

## **RADAR PHOTOGRAPHS PRODUCED BY THE ROYAL DANISH HYDROGRAPHIC OFFICE**

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Lecture given by Captain I.V. TEGNER of the Royal Danish Navy  
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The advent of radar has undoubtedly presented most hydrographic offices with the problem of having to produce some form of radar chart or radar photos that might help the navigator interpret the picture seen on his scope, in order that he may get the maximum benefit from this excellent new navigational aid.

The work of the Danish Hydrographic Office covers 3 areas : Danish home waters, Faroe Island waters and Greenland waters, that differ considerably from each other.

Practically all of Denmark and the Danish coasts are very low and make very poor radar country and consequently it is extremely difficult, if not impossible, to compile radar charts for this area which would be of any value to shipping.

But as the Danish home waters are well marked with lights and buoys and are, moreover, covered by a Decca chain, there is very little need for radar charts.

The Faroe Islands need have no specially compiled radar charts owing to the fact that practically all the islands have very high, perpendicular coasts that show on the scope in such a way that no mistake is possible when comparing them to the ordinary nautical chart.

In Greenland conditions are quite different, even if the coast is a rocky one. The mainland with its deep fjords lies behind an extensive archipelago consisting of islands of the most varying size and form. This long desolate coast presents, in clear weather, great difficulties of identification even using the artistic views one can find in the pilot handbook, or the modern charts complete with topographic detail.

When low hanging clouds mask the characteristic mountain tops, identification becomes well nigh impossible and when the thick arctic fog, which is encountered very often, rolls in from the sea, nothing can of course be seen.

Surface navigation is therefore a problem to anyone who is inexperienced in these waters. Add to this that lights and radio beacons are few and far between, that these waters are but partly surveyed, and that insufficient information is known about the tidal currents which vary

considerably along the coast, and it becomes clear that shipping is forced at least 10 to 15 miles out to sea in order to be safe.

Until the early fifties, all local traffic was handled by ships of the Greenland administration manned by experienced navigators, most of whom had spent their whole life in this trade and they of course had little difficulty finding their way about the coast and were not too pressed for time either.

The ships of the foreign fishing industry that have worked in these waters have, as a rule, kept out to sea, but if they ventured near the coast or entered the archipelago it was done at considerable risk and often with dire results.

Since the early fifties, however, the development of the country has led to great intensification of shipping, so much so indeed, that it has become impossible to have an experienced Greenland navigator on each ship, and this, coupled with a few disasters in recent years, has made it absolutely necessary for the Danish Hydrographic Office to try to help shipping get full benefit from their radar equipment.

Fortunately, some experience in radar photography had been gained by the Danish Hydrographic Office before the problem of compiling a book of radar photos arose in earnest.

During the years 1956 to 1959, special hydrographic surveys had to be made on the east coast of Greenland in Kong Oscars Fjord — 72°00' N — in order to help traffic for the lead mine at Mestersvig.

The only material available for making survey sheets on a scale of 1/100 000 were maps of 1/500 000, and consequently the survey sheets could only be considered as sketches giving very little detail. To make the survey even more difficult, the geodetic basis for these maps was very sparse and no trigonometrical points were visible from the survey vessel (a cutter of 120 tons) at sea level. Establishing new trigonometrical points on the coast was out of the question owing to the very short working season.

The sketchy coastline could not be used for surface navigation, so the only means left for something near adequate positioning was radar.

In the beginning, radar distances were tried, but again owing to the sketchy nature of the coastline, positions as a rule resulted in rather oversized cocked hats.

In order to retain the actual radar picture of the various survey positions for later use, an ordinary 24 × 36 mm camera was therefore mounted on the scope in 1957 and photos were taken from every position.

To be able to use these radar photos in conjunction with the survey sheets presented the difficulty of finding sufficiently accurate and stable equipment. However, this problem was overcome by using a component from a so-called multiplex normally used for vertical aerial photos.

When drawing the smooth sheets it became clearly evident that the radar photos gave a lot more information on the coastline than was contained in the sketchy survey sheets, and as distances between the coasts differed from the survey sheet too, it was decided to try to improve the chart by means of the radar photos.

To begin with, an effort was made to prepare a mosaic of the photos, but as there was no way of keeping control of the azimuths it became necessary to use the basic chart as a skeleton.

In this way a completely new chart was compiled using vertical aerial photographs for extra detail, where such were available.

It is the considered opinion of the Danish Hydrographic Office that the resulting chart is highly improved in this way, because radar photographed survey positions could be placed on this new chart to within plus or minus 100 metres, 1 mm on the chart. Later radar measurements and independent radar photos taken from other ships fitted nicely in this rather untraditional chart.

On a purely experimental basis, the Danish Hydrographic Office compiled a mosaic of radar photos of the Kong Oscar Fjord area on a scale of 1/500 000; some navigators have been happy to have this on board.

As a consequence of the experience thus gained, radar photographs have since been used extensively for positioning in reconnaissance surveys in the deep fjords, on the inshore routes, and as a secondary position line where only one of the hyperbolic systems of the portable Decca chain is available.

For control reasons, radar photos have been taken in Danish home waters where distances and azimuths are well known, and experience shows that with a 2/3 overlap between photos it is possible to keep the distance error down to 1 %. Complete control of the azimuths has not been obtained, but accuracy on positions taken on the 3-mile and 10-mile range has normally been within 1 mm on the charts. Experiments have been made on charts on a scale of 1/30 000 for the 3-mile range and charts of 1/100 000 for the 10-mile range.

It is, however, essential that the radar employed be as well trimmed as possible, and that the axis of the camera and enlargement equipment be exactly at right angles both to the scope and to the chart to be compiled. Other errors of the radar can be reduced to a minimum by a sensible interpretation of the echoes on the photos.

In 1959, after the sad loss of the newest ship of the Greenland administration, it was decided by the commission of investigation set up by the government that among other things the hydrographic surveying of West Greenland should be stepped up and that radar photos of the coast should be produced.

The Danish Hydrographic Office felt that with the experience already gained, radar photos could be taken with the object of compiling some suitable form of aid to navigation for the area.

It was, however, no new thought at the Danish Hydrographic Office because it had frequently been discussed what could be done to help shipping get full benefit from their radar equipment; which would be the best way to present the information, and where to start?

One group thought it most important to give the navigator a series of radar photos of the approaches to the bigger ports, another that a series of photos of the coast taken at a suitable distance would be of value.

As to presentation there were quite naturally several different ideas,

but all were agreed that a collection of photos in itself would be of scant value. The photos had to tie in with the existing charts in some way.

The best solution, it was thought, would be to have the series of photos taken, enlarged to fit a certain chart or chart series, similar to what had been done experimentally on the east coast charts mentioned earlier.

It was also agreed that, to get as close as possible to conditions on board the majority of ships operating in these waters, a commercial type of radar should be used, and for the same reason the height of the scanner used ought to be as near as possible to the height normally used.

The Danish Hydrographic Office being still somewhat uncertain as to the best way to proceed, decided to tackle the problem experimentally, hoping to be able to get sufficient cooperation from the navigators of the Greenland administration when it came to trying out the results.

No ideal ship, however, was available that year, and the Danish Hydrographic Office had to start the experiment using a cutter of 120 tons, the scanner of which was at a height of only about 6 metres, or well under half the normal height.

The radar photos were taken in the approaches to Godthaab, the capital of the country, one series in the normally used approach line and two more series at the outer limits of the approach sector beginning 10 miles out from the outer islands. In continuation of these series further radar photos were taken from the outer islands right into the harbour. These photos were enlarged to the scale of the existing chart of 1/80 000.

Now came the problem of presentation.

As can be seen from the copy of the first book produced, it was decided to print the photos as positives, looking like the actual picture seen by the navigator on the scope. The range rings were deleted because different radar types used different standard range systems, but the scope centre spot (the position of our own ship) was retained to show from which position the photo had been taken.

From the corresponding chart a series of cuttings, showing only coastline, each corresponding to one of the photos, were printed on tracing paper, and the photos with their corresponding overlays were bound together in a book.

It was, however, immediately seen that this form of presentation was extremely unpractical, mainly from a book binding point of view, and it was decided to give it up just before the book was finished.

Nevertheless, the book was sent out in 1960, as an experiment, to the ships of the Greenland administration and others, asking the navigators to give their opinion on the usefulness of the photos, on whether it was thought necessary to have photos at shorter intervals, on the chart scale, etc.

As already mentioned, it was the opinion of the Danish Hydrographic Office even before any comments had been received on this first book that this way of presentation should be discontinued.

Instead, it was decided that the photos should be produced as negatives using a dark, translucent magenta colour for the radar echoes, and that instead of printing special chart cuttings, which had been rather complicated to compile, it would be much simpler to draw the graticule of the

corresponding chart on the enlarged radar photos. The range rings were to be deleted, but the scope centre spot should be retained as before. Using the graticule for registration when placing the enlarged photos on the charts proved a simple and easy way to get a means to interpret the scope picture and thereby help identification of the various things seen.

When comparing the radar photo to the actual coastline drawn on the chart, it will sometimes be noted that not all the islands show on the scope picture as would be expected. This is probably due partly to the form of these islands and partly to other unknown conditions. It stresses, however, the necessity of having made a firm identification of the picture seen before positioning is tried. If icebergs and growlers are met with, even more caution has to be shown.

At shorter distances, the picture on the scope corresponds very closely to the coastline on the charts, and the Danish Hydrographic Office has therefore come to the conclusion that no radar pictures will be needed for the inshore routes where the modern charts with accurate coastline and wealth of topographic information will be sufficient.

During the summer of 1960, the captain of the survey expedition in Greenland discussed the whole problem with various navigators of the Greenland administration and was informed that a series of photos taken along the coast at a distance of about 10 miles offshore was of interest and accordingly an extensive series was taken at 5 to 10 mile intervals.

Later in the year, a meeting was held attended by the same navigators to discuss formally the value of the first experimental book of radar photos.

The general opinion at this meeting was that photos of the approaches were of less value than a series of photos taken at a distance of about 10 miles. There was, as had been expected, a remarkable difference of opinion as to the value of the radar photos among the older experienced skippers and the younger navigators. The first group saw no reason to go to the trouble to produce the photos; the second thought them of great value and had been happy to use even this first limited book.

The Danish Hydrographic Office explained why it was thought easier to present the photos as negatives and how registration could be obtained using the corresponding chart graticule and both these ideas were accepted by the meeting.

The photos taken in 1960 were then enlarged to fit the chart series on a scale of 1/400 000 supplied with the chart graticule and printed on tracing paper so that they could be used as overlay on the charts.

Before the book was finished it was discussed whether to publish it as a looseleaf book or have the collection mounted on rings. It was agreed that the looseleaf solution might well be the best, but on the other hand the pure looseleaf book might prove unpractical in the chart house in bad weather, so in the end it was decided to produce a ring book which allowed the easy use of single radar photos as overlays.

The 1961 trials proved that the negative solution is a good one.

However, it was seen that in order to be able to pick out the parts of the coast more conspicuous to radar and that appear on perhaps several consecutive photos, and in order to see how the picture of the coast would develop, and, so to speak, be able to interpolate, it would be of value to

be able to use two or more photos simultaneously. So, in spite of the disadvantages the looseleaf system might have, it was decided that the final form of the book had to appear as such.

The 1961 book had also been sent to the Hydrographic Department in London, to the German Hydrographic Office and to the Italian Hydrographic Service, asking for comments and criticism.

The comments received from these offices have been very much appreciated by the Danish Hydrographic Office and have in many respects proved to be of great help when it came to deciding on which way to plan the final presentation and on the principles to be laid down in the 1962 book, which has recently appeared.

For this kind help the Danish Hydrographic Office would like to extend its most hearty thanks. The 1962 book of radar photos is a pure looseleaf book but, in order that the navigator need not have all the radar photos of the entire coast strewn around his chart house at the same time, the book contains an envelope for each of the charts in the 1/400 000 series meant to hold the corresponding photos. Moreover, the photos are supplied with the number of the chart to which they belong and with a consecutive number beginning in the south. The same numbers are to be found on each envelope so that it should be comparatively easy for the navigator to keep the photos in order.

The pure looseleaf solution gives the extra advantage that spoiled or lost photos can be replaced easily and at small cost.

Not all the series of photos corresponding to the charts at the scale of 1/400 000 are considered complete, but it is the intention of the Danish Hydrographic Office to produce supplementary radar photos where such are needed.

When new charts of the series are produced, corresponding radar photos will be produced as time and opportunity allow, and notice of their appearance will be published in the Danish Notices to Mariners.

Just before issuing the 1962 book, another meeting was held with the masters and navigators of the Greenland administration to discuss the 1961 issue, and it was with great satisfaction that the Danish Hydrographic Office could note the interest with which this book had been received.

There was no doubt that it was considered of great value, mainly of course by the younger navigators, but also by the experienced masters.

The Danish Hydrographic Office is quite certain that the book of radar photos will be a valuable aid to navigation in Greenland waters, also to the many foreign fishing vessels fishing the year round in these difficult waters, but, as is always the case with new things, it may take some time before navigators learn to use this aid properly and appreciate its value.

Even if the charts of Greenland waters issued by the Danish Hydrographic Office in the future are supplied with more and perhaps better topographic information, it is our opinion that the radar photos will constitute a valuable and comparatively cheap supplement to the charts, a help in interpreting the picture seen on the scope, that will make navigation safer.

The Danish Hydrographic Office does not, at the moment, expect a

run on this publication, but it is thought that when it becomes more widely known the demand will grow accordingly.

For this reason, which is not a commercial one, the Danish Hydrographic Office is in close contact with the navigation schools of our country, hoping that publications of this sort will be mentioned in future handbooks of navigation.

In conclusion, it may be of interest to get an idea of the economic side of this project.

Apart from the photographic work in the field, which cannot be worked out in dollars and cents, the photographic work involved in producing the enlargements of the 68 existing radar photos amounts to about 1 000 dollars. Printing costs for the handbook as it looks to-day amount to another 1 000 dollars. This, of course, means that the first issue, which is of 200 copies only, comes out fairly expensive, but if and when the book can be produced on a larger scale the price per book will go down considerably.