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COASTAL SURVEYING BY SATELLITE AND HELICOPTER OVER THE CHANNELS OF THE ARCACHON BASIN

by J.Y. LE VEN [1], M. CHAUMET-LAGRANGE [2], H. VALLOT [3]

Abstract

During the winter season of 1990 and 1991, bathymetric surveys of the entrance channels to the Arcachon Basin (Fig. 1) by conventional surveying methods, i.e. from a small vessel, proved impossible to carry out; the roughness of the sea surface and the presence of dangerous shoals doomed all attempts to failure.

Faced with the urgent need for reconnaissance surveys, the Directorate of Marine Development and Environment of the Port of Bordeaux proposed to the authorities responsible for safety in the channels of the Arcachon Basin that unconventional methods should be employed, using satellite and helicopter.

Spatial remote sensing, which furnishes information that is rich as regards the morphology of the site but poor as regards bathymetry, finds that bathymetric surveying from a helicopter, which is poor in sounding points but rich as regards their spread over the area to be sounded, is an indispensable supplement to back up the bathymetry of the "pixels" composing the "Spot" image.

The complementary nature of the two techniques proved to be most efficient in situations where reconnaissance was urgent but when meteorological conditions on site prevented conventional surveys being carried out using a boat.

[1] Directeur de l'Aménagement et de l'Environnement du Port autonome de Bordeaux.

[2] Head of Hydrographic Service, Port autonome de Bordeaux.

[3] Hydrographer in charge of mission, Port autonome de Bordeaux.

I - BACKGROUND CIRCUMSTANCES

Studies on the evolution of the access channels to the Arcachon Basin (Fig. 1) have shown that there exists a cycle, estimated at 80 years, during which the principal channel evolved from a due west position towards a due South position. During the present decade, which corresponds to the final phase of the cycle, the cross-position of the channel compared with the dominant waves from the western sector, renders access very dangerous as soon as the height of swell is greater than 1.50 metre and favour the process of silting in the channel outlet towards the open waters. The marking of the navigable channel by buoys and beacons must be frequently reviewed on the basis of sounding documents drawn up beforehand.

Up to 1985, bathymetric surveying took place only once per year, in June, so that the buoyage might be checked or readjusted before the summer season. Such reconnaissance surveys were not at all difficult to carry out as they took place during a syzygy [1] period under the influence of the anticyclone of the Azores.

During the years 1986-1989, acceleration of the sediment evolutions made more frequent sounding necessary, but never in winter. However, since 1990, following a number of dramatic shipwrecks, the General Council of the Gironde Department and the Inter-communal Syndicate of the Arcachon Basin have asked the Maritime Service of the Gironde to have the approach channels sounded more frequently, which has meant that sounding must take place in the winter season too.

The Hydrographic Service of the Port Autonome de Bordeaux, responsible for carrying out these reconnaissance surveys, sought in the first place to do so using conventional methods. But the state of the sea in the approach channels between the months of November 1990 and February 1991 doomed all attempts to failure.

It should be specified that the diffraction of the swell over these shallows, and the refraction and breaking of waves over uncovered shallow areas, create in this area, in a random way, solitary waves or a "wafer" effect of the swell, the amplitude of which may be double that of the swell outside the bar. In the Arcachon Basin these are referred to as "Bastards".

Faced with these difficulties, and the urgency with which the soundings had to be made, it was decided to turn to new solutions, that had never been used before.

[1] Position of the moon (and, by extension, of a planet) in conjunction or in opposition to the sun, (new moon and full moon).

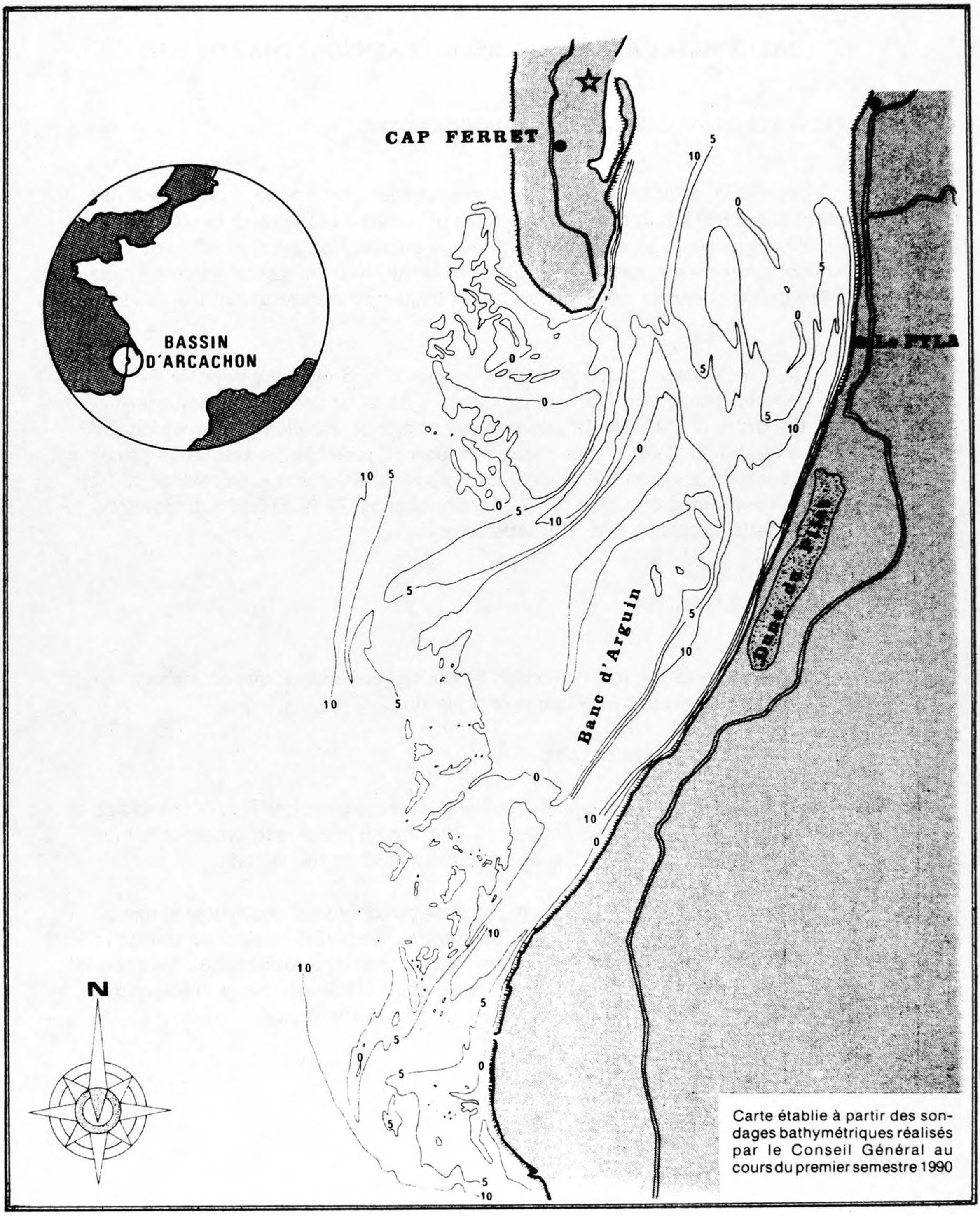


FIG. 1.- Plan of the channels of the Arcachon Basin.

II - BATHYMETRY BY SPATIAL REMOTE SENSING (MARCH 1990)

II.1 - PRINCIPLE OF MEASUREMENT (F. POUGET, GEOSYS)

The SPOT satellite traces a heliosynchronic orbit round the earth at an altitude of about 850 km. It takes photographs of portions of the earth of 60 x 60 km. The sensors in its payload record the luminous intensity of the sun reflected by a basic unit of the earth's surface in several bands of the electromagnetic spectre. These bands are called channels and the basic strip measured on the ground is called a pixel.

The panchromatic mode is of value in coastal hydrography because it offers a level of spatial perception (10 x 10 m) enabling it to be used for cartography at scales of the order of 1:20 000. In addition, the range of wavelengths in which the data are acquired (0.51-0.73 micrometres) makes it possible, in waters of slight turbidity, to obtain information to depths of about 15-20 metres. Depths of 30-50 metres may be attained by using the XS1 channel of SPOT (0.50-0.59 micrometres) but with a spatial accuracy that is unsatisfactory.

II.2 - PROCESSING EFFECTED

The image was put in a projection by taking reference points on a chart; the image was rectified and put into Lambert projection.

Establishment of a palette of colours:

The fundamental principle is as follows: the radiometric values of the image (signals recorded) are directly linked to the depth (low radiometric values correspond to deep areas where the water density absorbs the signal).

In order to visually translate in the best possible way the whole range of depths over the area observed, at each radiometric step (2-3 values), a colour is attributed, ranging from dark blue to yellow-red, as the depth diminishes. Breakers (areas with strong reflecting quality) have been isolated by a radiomeric threshholding after masking the sandy areas present in the image.

II.3 - PLOTTING

A high-quality photographic film (format 24 x 24 cm) was made from the digital data using a digital laser plotter. By enlarging this film the document can be edited at the scale required.

For the approaches to the Arcachon Basin, the plotting scale was set at 1:20 000; a larger scale would have been illusory in view of the definition of the basic areas by "pixel".

The quality of the plotting is astonishing (Fig. 2). It is very rich in qualitative information on the area, notably for a site like this one, the waters of which are quite clear and, above all, shallow. Each colour corresponds to a sub-surface or under-surface depth band which it is possible to link to the bathymetry if a few well distributed soundings over the site are known.

II.4 - CONTRIBUTION MADE BY SPATIAL REMOTE SENSING TO CONVENTIONAL HYDROGRAPHY

For shallow coastal maritime areas, with irregular bottom morphology where banks, channels and bars abound, spatial remote sensing constitutes a valuable aid to supplement the definition of isobaths or more specifically to remove any ambiguity in interpreting them from scattered soundings. Without bathymetry, it is sufficient to define the buoyage of a channel or to rectify this.

Finally, it can considerably reduce bathymetric surveying on the site by limiting this to a few profiles carefully arranged to back up the colours of the plotted image.

One must not expect from this technique the high bathymetric accuracy required by marine cartography. But, for coastal sites with difficult access for small sounding units, often dangerous because they suffer the effect of breakers caused by the presence of shallow banks, and, above all, that are subject to very rapid movements of sediment which render the validity of soundings short-lived, this new technique represents a supplement that is very rich in information for all these unstable areas. It thus gives the hydrographic engineer valuable information on the changing trends of the seabed which makes it a very useful forecasting tool for the safety of navigation and port or coastal improvements.

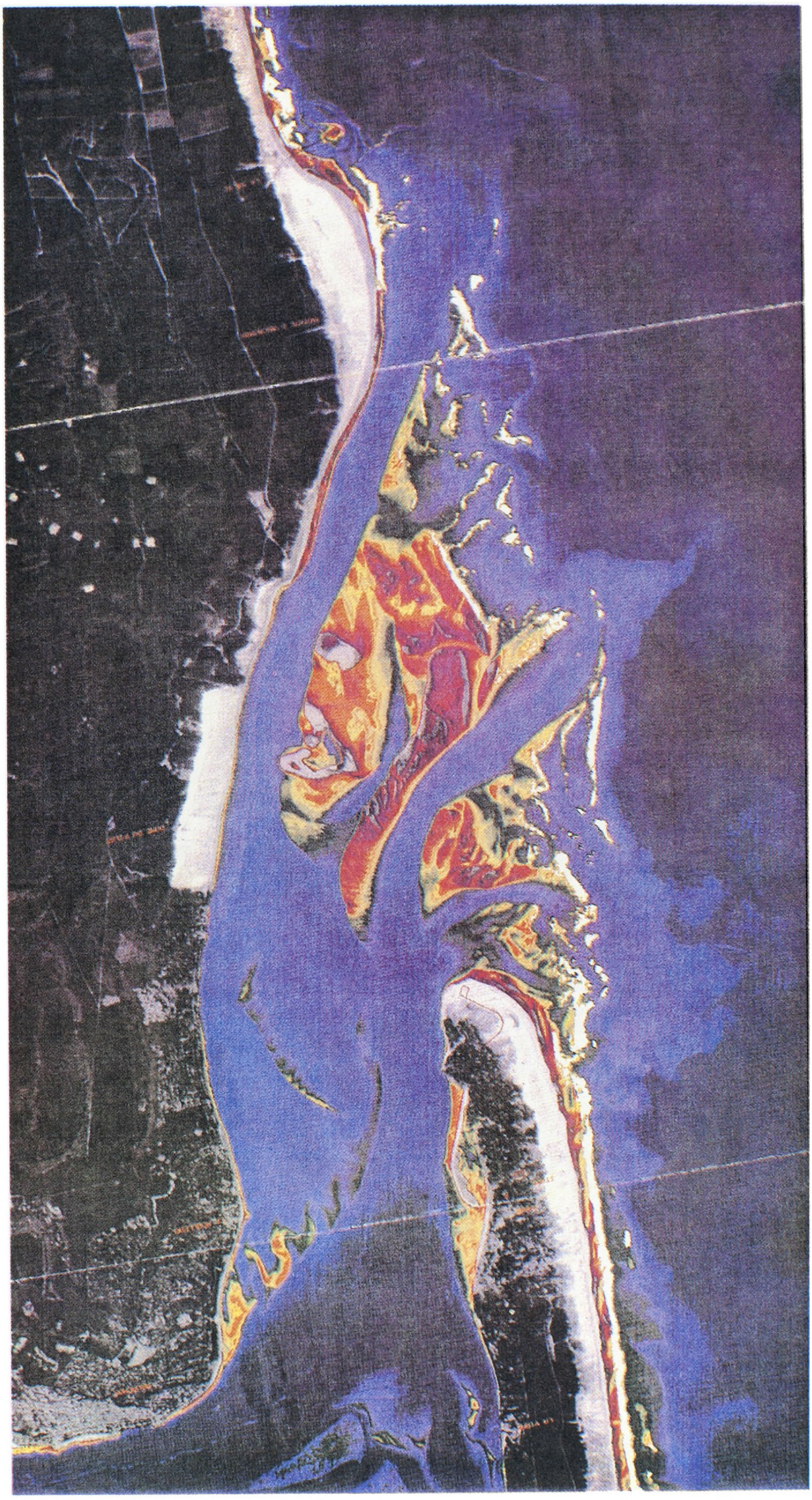


FIG. 2.- Plotting of the colour SPOT image at scale 1:20 000 (Source: General Council of the Gironde).

III - BATHYMETRY BY HELICOPER (MARCH 1991)

III.1 - THE SOLUTIONS ENVISAGED (Fig. 3)

Three techniques could be envisaged:

1. The helicopter tows a small catamaran carrying the acoustic base: this solution was discarded because of the breakers in the area which by carrying away the float, might have rendered the whole operation hazardous.

2. A submerged "salmon" is suspended below the helicopter; it is fitted with two acoustic bases, one directed towards the surface to measure the depth of immersion, the other towards the seabed. This solution, easier to carry out than the preceding one, ran the risk of meeting an unexpected "obstacle" under the surface.

Both these techniques have the advantage of sounding depths continuously according to the same principle as surveys carried out aboard survey launches.

3. The helicopter, in a hovering position, submerges the acoustic base, hanging under a float, in a pre-determined position. The operation is repeated as many times as there are points to be sounded. The principal advantage of the method is its simplicity. It also offers, for a method that was experimented for the first time, more security than the preceding ones. It is essentially for the latter reason that the method was chosen.

III.2 - THE MEANS USED

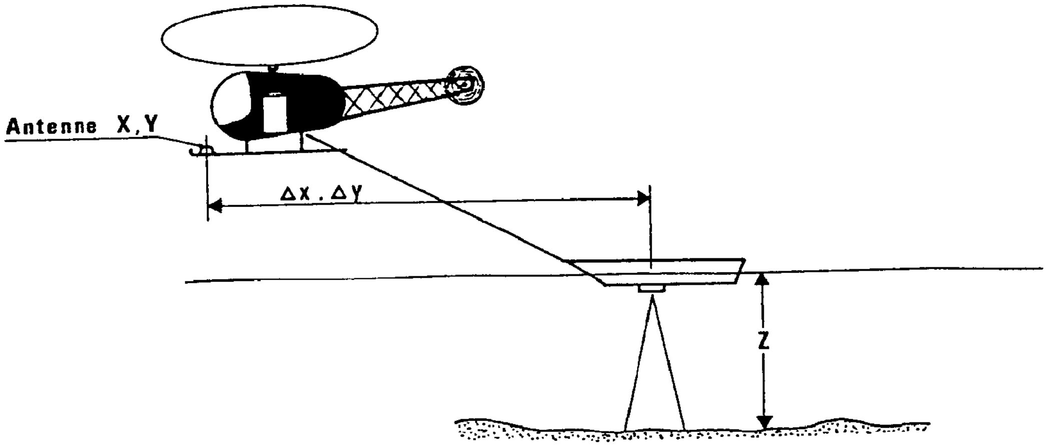
A helicopter from the firm AIRLEC, based at Merignac airport, was fitted with a SYLEDIS positioning system and an ATLAS DESO 20 sounder. An electricity supply of 24 Volt DC 5 KVA was available on board to run the equipment.

The urgency for the surveys having been such that there was no time to make special supports for this equipment, it was merely strapped onto one of the two rear seats; the other seat was reserved for the hydrographer (Fig. 4); only the pilot and the hydrographer were on board.

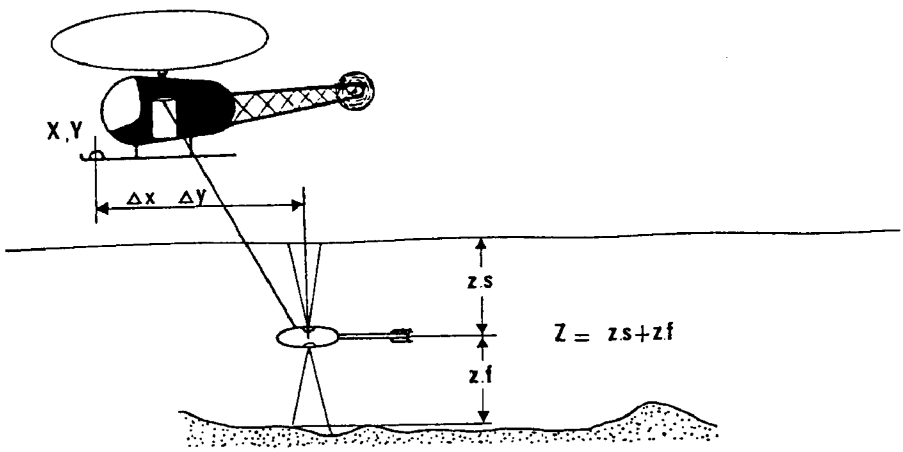
The antenna of the SYLEDIS receiver (Fig. 5) was chosen in a hemisphere shape so as to be placed at the extremity of one of the skates and so as to be free from the structure of the craft; it was locted, approximately, directly above the acoustic base.

The positioning system of the SYLEDIS (SERCEL) type was used because the area was covered by a SYLEDIS radiopositioning network required by the Landes Trials Centre. As the position was known to within ±5m, it was perfectly suited to this type of reconnaissance. In order to position itself for each point

1. With catamaran - rapid dynamic mode



2. With "salmon" - slow dynamic mode



3. With weight - static mode

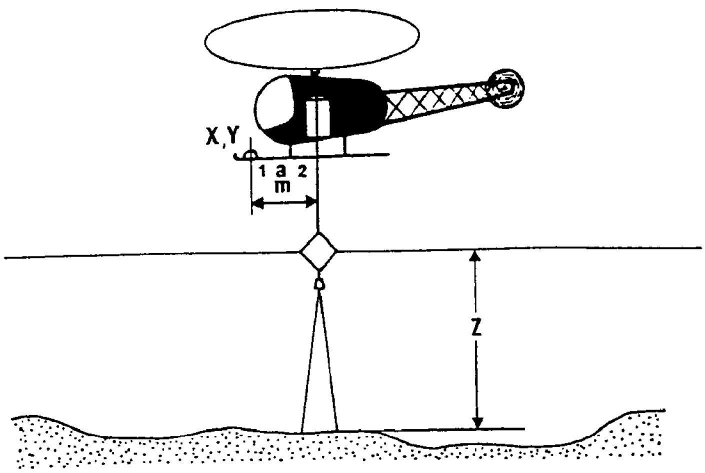


FIG. 3.- Methods of bathymetry by helicopter.

FIG. 4.- Hydrographer in working position.

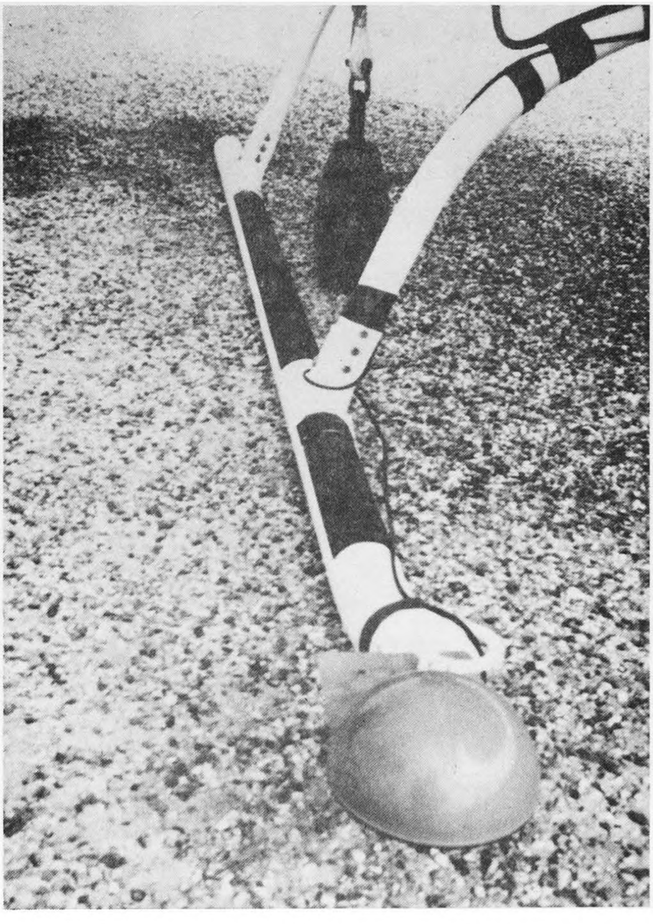


FIG. 5.- Syledis antenna.

to be sounded, an 8-inch video screen was installed above the flight panel (Fig. 6). This screen, linked to the SYLEDIS receiver, displayed the track to be followed as far as the point, symbolised by a cross, over which the helicopter should begin to hover in order to begin to take the measurement (Fig. 7). The pilot thus had a perfect knowledge of the route between points and the location of the fixed point to be held. After each measurement, the hydrographer programmed a new point to which to proceed.

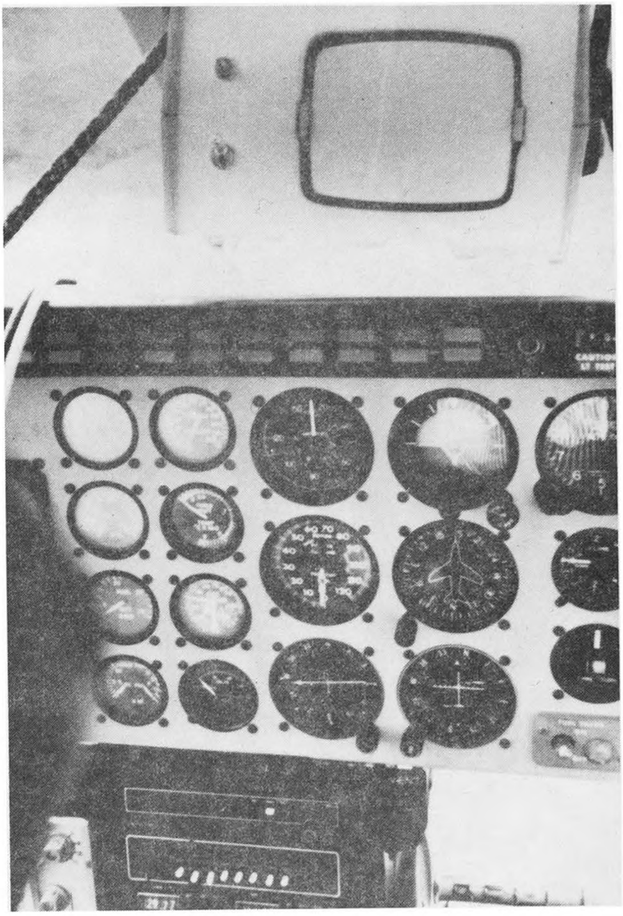


FIG. 6.- Video screen over the flight panel.

The hydrographic sounder employed was a DESO 20. Only the 210 Khz outlet was used. Both the 30 and 210 KHz outlets would have been used if the "salmon" method previously described had been chosen).

The acoustic base was mounted in a weight in the form of a sounding lead suspended 1 metre below a float (Fig. 8). An immersion test before the operation had shown with precision the depth of immersion of the transducer. This set of equipment, suspended at the end of a line 10 metres below the aircraft, could be

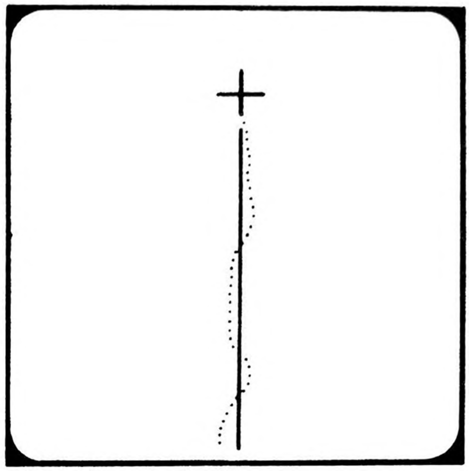


FIG. 7.- Track and point of measurement.

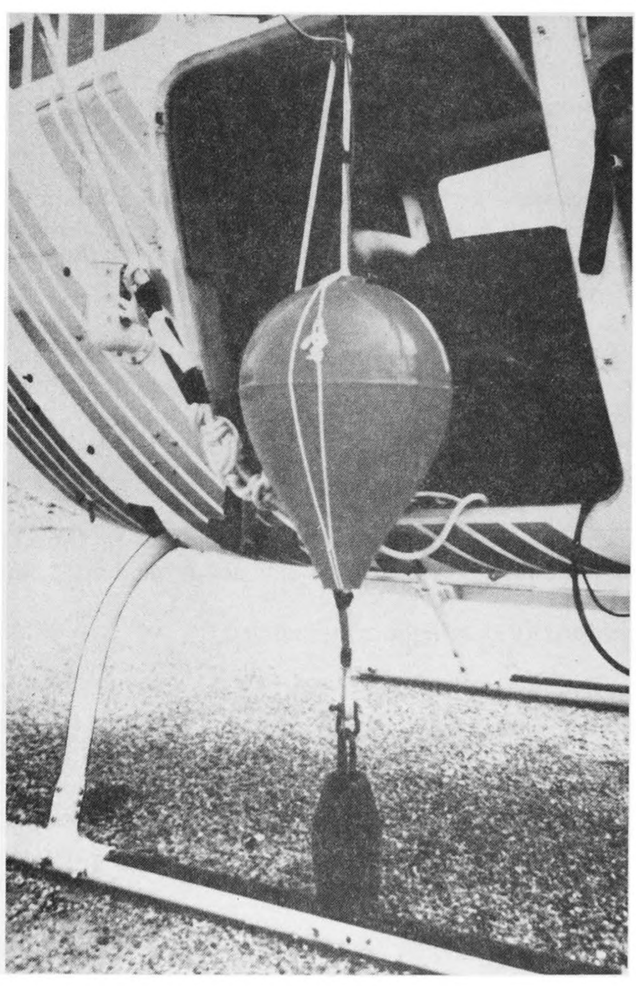


FIG. 8.- Acoustic station.

manoeuvred by the hydrographer using a bracket situated to the right of the door, which had been removed for the purpose.

III.3 - SURVEYING PROCEDURE

It must be remembered that the urgency of the mission did not allow for any very thorough initial preparation; only one half-hour trial had been made to check the feasability.

III.3.1 - Preparation in hydrographic room

This preparation consisted in defining the X, Y Lambert III coordinates of the 150 points to be sounded. These points, identified beforehand on a plotting sheet from the previous year, were subsequently digitised on an AO BENSON plotter, then published on a printer. The number of points to be sounded was limited because of the method used and their selection was particularly carefully studied as a function of the topography of the sea bed.

III.3.2 - Organization of the rotations

The surveys were scheduled on the basis of 1-hour rotations from a service area prepared on the end of Cap-Ferret. A service vehicle provided refuelling facilities for each flight of the helicopter. The length of the flights was limited to about 1 hour for the following reasons:

- so as not to overload the helicopter with fuel, thus making it more easily manoeuvrable in these operations at only a few metres above the sea;
- to give the pilot a chance to rest, as his attention had to be very concentrated during sounding;
- the number of positions it is possible to memorize on the SYLEDIS receiver is limited to 31 points, which represents about one hour's sounding.

The procedure for one flight included:

- filling up with fuel,
- entering the 31 points to be sounded into the SYLEDIS receiver,
- after take-off, taking a fixed point on the landing area to check the position,
- flying to the sounding area,
- display on the pilot's video screen of the 1st sounding point to be reached,

- descending the sounder to 10 m below the helicopter. The sounding operation itself, then, proceeds as follows:
- the helicopter is placed above the point to be sounded. This operation proved to be without obvious difficulty because of the great manoeuvrability in three dimensions of this type of helicopter;
- the hydrographer gives the pilot the order to descend (the position of the sounder below the helicopter remains fixed), immersing the sounder until the float performs its function;
- at that instant, the sounder is activated and a first position (X, Y) is noted. After measuring for 20 seconds, the sounder is stopped and a second position (X, Y) noted;
- the order is then given to the pilot to fly upwards again;
- the pilot's screen displays the second sounding point to which he must fly;
- the helicopter then flies to the next point, and thus a series of 31 measurements are taken, after which the sounder is brought back aboard before returning the base.

III.4 - Plotting of the surveys

In the plotting room, the average sounding corresponding to 20 seconds' measuring is calculated, reduced to sounding datum, then entered into a calculator with its position, the average of positions, and the start and end of the measurement.

Plotting is then done automatically on a plotter in the LAMBERT III projection. The isobaths in this particular case are drawn by hand (Fig. 9)

III.5 - Improvements to be made

Although the operations went well, some improvements might be made as regards the following aspects, for future missions:

- use of a printer so as not to have to note the X, Y positions manually. This would free the hydrographer from this task and make it possible to re-schedule new points beyond the 31, thus bringing the number of points sounded per hour to 45;
- reduction in the weight of the sounding lead. The lead support of the acoustic base weighed 15 kg. A weight of 5 kg would suffice and would facilitate manoeuvres to deploy and retrieve the sounding lead;
- use of an electro-carrying cable of 14 mm diameter used with a 24 Volt DC auto-blocking electric winch;

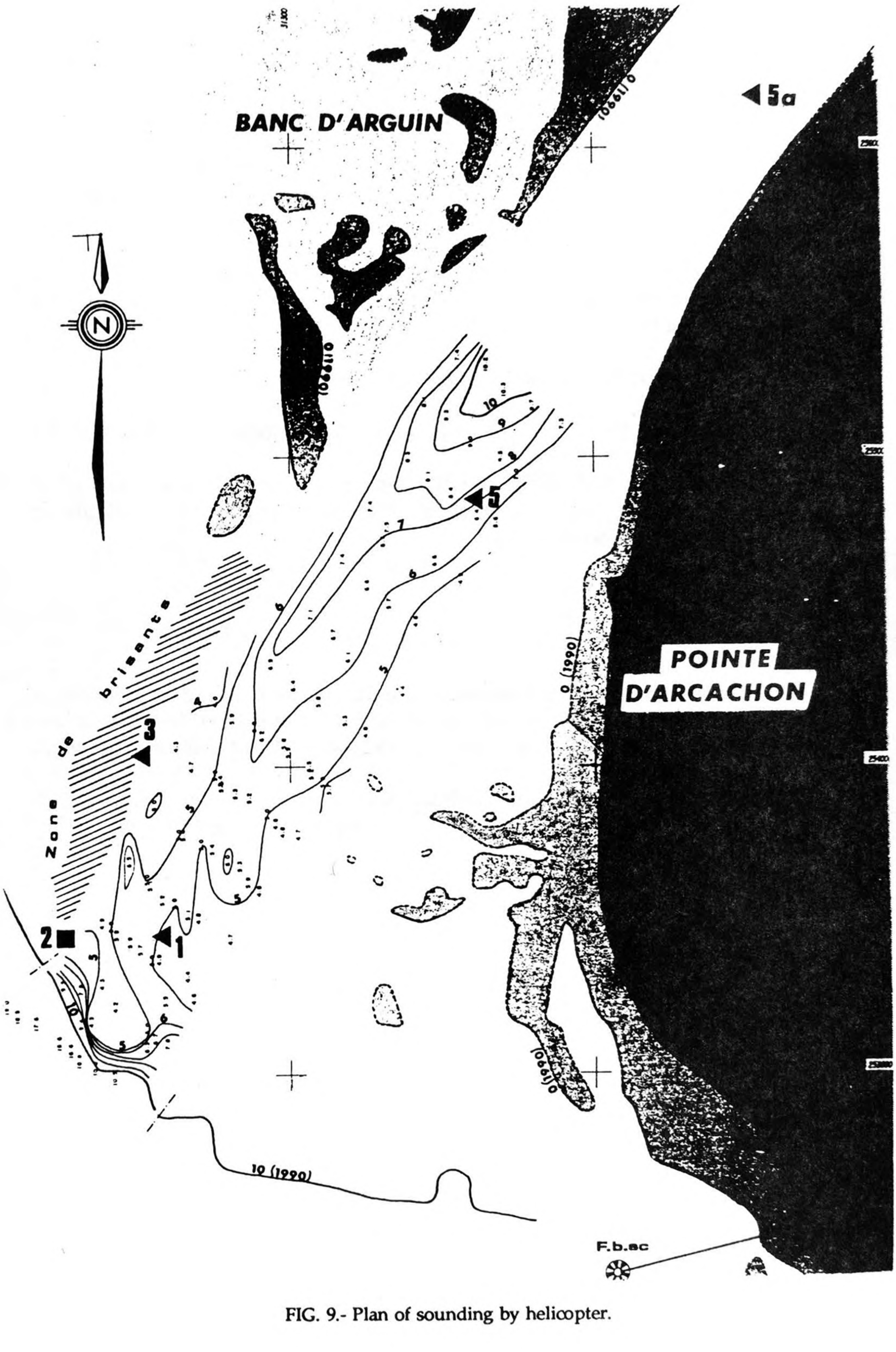


FIG. 9.- Plan of sounding by helicopter.

- reduction in volume of the float of the sounding lead (30 l rather than 60 l);
- finally, for safety reasons, provide, if possible, a twin-turbine helicopter of the same type as those used by pilots for helicopter hoisting operations.

IV - CONCLUSION

Although these two techniques of hydrographic reconnaissance have been applied to bathymetry in the context of missions by the Service hydrographique et océanographique de la Marine, they were, for the maritime port services a most interesting investigation for the future.

Indeed, such services are very often called upon to survey coastal areas where commercial, fishing and pleasure shipping are often dense and where sediment movements are as rapid as they are sudden. Generally, evolutionary phenomena are more rapid as the winter season advances and, therefore, the use of conventional means of surveying is impossible or dangerous.

The SPOT satellite and "the survey helicopter", thus named, have just made their entry into the array of methods that any port hydrographic service may use. They may be used independently of each other, but the fact that they complement each other enriches reconnaissance surveys and, for widespread areas, they are financially more economical than traditional methods.