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SURVEYING AND CARTOGRAPHIC ASPECTS OF UTILITY NETWORKS IN SLOVAKIA AND POLAND

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Summary

Utility networks provide transport for various types of raw materials. They comprise a network of pipes, cables and ducts running on, under and above the surface of either ground or water. They connect individual customers with distributors within water supply, sewage, heating, telecommunications, electricity, as well as oil, gas and chemical networks. They serve an extremely important role in today's urbanised world. However, utility networks require specialised treatment not only in legal, technical or social terms, but also geodetic and cartographic.

It is necessary to conduct a precise and accurate inventory to prepare and implement projects of utility networks, as well as all kinds of other construction works. Mapping is another task required, along with the preparation of databases on networks that provide comprehensive (graphic and descriptive) information on objects. In each country, the execution of surveying and cartographic works observes internal laws and technical standards and norms. This paper presents the issues of surveying and cartographic works in relation to utility networks, as well as their implementation in Slovakia (Bratislava) and Poland (Kraków). The rules for the presentation of networks on maps, as well as technical standards for collecting, processing and sharing network databases based on legal provisions that are valid for both countries, were compared.

Keywords

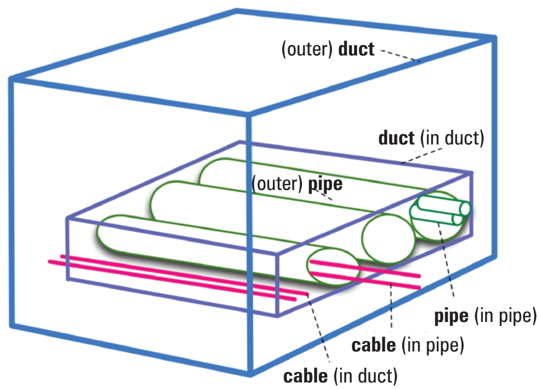
utility networks • cartography • cartographic objects • legal and technical standards

1. Introduction

Utility services and networks refer to physical infrastructure used for the transportation of various types of products and raw materials. We distinguish the following types of utility objects: pipelines (for transporting water, sewage, oil, and gas), transmission lines (of electronic and telecommunications networks), cables or other elements enabling the transport of products. Such transmission lines (networks) are deployed both on land and on water, they can run underground, under the water, as well as an overground network in the air. All types of transmission systems and networks have nodes, which connect devices designed for the production of various types of raw materials with devices that process them. Six basic types of utility networks are distinguished: water supply network, sewage network, heating distribution network, telecommunications network, electricity network, as well as oil, gas and chemical network [INSPIRE 2021].

Public utility networks come in different types (pipes, cables, ducts) and are set up in different ways (ground, underground and overground networks). Then, the basic types of networks refer to the connections that generate a model of their real-life relationships. There are various types of wire, duct, pipe and cable configurations (Fig. 1). All these relationships require appropriate design, as well as subsequent accurate inventory [INSPIRE 2012].

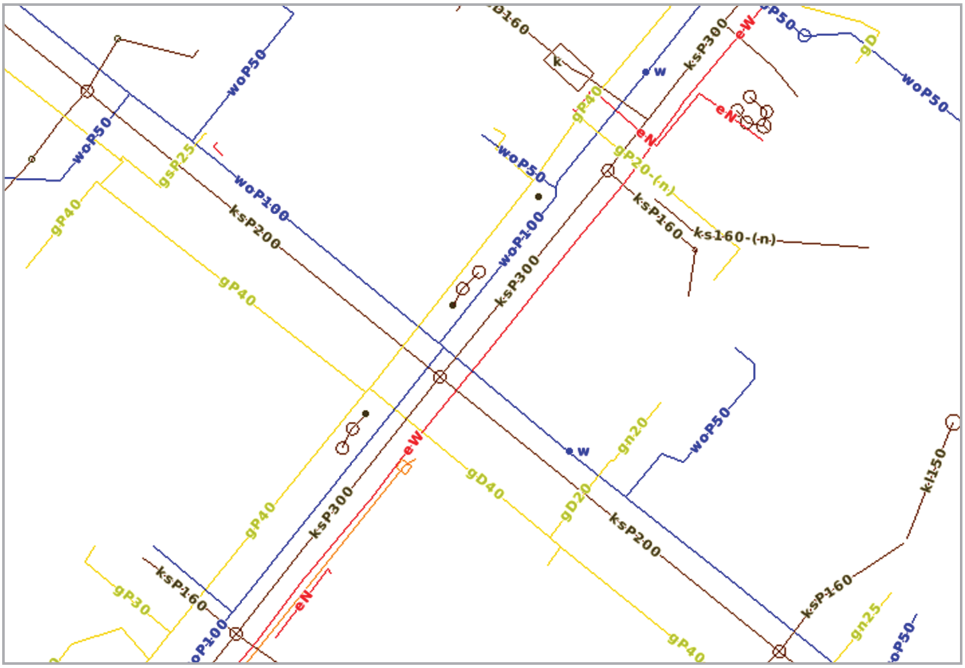
Utility networks are the medium that transports raw materials from extraction or production point to their destination – i.e. all types of intermediaries and users of raw materials. This ranges from residential buildings to public facilities, companies and businesses to huge multinational corporations and every single user of raw materials (Fig. 1).



Source: INSPIRE [2012]

Fig. 1. Physical relations between cables, pipes and ducts

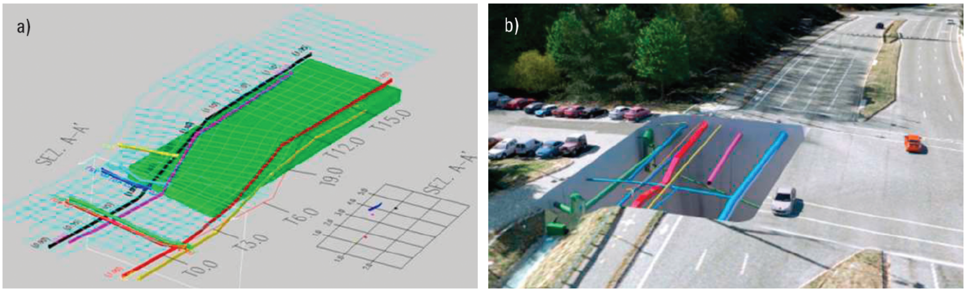
Growth of world population and urban development have increased the need for various basic utility services such as electricity, water, sewerage, gas and others. Cities, especially highly urbanised ones, show the greatest demand for such services, which need constant development, installation of new networks, as well as numerous maintenance and repairs of existing facilities. For this reason, it is so important to conduct proper inventory, marking and mapping of these networks [Lester and Leonard 2007]. Most of the utilities are installed in the ground under the streets and sidewalks. The assigned information on their location, as well as the ordinate depth of their foundation, have been (should be) presented on an appropriate map in such a way that they can be located and identified quickly and without errors in the field. Unfortunately, many of these networks were made many years ago, and the information about their routes is scarce, and sometimes unavailable. Conducting construction, renovation and other works related to their excavation can be dangerous and risk disrupting the network. Due to the difficulty of assessing the condition and direct course of public utility networks from the surface of the ground, it is so important to create appropriate documentation, e.g. in the form of two- and three-dimensional maps of all networks along with spatial and descriptive information being their integral part [Aydin 2008; Jaw and Hashim 2013; Boates at al. 2018].



Source: mapy.geoportal.gov.pl

Fig. 2. An example of a map of the utility networks

Accurate knowledge of the location and routes of networks is particularly important in places where the design and construction process of all types of structures is carried out. As part of the inventory of newly created networks, geodetic measurements are taken in the so-called open excavation or exposed sites (opencasts) allowing the type of network and its position in space to be precisely and accurately determined – especially in places where there are bends, changes in the foundation height, changes in the types of the network, crossings of different types of networks, the presence of technical facilities, as well as all kinds of technical devices used to operate the network. As part of surveying measurements, various types of techniques, methods and tools are used to obtain information on the location of individual points on the network in a three-dimensional space (X, Y, Z). These include tachometers, levellers, GNSS receivers, photogrammetry, laser scanning, as well as – if the existing network runs underground – georadars and other types of detectors enabling identification and determination of the network location. Then, in the process of collecting and processing information, cartographic studies prepare maps or 3D models [Yan at al. 2018], and even photorealistic visualizations (Fig. 3 a, b) [Sărăcin 2017]. The studies should include not only the drawings (models) of the existing network, presenting its location and height in specific places, but also all descriptive information on a given network and its components. Finished studies should be prepared in a way that allows easy and quick integration of data into geographic information systems (GIS) [Sărăcin 2017].



Source: Sărăcin [2017]

Fig. 3. Presentation of utility networks in a three-dimensional form: a) 3D map, b) virtual-realistic image

Any measurements intended to map the routes of underground networks must be taken in accordance with the adopted accuracy standards presented in the form of guidelines provided by the authorities. These guidelines should include information on the principles of field measurements (including the required quality and accuracy levels), the mapping of networks, the level of quality of network data and its extent, the form of the map or possible network design, as well as the development of an underground utility database. With accurate and precise information recorded in the form of a map (database), catastrophic damages to underground utilities and adjacent surfaces can be avoided, and disruptions to existing network services resulting from 'blind' excavation works can be reduced [Jaw and Hashim 2013]. As reported by the European Commission [INSPIRE 2012]: rough pipeline and utility service databases exist at the European level. An example of such a solution is the GISCO database, implemented at a scale of 1:1 000 000. However, the data held and processed by individual countries are heterogeneous, significantly hampering their mutual integration. In many countries (including Poland and Slovakia) there are maps at local, regional and national levels that show the location of public utility networks, e.g. as dedicated Geoportal websites.

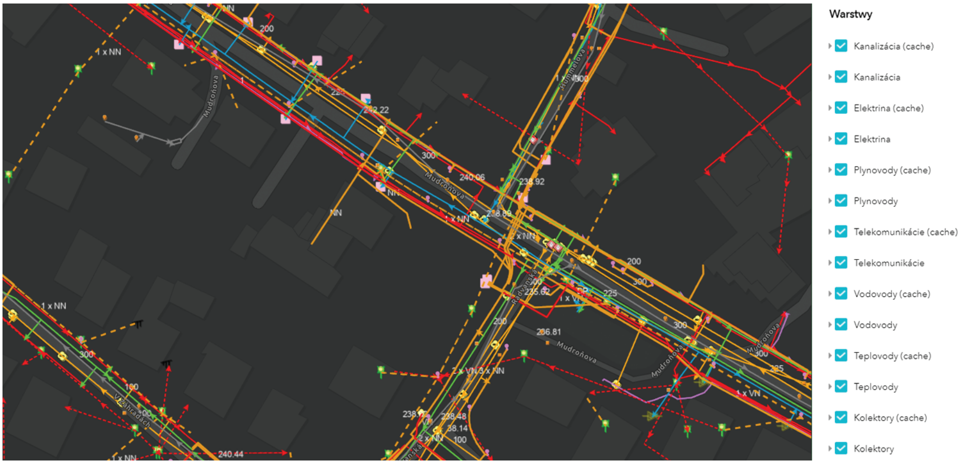
The purpose of this paper is to discuss and conduct a comparative analysis of the rules of operation of the register of utility networks in Slovakia and Poland. Utility networks (i.e. water, gas, electricity, sewage, telecommunications and others) are one of the most important elements of land development, ensuring its economic, industrial and construction properties. Due to differences in the way these objects are presented in different countries, or even in different regions of Slovakia, databases on utility networks for Bratislava (Slovakia) and Kraków (Poland) were used as an example. The rules for the presentation of networks on maps, as well as technical standards for collecting, processing and sharing network databases based on legal provisions that are valid for both countries, were compared.

2. Legal issues in the field of surveying and cartographic service of utility networks in Slovakia (Inžinierske siete)

According to the Slovak Central Government Portal (Ústredný portál verejnej správy – ÚPVS) utility networks (Inžinierske siete) are distribution networks in the form of ground and underground transmission systems for gas, electricity, water, sewage, telecommunications networks and individual connections to households. All connections to utility networks must be properly secured, marked and publicly available [www.slovensko.sk].

The register of utility networks under the Slovakia's national regulations is maintained by the relevant industry services. This system is governed by relevant laws, which set out the rules for obtaining, storing, processing and making available information on individual utility networks. Under the Act "Zakon z 19. júna 2002 o verejných vodovodoch a verejných kanalizáciách a o zmene a doplnení zákona č. 276/2001 Z.z. o regulácii v sieťových odvetviach", the following information is regulated: water supply and sewage networks [442/2002 Z.z.]; telecommunications networks and all types of electronic communications: Zákon o elektronických komunikáciách [Zákon č. 452/2021 Z.z.; Zákon č. 533/2021 Z.z.]; energetic networks, i.e. power, gas, oil and heat: Zakon z 31. júla 2012 o energetike a o zmene a doplnení niektorých zákonov [251/2012 Z.z.].

Public utility networks are also registered and accessible through municipal offices, in so far as they have such datasets. The capital city of Bratislava on the basis of the current Regulation No. 1/1995 of 23 March 1995 on the digital technical map of Bratislava (Všeobecne záväzné nariadenie hlavného mesta Slovenskej republiky Bratislavy č. 1/1995 z 23. marca 1995 o digitálnej technickej mape Bratislavy) carries out the register of utility networks within the city boundaries. The contractor (network manager) is obliged to provide documentation of the position-height measurements taken on the site (during construction or modernisation) in the form of a measurement sketch and list of coordinates or in the form of a measurement sketch and a data file (e.g., in *.dxf format) [VZN 1/1995]. Access to information about the route, kind and type of network is also included on the city's official website https://geoportal.bratislava.sk (Fig. 4).



Source: https://geoportal.bratislava.sk/pfa/apps/sites/#/verejny-mapovy-portal/pages/technicka-mapa

Fig. 4. Fragment of the map of the public utility network of the city of Bratislava

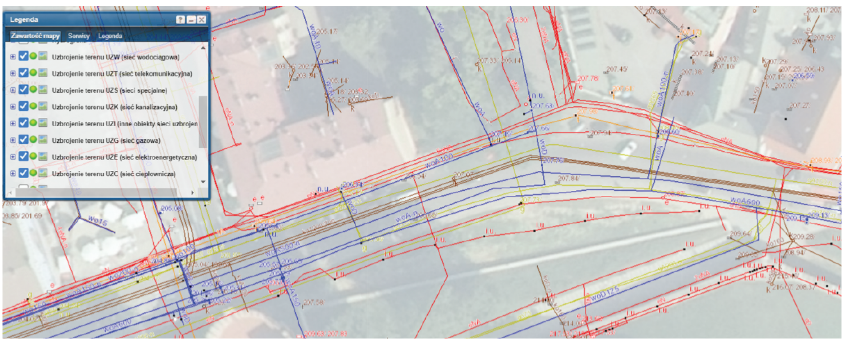
3. Legal issues in the field of surveying and cartographic service of utility networks in Poland (Sieci uzbrojenia terenu)

According to the Geodetic and cartographic law (Prawo geodezyjne i kartograficzne, Dz.U. 1989 Nr 30 poz. 163) "all kinds of overground, ground and underground wires, ducts and devices transporting water, sewage, gas, heating, telecommunications, power and other, excluding detailed land improvement devices, as well as underground structures which are not buildings in the meaning of the regulations on public statistics" are defined as utility networks. The GESUT database functions as a part of the Polish system – "surveying register of utility networks, which according to law is defined as an information system ensuring the collection, updating and sharing of information on utility networks, in a uniform manner for the entire country". GESUT includes all information on the routes, types and functions of utility networks from the design stage, through the facilities under construction, to the existing networks. The database collects information on the location, purpose and basic technical parameters of these networks, as well as the entities that operate them (Dz.U. 1989 Nr 30 poz. 163).

The routes of the utility networks and the location of all technical devices are subject to geodetic service. The principles of marking and inventory, as well as the accuracy level of the measurement of utility networks carried out, must comply with the guidelines provided by law. All elements of public utility networks, as well as related technical devices, must be inventoried with the highest possible accuracy (to at least 10 cm) (Dz.U. 2020 poz. 1429).

The system (GESUT) is built as an object database, maintained uniformly and consistently throughout the country. This database collects information about water, sewage, gas, heating, telecommunications, and special and unidentified networks. The register of utility networks (as well as setting up and running the system) are the responsibility of the district administration – the GESUT district database, the Surveyor General of Poland (Główny Geodeta Kraju) – the GESUT national database (k-GESUT) [Dz. U. 1989 Nr 30 poz. 163; Dz.U. 2021 poz. 1374].

The GESUT district database is established and maintained by processing source materials that are data and information. This database is created and maintained in the ICT system on the basis of materials accepted into the state geodetic and cartographic resource; documents that were the result of coordination meetings, data and information obtained from entities in charge of the networks, as well as data and information obtained from other public registers. By processing the data and information contained in the GESUT district databases (together with additional information), the GESUT national database is established and maintained. The information contained in the district GESUT database and the national k-GESUT database is available electronically through web browsing and downloading [Dz.U. 2021 poz. 1374]. The data are presented via Geoportal, a geoinformation website for the entire country (www.mapy.geoportal.gov.pl), or via local websites, such as the Małopolska Infrastructure for Spatial Information website for Kraków (Małopolska voivodeship) – www.miip.geomalopolska.pl (Fig. 5).



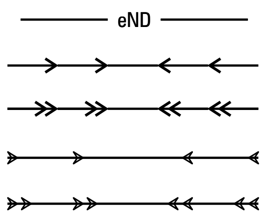
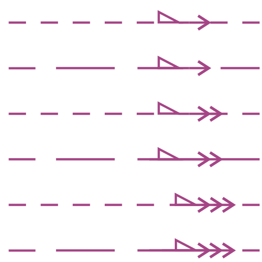
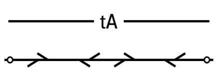
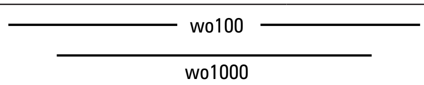
Source: https://miip.geomalopolska.pl/imap/#gpmap= gp15

Fig. 5. Fragment of the map of Kraków utility networks

4. Comparative analysis of cartographic technical aspects of the operation of utilities in Poland and Slovakia

A comparative analysis of utility networks was presented in the form of a table (Table 1) with a Summary and graphic presentations of individual kinds and types of networks on the map.

Table 1. List of cartographic signs of utility networks used on maps in Poland and Slovakia

Poland	Slovakia
Types and basic designations of networks	
Overground: Solid line with the symbol appropriate for the relevant type and kind of network + colour in RGB (according to the type of network). On the ground: Solid line + description (by network type) + colour in RGB (according to network type), Underground: Solid line + description (by network type) + colour in RGB (according to network type).	Overground: Underground: Underground (unverified axis):
Network description	
Descriptions of utility cables are formulated according to the diagram described below: 1) designation of the kind of utility network; 2) designation of the type of utility network; 3) designation of the source of location data, 4) designation of the diameter of the cable or the vertical and transverse dimensions, 5) if the cable is out of service – the "OOS" sign [Rozporządzenie w sprawie standardów].	Designations and descriptions of networks are presented by a cartographic sign appropriate for the kind and type of network
Electricity network	
 underground network NN, overground ŚN, overground VN, overground RGB colours 255, 0, 0	 NN, overground NN, underground VN, overground VN, underground VVN, overground VVN, underground
Telecommunications network	
 underground network overground network	 underground network overground network
Water supply network	
 RGB colours: 191, 191, 0 When the value of the diameter expressed on the map scale is less than 1.5 mm, the cable is represented by a cable axis. For larger values of the diameter, cable edges are drawn.	

Sewage network	
ks100 kd1000 RGB colours: 210, 0, 210 When the value of the *diameter* expressed on the map scale is less than 1.5 mm, cable is represented by a cable axis. For larger values of the *diameter*, cable edges are drawn.	
Gas network	
gn50 gn140 RGB colours: 191, 191, 0 When the value of the diameter expressed on the map scale is less than 1.5 mm, the cable is represented by a cable axis. For larger values of the diameter, cable edges are drawn.	
Heating network	
cn150 cw900 RGB colours: 210, 0, 210 When the value of the *diameter* expressed on the map scale is less than 1.5 mm, cable is represented by a cable axis. For larger values of the *diameter*, cable edges are drawn.	
Special network (e.g. petroleum network)	
S	
Other unidentified networks	
x100 x1100 RGB colours: 0, 0, 0 When the value of the *diameter* expressed on the map scale is less than 1.5 mm, the cable is represented by a cable axis. For larger values of the *diameter*, cable edges are drawn.	

Author's own study based on: Dz.U. 1989 Nr 30 poz. 163; Dz.U. 2021 poz. 1385; Zákon č. 215/1995 Z.z.; STN 01 3410; Hudecova and Kysel [2019]

All utility networks consist of cables and technical devices. Graphical representations of routes for every kind and type of networks on the maps is presented in a tabular form (Table 1). The network routes are linear, which means they can be located in the field. Standardised cartographic symbols are used for the identification of technical equipment, presented on the map in the form of point signs, which have been compiled in Poland in a legal act (Dz.U. 2021 poz. 1385), whereas in Slovakia they are articulated as a technical standard [STN 01 3410].

5. Summary and conclusions

Utility networks are the medium that transports raw materials from extraction or production point to their destination – i.e. all types of intermediaries and users of raw materials. Public utility networks come in different types (pipes, cables, ducts) and are set up in different ways (ground, underground and overground networks). Although each country follows different principles of their recording, as well as processing and sharing of information on their routes and functions, the general principles of obtaining information through surveying inventory, as well as the possibility of making information about the routes of networks available to relevant institutions operate in an open way to ensure access to reliable information.

Both in Poland and Slovakia, principles and procedures for obtaining, collecting and sharing information on utility networks have been formulated. However, respective systems of recording information on utility networks are run differently. In Poland, in the form of the GESUT database (Geodezyjna Ewidencja Sieci Uzbrojenia Terenu, i.e. the Geodetic Register of Utility Networks) implemented within the framework of district databases maintained by the district administration and the national database (k-GESUT) maintained by the Surveyor General of Poland. In Slovakia, the network register database is implemented by the institutions belonging to each industry. Each public utility network is operated separately by the relevant industry body. Slovakia also has urban registry databases, which, however, are only maintained for large agglomerations, i.e. Bratislava. In both countries (as part of the Geoportal geo-information website), it is possible to view information on the routes of utility networks; while in Poland it covers the entire country, in Slovakia such information is provided on a regional scale. This stems from how information on networks is acquired, collected and shared. In Poland, this is carried out within the framework of a nationally uniform base map containing the GESUT database. In Slovakia, there are technical maps, which serve on the basis of local regulations, e.g. in force in the city of Bratislava. Local regulations define the method of mapping and presentation of data on maps. These principles may vary depending on the region.

The legislators in both Poland and Slovakia have prepared a number of legal provisions and standards and principles for maintaining databases on utility networks. These rules include the need to use an appropriate and uniform sign system, covering different types and kinds of networks, as well as cartographic descriptions used in maps. To obtain information on networks a geodetic inventory of the network is also required. It is therefore mandatory to obtain, collect and share network data with the users and institutions concerned. However, at the moment it is not possible to directly integrate databases on utility networks in Poland and Slovakia in accordance with the

INSPIRE Directive [INSPIRE 2012]. It is necessary to find agreement on the consistency and coherence of such record, and the extent of the processed data. In Poland, the k-GESUT database functions uniformly and coherently for the entire country. In Slovakia, the network records are kept by individual industry groups for each type of network, as well as by the city offices – within their boundaries and in accordance with their own (regional) requirements and standards.

The utility network system both in Poland and Slovakia operates correctly, providing access to information for users and institutions concerned. The cartographic studies that constitute the graphical presentation of the information contained in these databases are carried out according to similar principles with observance of the rules and technical standards obligatory in the country in question, with the use of appropriate graphic signs and descriptions, and with setting up a database that includes all relevant information on the networks.

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533/2021 Z.z.: Zákon, ktorým sa dopĺňa zákon č. 452/2021 Z.z. o elektronických komunikáciách a ktorým sa mení a dopĺňa zákon č. 355/2007 Z.z. o ochrane, podpore a rozvoji verejného zdravia a o zmene a doplnení niektorých zákonov v znení neskorších predpisov.

452/2021 Z.z.: Zákon č. 452/2021 Z.z. Zákon o elektronických komunikáciách.

251/2012 Z.z.: Zákon z 31. júla 2012 o energetike a o zmene a doplnení niektorých zákonov.

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