CANADIAN AIR SURVEY: ITS PROBLEMS AND FUTURE OUTLOOK*

Douglas N. Kendall, Managing Director, Photographic Survey Co. Ltd., Toronto

SINCE the subject of this paper is very broad, it would be impossible in the space available to cover all the many problems associated with Canadian air survey. In any case, many of these problems are common to air survey in any part of the world, and I have therefore attempted to stick to those which are peculiar to Canada and which may therefore provide some new and possibly useful information.

Canada, like most parts of the world, has seen a great acceleration in mapping since World War II, and naturally this has been along photogrammetric lines. Mapping in Canada, however, involves a somewhat different approach to photogrammetry than, for instance, that adopted in the United States or in Europe.

Canada's problem must be viewed in the light that she is ninety per cent uninhabited; she is the second largest country territorially in the world, yet with only a thirteen million population, the bulk of whom live in a narrow southern fringe. It follows, therefore, that the national commitment per head, whether it be food production, miles of highway to be maintained, manufacture or, as in our case, map production, is higher than anywhere else in the world. It is not surprising, therefore, that much of Canada remains to be mapped. What is surprising to me, a comparative newcomer to Canada, is the amount of mapping which has been achieved in spite of all difficulties.

Obviously, survey must proceed in logical scale steps, at least from the point of view of an over-all plan. The Federal Government is therefore producing first an eight mile to one inch map series, then a four mile to one inch map, and the final aim is to compile one mile to one inch topographic sheets for the whole of Canada. This latter aim will take several generations to complete. The prior need for small-scale maps is, however, only too apparent, when this year some six thousand square miles of islands not previously known to exist were found. In other words, photogrammetry added this year to the Dominion of Canada, an area roughly equivalent to twice the size of Long Island.

The small-scale maps are produced from trimetrogon photography, which is flown entirely by the Royal Canadian Airforce. The maps are based for control on astro points established by the Geodetic Survey of Canada at about fifty-mile intervals. So far, these maps have been issued without contour information, but this is now being considered, the height control to be compiled from profiles obtained by use of a narrow beam radar altimeter carried in an aircraft.

One of the biggest problems in Canadian mapping, particularly at the larger scales, is the lack of geodetic information. In the United States and in Europe, a relatively dense network of triangulation points and bench marks exists for most areas, and the main emphasis is on map revision and the provision of large-scale plans with contours of the more important areas. In Canada, most of the mapping is ab initio, or nearly so, with no better ground control than the occasional astro point.

It is natural, therefore, that much thought is being devoted to finding methods for accelerating ground control, and at the same time evolving photogrammetric bridging techniques to reduce the amount of control required. It may

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interest you to know some of the ways in which these problems are being tackled.

First of all, a serious attempt is being made to accelerate geodetic survey by use of helicopters. The main delay in this work has always been transportation and the pure "foot-slogging" through the bush. The helicopter, as its performance and operating costs improve, promises very largely to eliminate this and thus to speed up the work three or four fold.

A second approach to the geodetic problem is being made through Shoran and other radar fixation methods. The R.C.A.F. has now established a Shoran squadron and, hopes to produce some results next year. Obviously, Shoran or its equivalent has great possibilities, owing to the great distances to be bridged in Canada. While astro fixation has served Canada well in the past, it is unfortunately subject in our northern latitudes to extraordinarily large gravity errors.

A third approach is, of course, by photogrammetric bridging. The templet method has its applications, but for bridging over great distances, some instrumental method of air triangulation is obviously necessary. In Europe, claims have been made involving bridging over great distances using the Wild A.5 equipment. We as an organization hope to be able to bridge even greater distances in Canada, and believe this to be possible for a number of reasons. The initial experiments involve bridging over 25, 50 and then 100 miles. To do this, we propose to fly from an altitude of 25,000′ with a 6″ focal length camera. This would give us a forward gain of 2.8 miles per exposure, and a total of thirty-six prints for one hundred miles. The run will start and end over geodetic points and we shall have perfect four-point settings at each end. For the plotting we propose to use the Wild A.5 autograph. We appreciate that we may have to use glass plates in the camera, but we are hoping to manage with film as our investigations indicate that film distortion can be kept within reasonable dimensions by proper humidity control.

One of the chief reasons why we feel optimistic about bridging further distances in Canada than in other parts of the world, is that throughout the area there are numerous lakes. We know, therefore, that we shall be able to get frequent checks on our lateral tilts from lakewater levels. We may even get the photography while the lakes are still frozen, in order to get control over the whole water surface. Our main new approach, however, lies in our ability to eliminate the tendency to climb as we bridge. This we are doing by obtaining a radar altimeter profile from 4,000′ down the centre of our run. This involves the use of new equipment which we have recently developed and which enables us by analysis to determine relative heights between air stations.

Before leaving the ground control subject, I might just mention two further "tricks" which we have found useful in supplementing ground control. The first is applicable to areas where there is a great deal of water to be bridged and possibly off-shore islands to be established. Under these conditions, frequent in Canada, we have been able to obtain winter photographs while the water was still frozen, and to air triangulate on the ice pattern. The second method we use sometimes in the absence of adequate height control. It involves analysis of drainage and the logical use of lake levels as a basis for contours.

No talk on Canadian problems would be complete without a mention of contouring under forest conditions. We have found that we can produce contours of reasonable accuracy, by spot-heighting all points at which we can see the ground and then contouring the tree canopy, but tying the contour to our spot heights. We have also found it of advantage to pass the photographs through our Forestry Division, which types alternate prints and gives the tree heights. These tree types can be marked on alternate negatives prior to the preparation of diapositives and thus appear in the Multiplex model without interfering with stereoscopy.

So far I have mentioned mainly mapping problems. Canada also has its flying problems, and to mention only a few:

(a) Airfields are few and far-between.
(b) Fuel costs are high. We have paid up to $2.00 per gallon for gasoline in some areas.
(c) We have only a five-month photographic flying season, yet must support permanent flying crews.
(d) Most of our territory being uninhabited, we have to carry up to 300 pounds in emergency rations, sleeping bags, rifles, fishing tackle and other paraphernalia in each aircraft. One of the most important items is, of course, insect repellent.
(e) Most of our operations are from fairly primitive bases, which bring in their train communication problems and personnel problems.

You will readily appreciate from the above that our flying has to be carried out in fairly large, long-range aircraft. When you add to this the fact that we have to pay approximately thirty per cent duty and purchase tax on any aircraft purchased from the United States, and have to charge a client eight per cent sales tax on every contract we carry out, you will understand why it costs more per square mile to photograph in Canada than in the United States. Besides, it is commonly believed by most Canadians that, very unfairly, the United States enjoys eleven-and-a-half months of perfect sunshine, while Canada gets the other half-month.

In discussing mapping so far, I have had in mind mainly the Federal Government requirements. Its over-all plan involves scales down to one mile to one inch. Natural resources are, however, Provincial (corresponding to State) Government responsibilities. Normally for their purposes, much larger scales, such as four inch to one mile, are required, particularly for forest inventories. Fortunately there is a tremendous movement in Canada today to bring the forests under proper management on a sustained yield basis. Air survey provides the only rapid, economical and accurate method for compiling the necessary data, and this type of work provides the bulk of our output today. We, as an organization, have found it necessary to set up a Forestry Division, and to go through all the survey steps from establishing ground control to turning out forest inventory maps with complete volumetric data. In much the same way, we have had to set up Geological and Geophysical Divisions within our organization. I might mention that we have also found it economical in most cases to obtain separately the small-scale photography required for mapping and the large-scale photography required for economic information. The securing of the latter information can often be obtained by the use of three cameras with long focal lengths, mounted as a tri-camera installation. The use of multiple cameras has reduced very greatly the cost of obtaining large-scale photographs for purely information purposes.

I should like to conclude by generalizing quite briefly on the future outlook for air survey in our part of the world. I personally believe that air survey in Canada, or anywhere else for that matter, will only really come into its own when it has established in the minds of the ninety-nine people out of one hundred, not yet aware of the fact, that photogrammetry can provide accurate large-scale topographic and engineering maps economically. For every job requiring small-scale maps, there are a hundred involving 5′ and 10′ contours, admittedly of smaller areas; but whereas the small-scale job may involve 10,000 square miles at $5 per square mile, the large-scale job, involving 10 square miles at, say, $5,000 per square mile, may be more worthwhile doing. Unfortunately out of the one hundred large-scale jobs potentially available, perhaps only two per cent are yet solved photogrammetrically in Canada. Much education and demonstration yet remains to be done, but as it is done the whole field will widen. As a generalization, it is also true to say the "survey begets survey," meaning that as the small-scale maps become available, plus the reconnaissance resources mapping, the whole country opens up and the demand for large-scale maps is created.

To this picture, we must add the fact that ninety per cent of Canada is unexplored minerally, and represents one of the few fairly accessible, handy and stable areas where exploration companies can seek replacements for their reducing reserves of base metals. For exploration in Canada air survey is an absolute necessity. I conclude, therefore, that the future requirements for air survey in Canada, whether carried out by Government agencies or commercial companies, will certainly not diminish; in fact, a great volume but with increased emphasis on larger scales is a probability.

NEW DEVELOPMENTS IN PHOTOGRAMMETRIC LENSES*

By Irvine C. Gardner, Chief Optical Instruments Section, National Bureau of Standards

FROM one viewpoint, our present process of mapping by a photogrammetric method may be considered to be a process of accurate interpolation. In the multiplex process, for example, the projectors are adjusted until a model is produced which fits the control points. It is advantageous, for accurate orientation, to have the control points include the maximum and minimum elevations present in the model. The position and elevation of any intermediate point is then readily determined by what is essentially an interpolation. If the images formed by the projectors are free of the errors customarily considered, the interpolation will be correct, and it is even safe to extrapolate to some extent when necessary. When satisfactory adjustment of the projectors has been attained, it is said that the principal point of the projected image has been brought into the position corresponding to that of the camera when the photograph was made. If the exact altitude and orientation of the camera at the time of exposure were known, and if the corresponding values could be readily read from scales on the multiplex projector, a comparison of the two sets of values would probably be rudely surprising. It would be found that all of the small errors arising from distortion by the lens, film shrinkage, refraction of the atmosphere, etc., have been automatically absorbed in the process of making the adjustments and that a false positioning of the projector has been determined which smooths out the errors. The greater the errors that are smoothed out in this manner the greater the need for control points and the less satisfactory is any bridging process.

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