

Reconstructive 3D models of the Brno for the years 1400, 1645 and 1749 and their use in education

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Extended Abstract

Reconstructive virtual 3D models are very illustrative tool for presenting knowledge about the historical character and urban development of cities. Creation of 3D city models is available today for anyone, who would like to take this opportunity to present information, thanks to using high-quality free software. Probably the largest one - the model of ancient Rome - was open to the public in Google Earth software in 2008 (Rome Reborn, 2013). 3D city models have been made also for Koyto (Takase et al. 2004), historical area of Istanbul (Dursun et al. 2008), for Roman Cologne (Bauerlein et al. 2007) and many other cities. Reconstruction 3D models are also produced in the Czech Republic. For example Hájek et al. (2015) describes the process of 3D modelling of the Terezín fortress and Popelka & Brychtová (2012) created 3D models of fortifications of the Olomouc city.

Creation of a 3D model of the city Brno (Czech Republic) expressing its appearance at the time of Swedish siege in 1645 began in 2009. 3D models for two other periods, namely the years 1400 and 1749, have been processed subsequently (from 2011). All three models were made in connection with the project *Internet Encyclopaedia of History of Brno* (2004). The reason, why it was first processed the model for year 1645, was not only a historical significance but also the availability of suitable iconographic, cartographic and other relevant resources.

The availability of data for creation of 3D model is obviously different for particular period. While we have almost no contemporary cartography or iconographic sources for the year 1400, many detailed representations of the city as well as maps and plans are available for the 17th century. Ap-

pearance of individual buildings is rather hypothetical in the case of a model for the earliest period and it is based both on archaeological investigations and on analogies with similar objects preserved in other locations. Because medieval allotment in Brno stayed largely unchanged until the 19th century, the most useful source of spatial information (for all three models) has been Stable cadastre from the beginning of the nineteenth century. Following maps and plans were used for creating 3D models:

- Map from book “Topographia Bohemiae, Moraviae et Silesiae” (author: Matheus Merian, 1650);
- Map from book “Relazione dell' assedio di Bruna e della fortezza di Spilberg” (author: N. H., 1672);
- Plans of fortifications from War Archive (Kriegsarchiv) in Vienna (1658-1749) – see figure 1;
- Plan of Brno (author: J. Anneis, 1784);
- Stable cadastre (1824);
- Old plans of particular buildings from National Heritage Institute, Moravian Archives and the Archives of the City of Brno.

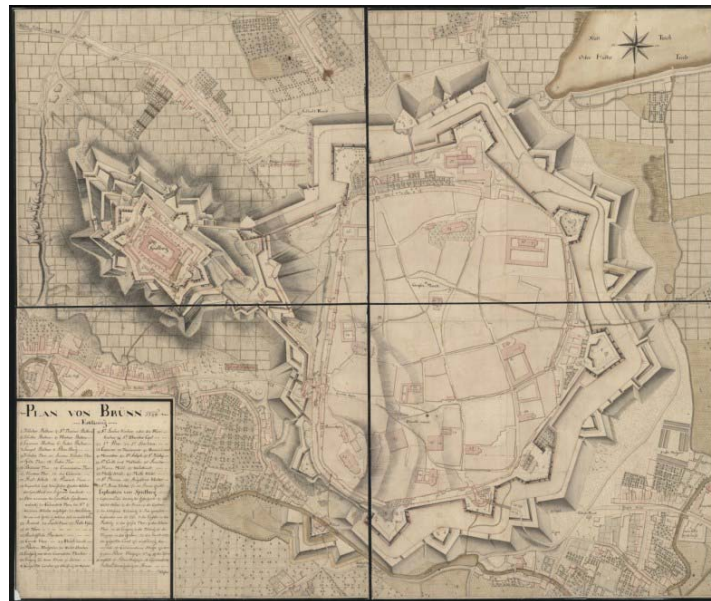


Figure 1. Comprehensive plan of fortification of Brno from 1749 (from Kriegsarchiv in Vienna).

Below mentioned vedute and old paintings were also used in the process of 3D modelling:

- Brno - panorama (author: Johann Willenberg, 1593);
- Brno - panorama (author: Joris Houfnagel, 1617);
- Brno – Orlí street (author: Max Groer, 1644);
- Brno from nordwest and from south (authors: H. B. Bayer & H. J. Zeiser, 1645) – see figure 2;
- Bird's-eye view of Brno (authors: H. B. Bayer & H. J. Zeiser, 1645);
- Brno - panorama (author: J. B. Speiss, 1675);
- Brno - panorama (author: Folpert van Ouden Allen, 1690);
- Paintings from second half of 18th century (author: Josef Masserle);
- Paintings from first half of 19th century (author: Franz Richter).



Figure 2. H. B. Bayer & H. J. Zeiser (1645): Brno from nordwest and from south.

Methodological approaches were used for consolidation and conversion of data from all mentioned sources into digital form. The Bentley Microstation software was used for vectorization building footprints from the maps of Stable cadastre (see figure 3). Resulting data were compared with data obtained during archaeological excavations in the historical centre of Brno. Historic building plans and surveys of selected buildings, primarily from the archives of the National Heritage Institute, Moravian Archives and the Brno city Archives, have been also used. Terrain model has been based on the present state and has been corrected according to the results of archaeological excavations.

City model has been finally created using the free software Google (today the Trimble) SketchUp. Complexity of the model can be demonstrated by fact, that the Brno inside the city walls has been formed from about 400 houses in the late medieval times. All of these are represented by simple models in the LoD2 (Level of Detail 2). Important objects such as churches, monasteries, fortifications and Špilberk Castle, whose historical form we know better, are modelled in more detail way (LoD3). 3D models were localized in the program SketchUp into coordinate system WGS-84 and exported to KML (*Keyhole Markup Language*) files that enable their subsequent display in Google Earth application.

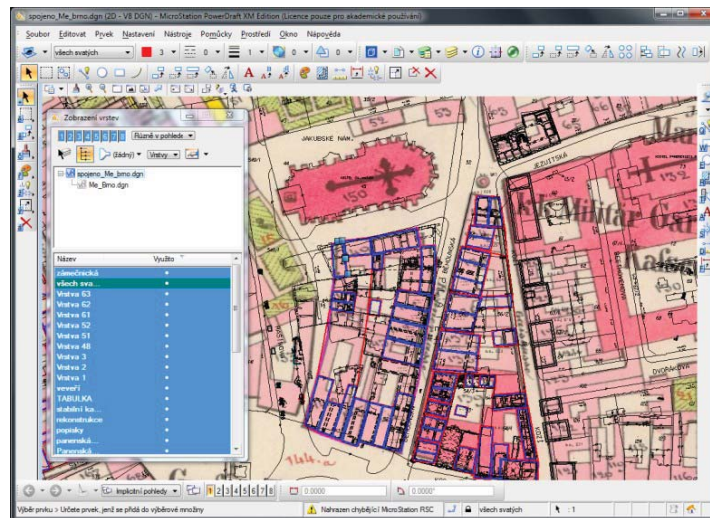


Figure 3. Vectorization building footprints from the maps of Stable cadastre in Bentley Microstation environment

All three virtual models are available on the website www.brno1645.cz (in Czech) City model from 1645 has been used for creation of the bronze sculpture in scale 1:1000, which is now located on the Moravian Square in the centre of Brno. Historical state of the city is presented to the general public by these ways. 3D models can be used also in school education in the curriculum of geography or history, where models can demonstrate the urban development. Example of the development of the selected area in Brno center is shown in figure 4.



Figure 4. Urban development evolution of the Conventual Franciscans monastery neighbourhood area (years 1400, 1645 and 1749)

The models were thus presented to high school students, for example, during the GIS Day 2014, organized by the Department of Geography at Masaryk University in Brno. However, the models can be used in teaching at universities, whether in courses focused on local history of urbanism. Finally models serve as examples of the methodological approaches and technology available for creation of 3D models in GIS (Geographic information system), they were demonstrated during the lessons of the course *3D modeling and visualization* (code Z8311).



Figure 5. Superposition of 3D model of chapel of Virgin Mary on Žerotínovo Square on present buildings.

Continuous updating of 3D models and correction of errors (based on the new findings) as well as the gradual increase of the detail is ongoing. Aim is to replace the existing underlying reconstructive maps placed in 3D models and to add information attached to each captured objects. There are other ways of utilizing existing models, e.g. combination (superposition) of data from 3D models to the current situation (photos, video), or in real-time use

of the augmented reality technology (an example of this superposition id shown in figure 5). Establishment of so-called serious game, where users went through virtual models, is also considered in terms of utilization of 3D models.

As it was mentioned, created reconstructive models of Brno have a wide range of applications. They are fully comparable from this point of view with other 3D city models that have been created in the Czech Republic or abroad. It is an indisputable fact that wide use balances the challenging process of creating 3D models.

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