CHAPTER 27

Measurements from a fast-moving air-cushion platform

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Abstract

In 1976 the Belgian Government decided to enlarge the harbour of Zeebrugge and to execute an artificial beach renourishment on the beaches at Knokke-Heist. A comprehensive survey program along the 24 km coastline was conceived using remote sensing techniques. This enabled correct momentary recordings of the beach areas, the production of differential charts and calculations of dune and beach volumes. However, the observations of the nearshore and offshore areas from ordinary survey vessels take too long so that no accurate momentary recordings of the seabottom topography can be achieved. On these grounds, in 1983, the Belgian Authorities have instructed the Eurosense Belfotop Company to develop an effective measuring method based on the use of a hovercraft.

This hovercraft platform, named "BEASAC" and designed for hydrographic surveys, is now used for monitoring the coastal morphology and the dredging activities in the access channels to the major Belgian seaports. On the basis of the "Beasac"-soundings of the nearshore area and the aerial remote sensing data of the beach, charts and differential charts of the combined beach and nearshore area are produced.

The results of this technique are very promising and will be incorporated in the further survey programs ordered by the Belgian Authorities as a substitute for the classic bathymetric vessel soundings.

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1. Introduction

As already reported in former conferences and technical papers, the Belgian authorities have always paid special attention to efficient shore protection of the Belgian East Coast (ref. 1,2). Picture 1 shows a Landsat-satellite picture of the Belgian Coast and the seaward side of the Westerscheldt estuary in 1984. Significant sediment movements are clearly visible around the harbour extension of the port of Zeebrugge. The Belgian East Coast is situated in the area between Blankenberge (4 km west of Zeebrugge) and the Belgian-Dutch border (10 km east of Zeebrugge).

Picture 1 : satellite picture of the Belgian Coast and the Western Scheldt Estuary

The reason for the coastal protection of the Belgian East Coast is obvious : for several decades the alarming regression of the shoreline on those beaches has offered a real threat to the important tourist and residential resorts of the city of Knokke-Heist and the nature reserve "Het Zwin".

Two phenomena are the main causes for this evolution (see figure 1). First of all in front of the beaches at Knokke-Heist a gully called the "Appelzak" with a depth of about 8 m under low water level developed to within a distance of 500 m of the seawall causing important beach erosion via offshore transport. Moreover the port of Zeebrugge - built at the turn of the century - intersected the easterly flow of longshore drift so that the incoming sediment was not sufficient for natural beach replenishment.

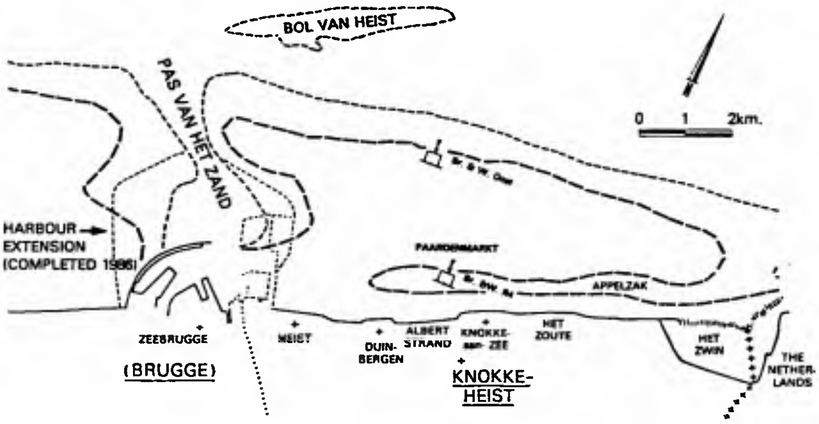

Fig. 1. : The Belgian East Coast : General Situation in 1976.

As a result, a strip of beach of only 50 to 100 m remained available in front of the seawall at low tide and the beaches disappeared nearly completely at high tide. Storms damaged the seawall on several occasions so that coastal protection works became very urgent. Picture 2 illustrates very clearly the precarious situation before 1976 when during storms, waves could overtop the existing sea-dike.

Picture 2 : During storms, waves overtop the existing sea-dike (winter 1975)

2. Coastal protection works

In 1976 the Belgian Government decided to enlarge the harbour at Zeebrugge. This included the construction of new breakwaters extending approximately 3,5 km into the sea from the existing seawall. Picture 3 gives an overall view of the harbour extension; behind them : the East Coast beaches. From the start the new expansion works of the outer Zeebrugge harbour were considered as a possible supplementary threat to the East Coast beaches. Therefore, and after a comprehensive study of the problem, it was decided to execute preventative coastal protection works on the beaches at Knokke-Heist starting at the same time with the harbour extension.

Picture 3 : The new outer harbour at Zeebrugge (1986)

In 1977 the decision was taken to execute an artificial beach renourishment of about 8,4 millions m^3 of coarse dredged sea sand. This work was completed between December 1977 and March 1979. As a result a new beach with the width of about 100 m at high tide was created. Picture 4 shows clearly the newly created beaches at Knokke-Heist. In comparison with the previous situation in 1976, the positive result is spectacular. In order to observe the evolution of the restored beaches, a comprehensive survey program along the 24 km coastline was conceived and started in june 1979. This was particularly important with regard to the influence on the beaches of the harbour extension works.

Picture 4 : Beaches at Knokke-Heist after beach renourishment

3. Coastal survey techniques

The aim of this paper is to give more details upon an important new development in the survey technique which was invented and applied to the considered coastal area. First of all it is important to know that an important contribution to the survey program was given by remote sensing techniques. This means the use of a specially conceived aeroplane, equipped with the most sophisticated cameras and multispectral scanners. These instruments are necessary in order to collect all the necessary data and to treat them by means of stereoscopic techniques. The results are then stored and ranged by specially developed computer software. The advantages of this method are obvious : speed and accuracy of measurement, the ability to provide easily assimilated results (i.e. differential charts and calculations of beach surfaces and volumes) and last but not least a correct momentary recording of a large area of observation.

In this way differential charts of the east coast beaches resulting from two aerial observations were made giving erosion and/or acretion areas.

So far, aerial remote sensing techniques in coastal engineering have been mostly limited to surface observations above the low water level especially in muddy or silty seawater areas. Sedimentological processes are however not solely restricted to the beach area itself. Important morphological phenomena occur offshore and cannot be reached by aerial remote sensing techniques. These offshore areas are even of a larger extend than the beach area and need other solutions in order to detect e.g. longshore and tidal transport.

Until now, the observation of the seabottom morphology was performed from classic bathymetric vessels. However, these vessels possess two essential disadvantages. In many cases the bathymetric soundings cannot be performed close enough to the beach so that the link with aerial remote sensing data of the beach is difficult to achieve or even impossible. Moreover, in practice, the observations from an ordinary survey vessel take too long - sometimes several months for one area - so that no accurate momentary recording of the seabottom topography can be achieved as the beginning and the end of the observations are difficult to compare.

This can result into mistakes; especially in coastal areas with rapidly changing morphological conditions. Only the use of a fast moving survey platform , capable of reaching the most shallow waters can provide an effective solution.

On these grounds, in 1983, the Belgian Authorities have instructed the Eurosense Belfotop Company to develop an effective measuring method based on the use of a hovercraft.

4. The "BEASAC"-platform

Picture 5 gives a general view of the new hydrographic measuring system, named "BEASAC".
"BEASAC" is the acronym for "Belfotop Eurosense Acoustic Sounding Air Cushion" platform.

Picture 5 : The BEASAC-platform

Although the idea to use a hovercraft for hydrographic purposes is not new, earlier attemps encountered numerous difficulties. Nevertheless the demand for hovercraft in surveying is likely to increase significantly. A first problem to be solved is the realisation of an accurate positioning system, not only with regard to the horizontal coordinates but also for the vertical location with respect to a fixed datum. Furthermore the speed of the craft leads to registration and treatment of a great amount of data, which is only feasable using special computer techniques. Finally, the craft had to be equipped as a reliable, fast and manoeuvrable high speed survey vessel.

An extended test program was set up and realised. The accuracy of the depth measurements in shallow water was checked by the terrestrial surveying of control points in the tidal zone between high and low water. The deviations between both methods were, on average, less than 10 centimers and consequently acceptable.

5. Combined charts of beach and nearshore area

On the basis of the aerial remote sensing data of beach topography and the BEASAC-platform soundings of the nearshore area a chart showing the combined beach and nearshore area was realised. Differential recordings of this total area, above and beneath the low water level line are easy to produce and give a much better insight into the morphological changes of the coastal area.

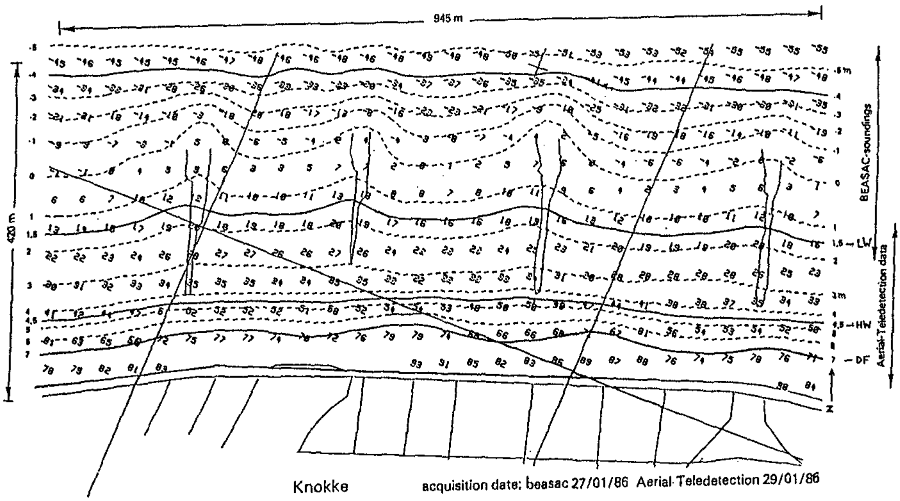

Fig. 2. : Combined chart of remote sensing and BEASAC data

Figure 2 shows the very first combined relief map realised with both aerial remote sensing techniques and Beasac soundings. The difference in data between the two methods in the overlap zone is only 10 centimeters on average.

In this way, charts of the total area east of the Zeebrugge harbour were made by a combination of remote sensing and Beasac data. While this area was normally covered by classic bathymetric vessels over a period of two to three months, it is now done by the BEASAC-platform in four to six days. Such a map can be produced on regular basis and accurate differential charts become also possible now.

After the execution of the test program, the newly developed sounding platform was accepted by the Belgian Authorities. It is now used to observe the beaches and nearshore areas of the Belgian Coast.

6. Control and monitoring surveys

The advantages of a fast moving survey platform are also obvious in other applications such as : the control and monitoring of dredging activities, and the monitoring and charting of large remote oceanographic territories. The accuracy of the measurements effected at high speeds of up to 50 km/h, in large areas such as open sea channels or sand bank configurations, was checked by classic bathymetric soundings from an hydrographic vessel. Under normal conditions the difference between both methods is less than 20 centimeters.

In this manner the Beasac platform is successfully employed for monitoring the evolution of the access channels to the major Belgian seaports, and for supervising the extensive dredging operations at these locations. The major advantages of the Beasac-system - namely the fast moving and accurate soundings - have proved to be important assets in observing and controlling sedimentological and dredging processes. More frequent charting allows evaluation of the need for, and the effectiveness of, dredging operations.

Figure 3 shows a nautical chart with absolute depth values realised with the BEASAC-platform. The represented zone is the entrance channel to the new outer harbour of Zeebrugge.

Differential depth charts of the the same area between two Beasac observation campaigns are also produced. These charts are very useful to monitor dredging operations.

The newly developed air cushion platform can indeed be considered as an important contribution towards more accurate and economical observations of morphological processes both natural and/or artificial.

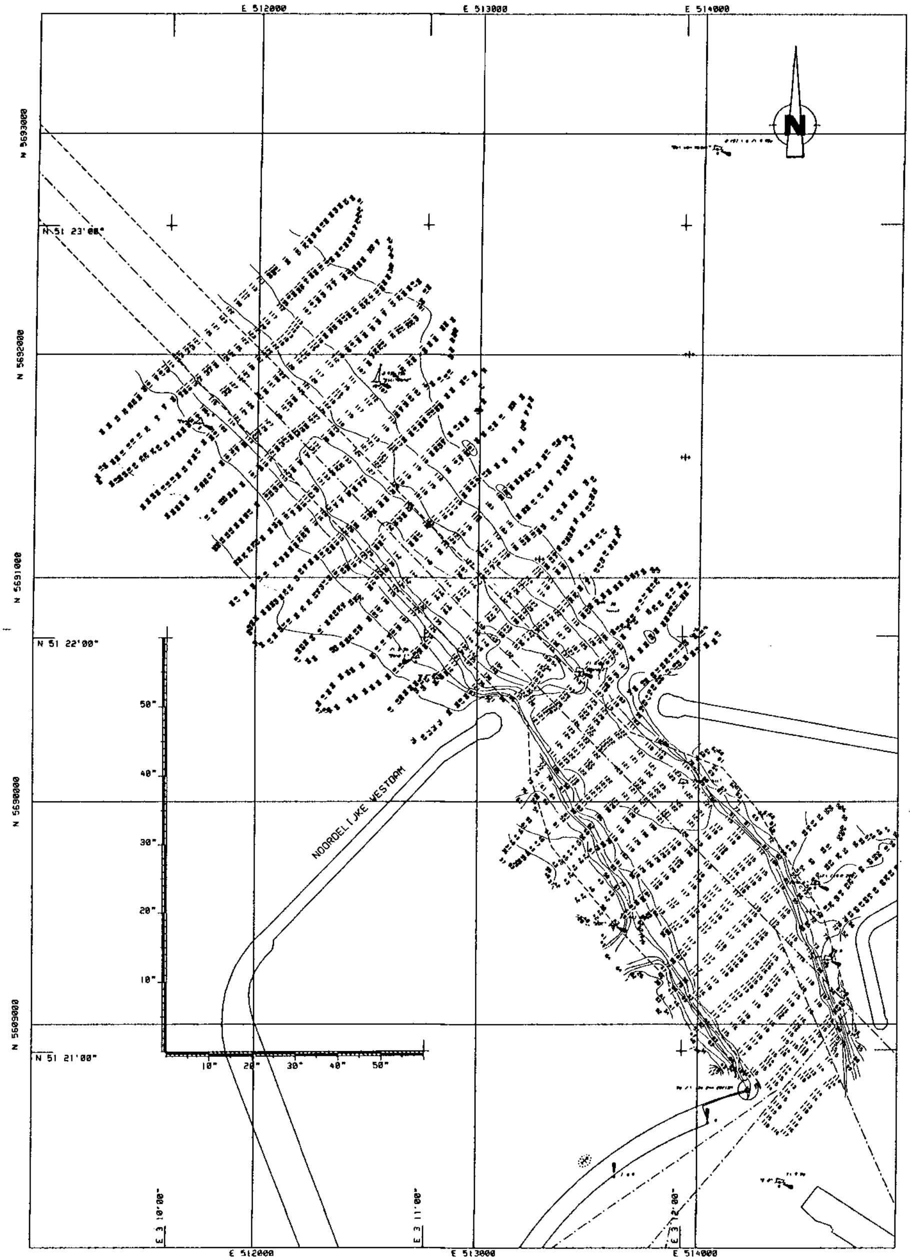

Fig. 3. : Nautical chart of the entrance channel to the port of Zeebrugge made by BEASAC

7. Survey equipment

Picture 6 shows the main cabin with the survey equipment : two Atlas Deso 20 - with 33 and 210 Khz transducers - and system control terminals are installed.

In front of the pilot, a navigation screen is mounted near the instrument panel on which the predefined tracks, the position of the hovercraft, its speed and the distance off-track are displayed.

Studies about the subject of dynamic positioning at sea resulted in the development of a very accurate and reliable positioning and navigation system, combining the use of a hyperbolic (Toran) and a circular (Trisponder) system.

Picture 6 : The main cabin with the survey equipment

On both sides of the hovercraft an acoustic transducer is installed in a stainless steel fish (see picture 7). The streamlined profile of the fish is designed for a survey speed of 27 knots, although higher speeds are possible.

The fish can be brought in or out of the water by manual or computer control. A mechanical weak link construction prevents damage to the sword or the craft in case of collision with floating objects. When approaching the shoreline the fish are retracted automatically.

Picture 7 : Stainless steel, sword and fish

In the hangar, a modern jacking system with eight jacks can lift the craft for periodic skirt inspections.

Picture 8 shows the Beasac-platform in operation near the beach. During these surveys a mobile shore beacon mounted on a jeep helps to optimise the dynamic positioning of the craft.

After each survey mission the data is transferred to the host computer system of the data center in Zeebrugge. Immediately several routine procedures are started which result in graphical and numerical reviews of the raw data. The tide-corrected data can then be plotted on a hydrographic chart.

Picture 8 : BEASAC-platform in operation near the beach

8. Conclusions

- The morphological research campaign started in 1979 on the Belgian East Coast, and, supported by aerial remote sensing techniques, it can be considered as very successful. On the basis of this campaign the decision was taken to execute a new beach renourishment of about 1 million m^3 of sand in the period March-April 1986 on locations resulting from the observations of the past survey program.

- At the same time, an important and fundamental contribution was made to more accurate observation of the nearshore and seabed area by means of a fast moving hydrographic-survey hovercraft : Beasac. The results of this new technique are very promising and will be incorporated in the further survey programs ordered by the Belgian Authorities as a substitute for the classic bathymetric vessel soundings.

Appendix - References

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