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IMPROVEMENT OF RAILWAY TOPOGRAPHIC PLANS UPDATING TECHNOLOGIES

Jūratė Sužiedelytė-Visockienė

Department of Geodesy and Cadastre, Vilnius Gediminas Technical University, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania, E-mail: j_visockiene@hotmail.com

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Abstract. Peculiar technologies on the update of topographic map linear objects to scale 1:500–1:2000 are presented. Due to that resulted peculiarities make aerial photographs, carrying out digital aerial triangulation, renewing the topographical plan.
The article deals with the submitted example of the topographic plan exhibiting the renovated railway in the city of Vilnius. The updating has been made on the aerial photograph on 1:4000 scale with the photogrammetric instrument *PlaniComp P3*. The objects possessing no identification in photogrammetry are measured by means of a geodetic method. The redacting varied objects in a database are drawn with *AutoCad* software.
On the basis of this work it is possible to state that for fast and exact updating of topographic plans a progressive photogrammetric method is recommended. It is advised the edition data base to be made by the same operator who made photogrammetric work. The objects are visible in an aerial photo, but no identifying photogrammetry should be applied locally.
Digital, renewed data are necessary for drawing up geo information systems (GIS) of the railway, to be able to make fast decisions of urgent problems.

Keywords: aerial photogrammetry, railway, stereo model, digital aerial triangulation, update.

1. Introduction

Demand for mapping linear objects such as roads, railways, communication lines has increased recently. The modernization of these objects capacitates the development of new technology which helps to obtain right quality cartographic data in a fast and cheap way. This data will be used for the improvement of infrastructure. Progressive aerial photogrammetric method is recommended for updating the linear objects to scale 1:500–1:2000. This method is used for updates in some European countries. This method is not used in Lithuania yet, because peculiarities and quality of this technology are not investigated. There are no data on in special literature.

The example of the updated topographic plan of the railway station Pusynas and Vaidotai in Vilnius is presented in the paper. Consulting was done by German company *GeoTec*.

The review of the renovation process is performed and practical recommendations are given in the paper.

The major stages of the technology are:

- a new aerial photo of creation (preferably in colour);
- scanning of aerial photos;
- digital aerial triangulation;
- importing of old topographic information into a new data base;
- update of local situation by a stereo photogrammetric method;
- control of new data base objects on site and unknown objects identification by geodetic methods;
- editing of a new data base.

Topographic large scale (1:500–1:2000) plan of a railway strip with introduced changes of the situation and major elements of railways, such as rails and turnout numeration, longitudinal and transverse profiles with height was produced.

2. Technology of topographic plan renovation

Aerial photograph. It is very important to select the right minimum height of fly, the focal length of photo camera and the scale of a photograph at this work stage [1, 2]. High quality *Carl Zeiss* company (Germany) photo cameras *RMK*, *RMK-TOP*, *RC*, *LMK* are used in Europe [3, 4]. 23×23 cm size, 1:4000–1:15000 scale aerial photographs can be produced by these photo cameras. The production of new model high radiometry and geometry quality digital module *DMC*, sensor *ADS 40* photo cameras have been started in 1999 [5]. Fly calibration data, the quality of aerial photos and the accuracy of these cameras were evaluated very well. The data of cameras calibration is used for photogrammetric network adjustment.

Digital aerial triangulation. Aerial triangulation is important for a photogrammetric reference densification process. The precision of points coordinates stated in aerial triangulation depends on the quality of aerial photograph, the error of ground control points and methods of photogrammetric network establishment and adjustment methods. Currently, the major digital aerial triangulations (AT) software packages are [6]:

1. The Helava Automated Triangulation System (HATS) from LH Systems;
2. ImageStation Z with Match-AT from Inpho;
3. Silicon Graphic with Match-AT from Integraph;
4. Phodis-AT from Zeiss.

Technical papers of vendors and users about aerial triangulation software are shown in Table.

In order to achieve a high level of automation in digital triangulation, the following features are important for the triangulation software:

1. Interior orientation is a simple task, which should be performed fully automatically today.

2. The integration of DTM supports the performance of the automatic point transfer significantly, especially in difficult terrain with large height differences.

3. The integration of GPS data (X, Y, Z coordinates of the centre picture).

4. APM is the key module of automatic digital aerial triangulation (Table).

5. The measurement algorithm influences the quality of measurement points. The combination of feature (rough measurement) and area (precise measurement) based least squares matching achieves better precision than cross correlation.

6. IPM provides the capability for the operator to measure semi-automatically control point and additional tie points in a mono or stereo mode.

7. The integration of the bundle block adjustment increases the automation of the triangulation significantly, it is easy to use and automatic functionality for the analysis of the results and quality control is available.

The accuracy of aerial triangulation results is defined by:

Table. Technical possibilities of software used for aerial triangulation

Important features	HATS	Mach-AT (Inter-graph)	Mach-AT (Inpho)
Interior orientation	Automatic	Semi automatic	Semi automatic
DTM integration	Yes	Yes	Yes
GPS integration	Initial values	Yes	Yes
APM	Yes	Yes	Yes
Algorithm	Cross correlation	FBM/ABM	FBM/ABM
IPM	Stereo	Stereo	Mono
Bundle block adjustment	Module	Integrated	Integrated
DTM – Digital Terrain Model GPS – Global Position System			
APM – Automatic Point Measurement			
FBM/ABM – Combination of feature and aerial based least squares matching			
IPM – Interactive Point Measurement			

- mean square standard for points measured in a stereo model;
- standards of photogrammetric points after bundle block adjustment;
- deviations of ground control points from the values defined by GPS;
- standard deviations of model centre coordinates defined by GPS receiver on the plane.

Recommend mean square standard is 3–6 μm when the scale of an aerial photo is 1:4000.

Orientation data of triangulation results are transferred to other photogrammetric systems:

- *ImageStation* (*Zeiss*) system;
- various analytical plotters which are supported by *BC2, BC3, PlaniComp P* series;
- orientation data are exported in the format of block adjustment program *PATB-GPS*. PATB format is a world-wide standard and can therefore be imported by numerous photogrammetric systems.

Updating of topographic plans. New objects or changes of old objects in a orthophotographic map or stereo model are imported into the old data base. The objects visible in an aerial photo but not identified should be mapped by geodetic methods [7].

Editing of the topographic map is recommended with *MicroStation*, *AutoCad*, *ArcGis* software. Results are obtained in *DXF*, *DWG* or *SHAPE* formats. Topographic plan should satisfy the standards for topographic large scale mapping [1].

3. Update of railways topographic plan

The investigated objects are the railway station of Vaidotai and Pusynas in Vilnius. Two longitudinal photogrammetric network strips are projected in these objects (Fig 1).

Aerial photographs were made in spring of 2005 with *RC-30* model camera (focal length $c=153{,}286$ mm). 25 aerial photos of 23×23 cm format and the scale of 1:4000 were made and scanned. Aerial triangulation was made with *Match-AT* (*Integraph*) computer software [8]. Results are 25 orientation files (one file per every model) in *PEX* formats and imported to the analytic photogrammetric instrument *PlaniComp P3*. Stereo models were created by this instrument and imported the old data created by the corporation "Matininkai" in 1995. The old data are corrected and new drawing a performed with stereoscopic instrument. Changed or disappeared objects marks in new objects layers of the data base are marked by newly created colour symbols. Data fragment is presented in Fig 2.

It is very important to introduce new elements of railways in an updated plan of the railway strip. Railway elements are seen well in the stereoscopic model. Such elements are shunts, shift mechanisms, signal marks etc. Such marks are drawn in the plan by marks described in specification, if they are identified by a photogrammetric method. Other unknown points marked by red colour are identified in the data base by a geodetic method later (Fig 3).

Fig 1. Distribution of aerial photograph centres on the objects' site

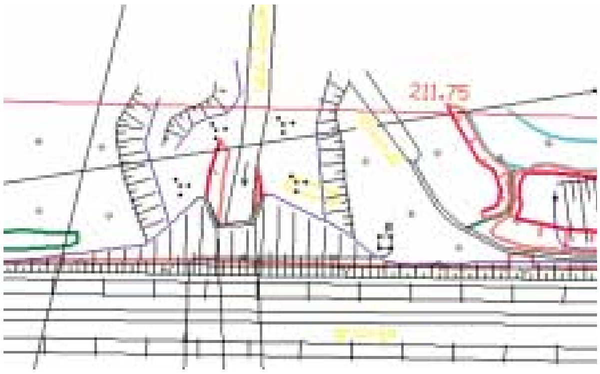

Fig 2. Fragment of data after photogrammetric update

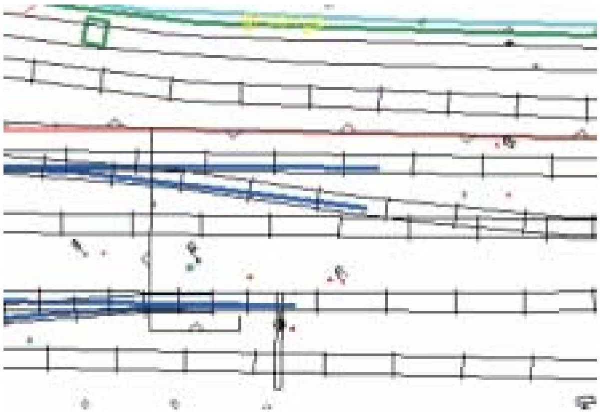

Fig 3. Railways with inserted new points

25 models were renovated in about one week. The plan was obtained in *DGN* format and transformed to *AutoCad DWG* or *DXF* formats for further correction. Changes are corrected by means of photogrammetry and the data of identified points from geodetic sources are introduced to the data base by standard mark. The best was is, if the work is made by the same person, who has done photogrammetric work. Other person could get wrong understanding what was corrected by photogrammetric means. Corrected data are presented in Fig 4.

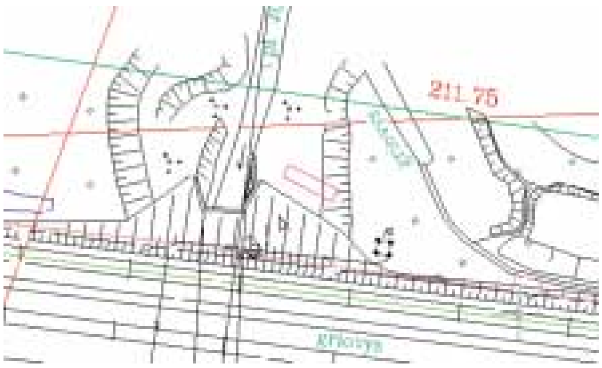

Fig 4. Corrected data base

Longitudinal and transverse profiles of the railways with heights are drawn in plans to 1:500 scale. Updated large scale topographic plans will be used in design work.

4. Conclusions

The modernization of railways is a very long and systematic process, therefore the role of geodesy (photogrammetry) is very important. New possibilities and possible problems of the modernization process of railway infrastructure by means of modern geodesy and photogrammetry are presented in the paper. The following recommendations could be presented:

1. A progressive and quick photogrammetric method is recommended for updating of large scale topographic plans.
2. Objects introduced by a photogrammetric method are recommended to be identified by geodetic methods on the site.
3. Data base must be edited by the same person who has made photogrammetric work.

The next step is the creation of the geographic information system (GIS) of railway. This could solve many problems. Important decisions could be accepted faster after the introduction of a new method of data management.

References

1. Technical specification of geodesy and cartography GKTR. Specification of aerial work. 2001. 19 p. (in Lithuanian).
2. Sužiedelytė-Visockienė, J.: Žalnierukas, A. Technologic peculiarities of large-scale orthophotogrammetric mapping in urbanized territories. *Geodezija ir kartografija (Geodesy and Cartography)*, Vol XXX, No 2. Vilnius: Technika, 2004, p. 51–57.
3. Fricker, P.; Sandau, R.; Walker, R. Digital photogrammetric cameras: possibilities and problems. *Photogrammetric Week'99*, Wichmann: Verlag, Heidelberg, Stuttgart, 1999, p. 71–82.
4. Christian, Th.; Souchon, J. The IGN digital camera system in progress. *Photogrammetric Week'99*, Wichmann: Verlag, Heidelberg, Stuttgart, 1999, p. 89–94.
5. Hinz, A.; Dorstel, Ch.; Heier, H. DMS – The digital sensor technology of Z/I–Imaging. *Photogrammetric Week'01*, Wichmann: Verlag, Heidelberg, 2001, p. 93–103.
6. Kersten, Th. Digital aerial triangulation in Production–experiences with block Switzerland. *Photogrammetric Week'99*, Wichmann: Verlag, Heidelberg, Stuttgart, 1999, p. 193–204.
7. Poljanac, I.; Paar, R.; Cetl, V. The role of geodesy in modernization Croatian Railways. In: INGEO 2004 and FIG Regional Central and Eastern European Conference on Engineering Surveying Bratislava, Slovakia, November 11–13, 2004, p. 1/10–10/10.
8. Sigle, M.; Heuchel, T. MATCH-AT: Recent developments and performance. *Photogrammetric Week'01*, Wichmann: Verlag, Heidelberg, 2001, p. 189–194.