Hydrographic Surveys at the Port of Sines

The Hydrographic Institute of Portugal (HIP) has been executing hydrographic surveys at the port of Sines since 1973 as part of successive contracts signed with the Port of Sines Authority. Surveying at Sines as been made mainly for port engineering planning, construction and monitoring purposes.

"Sines was chosen as the site for the construction of a national deep-water harbour in the early 1970s in response to the increasing trend worldwide towards very large vessels. The Port of Sines began operating in 1978 and its location is 58 nautical miles south of Lisbon. It is one of the few deep-water ports in Europe, thus allowing vessels up to 350,000 DWT to come alongside.
Since it is a wide open sea port of natural depths with no need for dredging, large annual values of cargo handling were soon achieved, which turned Sines into Portugal's first national port regarding annual tonnage handled.
The Port of Sines comprises four Terminals: Oil, Petrochemical, Multi-purpose and General Cargo and two inner harbours, one for fishing and the other for yachts. Between the two inner harbours is located a sandy beach." (from the Port of Sines web page)

The Need for hydrographic Surveying
Since 1973 the HIP has been conducting topographic, hydrographic and oceanographic works as part of contracts established with the Port of Sines Authority (PSA). The purpose of these works were to satisfy the following projects:

- Engineering design
- Monitoring breakwater construction in accordance with the design project
- Periodic breakwater and pier monitoring to verify structural variations after construction
- Control changes in sediment transport caused by the breakwaters
- Collect data for nautical publications

All hydrographic and topographic works accomplish the accuracy requirements of the International Hydrographic Organisation (IHO) and are used to update nautical charts.

Preliminary Surveys
Hydrographic data are obviously important for the design of a breakwater. Water level changes caused either by tides or by storm surges may be important for determining the crest elevation of the breakwater. Wave heights and their frequency of occurrence must also be considered in the design process.
In 1972, a hydrographic survey was conducted for the purpose of providing bathymetry information for the design project and to establish a reference for future studies concerning the changes in sediment transport.
This survey was executed using a single-beam echo sounder Atlas Deso 10. The positioning was achieved at three stations using theodolites Wild T16 by simultaneous angular observations to the top of the echo sounder transducer.
All information was gathered in the office. The computations were made using primitive calculators and mathematical tables. The final plots were made by hand. The final depth and positioning accuracy was within decimetre level.

Breakwater Construction
The maritime works started in 1973 for the construction of the fuel terminal. Hydrographic surveys were conducted in order to monitor the works in accordance with the design project.
The accuracy requirements were very restrictive and all the measurements were made using the most advanced methods through the use of Deso 10 echo sounders and Wild T16 theodolites by experimented personnel. The depth accuracy was determined about 50 cm and the positioning accuracy was 50 cm (95 per cent confidence level). From redundant measurements it was found that simultaneous observations give an error less than 15 cm when made by experienced surveyors.
In 1978 a storm destroyed part of the already finished west breakwater. One buoy registered a maximum wave height of 12 metres at 60 metres depth. The harbour had to be re-designed and re-built to account for such violent storms. Between 1978 and 1981 all the works almost stopped. During this period hydrographic surveys were conducted for the purpose of monitoring the breakwater sitting down. After 1981 hydrographic surveys were executed with the purpose of monitoring already finished works and to execute an accompaniment of the works as the harbour expands.

Structural Monitoring
For structural monitoring it is required to systematically execute topographic and hydrographic surveys in order to characterise the condition of maritime structures such as breakwaters and piers.
When the works were finished certain control points were defined in the structures to be observed. The position of these control points must be observed periodically and the observations are compared. Such observations were made by classical methods using theodolites Wild T2 and levelling techniques. The required accuracy is within centimetre level.
In 1999, the observation of control points was executed with GPS OTF. First, it was required to compute a co-ordinate calibration model in order to transform local co-ordinates to the local datum. Second, GPS observations were made at all control points in â€˜stop and goâ€™

mode. Finally, all observations were post-processed in order to compute the WGS 84 baselines and apply the calibration model. This method significantly reduced the time and personnel when compared to classical methods.
The final results show that co-ordinate variations from successive surveys are less than 3 cm for all control points. These variations are within the observations' noise level. Therefore, no structural deformations were detected.
To control for deformation of the underwater structure of breakwaters periodic surveys were made along planned lines. The purpose of these surveys required the highest possible accuracy level. Three positioning methods were used: theodolites, POLARFIX and DGPS. The DGPS was employed only in 1998, after the appearance of commercially available narrow correlator receivers which allow sub-metre level accuracy. Depth measurements were made by single-beam echo sounders. The hydrographic data acquisition and processing software, HYPACK, has been used since 1998. With this new equipment and software it is possible to survey and deliver the final product to the client on the same day.

Beach Survey
The sandy beach located in the inner harbour, designated as â€˜Praia Vasco da Gamaâ€™ already existed prior to the choice of Sines as the site for the construction of a national deep-water harbour. Changes in sediment transport caused by the breakwaters may affect the beach maintenance. As part of an environmental project it is required to maintain the sandy beach for the use of the local population and tourists.
Periodic surveys were made at â€˜Praia Vasco da Gamaâ€™ and used as information sources to plan protection for it from erosion. The dry area was surveyed using topographic methods following the same planned lines that were used for the hydrographic survey.
The methods to survey the submersed area were the same as mentioned before with a single beam echo sounder. Until 1998 theodolites and distance meters were used to survey the dry area with guidance provided from a visual reference. GPS OTF in real time was used for the first time in 1999. This was a significant improvement in efficiency. Only one man was required to collect real-time data in less time than two or more men using theodolites and distance meters.

Multibeam Comes to Sines
In 1996 the HIP purchased its first Multibeam Echo sounder (MBES), the Simrad EM 950. Due to its unique characteristics - deep-water harbour, Sines was chosen as the multibeam test place.
In 1997, Sines was the first Portuguese harbour to be surveyed with this recent technology. The multibeam survey lasted for seven days for an area of 7.5 km2 (Figure 2). At the same time a single-beam survey was carried out, which allowed the comparison between the two technologies, as presented in Figure 3.
The graph presents the cumulative percentage of soundings by depth difference.
The large differences obtained when comparing the single-beam survey with a digital terrain model generated with multibeam data may be explained by several factors, such as: high irregularity of the bottom, differences between the footprint dimension, heave compensation and DTM approximation. In the few areas with smooth bathymetry the differences were below 30 centimetres.
Considering the major concern of a â€˜goodâ€™ coverage of the sea floor, the single-beam survey was carried out with very narrow line spacing. As a result, this survey lasted for approximately three months and was several times delayed due to the weather conditions.
The multibeam survey was planned to achieve a full coverage of the bottom and produced a huge data volume. Therefore, data processing was very time consuming when compared with the data acquisition.
The Port of Sines is now in a process of expansion. Another terminal for large container ships is projected. The last survey using an MBES was executed in 2000 as a preliminary survey to achieve sounding data for engineering planning purposes.

Historical Note
Sines is the birthplace of the Portuguese navigator Vasco da Gama. In 1497 he sailed from Lisbon for an enterprise that opened the maritime route from the eastern world to India and the East.