The Measuring Qualities of Archival Aerial Photographs as A Function of Time

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In the process of aging the usable properties of the material change over time. Aging is detrimental for a lot of materials and results in the deterioration of their properties. In case of aerial photographs, elapsed time predominantly dictates their interpretative and measuring value, which, while linked to physical properties of the photographs, depends on external factors as well. Supposing the physical properties of aerial photographs do not change, the process of aging may only be considered with regard to the degree of changes of the depicted topography, and such an aspect of the aging process is the subject of the present research. The degree of aging of aerial photo may be indicated through evaluating the possibility to project and measure the ground control points, which comply with the required criteria of completeness and layout, within the block is a part of. It was agreed the points should be clearly identified in archival aerial photographs, and directly measured, taking current topography into account.

The purpose of this research was to determine the time resolution of the aerial photographs block, for which the block could be prepared in compliance with the Polish quality standards. In order to determine the indicator, aerial triangulations of 10 blocks of aerial photographs obtained in different time periods between 1972 and 2013 were elaborated. The photographs taken with analogue cameras, scale from 1:5000 to 1:30000, and digital cameras of GSD spatial resolution between 10 and 15 cm, were used in the research. The arranged blocks included from 60 to 4000 aerial photographs with standard overlaps of 60% and 30% in flight and cross flight direction taken analogue images respectively, and 70% and 50% for digital images. The images covered approximately the same urban area, with minor height difference, spreading circa 900 km2. In order to examine the aging degree of an aerial photograph, the requirements for measuring control and tie points of the block, and the accuracy of the aerial triangulation results, were determined. Derogations from these requirements dictated the value of the aging degree of aerial photograph coefficient. Two tie points had to be measured in each Gruber position, assuming they are measured in all photographs. For the image coordinates measured with standard deviation of more than 5 micrometres, three binding points had to be measured in the position of six-fold photo coverage. It was also agreed that the tie points measured in at least 4 photographs, should be no less than 35% of all tie points. The number and placement of the control points in the block, and their position in the aerial photograph, were to assure the required accuracy of the result and its homogeneity.

The project of control points included individual properties of the block, such as shape, the measuring hindrance resulting from the topography and possible inconsistencies in the lateral overlap. It was agreed that when measuring the perspective centres for all photographs in a block, one had to measure two control points in the angular models of the block and eight bases on its edges, along the fly direction. If there were no measurements of the perspective for some photographs in a block, it was agreed that an additional control points will be measured, which has to be closest possible equivalent of the missing measurement, particularly with regard to accuracy of the determine of altitude of tie pints. It was agreed that due to the determination of additional adjustment parameters and to systematic errors of absolute orientation elements of the photographs, the number of ground control points should not be less than 1 control point for every 17 photographs.

For unsuccessful measurements of the perspective centres for all photographs in the block, the control points network had to be rearranged in such a way so as to place the points on the edges of the block and in every second lateral overlap, not less frequently than every 4 bases. It was agreed that the photo control points at the end of strips have to be placed in lateral overlap so as to enable their measuring on 4 photographs, and that control points on the edges of the block, along the axis of strips, have to be placed in triple coverage, with

the exclusion of the points in angular models of the block. The ground control points were placed in such a way to enable semi-automatic measurements on all photographs with the particular control point.

The photo-measurements and adjustments of individual aerial triangulations were obtained and conducted with the software module Match-AT by Inpho. The accuracy measure of the aerial triangulation result was the average root mean square error of determining the ground coordinates of the tie point. The error was calculated as a root mean square of all root mean square error of the coordinates of the tie points in the block. The value of the error was in strict correlation with the scale of the aerial photograph, its spatial resolution, and the focal length of the photogrammetric camera lens. As a result of the analyses conducted the ranges for the indicator of the aging of aerial photographs, in relation to the completeness of the ground control points network and the maximum value of the average root mean square error of the coordinates of the tie point defined for individual aerial triangulations, were determined. The indicator equalled 0 if all ground control points in the block were projected and measured, and the root mean square error of determining the ground coordinates of the tie point did not exceed half of the value of the maximum error. The indicator equalled 0.1 if all required control points of the photogrammetric network in the block were measured and the root mean square error of determining the ground coordinates of the tie point was close to the value of the maximum error. If more than 80% of the nominal value of the control points were planed and measured, and the criterion for the root mean square error of determining the ground coordinates of the tie point was met, the indicator of the aging of aerial photographs equalled 0.2. For other values of planned ground control points within general required scores of 70%, 60%,...,10%, the indicator equalled 0.3, 0.4,...., 0.9 respectively.

The criterion for the root mean square error was met if the indicator was more than 0.4. It was determined, on the basis of the analysis, that for the aerial photographs with time resolution less than 6 years, the value of the indicator was within the number range of <0.0-0.1). It was determined, on the basis of the analysis that for the aerial photographs with time resolution less than 8 years, the value of the indicator was within the number range of <0.1-0.2).

Increasing the time resolution of the block of aerial photographs to 11, 15 and 21 years resulted in the increase of the indicator of aging of aerial photographs to more than 0.2, 0.3 and 0.4 respectively, which means that it is impossible for more than 21-year-old aerial photographs to obtain the results of aerial triangulation meets the accuracy criterion. It is justifiable to investigate the possibility to adopt a sequential measurement of control points of archival aerial photographs on the basis of the aerial triangulation developed for other archival blocks with lesser time resolution.

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