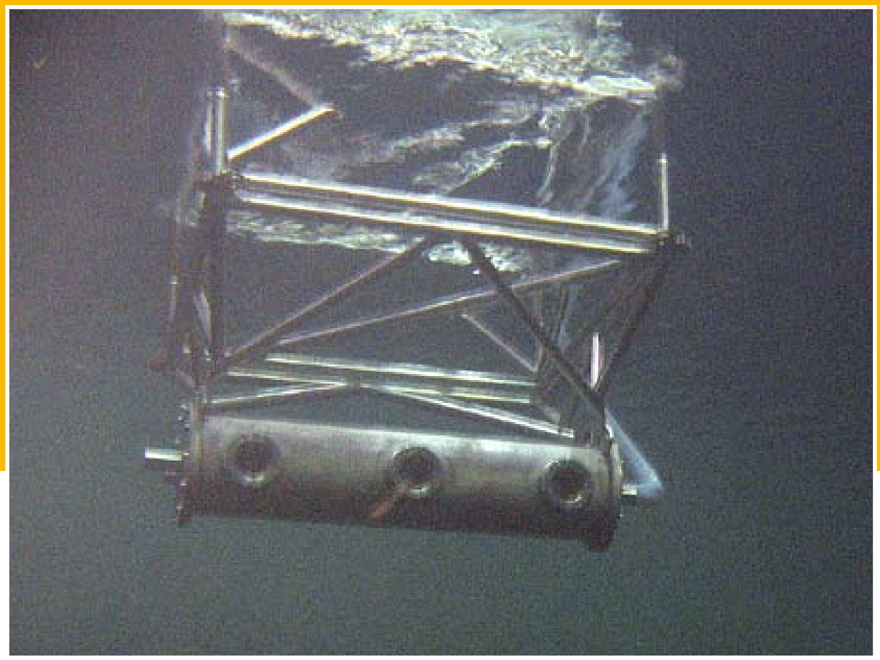
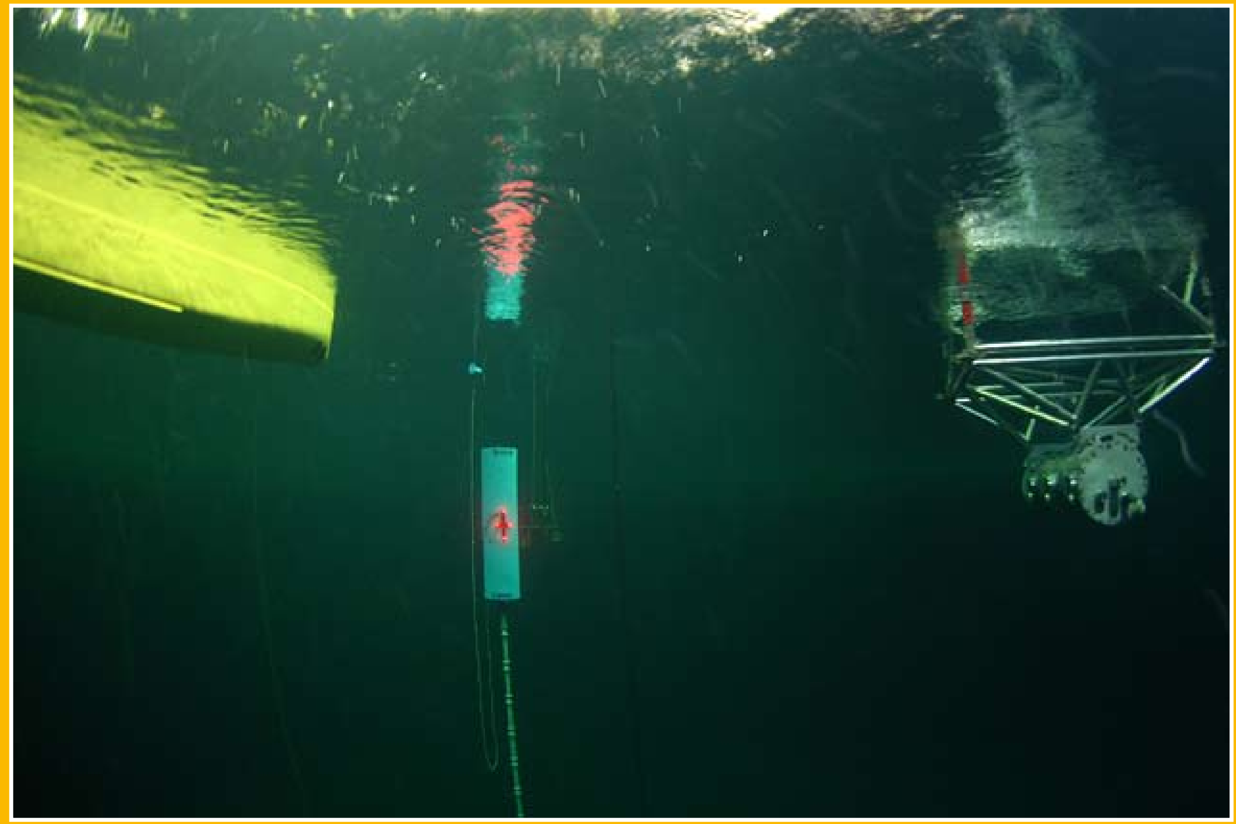
MARIN develops unique Underwater Measurement System



UMS: MARIN's special eye for underwater behaviour



UMS camera and ultra bright red LEDs

MARIN decided to tackle the problems associated with measuring underwater motions by developing a new Underwater Motion Measurement System. Report outlines the UMS.

Reinier Bergevoet &
Edwin van de Bunt
r.bergevoet@marin.nl

For years, MARIN has been able to measure 6 Degree of Freedom (DoF) motions for floating structures using Krypton (now Nikon), Rodymm DMM optical measurement systems. This system uses three cameras mounted on a beam which track synchronised active markers on the model. These systems can measure motions of structures with the active markers above the water surface.

Traditionally, motions of submerged structures were determined using accelerometers or video recordings. Determining low-frequency motions from accelerometers is very inaccurate. Using video recordings to determine the motions is very time-consuming and this technique can only be used to determine motions in the camera plane. Due to an increasing number of projects containing subsea structures, such as disconnectable turret mooring systems and mid-water riser support arches, and the industry's questions about their underwater behaviour, in 2004 MARIN decided to develop a 6 DoF, contactless Underwater Motion Measurement System (UMS), comparable to the above-water system. In close cooperation with the Krypton Corporation a modified version of its K600 optical measurement system was developed.

K600 adapted for underwater Several changes had to be made to the original K600 system to be able to use it underwater. First, the infrared Light Emitting Diodes (LEDs) used for structures above water had to be replaced by different colour LEDs because the absorption of infrared light underwater is very large. After some research ultra bright red LEDs were chosen for the new UMS.
Secondly, a watertight housing for the camera beam, including a stiff connection frame to the basin carriage, had to be manufactured. Using MARIN`s diffraction software, DIFFRAC, the wave loads on the connection frame and camera housing were determined and taken into account in the design. The frame has to be very stiff in order to minimise the motions of the camera beam because that has a big impact on measurement accuracy.

Improved measurement quality Furthermore, a system of tracks was developed to be able to mount the camera on the basin floor, allowing camera positions below the object to be tracked. This track-mounting option reduces the chance of reflections of the LEDs on the water surface, thus improving measurement quality and accuracy.
The engineering of the camera control software comprised the last stage of the development. An important requirement in the specifications was that the UMS should be able to measure in the same coordinate system as the above-water system. This is essential for disconnectable turret systems for instance, to be able to determine buoy positions with respect to the floater. A special calibration device was developed to be able to convert the UMS coordinate system to the MARIN standard coordinate system.

This new measurement system is able to measure 3 DoF of up to 30 individual LEDs (e.g. for riser shape measurement), or 6 DoF of up to 3 bodies, (e.g. for underwater buoys). The system can measure in a large area (maximum of 3 * 3 metres at a distance of 6 metres from the camera), with a typical specified measurement resolution of 0.02 mm and a specified measurement uncertainty of 0.3mm (U95).

In recent years the UMS system has been applied for numerous complex measurements. It enabled the study of disconnectable turret systems in survival conditions, hybrid riser towers and other subsea systems in current and waves. The accurate measurements made it possible to study motion behaviour but also possible interactions between different structures that could otherwise not have been quantified.