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BEASAC

A SURVEY HOVERCRAFT FOR OBSERVING THE BEACHES AND OFFSHORE AREAS NEAR THE BELGIAN COAST

A joint development of the Belgian Ministry of Public Works (*) and Eurosense (**)

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Abstract

In 1983, the Belgian Government instructed the Belgian company Eurosense to start with the development of a new hydrographic measuring system: a specially designed hovercraft-based sounding system. After a period of extended testing, the craft and its special purpose hardware and software was accepted in 1985 by the Coastal Hydrographic Office of the Belgian Ministry of Public Works. Now the system is successfully employed for monitoring changes to access channels of the major Belgian sea ports and for supervising the extensive dredging activities. Moreover, it is used to observe the beaches and offshore areas near the Belgian coast.

1. INTRODUCTION

Aerial remote sensing techniques have recently been developed and extensively used by Eurosense to give reliable results on coastal stability and beach erosion. The advantages of this method are obvious: speed and accuracy of measurement, the ability to provide easily assimilated results (i.e. differential charts, calculation of beach surfaces and volumes), a correct momentary recording of a large area of observation. So far this method has been limited to surface observations above low water level.

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Sedimentological processes are, however, not solely restricted to the beach area. Important phenomena also occur nearshore, below the surface of the sea, in a zone not accessible by aerial remote sensing techniques. Until now, the detection of the variations in sea bottom morphology was performed solely from classic bathymetric vessels. These vessels possess two essential disadvantages. In many cases the bathymetric soundings cannot be performed close enough to the beach, so as to properly achieve the link between them and the aerial remote sensing data. Moreover, the observations from a classic survey vessel take too long (sometimes several months for one observation area), so that no accurate momentary recording of the sea bottom topography is achieved, because the beginning and the end of the observations are difficult to compare. This can result in inaccuracies, especially in coastal areas with rapidly changing morphological conditions, such as in muddy or sandy areas, e.g. in large deltas or estuaries.

Only the use of a fast moving platform, capable of reaching the most shallow waters, can provide an effective solution. These arguments (speed and the ability to reach otherwise inaccessible regions) made Eurosense decide to evaluate hovercraft as sounding platforms.

Although the idea to use hovercraft for hydrographic purposes is not new, earlier attempts encountered numerous difficulties. Nevertheless, the demand for hovercraft in surveying is likely to increase significantly.

2. SYSTEM DEVELOPMENT

The B.H.C. SR.N6 Mk 1S hovercraft

Several hovercraft have been evaluated since 1981 by Eurosense. Finally, the best results concerning speed and stability were archieved with a B.H.C. SR.N6 Mk 1S hovercraft which is driven by a Rolls-Royce gas turbine. This platform has been called the BEASAC platform (Belfotop Eurosense Acoustic Sounding Air Cushion-platform) (see fig. 1).

The craft is a passenger version. In preparation for use as a survey craft, extensive modifications were studied by, and completed under the supervision of, Eurosense's technical staff. The main cabin has a large table for survey operations. Several removable and adjustable seats are mounted on the floor. A remote navigation screen is mounted near the instrument panel. Next to this survey room is an air-conditioned computer room and a hydraulic control room with general domestic facilities.

Two identical electric power supply units driven by diesel engines are mounted inside the raised side decks. Two acoustic transducers are installed in a fish made from welded stainless steel sheet. The streamlined profile of the fish is designed for a survey speed of 27 knots, although higher speeds are possible in practice.

The hydraulic retractable arms mounted on both sides of the craft bring a streamlined sword with the fish in or out of the water (see fig. 2). A mechanical

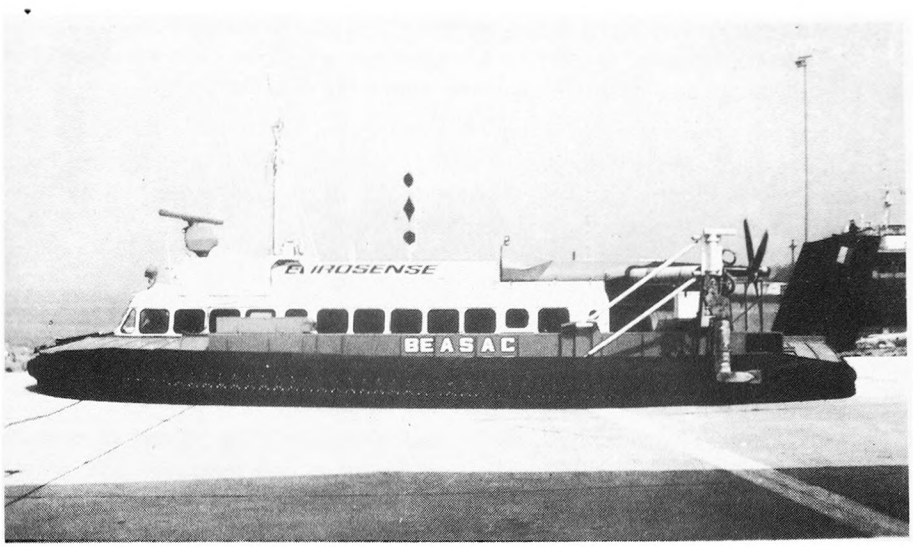

FIG. 1. — The BEASAC platform, side view.

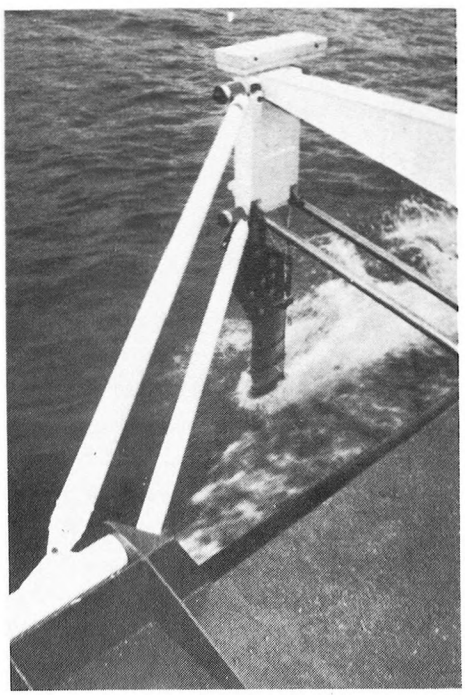

FIG. 2. — Hydraulic retractable arms.

weak link construction prevents damage to sword, fish or craft in case of collision with floating objects. Eurosense developed this automatic retracting and deployment system especially for acquisition in shallow waters.

Servo-controlled rudders, tinted windows and sound isolation make the survey missions less fatiguing for the pilot and surveyors. Four extra fuel tanks and the above mentioned modifications insure an autonomy of seven hours.

A hangar, specially designed by Eurosense, houses the hovercraft. A workshop, a spare part storehouse, a data processing room, a computer room, offices and sanitary infrastructure complete the plant at Zeebrugge. An hydraulic lifting system makes it possible to maintain the craft.

Survey equipment, sensors and acquisition system

Positioning system

Several studies conducted by Eurosense, concerning the subject of dynamic positioning at sea, resulted in the development of a very accurate and reliable navigation and positioning system. The combined use of a hyperbolic (Toran) and a circular system (Trisponder) gives a great redundancy. By correct use of this redundancy, one can detect and correct lane slip and small drift of the hyperbolic system and calculate an accurate position even when line-of-sight conditions are not fulfilled for the circular system.

The on-line calculation of a quality number for the position prevents the use of doubtful information. A GDOP calculation (Geometric Dilution Of Precision) gives on-line data or, in the mission preparation phase, information about the quality of the configuration of the used shore beacons in the survey area. For special missions, the surveyors can decide to use modified beacon configurations by means of movable shore beacons mounted on a jeep or a trailer.

Depth measurement and sensors

The hydraulic retractable arms let the fish penetrate the water surface during a survey. The acoustic transducer sends a sound burst and captures its echo signal which is digitally treated and memorized. This information is called the raw depth data in the rest of this paper.

As well as the raw depth data, other information is gathered, processed, synchronized and memorized:

— roll and pitch are measured by the gyroscope;
— the heading is measured by a flux gate compass;
— the air cushion's height is detected by a specially designed device, mounted on the front side of the swords mentioned earlier;
— a heave compensator determines the heave information;
— two electromagnetic positioning systems give horizontal position data at the highest update rate.

As one can see, every movement of the survey platform is detected by a series of sensors specially designed and interfaced by Eurosense.

Acquisition system

An extremely powerful computer system is extended with dedicated inter-

facing networks which communicate with the above mentioned sensors and measuring systems. The multi-user operating system runs the major acquisition program and allows other tasks to be executed at the same time. Adapted driver software is written to interrogate and synchronize the different sensors. Eurosense's acquisition software on board the platform controls a high resolution graphical navigation screen. This screen contains all relevant information for the pilot and the surveyors:

— required tracks;
— actual track;
— planimetry;
— numerical navigation data;
— nautical data;
— information about the platform's dynamic behaviour;
— alarm indications.

The program outputs its data on Winchester disks.

Installation of a data center in Zeebrugge

After the completion of an extended test program, the newly developed sounding platform was accepted in 1985 by the Coastal Hydrographic Office of the Belgian Ministry of Public Works. The data processing software has been installed by the Research & Development Department of Eurosense in a host computer system in Zeebrugge.

3. PRODUCTION PHASE

Mission preparation

Every new mission is prepared by the crew, by means of interactively working software utilities. This preparation is done at the data center in Zeebrugge and consists of:

— determination of parameters concerning the area to be surveyed (track definition, determination of the beacon configuration for an optimal positioning system, etc.);
— planning, administration, flight control, etc.

The survey flight

The platform flies at a speed of 30 to 40 knots to the sounding area. The survey speed is about 20 to 30 knots, depending on weather and traffic conditions. Pilot, flight engineer and surveyor control the craft, radar equipment and acquisition equipment by means of ergonomic designed displays and control boards. The surveyor has full control over the quality of the captured data and can take appropriate action in an interactive manner.

Data processing

After a survey mission, the data is transferred to the host computer system of the data center in Zeebrugge. Immediately, several procedures are started which result in graphical and numerical reviews of the status of the process: the raw depth data is corrected with several preprocessed and enhanced sensor data (e.g. roll, pitch, heave, air cushion altitude). Special purpose filtering algorithms developed by Eurosense, which employ prior knowledge of the signals dynamic characteristics, are used. After this correction phase, data is compressed and tide corrected. The compressed depth data can immediately be plotted on a hydrographic chart, complemented by data from an extended data base of planimetry, buoys and other items of interest (see fig. 3).

While plotting the hydrographic chart, the multi-user system of the host computer determines a digital terrain model (DTM) of the surveyed area. Contour lines are calculated from the DTM. Also interpolated depths on a fixed grid can be reproduced. One can make a differential map for an area sounded earlier and, by this means, have a fast and accurate view on the sedimentological processes. This way of charting and volume computing makes accurate supervision of dredging operations possible.

Connection of BEASAC and aerial remote sensing data

For the nearshore missions, the BEASAC hydrographic data can be connected with remote sensing data. These remote sensing data are acquired by Eurosense at low tide by means of high resolution photogrammetric cameras onboard an aircraft and further processed on analytical stereoplotters at Eurosense's facilities. Differential charts between two or more consecutive recordings of this total area, above and beneath the low water level line, are easy to produce and give an insight on the morphological changes of the coastal area. This feature gives a more general view on beach erosion, coastal stability and sedimentological processes.

Three-dimensional representation of sea bottom topography is one of the possible outputs of the flexible software package installed at the data center in Zeebrugge.

Advantages of the BEASAC platform

Because the hovercraft has no draught, it can reach otherwise inaccessible regions. Classic bathymetric vessels do not penetrate close enough to the beach, not even at high tide. The BEASAC platform automatically retracts the fish from the water while approaching the beach. This ensures an overlap region between the hydrographic data and the remote sensing data.

Due to the great speed of the BEASAC platform, the produced charts can be seen as correct momentary recordings, even for large coastal observation areas, with rapidly changing morphological conditions.

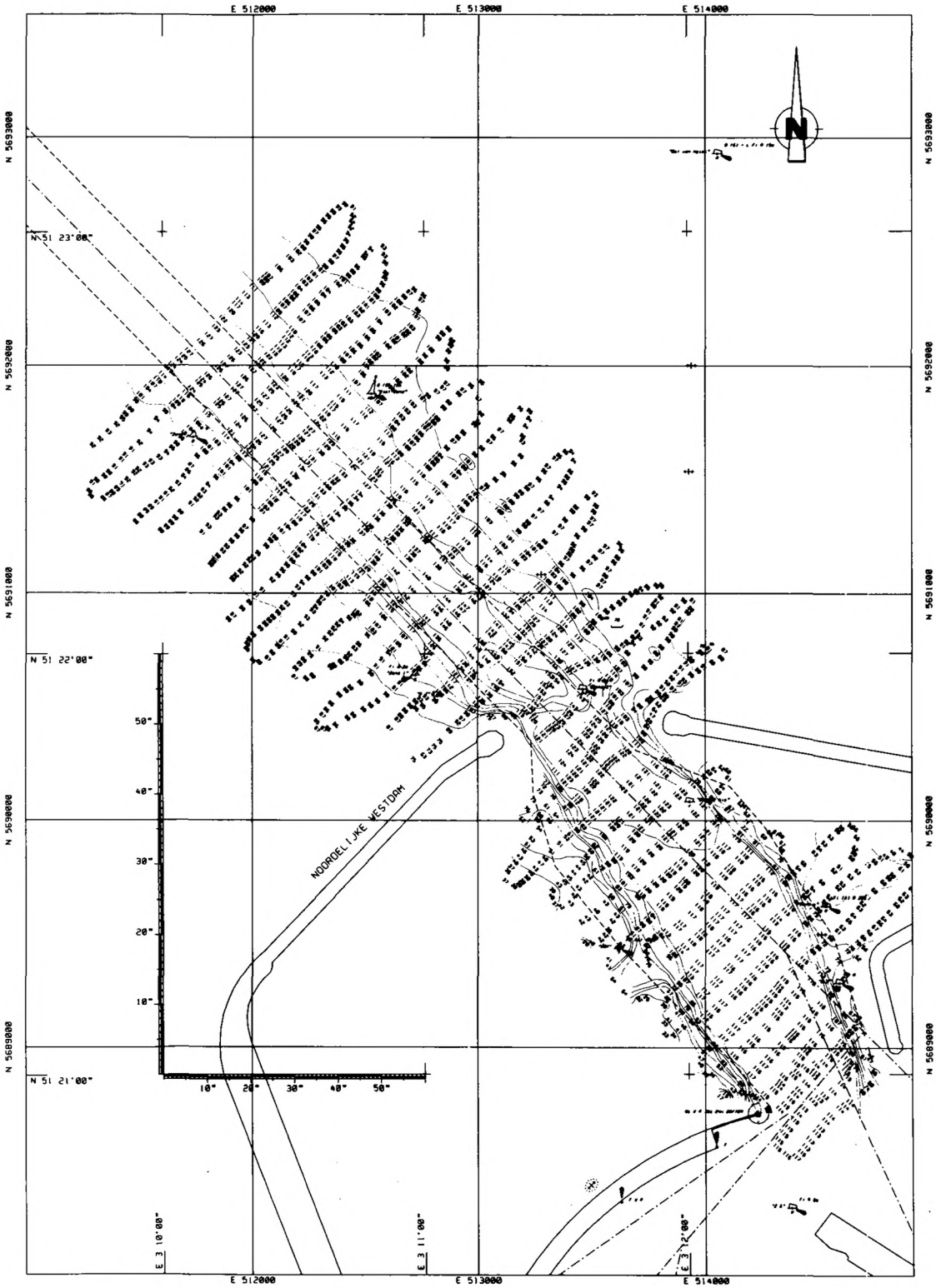

FIG. 3. — Detail of the fairway at the entrance of the port of Zeebrugge — hydrographic chart.

The craft is successfully employed by the Coastal Hydrographic Office for monitoring the evolution of the access channels to the major Belgian sea ports and for supervising the extensive dredging operations at these locations. The major advantages of the system (i.e. fast moving and accurate soundings) have proved to be important assets in observing and controlling sedimentological and dredging processes.

4. CONCLUSIONS

The introduction of this new concept in the world of hydrographic surveys has shown various advantages in comparison with classic systems (bathymetric vessels). The great speed and manœuvrability of the hovercraft result in:

— an enormous time gain;
— the possibility of making accurate sediment transport and erosion studies in shallow and offshore waters.

Eurosense developed a new air-cushion platform for data acquisition of the sea bottom topography which was made fully operational through the use of specially developed software. This project is considered by the Coastal Hydrographic Office of the Belgian Ministry of Public Works as an important contribution towards more accurate and economical observations of morphological processes, both natural and/or artificial.