

UPDATING DIGITAL TECHNICAL MAPS FOR THE NEEDS OF BUILDING DESIGN

Ondřej Vystavěl^{*,1}

*ondrej.vystavel@vutbr.cz

¹Brno University of Technology, Faculty of Civil Engineering, Institute of Geodesy, Veveří 331/95, 602 00 Brno

Abstract

The aim of the paper is to present selected experiences with the updating of the digital technical map (DTM) data set after less than a year of its operation, to specify its advantages from the surveyor's point of view and its consequences for building design. When updating the basic spatial situation (ZPS) data set, problems were identified concerning photogrammetric surveying, the unprofessional vectorisation of mobile mapping data, and inconsistencies between digital technical maps and digital cadastral maps. Problems were also identified during the update of the transport and technical infrastructure (DTI) data set, these being the incompleteness of available data and the incorrect assignment of descriptive attributes.

Keywords

Digital technical map, basic spatial situation, surveying

1 INTRODUCTION

On 1 July 2024, digital technical maps (DTMs) were introduced in the Czech Republic. According to Act No. 200/1994 Coll., they are maintained for the territory of individual regions [1]. Together with cadastral maps and orthophoto, they form a functional unit in the Digital Map of Public Administration (DMVS) [2]. The structure and contents of DTMs are regulated by Decree No. 393/2020 Coll. [3].

Digital technical maps contain two basic sets of data, which are initially compiled and updated in different ways, namely:

- Basic spatial situation data (“základní prostorová situace” – ZPS)
- Transport and Technical infrastructure data (“dopravní a technická infrastruktura” – DTI)

Responsibility for the accuracy, completeness and timeliness of *transport and technical infrastructure* data rests with the relevant owner/manager/operator or an external editor authorised by the owner/manager/operator (if the owner/manager/operator is not the editor of their own data).

The *basic spatial situation* data is handled differently. The editor is the administrator of the digital technical map of a given region, i.e. the competent regional authority in the case of delegated competence. Updating of the basic spatial situation is only possible on the basis of the *Geodetic basis for maintaining the digital technical map* (§ 5, subsection 4, [3], referred to as the *geodetic update documentation*, abbreviated as GAD [2]). The submission of GAD to the administrator of the digital technical map of a given region is the responsibility of the developer if their activity results in the creation, modification or termination of a structure or facility that is the contents of the ZPS.

GAD, being the result of surveying work, must be verified by an authorised survey engineer (AZI) authorised under §16f, subsection (1), letter c) [1]. The accuracy, completeness and timeliness of GAD are the responsibility of the AZI who verified it.

When applying for a building permit, the developer must provide what is termed the GAD record identifier, which proves that the obligation to submit data on changes to the contents of a digital technical map has been fulfilled. This identifier must also be provided in the notification to the competent building authority for buildings not subject to approval.

DESCRIPTION OF THE PRESENT STATE

The following is an overview of the legislation related to the DTM:

- Act No. 200/1994 Coll., on Land Surveying [1]
- Act No. 283/2021 Coll., on the Building Act (new) [4]
- Decree No. 393/2020 Coll., on digital technical maps [3]
- Decree No. 131/2024 Coll., on documentation of buildings [5]
- Methodology for geodetic surveying of ZPS DTM and for working with documentation (State Administration of Land Surveying and Cadastre – ČÚZK) [6]
- Methodology for acquiring digital technical map data (ČÚZK) [7]
- Methodology for the ZPS DTM Regional Editor (ČÚZK) [8]

DATA AND METHODS USED

The analysis was carried out using ZPS DTM data from selected sites downloaded from the DMVS portal [2] in JVF exchange format, which the authors further treat as anonymised data. Classical geodetic data acquisition methods were used as reference control measurements - tachymetry with georeferencing to S-JTSK and Bpv using GNSS-RTK with the control point accuracy corresponding to class 1 accuracy according to ČSN 01 3410. The data were acquired in cooperation with the company GEODETIKA s.r.o.

The aim of the paper is to present selected experiences with the updating of the digital technical maps data set, to specify its advantages from the surveyor's point of view, and to present the methods used in the initial compilation of the DTM data with the new mapping of regional roads and the territory of the administrators of the defined territory. During the ZPS update, problems were identified concerning photogrammetric surveying, the unprofessional vectorisation of mobile mapping data, and inconsistencies between digital technical maps and digital cadastral maps. Problems were also identified during the update of the transport and technical infrastructure (DTI) data set, these being the incompleteness of available data and the incorrect assignment of descriptive attributes.

2 BENEFITS OF DIGITAL TECHNICAL MAPS

During the construction process, a large number of documents are produced, including as-built documentation of underground and aboveground assets, particularly in the case of the construction of transport and technical infrastructure. This documentation, often in proprietary formats, has at best remained within the internal systems of DTI owners or facility managers. The introduction of DTMs is beneficial in the sense that the acquired data is collected in a consistent manner in a central repository.

According to [9], from 2010 until 1 July 2024, municipalities could maintain a technical map of the municipality (TMO), but it was not produced according to a uniform methodology and data model. Therefore, another benefit of DTMs is the unification of the procedure for inputting and updating DTM data by introducing a machine-readable standardised format, known as the unified exchange format (JVF DTM). The data model is described in the DTM data model dictionary [10], which specifies, among other things, how objects are to be measured in the field. A detailed description of the process relationships involved can be found in the DTMwiki web pages administered by the DTM methodology working group [11]. The requirements for data acquisition for DTMs are currently systematically addressed by the DTM requirements catalogue [12].

Another very significant change brought about by DTMs is the need to capture objects in the field in 3D, i.e. both position and height. This implies the need for data processing in the form of 3D vector drawings, which have been introduced, for example, in the data models of the Railway Administration (SŽ) and the Road and Motorway Directorate (ŘSD). Real world objects are represented as 3D perimeters, while individual 3D spatial edges can be drawn with additional lines (Fig. 1 and Fig. 2).

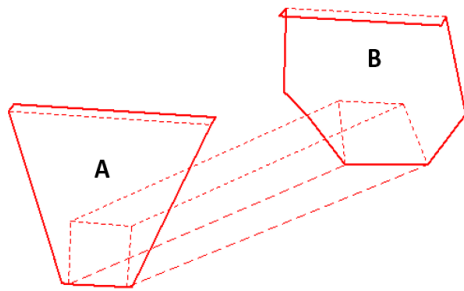


Fig. 1 Solid lines = face of a culvert – 3D perimeter, dashed lines = bottom - bottom of the culvert, dotted lines = optional internal subdivision of the structure.



Fig. 2 Photo showing face A of the culvert depicted in Fig. 1 in reality.

Another advantage of DTMs is the need for drawings to exhibit topological purity, controlled by automation, and a flat topology, resulting in the creation of ZPS objects that can be processed by standard GIS tools. An example of a ZPS representation is shown in Fig. 3. In the DMVS information system, the areas with flat topology are shown in colour.

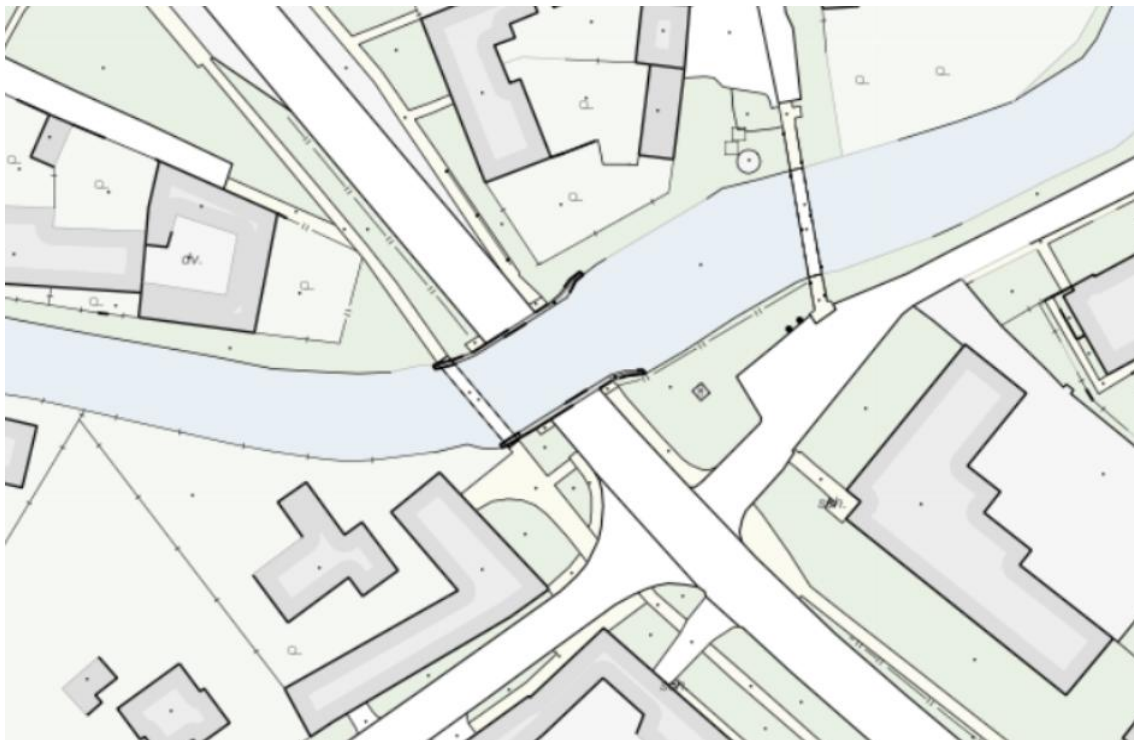


Fig. 3 Example of a ZPS with flat topology.

3 INITIAL COMPILATION OF ZPS DATA

The data of the basic spatial situation (ZPS) data set are processed according to a unified methodology, and their use is assumed to be in the public interest. This is because they are employed for the automated expression of the existence of technical infrastructure for the needs of urban planning and construction processes and for the needs of authorities, municipalities, designers, surveyors, etc. The ZPS does not yet cover the entire territory of the country continuously, but the data are mainly generated where they are needed.

These are also guaranteed data; for all newly acquired position and height data at least accuracy class 3 is required (although not specified in the current version of Decree [3], it is understood that according to ČSN 01 3410, $\sigma_{x,y} = 0.14$ m, $\sigma_h = 0.12$ m). Although the current version of Decree [3] does not specify the limit deviations or how the accuracy is to be assessed (whether according to ČSN 01 3410 or according to cadastral rules), the geodetic basis for digital technical maps (geodetic update documentation – GAD) must be verified by an authorised survey engineer (AZI) with the appropriate authorisation.

Prior to the start of the DTM service, what was termed the initial compilation of ZPS data was carried out. The experience of updating the different types of data for the initial populations during the preparation of GAD, which is always based on existing ZPS data, is described below.

New mapping of regional roads

In most cases, the ZPS was completely remapped in a strip at least 15 m wide on both sides of the road axes due to the obligation of regions as owners of 2nd and 3rd class roads to import data on this transport infrastructure to the DTM data set, and the obligation of the regions to maintain the ZPS.

The undeniable advantage of the new mapping approach is the creation of data in accordance with the currently valid data model (means of data acquisition (points on objects – position and height, the degree of generalisation, etc.)). Given the large number of kilometres of these roads, mapping is carried out using mobile mapping systems. It should be noted that this was performed without the existence of standardised and validated measurement methodologies.

Consolidation of existing Technical Maps of Municipalities (TMO)

The existing technical maps of municipalities (TMOs) were also used for the initial compilation of the ZPS. They were processed into a digital technical maps of municipalities (DTMO) and integrated into the DTM data set by the united exchange format (JVF). Individual municipalities were requested by the regional authorities to provide TMO data, which were then assessed for suitability for reworking. The TMO data were then classified into accuracy classes 3 to 5 based on control measurements. If the accuracy was not sufficient for classification in any accuracy class, attribute 9 was used instead of the accuracy class.

The process of reprocessing data from TMOs or other sources has been partially automated, particularly with regards to the conversion of vector drawings to the DTM data model, including the filling in of descriptive attributes, often with escape values for the 'not identified' status attribute. The method of acquiring the object position and height data from the DTM data model was not investigated. Another aspect not addressed was the incompleteness of the data. If an object type, such as a staircase, is missing in the existing data, it cannot be converted to the DTM data set.

Managers of defined territories

Due to the fact that two large state companies, the Railway Administration (SŽ) and the Road and Motorway Directorate (ŘSD), have their own infrastructure spread across the territory of the whole country, it was agreed that they would also perform the ZPS data collection in their own “defined territory”, in addition to their statutory obligations. Therefore, in addition to the 14 regional DTMs, there is also the Digital Technical Map of Railways (DTMŽ) and the Digital Technical Map of the Road and Motorway Directorate (DTM ŘSD). Both organisations have their own information system, which is compatible with the individual DTMs through the JVF and the DMVS tool.

The SŽ and ŘSD have long had their own regulations for the collection of geodata, and surveying activities for construction work related to their infrastructure are not possible without their knowledge [13]. As far as the assets

they manage are concerned, ZPS data collection is carried out from their information systems. The data transfer and its connection to the regional DTMs is gradually being addressed but the pace is slow due to the large volume.

4 CURRENT ISSUES WITH UPDATING THE ZPS DATA SET

The unprofessional vectorisation of mobile mapping data

When a mobile mapping system based on laser scanning technology is used for data collection, the current contents of the basic spatial situation (ZPS) data set must be correctly vectorised.

Fig. 4 shows a drainage trench between culverts, with the upper terrain edges parallel to the roadway and pavement. The upper edges of the trench are just made by connection the opposing edges of the culvert faces.



Fig. 4 Drainage trench in reality.

Fig. 5 shows an example of the ZPS reference data. The upper edges of the trench are incorrectly vectorised as being oblique to the edge of the roadway, which does not correspond to reality. Fig. 6 shows an example of the correct vectorisation of the top edges (in green).

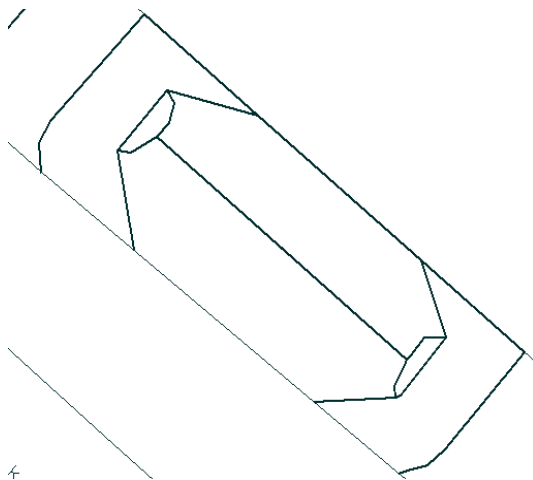


Fig. 5 ZPS – incorrect interpretation from mobile mapping data.

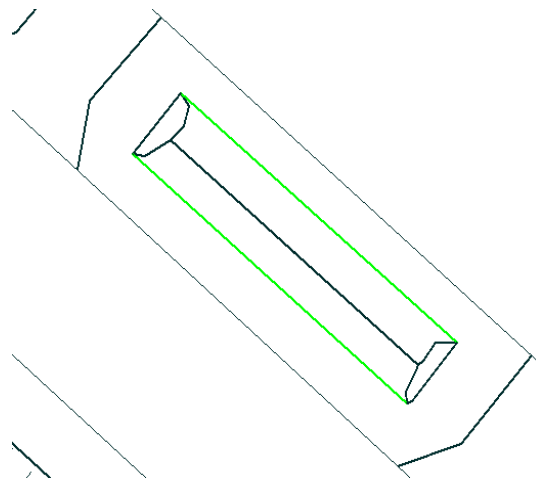


Fig. 6 ZPS – how it should be (green lines) – correct interpretation.

The shape of the culvert face itself is also misinterpreted in this example. In Fig. 7, the geodetic measured as-built shape of the culvert face (symmetrical on both sides of the culvert axis) is shown in red, while the black shape is the state from the ZPS reference data generated by vectorising the mobile mapping data. The deviations in position between the corresponding edges are up to 20 cm.

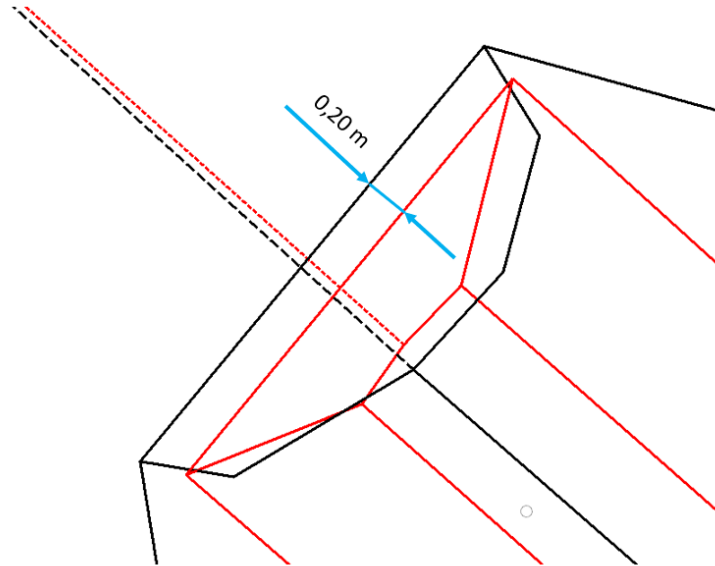


Fig. 7 Difference between the true shape of the culvert face (red) and the shape from the mobile mapping system (black).

Incomplete photogrammetric survey

Another example of problematic basic spatial situation (ZPS) data acquisition comes from the new maps gained via photogrammetry. Fig. 8 shows an example of incorrectly measured object, a stone arch bridge. Fig. 9 is an example of its interpretation in the ZPS data set. The correctness of the drawing corresponds only to the superstructure of the bridge as seen from above, while the drawing of the heel of the arch does not correspond to reality. The retaining walls along the footpath under the bridge are also incorrectly shown. Therefore, the photogrammetrically unmeasurable areas were not remeasured. But the flat topology has been solved – it appears that a complete survey has been carried out.



Fig. 8 The surveyed arched stone bridge in reality.

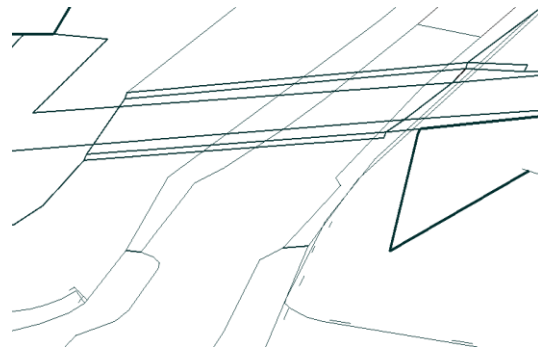


Fig. 9 Drawing based on the photogrammetric data acquired for the stone bridge. The drawing does not correspond to reality.

Fig. 10 is an example of the current state of a small urban road. Fig. 11 is the road shown in the ZPS data set (a 3D view): the red lines are the true shape (terrestrially determined), while the black lines represent the ZPS reference

data determined by photogrammetry. The relative height differences between the two data sets reach up to 0.60 m at the location of the staircase.

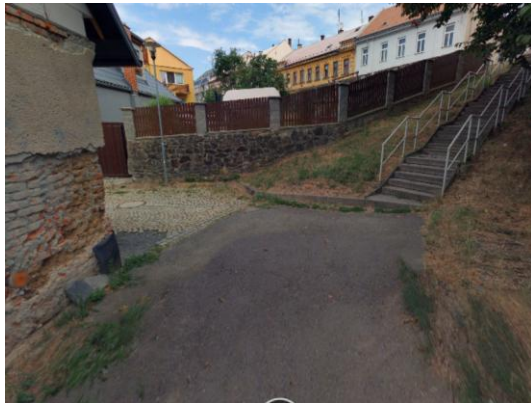


Fig. 10 Small urban road as it appears in reality.

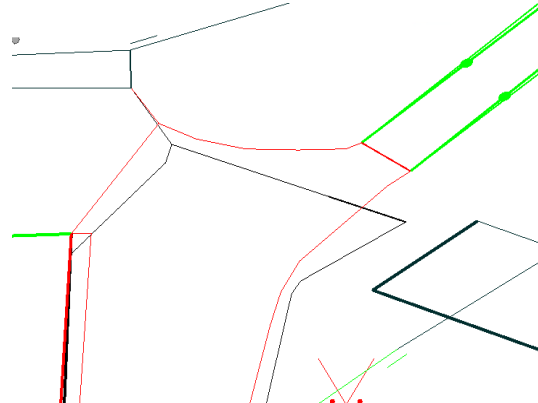


Fig. 11 Incorrect heights of points obtained from photogrammetry.

Inconsistencies between digital technical maps and digital cadastral maps

Fig. 12 shows an example of the discrepancy between the black-marked actual state in a DTM and the green-marked drawing in the corresponding digital cadastral map (DKM) with quality code 3 (KK3, according to the cadastral decree [14]). Fig. 12 shows the distance between the fence and the property boundary, which is 2.70 m. This drawing is contradictory and can be interpreted differently by the public. The design must therefore consider the difference in contents between the DTM and the cadastral map.

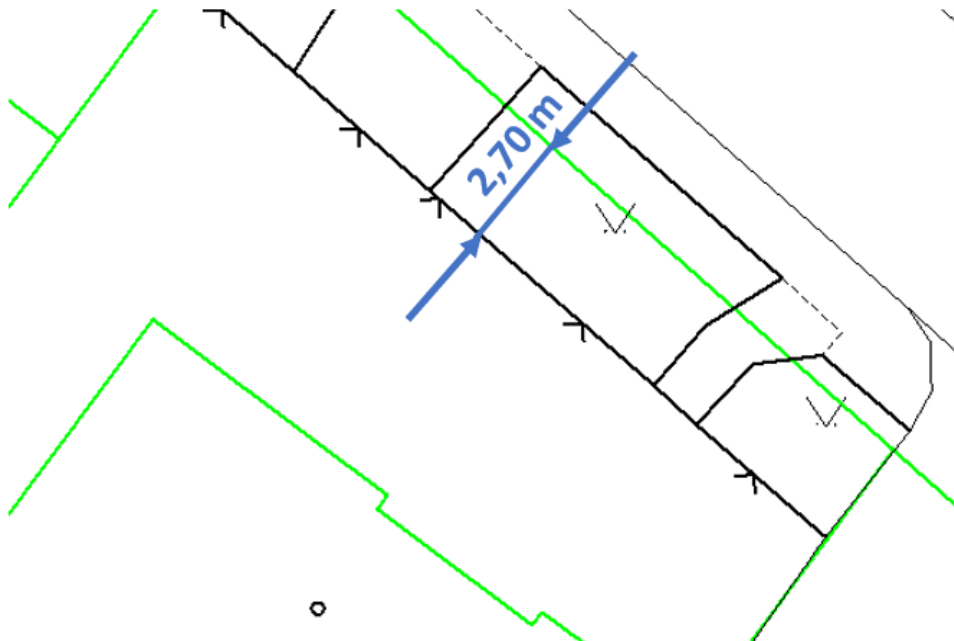


Fig. 12 Comparison of a DTM and a DKM.

5 CURRENT ISSUES WITH THE UPDATING OF DTI DATA

The editor engaged by a transport and technical infrastructure (DTI) owner is responsible for the accuracy of the DTI data under his or her purview, and also updates it. Most DTI data are available as public data on the DMVS portal [2], where they can be downloaded, except for those concerning what is termed critical infrastructure (non-public).

Incomplete data

The legal obligation of DTI owners according to [1] is to record data in the appropriate digital technical map (DTM). This data should exhibit the accuracy characteristics defined in the relevant implementing regulation [3]. If DTI owners do not have such data for their existing infrastructure, they can enter it in a simplified way. One of the reasons for the incompleteness of the DTI data that needs to be entered into DTMs is that most of the geodata collected to date has only been recorded in terms of positions in 2D space, or as positions and heights in the form of attribute or descriptive text. As a result, DTI data may have a zero-height entry in a DTM.

Fig. 13 shows an example of a 3D spatial view of DTI data in a DTM. At the location marked A, the DTI data has been inserted at height 0, at the location marked B, the DTI data has been inserted as spatial data at the actual height (above the red line), and at the location marked C, the vertical joins of the points in the data occur at the actual height and at zero-height. To date, the majority of such incomplete DTI data in the DTM is kept at zero-height.

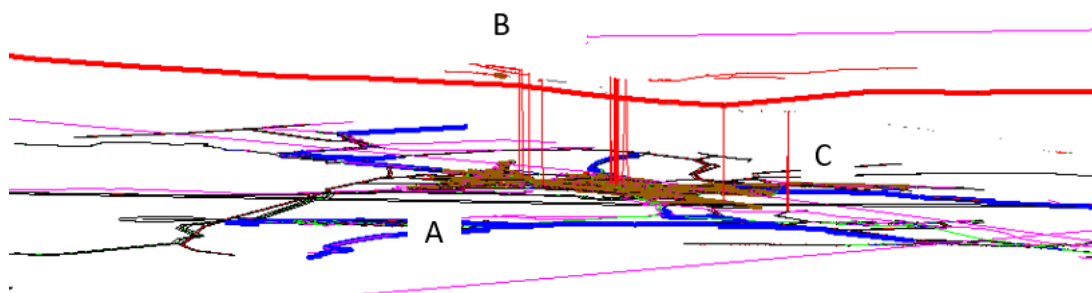


Fig. 13 3D view of selected technical infrastructure data.

The incorrect assignment of descriptive attributes

A large amount of descriptive data is associated with the geometry in the data model. Fig. 14 shows an example of incorrectly entered descriptive data for local road axes in the DTM data set. In the DTM, the designation D I = Class 1 motorway is incorrectly entered instead of the corresponding class of local road.

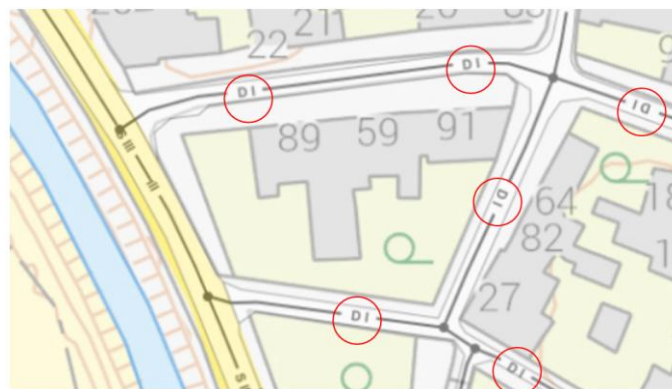


Fig. 14 Example of incorrectly assigned descriptive data.

6 DISCUSSION

The creation of the DTM data set, which became fully operational by 1 July 2024, can be considered a major milestone in the process of digitalising the Czech state. Given the complexity and scale of this work, some 'teething troubles' can be expected. This paper presents selected problems identified from a sample of DTM data during their updating by geodetic measurement methods (GNSS + tachymetry). The problematic data are not unique. The DTM data are considered to be guaranteed due to their authorised surveying engineer (AZI) verification, and the problems identified in them do not create a good reputation for surveyors. Incorrect data in the DTMs will lead to incorrect interpretations of reality, resulting in complications in design, construction management or asset management. Therefore, when using DTM data for design, it is necessary to assess its completeness and the accuracy of the AZI responsible, and to measure elements that are not part of the DTM data set.

We attribute the cause of the problems with DTM data described in the article to the mismanagement of the project related to the creation and development of digital technical maps, in the sense of the unavailability of the necessary number of professionals to work on their creation, the pressure imposed by the need to attract funding, the need to meet unrealistic deadlines at the expense of quality, and the absence of standardised and proven technological procedures for the bulk collection of geodata. Modern technologies for bulk data collection (mobile mapping systems, photogrammetry) clearly speed up the collection of field data in comparison with traditional terrestrial surveying, but they are not "miraculous", as "some" would like to see them, and need to be properly combined with other geodetic methods. At the same time, it would appear that the evaluation of data obtained by bulk data collection technologies must be carried out by competent persons, according to validated methodologies, and the process also requires checking the accuracy and completeness of results against the real situation on the ground.

The digitalisation of the construction process makes the use of geodata a necessity. The basic prerequisite is the taking of measurements and the preparation of documentation for real construction projects, from which it is appropriate to create the required outputs – DTMs or BIM/GIS (as addressed in [15]).

7 CONCLUSION

Digitalisation in the construction industry is an unstoppable phenomenon, and the need for data management is growing. The aim of digitalisation is to automate processes, including their simplification, streamlining and standardisation, with a positive impact on savings in the public sector and on the development of the business sector.

The DTM data set is also a major contributor to the digitalisation of the construction industry, which generates a large amount of geographic data that was not effectively used until the introduction of DTMs. Once the DTM data set is in place, the acquired geographic information will be transferred to other public administration agendas. If DTM data describes real world correctly, inconsistencies with digital cadastral maps (DKMs) can be effectively identified and used to update it.

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