THE USE OF A COMMON DATA ENVIRONMENT FOR DATA EXCHANGE IN BUILDING INFORMATION MANAGEMENT

Ondřej Vystavěl*,[1]

*vystavel.o@fce.vutbr.cz
[1]Brno University of Technology, Faculty of Civil Engineering, Institute of Geodesy, Veveri 331/95, 602 00 Brno

Abstract
Building Information Management (BIM) represents a modern approach for managing all aspects of building information throughout the construction lifecycle. In order to ensure an effective management, it is necessary to use a Common Data Environment (CDE). Various CDEs platforms are available and this paper examines, discusses, and compares the types of data stored in CDE, as well as methods of georeferencing. The analysis is based on a case study involving the remodelling of a geodetic section of as-built documentation, transitioning from Computer-Aided Design (CAD) to BIM.

Keywords
Building Information Management, Common Data Environment, georeferencing

1 INTRODUCTION

Building Information Management (BIM) stands as the current trend in managing all available information (geometric and non-geometric) throughout building's life cycle. In order to remain accessible at any time, valid and up-to-date documentation must be readily available to those requiring access. The Common Data Environment (CDE) serves this purpose.

According to the Czech Standardization Agency's document on CDE selection requirements [1], the CDE serves as the central source of information used for its collection, management and dissemination for the entire project team. The creation of this central source of information facilitates collaboration between project participants, clearly defines a single valid version of the information and helps to avoid misunderstandings, duplication and errors. The CDE can be thought of as a "place of single truth".

According to [2], three main data categories should be stored in CDE:

- graphical (better term geometric),
- non-graphical (better term non-geometric),
- associated construction project documents.

CDE serves as a hub for inter- and intra-organizational collaboration. The introduction of CDE platforms in the construction process has improved efficiency mainly in inter-organizational collaboration.

An evaluation of several CDE platforms used in the Czech Republic is provided in [3], these are Dalux Tender, Viewpoint for Projects, Trimble Connect and Bentley ProjectWise. These platforms share a lot in common, but the main advantage of Bentley ProjectWise is the ability to accommodate tender time scheduling.

In [4] authors conduct a comparison of current Common Data Environment tools in the construction industry, assessing their level of maturity. Cloud-based repositories (such as Google Drive, Microsoft OneDrive, DropBox, etc.) can be used as CDE platforms, but only at a basic level of maturity. They enable the basic CDE function such as data storage in a single place, but lack analytic tools/functions. However, the basic setup is sufficient for some specific purposes.

The problem of georeferencing (i.e. the location and orientation of the building within a binding geodetic reference system) of BIM models is dealt with, e.g., in [5] and [6], where the fundamental difficulties of 3D computer modelling are discussed. Such difficulties are mainly the following:

- CAD/BIM software uses a 3D Cartesian coordinate system, which is counter-clockwise conflicting with the clockwise system used in geodesy.
- The binding geodetic reference systems in use are not standard 3D Cartesian coordinate systems (e.g. S-JTSK and Bpv in the Czech Republic).

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- The CAD/BIM software cannot model the reality of the curvature of the Earth. The software works with the numerical value of the Z coordinate of the Cartesian coordinate system to represent the altitude.
- Territories and objects on the Earth's surface are generally located at different altitudes. In order to represent them into the plane, the dimensions must be reduced to the same altitude (usually zero) and the mathematical apparatus of a suitable map projection has to be used to represent them into the plane. The cartographic image of the territories and objects on it is slightly distorted compared to reality.

Using data from a case study of remodelling of the geodetic part of the as-built documentation (G-ABD) from CAD into BIM, the paper presents following:

- types of data stored in CDE,
- and georeferencing of individual BIM models.

2 THE USE OF CDE PLATFORM FOR EXCHANGE OF SELECTED GEODATA IN RAILWAY CONSTRUCTION

In the presented case study, the focus is the Reconstruction of the Šumice railway station. The construction documentation process has been recently completed, with the preparation of the G-ABD according to the currently valid regulations.

In this case, it is a 3D vector drawing featuring 2D elements (cartographic features and texts) in DGN format. However, the drawing is not a full 3D model, because not all objects are displayed as three dimensional. Descriptive (non-geometric) information is attached to the objects and plotted as text in the drawing.

In contrast, the BIM model is an object-oriented database. The first step involved creating 3D objects, during the remodelling process using BIM software. Two software were used for creating the BIM models of the individual building objects. Autodesk Civil 3D was used for linear objects (such as railway superstructures or cables) and Autodesk Revit was used for complicated 3D objects (such as bridges or platforms). Descriptive information was then linked to these objects in the form of values in the database.

In the end, all BIM models were imported into the Bentley ProjectWise CDE platform and coordinated. This choice was motivated by the platform’s widespread use in numerous BIM pilot projects by Railway Administration, and because its availability at our Institute.

Types of data stored in CDE

The underlying G-ABD adheres to the currently valid regulations, which in the field of railway geodesy encompass legally binding standards (laws, decrees) and internal regulations of the Railway Administration (RA), which define the mandatory data model [7].

However, the data model for BIM is governed by the Data standard of the State Fund for Transport Infrastructure (SFTI) [8]. The SFTI data model, unlike the RA data model, also extends its requirements to non-geometric information. The challenge during remodelling was the heterogeneity of the object classification, so it was necessary to classify the elements from one data standard into another manually.

In any Common Data Environment platform, it is essential to store three types of data (see Fig. 1):

- geometric (part A of Fig. 1),
- non-geometric (part B of Fig. 1),
- associated construction project documents (part C of Fig. 1).

Geometric data are represented by a 3D object-oriented model, created in a desktop software and then imported and managed in Bentley ProjectWise CDE platform by iModel tool. Using this tool we can explore, comment on, and evaluate the model.

Non-geometric data are attached to individual objects and are available in the table when selected. According to the SFTI data model, information is categorised, each starting with the CZ_ prefix (in Fig. 1 see for instance CZ_M1 or CZ_S32). It is necessary to have individual descriptive information categorised and attached to objects already in the desktop version.

Associated documents (for instance in PDF format) can be connected to a particular place in iModel (symbolised with a red flag in Fig. 1) without the need to be connected in the desktop software. These documents can be, for instance, downloaded from here.

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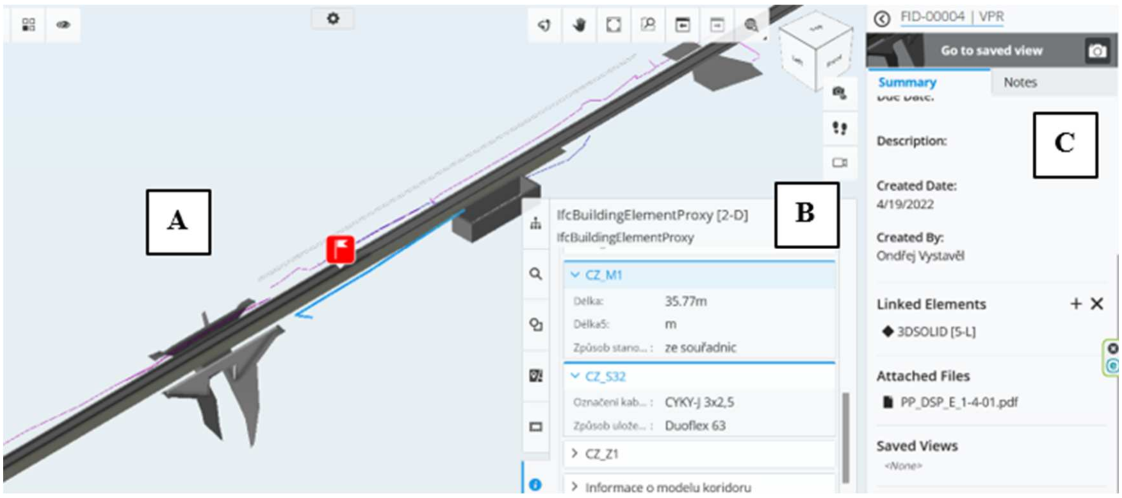

Fig. 1 Three types of data stored in CDE: A – geometric, B – non-geometric, C – associated documents.

Georeferencing of individual models

Georeferencing is an essential functionality within the common data environment, because it is the only way to ensure correct, easy and fast coordination of all individual models. BIM models can be viewed in the iModel Manager. As part of the iModel creation, it is necessary to assign a coordinate system. The coordinate system is taken from the imported model in the native format of the desktop software in which the model was created (Fig. 2).

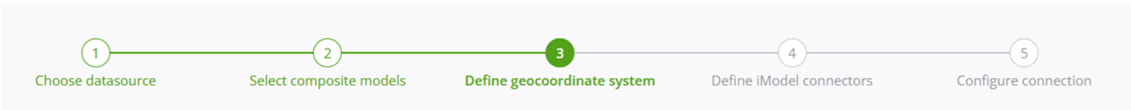

Fig. 2 Definition of coordinate system in Bentley ProjectWise CDE platform.

This setting is only possible when importing the first of the individual models. After that, it is necessary that all other models are made using desktop software in the same coordinate system. Only then the relative position of the individual models will be correctly displayed. As shown in Fig. 3, the coordinates of the iModel itself do not change after import. As for the S-JTSK coordinates, they are, as in any other CAD/BIM software, registered in terms of the S-JTSK / Krovak East North coordinate system (EPSG 5514).

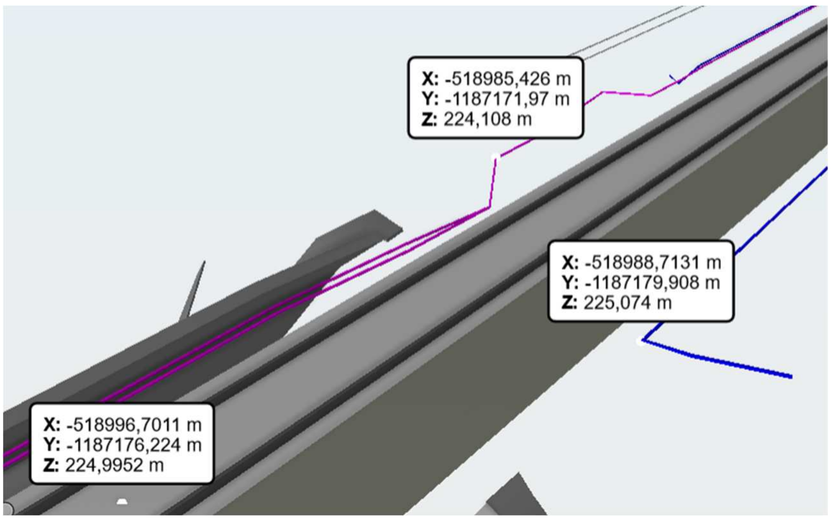

Fig. 3 An example of displaying the individual models together and verification of the invariance of their coordinates.

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3 DISCUSSION

The advantage of the object-oriented model lies in the possibility of storing descriptive (non-geometric) information in the form of database information. Unlike the classical CAD approach, it is not necessary to display this information as text in the drawing enhancing graphical representation (see Fig. 4). The descriptive information is also easier to export (in the sense of machine processing) in the case of database storage.

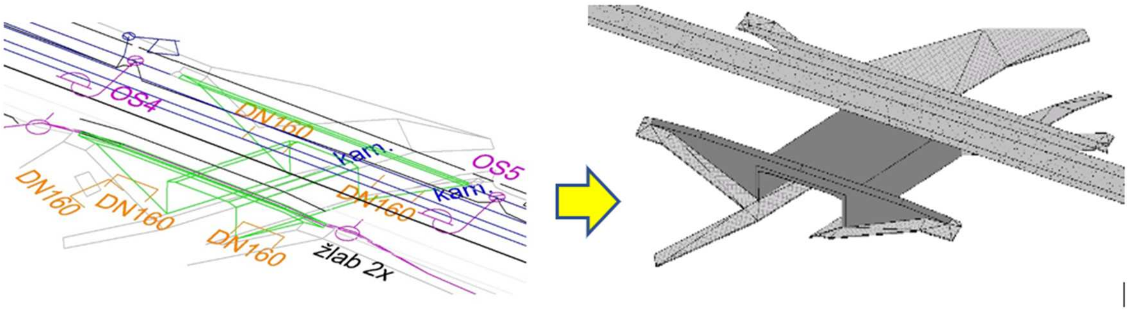

Fig. 4 An example of transforming the CAD documentation into BIM model.

BIM models must be georeferenced in order to be used in a Common Data Environment, otherwise the coordination of multiple models that is assumed in CDE is impossible. The Bentley ProjectWise CDE platform does not allow the setting of a coordinate system, only the coordinate system can be taken from an imported BIM model produced in desktop software.

As this is a Bentley product, it seems safer to use the DGN drawing (which is also from Bentley) as the first model. Using a different format (e.g. Revit's native format – RVT) may result in an imperfect adoption of the coordinate system settings, especially in terms of geodetic datum.

Georeferencing raises questions as posed in [5] and [6]. These questions must be addressed particularly in the case of linear structures or large objects with spatial composition (e.g. large warehouses/halls), where the scale change of the dimension in the terrain and in the plane of the map projection is already apparent.

A possible solution to this problem is to divide the building into parts, where local scale changes are insignificant. The individual models are then coordinated within the CDE to the correct position relative to each other and to the coordinate system. However, it is necessary to consider that the model is still distorted compared to reality. Hence, the analytic functions (such as measurement of distances) in the model will result in slightly distorted results. These discrepancies need to be kept in mind.

4 CONCLUSION

Building Information Management continues to evolve as an emerging approach in the Czech environment for handling building information. Common Data Environment platforms enable the cooperation of all those involved in the process of creating building documentation, consolidating data in a single location. The use of CDE tools simplifies this activity. Further research should explore tools related to tender time scheduling. From our point of view, the role of the surveyor is particularly important in the context of georeferencing as discussed above (i.e. dividing the whole building into parts). This approach is crucial in order to ensure a correct, easy and fast coordination of all the individual models.

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