GROUND COOPERATION FOR COAST-LINING WITH AERIAL PHOTOGRAPHS

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INTRODUCTION

Air-surveys — i. e. surveying with the help of aerial photographs — are more rapid, economical and dependable than surveying from the ground. The method can be used for surveying inaccessible areas. It can also be used for quick revision of existing surveys.

In hydrographic surveys also, considerable time can be saved by employing air-survey methods when delineating the high and low water lines and any topographical features that may be of value to the mariner in helping him to recognise the coast and determine his position, as well as the nature of the foreshore, etc. However air-surveying has a disadvantage in that if a first order survey is required then basic control and ground verification are essential.

Just as in war, where no matter how sophisticated the weapons used — atomic or hydrogen bombs for instance — the infantry must physically occupy the land in order to complete its conquest, so from the point of view of surveying with the help of aerial photographs must the surveyor on the ground play a vital role in completing the conquest of the land.

Air-surveying by itself is not a comprehensive method of surveying. It has to be supplemented by certain information and by details which cannot be picked out on photographs, for instance :

(a) Place names;
(b) Nature and type of beach;
(c) Types of vegetation;
(d) Pinnacle rocks;
(e) High and low water lines in the case of delta areas where changes occur frequently, especially when the photography is not very recent;
(f) Rock classification;
(g) Positions of beacons and other navigational aids;
(h) Topographical features such as temples, mosques, churches etc.

(i) Details which are obscured — due either to shadows, trees, clouds, or dead ground, or else to photographic defects. These have to be identified on the photographs.

Furthermore, the various photographs have to be braced together and reduced to a single scale so that the details are compatible with their geographical positions. Ground control stations thus have to be established, and their coordinates and heights determined and the positions indicated on the photographs.

Thus close cooperation is necessary between the surveyor on the ground and the photogrammetrist in the office in order that the final survey may be really meaningful.

The field work required from the ground surveyor can be broadly divided into two categories :

(a) Photo-verification : Identification of doubtful details on the ground and provision of supplementary information.

(b) Control work : Provision of conveniently placed control points meeting all the requirements of photogrammetry.

In the succeeding paragraphs an attempt is made to describe the methods of collecting such information on the ground.

PHOTO-VERIFICATION

The process by which air photographs are taken to the site where the various details which are not clear are verified under stereoscopic fusion and inked in using the appropriate symbols is known as "photo-verification" Such supplementary information as place names, types of vegetation, etc. is also included at this stage.

For this photo-verification the surveyor ashore has to walk over a few selected routes in order to verify various details on the ground. With the help of a pocket stereoscope, the relevant pairs of photographs are fused. After careful identification under fusion the necessary detail is later "inked in" using water colours employing the appropriate symbols on a copy of one of the photographs making up the pair. It is convenient to choose the even numbered photographs for this purpose.

Before photo-verification is started, the limits of the area to be verified have to be marked on each even number photograph. It may be noted that in every photographic strip each photograph has an overlap of about 60 % with the adjacent photographs in the fore and aft direction and about 25 % overlap with those in the adjacent strip in the lateral direction. The limits of the verification in the fore and aft direction should be the lines passing through the transferred "principal points" of the photographs adjacent to it. In the lateral direction these limits should be the lines drawn through the mean of the lateral overlaps in adjacent strips. An overlay trace should also be maintained separately for each even numbered photograph showing the various types of detail in different colours, with their limits.

The shore party charged with the task of photo-verification should pay particular attention to the high water line, type of beach, extent of foreshore area, types of vegetation area along the coast, as well as to all identifiable dangers to navigation. The person charged with the interpretation and delineation of coastal features should first study all available charts and maps of the area and the appropriate sailing directions. In this manner he will obtain a general idea of the type of coast he is verifying and will therefore be better able to interpret the coastal features.

A few aids to better identification are given below.

a) Photo-resection

The principle of this method is the same as that of "theodolite resection" or "plane table resection". A sheet of tracing paper is fixed on a levelled plane table. With a sight rule rays are drawn from a point to three or more objects widely spaced on the ground and which can be identified on the photograph. The overlay is then adjusted over the photograph so that the various rays pass through the images corresponding to these objects and a point is pricked on the photograph to denote the surveyor's own position. Since the horizontal angles on photographs are true only at the "principal point" (for vertical photographs) and at the isocentric point (for oblique photographs) the position obtained by this method is not theoretically correct ; however, for practical purposes the error may be considered negligible, especially over flat terrain. This method should accordingly be used for guidance only.

b) By pacing

Distances from three or more differently positioned objects appearing on the photographs can be measured by pacing on the ground to a point whose position has been identified. For all practical purposes 25 steps on the ground can be taken as equalling one chain (66 feet). As the scale of the photography is known from the "Air information slip" or the "Air photo Index" this position can be plotted on the photograph with the help of dividers. As the scales will not be uniform, the position so obtained may be not exactly correct, but for practical purposes, especially over flat terrain, the error will be negligible. Once again, this method should be used for guidance only.

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It can be seen that by suitably employing one of the methods just explained any variations in the detail can be incorporated — for instance in delta areas where frequent changes in the alignment of the High Water line will be noted if the photography is not recent. In all such cases the surveyor ashore has to use his judgement and discretion.

Detail apart, the following information has also been inserted on all aerial photographs.

(a) Fiducial marks to determine the position of the principal point.
(b) Altimeter reading giving the aircraft's flying height above mean ground level.
(c) Chronometer readings giving time and date of photography.
(d) The tilt angle, i. e. the inclination of the camera axis.
(e) The number of the photograph.
(f) The number of the camera for quoting in the camera calibration report.
(g) The focal length of the camera lens.

From this information it is possible to determine the various factors like the scale of the photographs, g/b; the height of certain objects by the date, the time and the length of the shadows thrown; and the limits arising from the camera tilt.

CONTROL WORK

The details appearing on the photographs are subject to various distortions. Among these are the two described below which are of considerable importance.

a) Tilt distortion

This is due to the deviation of the camera axis from the vertical at the time the photograph was taken. Air-surveying can be satisfactorily carried out without too much complication in the case of vertical air-photographs. When taking these vertical photographs it is essential that the aircraft should not be tilted either forwards, backwards or sideways. Since no aircraft can fly quite perfectly level, tilt distortion is introduced.

b) Height distortion

This is due to the varying heights on the terrain. It results from attempting to depict three dimensional terrain on two dimensional photographs. The scale will thus not be uniform on each photograph.

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Hence control points are necessary both for eliminating these distortions and for reducing the topographic details appearing on various photographs to a single scale so that they are represented in their geographical positions.

Stations are established on the ground at places which can be easily identified on the photographs, and the coordinates and heights of these stations are determined by either triangulation, trilateration or traversing. These control points are of two different types.

a) Planimetric control points

The main purpose of these points is to determine the planimetric positions of the details. The coordinates and heights of these points are invariably required.

b) Height control points

These are required in order to determine both the relative and the absolute height of any other point, and thus for facilitating the contouring. Only heights are required for these height control points : coordinates are not necessary.

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Control points on the ground can be provided either before or after photography. The first case is called "pre-pointing". Here the points on the ground are constructed before photography in order that they may show up on the photographs. The second case is called "post-pointing" and is where the points are constructed after the photography and after careful identification are pricked on the photographs themselves. In "post-pointing" better planning is possible as the points are constructed with the photographs available. Furthermore, "pre-pointing" is uneconomical.

The density and layout of control points depends on the survey method and its scale, and on the accuracy required. Planimetric control points for the start and closure of each strip are imperative, with additional control points at intervals of 10-12 miles for the graphical method of combination when medium scales of about 1/50 000 are concerned. For the slotted template method of combination the control required is about 40 % less than for the graphical method.

These control points must be carefully distributed so that there is at least one point at the start and one at the closure of each strip of photographs.

Height control points are necessary for contouring. When the tilt is not more than 2°, the contours can be traced on the photographs under stereoscopic fusion if we know the heights of 9 points per photograph (6 per optical model) and, depending on the nature of the ground, up to 12 additional uniformly distributed points. When the ground is very irregular the heights of even more points will be required. In any case the heights to hilltops, saddles, changes in gradient, and to river beds at certain specified points are essential.

A convenient method of providing height control points is by using the Indian Clinometer. This enables the values of tan θ to be directly read from known points to the various points, and then the vertical components are deduced in the office by multiplying these readings by the respective horizontal distances.

Knowing the heights of a minimum number of points, the height at any place on a model can be determined by using a parallax bar. If the heights of points at the four corners of each model are known contouring can be carried out directly with the aid of the floating mark in a stereotope.

Most of the control points that have already been provided along the coast for hydrographic purposes will meet the requirements of photogrammetry. However the officer in charge of the control work for hydrographic surveys, after careful reconnaissance, should select his stations, intersection points and benchmarks so that they also meet the photogrammetric requirements. This he should do by reference to a photo-index showing the layout of the photographs in the area. All such points should be identified on the photographs, and then pricked — their names, numbers, heights, etc. being entered on the back of the photograph. All odd numbered photographs should be used for this purpose as all the even numbered ones are being used for photo-verification, as explained above. A separate overlay can also be maintained for each photograph on which the description of the control points will be recorded.

CONCLUSION

The various methods and stages of air-survey work discussed in this article are not exhaustive. They merely give an idea of what is required before going ahead with the processing work. Techniques involved in, and the requirements of, aerial triangulation and the more sophisticated stereoplotting machines like the Wild A 7, A 8, or A 9 and the Zeiss C 8, etc. are not discussed here.

Bearing these requirements in mind, the various international hydrographic agencies should lay down specifications and instructions for the different tasks. In a survey where it will be sufficient if the contours are incorporated from the available topographic maps of the area, the height control work can be dispensed with. Similarly, in an area where the coordinates for such features as streams, roads, rail junctions, etc. may be read from larger scale maps of the area as these features will be identifiable on the photographs, then planimetric control work can be avoided, and only photo-verification is called for.

Air-surveying is a comparatively young discipline, and its applications to hydrographic surveying are still in their infancy. Hydrographic surveyors and photogrammetrists should endeavour to bring about an improvement in the methods for coast-lining and surveying of coastal features, for at present most countries still employ the classical "ground survey" methods. With

proper coordination between the hydrographic surveyor on the coast and the photogrammetrist in the office, the time required for such surveying can be minimised, and very reliable and accurate charts can be produced.

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