International Cartographic Association
Association Cartographique Internationale

Tasks and challenges of the Head Office of Geodesy and Cartography in the area of developing topographic maps in 1:25,000 scale

Alicja Kulka[a], Anna Bober [a], Marcin Lebiecki [a], Anna Makowska [a]

[a] *Head Office of Geodesy and Cartography, alicja.kulka@gugik.gov.pl, anna.bober@gugik.gov.pl, marcin.lebiecki@gugik.gov.pl, anna.makowska@gugik.gov.pl*

* Corresponding author

Abstract:

In accordance with the legal regulations in force in Poland in the field of cartography, i.e. the Geodetic and Cartographic Law, one of the tasks of the Chief National Surveyor is to create and provide access to topographic, general geographic, thematic and special maps. Moreover, the topographic maps are developed in close cooperation with the Minister of National Defense. The basis for the development of topographic maps is, in particular, the Topographic Objects Database BDOT10k with the topographic objects' level of details corresponding to 1:10,000 scale, the National Register of Geographic Names and the Digital Terrain Model.

Considering the above, in 2022, the Head Office of Geodesy and Cartography, as part of its own work, launched a pilot project aimed at developing tools to automatically generate topographic maps in 1:10,000 and 1:25,000 scale. At a current stage, as part of the II iteration, the maps do not yet constitute full-fledged topographic maps, but we are striving for such a goal. The tools are constantly developed and corrections are made to eliminate errors that still occur. The maps in 1:10,000 and 1:25,000 scales, developed so far under this project in a fully automatic manner, are available free of charge to all interested users on the www.geoportal.gov.pl website.

In the article, the results of the developed tools and generated topographic maps 1:25,000 will be presented, as well as the problems faced both in the context of the methodology and the limitations resulting from the software used.

Keywords: topographic map, the Topographic Objects Database BDOT10k, automatic generalization, map editing

1. Conditions, needs and goals

In accordance with the applicable polish law - the Act of May 17, 1989 - Geodetic and Cartographic Law (Journal of Laws of 2021, item 1990) - the Chief National Surveyor creates, runs and provides standard cartographic studies in 1:25000, 1:50000, 1:100000, 1:250000, 1:500,000, 1:1000000 scale. Standard cartographic studies form two groups: topographic maps (scales: 1:25000, 1:50000, 1:100000) and general geographic maps (scales 1:250000, 1:500000, 1:1000000). Standard cartographic studies also include topographic maps in 1:10000 scale, but the creation, maintenance and sharing of these, is the voivodeship (16 administrative units) marshal's responsibility. Since, due to the act mentioned above, standard cartographic studies are of the defense and security of the state importance, close cooperation between the Chief National Surveyor and the Minister of National Defense is being undertaken in their development.

Topographic maps are created on the basis of, among others, the Topographic Objects Database (BDOT10k) with the level of details ensuring the creation of standard cartographic studies in 1:10000 to 1:100000 scales, while the basis for the general geographic maps is the General Geographic Objects Database (BDOO).

The general scheme of the development of tools enabling the creation of topographic and general geographic maps based on the latest knowledge and available technologies, in accordance with the legal provisions is shown in Figure 1.

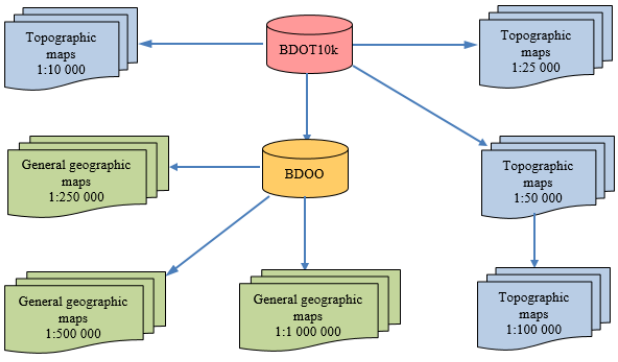

Figure 1. The scope of planned works in the field of preparation of tools for automatic generalization and cartographic editing.

Till now, the topographic maps constituting the National Geodetic and Cartographic Resource (PZGiK) have been developed in a way requiring manual editing. This way of creation provides great accuracy, but at the same time the whole process is expensive and relatively long. By now on, the topographic maps have been developed under public procurement by various Contractors selected in public proceedings. Since the geopolitical situation has changed significantly (the state of war in Ukraine), the great need for creation of topographic maps of high up-to-dateness (correlated with the source data's up-to-dateness) and for ability to create them automatically, for any area of the country at any time, rapidly increased. Within the framework of the cooperation between the Head Office of Geodesy and Cartography (GUGiK) and Ministry of National Defense (MON), thanks to mutual knowledge and experience exchange, efforts aiming at generating accurate, up-to-date, on an ongoing basis maps meeting specified key user's needs (fit for purpose).This approach ultimately also reduces the production costs. It is also important that a uniform methodology for creating topographic maps and a uniform method of generalization and cartographic editing are used for the area of the whole country. In addition, as a result, we have reproducible results of generalization and cartographic editing, which is also important in multi-time analyses. It seems, therefore, that the automatic generation of topographic maps is a necessity today and at the same time the "golden mean" between rationality if spending public funds, the quality of maps and their manual development.

Considering the above, for the purposes of the topographic maps in the scale of 1:25,000 (MT25k) production, the Head Office of Geodesy and Cartography has prepared tools and processes enabling fully automatic generalization and cartographic editing of BDOT10k to MT25k. Moreover, analogous tools and processes for automatic generalization and cartographic editing of object database resulting in the creation of topographic maps in the scale of 1:50,000 and 1:100,000 are also under preparation. In 1:100,000 scale maps case, the source data is drawn from the cartographic objects database of 1:50,000 scale.

The results of each of the processes shown in Figure 1 are saved in the Oracle database consistent with the data model defined in the Regulation of the Minister of Development, Labor and Technology of July 27, 2021 on the topographic objects database and the general geographical objects database and standard cartographic studies.

This approach allows for the preparation and sharing not only of traditional topographic and general geographic maps in the form of services or in paper form, but also as a WMS and WMTS service presenting a continuous image of the map content on a national scale.

Implementation of the briefly pointed out above approach for creating maps, for which the Chief Surveyor of the Country is responsible, aims to achieve the following goals:

1. ensuring high up-to-dateness of maps, correlated with the up-to-dateness of the source data,
2. ensuring universal availability of the generated maps in the services of the www.geoportal.gov.pl portal,
3. reduction of map preparation costs,
4. ensuring the uniform quality of studies within the country (by maintaining a uniform method of generalization and cartographic editing),
5. ensuring reproducible results of generalization and cartographic editing.

The fulfillment of those objectives will bring measurable benefits for the country's economy and will contribute to the development of the spatial information infrastructure. However, it definitely needs to be noted, that while automation of the processes of generalization and cartographic editing, the final studies bear the consequences of compromise between quality and defined assumptions.

There is no turning back from this road, since the users are primarily looking for up-to-date and reliable spatial information, while manual production of topographic maps is way too expensive and time-consuming today. The quality of cartographic studies is to increase gradually through the improvement of the existing processes (also based on the consideration of submitted comments). The modular structure of processes and tools greatly facilitates this task. There is also great possibility of the constant growth of usage of artificial intelligence in the processes being built (e.g. to improve the placement of inscriptions and labels). The significant role in improving the quality of the cartographic studies plays the increasing the quality of source data - especially the Topographic Objects Database (BDOT10k) data.

The process covering automatic generation of these maps for the area of the whole country is a very complex process. In simple terms, it involves generalization of source data, preparation of visualization and map composition, and then preparation of the process of automatic map saving, while maintaining the optimal time of generating a single sheet. It also needs to be noted that Polish topographic maps are very rich in content. It is essential then to use appropriate methods of automatic qualitative generalization of the BDOT10k data, such as e.g. simplifying and smoothing the shapes of linear and surface objects, enlarging fragments of surface objects, aggregating surface objects, removing narrowing of surface objects, automatic quantitative generalization, e.g. in order to reduce the number of vertices of objects surface and linear ones, but it is also necessary to eliminate conflicts resulting, for example, from the conducted objects' generalization. Appropriate setting of symbolization or the order of displaying layers and objects also requires solving some problems related to, for example, the arrangement of descriptions and labels in such a way that the map is legible. Setting up the marginalia along with all map elements so that appropriate content was automatically generated depending on the

31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa. This contribution underwent single-blind peer review based on submitted abstracts. https://doi.org/10.5194/ica-proc-5-9-2023

sheet also required significant effort. The greatest challenge, however, is the automatic development of the relief for the needs of a topographic map, since due to the great diversity of topography of Poland, both lowland and upland areas as well as mountainous and high mountain areas need to be covered.

2. Software and technical solutions

Main headings The automation process became possible and the vast majority of it has been created and runs in the ETL (Extraction, Transformation and Loading) type software. The way that software capabilities have been used deserves special attention.

The current processes and tools for automatic generalization and cartographic editing of BDOT10k to MT25k use algorithms that allow, among others:

- quantitative selection of objects, e.g. removal of overlapping point marks such as a monument, tower, windmill, light signal, etc.;
- simplification (Douglas's algorithm) and smoothing the shapes of linear and surface objects (McMaster's algorithm), e.g. simplifying and smoothing the coastline;
- aggregation of surface features, e.g. in the case of surface waters - small ponds separated by dikes got connected;
- removing narrowings of surface objects, e.g. a coniferous forest less than 20 m (0.8 mm on the map) wide and less than 50 m (2.0 mm on the map) long, is shown with a point mark (small forest mark);
- reduction of graphic conflicts by, for example, moving objects away from the road (when the symbol, for example, obscures the course of the road).

These processes consider and maintain the topological relationships between different classes of objects. In most cases, the criteria contained in the Regulation of the Minister of the Interior and Administration of 17 November 2011, on the topographic objects database and the general geographic objects database and standard cartographic studies, were used in their construction.

Work on processes for automatic generalization and cartographic editing of BDOT10k to MT25k building, was based on experience gained in building processes for automatic generalization of BDOT10k to BDOO. From the beginning, FME Desktop software by Safe Software was used, later enhanced with ESRI - Python - ArcPy library, which extended the range of available tools for generalization process. Thanks to this, the number of PythonCaller transformers containing scripts written in Python has been kept to a minimum. All these efforts were dictated by the need to effectively maintain processes and easily remove errors in these processes.

All of the above-mentioned efforts were dictated by the need for effective maintenance of processes and easy debugging them. An additional facilitation was the object cash-processing released by the software manufacturer in FME Desktop. That allowed for the analysis of the input and output data of each transformer without the need to restart the entire process. The whole thing was completed by the exceptional stability of the FME software, which is very important when building such complex processes.

As a result of the work that had been carried out, in 2022, the first fully automatic process of BDOT10k generalization to MT25k was implemented, resulting in the first edition of cartographic visualizations in 1:25,000 scale for the entire country. Currently (at the beginning of 2023) the second iteration of these studies has already been published.

The process is run on FME Server and simultaneously can be run for 5 sheets of map. The main - control process consists of the following transformers:

- transformers reading BDOT10k data (including initial selection of objects) from the Oracle database and saving the results to ffs files and then to ESRI Geodatabases,
- transformers designed to start generalization processes for individual classes of objects,
- transformer starting process of trimming generalized data to the sheet's boundaries,
- transformers running 3 resolving graphical conflicts processes,
- transformer initiating the process responsible for the preparation of out-of-frame map content (some of that out-of-frame map content are generated automatically, such as subtitles or administrative division),
- transformer activating generating subtitles in the map content,
- transformer setting in motion process responsible for transferring cartographic vector data from ESRI Geodatabase to Oracle database,
- transformers responsible for starting the processes of generating the pdf file of the final map.

The main process orders the execution of subprocesses on the FME Server, where the tasks are queued and performed in parallel with the use of multiple engines. It currently takes 5 months of continuous operation of the FME Server to complete the automatic generalization and cartographic editing of BDOT10k to MT25k for the area of Poland, resulting in 4435 map sheets occupying 17.5 GB of space.

Although the whole process runs automatically, it is supplemented with manual verification of each map sheet. Collected comments (also noticed deficiencies, found errors) are premises for improving processes in subsequent iterations.

The graphic (Figure 2) showing only the main – control process, can give an idea of the complexity of the process as a whole.

Proceedings of the International Cartographic Association, 5, 9, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa. This contribution underwent single-blind peer review based on submitted abstracts. https://doi.org/10.5194/ica-proc-5-9-2023 | © Author(s) 2023. CC BY 4.0 License.

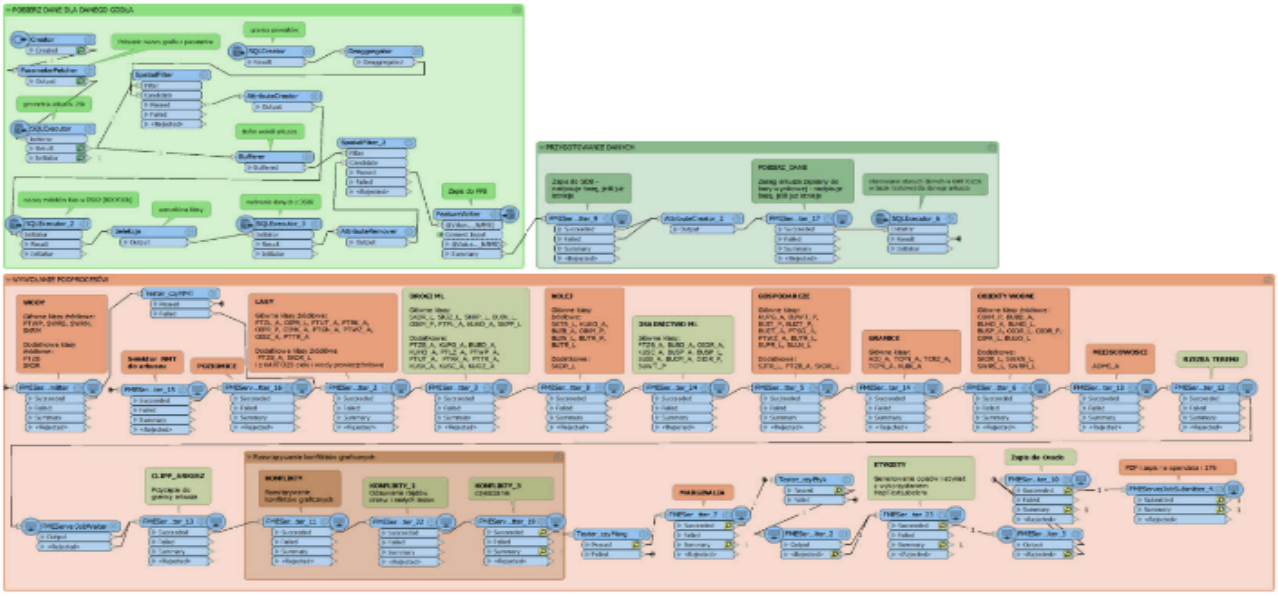

Figure 2. The main – control process of generalization and cartographic editing of BDOT10k to MT25k.

Various types of graphical conflicts have been met due to scale change (from 1:10,000 of BDOT10k to 1:25,000 of final visualization) and needed to be solved during work on the construction of cartographic generalization and editing processes.

The ArcPy library was used to simplify and rectify buildings and move them away from roads (see Figure 3).

Figure 3. The results of moving buildings away from the roads (the right picture shows the buildings after being processed).

The multitude of available FME transformers allowed, for example, to move linear objects away from other linear objects – being solution for moving the borders of nature reserves, national parks and landscape parks away from the roads (see Figure 4).

Figure 4. The results of moving the boundaries of the reserves away from the roads (the right picture shows the boundaries after being processed).

One of the most difficult issues to be faced was the automatic placement of descriptions in the map content. In this case, the FME extensions – MapTextLabeller and MapTextStyler came as a solution. They were essential in arranging descriptions and generating flow direction arrows for the watercourse network. The source data for descriptions were both BDOT10k and the National Register of Geographical Names (PRNG) data.

In the next – third iteration of 1:25,000 scale topographic maps generation (which is too be launched soon), contour lines are assumed to be created. The source data for the descriptions of this layer is to be the Digital Terrain Model (DTM). To achieve intended result, smoothing, but above all, cartographic generalization is crucial so that the readability of the map is preserved. It should also be borne in mind that the terrain in Poland is very diverse, there are both mountainous areas, old glacial relief (not very diverse, where plains predominate, locally diversified by extensive, low hills or hills of glacial origin, cut by shallow and wide valleys or flat and extensive depressions), as well as the early-glacial relief, with high dynamics of the relief, abundance of concave forms and the presence of lakes.

In the existing processes and tools, also the MapTextLabeller transformer was very useful. It allows not only to generate descriptions for individual layers, taking into account the geometry of the objects from which the inscriptions come, but also to introduce restrictions, barriers for inscriptions from other layers. An example may be the condition that the inscription of a place whose source geometry is the polygon of the place cannot intersect expressways, highways and, for example, rivers. In the inscriptions generating process, iterative – two-step approach was implemented. The first step – only the inscriptions which arrangement meets the restrictive conditions of location in relation to other elements of the map content. The second step – the ones that were not placed in the first step, but are important enough not to be omitted and should not be removed, are being situated. For these, the restrictions are less.

What is shown below is the comparison of two fragments (presenting approximately the same area) of the MT25k sheet: one (Figure 5) was generalized and edited manually

by the cartographer, while the other one (Figure 6) presents the effect of automatic generalization and cartographic edition. Due to the different time of maps creation, the content of the map also slightly differs due to actual objects changes in the field.

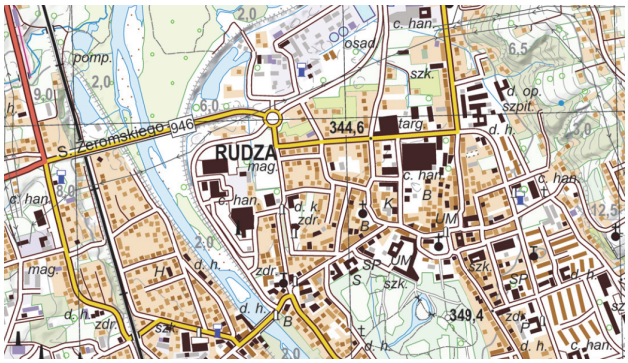

Figure 5. Fragment of the M-34-075-C-d Zywiec map sheet – created manually.

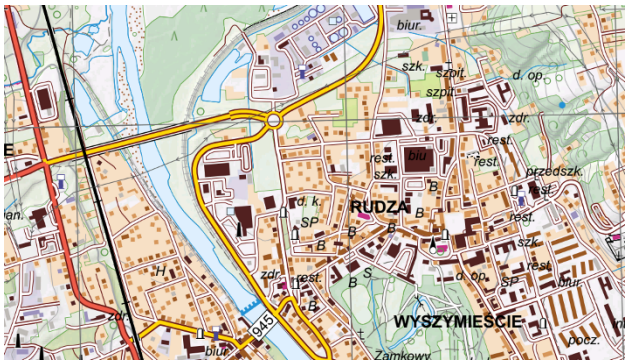

Figure 6. Fragment of the M-34-075-C-d Zywiec map sheet – created automatically.

3. Availability and future plans

Main headings As it was mentioned before, the results of the latest version of cartographic generalization and editing process – covering the whole area of Poland, sheets of cartographic visualizations in 1:25,000 scale, are now universally available and can be downloaded from the http://www.geoportal.gov.pl website in pdf format. Within a “Map content” window, tab named “Data to download” can be found, and expanded, shows the “Topography – BDOT10k cartographic visualization” tab. After selecting 1:25,000 scale, using the information tool “i”, the sheet of interest should by indicated. Choosing “WMS, BDOT10 cartographic visualization” causes basic information and link for selected sheet’s download (pdf format file) to appear (see Figure 7).

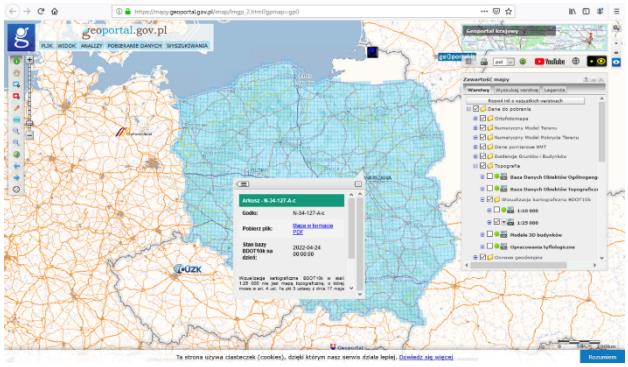

Figure 7. Downloading MT25k data from www.geoportal.gov.pl.

Created by the Head Office of Geodesy and Cartography process enabling fully automatic generalization and cartographic editing of BDOT10k to MT25k is a powerful tool allowing, above all, to produce up-to-date maps for the entire country in a relatively short time and thus meet the needs of the key user – the Ministry of National Defense. At the same time, this resulted in a significant reduction in map production costs, which is not without significance when it comes to rational spending of public funds. Finally, the iterative approach, enables ongoing improvement, based on the submitted comments and increasing the cartographic quality of the maps. At a current stage, there is still the element that is essential in the map content and needs to be and will soon be added and tested, i.e. contour lines. Additionally, tests using shading analysis are to be carried out, aiming at contour lines readability (map plasticity) improvement, as well as better perception of the map content for the average user.