Large scale orthophotoplan
of Sofia municipality

K. Ivanova, Y. Nikolaeva, GIS-Sofia Ltd., Bulgaria

In 2008 Geographic Information - Sofia Ltd. (GIS-Sofia Ltd.) performed its biggest project for updating and maintaining the cadastral information by large-scale orthophotoplan of Sofia Municipality. It was one of the greatest challenges faced by the working team at Photogrammetry Department, and it has been finished successfully within one year. The orthophotoplan finds application in the other departments at GIS-Sofia, as well as many clients, companies and organizations, among which is the Ministry of Agriculture and Food.

Photogrammetry Department has eight-year experience in producing digital orthophotoplans, digital elevation models, updating cadastral and topographic information on the base of aerial and satellite images. The working staff consists of 9 specialists, among them a head of department. The team was highly supported by a consultant and it owes a great deal of its success to him.

In the beginning of 2008, GIS-Sofia began the most challenging project using aerial images for producing orthophotoplan at 1:1000 and 1:2000 scales and precise digital elevation model for Sofia Municipality. The entire project area is 1470 sq. km, including 810 sq. km urban territory of Sofia Municipality, 530 sq. km rural territory of Sofia Municipality and 130 sq. km outside its eastern border which is frequently flooded. The territory has highly varied terrain – from 500 m over the sea level in its flat part to 2200 m in Vitosha Mountain. According to the orthophotoplan scale Ground Sample Distance (GSD) is 10 cm for urban and 20 cm for rural area. In order to achieve better results in the orthophoto representation (avoiding of the high building inclinations) the flight is executed with 80% overlap along the flight axes for urban and 60% for rural area. Image overlap across the flight axes is 30 % for both areas. The flight height is 1000 m and 2000 m over the terrain.

The territory has been pre-marked by 5 working teams for one week. There were two types of targets – circles with diameter 30 or 45 cm (depending on the GSD), white or yellow painted on the solid surface (asphalt, pavement, etc.), and square plastic tiles 30x30 or 45x45 cm. The coordinates of the ground control points were determined by GPS-receiver Topcon GGD with accuracy of ±2 cm in position and ±3 cm in height. The number of all pre-marked points is 550.

Hansa Luftbild Sensorik und Photogrammetrie, Muenster, Germany executed photo flight with Cessna C402 aircraft from the second half of April to the first half of May 2008. Digital aerial camera DMC (Intergraph) was used. The weather conditions did not permit the flight to be executed within several days. Therefore two thirds of the territory was shot in May. All taken images are 6912 with a resolution of 13824 x 7680 pixels, 12 x 12 m pixel size and take 418 Mb disk space. All the data needed around 3 Tb disk space.

Source images are organized in 36 blocks for processing by PHOTOMOD. They are adjusted separately, and after that regrouped in 6 larger blocks: 3 of them with GSD 10 cm and 3 with 20 cm. Blocks covering the urban territory are built with 80 % image overlap, and the rural area - with 60 % overlap. Due to that not all the blocks with 10 cm have 80 % side overlap, the total number of used images is 5669. The average number of ground control points (GCP) used in the larger blocks for urban area is 110, and 21 check points. For the rural area this number is respectively 21 GCP and 9 check points. All the projection centers are included in the block adjustment.

Project is processed in Sofia coordinate system and Baltic height system. Manual tie point measurements is applied. The method of bundle block adjustment with projection centers is used in Solver module. Projection centers improved considerably the accuracy of blocks where some of the pre-marked points missed on the images. For some blocks systematic error compensation of projection centers is used. The option "excluding the worst tie points" is applied where it was necessary. After the first adjustment and defining areas with less GCP, some new points on the ground were measured. The accuracy of the adjustment is improved by including visible on pictures control points from the state and regional geodetic network. The achieved average accuracy of the adjusted blocks with 10cm GSD is ± 8.5 cm in position and ± 8.5 cm in height. For blocks with 20 cm GSD this results are ±13.7 cm in position and ±11.5 cm in height.

The main purpose of the project is creating orthomosaic for the entire territory of Sofia Municipality and the area with 130 sq. km located to the east of its border. The urban area is covered with 800x500m sheets of orthomosaic with 10cm pixel size for 1:1000 scale. The rural area is covered with 1600x1000 m sheets with 20cm pixel size for 1:2000 scale. They are built with DEM from vectorised existing topographic maps. The project was successfully finished within 12 months. The large scale orthophotoplan is highly valuable for the working process in the other departments in GIS-Sofia, as well as for many external clients. The accuracy of the orthomosaic is being improved by extracting new DEM in stereo mode and building precise regions of interest in Mosaic module. One quarter of the urban territory is already covered with DEM with 5m cell size.

Another main purpose of the project is extracting precise digital terrain model along the river flows in Sofia Municipality and Lesnovska River flowing from Ognyanovo Dam to the eastern border of Sofia Municipality and running into Iskar River. Contours in these areas are being vectorised manually. Terrain data is going to be used by the local authorities in order to make a prevention strategies and plans against flood risk.

The project has many applications where geographic information, combined with visual data is necessary. It has been used for example as a supplement and reference in creating cadastral map of a part of Krasna Polyana District in Sofia Municipality. It is also applicable in land parcel identification for the period of flight execution as it contains real information about the land use.