A HUNGARIAN ON-LINE MAP SERVICE BASED ON GIS DATA AND VISUALISED BY CARTOGRAPHIC APPROACH

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Abstract
Hungary has two separate national mapping agencies, a civil and a military. Although their tasks have been well defined since 1996, the task allocation is practically based on the map scales. None of these authorities are providing on-line free map services, although they sell their data. A Hungarian private company decided to integrate data from various official sources (with the co-operation of the two national mapping agencies) and provide a frequently updated on-line map service focusing on road network. This map service is based on official GIS data, but the visualisation of these data is intentionally based on cartographic rules and traditions. The recent map service has been using raster tiles since its release, but the company is considering moving to vector tiles or providing its on-line service in both ways. It is interesting to review how the map feature data can be officially obtained and also how they guarantee the regular updates.

Keywords: data-driven cartography, spatial data integration, automated cartography, map services, cartographic approach, representation

INTRODUCTION

This article is focusing on describing the process and the results of creating a periodically updated, multi-scale commercial map service based on GIS datasets from heterogeneous sources. This map of Hungary (covering 93,023 square kilometres) is currently published in the format of raster tile-sets at pre-defined map scales and made available as web map services (TMS1 and WMS2). The first version of the map was released and published more than ten years ago (2006), and although the principles of the procedures and the objectives are still the same: the company is continuously developing the processes of map preparation and production, optimizing the graphical layout of the maps and the supported range and variety of the output data formats, and increasing adopted standards. Being a licensed, proprietary product of GeoX Ltd, it is shipped, utilized and installed at several governmental public organizations and agencies for local and internal use as well as made available for public browsing. According to the data content of source datasets, the type of the map can be referred as road map or city map at closest (including also some elements of topographic and geographical maps, depending on the zoom level) (Schmidt, Weiser 2012).

The following chapters introduce the idea, the purpose, the positioning, the creation, the maintenance and the development of the map design and the production. This paper is slightly related to another paper of the conference (Nr. 148), which is presented by the co-author, László Zentai.

2 Web Map Service: http://www.opengeospatial.org/standards/wms
Planning and preparing a private map service

Being a GIS-company, GeoX has tended to publish and visualize its spatial datasets in order to demonstrate the level of details, correctness, preciseness, completeness, currency, utilization and value of the data. Earlier publications of the spatial datasets did not – or could not – aim at these objectives due to the lack of appropriate and sufficient tools, technology, knowledge, determination and purpose. The company’s main fields of business has been spatial data collection, management and analysis at large scales, on the “level of house numbers” in the subjects of business GIS. During its activity of more than 20 years in the spatial business, and with the help and cooperation of governmental/public partners and agencies, GeoX has managed to build, develop and maintain the digital street network database and the register of addresses for Hungary. This spatial dataset is primarily targeting to provide base data for general GIS tasks like geocoding (addresses), routing and navigation, but it is also suitable for spatial analysis, catchment area planning and analysis or districting. Besides mainly focusing and continuously collecting, surveying and updating the street network elements, the address information and the ZIP-code areas, the dataset is also completed with topographic elements and the features describing the administrative areas and land use acquired from the public partners and agencies. The overall objective has been to establish a frequently updated map product and web map service as well as design, develop and set the tasks and procedures of production and update. While the use and the characteristics of the base datasets are primarily compiled to GIS and IT tasks, particular focus has been set on the cartographic approach of the map design and output in order to provide a clear, effective and expressive visualization. At that time there were no other frequently updated, free on-line map services or these services were in embryonic phase (Parsons, 2007).

In this context, a map or map view is the complex visual representation of real world objects, phenomenon, and localized information at a specific scale level. The multiscale attribute is standing for displaying and symbolizing data in different ways in respect of the particular zoom level, but still with similar style across the range of scales, giving an almost seamless display of the features, along with providing more accurate and more detailed information to the user as the scale increases. Due to its functional and user-side role, the map is intended to provide geographical “background” and the spatial relevance in the visual communications to the final users/readers and a reference for location related information for additional spatial data (Gartner, 2013).

Web map publishing today usually performed along the following process. Base map data are managed, stored and integrated in a spatial (usually relational) database. Map data are distributed to tables (layers) according to their content and the conceptual category of the features. Real-world objects and phenomena are stored as geometries with additional attributes (description of characteristics, data categories) attached to them. Utilizing and processing these datasets and tables in GIS applications, map images or map views can be rendered from these features, based on complex sets of rules. These rules are standing for the graphical representation of geometries and symbols, the labelling and annotation of the geographical features and also the visual order and appearance of the features. Both current and traditional map publication methods are following the layered data visualization approach. In practice, during the preparations and the composition (rendering) of map images, source data are selected and organized into map layers by their theme and particular purpose, importance and level of map scale. Subsequently, these layers are drawn in pre-defined order on each other resulting in composed map views. The other very important aspect of map rendering is the graphical and typographical characteristics (symbology) of the map data. Designing the map symbology, the representation of features are organized into distinct, visually well separated, easily identifiable and recognizable representation groups regarding the characteristics of text and graphical elements. For the general graphical design of maps, the map composition and map visualization, the following generic and basic assumptions on the map-design principles were followed (Veenendaal et al, 2017):

- clarity: focus on the main purpose of the map;
- balance: distributing elements properly;
- contrast: highlight important elements with graphical and typographical attributes;
- order: map elements are organized to guide the reader to accomplish the intended purpose;
- follow the traditions and conventions of map symbology and label placement;
- harmony: map elements to show a “natural fit”.

Other important tasks of the process are the scheduled update process and results, the production of uniform and standardized output, the validation of results, and the feedback to source data maintenance (Jenny et al, 2008).

PREPARATION OF THE UNDERLYING DATA

Process of map production is set up and can be divided into the following steps of tasks and phases. First step was framing the objectives against the graphical style and the technical characteristics of the map and the map images. It
was decided to offer pre-generated, raster format map images as elements of a tile-set defined by a tiling scheme. With the clarity of the goals the production process has been designed and set up. The initial step was the analysis and determination of ways of utilization of the source datasets along with setting up the data integration and data manipulation procedures. In respect of the characteristics of the source datasets and their way of use in the map production process, a map database has been designed and set up resulting in an integrated and optimized data source utilized for map display and rendering. Going back in 2006, when the GeoX project was released; this was the time when GoogleMaps just started unfolding and dispersing, OpenStreetMap project was starting up, on-thy-fly (web) map renderers (like Mapnik) were not even existing or were in a pretty immature state (Veregin, 2013 and Ingensand et al, 2016).

A GIS-application has been selected for producing the final map images. It has been declared that the application should offer high graphical quality, large variety of symbology, should support sophisticated and complex labelling methods, should offer tools and interfaces for automation and also should support the manipulation and the efficient management of the source data. For this purpose, the ESRI ArcGIS Desktop application with the Maplex labelling extension has been selected, which provides high level of capabilities and quality in output-oriented geovisualization. ArcGIS supports setting up and saving map documents, which stand for the specific definition of the visualization and the order of appearance of spatial data and its certain subsets. In this process it has been decided to create individual map documents for each scale (zoom level) with specific symbology settings and visualization rules with keeping the consequent and coherent symbology between the scales. Map documents were completed with scripts and macros (VBA) later, creating generated features and setting the labelling properties and turning them to annotations for specific map layers. Map tile production required software development tasks for creating a specific application utilizing the ArcGIS components and interfaces in order to offer the batch rendering of map frames and exporting map images as raster files. The final step of the production process is loading and utilizing the exported map tiles, feeding the data in GIS Server applications for publishing (Figure 1-4).

Figure 1. Zoom level 16 (~1:9027)
Figure 2. Zoom level 13 (~1:72,223)

Figure 3. Zoom level 11 (~1:288,895)
Description of source datasets

The base data of the map is created from and integrated from several sources. The primary data source – and the principal purpose of the map – is the street network, the street map of the country. This digital street map data is originated from the DTA-50 digital map database developed and maintained by the MH Geoinformációs Szolgálat, the national military mapping agency of Hungary. DTA-50 is the digital version of the 1:50,000 scale military topographic map series of the country. Initially this database has been used for acquiring the initial shape and attributes of the street network features, and for providing additional topographic framework for the integrated dataset. Later, GeoX has continuously updated the street network data by executing field surveys and completed it with attributes describing the address, administrative and ZIP-code information along with attaching additional information on road classes, road numbers, type of road surface. In order to make the dataset suitable for routing and navigation purposes, traffic regulations like speed limits, turning rules or weight limitations have also been collected and assigned to the elements (edges) of the street network dataset. Besides the address information captured on the field, reference data is obtained, integrated and kept updated from the National Address Register (database KEKH) and by gathering information from the local authorities. ZIP-code areas are updated from the address register and integrated to the description of the districts acquired from the Magyar Posta (Hungarian Post). The DTA-50 topographic dataset is still taken as the main topographic data source for the map in respect of the elements representing the water features, the unpaved roads, pathways and trails, and selected features of land cover and land use. Features and information on the administrative units, boundaries and land use (legal) are obtained from the MKH-50 database (Boundaries of administrative units) maintained by the civil mapping agency of the country, the Budapest Főváros Kormányhivatala Földmérési, Távérzékelési és Földhivatali Főosztály (Government Office of the Capital City of Budapest – Department of Geodesy, Remote Sensing and Land Offices; successively FOMI (Institute of Geodesy Cartography and Remote Sensing) aggregated from the register on legal land property register managed by the territorial and local offices of the Hungarian Land Administration). Additional statistical and demographic data on the administrative units are acquired and updated from the Helység névtár (Gazetteer of Hungary) and annual reports published by the Központi Statisztikai Hivatal (KSH, Hungarian Central Statistical Office). All these data sources are utilized by GeoX and integrated in its spatial products: the DSM-10 (Digital Street Map of Hungary, scale 1:10,000), and ArcHungary (General GIS database of Hungary, scale 1:300,000) databases in harmonized structure, content and spatial reference (Figure 5).
GeoX also maintains one POI-database of the country (POIX), several categories of features (shopping, public offices, transportation, etc.) are selected to be represented on the map. Besides KSH reports all source data is proprietary and licensed for further processing and publication. There are no free sources from the governmental agencies (Table 1).

Table 1. Basic measurement indicators on data sources and features (1 March 2018)

<table>
<thead>
<tr>
<th>Data source</th>
<th>Feature type</th>
<th>Number of features in the map geodatabase</th>
<th>Total length (km)</th>
<th>Total area (sq km)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DTA-50</strong></td>
<td>transport network elements</td>
<td>detailed at: GeoX – roads and railroads</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>DTA-50</strong></td>
<td>water features (line)</td>
<td>130 981</td>
<td>83 759.6</td>
<td>-</td>
</tr>
<tr>
<td><strong>DTA-50</strong></td>
<td>water features (polygon)</td>
<td>8 631</td>
<td>-</td>
<td>643.8</td>
</tr>
<tr>
<td><strong>DTA-50</strong></td>
<td>woods (polygon)</td>
<td>7 982</td>
<td>-</td>
<td>17 573.8</td>
</tr>
<tr>
<td><strong>DTA-50</strong></td>
<td>parks (polygon)</td>
<td>12 393</td>
<td>-</td>
<td>389.7</td>
</tr>
<tr>
<td><strong>DTA-50</strong></td>
<td>industrial areas (polygon)</td>
<td>6 6550</td>
<td>-</td>
<td>600.1</td>
</tr>
<tr>
<td><strong>DTA-50</strong></td>
<td>other residential areas/allotments (polygon)</td>
<td>6 458</td>
<td>-</td>
<td>2 027.1</td>
</tr>
<tr>
<td><strong>MKH-50</strong></td>
<td>built-up/residential areas (polygon)</td>
<td>4 594</td>
<td>-</td>
<td>6 931.1</td>
</tr>
<tr>
<td><strong>MKH-50</strong></td>
<td>Administrative units (line/polygon)</td>
<td>3 177</td>
<td>42 466.0</td>
<td>93 011.5</td>
</tr>
<tr>
<td><strong>Hungarian Central Statistical Office</strong></td>
<td>Gazetteer (complementary tabular data on administrative units and populated places)</td>
<td>13 520</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### Setting up the map database

The data sources listed above are stored in different GIS-formats, structure and projection. Thus the preliminary step of map production and rendering is the transformation, harmonization and optimization of the necessary and selected data to a common map database. According to the selected ArcGIS application, all data is converted to an ArcGIS geodatabase with the support of the ArcCatalog application. This process includes spatial transformation, manipulation, harmonization and setting up the cross relations (both by location and attributes) of the source data along with the production of aggregated, derived and simplified objects from the features. The data import and integration process is executed by newly developed Python scripts and commands built on the Geoprocessing framework offered by the ArcGIS platform. As a result, a geodatabase is created that is optimized in respect of map rendering and offers the same real-world objects with different types of features and varying spatial preciseness and resolution for multiple scale levels. Besides the transformation and harmonization of the source layers, there are some more advanced data manipulations executed to improve the quality of the cartographic visualization and increase performance of rendering. The re-classification of the street network elements is performed by using more attributes together (road class, name, type of pavement) of the street network elements finally resulting in 38 style classes for the graphical display and 10 classes for labelling. Besides the attributes holding these values for the classes, the feature geometries are also aggregated for some classes helping the optimized placement of labels and the rendering of features in respect of scale level, vertical level and masking. This includes the set of main roads, the one-way streets, bridges and tunnels and the geometries building up place-like features. Reference points for roundabouts and highway junctions/intersections are derived from the road geometries for small scale point type display. Similar methods are applied for the elements of the railway network. Separate sets of features are created in respect of the vertical level of the features and types regarding the use of the railroad (city, rail, subway). A topological network of edges is created from the polygons representing the administrative units supporting the correct display of boundary lines and the names placed along them, graphical style classes are defined by the administrative level. Selected and aggregated sets of records and geometries are created for the main elements of the built-up areas representing the central units of the municipalities along with reference points for point symbol display and labelling. After the import process, clean-up and proper spatial and attribute indexing of the tables is performed, ending up the preparations with the validation and verification of the imported data.

<table>
<thead>
<tr>
<th>Source</th>
<th>Description</th>
<th>Qty (line)</th>
<th>Qty (point)</th>
<th>Qty (polygon)</th>
<th>Code (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GeoX Ltd.</strong></td>
<td>road network (line)</td>
<td>1 207 902</td>
<td>248 707.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>rail network (line)</td>
<td>33 091</td>
<td>14 622.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>rail stations (point)</td>
<td>1 814</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>other populated places (point)</td>
<td>1 207</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>highway junction/interchange (point)</td>
<td>211</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>House number reference points (point)</td>
<td>3 149 759</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>POI (point; subset of POIX database)</td>
<td>83 594</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>OpenStreetMap</strong></td>
<td>buildings (polygon)</td>
<td>965 092</td>
<td>-</td>
<td>505.6</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>-</td>
<td>5 696 956</td>
<td>389 556.0</td>
<td>121 682.7</td>
<td>-</td>
</tr>
</tbody>
</table>
Map documents

Utilizing the content and the features of the harmonized map database, map documents are created by each pre-defined scale level. These map documents are finally standing for the definition of list and subsets of the source data tables organized in layers in the visual order of the appearance and the particular sets of rules based on principles of cartographic display for displaying and labelling the spatial features. Regarding the symbology and the visual styling and layout, the appearance of the graphical and text elements, map documents are set up and designed to fulfil cartographic requirements in the most possible aspects. Obviously, implementing this intention in practice is affected and limited by the capabilities, the possibilities provided by the GIS application, the characteristics of the source datasets, the available resources and the requirements set against the workflow. Each layer of the map document and display corresponds to a certain conceptual category of real-world objects or phenomena in respect of its role and type in cartographic visualization. In general, the map documents are built up from the ordered sequence of the following layers for visual display (Frye, Eicher, 2003).

- Labels and annotations (dynamic labels and stored annotations):
  - Names of municipalities
  - Names of other built-up areas and town districts
  - Other place names, populated places
  - Names related to elements of the transportation networks:
    - Road numbers and signs
    - Numbers and names of junctions and interchanges
    - Names of rail stations
    - Road and street names
  - Names of places
  - Names of other points of interest, labels of additional description
- Elements of other man-made features:
  - Point symbols of POIs, rail stations, junctions, roundabouts
  - Boundary lines
  - Lines representing the rail network elements
Accordingly for each particular label class.

At global level in the map document, the script controlling the generation of annotations is manipulating this setting for municipality names, but allowed for placing names of streets or POIs. Since this setting is only available to be defined/or set for each labelling class. In order to have more control over the results of labelling (verification, validation), to ensure fulfilling some requirements against the text placement (e.g. names of municipalities should not be duplicated, names should not overlap, certain types of names are required to be guaranteed to be placed at specific scales, etc.), it is decided to follow the approach of storing the labels as annotations. In this context, it means the pre-generation of the map labels and storing them as features (objects, geometries) in the underlying geodatabase with keeping the relation to the referenced map features. Although this process comes with some overhead in preparation, it still saves processing time in the batch export process. One script is controlling the generation of the annotation objects with assigning predefined parameters to each label class and manipulating the global and mutual display and placement settings in respect of the certain class.

As an example in high scale display, polygons of the built-up areas are set as exclusion spaces for placing the municipality names, but allowed for placing names of streets or POIs. Since this setting is only available to be defined at global level in the map document, the script controlling the generation of annotations is manipulating this setting accordingly for each particular label class.

**The platform**

The ArcGIS platform offers the feature of the management of map representations. This feature stands for assigning and storing attributes of the visual display of certain features in respect of the attributes, the applied projection and the scale level. These representation rules do not only support the storage of the graphical styles, but also offer to assign modified, displaced geometries to the source features resulting in an independent and modified graphical representation of the geometry regardless of its original location. Thus, the representation of features with modified geometries is offered without altering the coordinates describing the source feature, finally separating the representation from the geometry. Applying representation rules for features is not only resulting in attributes describing the graphical attributes of the features, but the resulting representations can also be considered as spatial features. This helps creating masks for displaced (dispersed) point symbols and analysing graphical overlaps at certain scale levels. For the current map, representations are created for all the point type symbols drawn on the map and stored separately for each scale level. Geometries derived from the representations of the transport network elements are used in the visualization of bridges, overpasses and the graphical masking of the underlying symbols. Border lines are also stored and drawn as representations, with additional masking applied for the water elements. As for transforming the labels to annotations, representations and masking geometries are also produced executing scripts with pre-defined parameters set for each affected layer and data source.

The source database can be considered as a template, a framework that provides the structure, the rules associated to the datasets and the declaration of the relations between them. During the update procedure, the content of the feature classes (data layers, data tables) are fully replaced with the data imported from the source databases. All data associated with certain features are transposed to the newly imported features by unique identifiers or specific set of matching attribute values. Derived elements, masks, representations and annotations are produced by each update process individually.

- Lines representing the road network elements
- Water features
- Polygons of built-up areas
- Polygons representing other land cover and land use classes (industrial zones, woods, parks)

**Relief**: shaded relief

Besides these common, conceptual categories there are other layers included in the map which stand for helping the placement of labels, define areas excluded from labelling and masking features or labels for certain locations. This data and layers are generated for each map document according to the particular scale. The process of the production of these layers are also automated and helped by functions implemented in VBA macros attached to the map documents. One of the main emphases on the cartographic approach applied in the production of the map series is the optimization of the appearance of map texts. This includes the placement of map labels, the declaration of label classes corresponding to conceptual feature types and finally, the definition of placement and typographic attributes helping the efficient visual distinction of the annotation categories. In the current context of the GIS applications, labelling is standing for placing map text automatically. The ArcGIS platform supplied with the Maplex extension offers a highly customizable and sophisticated, complex tool for placing the names assigned to features on the map. Priorities, weight, order of label classes can be managed, feature weights can be set to avoid map objects, label placement properties (position, fitting, repetition, anchor points, stacking, and overlaps management) along with the range of typographical attributes settings. All layers for labelling are configured individually for their specific role, and labelling settings are set for each labelling class. In order to have more control over the results of labelling (verification, validation), to ensure fulfilling some requirements against the text placement (e.g. names of municipalities should not be duplicated, names should not overlap, certain types of names are required to be guaranteed to be placed at specific scales, etc.), it is decided to follow the approach of storing the labels as annotations. In this context, it means the pre-generation of the map labels and storing them as features (objects, geometries) in the underlying geodatabase with keeping the relation to the referenced map features. Although this process comes with some overhead in preparation, it still saves processing time in the batch export process. One script is controlling the generation of the annotation objects with assigning pre-defined parameters to each label class and manipulating the global and mutual display and placement settings in respect of the certain class.
For the current geovisualization and map production workflow special generalization processes are applied. Geometrical generalization is applied on features by simplifying their shape in respect of the scale level. Augmentation/enlargement of symbols representing features is applied by the definition of the symbology. Selection of features from the source conceptual categories is implemented by the definition of specific subsets of the data layers in respect of the scale and the importance of the data content and feature types.

**Scales**

The content and setup of the map documents covering the range of the scales of the map series can be typified in four scale level categories. Very large scale maps are considered and designed as types of city maps, and include scales 1:4,500–1:18,000. Since these elements are covering the largest scale of the series, these maps are containing the most detailed, richly classified and distributed, and most complex information from the source datasets. In these scales all available transport network elements are drawn with the most possible labels placed. The 38 style classes of the road network elements are resulting in 18 different types of line symbols representing the features, while label classes are covering the categories of road signs and numbers, names of main roads, street names with line label placement and separately the names of places with the same categories and horizontal placements. Railway network features are distributed to rail, city and subway feature categories and all stations and stops are displayed and labelled with their names classified by the type of the stop. All built-up areas, industrial areas, buildings, parks are displayed. Water features are displayed using the topographic data sources with aggregated data categories of rivers, lakes (polygon shapes), streams and canals (line symbols). All administrative boundaries are drawn with line symbols in respect of the type and level of the related unit. All the names of the municipalities, districts and populated places are labelled. Regarding the administrative units, two types of labels are placed: first the corresponding polygon representing the main built-up area is annotated, and in addition, the names are also placed along the border lines multiple times (if necessary).

In very large scales, the point symbols representing the pre-defined elements of the POI database and important buildings are also displayed and labelled with their names. Regarding the priority order of the labels, the following order is taken: names of administrative units, names of built-up areas and populated places, rail stops, road signs and numbers, names of main roads, place names, street names, other names and texts. Except the street names and the names of the administrative units placed along the boundary lines, all other labels are converted and stored as annotations in the map documents covering very large scale levels. Map documents of the largest scale levels are organized in 48 layers and additional 87 thematic layers (sublayers) standing for the symbolization of the features, 14 layers of annotations with 52 label classes, 18 layers providing masking and helping the labelling process and 6 technical layers and tables offering additional and control data for the automated processes.

The next section of scale of the map series is the set of less large and medium scale maps, covering two types of maps: the overview city maps (1:36,000–1:144,000) and the road maps (1:144,000–1:577,000). For the overview city maps, shaded relief is displayed in the background of the map. The coverage information is still represented with polygon features, but along the decreasing scale first the industrial areas and buildings with their size too small for the certain scale are skipped for visualisation. In these scales water features are highly generalized and simplified: only the most important features are displayed. The graphical display of boundary lines is getting more emphasis in order to provide a clear overview of the spatial distribution and extent of the administrative units. The display of the transport network elements is highly simplified along these scales: the representation of the detailed layout of the junctions and roundabouts are replaced with point symbols. Supplementary and low-level features like steps, stairs, bicycle roads, pedestrian zones are omitted, and the display of streets changes to simple line symbols and tends to help to unfold the structure of blocks building up the cities and villages. Only labels of the municipalities and place names referring to the representing polygons, the names and numbers of main roads and places are displayed.

The road maps (1:144,000–1:577,000) are aiming to provide the visualization of the general overview of the transport network and administrative units of the country. Relief is still displayed with hill shading, land coverage information is limited to forests and built-up areas are still shown with polygon geometries. It has been previously set as a requirement that in the scale of 1:300,000, all independent municipalities should be represented with the polygon geometry of the main settlement and also be assigned with labels. In smaller scales, where it was not possible to label all the settlements, the display of the geometry of the built-up area is depending on whether its label was successfully created. Priority of the display and labelling follows the administrative function and the population of the municipalities. Boundary lines are more simplified in these scales, and only higher level units (the capital, the counties and regions) are displayed. The visualization of the transport network elements are restricted to the features of the elements of the countrywide road and rail network with all settlements connected (this is also an important element of the cartographic approach). Labelling covers the road and rail signs and numbers. In these scales, map documents are becoming less complex, and certainly hold and display fewer features. Map document of the 1:300,000 scale contains 35 layers with 52 thematic layers, 8 layers of annotations with 20 label classes, and 14 technical and masking layers. In the smallest scales, covering the
range of 1:1,155,000–1:4,622,000 the main objective is to display a clear overview of the top elements of the transportation network and the administrative structure. Representation of the municipalities are changed to point symbols, areas are only displayed for the cities with high population or spatial extent. Labelling covers the county seats. Road network is drawn highly simplified and limited only to the features of the highways, motorways, first and secondary class main roads and displayed with single line symbols.

PRODUCTION OF THE MAP: CREATING THE MAP TILES

Map tiles generation is the most time consuming part of the map update process. Taking into account the scale levels, the spatial coverage and, as a consequence, the number of the output map tiles, the map tile generation process should be automated. In order to help tile generation, a desktop application has been developed built on the ArcGIS .NET SDK. The application is capable of opening one map document and by “stepping” through square and adjacent map frames (spatial extents) in conjunction with the tiling scheme of the resulting tile-set, on the corresponding scale level of the map document, it renders the map view and exports it to raster files. Output files are two-fold: besides the 256x256 pixel size PNG-format bitmaps applicable for the tiled map services, there are high resolution, merged outputs of multiple neighbouring tiles also created. Although most of the features of the source datasets are stored in the Hungarian EOV projection (Uniform National Projection system) and coordinate system, the projection of the underlying geodatabase and the output tiles is the WebMercator projection. The output files can be handled in map server applications for high resolution display and seamless scaling. Tiles for the highest scale are processed in 72 to 96 hours for the whole country, while the entire tile-set requires about six days of processing. The range of utilization of the output map tiles is quite wide. Since both the dimensions, the format and the naming of the files are following the TMS standards (Tile Map Service naming scheme), common web mapping frameworks are capable of utilizing the map series by default (e.g. OpenLayers, Leaflet). The high resolution merged map tiles are completed with world files and projection information, which allows their adequate display in GIS applications and map server applications. The map series is updated quarterly. The overall map update process starting with receiving the source datasets and ended with publishing the output raster tiles is taking 7 to 8 days (Table 2).

<table>
<thead>
<tr>
<th>TMS zoom level</th>
<th>Number of map tiles</th>
<th>Size (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>2 153 982</td>
<td>4 841</td>
</tr>
<tr>
<td>16</td>
<td>553 335</td>
<td>2 680</td>
</tr>
<tr>
<td>15</td>
<td>142 149</td>
<td>1 493</td>
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<td>14</td>
<td>46 134</td>
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<td>13</td>
<td>13 738</td>
<td>208</td>
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<tr>
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<td>3 523</td>
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<tr>
<td>11</td>
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<tr>
<td>Total</td>
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</tr>
</tbody>
</table>

Publication

Along with output formats and files the map series is published in several ways. The most obvious method of publication is making the output tiles corresponding to the TMS standard available in web services: 256x256 pixel size, 24 bit, 96 dpi PNG raster images (map tiles) are produced and finally offered in a web resource. High resolution map tiles are published in Geoserver, a web mapping server application. Geoserver implements the most prevalent web mapping standards and conforms to the OGC standards of WMS and WFS. The application is able to manage a tiled set raster file as a virtual mosaic and on receiving request about a certain set of map tiles on any extent and scale it responds with a merged view of the map tiles. This general service of the private company is available for the public use and special, customised services are generally based on this cartographic representation, but the visualisation can be different for other services: https://terkep.geox.hu.
FUTURE/DEVELOPMENT

The company plans to develop further the map database aiming at converting it into a cartographic database and utilising its content and features as a source for other publication methods like vector tiles (Figure 7). Advanced, complex generalisation methods are to be implemented along with their automation. The plan also includes extending the content with more data sources as well as migrating features form the Corine Land Cover and OpenStreetMap databases.

Figure 7. The screenshot of the vector-based on-line map service of GeoX

CONCLUSION

The current map product offers an adequate and consequent visualization of the map datasets maintained and offered in other products of the company and also stands as the most efficient content for demonstrating the value and the utilization of the products and services developed by GeoX. Regarding the map production process, developments have been continuously implemented both in optimizing and automating the import procedures, the symbology, the labelling rules and the efficiency in the map documents, and the adaptation of the outputs to necessary standards.

In the beginning (twelve years ago), at the invention of the idea of creating a private map service, the question was if it were possible to deliver the results with respectable and correct information using realistic and reasonable amount of human and time resources. By today, the current map has already been a standalone product of the company. Specific versions (with varying content and symbology) are designed and produced for several clients and the generated map data is re-used and served as supplementary data in our base GIS datasets.
REFERENCES

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BIOGRAPHY

Gábor NYŐGÉRI
MSc in Cartography and Geoinformatics, 2018, ELTE Eötvös Loránd University, Budapest, has been employed at GeoX Ltd. since 2004. Main tasks are publishing and visualizing spatial data, designing and implementing specific initial (and background) spatial databases for different projects and goals, automation issues of data-processing. Having wide experience in data-modelling, data-analysing, data-visualization, map production and using a wide range of data-source-types and GIS-applications. Responsible for designing, building and maintaining map services of the company.

László ZENTAI