GCM On The Project Report by Mustafa ÖNDER, Oktay AKSU, Bülent SEZER
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'Automatic Aerial Triangulation'

General Command of Mapping (GCM-Turkey) has decided to use digital photogrammetric systems for planned missions in 1997. And so, one roll film scanner (SCAI, C.Zeiss), one Phodis ST-10 (C.Zeiss) and seven Softplotter-1.7 (Vision Int.) have been bought in that year.

OEEPE test Project on "Performance of tie point extraction in automatic aerial triangulation" was almost the formal activity which was carried out by these system, in GCM.

We have used only Phodis-AT (C.Zeiss) software, as the automatically extracted tie points were required. The hardware used for that purpose is a Silicon Graphics Indigo 2 High Impact computer and system has thre external disks in 9 GB each.

The adopted workflow for the Project is given at figure 1.

Interior orientations of the images, except six were measured automatically. Nevada Block could not be measured, as the fidicual marks can't be seen. Initial values of projection centers for block Kapellen were changed by us. We have not encountered any other problem during measurements.

Feature based matching is used to determine conjugate points in image pairs during block formation in Phodis-AT.

In order to precisely measure the image coordinates of the point in the tied images, a least square matching is performed pair by pair through the pyramid levels down to the original image resolution.

We have used 6 pyramid levels, 2 Track point factor which determines the number of points per image, 2 track points (2X in strips) which determines the number of dual tie points in strip, 2 track points (2X strip to strips) which determines the number of dual tie points transverse to the strip, 5 track points (3X) which determines the number of triple tie points.

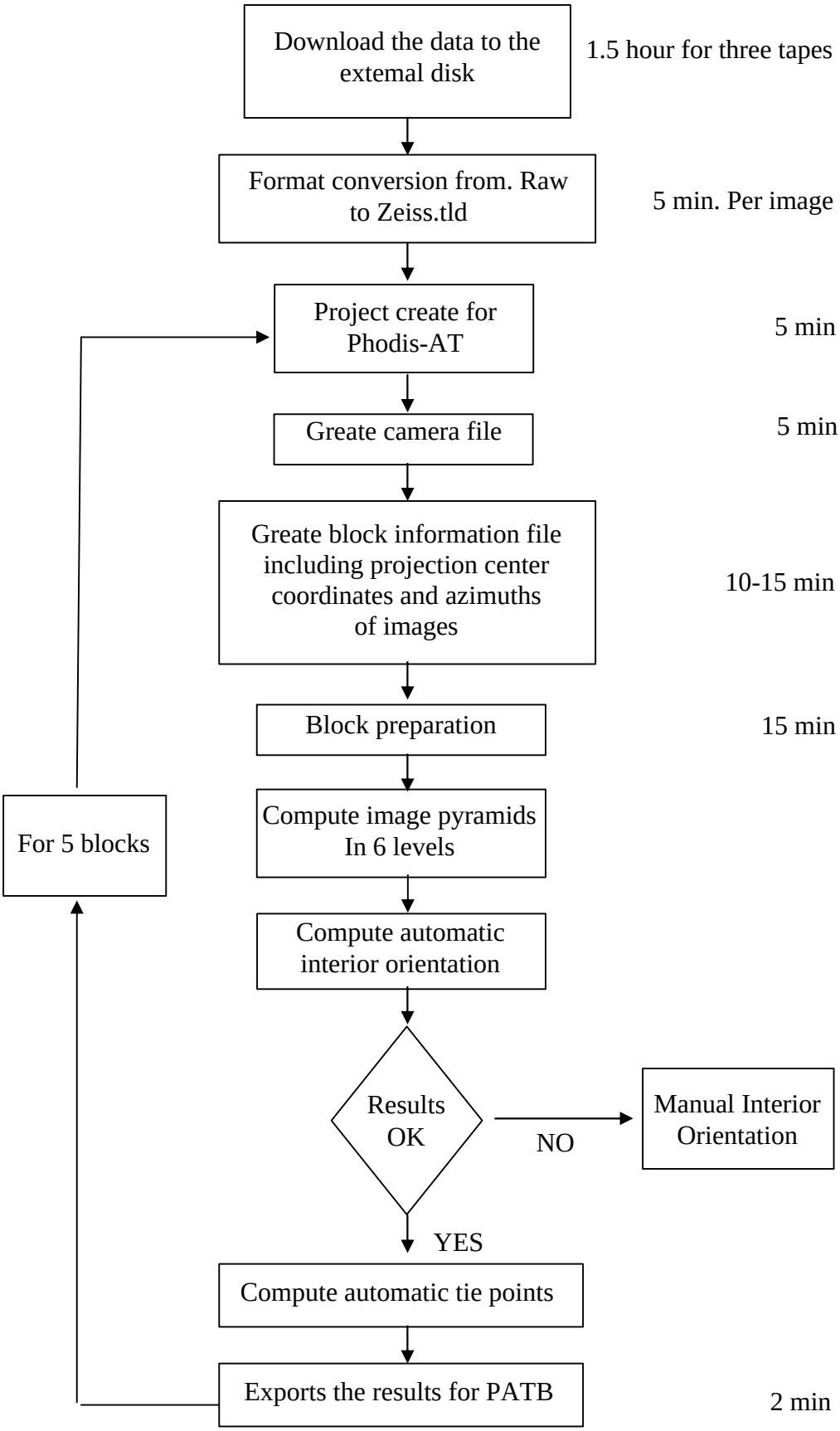

Figure 1. Adopted workflow for blocks

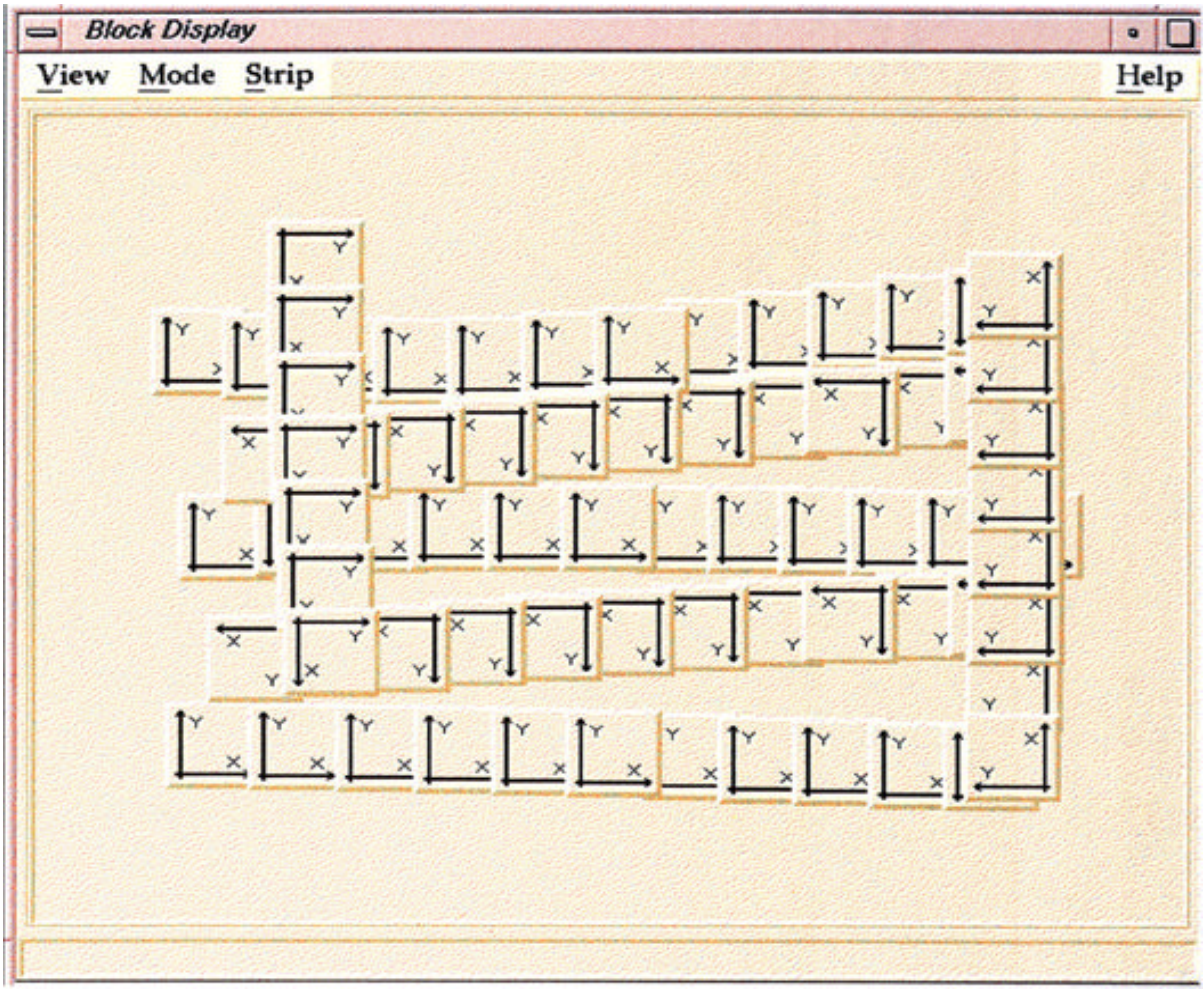

Figure 2. Example block (image scale is 1:4500)

We have also carried out some comparative measurements by using both analytical and digital instruments. A block, consisting of 72 photographs at 1:4500 scale was selected. 5 normal, 2 crossing strips with % 60 forward overlap and % 30 side overlap are available in that block (figure 2). Projection center coordinates were calculated by kinematic GPS measurements. Images were scanned by SCAI in 28m pixel resolution. The block was measured by using first Planicomp C 100 analytical instrument, later by Phodis ST 10. Obtained results and time consumption are given at below tables.

Private and public sectors have been using digital photogrammetric workstations for almost two years in Turkey. Some of them have applied manual and semi-automatic aerial triangulation methods. Here, we have tried to evaluate the existing situation considering automatic method.

Table 1. Comparative results of the block

		Digital	**Analytical**
Number of observation		50765	3714
Number of unknowns		32076	1833
Redundancy		18689	1881
Image points x,y		25265	1684
	rms xy (μm)	1.76/2.28	3.26/3.54
Ground control points	X, Y	8	8
	Z	9	9
	rmsX/Y/Z (cm)	7.6/7.1/10.3	5.3/7.2/15.1
Check points	X, Y	41	45
	Z	36	39
	rmsX/Y/Z (cm)	7.4/8.1/14.6	3.7/5.3/3.8
A posteriori σ_0		3.38μ=1.6 cm	4.92μ=2.3 cm
Mean stand. deviation of PC		6.9/8.8/4.7 cm	10.7/12.3/4.7 cm
Mean stand. deviation of $(\Omega, \phi, \chi)^{cc}$		39/29/9	62/49/19
Mean stand. deviation of tie points		2.1/2.3/7.6 cm	2.2/2.4/7.4 cm
Minimum stand. deviation of tie points		1.1/1.6/3.4 cm	1.2/1.2/3.1 cm
Maximum stand. deviation of tie points		10.3/4.2/33.7 cm	6.8/6.6/19.7 cm

Table 2. Time consumption in analytical method

Analytically	**Hours**
Preparation	12
Point transfer	16
Measurement	40
Block adjustment	1
TOTAL	**69**

Table 3. Time consumption in digital method

Digital	**Hours**
Scanning	16
Block definition	0.25
Pyramid computation	2.25
Automatic interior orientation	1
Automatic tie point detection	3
GCP measurement	2
Block adjustment	1
TOTAL	**25.5**

Private and public sectors have been using digital photogrammetric workstations for almost two years in Turkey. Some of them have applied manual and semi-automatic aerial triangulation methods. Here, we have tried to evaluate the existing situation considering automatic method.

It is obvious that the main steps in analytical aerial triangulation, such as block preparation, block measurement and block adjustment are also valid in digital methods. But the first attractive difference appears in time consumption between these two methods. In the case of automatic aerial triangulation method, there is no need for preparation work with diapositives and positive printing for tie points. Also, another advantage of automatic tie point detection is, to prevent wrong numbering for tie points on printings as occurred very often in the analytical method. So, one of the main error recourses in block adjustment is eliminated in the automatic methods.

According to our experiences with automatic aerial triangulation, there is a rate 1/3 in time consumption as an advantage than the analytical method.

On the other hand, the scanning time for roll film or diapositives during the block preparation step may be evaluated as a disadvantage, compared with the analytical method. But the use of digital images become an advantage, when the overall system performance in digital production steps. Such as orthophoto, mosaics, etc. are considered.

Kinemetic GPS supported aerial triangulation also provides an advantage to the automatic aerial triangulation by means of derived projection center coordinates to be used in block topology.

As is well known, anly two images can be used at the same time for measurement in analytical method. The homologous points can be measured in six or more images at the same time in most of the digital methods.

Normally a human operator is not required for automatic tie point extraction. However, manual tie point measurement is required when the results of the block adjustment are transferred to the analog or semi-analytical instruments.

On the other hand, manual measurements of the control points are rether difficult and time consuming process, when the circular shape for signal of ground control points is used. There may be many white dots on the image and they cause to confuse the correct places of points.

We could not get result with automatic tie point extraction in an area which covers partly forest region and two sides of the block has coast line. There was also conjugate point on a boat which had white trace at the rear part. Also, the lines because of the photo laboratory process cause problems. In such example, where image scale was 1:35000, we had slightly worse result with manual tie point measurement than the analytical method.

Although some existing problems, automatic aerial triangulation is highly favorable and provides good accuracy results.