AN APPLICATION OF KINEMATIC GPS-SUPPORTED AERIAL TRIANGULATION IN GENERAL COMMAND OF MAPPING (TURKEY)

Mustafa ÖNDER, Oktay AKSU, Ufuk NARLI
General Command of Mapping
06100 Ankara,TURKEY

Commission IV

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ABSTRACT

As a big official mapping organization, General Command of Mapping (GCM) aimed to apply the kinematic GPS supported aerial triangulation for the first time in Turkey. The following test project was implemented for that purpose and satisfied results were obtained. Detailed information and results related to project are given in this paper.

1. INTRODUCTION

The most significant developments for applications of aerial triangulation are to use of kinematic GPS data in aerial triangulation and improvements of automatic aerial triangulation using digital images in recent years. GCM, which emulates these developments with close attention, has decided to test of kinematic GPS supported aerial triangulation, for both to be a pioneer in mapping field as occured a lot of times before in Turkey and to make profit by using that method in its intensive photogrammetric activities.

GCM is one of the two biggest official organization responsible from map production at various scales in Turkey. Focal point of production is, 1:25000 scale map revision and production capacity is almost 400-450 map sheets in a year. Furthermore, it also interests with the map production at the scales 1:5000 and 1:1000. The significance of profits to be gained from the method can be seen easily when the time and cost demanding field works are considered for required control points for every year.

2. TEST FIELD

Selected test field is near Ankara (Gölbasi) and has a rectangular shape at 35km. x 15km. sizes (Figure 1.). Almost 180 control and check points have been established in that field. Some of these points were surveyed 2-3 years ago and they were not surveyed again, just signalized.

Three separate blocks have been established by covering each other in that project area (Figure. 1., 2., 3.). The area is ratherly flat and outside of the city center.

3.TEST FLIGHT AND DATA ACQUSITION

3.1.Technical Data

Test flights were completed in two days (12-13 October 1995). Summarized information is given in Table 1.

3.2. GPS Data

TRIMBLE 4000 SSE Geodetic Receivers (three for block I and II, four for block III) were used for data recording. One of them was mounted in Beechcraft B200 aircraft, others were located on the ground and 20-40 km. away from project area. One stationary recevier was located on a known point for every block.

Table 1. Technical data of the blocks.

TECHNICAL DATA	BLOCK I	BLOCK II	BLOCK III
Flight Altitude	5600 m	2500 m	1300 m
Scale	1/36000	1/16000	1/4300
Block Size	35 km x 15 km	12 km x 15 km	5 km x 3 km
Overlap	p = 60 % , q = 30 %	p = 60 % , q = 30 %	p = 60 % , q = 30 %
Camera	Zeiss RMK-TOP	Zeiss RMK-TOP	Zeiss RMK-TOP
Camera Constant	152.769 mm	152.769 mm	305.334 mm
Type of Adjustment	Independent models, Bundle Block	Independent models, Bundle Block	Independent models, Bundle Block
Adjustment Program	PAT-MR , PATB-GPS	PAT-MR , PATB-GPS	PAT-MR , PATB-GPS
Type of Tie Points	Artificial	Artificial	Artificial
Type of Control Points	Targeted	Targeted	Targeted
Type of Check Points	Targeted	Targeted	Targeted

Data rate was, in continuous mode, 1 second for block I, and 0.5 second for block II and III.

Aerial camera was fixed along the strips. Eccentricity vector from GPS anten to camera in aircraft was surveyed on ground by tachymetric measurements. Horizontal and vertical components are sequentially 14 cm., 3 cm. and 164 cm. .

3.3. Data Processing

GPS data were downloaded to laptop PC's in real time and data processing was performed by using SKIP (Inpho GmbH) software. The GPS observations are differential phase observations of the L1 signals and C/A code pseudo range observations.

Phase ambiguity is solved approximately, using pseudorange observations in SKIP software. Positions were reduced by eccentricity vector during data processing.

The exposuring time of the camera was recorded by the GPS receiver in the aircraft, by means of an electronic pulse, sent automatically from camera to receiver. A third degree polynomial interpolation is done by the program.

GPS positioning results are referenced to WGS 84 coordinate system. The local coordinate system is UTM in Turkey. Datum transformation parameters from WGS 84 to ED 50 were introduced to program and an initial transformation was provided during the data processing. Final transformation was solved in block adjustment.

The GPS data had no any serious problem. There were no missing epoch or observations less than four satellites inside the photo strips. Data recorded by a stationary receiver located in settlement area, had detectable 20 cycle slips. As it expected normally, the geometry of satellite was good and the mean value of dilution of precision of 3-D positioning (PDOP) was lower than 3.

4. BLOCK ADJUSTMENT

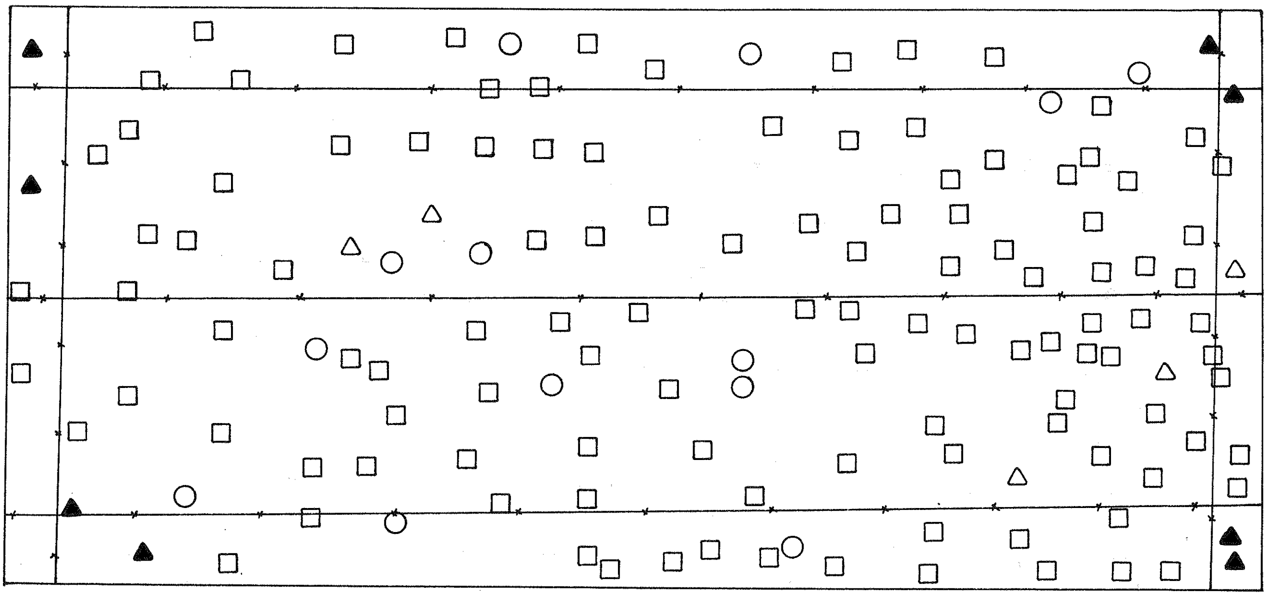
Planicomp C 100 (Zeiss) analytical instrument was used for photogrammetric measurements and both photo and model coordinates were stored . All three blocks were adjusted first in standard control point configuration (i=2b, 4b) according to the bundle (PATB) and independent model (PATMR) methods, without GPS data.

PATB-GPS software was used for combined photogrammetric block adjustment. The block configurations can be shown in figure 1., 2., 3.. The interpolated GPS antenna coordinates are introduced into the combined block adjustment as additional observations for each camera position. Control points selected at the corners of the block are used to solve datum transformation and six drift parameters which is applied for every strip.

First, the solution with 12 additional parameters, later, normal equation matrix inversion was applied. Detailed information related to blocks are given in table 2.

Table 2. Empirical Results.

	Block I (5 strips)		Block II (7 strips)		Block III (9 strips)	
	a. without GPS	b. with GPS	a. without GPS	b. with GPS	a. without GPS	b. with GPS
Apriori Estimates and Weights	X/Y Z (cm)	X/Y Z (cm)	X/Y Z (cm)	X/Y Z (cm)	X/Y Z (cm)	X/Y Z (cm)
Control Points	25 37	25 37	10 15	10 15	3 5	3 5
Check Points	25 37	25 37	10 15	10 15	3 5	3 5
GPS Measurements	-	10 10	-	10 10	-	10 10
Photogrammetric Measurements	7 μ	7 μ	6 μ	6 μ	6 μ	6 μ
Number of Photos	46	46	70	70	90	90
Number of Image Points	919	928	1602	1602	2093	2093
Available Control Points						
- Ground Control Points	27 26	8 8	33 32	4 6	37 36	8 9
- Check Points	90 81	107 98	45 42	66 62	20 19	47 41
Resulting RMS of Differences						
- Photogrammetry - GCP	18/19 31	18/17 18	7/7 12	3/4 4	3/4 3	2/3 6
- Photogrammetry - CP	26/25 57	31/44 61	11/14 19	19/16 20	5/6 6	6/5 9
Aposteriori σ_0	6.93 μ	7.81 μ	6.14 μ	6.22 μ	5.17 μ	4.88 μ



▲ Control Point in X,Y,Z
● Control Point in Z

□ Check Point in X,Y,Z
○ Check Point in X,Y
△ Check Point in Z

Figure 1. Block I (Photo scale = 1 : 36000)

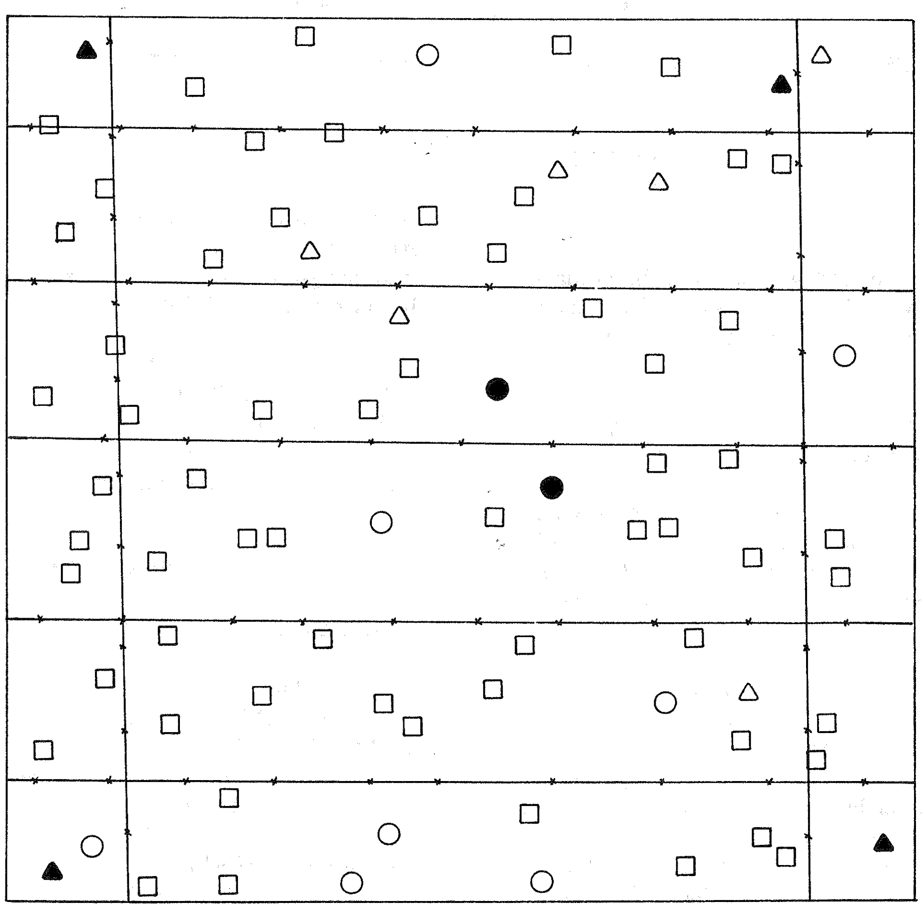


Figure 2. Block II (Photo scale = 1 : 16000)

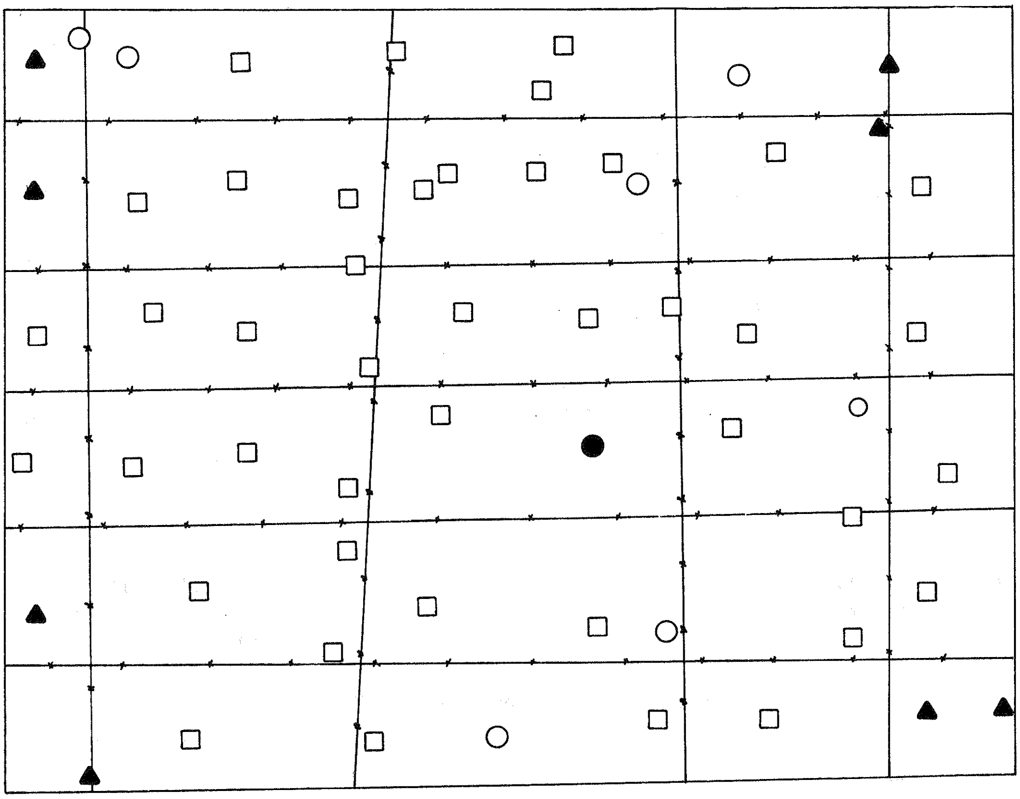


Figure 3. Block III (Photo scale = 1 : 4300)

5. CONCLUSIONS

The aim of that test project was to check the available hardware and software for official applications and to analyze the obtained results under the national mapping specifications.

We have not had any problem except the interruptions of communication among the stations in that project.

As it well known, accuracy expected for GPS supported blocks with cross-strips and free drift parameters per strip is about 1.5 (σ_0 x s) in planimetry and about 2.0 (σ_0 x s) in height (Ackermann 1992) (σ_0 : photogrammetric measuring accuracy).

We had the accuracy compatible with that expectation for block I and II (1.1/ 1.5 - 1.8/1.5 (σ_0 x s) for X,Y and 2.4- 1.8 (σ_0 x s) for Z). The accuracy for large scale application (Block III) is 2.5/2.4 (σ_0 x s) for X,Y and 4.1 (σ_0 x s) for Z. The height accuracy is ratherly high at first glance but, when it compared with flight altitude, it is lower than the value of 0.0001x h (equal to 0.00007 h). That result fits the expectation included in national mapping specification.

Also we have seen that the results of adjusments with independent models without using GPS data (which were not given here) almost the same with the results of bundle blocks with GPS data.

It is clear that the number of control points will be reduced almost 90% by using kinematic GPS supported aerial triangulation. That means, highly significant savings can be provided in time and money for an organization which has a big production capacity.

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