Spatial Visualisation of the Infantry Blockhouse OP – S 25 "U trigonometru"

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Abstract:

The article describes a creation of spatial visualisation of the infantry blockhouse OP – S 25 "U trigonometru". The history of both the Czechoslovak fortification and the infantry blockhouse is briefly mentioned here. The main part of this contribution deals with field work to collect input data and with their processing during creation of a 3D model. A demonstration of the final model from all cardinal directions follows. The conclusion describes possibilities of using the visualisation of the infantry blockhouse OP – S 25 "U trigonometru" not only from the historical, but also from the modern point of view.

Keywords:

Spatial, 3D model, historical, infantry blockhouse, surveying, visualisation

1. Introduction

The Republic of Czechoslovakia was founded on October 28th, 1918 as one of the succession states of the dismembered Austro-Hungarian Empire. Already from the first day of its existence, the security of the newly-formed state borders was dealt with. Some small aggressions of groups which did not agree with the foundation of Czechoslovakia, especially from the side of Germans and Poles, were initially faced by the border guard troops. The increasing pressure in 1919, however, requested the formation of so called financial guard which also dealt with the customs.

In 1933 the newly appointed Chancellor Adolf Hitler took over the power in the neighbouring Germany and the need to protect Czechoslovakia even increased. Therefore, in 1936, the corps of state defence was established. This corps together

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with the government had in the shortest time to decide how to most effectively protect state borders. A formation of a motorized mobile army which would be shifted as needed was one possibility. Another option was to build a so-called system of stable fortification in the endangered border areas. Considering that the most endangered areas were in the western part of the Republic, which was only protected by natural barriers in the form of mountains, the system of permanent fortifications was adopted. The choice of this option was also recommended by France, the western ally of Czechoslovakia.

The system of the Czechoslovak permanent fortification was being built from 1935 to 1938 along the borders with all at that time neighbouring states. The system consisted of several main parts: light fortification structures of type 36 and 37 (known as "řopík"), heavy fortification structures and artillery fortifications. Among these structures, there was an obstacle system, both against the infantry and against the military equipment.

In total, 9 blockhouses, 227 heavy structures and nearly 10,000 light structures were built according to [1]. After accepting the terms of the Munich Agreement in 1938 and loss of the borderland, most of the areas with fortifications fell, however, to Germany.

After the World War II, most of the fortifications were in deplorability. Some structures, especially the artillery fortifications on the northern border, were used by the Czech military. However, in 1999, the platoons of the crew were abolished and fortifications were emptied and abandoned.

2. The Infantry Blockhouse OP – S 25

The infantry blockhouse OP – S 25 "U trigonometru" (see Fig. 1) is situated in the north-east of the municipality Milostovice in the district of Opava. It was built as the first structure of the third construction subsector Milostovice, the fourth engineer group headquarters in Opava, according to [2]. It is a two-floored, two-sided, two-winged infantry blockhouse, with two bells, having the size about 30×15 m and the height of 6 m from the ground plan to the top of the gun turret. The ceiling thickness is 250 cm, frontal walls are 275 cm and other walls 125 cm thick, which corresponds to the endurance class III. Both gun rooms were equipped with the weapon combination L1 (antitank cannon type 36, and heavy machine gun type 37) and M (heavy machine gun twins type 37). To protect the main gunports, the rear and the entrance, a quaternion of N-type weapons (light machine gun type 26) was used.

The construction of the infantry blockhouse OP – S 25 was awarded to the company Ing. Bohuslav Krýsa et al, Moravská Ostrava on February 14th, 1938. From May 2nd to 7th, 1938, object concreting was done, during which 1807 m^3 of concrete were manually crammed into the prepared timbering. The concrete strength in pressure showed up to 650 kg/cm^2 (64 MPa) after 28 days of setting. The regulatory standard for this structure type, 450 kg/cm^2 (44 MPa), was fulfilled. The infantry blockhouse construction was finished and the blockhouse was equipped with L1 and M guns in September 1938, but the light machine gun carriages were not supplied. Three and four embrasure bell with resistance (endurance) V (armour thickness in the level gun ports is 30 cm) served for observation and firing a light machine gun model 26. Both bells should have been produced by Škoda works and delivered by February 1939.

However, the infantry blockhouse OP – S 25 has never been fully finished. Both water and power distributions were missing. Neither telephone exchange nor ground telegraphy station and the entire internal network of lines were operating. There was a lack of food and fuel supplies in the storage rooms. The infantry lieutenant Vavřinec Vejmola was the chief of the object.

Fig. 1 Infantry blockhouse OP – S 25 "U trigonometru"

The infantry blockhouse OP – S 25 was falling into disrepair until 1998, when the members of the Military History Club Opava took charge of it. Time-consuming and costly reconstruction, which is still in progress, has led to the declaration of the blockhouse as a technical and cultural monument of the Czech Republic. The infantry blockhouse OP – S 25 is at the same time a memorial of the Czechoslovak army and the Czechoslovak fortifications. This object is open to the public from 2 to 6 p.m. every Sunday in the summer months.

3. Construction of 3D Model

Gradually formed various clubs or associations try to refresh the military history of our country and bring it closer to the public. These organizations are collecting valuable historical artefacts, documents or period photographs. In the present-day modern time such information occurs on many internet websites devoted just to the Czechoslovak fortifications.

If original structural drawings are preserved, some enthusiasts create from them spatial models of individual structures. This approach is most often used today. Spatial visualisations are mostly made in freely available applications for 3D model creation. However, only some military objects are preserved in the original state and thus the model does not always need to correspond to the today's reality.

There are several options of data acquisition for spatial model creation from the point of view of geodesy. Probably the simplest method is the photogrammetrical one. The resulting model is very realistic due to the possibility of texture attachments directly from photographs. However, if the created model includes internal areas as

well, there may be a problem with linking of individual photograph sets. Another option of 3D model creation is the usage of laser scanning systems. This technology is very expensive and rarely available. The present-day total stations, however, offer the possibility of slope distance survey in so-called non-prism mode, when passive reflection from almost any surface is achieved. This offers a possibility of obtaining data to create spatial data of any object using the spatial polar method.

3.1. Survey of the Infantry Blockhouse OP – S 25

For the survey of the infantry blockhouse OP – S 25, the spatial polar method was applied using the total station Leica TS30. The spatial polar method has been the basis for most of modern geodetically surveys since the universal total stations with integrated electronic distance meters came into practice. Using the spatial polar method, the space coordinates X, Y and Z of the measured or detailed survey point are computed.

When using this method, the survey network has to be prepared in the mapping area; consequently, it is possible to carry out the detailed survey. Given the size and the extent of the whole object, the survey network consisting of five fundamental points was built, where one point was situated inside the object. Points of the survey network (survey stations) were marked with numbers from 4001 to 4005 and their monumentation was realized by survey nails. Their location, which is shown in see Fig. 2, was chosen with respect to good visibility over the entire object.
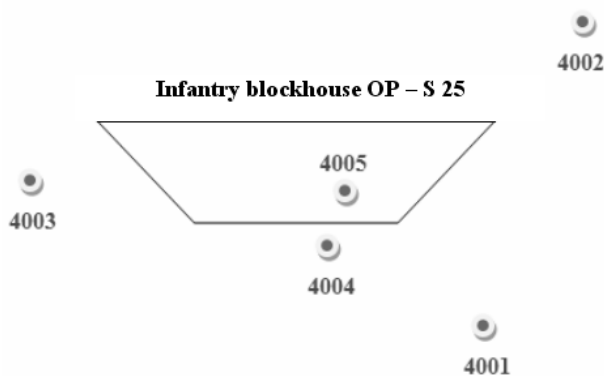

Fig. 2 Survey network

The spatial polar method (see Fig. 3) is based on the measuring of slope length d from the known point (survey station S), horizontal angle (for the determination of the bearing σ) and zenith angle z to the determined point (detailed survey point P).

The equations for the calculation of coordinate differences between the survey station S and the determined point P result from Fig. 3:

$$\Delta X_{SP} = d_{SP} \cdot \sin z \cdot \cos \sigma_{SP}$$
$$\Delta Y_{SP} = d_{SP} \cdot \sin z \cdot \sin \sigma_{SP} \tag{1}$$
$$\Delta Z_{SP} = d_{SP} \cdot \cos z$$

The bearing σ, as shown in Fig. 4, is an angle which is closed by the parallel with the positive semi-axis X pointing to the south, passing through the station S, and by

the requested side. The bearing therefore cannot be directly measured, hence the horizontal angle ω from another known point (orientation O) is observed.
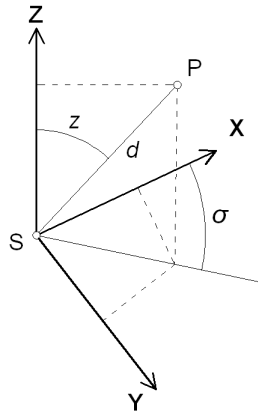

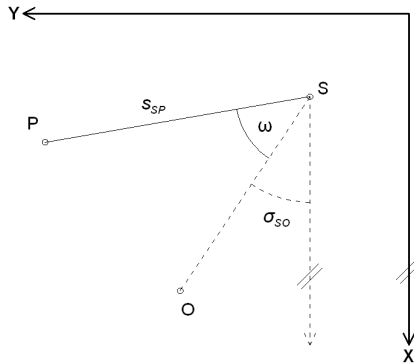*Fig. 3 The scheme of the spatial polar method*

Fig. 4 Principle of bearing calculation

The bearing σ_{SP} is calculated from the bearing σ_{SO} (determined from the known coordinates of the points S and O) and the measured horizontal angle ω using the expression:

$$\sigma_{SP} = \sigma_{SO} + \omega \tag{2}$$

Basic equations for space coordinates computation of a detailed (measured) survey point have the form:

$$\begin{aligned} X_P &= X_S + \Delta X_{SP} \\ Y_P &= Y_S + \Delta Y_{SP} \\ Z_P &= Z_S + \Delta Z_{SP} \end{aligned} \tag{3}$$

Substituting the expression (2) into equations (1) and subsequently into equations (3), we obtain resulting equations for space coordinates computation of a detailed survey point using all measured quantities:

$$X_P = X_S + d_{SP} \cdot \sin z \cdot \cos(\sigma_{SO} + \omega)$$
$$Y_P = Y_S + d_{SP} \cdot \sin z \cdot \cos(\sigma_{SO} + \omega) \qquad (4)$$
$$Z_P = Z_S + d_{SP} \cdot \cos z + v_p$$

In the equation for Z-coordinate, the height of the instrument v_p above the monumentation mark defining the survey station must be added to the basic term.

Owing to the extent of the object, the actual survey of the infantry blockhouse OP – S 25 was carried out in two stages.

During the first stage, the outer skin of the blockhouse was measured. The survey was gradually realized from all four outer survey stations 4001-4004. The height of the instrument was measured on all survey stations. The other survey stations were used as orientations. In this first stage, the total of 126 detailed survey points was measured. All detailed survey points were plotted into the field sketch which simplified the orientation during the subsequent model processing.

The second stage comprised of the survey in inner areas of the infantry blockhouse OP – S 25. The inner space of the blockhouse is very rugged; therefore it was measured only from one survey station 4005. This station was built inside the object using a small loophole in one of the frontal gunports. The height of the instrument was again measured on the survey station 4005. The point 4004 was used as an orientation and all important and clearly identifiable main points of the inner area were surveyed. With respect to the fact that most of the inner walls are rectangular, the method of construction measures (orthogonal method) was used to survey the missing parts. This means that all proportions of the inner space were measured by a tape. At the same time the height of the ceiling was always measured to be able to display the surveyed ground plan in the space.

The total of 192 detailed survey points was measured which reflects the basic shape of both outer and inner layout of the infantry blockhouse OP – S 25.

3.2. Spatial Visualisation

The processing of measured data and the construction of a 3D model of the infantry blockhouse took place in several following sub-steps, including computing and graphic parts.

All computing work was carried out in the Groma v. 8.0 software. Since it is not necessary to survey in the mandatory reference system S – JTSK for the 3D model creation, the coordinates including the heights of all detailed survey points were computed in a local coordinate system. 4001 was chosen as the point of origin of local coordinate system. Positive *X* axis of this coordinate system was identical to the line connecting the points 4001 and 4002. To prevent negative coordinates, the input coordinates were chosen as follows (see Tab. 1):

Tab. 1 Input coordinates of the points in local system

point Nr.	Y (m)	X (m)	Z (m)
4001	100.000	100.000	100.000
4002	100.000	$X_{4001} + s_{4001,\,4002}$	$Z_{4001} + h_{4001,\,4002}$

Computing of spatial coordinates of detailed survey points runs in the Groma software automatically using the function "polar method batch". The final list of the

detailed survey points coordinates was subsequently exported into a CAD-file with the extension *.dxf.

To process the 3D data, the graphic AutoCAD 2008 software was used. This software offers a very good user interface for working with spatial data. In addition, it enables to assign any elements into particular layers which can be switched off and on for better working. The coordinate list of detailed survey points including their numbers was loaded into the first level, as shown in Fig. 5

Fig. 5 Graphic projection of spatial coordinate list of detailed survey points

In the second layer, particular detailed survey points were matched by lines and arcs, based on the field sketches. Figure 6 shows the basic wire model of the infantry blockhouse OP – S 25.
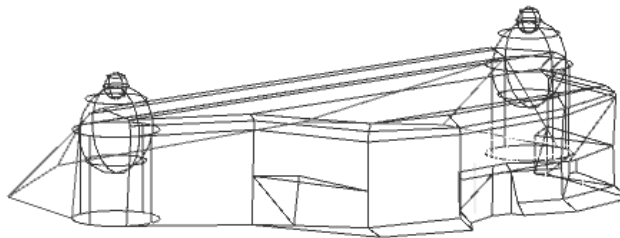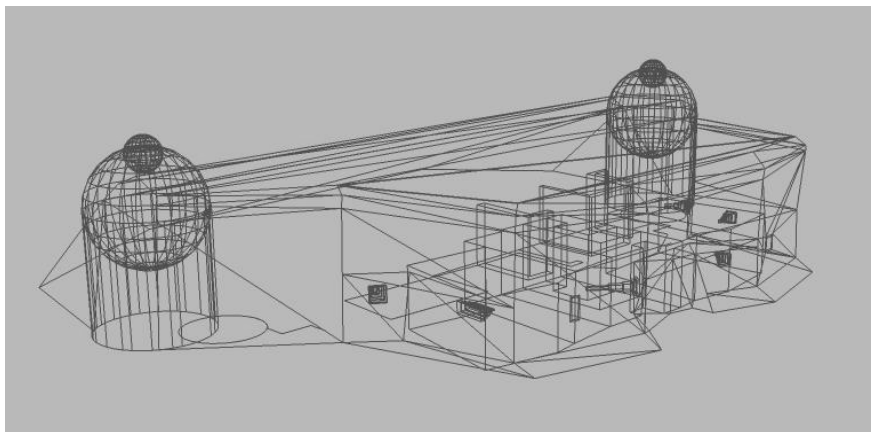

Fig. 6 The wire model of the infantry blockhouse OP – S 25

To complete the spatial model, the SketchUp 8Pro software was used. This software [3] from the Google Company has been chosen due to several reasons. First of all, the basic SketchUp 8version is unlike software AutoCAD, freely available to the public. The extended SketchUp 8 Pro version, which offers a great amount of other functions, is after filling in a short register form also free of charge for a trial period of 6 days. Nevertheless, the trial period is for model completing fully sufficient. Another

aspect of the software selection was its very simple operation and the possibility of exporting the final model into several, for public freely available, applications.
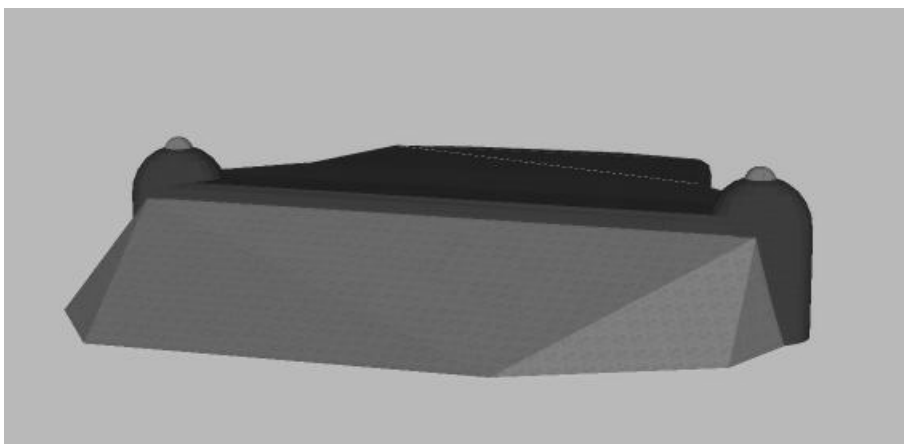
The wire model of the infantry blockhouse created in the AutoCAD 2008 software was imported into the SketchUp 8 Pro software. The graphic interface of the SketchUp 8 Pro software with the imported wire model can be seen in Fig. 7.

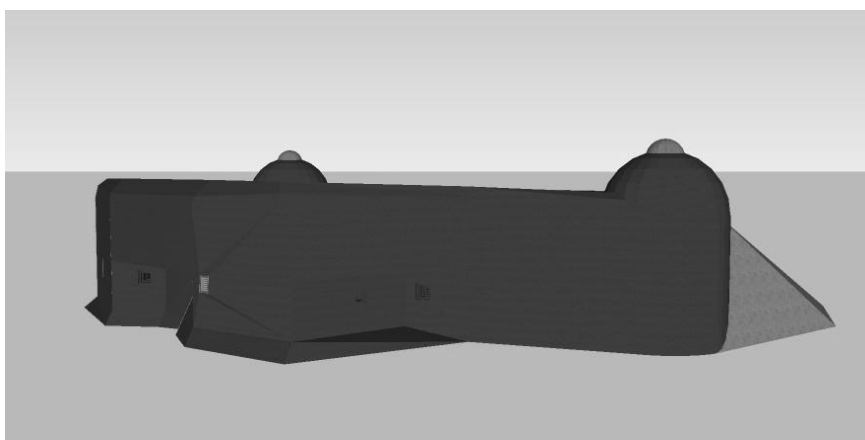*Fig. 7 The wire model of the infantry blockhouse OP – S 25 in the SketchUp 8 Pro software*

The whole wire model of the infantry blockhouse OP – S 25 was covered by textures. The SketchUp 8 Pro software offers the possibility to assign a realistic texture directly from a photograph. However, the owner of the blockhouse did not agree with taking photographs especially of inner rooms. The SketchUp 8 Pro software provides an extensive texture library with realistic materials. Therefore, for the outer skin of the blockhouse, the texture of poured concrete was chosen. The inner space was covered by white coloured texture.

The final model can be arbitrarily rotated thanks to a simple function. The following four figures show the finished model from all cardinal points.
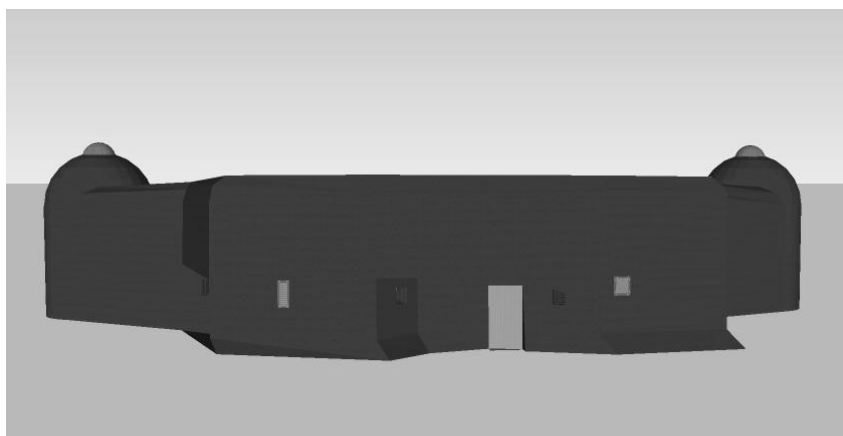

Fig. 8 View of the finished model of the infantry blockhouse OP – S 25 from the north
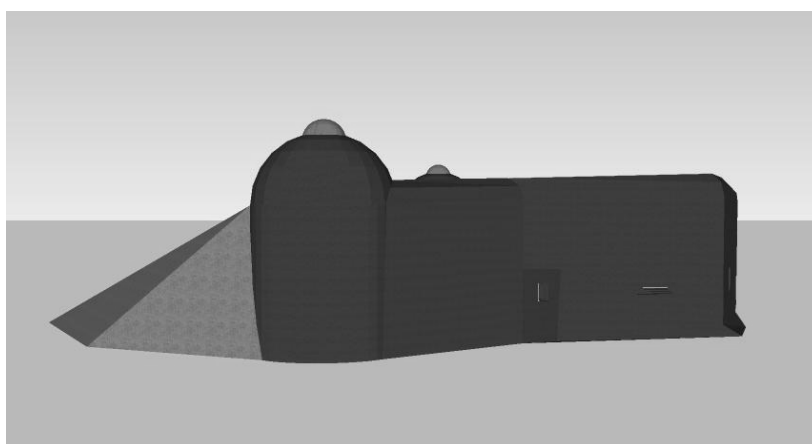
Fig. 9 View of the finished model of the infantry blockhouse OP – S 25 from the east

Fig. 10 View of the finished model of the infantry blockhouse OP – S 25 from the south

Fig. 11 View of the finished model of the infantry blockhouse OP – S 25 from the west

The SketchUp 8 Pro software offers many export and saving options of the final model. One of the best options is the export of the model into the application Google Earth, which is a virtual globe that allows seeing the Earth like from a satellite. At first, the location where the final model should be displayed is assigned to it in the SketchUp 8 Pro software. For the choice of the location, there is a simple function "Add Location" where the precise position can be chosen to place the model in the virtual world map. The function "Preview Model in Google Earth" follows which places the model into the pre-defined location (see Fig. 12).

Fig. 12 A 3D Model of the infantry blockhouse OP – S 25 in the application Google Earth

Another way to bring the final model closer to public, without installing special software, is again offered by Google. It is a web-based "3D model gallery", which allows to upload spatial models of any objects for the registered users. In order to upload the spatial model of the infantry blockhouse OP – S 25 in this gallery, the model had to be saved in the SketchUp 8 Pro software in the format *.kmz at first.

On the website http://sketchup.google.com/3dwarehouse/?hl=cs it is necessary to log in the Google account, or to create it for free. It is the same account which is used for login to E-mails. Then you must complete a short information form and the import of the spatial model in the format *.kmz follow. A cut-out of this internet database with the 3D model of the infantry blockhouse OP – S 25 can be seen in Fig. 13.

Fig. 13 The spatial model of the infantry blockhouse OP – S 25 in the 3D model gallery

The whole model, including the possibility to see the model both from all sides and from inside, can be found on the website:

http://sketchup.google.com/3dwarehouse/details?mid=6929c014511b23d9750266 0dec192f52&ct=mdsa

A detailed description of the usage of all options and functions in the SketchUp 8 Pro software was not the aim of this chapter. The software is very helpful and above all, it is possible to download and try it for free.

4. Conclusion

The Czechoslovak fortification, its history and present, is an inseparable part of the history of our country. It is getting recognized by the wider public through a variety of military historical clubs. The Military History Club Opava has several structures of light and heavy fortification in its administration. A key project is the reconstruction of the infantry blockhouse OP – S 25 "U trigonometru" into a form that would most approach the state before the World War II.

The club in Opava was able to obtain many period materials which can be seen both in the infantry blockhouse OP – S 25 and on its website. Many similar websites dealing with the Czechoslovak fortifications offer their readers for example virtual tours created from panoramic photographs as well. In the application Google Earth, several 3D models of infantry blockhouses and fortifications can be found again, but they were mostly created from old drawings.

This article with the demonstration of spatial visualisation of the infantry blockhouse OP – S 25 has been written to offer another dimension to the interpretation of our history. The creation of the model described above is not too time-consuming. Moreover, spatial data obtained by direct measurements enable the creation of a realistic model of any object in the actual, real state. Models based on drawings several decades old may not always match reality. Spatial coordinates of detailed survey points determined as described above achieve positional accuracy of $\pm$ 5mm and therefore a model with all details and particularities can be created in this way.

The resulting model of the infantry blockhouse OP – S 25 "U trigonometru" was made available to the Military History Club Opava and the municipality Milostovice. It will be used both for the diversity of their websites and for the demonstration purposes during the explanation before the visit of the real object.

References

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