REVISION OF THE LARGE-SCALE TOPOGRAPHIC MAP IN BULGARIA
ERNEUERUNG DER GROSSMASSSTÄBIGEN TOPOGRAPHISCHEN KARTE BULGARIENS
ACTUALISATION DE LA CARTE TOPOGRAPHIQUE À GRANDE ÉCHELLE DE BULGARIE

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ABSTRACT

The civil survey office of Bulgaria (now Main Department of Cadastre and Geodesy at the Ministry of Regional Development and Construction) began the compilation of a large-scale topographic map in 1954, which was completed in 1984. About 90% of the map for the intensive activity regions of the country is at scale of 1:5000 and about 10% for the high mountain and forest regions is at scale of 1:10 000 . The contour interval is 1, 2, 5, and 10 m depending on the scale and the terrain slope. The map is three-coloured and the sheets are 50x50 cm in size. Gauss-Krueger Projection, Plane Coordinate System 1970 and Baltic Sea Level Datum are used. An average of 1 to 2 triangulation points are to be found in one 1:5000 map sheet. The map is produced and periodically revised by aerial photogrammetry. For some specific purposes (mainly designing of linear, hydro-technical and industrial projects) maps at scale of 1:2000 and larger are made. Maps and orthophotomaps at scales from 1:10 000 to 1:500 for the needs of rural and urban cadastre are produced.

KURZFASSUNG

Der zivile geodätische Dienst Bulgariens (jetzt Hauptverwaltung für Kataster und Geodäsie) begann die Herstellung der Grossmassstäbigen Karte im Jahre 1954 und beendete sic 1984. Ungcfahr 90% der Karte der intensiven Gebiete des Landes ist im M 1:5000 und ca. 10% der hochgebirgigen und bewaldeten Gebiete ist im M 1:10 000 ausgearbeitet. Die Eguidistanz des Reliefs ist 1, 2, 5 und 10 m, abhängig vom Massstab und Gelandeneigung. Die Karte ist dreifarbig und die Kartenblätter mit einem Mass von 50x50 cm . Angewendet war die Gauss-Krueger Projektion, ebenes Koordinatensystem 1970 und das Baltische Höhensystem. In einem Kartenblatt 1:5000 sind durchschnittlich 1 bis 2 Triangulationspunkte. Die Karte ist mittels photogrammetrischen Methoden hergestellt und wird periodisch erneuert ebenfalls mit Hilfe photogrammetrischer Methoden. Fuer einige spezifische Zwecke (Projektierung linearen Objekte, Hydrotechnische – und Industrieobjekte) werden Karten im M 1:2000 und grösser, hergestellt. Fuer den Bedarf des Ortskatasters und den Kataster ausserhalb der Ortschaften werden Karten und Fotokarten im Massstab 1:10 000 bis 1:500 hergestellt.

RÉSUMÉ

Le service géodesique civile de Bulgarie (actuellement Direction Général de Cadastre et Geodesie) a commencé la création de la Carte topographique à grande échelle en 1954, terminеé en 1984. Environ 90% de la Carte pour les regions intensives du pays est à l'èchelle 1:5000 et 10% pour les régions à grande altitude et régions forestières est à l'échelle 1:10 000. Les courbes du relief sont 1, 2, 5 et 10 m, dépendant de l'échelle et du déclin du terrain. La Carte est à trois couleurs et les feuilles out des dimensions 50x50 cm. On emploie la projection Gauss-Krueger, système des coordonneés 1970 et système d'altitude Baltique. Chaque feuille de la Carte contient en moyenne 1-2 points triangulaires. La Carte est terminée et se actualise périodiquement par photogrammetrie aèrienne. Pour certains buts spécifiques (principalement projection d'objets linéaires, hydrotechniques et industriels) on élabore des cartes à l'échelle 1:2000 et plus grandes. Pour les besoins du cadastre des localités et des territories nonurbains on produit des cartes et orthophotocartes a l'échelle de 1:10 000 jusqu'a 1:500.

1. INTRODUCTION

The changes in Bulgaria by the end of 1989 strongly influence the economy of the country. The economic structures are changing, the participation of the government in the economy is decreasing considerably, the relations between it and the private physical and legal entities are changing, the private incentives in the trade, commerce and banking are stimulated.

The economic changes are accomplished in four directions:

(i) Restitution of ownership of urban property and industrial enterprises,
(ii) Privatisation of state-owned industrial enterprises,
(iii) Restitution of private ownership of agricultural lands.
(iv) Restitution of private ownership of forests.

All this requires considerable changes in the organisation, management and performance of the geodetic, cartographic and cadastral activities in the country, including the introduction of new technologies and equipment.

The territory of Bulgaria is 111 thousand sq. km 60% of which are farming lands and 40% are arable lands. The settlements are above 5 thousand and occupy 4.5% of the territory. The population of Bulgaria is 8.5 million.

2. MANAGEMENT

The geodetic, cartographic and cadastral activities are managed by the Main Department of Cadastre and Geodesy at the Ministry of Regional Development and Construction. Some 28 Regional Offices of Cadastre and Geodesy are established on the territory of the country which are local bodies of the Main Department of Cadastre and Geodesy. The Department, together with its Regional Offices, carry out the state policy, planning, financing, control and approval of all technical activities on cadastre, geodesy, photogrammetry and cartography, which are for civil purposes.

Numerous companies most of which have surveying as the main production are involved in geodesy, surveying, cartography and cadastre in this country. About 60 of these companies are state-owned. The proportion of the technical activities done by the state companies is 75% and by the private companies – 25% (Katzarsky and Koleva, 1996).

3. GEODETIC, CARTOGRAPHIC AND CADASTRAL MATERIALS AND DATA

Except for some attempts in the remote past for mapping the territory occupied by present-day Bulgaria, as well as the plane-table survey at scale of 1:42 000 made by the Russian Topographic Corps during and right after the Russian-Turkish Liberation War of 1877-1878, the surveying and mapping activities in the country have more than hundred years history. In comparison with some other countries of similar size, historical destiny and economic potential, Bulgaria is well provided in geodetic and cartographic aspects (Katzarsky and Koleva, 1996).

3.1. Geodetic Networks

On the territory of Bulgaria geodetic networks are constructed consisting of about 60 thousand triangulation points, 15 thousand bench marks, as well as 335 fundamental bench marks, about 400 gravimetric and 800 magnetic points. Due to the intensive development of particular regions about 15% of the triangulation points were destroyed and the portion of the destroyed triangulation points in the settlements and in the industrial areas may reach 40%.

Four tide gauge stations on the Black Sea coast, two control measurement bases, one magnetic station and one gravimetric polygon were built. A space station for observation of earth artificial satellites for geodetic purposes as well as a geodynamic station were built.

3.2. Topographic Maps

The country is covered by a topographic map at scale of 1:25 000 with contour interval 5 and 10 m, as well as with by-product maps at smaller scales. The map is five-coloured and is revised every 8-10 years.

The compilation of a large-scale topographic map began in 1954 and was completed in 1984. About 90% of the map is at scale of 1:5000 and about 10% - at scale of 1:10 000. The contour interval is 1, 2, 5 and 10 m depending on the scale and the terrain configuration. The map is five and three-coloured and about 40% of it is updated.

For some specific purposes (mainly for investigation of linear and hydro-technical projects) maps at scale of 1:2000 and larger are made.

3.3. Orthophotomaps

In the 1981-1991 period orthophotomaps without contours were made at scale of 1:5000 of 60 thousand sq. km and at scale of 1:10 000 of 24 thousand sq. km of the territory of the country. Orthophotomaps at scale of 1:2000 are prepared for some parts of the country.

3.4. Urban Maps

In Bulgaria there are above 5 thousand settlements of different size and type as well as other settlement formations (hamlets, railway stations, industrial zones). For most of them maps at scale of 1:1000 and 1:500 are made and for some central parts of the towns - also maps at scale of 1:250. About 50-60% of the urban maps are actual. The maps are three-coloured with contour interval 1 and 0.5 m.

3.5. Cadastral Information

Orthophotomaps at scale of 1:2000, 1:5000 and 1:10 000 serve mainly as a basis of the rural cadastre. Maps at scales of 1:1000, 1:500 and 1:250 serve as a basis of urban cadastre.

A cadastral information system is created for about 20 thousand sq. km of the territory of Bulgaria and for another 30 thousand sq. km input cadastral data are collected to be entered into the system. The main products of the cadastral information system are about 20 types of balances which contain summarized data on definite indicators for each object. For those communes, for which an informational system is created (18% of the territory of the country) 80% of the data necessary for the land reform are available. The cadastral maps included in an information system, are ready maps of the land and serve as a basis of the land reform.

3.6. Land Consolidation Maps

For the needs of the land consolidation which began in 1911 but was carried out on a mass footing in Bulgaria during the period 1932-1942, land consolidation maps at scale of 1:2000 are compilated for some lands with total area of about 1,5 thousand sq. km.

4. LARGE-SCALE TOPOGRAPHIC MAP

4.1. Aim and Purpose of Use

The compilation and the periodic revision of the large-scale topographic map is assigned by the Bulgarian Government to the Main Department of Cadastre and Geodesy at the Ministry of Regional Development and Construction.

For the intensive activity regions of the country it is made at scale of 1:5000 and for the unintensive ones - high mountain and forest regions - at scale of 1:10 000. Maps at scale of 1:2000 are made for special purposes to the order of separate users, mainly in the industrial regions.

The large-scale topographic map aims at representing the location, form, dimensions and crops of the separate units and all situation details and objects, visible within the map scale, all hydrographic and transport objects and structures, as well as the terrain relief.

The large-scale topographic map is intended for the investigation, designing and planning of economic activities, for the solution of research problems as well as for defence. It is used as a basis for the preparation of thematic cartographic products.

The content and scale of the topographic map is determined in accordance with the purpose of its use in: agriculture, forestry, geological surveys, hydrographic and hydromeliorative construction, regional development, environment protection, rural cadastre, etc. (Instruction, 1985).

4.2. Coordinate System, Sheet Division and Nomenclature

The large-scale topographic map is produced in 1970 Coordinate System, introduced for the entire territory of the country. The Baltic Sea Level Datum serves as basis for the altitudes. The sheet division is done in a Cartesian coordinate system and all sheets, irrespective of the map scale, have frame of 50x50 cm.

The sheet division is connected with that of the map at scale 1:100 000. Each map sheet at scale of 1:100 000 is divided into 4 map sheets at scale of 1:50 000, into 16 map sheets at scale of 1:25 000, as well as into 64 map sheets at scale of 1:10 000 and 256 sheets at scale of 1:5000. The sheet division at scale of 1:2000 is connected with the map at scale of 1:10 000, where each map sheet is divided into 25 map sheets at scale of 1:2000.

The nomenclature of the map sheets at the di8erent scales is connected with the nomenclature of the map sheet at scale of 1:100 000 to which Cyrillic letters and numerals are added.

On the sheets at scale of 1:10 000,1:5000 and 1:2000 a Cartesian coordinate net is plotted at intervals of 10 cm. The coordinate net, the corners of the map sheets and the geodetic points are plotted with accuracy of +0.05 mm. The admissible deviations of the measured distances between the sheet corners from their theoretical values are: + 0.3 mm for the sides and + 0.4 mm for the diagonals.

4.3. Geodetic Basis

The following geodetic networks serve as a basis of the large-scale topographic map:

(i) The national triangulation network from I to IV class and the local triangulation and polygonometry;
(ii) The national levelling network from I to III class, as well as the triangulation points of known heights.

The triangulation points and bench marks provide the geometric relation between the map and the terrain. The triangulation points are evently distributed so that there are 4 to 6 points on average in one 1:10 000 map sheet; 1 to 2 points - at scale of 1:5000 and 1 point in 1 to 1.5 sheets at scale of 1:2000.

4.4. Contour Interval

The relief is presented in contours, symbols and spot heights. For the scale of 1:10 000 the contour interval is 1, 2, 5 or 10 m; for the scale of 1:5000 it is 1, 2 or 5 m; for the scale of 1:2000 -1 or 2m.

For each map sheet a uniform contour interval is taken, dependent on the predominant terrain slope.

4.5. Accuracy

The accuracy of the situation on the large-scale topographic map meets the following requirements:

(i) The error in the location of the situation elements in respect to the near geodetic points should not exceed + 0.4 mm.
(ii) The distances between clearly depicted objects and borders of the terrain (buildings, railways, roads and structures, iron and concrete columns, etc.) located at a distance of up to 150 m, measured from the map and on the terrain should not differ by more than 0.6 mm;
(iii) For the other situation details these differences should not exceed + 1 mm.

The accuracy of the contours meets the following requirements:

(i) In open (unforested) regions the differencesbetween the altitudes measured on the terrainand those, obtained by interpolation between thecontours, should not exceed:
for the scale of 1:10 000 $+ (1+ 4 \operatorname{tg} \alpha)$,
for the scale of 1:5000 $+ (0.8 + 3.5 \operatorname{tg} \alpha)$,
for the scale of 1:2000 $+ (0.5 + 2 \operatorname{tg} \alpha)$,

where α is the terrain slope angle near the check point.

(ii) For forest regions of an area up to 1 sq. km irrespective of the height of the trees, and for forest regions of trees height of up to 4 m irrespective of the area, the accuracy of the relief depicted on the map is as in the previous item (i);

(iii) In forest regions with trees height of more than 4 m the required accuracy is lower.

5. REVISION OF THE LARGE-SCALE TOPOGRAPHIC MAP

Only map at scale of 1:10 000 and 1:5000 in coordinate system, sheet division and nomenclature as in 4.2 above are revised. For this purpose mainly photogrammetric methods (analogue stereoplotting and orthophotoscopy) and in rare cases survey methods (electronic tacheometry) are used.

Survey methods for map revision are applied in the cases when the changes in the map content are relatively small, when the map content is scarce in situation details or when it is impossible to take the aerial photographs. The photogrammetric methods for revision of the topographic map are applied when the changes in the situation are more than 20% and the situation content is very rich.

The revision of the large-scale topographic map is done every 4-5 years for the intensive regions of the country and every 8-10 years for the other regions (Instruction, 1985).

6. PHOTOGRAMMETRY

6.1. The Beginning

Bulgaria was probably the first country on the Balkan Peninsula to begin to apply photogrammetry. Terrestrial photographs were taken during 1907-1908 and were plotted in the Vienna Cartographic Institute by Eduard von Orel by means of a Stereoautograph designed by him. During the Balkan War (1912) and the World War I (1914-1918) aerial and terrestrial photographs were taken for military reconnaissance and road construction,

More considerable attempt to apply terrestrial photogrammetry for compilation of a topographic map at scale of 1:25 000 was done in 1928. For the same purpose in 1930 began the implementation of single-frame aerial photogrammetry and in 1940 - of aerial stereophotogrammetry. For large-scale mapping single-image photogrammetry was applied after the end of World War II and stereophotogrammetry - since 1954 (Katzarsky, 1988; Katzarsky and Kolewa, 1996.).

6.2. Current Practice

The aerial photogrammetry for civil production purposes in Bulgaria is concentrated in the following state enterprises:

- Geoplanproject Co., Sofia,
- Geodesia Co., Plovdiv
- National Centre of Cadastre Ltd., Sofia,
- Research in Geodesy and Photogrammetry Ltd., Sofia,
- Patproject Ltd., Sofia,
- Transproject Ltd., Sofia.

Geoplanproject and Geodesia implement analogue stereoplotting of aerial photographs for compilation and revision rural and urban topographic maps at scales of 1:10 000 up to 1:500. The National Centre of Cadastre makes orthophotomaps at scales of 1:10 000 up to 1:2000. Research in Geodesy and Photogrammetry Ltd. accomplishes mainly specific photogrammetric works. Patproject and Transproject make maps at scales of 1:2000, 1:1000 and larger, as well as digital models for the purposes of designing and reconstruction of motorways, railways and structures, as well as for inventory of the road and railway networks (Katzarsky and Koleva, 1996).

6.3. The Photogrammetry in Compilation and Revision of the Large-Scale Topographic Map

For compilation and revision of the topographic maps at scales of 1:10 000, 1:5000 and 1:2000 aerial photographs are taken mainly by wide angle metric aerial photocameras (focal length 15 cm and picture size 23x23 cm) Zeiss - RMKA 15/23 and MRB 15/2323, as well as Wild RC10 and RC 30 carried by the aeroplanes AN-30 (Russia) and L-410 (Czech). Depending on the map scale and the physico-geographycal features of the terrain, aerial photos are taken at scale of 1:20 000 up to

scale 1:8000 using Agfa-Gevaert or Kodak panchromatic aerial films. By means of the copier Elcop of Zeiss diapositives are prepared on Agfa-Gevaert film.

The necessary control points for absolute orientation of the aerial photos are provided by analytical block aerial triangulation. The marking of the points on the diapositives is done by Wild PUG-4 or Zeiss Transmark and the photogrammetric measurements are done by the stereocomparators Stecometer and Dicometer of Zeiss which are connected with personal computers. The block adjustment is done by means of the technology for aerial triangulation by polynomials and bundles, created in this country. As basis for the aerial triangulation serve the existing triangulation points which are pre-marked on the terrain (Katzarsky, 1980, 1987).

The stereoplotting is done by means of analogue mashines Stereometrograph and the orthophotoscopy - by Topocart-Orthophot and Topomat, all of Zeiss..

A technology has been developed for the creation of a digital model of the plotted region from direct photogrammetric measurements. This digital model is compatible with the digital model created by direct survey by means of electronic total stations (Katzarsky and Postadjian, 1992).

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