Is the Canadian Adjustment on Schedule ?

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This report is intended to answer some questions about the re-adjustment of horizontal control in Canada that is now under way.

The last general adjustment of Canadian networks was made when the North American geodetic networks were adjusted about 1932, based on what we know as the 1927 North American Datum. The adjustment was carried out by the United States Coast and Geodetic Survey and included the major Canadian networks then in existence. Geodetic Survey of Canada participated by supplying data and by carrying out some of the computations on the networks in the Maritime provinces. At that time our networks consisted of triangulation along the 49th parallel in the west, some area triangulation in southern Ontario and southern Quebec, and several loops of triangulation in the Maritime provinces. Several spurs and secondary loops of triangulation that also existed at the time were not included in the adjustment but were adjusted later to the base triangulation. Since then, the pattern has been to add on arcs of triangulation, and to adjust each new arc to previous values, generally building northwards. This process of adding on has not only perpetuated errors present in the 1927NAD but has seriously distorted the newer work. In addition, some networks lacked adequate geometric strength. The result is that today our geodetic networks fail to meet modern standards, and co-ordinate values in many areas do not reflect the quality of the survey work. In fact, roughly half of our primary geodetic networks fail to meet first-order standards!

The 1974 local adjustment of Ontario networks improved the accuracy by including some newer survey work, but the networks still fail to meet first-order standards in some areas.

Pressures from users both here and in the United States have been growing for some years to improve and recompute the complete geodetic network to produce a more uniform and accurate horizontal control system. As a result, we have been working with the United States, Mexico and Denmark (for Greenland) towards a re-adjustment of continental networks in 1983 on an international geocentric datum. At the same time we are working on a second adjustment, this one distinctly Canadian. The Canadian adjustment was agreed upon at a special meeting of the Canadian Council on Surveying and Mapping held in Fredericton in June, 1975, and it is scheduled to meet the needs of some provincial programs that cannot wait until 1983. It is to be based on the present datum, and consists of adjustment of the primary geodetic framework in 1977 followed by integration of secondary networks on a regional basis.

The Canadian adjustment will serve domestic purposes including national mapping. The continental adjustment will be used for international and scientific purposes.

Geodetic Survey of Canada has assumed the responsibility for the adjustment of the primary framework. The integration of secondary networks must be a co-operative effort on the part of Geodetic Survey and the provinces, since most of the secondary system was established by provincial and municipal agencies.

Work has been going on for several years to prepare the primary framework for adjustment. The data for the approximately 5500 stations of the framework were prepared, and individual networks were adjusted and analysed to determine the order of accuracy and where additional measurements should be made to bring the accuracy up to desired standards. By the end of 1976 a total of approximately 600 lengths will have been measured and about 50 Laplace azimuths re-observed in older networks.

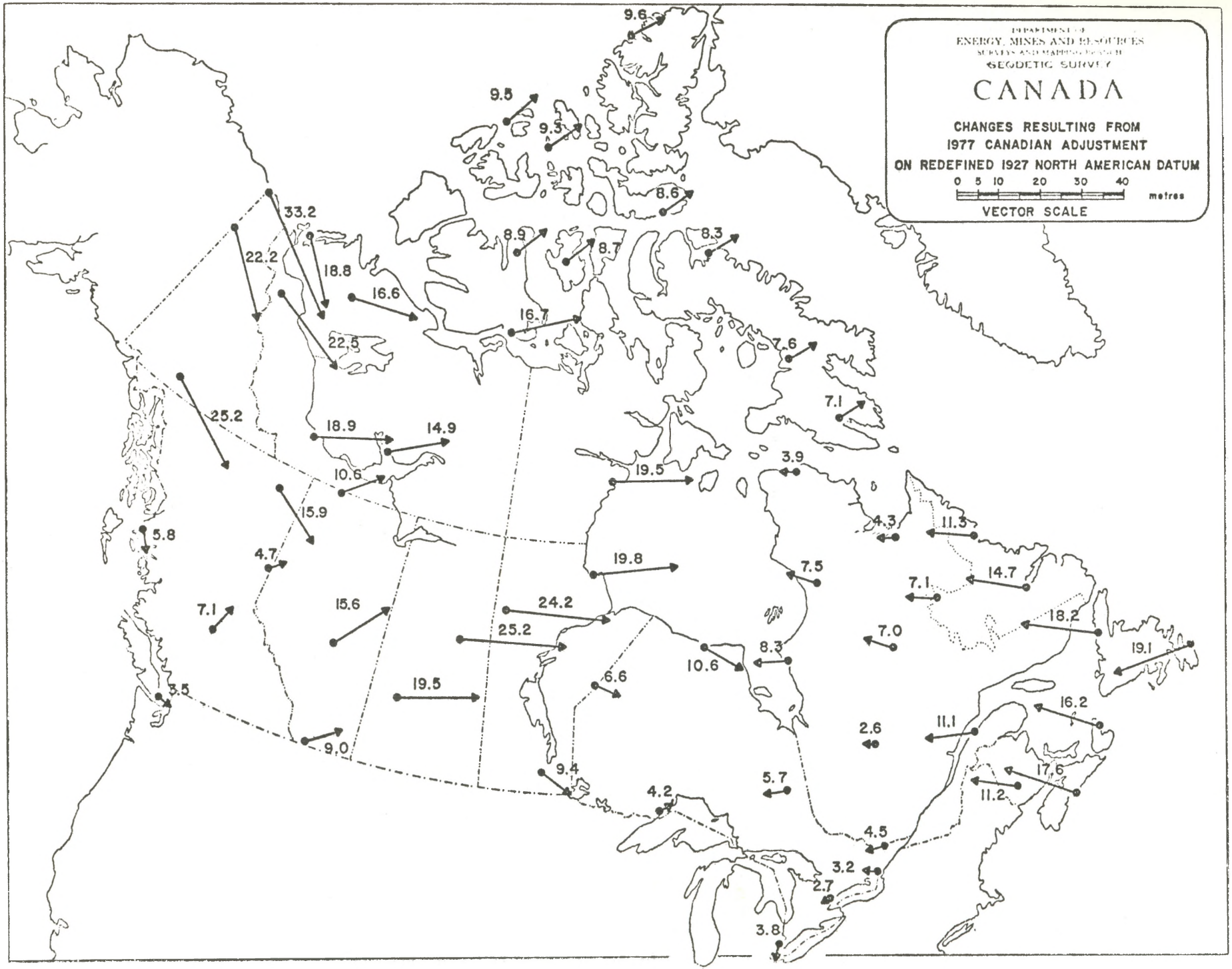
Satellite Doppler observations were begun in 1972, and at the end of 1975 there were 135 first-order stations in place. Another 40 will be added this year to complete the control for the primary adjustment. The stations are spaced 200 to 500 km apart all across the country, and 125 will be either coincident with or connected to primary stations. The grid of satellite Doppler positions when mathematically transformed to the appropriate datum will form the strongest component of the adjustment in determining both datum and position in the absolute sense. In the relative sense, any two satellite positions have a relative standard deviation of about 1 metre when computed in correlated station groups. Thus in many areas the satellite positions will be the major factor in determining relative position as well.

The datum for the Canadian adjustment will be a close approximation of the present 1927 North American Datum and will result in position shifts of less than about 30 metres anywhere in the country. A preliminary datum definition was derived from a best fit of 18 satellite Doppler values to 1927NAD values plus a slight scale change and longitude rotation of the satellite values. The Clarke 1866 ellipsoid is retained. The final datum definition will probably include more satellite Doppler stations in the best fit solution and the best available values for scale change and longitude rotation. Expected shifts resulting from the adjustment were calculated from preliminary satellite Doppler values. These shifts are 33m at the northern end of the Alaska-Yukon boundary, 25m at Whitehorse, 3m at Victoria, 16m at Edmonton, 24m at Lynn Lake, 19m at St. John's, 18m at Halifax, and in Ontario, 3m at Toronto, 4m at Ottawa, 3m at Kingston, 4m at Windsor, 6m at Timmins, 4m at Thunder Bay and 11m at Winisk. The shifts on either side of longitude 85° are generally opposite in direction, with no shift somewhere in northern Ontario. The varying changes reflect the distortions present in the framework. For the continental adjustment the position shifts will be up to about 125 metres. The largest occur on the western and northern extremities. On the eastern extremity the largest shift is about 60 metres. The shifts are generally opposite to those resulting from the proposed Canadian datum. A null occurs in northern Ontario with shifts outwards from that area.

Although the adjustment of the framework is scheduled for 1977, we will have computed two preliminary adjustments by then to test and refine both our data and methods. We are now in the midst of the first preliminary adjustment and I can report that it is going according to plan. The framework is divided into sections averaging about 300 stations each, and the adjustment takes place in three major stages:

1. Adjustments of individual sections for analysis and to produce junction and satellite station data.
2. (a) Adjustment of junction stations.
   (b) Combined adjustment of junction stations and satellite Doppler stations to produce final values of these stations.
3. Adjustment of sections to produce final co-ordinates for all stations.

On May 12 of this year stage 2 was successfully run, marking an important step in the development and testing of the adjustment method. As this report is written, stage 3 has been nearly completed. The next few months will be spent in analysing the results and putting finishing touches to the method. The second preliminary adjustment will be made during the six months from October, 1976, to March, 1977, and will include some of the 1976 field work and probably the final datum def-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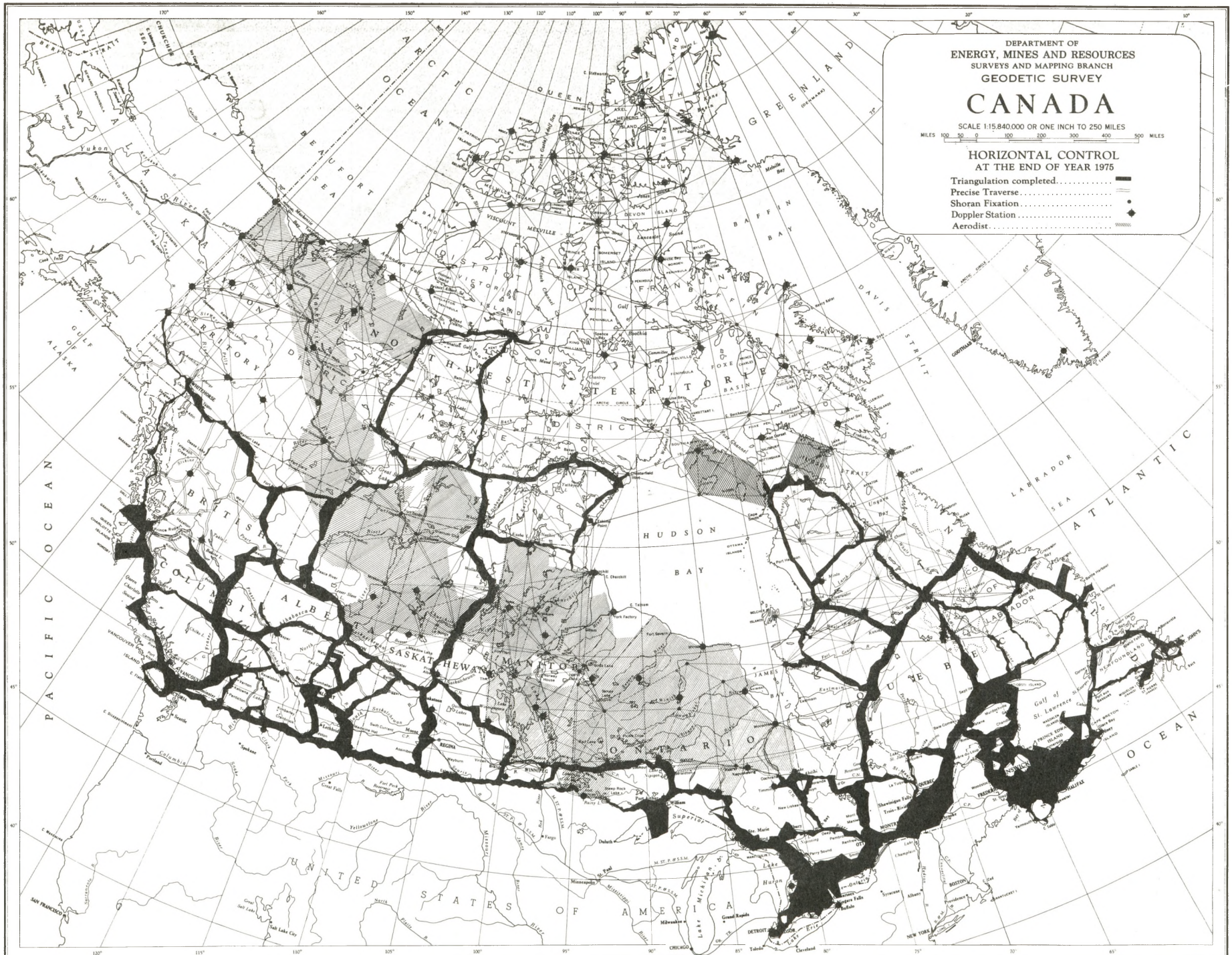
GEODETIC SURVEY
CANADA
CHANGES RESULTING FROM
1977 CANADIAN ADJUSTMENT
ON REDEFINED 1927 NORTH AMERICAN DATUM
0 5 10 20 30 40
metres
VECTOR SCALE
9.6
9.5
9.3
8.6
8.9
8.7
8.3
33.2
22.2
18.8
16.6
16.7
22.5
7.6
7.1
25.2
18.9
14.9
10.6
19.5
3.9
15.9
5.8
4.7
19.8
7.5
4.3
11.3
14.7
7.1
7.1
15.6
24.2
25.2
18.2
7.0
8.3
19.1
10.6
6.6
19.5
3.5
16.2
11.1
2.6
9.0
9.4
5.7
17.6
4.2
11.2
4.5
3.2
2.7
3.8



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inition. The final adjustment will be made during the following six months ending September, 1977. The result will serve as the national reference system to which the secondary networks can be integrated.

Integration of secondary networks is a massive task because it must include all surveys that can be adjusted to form the next logical breakdown of the framework. These should be surveys that either form a uniform system or are overlaid by a uniform system, and of course properly tied to the framework. A recent estimate showed that Geodetic Survey is partly or fully responsible for about 50,000 secondary points. Under provincial or municipal jurisdiction there are another 30,000 in British Columbia, 15,000 in Alberta, and 36,000 in the Maritime provinces. There might be a total of about 200,000 for the country. We are just beginning an inventory of horizontal control. The inventory will show primarily the work for which Geodetic Survey is at least partly responsible, and can then be used to plan secondary integration with provincial authorities and other agencies. While I can tell you that the primary framework will be adjusted in1977, I cannot, at this stage, say when we will see the new adjusted values for the secondary networks. The secondary integration will be done by region or province. The timing will depend on planning with provincial authorities, and this planning has just recently begun and with only a few provinces. In many areas considerable new field work will be required if an adequate integrated secondary system is to be developed.

In recent years we have been attempting to make each new survey a part of a larger plan rather than just another project survey. In meeting the needs of any project we also look at the overall picture, making sure that it is properly connected to other surveys in the area and perhaps doing a bit of maintenance work on the local surveys. Also, if we can achieve a good second-order grid in the project area at reasonable extra cost, it is usually considered a good investment. When we are working in the various provinces, the provincial authorities are part of the process.

Generally a greater awareness and appreciation for good integrated control survey is developing in Canada, and we find some municipalities across the country with very good third-order systems. Several cities and towns of Alberta are particularly good examples of multipurpose control that is in day-to-day use. A number of Ontario municipalities are also developing good survey control systems. The same situation should some day apply to the whole country. That is the reason we are now working towards the integration and adjustment of the survey fabric across the land.