# BEASAC*

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

A joint realisation 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 Service of the Belgian Ministry of Public Works. Now the system is successfully employed for monitoring changes to access channels of the major Belgian seaports and for supervising the extensive dredging activities. Moreover, it is used to observe the beaches and offshore areas near the Belgian coast.



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- Eurosense, J. Vander Vekenstraat 158, B-1810 Wemmel - Belgium.

* Beasac is an acronym for Belfotop Eurosense Acoustic Sounding Air Cushion Platform.

## 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.

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 seabottom 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 seabottom 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

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

Several hovercraft have been evaluated since 1981 by Eurosense. Finally the best results concerning speed an stability were archieved with a B.H.C. SR.N6 Mk 1S hovercraft which is driven by a Rolls-Royce gasturbine. This platform has been called the BEASAC-platform (Belfotop Eurosense Acoustic Sounding Air Cushion-platform - See figure 1 : the BEASAC-platform - side view).

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 (See figure 2 : the main cabin with the survey equipment). A remote navigation screen is mounted near the instrument panel (See figure 3 : remote navigation screen and instrument panel). Next to this survey room is an air-conditioned computer room (See figure 4 : view on the computer room) and an hydraulic control room with general domestic facilities (See figure 5 : hydraulic control system).

Two identical electric power supply units driven by diesel engines are mounted inside the raised side decks (See figure 6 : electric power unit). 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 figure 7 : hydraulic retractable arms with sword and fish). A mechanical 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 7 hours.

Next to 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.

2.2.3. Acquisition system

An extremely powerful computer system is extended with dedicated interfacing 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 (See figure 3 : remote navigation screen and instrument panel). 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.

2.3. 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 Service of the Belgian Ministry of Public Works. The data processing software has been installed by the Research & Develoment department of Eurosense on a host computer system in Zeebrugge (See figure 18 and 19 : host computer system and data processing room in Zeebrugge).

# 3. PRODUCTION PHASE

## 3.1. 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 on optimal positioning system,...)
- planning, administration, flight control...

## 3.2. 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.

## 3.3. 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 sensordata (e.g. roll, pitch, heave, air cushion altitude). Special purpose filtering algorithms developed by Eurosense are used which employ prior knowledge of the signals dynamic characteristics.

After this correction phase, data is compressed and tidecorrected. Figure 20 shows a detail of the raw and corrected data as a function of time.

The compressed depth data can immediately be plotted on a hydrographic chart, complemented by data from an extended database of planimetry, buoys and other items of interest (see figure 21 : detail of the fairway at the entrance of the port of Zeebrugge - hydrographic map).

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 (see figure 22 : detail of the fairway at the entrance of the port of Zeebrugge - differential map - notice the southern region where the fairway has become almost 2 meters shallower). This way of charting and volume computating makes accurate supervision of dredging operations possible.

3.4. Connection of BEASAC and aerial remote sensing data.

For the nearshore missions, the BEASAC hydrographic data can be connected with remote sensing data (see figure 23 : beach and nearshore at Knokke - Heist : hydrographic map). 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 seabottom topography is one of the possible outputs of the flexible software packet installed at the data center in Zeebrugge (see figure 24 : beach and nearshore at Knokke - Heist : 3D - view).

3.5. Advantages of the BEASAC - platform.

Because the hovercraft has no draft, 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.

The craft is successfully employed by the Coastal Service 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 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 survey has shown various advantages in comparison with classic systems (bathymetric vessels). The great speed and manoeuvrability of the hovercraft result in :

- an enormous time gain
- the possibility of making accurate sediment transport and erosion studies in shallow and offshore water.

Eurosense developed a new air-cushion platform for data-acquisition of the seabottom topography which was made fully operational through the use of specially developed software. This project is considered by the Coastal Service 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.

May 1986.

5. FIGURES.


fig. 1 : the BEASAC-platform - side view.

fig. 2 : the main cabin with the survey equipment.

fig. 3 : remote navigation screen and instrument panel.

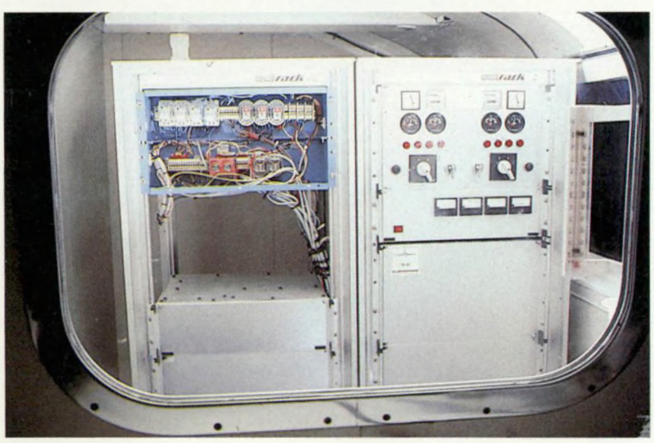

fig. 4 : view of the computer room.

fig. 5 : hydraulic control system.

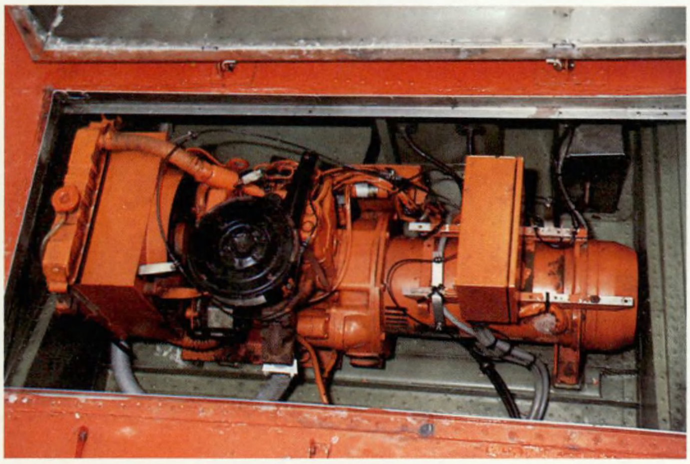

fig. 6 : electric power unit.

fig. 7 : hydraulic retractable arms with sword and fish.

fig. 8 : BEASAC at the entrance of the hangar.

fig. 9 : inside view of the hangar.

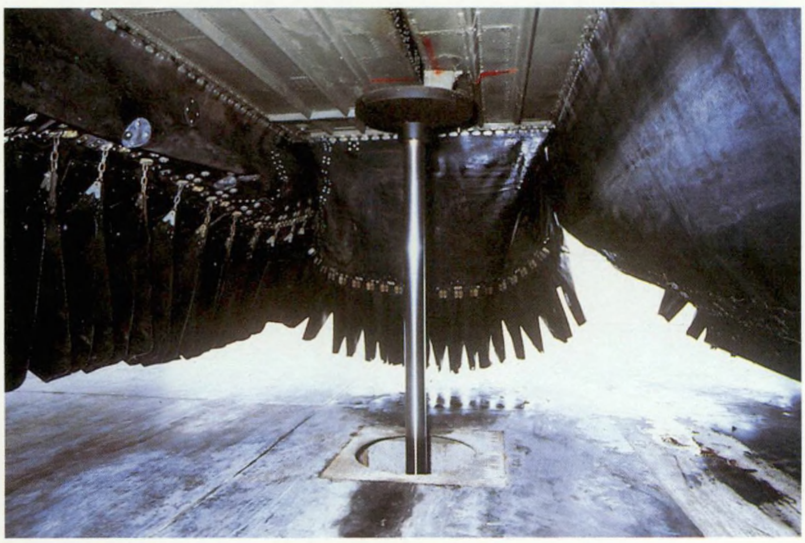

fig. 10 : BEASAC on jack.

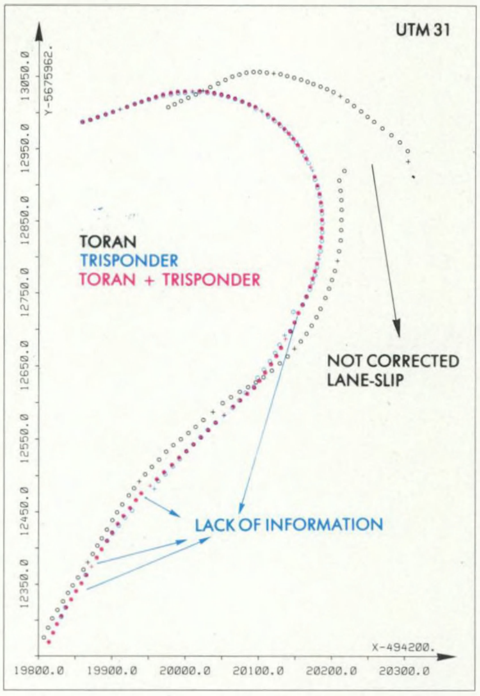


fig. 11 : radio equipment and the navigation systems Toran and Trisponder (above left)

fig. 12 : XY - plot of test track with lane-slip and small drift. (above right)

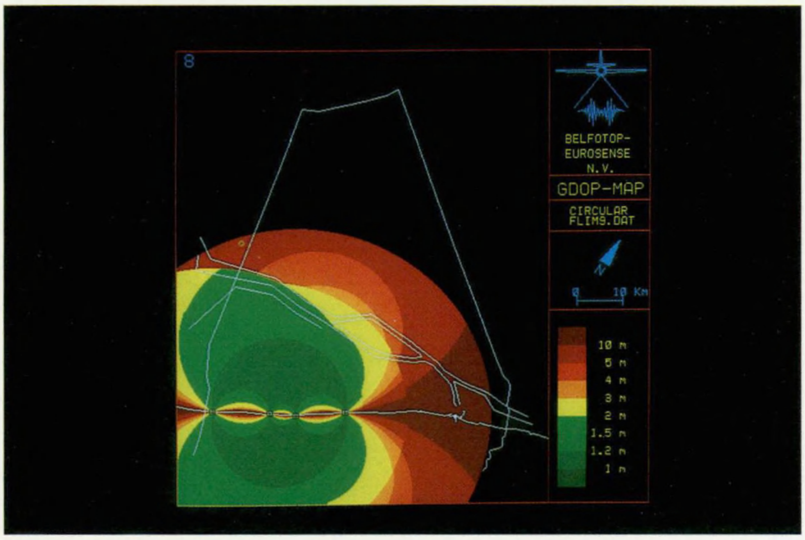


fig. 13 : GDOP - map for a beaconconfiguration of Trisponder at the Belgian coast. (GDOP : Geometric Dilution Of Precision)

fig. 14 : removable Trisponder beacon mounted on a jeep

fig. 15 : fish during survey. (above left)

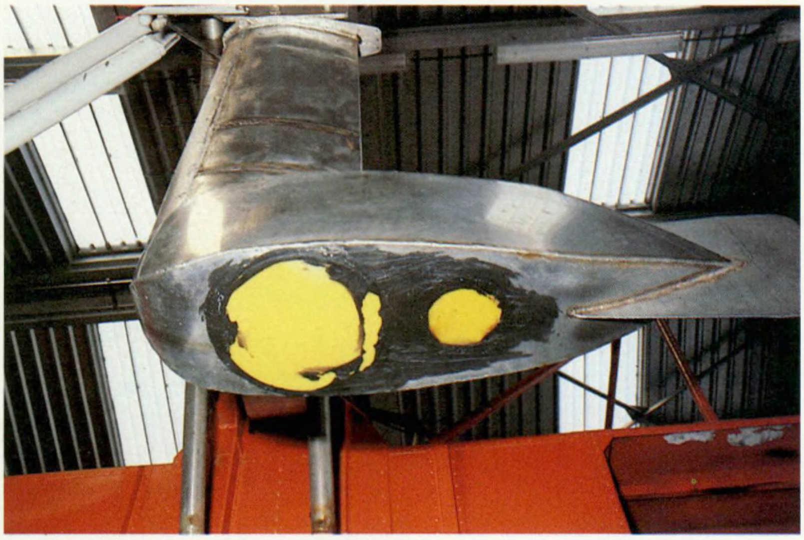

fig. 16 : bottom view of a fish with two acoustic transducers.

fig. 17 : depth measuring equipment.


fig. 18 : host computer system in Zeebrugge.

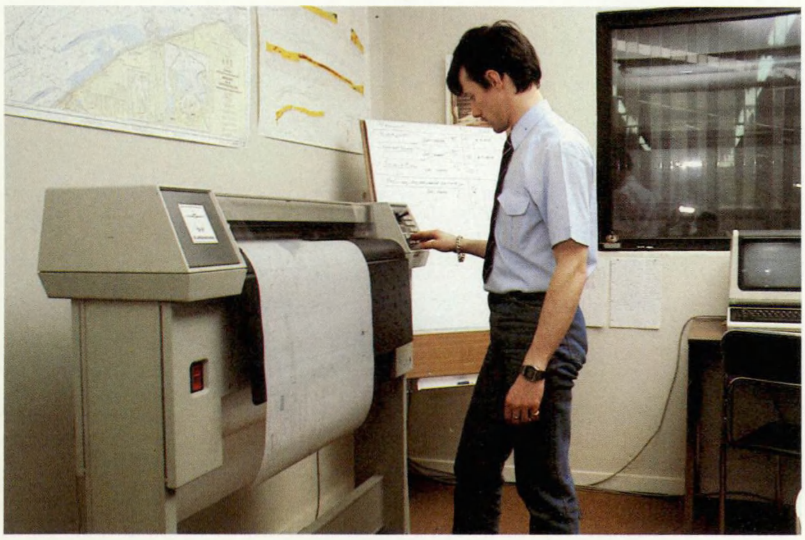

fig. 19 : data processing room in Zeebrugge.

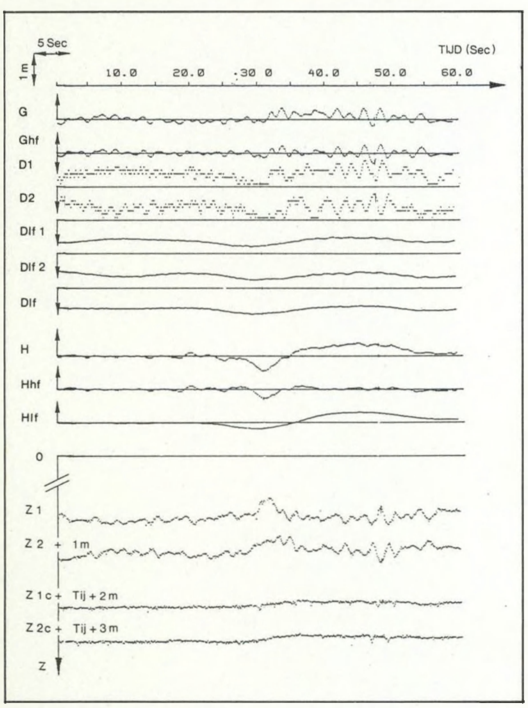


fig. 20 : detail of the raw, and corrected data, as a function of time.

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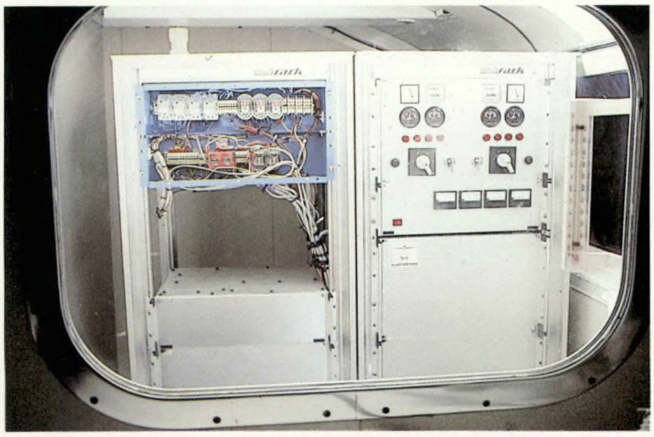

fig. 4 : view of the computer room.


fig. 5 : host computer system in Zeebrugge.

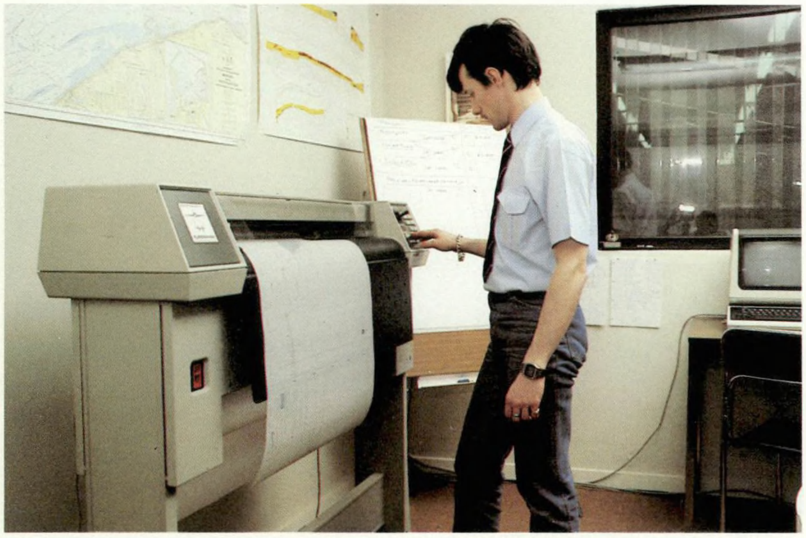

fig. 6 : data processing room in Zeebrugge.
fig. 7 : differential map of coupled data from Aerial Remote Sensing and BEASAC-Soundings.

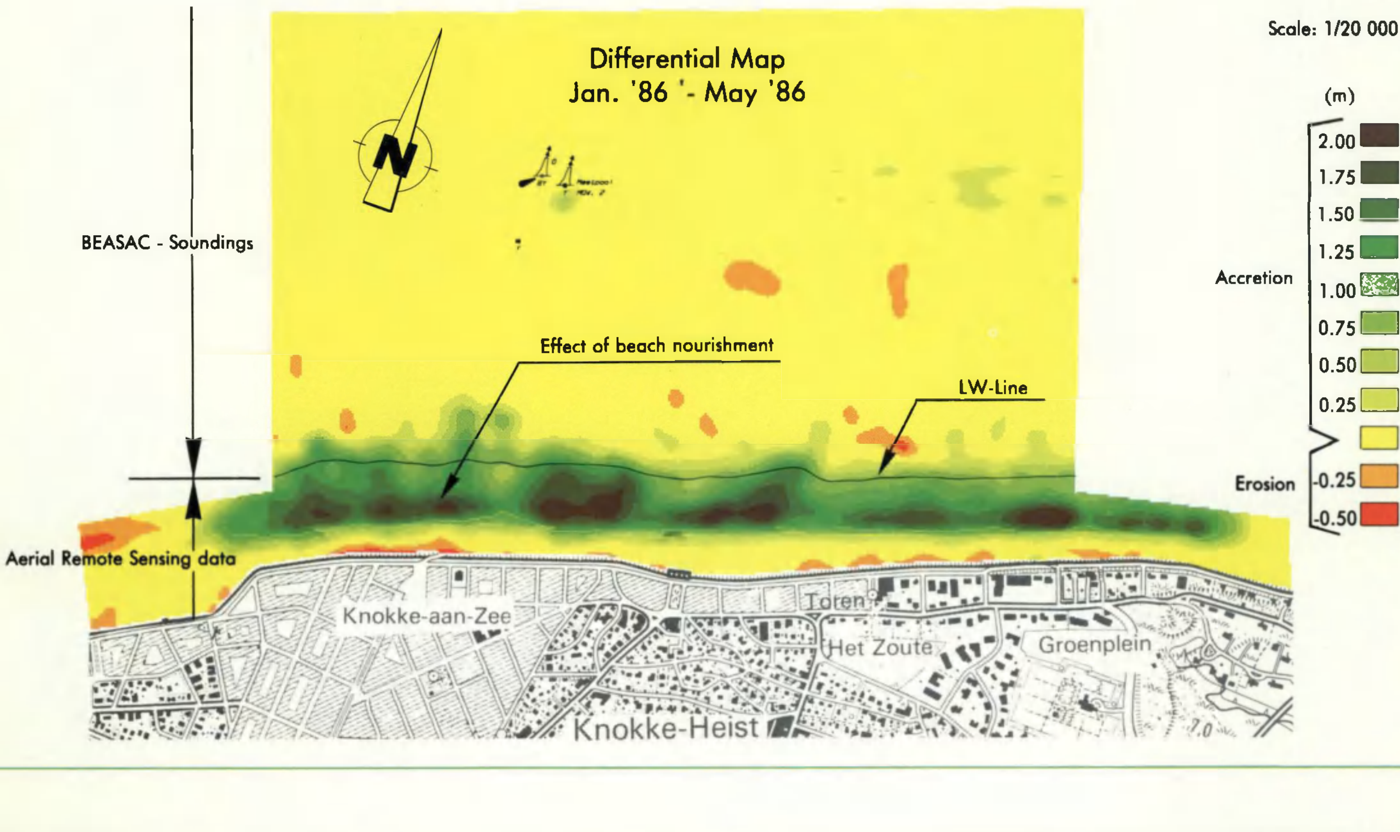

fig. 13 : BEASAC at the entrance of the hangar.

fig. 14 : inside view of the hangar.

EUROSENSE

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VORMGEVING EN DRUK: EUROSENSE-BELFOTOP N.V.

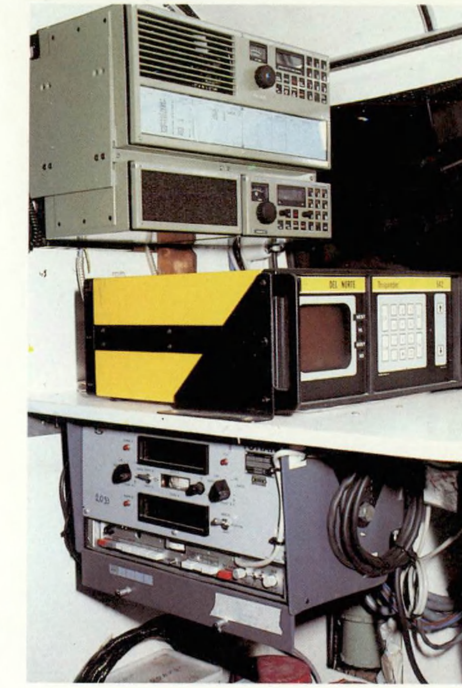


fig. 9 : sword and fish during survey (above left).

fig. 10 : radio equipment and the monitoring systems Toran & Trisponder (above right).

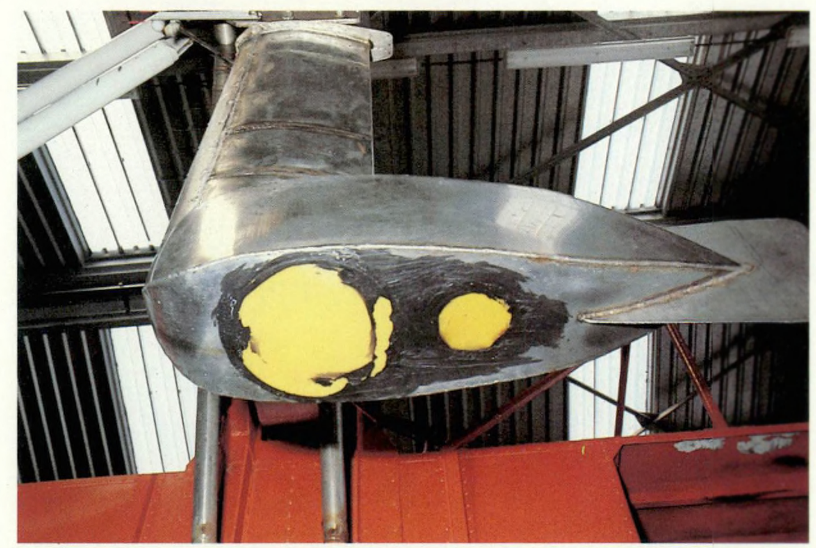
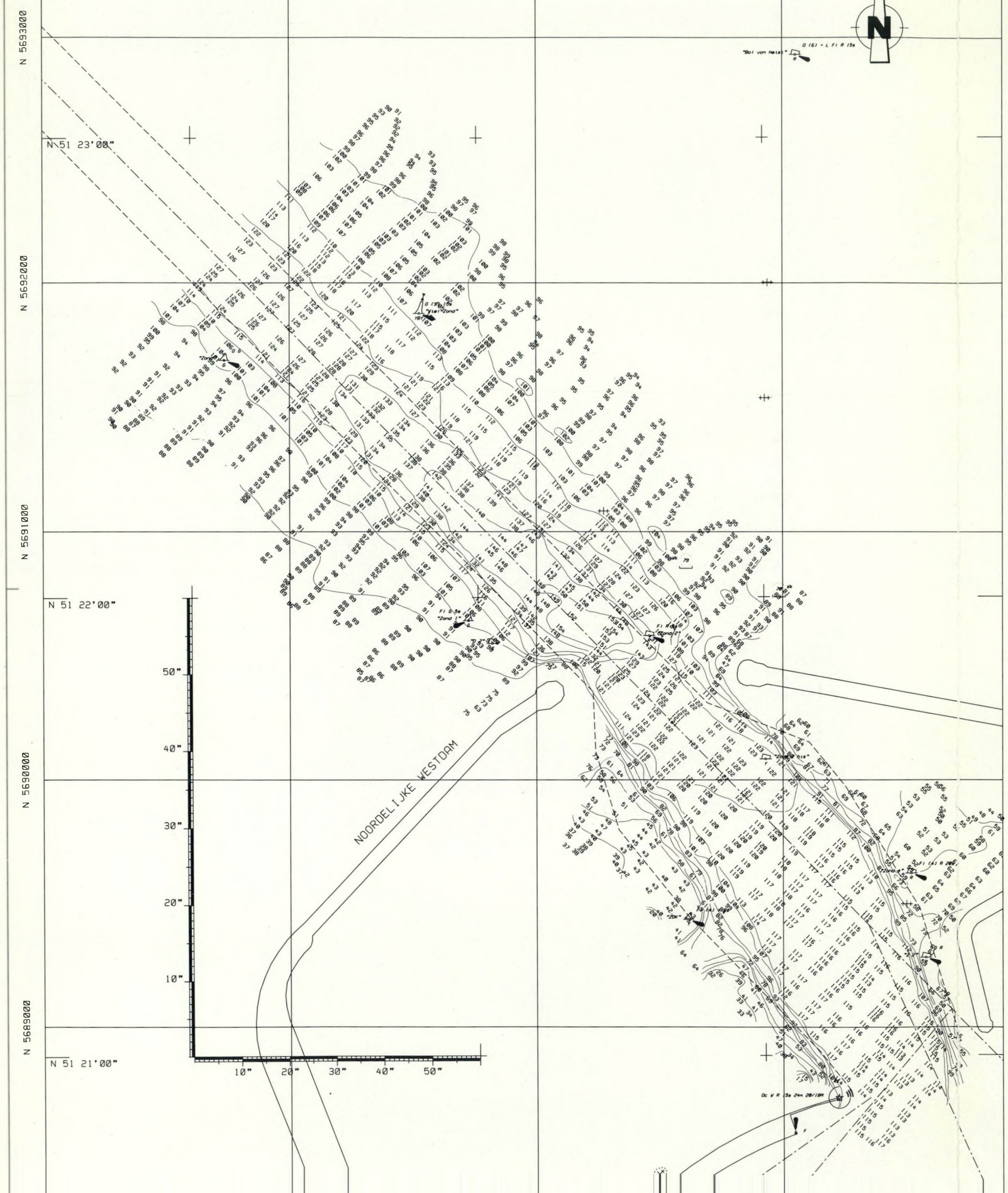


fig. 11 : bottom view of a fish with two acoustic transducers.




MINISTERIE VAN OPENBARE WERKEN

DIENST DER KUST

EUROSENSE
BELFOTOP

Lodingen uitgevoerd door het BEASAC - platform

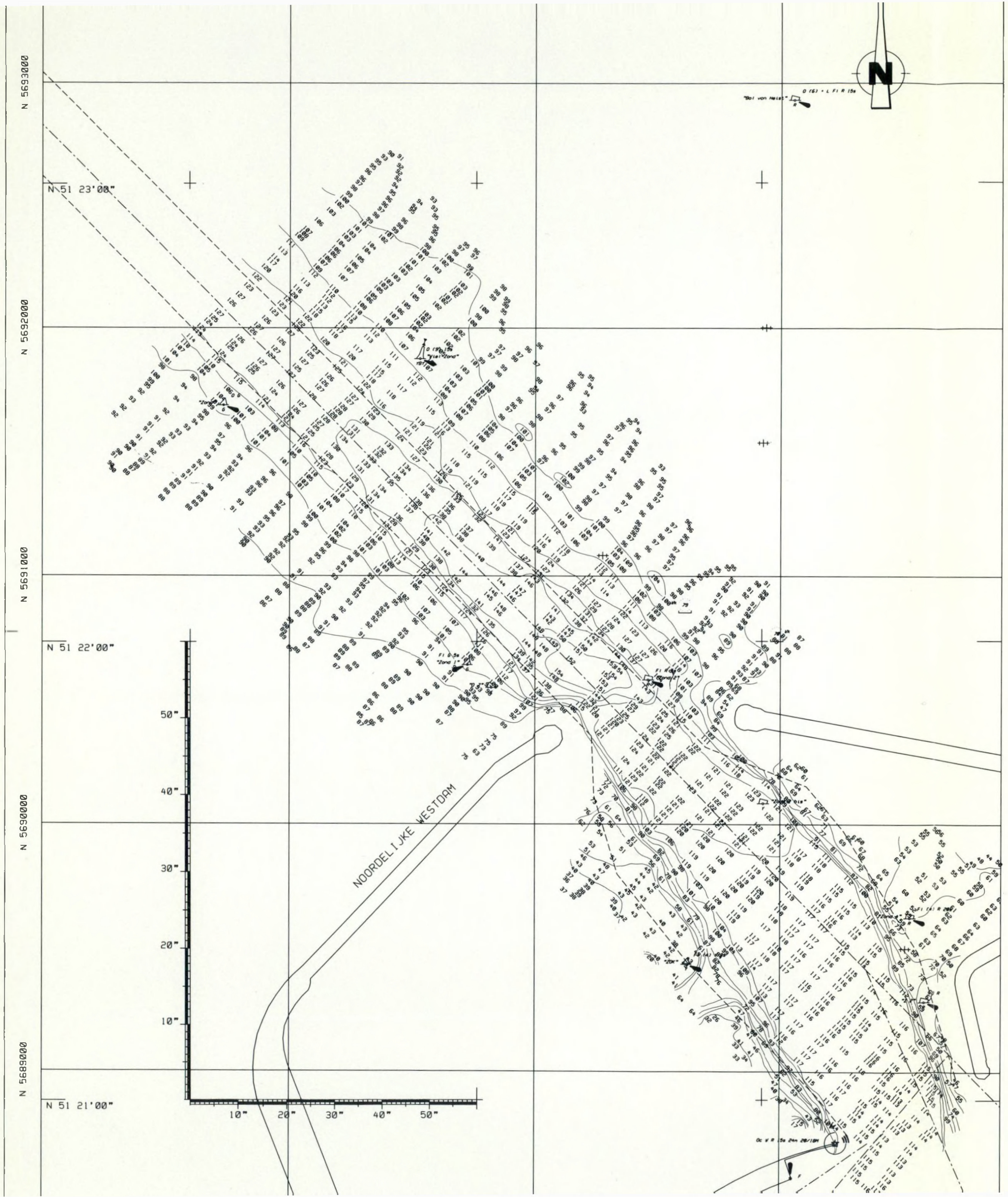
PAS VAN HET ZAND

Datum van opname : 2 APRIL 1986
Vorige opname op datum : 7 MAART 1986 vervolt
Windrichting : S - SW  Windkracht : 3 - 4 Beaufort

Diepten in dm t.o.v. H (GLLWS)
Reduktie : getijkromme van Zeebrugge
reductiekaart 1972

UTM ruitennet - Zone - 31
Geografische Europese coordinaten
Plaatsbepaling : TORAN + TRISPONDER
: Oficiele boeipositie
: Actuele boeipositie
Opname : 210 Khz en 33 Khz : slib aanwezig

BELANGRIJKE OPMERKINGEN :
Echolood : Atlas - Deso 20 (210 Khz)
Aangeduide diepten : minimum diepten

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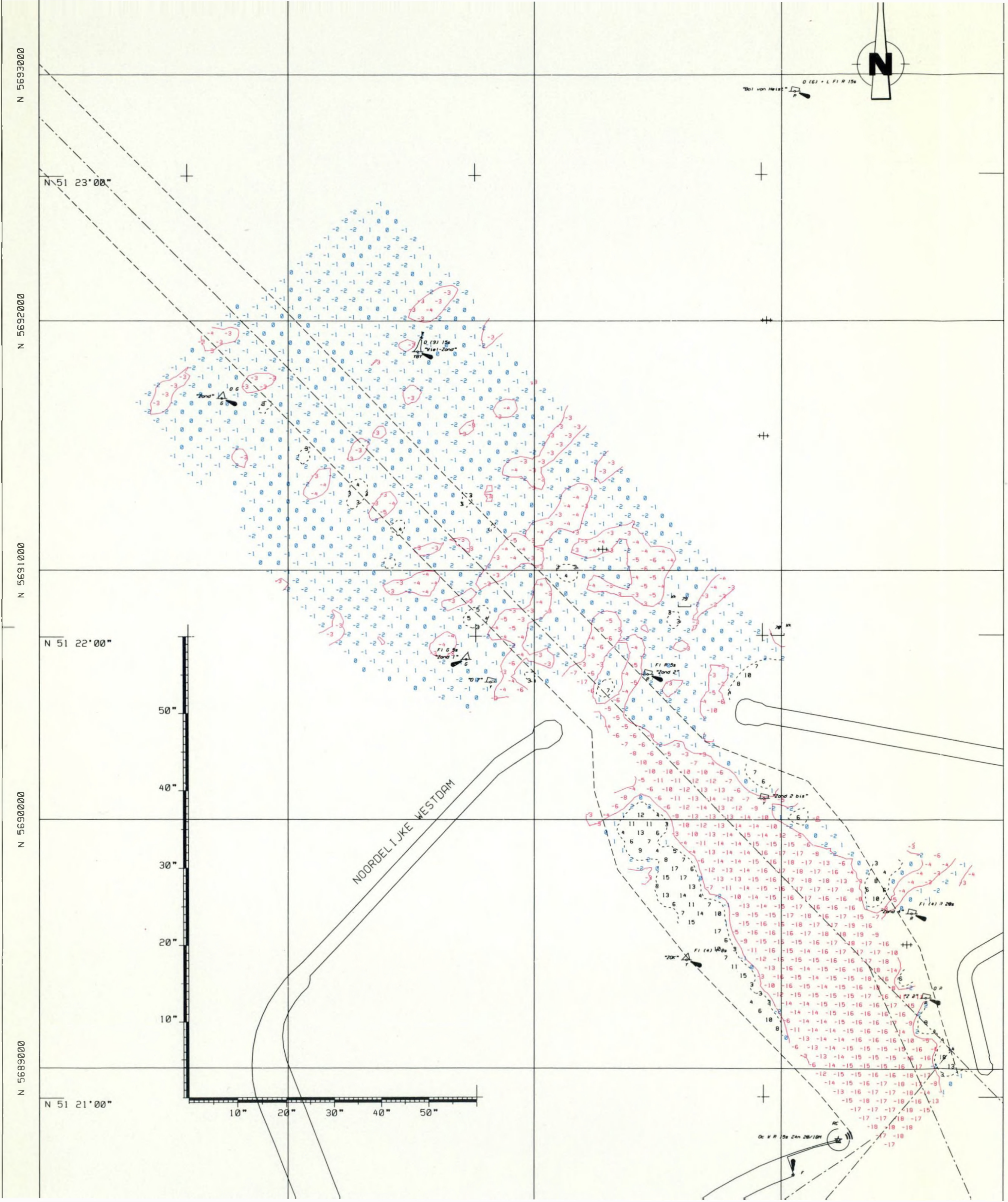


MINISTERIE VAN OPENBARE WERKEN

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BELFOTOP

Lodingen uitgevoerd door het BEASAC - platform

# PAS VAN HET ZAND
# VERSCHILKAART

Verschilkaart tussen de opnamen van 7 MAART 1986 en 2 APRIL 1986
Verschil (DZ) = diepte in dm op 7 MAART 1986 - diepte in dm op 2 APRIL 1986
Een negatief verschil stemt overeen met sedimentatie

Reductie : getijkromme van Zeebrugge
reductiekaart 1972

UTM ruitennet - Zone - 31
Geografische Europese coordinaten
Plaatsbepaling : TORAN + TRISPONDER
: Officiele boeipositie (B.A.Z.) op datum van 24 APRIL 1986
: Actuele boeipositie op datum van 2 APRIL 1986
Opname : 210 Khz en 33 Khz : slib aanwezing

BELANGRIJKE OPMERKINGEN :

Echolood : Atlas - Deso 20 (210 Khz)
Aangeduide diepteverschillen (DZ) : erosie tussen 7 MAART en 2 APRIL 1986
DZ > 2.5 dm --- : Verschillijn 2.5 dm
-2.5 dm < DZ < 2.5 dm

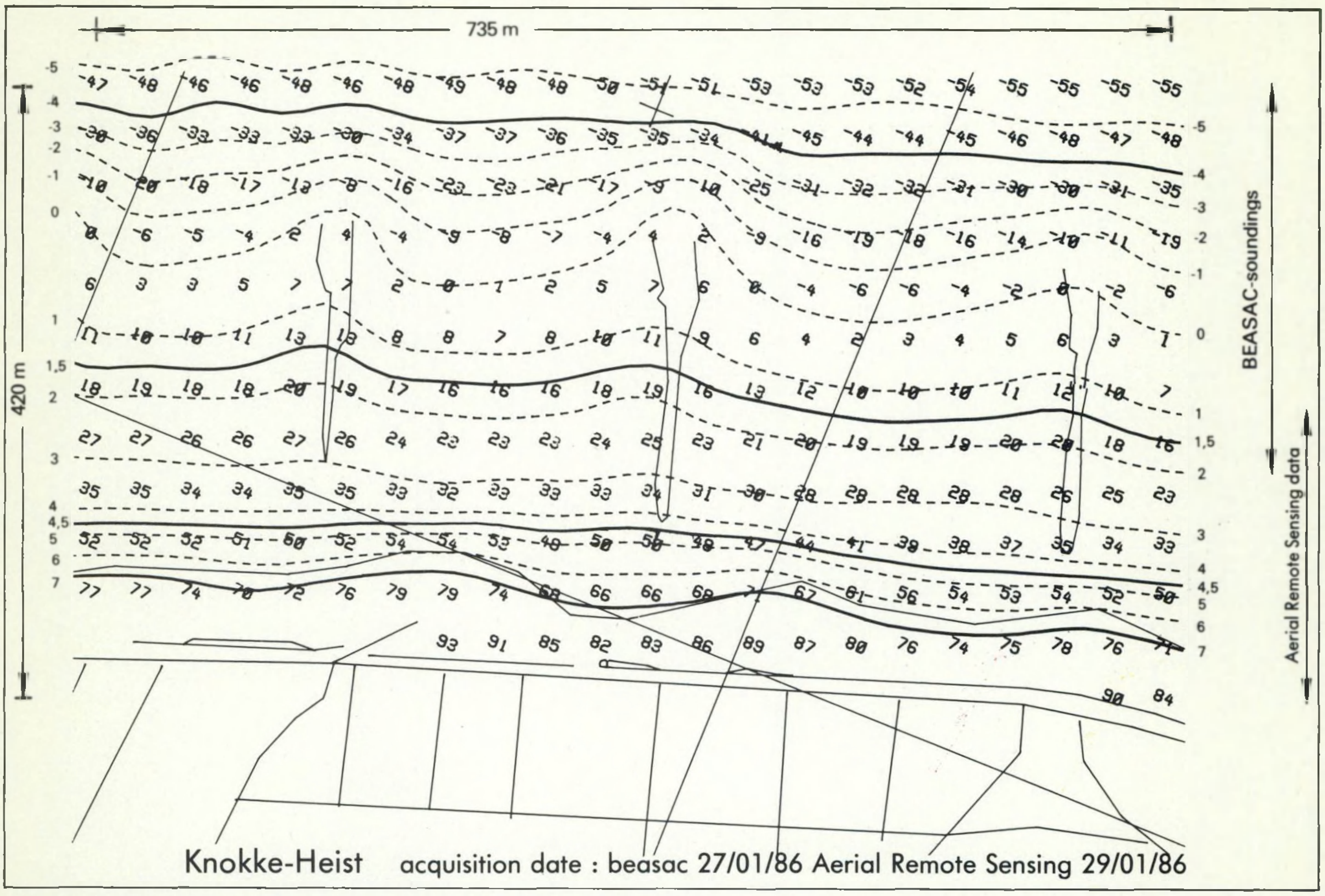


fig. 23 : beach and nearshore at Knokke-Heist : hydrographic map.

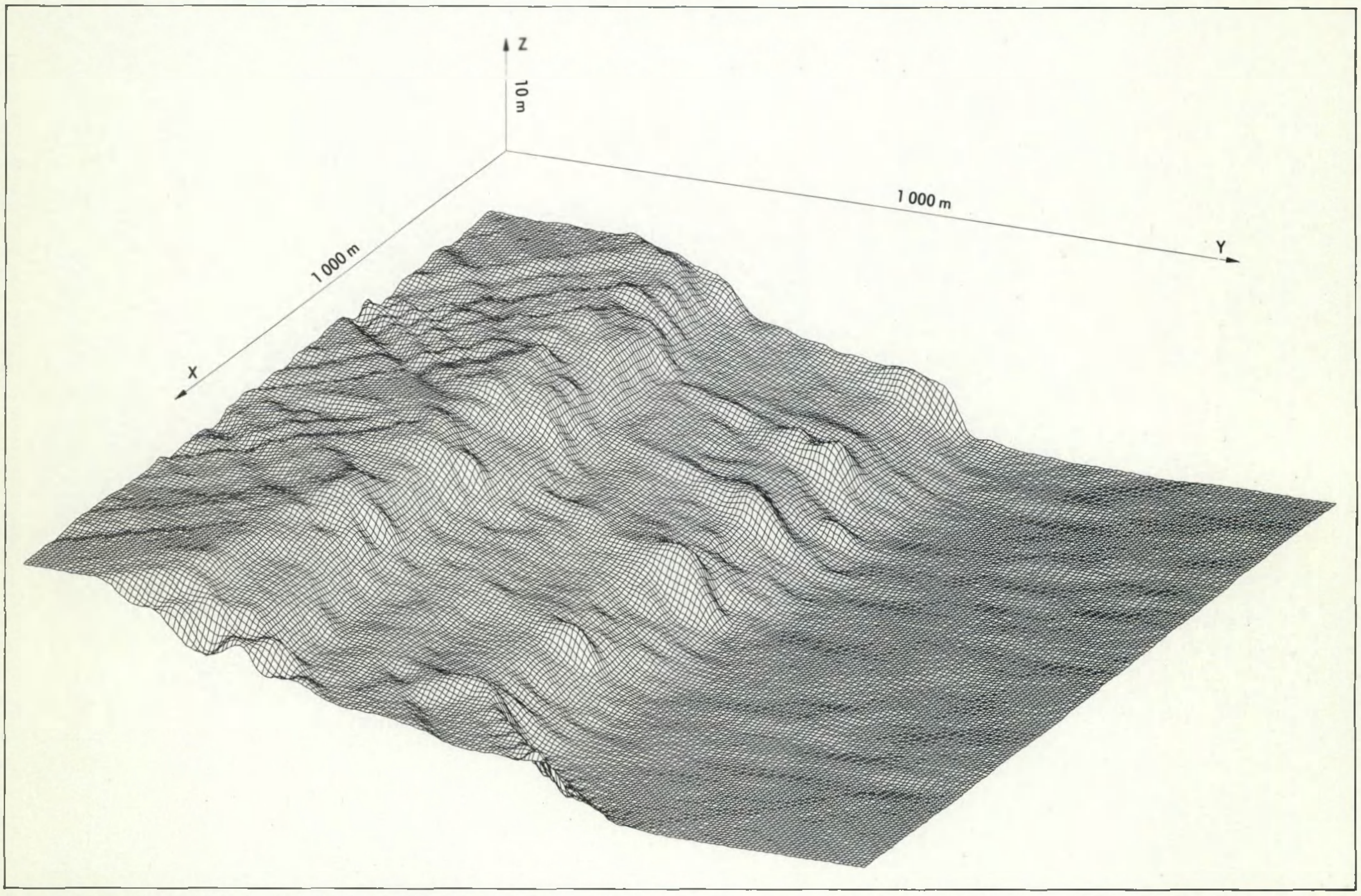


fig. 24 : beach and nearshore at Knokke-Heist : 3D - view.