A Photogrammetric Retracement Survey of a Manitoba Township

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Abstract:

Photogrammetric instrumentation and methods of analytical aerial triangulation have progressed in recent years to the point where accuracy, reliability and cost saving, makes the photogrammetric control extension an attractive adjunct to field control surveys. This is especially so in projects requiring the establishment of a moderate to high density of control points. A project undertaken by the Topographical Survey Directorate is cited to demonstrate the capabilities of control extension by photogrammetry.

Introduction:

To conduct a beneficial retracement survey program it is imperative to coordinate the legal monuments to geodetic control. These coordinate values would then facilitate repositioning of the point at any time. Using photogrammetric techniques we would achieve:

a. Tieing cadastral monuments to geodetic control.
b. Acquiring control points for large scale map compilation which could be used in a land registration information system.

In the last decade the proper function of analytical aerial triangulation for control extension in relation to ground surveying have caused a great deal of confusion among surveyors and photogrammetrists. This is understandable in view of the different methods that exist and the conflicting claims on accuracy and economy that have been put forward. There is a tendency to lump all methods of analytical aerial triangulation into a single, amorphous entity. In reality the difference between the best and poorest classes of aerial triangulation parallels the difference between the best and poorest classes of ground surveying. Yet no one is disturbed by admittedly coarse accuracies of a fourth-order survey, if that is what has been contracted for. With analytical aerial triangulation one generally pays as much for poor quality as one does for excellent quality.

This paper will attempt to clear up the confusion surrounding analytical aerial triangulation and the expected accuracies of control extension by photogrammetry. The results from a test project covering the area of a six mile D.L.S. system are given.

Preparation for photography:

All plans in the area were compiled to show the locations of possible existing monuments. These, where found, were targetted and in cases where monuments were un-identifiable, fence corners were used for positioning the target. The target used was an off-white coloured wallboard with design and dimensions as shown in figure1.

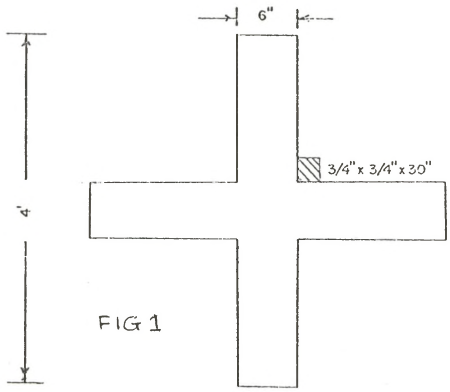

Figure 1: Target Dimensions for 1:8800 scale photography.

A ¾" x ¾" x 30" iron bar was placed in the north-east corner of the target to facilitate the ground measurements should the target be destroyed. Preparation of photography and targetting were performed by the Government of Manitoba.

Characteristics of the test block:

The area was covered with wide angle photography using a Zeiss Pleogon Camera. The flying height was 4,400 feet giving a photo scale of 1:8,800. The percentage of both the forward and lateral overlaps was 60%. The photography was flown in the south-north direction and the number of flight lines required to cover the area was thirteen. The total number of photogrammetric models in the block was 183. Flight specifications were designed to provide target images at photo-locations normally used for the selection of pass and tie points. The target and stereomodel location in relation to a Township Selection are shown in figure 2. Where these conditions were not met, other points were selected and marked on film diapositives.

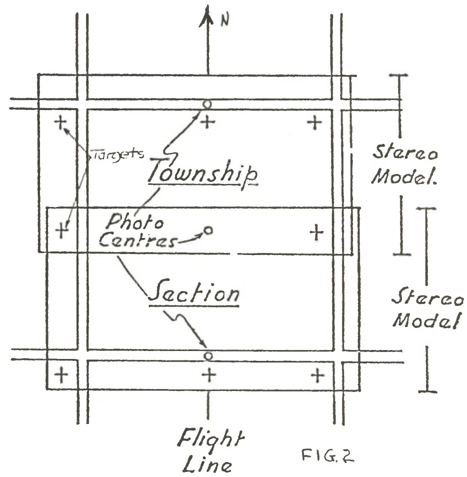

Figure 2: Target and Stereomodel location in relation to a Township Selection.

Ground Control Data:

The ground control data provided for the adjustment and accuracy check purposes consisted of 33 horizontal control points, 94 vertical control points and a total of 74 measured distances.

The Survey Control was carried out by Manitoba Government. Angular measurements were done both during the night using illuminated targets and during the early part of the day using forced centering targets. Distance was measured using Geodimeter - 76. The vertical control was obtained by running level lines between known bench marks. The order of both the horizontal and vertical control was not known to us and for the photogrammetric block adjustment they were considered error-free. The location of the horizontal and vertical control points is shown in figure 3.

Photogrammetric Mensuration:

The Wild STK-1 stereocomparator was used for the measurement of the independent model plate coordinates. The independent models were formed analytically using program APICOR. Corrections for lens distortion and atmospheric refraction were applied analytically in the model formation stage.

Block Adjustments

The following block adjustments were carried out using program PATM-43. A total of 24 horizontal perimeter control points was used in all adjustments. Nine horizontal control points in the middle of each adjusted block were used as horizontal check points. Of the 94

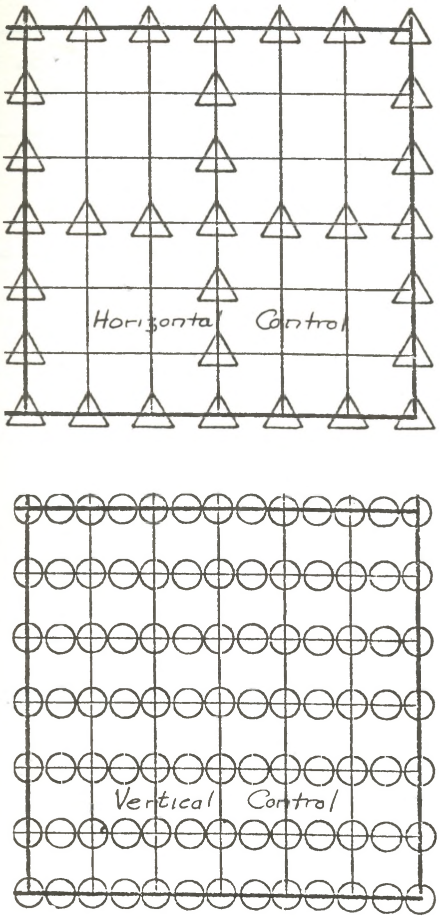

Fig. 3
Township Control Configuration

		TEST A		TEST B	
		R.M.S. (METRES)	R.M.S. (µM)	R.M.S. (METRES)	R.M.S. (µM)
MODEL POINTS	X	0.050	5.7	0.054	6.1
	Y	0.036	4.1	0.041	4.7
	Z	0.065	7.4	0.065	7.4
USED CONTROL	X	0.101	11.5	0.004	0.5
	Y	0.101	11.5	0.004	0.5
	Z	0.074	8.4	0.074	8.4
CONTROL CHECK POINTS	X	0.091	10.3	0.059	6.7
	Y	0.071	8.1	0.051	5.8
σ_{oH} (Planimetry)		0.068	7.7	0.072	8.2
σ_{oV} (Height)		0.094	10.7	0.094	10.7

Table 1
Township Retracement Survey Block Adjustment Test Results.

vertical control points available for the adjustment, five were found to be unusable (blunders), the 89 remaining points were all used in the test adjustments. Since we were mainly interested in evaluating the horizontal accuracy, no attempt was made to reduce the number of vertical controls used in the adjustment. The subject of vertical control distribution in photogrammetric block was dealt with separately (1).

Test A:

The photogrammetric block (183 models) was adjusted using weights equal to one for the X, Y and Z. of the used control points and the model tie points. Weights of 0.1, 0.1 and 0.25 were assigned to the perspective centers. Using a unit weight for the used horizontal and vertical control points in the block, they will be treated in the adjustment as stochastic variables, i.e. as variables requiring corrections.

Test B:

Same as test A except for the weights assigned to the used horizontal control points. A weight equal to fifty was assigned to X, Y horizontal Control coordinates to hold the photogrammetric block rigidly to the used control points. The results of the two tests are given in table 1.

Block Adjustment Accuracy

From the results of the block adjustments, the values of the standard deviation for the model points 6x, 6y and 6z were in the range of 4 um and 7 um expressed in the scale of photography. For the used horizontal control points the Root Mean Square Errors (R.M.S.) Mx and My were 11.5 um for test A and negligible for test B due to the use of high weight values. For the vertical control points the R.M.S. Mz was close to 8 um. For the horizontal check control points (points not used in the adjustment) the R.M.S. Mx and My were equal to 10 um and 8 um for test A and close to 6 um for test B.The overall estimate for the standard error of unit weight 6o in planimetry and height were 7 um and 10 um respectively. For Cadastral purposes using targetted points for photogrammetric tie and ground control points, the results are in a good agreement with the expected theoretical estimates.

Analysis of Comparative Distance Measurements

As aforementioned, a total of 74 distances between photo targets were measured in Township 7 of Range 4 using Geodimeter 76. These distances were measured, corrected and reduced to sea level by the province of Manitoba. From the tested photogrammetric blocks the 74 distances were computed using the adjusted photogrammetric coordinates as follows:

a. Transformation of U.T.M. coordinates to Geographic coordinates using program GEOUTM available in the Topographical Survey Directorate.
b. Computation of distances by program GEOCAL using the Geographic Coordinates.

The computed distances were compared with the geodetic distance using program GEOPHOT.

The R.M.S. and the means of the residuals of the two test blocks are given in Table 2. From the results of the comparison, the percentage of the distances at different accuracy levels are given in Table 3. The estimated accuracies at different probability levels are given in Table 4.

In order to accept the above com-

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parisons as a true test, the results were examined to check if the samples fitted a normal random distribution. Program "STATISTIC" available at the Topographical Survey Directorate was used. For all the performed tests, the difference between the theoretical and empirical distributions is considered random and all the samples corresponded to a normal distribution.

Test	No. of Lines	Mean (meters)	R.M.S. (meters)	R.M.S. (μm)
A	74	-0.007	0.064	7.3
B	74	-0.005	0.061	6.9

Table 2
Accuracy of Distance Comparisons.

Conclusions:

1. From the block adjustments, the accuracy in planimetry and height is in the order of 8 um in the scale of photography. For cadastral purposes, the results of the block adjustment are in a good agreement with the expected theoretical estimates.

	1:10,000	1:9,000	1:8,000	1:7,000	1:6,000	1:5,000	1:4,000	
No. of Lines	60	63	66	71	71	73	74	Test A
Percentage	81	85	89	96	96	99	100	
No. of Lines	62	66	70	70	71	73	74	Test B
Percentage	84	89	95	95	96	99	100	

Table 3
Percentage of Distances at Different Accuracies.

2. Comparing the Geodetic and Photogrammetric distances, the R.M.S. for the different tests was approximately 0.065

	Test A	Test B
R.M.S. (meters)	0.064	0.061
95%	0.125	0.120
90%	0.105	0.100
85%	0.092	0.088
68%	0.064	0.061
EXPECTED ACCURACIES		

Table 4

m over distances in the order of 800 - 850 meters.

3. From the results of Test B, 84% of the computed distances were better than 1:10,000 accuracy and 95% of the distances were better than 1:8,000 accuracy.

4. For the purpose of the comparative analysis, the distances measured were considered to be error free, thus those errors in distances computed from the block adjustment were assumed to be entirely due to photogrammetry. This assumption was adopted for reasons of the lack of knowledge of the accuracy of the measured geodetic distance. It is understood that this is not a normal procedure.

5. According to the statistical analysis tests the samples of the errors in the computed distances from the block adjustment correspond to a normal random distribution.

6. Applying the photogrammetric approach it was demonstrated that it is quite competitive with the classical approach. In addition, the Surveyor will benefit from the acquistion of control required for large scale mapping.

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with friends, and to give and accept recognition.

I have no doubt also that the voting by mailed secret ballot is a costly and cumbersome procedure. But so is our system of voting in national, provincial and local elections. Would anyone suggest that because this system is cumbersome, time-consuming and costly, henceforth we must travel to Parliament Hill, Queen's Park and the local Town Hall, to exercise our voting rights? If this Association is founded on the premise that it is run by its members, then our representatives in Council must assure that we, the members, have every opportunity to do so. The cost? Well, all worthwhile things have a price.

Yours sincerely
M. Iarocci, O.L.S.

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