DETERMINATION OF DANGER LINES WITH A HELICOPTER

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At the time the survey of the Arquipélago dos Abrolhos was first projected the determination of the limits of reefs and breakers in at least an approximate fashion was considered to be of capital importance for the efficiency of sounding operations. In other words, it seemed necessary to determine a " danger line " both around and close to these dangers.

The region is characterized by the light colour of the sea in all but the mouths of the rivers Caravelas and Peruípe. These dangers, for their part, cannot always be seen from the survey boat or ship unless it passes very close, and moreover some cannot be noticed except at Low Water.

However, it was known that these dangers could be seen from an aeroplane and that they would show up on aerial photographs, although with their submerged outlines ill-defined. This fact encouraged the Diretoria de Hidrografia e Navegaçao (DHN) to try to obtain colour films for aerial photography from the U.S.A. The difference in coloration would most certainly make a better determination of the submerged reefs possible.

After having considered the available means, and taking into account that the colour films were very unlikely to arrive in time, the situation was such that there remained only two solutions : we must either use a launch for determining the "danger lines", or, better still, a helicopter with a surveyor aboard as an observer. The second solution was given priority because of the speed with which work with a helicopter can be carried out without need of much manpower or equipment.

This project was laid before the Diretoria de Aeronautica da Marinha who were ready to embark a small instruction-type helicopter. Thus the use of a survey launch was not entirely abandoned and it remained as a standby in the event of difficulties with the helicopter.

As soon as we were certain that a helicopter would be available we realised that the following problems must be solved.

a) How to use the ship, either at anchor or under way, after the helicopter has taken off.

b) How to position the helicopter flying over, or close to, the dangers.

c) What would be the best track over the danger for an aircraft to fly, bearing in mind that the object is to determine the limits of the dangers.

d) What should be the means of communication between helicopter and ship and vice versa.

Regarding the first problem, it was immediately decided, because this was easy to carry out, to use the ship at anchor in the vicinity of the dangers, its position being fixed by visual bearings and radar ranges to fixed points ashore whose geographic coordinates are accurately known.

Concerning the positioning of the helicopter in flight, there were no other alternatives than to fix by visual bearing and radar range, or by radar bearing and range. For this, in view of the aircraft's small size, it was decided to improve the radar echo by means of a reflector designed for use in hydrographic launches and available on the survey ship.

Regarding the track to be flown over the danger, it was thought that the helicopter should make tracks across the region in the same way as for normal soundings. Thus when the aircraft reached the limits of the dangers the radar reflector would be lowered and its position would be determined by the ship, as previously described.

The limits sought would be obtained on the plotting sheet by connecting the fixes determined in this way. In actual fact this idea was not developed further for it was realised that it would entail a great loss of time and that, furthermore, the radar reflector could not be reliably lowered and raised, and that it would have only a small range.

Thus, from the first trial, with the helicopter flying over the limits of a reef uncovered at Low Water, it was established that much more reliability would be gained by using the procedure of making the helicopter fly over the limits whilst simultaneously plotting the fixes on board the ship. In this way the helicopter would be controlled from the ship where, by means of plotting, the time at which the helicopter would end its track over the assumed limits would be known. As a first experiment the helicopter was made to fly over the contour twice and it was found that both plotted tracks coincided without deviation.

At the time when the arrival of the helicopter was reported we learned that there was no radio installation on board, so we had a communication problem to solve. For the first trial a pair of portable "walkie-talkies" were used, and since the results were not good by reason of the equipment's small range, a 50 W voice transmitter/receiver was installed which gave excellent results. It was therefore necessary to work out a code so that with the minimum of words it would be possible to gain the maximum speed of intercommunication between ship and aircraft.

The plan of action being thus established, one officer watched the ship's radar and tracked the aircraft; at the same time another officer made alidade observations, and he also tracked the aircraft. When the first officer signalled the distance, the second gave the visual bearing. These observations were noted in a specially prepared log, and thus the necessary elements for a later and more accurate plotting were conserved. During this same time a rapid plotting was carried out, making it possible to follow the work of the aircraft from the ship, as in an operations room.

Procedure

After several small changes in the initial plan the following procedure was arrived at. Taking information drawn from old charts or from local pilots the ship would approach the dangers, whether submerged or not, and would anchor and fix its position by points ashore. From this position the helicopter would be released and given the magnetic track to be followed until the dangers were reached. Once there the surveyor in the helicopter flying at an altitude of about 50 m would report by radio that he was in *position*. Then while the aircraft was moving directly over the danger's limits these would be plotted with data from radar and visual bearings.

When the aircraft reaches the maximum radar range it would be radioed to change course and follow the limits of the dangers in the opposite direction, passing over the initial position and continuing up to the

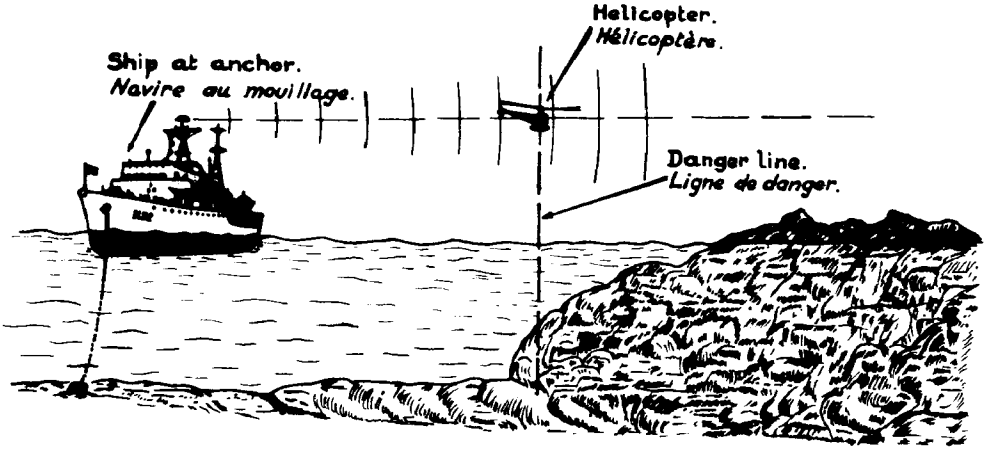

FIG. 1

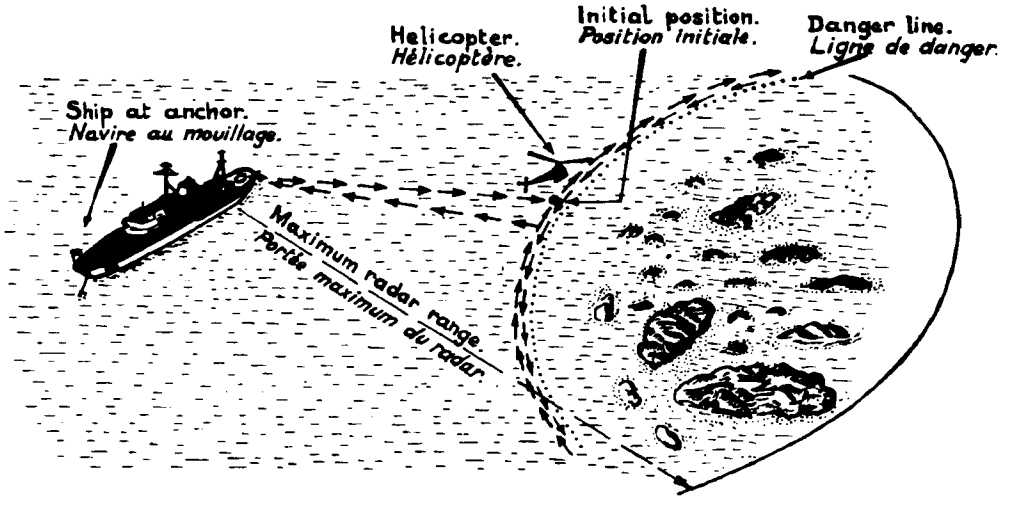

FIG. 2

maximum radar range on the other side. Here it would be ordered to change course and to return to its initial position. When plotting indicates that the aircraft has again reached its initial position it will be ordered to return to land on board.

Figures 1 and 2 give block diagrams of the procedure used for fixing dangers and for determining " danger lines ".

When a reef was small enough for the helicopter to be able to follow its limits remaining all the while within the radar range the aircraft would start to follow the "danger line" leaving the danger to its left and continuing thus up to the initial position. As a general rule the circuit was made twice.

Aircraft

A small instruction-type helicopter of the Hughes make, from the Sao Pedro da Aldeia naval airbase, was used, its call-sign being N. 5009.

Since this was a small helicopter and thus did not seem to us to give a good radar echo (the more so because the reflector had been installed in place of the reserve petrol tank) only when the aircraft had its tail towards the ship could the echo be improved.

Radar

A Raytheon, Pathfinder type, Model 1404A navigation radar was used, with a frequency of 9 375 mc/s, i.e. on a 3-cm wavelength. Its pulselength is 0.2 microseconds, with a 50-yard resolving power in range and 1°.5 in bearing.

As was expected in view of the wavelength, this radar is very sensitive to wave reverberations where small waves are concerned. Thus for ranges of less than 0.5 mile echoes from the helicopter or from a reflector were masked by reverberations. Consequently it was necessary to make certain that the aircraft passed outside a 0.5-mile circle for it to be tracked from the ship.

Radar observation was relatively simple because the equipment included a knob for controlling the movement of the CVV-CCW antennae, thus making it possible to limit the sweep on the screen to the sector in which the aircraft was flying.

The maximum distance obtained by the helicopter varied between 3.5 and 4 miles, although at the latter distance observation from the helicopter was difficult; it would therefore be better to consider 3.5 miles as the limit of the helicopter's range.

Light conditions

Although the helicopter carried out its circuit at around 50 m, light conditions and the sun's position are as important as they are for photogrammetric flights.

When the sky is cloud-covered the circuit could still be made provided that the sea-water coloration is similar to that in the dos Abrolhos region, i.e. a clear green, and provided that the dangers are close to the sea surface. Helicopter flights should ideally be made around Low Water times, or when the tidal range is small.

When there are scattered clouds it is inadvisable to make the circuit of submarine dangers because unless these are very well defined the observer may easily be misled by cloud shadows which appear as dark patches on the sea. We have noticed in this region that the scattered clouds which almost always appear immediately after sunrise disappear when the sun comes within about two hours of its meridian transit.

As regards light conditions due to the sun's position, we were able to ascertain that the best time is between 1000 and 1400. Before or after this, the incidence of light on the sea hinders observations; before 0900 and after 1500 reflections of the sun's rays will trouble the pilot.

Thus the limitations are practically the same as those for a photogrammetric flight, and moreover where possible it is advisable to fix the time of flight at about Low Water.

Work carried out

Figure 3 gives the plotting of the work carried out. This is a reproduction of part of Chart No. 1300 and shows the discrepancies between positions and limits of charted reefs and those seen from the helicopter.

The operations proceeded as follows.

28/11/64. The ship anchored at roughly 0.5 mile to the NNW of the Sebastiao Gomes reef at about Low Water.

The sky was cloudy, but fortunately the reef was practically uncovered, and this was the reason why it was chosen for this initial step as it would not be likely to present any visibility or identification problems.

At this point radar ranges to the Coroa Vermelha and Catoeiro lighthouses were respectively 5.8 and 7.2 miles. A total of 55 helicopter fixes were plotted, the ranges varying between 0.5 and 2.2 miles.

In view of the good results obtained it was decided to attempt the Parcel das Paredes reefs.

1/12/64. *a*) The ship anchored in the morning at position N2, the Ponta da Baleia, Catoeiro and Coroa Vermelha lighthouses being at radar ranges of respectively 12.6, 15 and 13.3 miles. As may be seen in figure 3, the ship's position at anchor was on the "danger line" as shown on the old chart.

From this point the procedure was slightly changed, and consisted of making the helicopter fly high enough to permit a general view. The aircraft then came down again to 50 m and passed over the ship which gave it the magnetic heading for bringing it back to the nearest point of the reef. After reaching this point it flew along a SE track following the

limits of the reefs at ranges from the ship varying between 0.4 and 3 miles. It was then ordered to change course and to proceed as indicated in figure 2. 129 helicopter fixes were plotted.

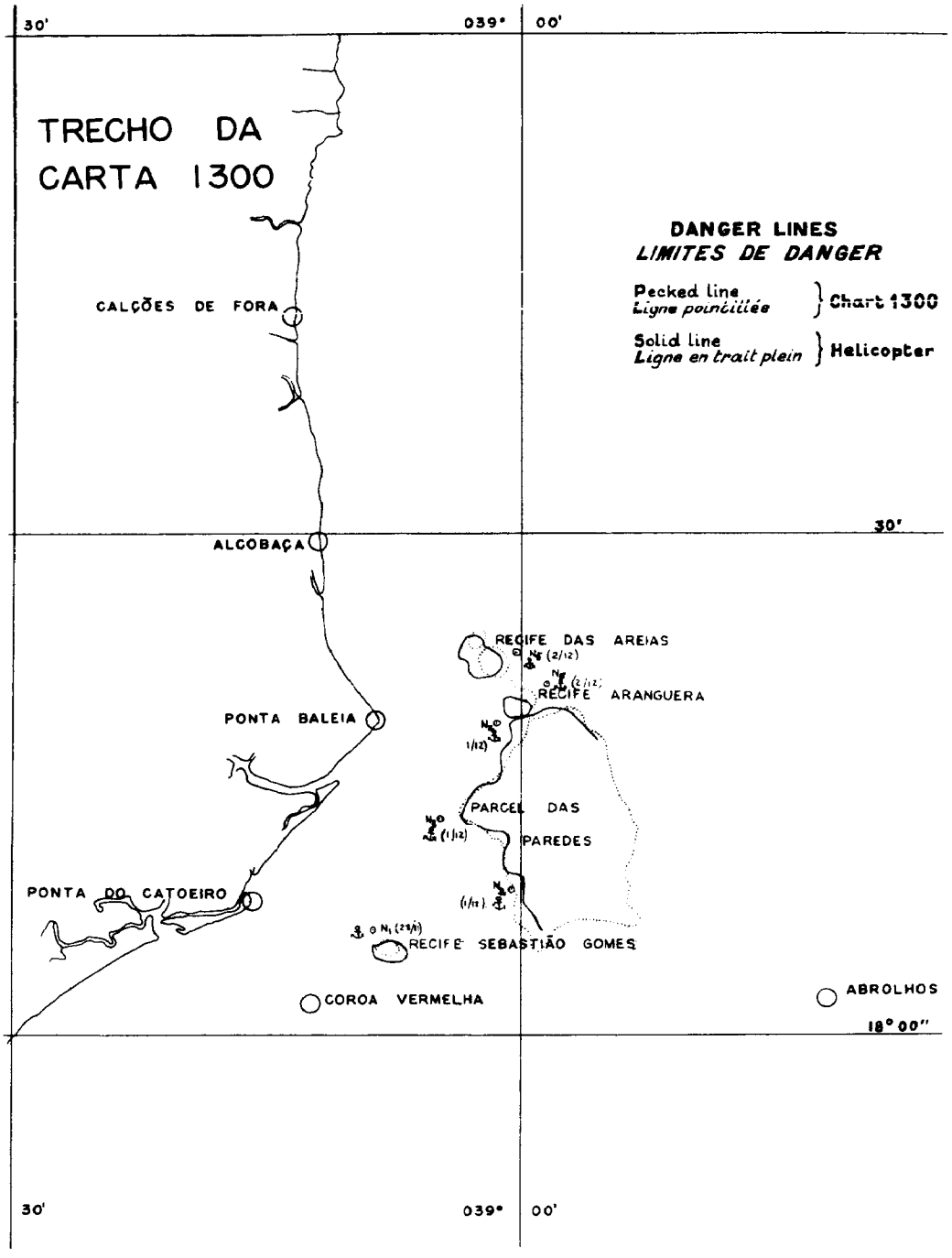

FIG. 3

b) On the morning of the same day, after the helicopter had landed, the ship suspended its work and took up position N3 at respectively 6.9, 11.2 and 13.2 miles from the Ponta da Baleia, Catoerio and Coroa Vermelha lighthouses.

From this N3 position the same procedure as for the N2 position was used, and 102 helicopter fixes were plotted at ranges between 1 and 3.4 miles.

c) During the afternoon of the same day, after having landed the helicopter, the ship got under way to take up position N4. Anchoring at 1400, its position was the Ponta da Baleia lighthouse at 270° and at 6.8 miles.

The procedure used from this N4 position was the same as for N2 and N3. A total of 88 fixes were plotted, ranges varying between 0.7 and 3.7 miles.

As conditions were unfavourable, the helicopter on its outward flight passed over the Parcel das Paredes reef's northern extremity, but on the return flight followed the Aranguera reef whilst trying to re-run the former.

2/12/64. In the morning the ship left position N4 and after having passed round the Areia reef anchored outside at position N5, the Ponta da Baleia lighthouse being at 8.9 miles and the Alcobaça lighthouse at 13.1 miles.

From this position onwards the procedure was similar to that of the N1 position. As the chart shows, the Areia reef was outlined. 62 helicopter fixes were plotted at ranges varying between 0.8 and 4.1 miles.

b) Subsequently, having landed the helicopter, the ship got under way to take up position N6, the Ponta da Baleia lighthouse being at 257° at a distance of 9.8 miles.

From this N6 position the helicopter determined the outline of the Aranguera reef using the N1 position procedure, and also the outline of the N and NE parts of the Parcel das Paredes reef using the same procedure as for the N2, N3 and N4 positions.

59 helicopter fixes were plotted for ranges varying between 1.3 and 4.3 miles. It is interesting to note that plotting disclosed a 0.1 mile wide channel between the Aranguera reef and Parcel das Paredes.

Improvements envisaged

From experience gained from this limited trial it is hoped to make the following improvements.

a) Radar reflector. We are already in the process of trying out another reflector, of the life-saving raft type, whose effective range will be about 10 miles. With this reflector the time taken up by this work will be shorter, for it will not be necessary to move the ship so often.

b) Echo-sounder in the helicopter. To make the survey complete, depths along the "danger line" should be determined with the aircraft.

Small size echo-sounders, whose projectors can be lowered and towed by the helicopter, are already available.

c) Gain in time. In two days the helicopter determined about 40 miles of "danger lines". Using a survey launch this would have necessitated several days or even weeks, with resulting risks to personnel and equipment. Although the "danger line" is only an indication, since subsequent stages of the survey will have to be carried out with a launch, the precautions then necessary will naturally be fewer than if an initial exploratory survey were being made.

At the later stages of work in this region greater experience will no doubt be gained. We believe however that it would be of interest to employ the procedure just described in other regions which, each with their own characteristics, will increase the knowledge acquired by the DHN on this particular subject.