STATISTICAL DATA ON AERIAL TRIANGULATION

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0. Abstract

As a joint effort of the OEEPE Commission A and ISPRS Commission III an attempt was made to collect statistical data on aerial triangulation. Information was desired on e.g. measuring instruments, triangulation methods, detection of gross errors and use of auxiliary data. 26 filled questionnaires were received. The paper gives a summary of the answers.

1. Introduction

In 1985 the Steering Committee of the OEEPE (Organization Europeenne D'Etudes Photogrammetriques Experimentales) made a decision to establish a Working Group for the Collection of Statistical Data on Aerial Triangulation under the chairmanship of the Helsinki University of Technology. A questionnaire with a small number of questions was prepared as carefully as possible to avoid misunderstandings. The questionnaire was distributed directly and through the OEEPE Steering Committee Members to national survey offices, research institutes and private companies in Europe.

2. Participants

Altogether 26 European organizations, i.e. 2 research institutes, 7 private companies and 17 national survey offices returned the questionnaire. In 1985 the respondents had carried out about 1140 triangulation projects which had involved approximately 50 000 photos.

3. Areas of applications

On the basis of the answers four main areas of applications can be distinguished, namely mapping (including topographic, cadastral and engineering), densification of geodetic networks, ortophoto-production (photomaps) and DTM-production. In addition there is the 5th area in which all the other application areas are included. The results of the classification are given in Table 1.

Application	Percentage of respondents [%]	Percentage of all projects [%]
Densification	11	3
Mapping	96	83
Ortophoto	15	7
DTM	7	2
Other	15	5

Table 1. Areas of the applications and their percentages of all projects.

4. Project parameters

4.1 Aerial photography

A distinct majority of the participants used Zeiss RMK or Wild RC 10 cameras for photography (11 and 9 users, respectively). As can be seen from Table 2, wide angle cameras were clearly dominating over other types of cameras.

Black-and-white films were mostly used for photography (Table 3). Two participants had used color films and one color-infrared films.

The scale of photography ranged from 1:2 500 to 1:80 000, but in most cases it was from 1:4 000 to 1:13 000. Several overlapping combinations were applied (Table 4).

The largest block contained over 700 models, but there were only a few blocks larger than 100 models.

Type of the camera	No. of users
Narrow angle	4
Normal angle	2
Wide angle	15
Super-wide angle	2

Table 2. Types of cameras used.

Type of film	No. of users
Agfa Aviophot Pan 150	4
Agfa Aviophot Pan 200	7
Kodak Plus-X	4
Kodak Double-X	4

Table 3. Films mostly used.

Side	10	20		25		30			35	40	60		
Forward	55	55	60	60	65	60	65	90	60	60	60	80	90
A						2			1				
B	1	1	5	2	1	6	1	4		1	2	1	1
C						2		1					
D			1			1							
TOTAL	1	1	6	2	1	11	1	5	1	1	2	1	1

Table 4. Number of users of the different combinations of the forward and side overlaps.

A = Network densification
B = Mapping
C = Ortophoto-production
D = DTM-production

5. Control and tie points and their targetting

The material available does not make possible any deeper analysis of the control point configurations. Perimeter control in planimetry seemed to be widely used anyway. Nearly 50% of the users applied it. Control distribution in height was commonly irregular.

In nearly all the blocks at least some control points were targetted. The square target was clearly the most popular one (Table 5).

Shape	No. of users	Size [µm]
Square	13	20 - 120 1)
Circle	3	24 - 60 2)
Cross	3	
Triangle	1	

Table 5. Use of different kinds of targets.

1) most often 50-70 µm
2) diameter

The number of tie-points between the computational units (photos or models) was typically 3-6 in the flight direction and 2-4 in the perpendicular direction. Information on the use of the different types of tie-points are given in Table 6.

Application	No. of users of different tie-point targets			
	Targetted	Natural	Artificial	Numerical
Network densif. Mapping Ortophoto DTM	3 7 1 1	2 12 2 1	1 13 3 1	 1

Table 6. Use of the different types of tie-points.

6. Mensuration

The number of the users of different types of measuring instruments is presented in Table 7. 13 repondents reported that the measuring process is controlled on-line.

Measuring instr.	No. of users
Analog instrument	12
Monocomparator	2
Stereocomparator	7
Analytical plotter	20

Table 7. Use of different measuring instruments.

7. Triangulation method

Triangulation methods were divided into analog, semianalytical and analytical methods depending on whether the measured data were strip, model or image coordinates, respectively. Analytical methods were further divided into sequential, model or bundle method depending on whether the computational unit in the block adjustment was strip, model or image, respectively. Table 8 shows, how many users different methods had.

Triang. method	No. of users
Analog	1
Semianalytical	
- 2D	3
- 3D	3
Analytical	
- Sequential	1
- Model	18
- Bundle	8

Table 8. Number of users of different triangulation methods.

8. Compensation of systematic and gross errors

The compensation of systematic errors was mainly based on component calibration. 8 respondents, however, reported having used self-calibration. Nobody had used test-field calibration.

Approximately 40% of the respondents had applied algorithmic methods for the gross error detection. Statistical methods (e.g. data snooping) had 8 users and robust methods (e.g. the Danish method) 2 users. The estimates for the number of gross errors in the data varied from 0.3% to 10%.

9. Use of auxiliary data

Only a few respondents had exploited auxiliary data (Table 9).

Auxiliary data	No. of users
APR-data	1
Navigation data	1
Geodetic data	5
Shoreline data	4

Table 9. Number of users of the different types of auxiliary data.

10. Accuracy of aerial triangulation

The accuracy information received was unfortunately rather scarce and there were in addition some interpretation difficulties. Therefore, any analysis was considered unfeasible and only some reported values are given as such in Tables 10 and 11.

Orga-nization	σ_o 1)	St.errors σ_{xy}	St.errors σ_z	RMSE 2) μ_{xy}	RMSE 2) μ_z
1	3	2		4	
2	10			6	
3	7			7	
4	7			7	
5	3-5			20	50

1) Standard error of unit weight.
2) Root mean square error.

Table 10. Accuracy information on bundle adjustments (at photo scale [µm]).

Organization	σ_o 1)	St.errors		RMSE 2)	
		σ_{xy}	σ_z	μ_{xy}	μ_z
1	18	13	11		
2	4-5				
3	30	30	27		
4	10	5	8		
5	18	13	10		
6	10/13	9	8	13	7
7	10/20-35	10	10-20		
8	8-17/12-17				
9	8-10	8	16	10	20
10	8-10				
11	6	6	10		
12	20	20	30		
13	7	7	10		
14	10	8-10	12-15	5-9	3-4
15	8-13/10-17	8-11	6-10	7-14	6-10
16	3-9/10-15	3-8	6-10	3-10	2-8
17	7/13				
18	11/13				

1) Standard error of unit weight. The values separated by a bar refer to planimetry and height, respectively.
2) Root mean square error at check points.

Table 11. Accuracy information on analytical (image coordinates measured) triangulation by independent models (at photo scale [μm]).

11. Acknowledgement

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