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Invited Paper

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MINIMUM AND MAXIMUM PROGRAM OF PHOTOGRAMMETRIC EDUCATION FOR GEODESISTS AND SURVEYORS

Abstract

In view of the fast development of the photogrammetry and its very wide application to mapping and surveying, it is necessary to choose the proper syllabi in photogrammetry for geodesists and surveyors.

Paper deals with optimum content of program for teaching photogrammetry on geodetical and surveying specjalizations /for non-photogrammetrist/ for different lewels.

The usually limited number of teaching hours assigned to photogrammetry requires very carefull selection of problems to be taught, which are really most important for geodesists and surveyors in their future professional activities.

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In view of the fast development of the photogrammetry and its very wide application to mapping and surveying it is necessary to choose the proper syllabi in photogrammetry for geodesists and surveyors.
Paper deals with optimum content of program for teaching photogrammetry on geodetical and surveying specjalizations /for non-photogrammetrist/ for different lewels.
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1. INTRODUCTION

To facilitate a good cooperation among geodesists surveyors and photogrammetrists the geodesists should be provided with the necessary knowledge of photogrammetry and vice versa.

In geodesy and surveying the following specializations can be distinguished: I. G e o d e t i c S u r v e y i n g, II. U r b a n S u r v e y i n g, III. E n g i n e e r i n g S u r v e y i n g, IV. M i n i n g S u r v e y i n g, V. C a d a s t r a l a n d L a n d S u r v e y i n g, VI. H y d r o g r a p h i c a l S u r v e y.

Taking into consideration the fact that geodesy and surveying

belong to the applied sciences or engineering, then in terms of the level of education one can group surveyors into following categories:

A. Graduate surveyors, with University /or its equivalent/ education of 5 years or more,

B. Survey Professionals; with post high school education of 4 years,

C. Survey Technicians and/or Technologists; with high school or Technical College education.

In spite of different specialization within geodesy and surveying one basic course of photogrammetry for non-photogrammetrists should be set up with following contents: 1.Basic principles of photogrammetry; 2.Photography and aerial photography; 3.Single-picture photogrammetry; 4.Stereophotogrammetry; 5.Multi-picture photogrammetry /aerial triangulation/; 6.Theory of errors and adjustment in photogrammetry; 7.Application of photogrammetry.

Instruments and photogrammetric devices can be presented during the lectures of subjects mentioned in 2,3,4 and 5.

2. PHOTOGRAMMETRY FOR DIFFERENT SURVEYING AND GEODETIC SPECIALIZATION

A. G r a d u a t e S u r v e y o r s

The University education in the field of Surveying and Geodesy gives theoretical and practical knowledge in Geodesy and Surveying which allows graduates to manage the complicated production procedure as well as undertake the constructive scientific research using new techniques. Extensiveness and complexity of geodetical knowledge is the reason that education in geodesy is run in six specializations.

Apart from basic surveying courses in Geodetic Surveying the following subjects are additionally studied:

- planning and surveying of precise geodetic nets on the basis of geodetic and astronomical measurements, gravimetrical surveys, magnetic measurements and other geophysical measurements using also observation of earth sattelites,
- survey for delivery of the net coordinates for the state and international purposes,

- research of earth shape, its changes, movements of the earth s crust on the basis of determination of the earth geometrical and gravimetrical parameters in time function.

Therefore in additional photogrammetry course special emphasis should be laid on aerial triangulation.

In Urban Surveying

- The principles of urban planning as well as in general and detailed local planning, town comunication,setting up the honsing, industrial terrain social building, recreation and sports areas. The horizontal and vertical control surveys in towns are also studied.
- The knowledge about the basic and thematic maps compilation, architectural documentation is required , as well as principle of cadastere organization in urban areas and map revision.

Therefore, photogrammetric large-scale mapping, application of photogrammetry to the town cadaster, the principles of architectural photogrammetry and application of the photogrammetric method to the traffic registration study are motivated in additional photogrammetric courses.

In Engineering Surveying

- planning, setting out and utilization of engineering structures and other projects
- dislocations, deflections and deformations of buildings, mechanical devices, and soils.

Therefore large scale mapping, industrial application of photogrammetry including investigation of deformation of engineering structures as well as monitoring of high-speed processes architectural photogrammetry, should be included in course contents.

In Mining Surveying

- surveying and mapping of under-groud and open-pit mines,
- situational and height survey and mapping of mineral deposits, shafts, tunnels and galleries,
- preservation of the earth surface against the influence of mining exploitation.

Therefore large scale mapping, volume calculation, investigation of deformation of buildings and terrains under influen-

ces of mining exploitation, mapping of geological structures etc. are the main subjects to be taught in photogrammetry.

In Cadastral and Land Surveying

- survey of land ownership, lot boundary and land utilization, as well as division of land, assignation of ownership law,
- renting /tenancy/ or insurance matters and survey of state forestry and agriculture areas,
- mapping for the purpose of collection of taxes and development or managing of cadastral systems.

Therefore, in photogrammetric additional course the following subjects should be included: principles of analytical photogrammetry and application to cadastral mapping, large scale mapping and principles of photointerpretation for agricultural purposes.

In Hydrographical Survey

- the measurements on the far away waters to establish sandbanks, reefs or platforms of drilling towers. This kind of survey requires the application of astronomical methods, electromagnetic methods, Doppler System or sattelite systems,
- survey of coastal waters, however, allows for mapping of the shore line and all details which are in the range of vision /for instance, navigation marks or water deepness/. In hydrographic measurements elektromagnetic or other echometers are also used,
- the knowledge about mapping of oceanographic flora and other underwater objects is needed. The hydrographical surveyors are prepared also for work on the determination of the geometrical shape of the water surface - see geoid.

It looks motivated therefore to include to the additional photogrammetric courses the following subjects: principles of photointerpretation based on densitometry for bathometrical mapping/; and aerial triangulation methods.

B. For post-high school students wishing to become S u r v e y P r o f e s s i o n a l s the basic program of photogrammetric education and complementary programs for specializations should contain similar subjects to the education program of Graduate Surveyors but emphasis must be laid on the execution

Table I: The content of the model-textbook for photogrammetry and weights /a,b,c/ for its subjects and paragraphs

Geodetic specialization	Number of the subject area Number of paragraph The syntetic minimum or /:/ maximum weights of the each model-textbook subject area Minimum initial clasification of paragraph Maximum initial clasification of paragraph Number of pages in each paragraph of textbook										
	1 1 2 3 4	2 1 2 3 4 5	3 1 2 3	4 1 2 3	5 1 2 3 4	6 1 2 3	7 1 2 3	8 1 2 3 4 5	9 1 2 3	10 1 2 3 4 5	11 1 2 3 4 5 6
I. Geodetic Surveying	0:28.25 - - - - b b b a	6.50:15 - a - - a a a a a a	20:30 a a a b b b	18.75:25 b b b c c c	25:50 a a a a c c c c	0 :12.5 - - - - a a	22:31.5 b a a c a c	45:60 b b b b b c c c c c	30:40 b b b c c c	30:45 a a a a a b b b b b	0 :37.5 - - - - - - a a a a a a
II. Urban Surveying	0:30 - - - - b b b b	10.5:30 - a a - a c c c c c	20:40 a a a c c c	18.75:25 b b b c c c	25:50 a a a a c c c c	12.5:18.75 - a a - b b	22:31.5 b a a c a c	45:60 b b b b b c c c c c	30:40 b b b c c c	30:45 a a a a a c c c c c	30:56.25 a a a a - - b b b b b b
III. Engineering Surveying	0:30 - - - - b b b b	10.5:30 - a a - a c c c c c	30:40 b b b c c c	18.75:25 b b b c c c	25:50 a a a a c c c c	18.75:25 - b b - c c	22:31.5 b a a c a c	45:60 b b b b b c c c c c	30:40 b b b c c c	30:45 a a a a a c c c c c	30:56.25 a a a a - - b b b b b b
IV. Mining Surveying	0:30 - - - - b b b b	10.5:30 - a a - a c c c c c	30:40 b b b c c c	18.75:25 b b b c c c	25:50 a a a a c c c c	18.75:25 - b b - c c	22:31.5 b a a c a c	45:60 b b b b b c c c c c	30:40 b b b c c c	30:45 a a a a a c c c c c	30:56.25 a a a a - - b b b b b b
V. Cadastral and Land Surveying	0:30 - - - - b b b b	10.5:15 - a a - a a a a a a	20:30 a a a b b b	18.75:25 b b b c c c	25:50 a a a a c c c c	15.5:18.5 - a b - a c	22:31.5 b a a c a c	45:60 b b b b b c c c c c	30:40 b b b c c c	30:45 a a a a a c c c c c	30:56.25 a a a a - - b b b b b b
VI. Hydrographical Survey	0:30 - - - - b b b b	10.5:30 - a a - a c c c c c	20:40 a a a c c c	18.75:25 b b b c c c	25:50 a a a a c c c c	15.5:21.75 - a b - b c	22:31.5 b a a c a c	45:60 b b b b b c c c c c	30:40 b b b c c c	30:45 a a a a a c c c c c	30:56.25 a a a a - - b b b b b b
min /1-6/	8|5|10|7 40 0:28.25	5|8|8|4|5 30 6.5:15	8|7|15 40 20:30	3|10|12 25 18.75:25	10|10|20|10 50 25:50	20|3|12 45 0:12.5	8|7|15 40 22:31.5	12|13|10|10|15 60 45:60	20|8|12 40 30:40	12|8|20|8|12 60 30:45	15|22|15|8|8|7 75 0:37.5

	12 1 2 3 4 5	13 1 2 3	14 1 2 3 4	15 1 2 3 4 5	16 1 2 3 4	17 1 2 3 4 5 6	18 1 2 3 4	19 1 2 3	20 1 2 3 4	21 1 2	
I. Geodetic Surveying	0:0 - - - - - - - - - -	0:0 - - - - - -	41.25:55 b b b b c c c c	60:100 - b b b b c c c c c	0:25 - - - - a a a a	0:0 - - - - - - - - - - - -	0:0 - - - - - - - -	25:37.5 a a a b b b	0:22.5 - - - - a a a a	0:20 - - a a	323.5:634.75 0.51
II. Urban Surveying	6.5:33.75 a - - - a b b b b b	0:20 - - - a a a	41.25:55 b b b b c c c c	60:100 - b b b b c c c c c	32.25:50 b b b - c c c c	33.75:45 b b b b - - c c c c - -	0:27.5 - - - - a a a a	5:25 a - - a a a	6.5:22.5 a - - a a a a a	0:20 - - a a	429.0:825.25 0.52
III. Engineering Surveying	6.5:45 a - - - a c c c c c	20:30 a a a b b b	41.25:55 b b b b c c c c	60:100 - b b b b c c c c c	24.75:50 - b b - c c c c	33.75:57.5 b b b b - - c c c c a a	27.5:41.25 a a a a b b b	25:37.5 a a a b b b	6.5:22.5 a - - a a a a a	0:20 - - a a	505.25:891.5 0.57
IV. Mining Surveying	6.5:22.5 a - - - a a a a a a	0:20 - - - a a a	27.5:41.25 a a a a b b b b	40:60 - a a a a b b b b b	24.75:50 - b b - c c c c	33.75:57.5 b b b b - - c c c c a a	14:27.5 a a - - a a a a	5:25 a - - a a a	6.5:22.5 a - - a a a a a	0:20 - - a a	418.0:779.0 0.54
V. Cadastral and Land Surveying	6.5:22.5 a - - - a a a a a a	23.75:33.75 a b b b c c	41.25:55 b b b b c c c c	60:100 - b b b b c c c c c	0:25 - - - - a a a a	0:27.5 - - - - - - a a a a - a	0:27.5 - - - - a a a a	25:37.5 a a a b b b	6.5:22.5 a - - a a a a a	0:20 - - a a	409.75:772.5 0.53
VI. Hydrographical Survey	6.5:22.5 a - - - a a a a a a	0:0 - - - - - -	41.25:55 b b b b c c c c	60:100 - b b b b c c c c c	0:25 - - - - a a a a	38.75:56.25 a a a a b a b b b c b	6:27.5 a - - - a a a a	25:37.5 a a a b b b	6.5:22.5 a - - a a a a a	0:20 - - a a	430.75:795.75 0.54
min /1-6/	10|10|10|12|3 45 -	25|5|10 40 -	10|15|15|15 55 27.5:41.25	20|20|10|30|20 100 40:60	10|25|8|7 50 0:25	5|10|15|15|15|10 70 -	12|16|20|7 55 -	10|25|15 50 5:25	8|12|20|5 45 0:22.5	20|20 40 0:20	= 1055 pgs 269.75:568.75 0.47

of engineering activity.

C. For students of S u r v e y i n g T e c h n i c a l C o l l e g e s only a basic course in photogrammetry is required, which familiarize the students with the possibilities and surveying potential of the photogrammetric methods.

3. DISCUSSION OF PHOTOGRAMMETRY CURRICULUM SURVEYORS

Let us assume that there are four possible levels of knowledge within the photogrammetry:

a/ encyclopaedic knowledge of photogrammetry,

b/ familiarisation; the knowledge of photogrammetry sufficient to take part in the technological discussion or to influence the decissions of specialists,

c/ the knowledge of photogrammetry on the heigh level which enables involvement in certain photogrammetric works under supervision of specialist,

d/ the full theoretical and practical knowledge of photogrammetry.

Photogrammetry is taught at the technical university on the level d only for professional photogrammetrists in the leading specialization subjects; in other photogrammetric subjects photogrammetrists receive education on the level c only. Photogrammetric university education for geodesists on the level c contains the knowledge of the subject areas connected directly to the leading specialisation in geodesy; other photogrammetric subjects are taught on the level b or even a. The technician/technologist of geodesy receives on the level c the practicaly oriented knowledge of photogrammetry related directly to the leading geodetic specialization; the less important subject areas are taught on the level a and some of them are quite neglected.

Not all the geodetic schools of various levels pay the same attention to the photogrammetric education of their students. It is assumed here that the lowest acceptable scope of photogrammetric education /program minimum/ for surveyors in various photogrammetric-subjects should not be lower more than 50% of the most advanced syllabus /see table I/.

The detailed analysis of lectures curriculum for various geodetic specializations is elaborated on the basis of the photogrammetric textbooks analysis presented in Procedings of IX-th National Surveing Teacher s Conference, June 1977,Univ. N.Brunswick, Canada by G.Gracie in the paper: "Evaluation of textbook content in photogrammetry", The following 21 photogrammetric subject area were determined /the numbers in brackets pointing the pages in each paragraph or each subject of the textbook/.

1. Optics/40/: 1.1.Mirrors prisms/8/; 1.2.Lenses, aberrations /15/; 1.3.Image quality/10/; 1.4.Depth of field /7/.
2. Photographic Materials/30/: 2.1.Illuminance and exposure /5/; 2.2.Photographic emulsions/8/; 2.3.Sensitometric properties/8/; 2.4.Base materials/4/; 2.5.Printing/5/.
3. Metric Camera/40/: 3.1.Functions and properties/8/; 3.2. Components and controls/17/; 3.3. Camera calibration/15/.
4. Simple Vertical Photograph Geometry/25/: 4.1.Object-image relationships/3/; 4.2.Scale and relief displacement/10/; 4.3.Position , height/12/
5. Stereoscopy and Parallax/50/: 5.1.Stereoscopic vision/10/; 5.2.Stereoscopes/10/; 5.3.Parallax/20/; 5.4.Simple stereometer mapping/10/
6. Simple Planimetric Procedures/45/: 6.1.Radial triangulation /20/; 6.2.Planimetric mapping with simple techniques and instruments/13/; 6.3.Mosaics/12/
7. Measurement and Correction of Image Coordinates/40/: 7.1. Measurement with simple scales/8/; 7.2.Comparators, corrections/17/; 7.3.Corrections for (film) deformation, lens distortion, refraction, etc./15/
8. General Photograph Geometry/60/: 8.1.Projective theory/12/; 8.2.Interior and exterior orientation/13/; 8.3.Parameterization of orientation matrix/10/; 8.4.Projective model, collinearity equations/10/; 8.5.Special cases, scale and tilt formulas, etc./15/
9. Space Resection and Intersection/40/: 9.1.Space resection and orientation geometry/20/; 9.2.Space intersection/8/; 9.3.Collinearity applied to resection and intersection/12/
10. Stereomodel Orientation/60/: 10.1.Analytical relative

orientation/12/; 10.2.Differential orientation formulas /8/; 10.3.Empirical and numerical relative orientation /20/; 10.4.Absolute orientation/8/; 10.5.Model deformation /12/

11. Stereoscopic Plotting Instruments/75/: 11.1.Optical projection plotters/15/; 11.2.Stereoplotters with mechanical and optical-mechanical projection/22/; 11.3.Plotter orientation/15/; 11.4.Analytical stereoplotters/8/; 11.5. Instrument accuracy and calibration/8/; 11.6.Instruments using approximate solutions/7/
12. Rectification/45/: 12.1.Projective principles, graphical and analytical procedures/10/; 12.2.Optical-geometrical considerations, Scheimpflug condition/10/; 12.3.Optical-mechanical rectifiers/10/; 12.4.Rectifier equations, procedures/12/; 12.5.Controlled mosaics/3/
13. Orthophotography/40/: 13.1.Differential rectification, orthophoto instrumentation/25/; 13.2.Orthophotomaps/5/; 13.3.Stereo-orthophotography/10/
14. Planning and Control for Aerial Photography /55/: 14.1. Parameters of Aerial photography/10/; 14.2Limiting factors, quality control, specifications/15/; 14.3.Ground control/15/; 14.4.Airborne control/15/
15. Photogrammetric Triangulation/100/: 15.1.Analog stereotriangulation/20/; 15.2.Analytical triangulation/20/; 15.3.Independent model triangulation/10/; 15.4.Strip and block adjustment/30/; 15.5.Error propagation,accuracy/20/
16. Terrestrial Photogrammetry/50/: 16.1.Terrestrial cameras, photo theodolites, stereometric cameras/10/; 16.2.Terrestrial photograph geometry/25/; 16.3.Planning and control for terrestrial photography/8/; 16.4.Plotting instruments /7/
17. Close-range Photogrammetry/70/: 17.1.Optical and photographic considerations/5/; 17.2.Close-range cameras, calibration/10/; 17.3.Planning and control, reduction procedures/15/; 17.4.Applications to medicine, engineering, architecture, etc./15/; 17.5.Underwater, X-ray photogrammetry/15/; 17.6.Hologrammetry/10/
18. Oblique Photography/55/: 18.1.Projective principles,

vanishing points/12/, 18.2.Orientation geometry, perspective grids/16/; 18.3.Position, height, direction, distance calculations/20/; 18.4.Convergent photography /7/

19. Dynamic-mode Photography/50/: 19.1.Basic principles, time-dependent geometry/10/; 19.2.Strip and panoramic photography/25/; 19.3.Frame scanning systems/15/

20. Automated Systems/45/: 20.1.Image correlation/8/; 20.2. Components of automated systems/12/; 20.3.Specific systems /20/; 20.4. System products/5/

21. General Background/40/: 21.1.History/20/; 21.2.Definitions, applications/20/.

Assumeing that to each paragraph of this model-textbook receives the classification of one of the four possible levels of education /level a,b,c or zero/ according to its usefullness for each discussed specialization of surveying studies, we also can connect the numeric weights to the various education levels. It was assumed that if 100% of knowledge is received within the class c, than class b obtains only 0.75% of that knowledge, and the class a only 50%. The knowledge passed to the students within the education-level c consists of the theoretical lectures accompanied by a big portion of practical /instrumental and analytical/ exercises. Theoretical knowledge received within the level b is accompanied by limited number of instrumental exercises, but rather big portion of analytical exercises. The knowledge received within the level a is purely theoretical, without practical exercises. The ratio of practical exercises within the considered three educational level c,b,a is as 3:1:0.

The table I shows the classification of importance of various paragraphs of model - textbook of photogrammetry for various surveying specializations, at maximum and at minimum level. The weights received by multiplication of number of pages of each paragraph by a weight-coefficient /a = 0,5, b = 0.75, c = 1.0/ are specified summarily for each chapter in table I. In the last column the final synthetic weights for program maximum and minimum are specified for each of six geodetic specializations. The proportion of this synthetic weights shows that the amount of knowledge received within

the minimum and maximum education program is as 1:2.

In all the programs of photogrammetry we have the same basic part of theoretical background of aerial stereophotogrammetry utilizing metric-cameras and wide information about the photographic recording of images. It seems to be obvious that the common program of this basic background of photogrammetry for all the geodetic specializations would ease the further, specialized photogrammetric education of chosen parts of photogrammetry /according to the programs individually selected for each surveying specializations.

4. CONCLUDING REMARKS

I. Photogrammetrical knowledge is necessary in the whole education of surveyors in each surveying specializations.

II. Choice of the content of curriculum depend on the number of teaching hours designed for lectures, and laboratories; it is also very often influented by peculiarity of particular university.

III. From authors experiences results that a minimum program of teaching photogrammetry containing 48 hours of lectures and 64 hours of laboratories is to small to acquaint students with the basics and with all other photogrammetric problems required by chosen geodetic specialization. At present the teaching hours of photogrammetry in Poland in relation to total teaching hours vary from 2.7% to 5.3%, however in the group of surveying science, engineering and design subjects the photogrammetry vary from 6.6% to 11.2%.

IV. In teaching photogrammetry not only lectures and laboratories but also field courses are very important. For instance in Poland the students of engineering surveying specialization have two weeks of photogrammetric field courses in addition to laboratories.