Advanced Techniques for Dredging Applications

Parametric Sediment Echo Sounder System SES-96 for Surveys in India

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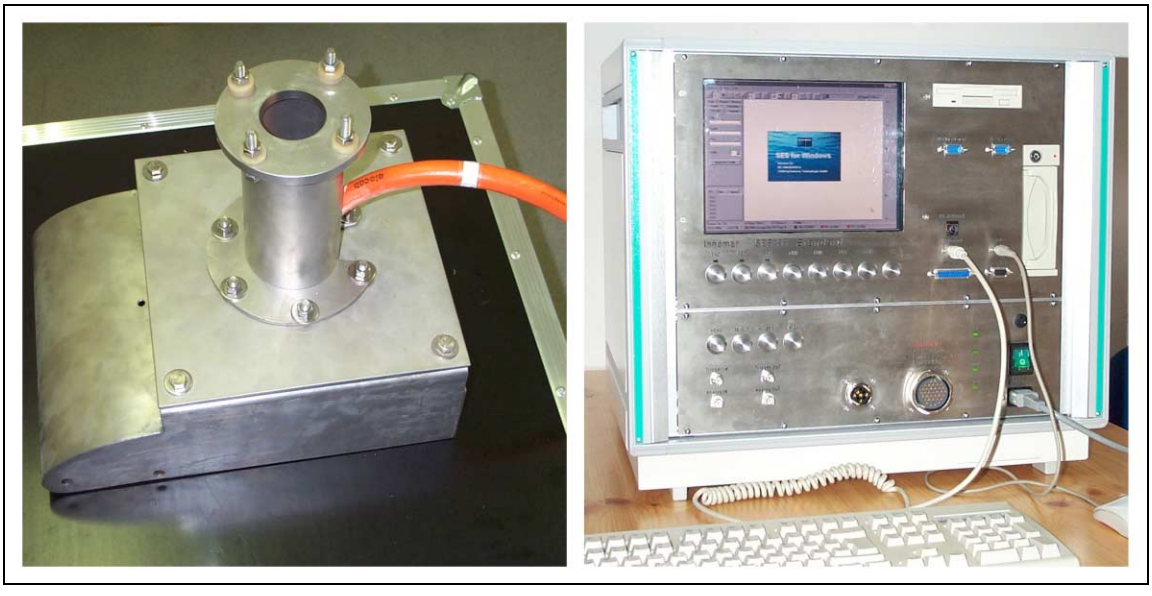
Dredging companies have a great interest in exact information about the dredging area and the existing material conditions, like sediment structures, sediment types and sediment volumes. New technologies can increase the efficiency of retrieving the needed information and data. The German company Innomar Technologie GmbH has worked in a dredging project of Ballast Nedam Dredging Netherlands for the construction of a harbour in India. During a period of three weeks in March of this year the new Parametric Sediment Echo Sounder System SES-96 *standard* was used to survey the dredging area and collect as much bottom information as possible. The main tasks were the determination of the required dredging level for the construction of breakwaters with high accuracy, the search for rock outcrops and embedded rock structures in the dredging area and the estimation of sand masses in nearby areas for the dredging project.

The Sediment Echo Sounder System SES-96 *standard* is part of Innomar's product line of parametric echo sounders. It uses the parametric acoustical effect, which has some advantages compared to normal echo sounders. Transmitting sound waves under high sound pressure results in non-linearities at the sound propagation. If two slightly different high frequencies are transmitted, they interact in the water column. Sum and difference frequencies are generated. The high frequencies can be used for the exact determination of the water depth. The generated difference frequencies are able to penetrate the bottom and give information about the sub-bottom structure.

SES-96 *standard* - System Overview

The system SES-96 *standard* consists of a 19 inch rack in a robust and portable device (weight: 45kg), the transducer with the cable (weight: 32kg) and a colour printer.



Transducer and SES-96 System Unit

The SES-96 system uses two primary frequencies near 100kHz to generate difference frequencies between 4kHz and 12kHz. A real advantage of the parametric SES-96 system against linear echo sounders is the achieved half power beam width of +/-1.8 degrees for the low frequencies with a small and portable transducer. This beam width is valid for all generated difference frequencies and results in the same footprint of the sound beam. At 5m water depth we have a footprint of 0,31m x 0,31m. Additionally the beam has no side lobes, so the survey in small areas, like harbour basins becomes possible with reduced influences from the side. The possible transmission of very short pulses without ringing effects, for instance one sinus pulse of 12 kHz, results in very good resolution of layers and objects up to 5cm layer thickness. The accuracy of the depth measurement is given with 0,02 m +0,02% of the water depth for the 100 kHz and the smallest range. With the system SES-96 *standard* it is also possible to steer the sound beam electronically. This is used to correct the ship movements in a range of about +/-5 degrees for roll and pitch movements. With an optional transducer the system can steer the beam for the roll direction in a range of +/- 16 degrees. The actual ship movement including the heave is measured by a Motion Sensor. The roll/pitch correction can be made on-line, the heave correction on-line or off-line. The SES-96 system has a pulse repetition rate of up to 50 pulses per second, depending on the water depth. Any possible navigation system on the market can be used, which has an ASCII-Interface, like NMEA. The data are digitally stored for the high and the low frequency. Additionally the information from a GPS receiver and the Motion Sensor data and the system parameters are stored.

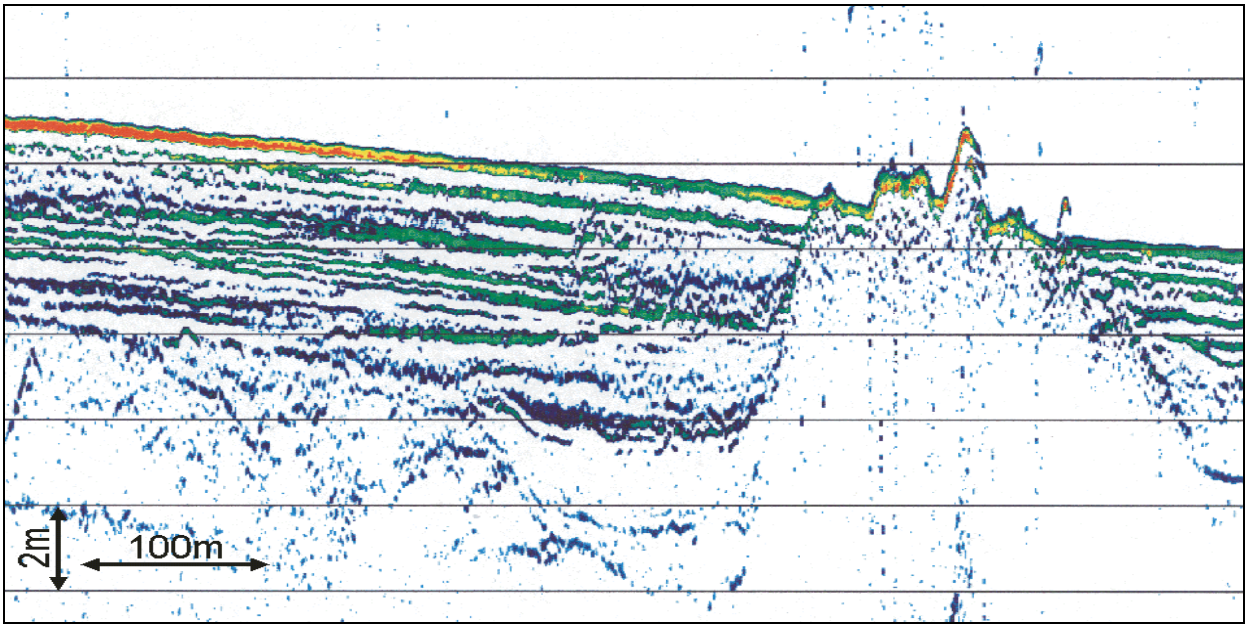
Remarks on the Survey in India

A local fisher boat was used as a survey vessel. The installation and calibration procedure of the echo sounder system was done within some hours. The small transducer of 20cm x 20cm was installed in a stainless steel frame and mounted on the side of the vessel.

Installation of SES-96

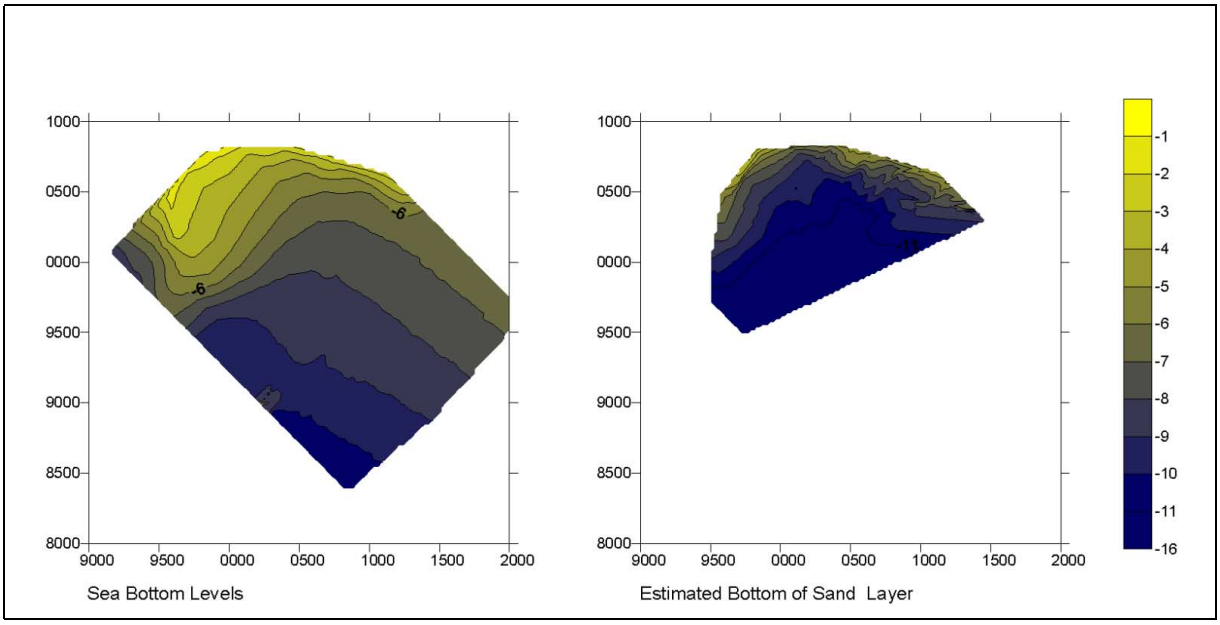
Different test profiles were surveyed to find the best system settings, for instance the adjustable low frequency. The penetration depth always depends on the bottom material. In general is the penetration depth of low frequencies higher than the penetration of high frequencies. Against this stands the rule, that the resolution increases, if higher frequencies are used and decreases, if lower frequencies are used. To reach the layer of hard material in the area for the breakwaters, it was necessary to choose a frequency of 6kHz. The layer of weathered rock was covered with about 8m of clay at water depths of about 10m. During the survey on-line echo plots were generated. The colours in the example picture are

indicating changes in the signal strength. Red means a strong change and blue a small change of the acoustical impedance of successive materials. Depth values in the echoplots are related to the measured sound velocity in the water column. A sound velocity probe was used to measure it. Advanced signal processing techniques in the control software SES for Windows generate high resolution pictures already during the survey. Therefore it is possible to adapt the survey to the existing conditions. The water depth values of both channels, the low and high frequency, will be automatically calculated and are also provided at an online ASCII output. Innomar's post processing software tool ISE 2.5 was used to correct the echo data with separately recorded tide information, to digitise the sediment layer information and to extract the data into compatible ASCII formats. Ballast Nedam has taken some boring probes in the area. The material classification of the probes and the information of the echo sounder data were put together. Differences of the sound velocity in water and in the sediments were corrected.



Echoplot sample with different clay and sand layers and a rock outcrop

One task during the survey was to find sand borrow areas. Surrounded areas were explored. The results from the survey in one bay were processed to estimate the sand resources. With the ISE 2.5 software were digitised the upper and lower border of the sand layer. These two borders are visualized in coloured contour maps. Within two days it was possible to determine the volume of the sand layer in the explored bay, including the survey and the processing.



Contour maps of an explored sand borrow area

Conclusion

During the project were surveyed more than 300km and were processed more than 10GB of data. Compared to the information of some single points, got by boring probes, a more complete idea of the sediment conditions in the interesting area was achieved. The definition of boring probe and sample positions are more efficient, if we have pre information about the sediment body structure from a sediment echo sounder survey. The amount of expensive and time consuming boring probes can be really decreased. The dredging volume calculations become more accurate by the use of such high resolution sediment echo sounder system compared to results of some single probes. After the successful trial in India Ballast Nedam will use the system SES-96 *standard* for further applications, not only during the harbour construction project in India.

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