USE OF GEOMATIC METHODS FOR FINDING AND DOCUMENTING HISTORICAL ARTILLERY REDOUBTS

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ABSTRACT

There are a lot of traces of wars or military activities throughout the Czech Republic. You can find fortifications from Roman times to the Cold War. In 2009, a big project started in the Czech Republic – aerial laser scanning of the whole national territory. It was finished in 2013; since this year there has been a possibility to use very precise digital terrain models (DTM), a new face of the landscape mainly in forested areas, derived from aerial laser scanners and INS instruments. For archaeology, the use of DTMs in shaded relief forms can be a tool for the investigation of landscapes to find relics from the past. After a quick overview of data in shaded relief forms, which is often used in archaeology with special lighting (a very low light position from the north-west, which gives long shades even to small humps), many new objects have been found or detected better than previously attempted. In the western part of the Czech Republic, we focused on finding potential historical artillery redoubts from the 17th century based on the Swedish invasion of our territory. Some known fortifications were detected and verified by terrestrial measurements of written sources, and, in some cases, new structures were identified. We focused on the investigation of a potential newly discovered artillery redoubt near the village of Černošín, which can be a light imperial fortification from the end of the Thirty Years' War (a battle at Třebel in 1647 took place near this area). This object consists of a ditch and a rampart, square in shape, ca 15×15 m, on a small hill near a ravine where a road has been preserved to the present day. The site has recently been deforested, which gives us a possibility of acquiring documentation; we used the Phantom Dji 4 multicopter for creating precise orthophotos, and a partial DSM (digital surface model) and a laser scanner for terrestrial measurement. The GEM GSM 19 Gradiometer/Magnetometer (Overhauser) was simultaneously used. As a result of magnetometric measurement, a digital model of this object was made, which is useful for archaeological and historical analysis.

Keywords: RPAS, DTM, orthophoto, magnetometer, archaeology

INTRODUCTION

One of the last important battles of the finishing Thirty Years‘ War took place at Třebel at the end of August 1647. After the conquest of the town of Cheb, Swedish troops led by Gen. Carl Gustav Wrangel moved to the south to the area near the town of Stříbro in July 1647 and attacked Třebel Castle. The Imperial garrison successfully defended it, thus the Swedes retreated to the eastern bank of the Michelsberský/Kosí Stream, where their headquarters was. The large clash finally happened three days later, on 22 August, and the Swedish troops pulled back over the Šumava mountains to the German side. The battle is thoroughly documented in a pair of engravings constituting a part of a detailed report on the Swedish campaigns in Bohemia of the end of the Thirty Years' War in 1647. The report was published in an extensive journalistic work, Theatrum Europaeum, issued by the Frankfurt engraver and publisher Matthäus Merian (1593–1650) since 1633 [2]. The publication is diverse; it includes political, military and geographic articles as well as social life reports. The texts are accompanied by illustrations – engravings that have a great artistic and, nowadays, documentary value. In the area of Třebel, systematic archaeological research took place between 1988–90 and 1999–2004 [1]. The research also included the criticism and confrontation of the engravings with a simple in-field comparison. In a similar way, geoinformation technologies were also used to explore the illustrations of the Thirty Years‘ War battles from several other localities, such as engravings of the siege of Plzeň (Pilsen) [3], [4].

ENGRAVINGS OF THE TŘEBEL BATTLEFIELD

The survey of the Thirty-Years-War relic of interest is closely related to the earlier published research of the Třebel battlefield, which continues on several locations around the then battlefield, introduces new geospatial methods and puts them in place.

The engraving of the state to 19th August 1647 with dimensions of 357 to 240 mm depicts an area of ca 11.5 to 7 km (ca 82 square kilometres), in an oblique view from north-west to south-east. It was published in Volume VI of Theatrum Europaeum. The engraving of the state to 22th August 1647 with dimensions of 342 to 275 mm depicts a much smaller area of ca 20 square kilometres, in an oblique view from the west. It was also published in Volume VI of Theatrum Europaeum [2].

Fig. 1: Engraving of the 1647 battlefield near Třebel (the scene dated of August 19th)

TECHNOLOGIES USED

The site was gauged by the RPAS method. The output represents a detailed orthophoto and a digital surface model that give the ability to detect field signs of building relics. A magnetometer was used for additional measurements. The scanning of the RPAS eBee was performed by a camera that records in the visible spectrum – red, green, blue channels and then also in the infrared spectrum – NIR. There, green, blue and NIR channels are used where NIR replaces the red channel. The processing took place in the Agisoft PhotoScan Professional software where an orthophoto and a digital surface model were acquired as outputs. Figure 2 shows the digital surface model in the Agisoft PhotoScan environment. A view of the redoubt model is shown in Figure 3. There, data processing was also performed in ArcGIS. The DSM has been highlighted as a shaded relief (hillshading) to show the current state and differential DSM. Magnetometric measurements were processed in the ArcGIS software and were displayed as a hypsometric chart of magnetic anomalies and a magnetic field gradient. Simple prediction kriging was used to calculate hypsometric charts [5].

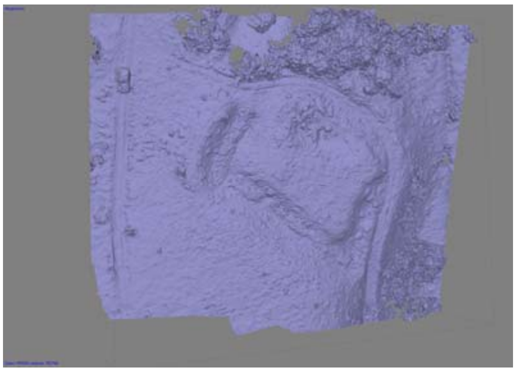

Fig. 2: Top view of DSM of the area of interest

Fig.3: Redoubt model rendition

OUTPUTS

Figure 4 shows the state orthophoto created by the Office for Surveying in cooperation with the Military Geographic and Hydrometeorological Office (VGHMÚř) in Dobruška. Aerial images are taken periodically at a two-year interval. The GSD of the orthophoto amounts to 20 cm and the redoubt identification is difficult here. In Figure 5, the orthophoto is taken using RPAS. The GSD is about 5 cm in size. The redoubt is well visible due to the removed vegetation that had been cut and logged in the meantime.

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Fig.4: Orthophoto created by the Czech Office for Surveying, Mapping and Cadastre (COSMS)

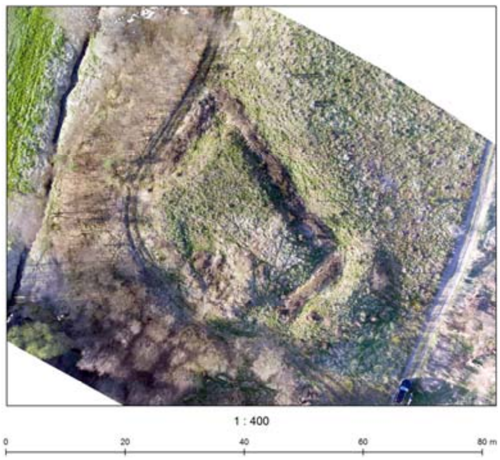

Fig.5: Orthofoto from RPAS

In Figure 6, a shaded relief from the COSMC map service is shown. There, the redoubt is relatively well identifiable. Figure 7 shows a DSM (Digital Surface Model) made using RPAS. The shape of the redoubt is very clearly visible there. The digital spatial model of the Czech Republic was obtained from aerial laser scanning.

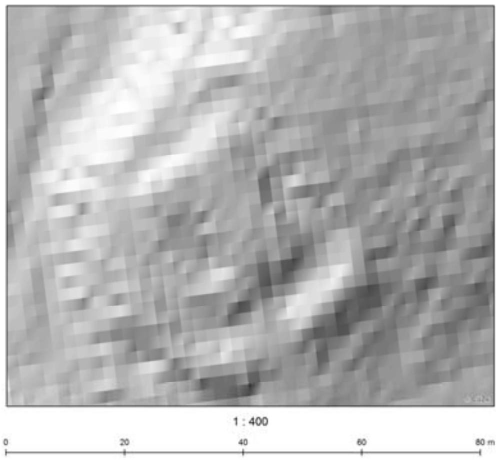

Fig. 6: Hill Shaded Terrain Model (COSMC)

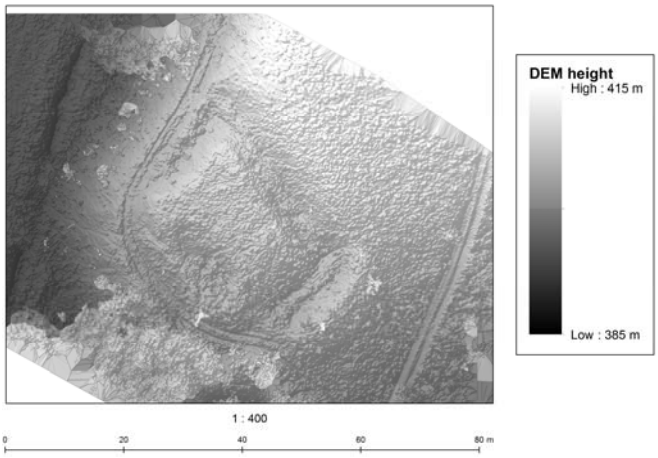

Fig.7: DSM from RPAS

Figure 8 depicts a differential DSM. For its creation, a 100-pixel smoothing circle mask was used. The differential DSM was created as a difference of the two abovementioned models.

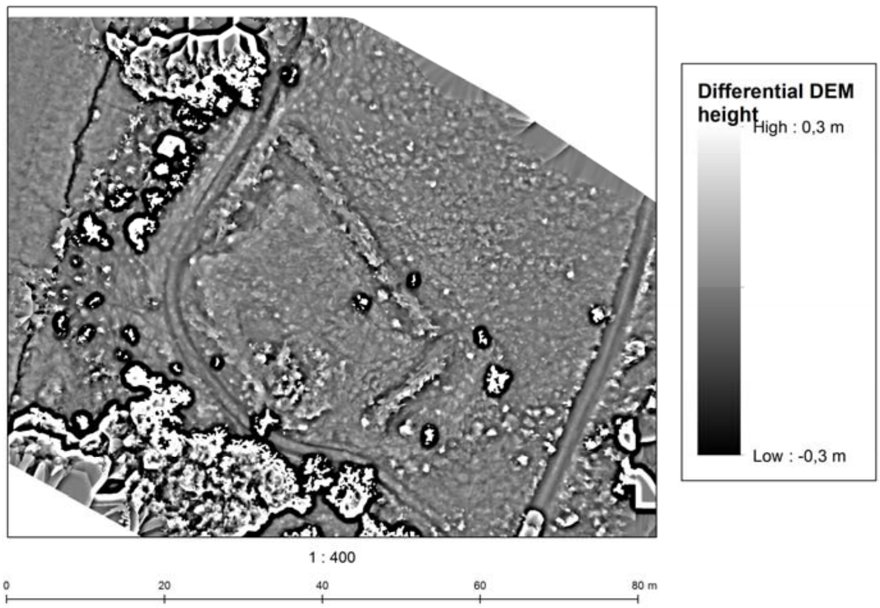

Fig. 8: Differential DSM

The processed magnetometric gauging is shown in Figures 9 and 10. In Figure 9, the gauging of the magnetic field intensity is processed, where virtually only the bedrock condition is shown. Figure 10 renders a magnetic field gradient where a slight contour of the redoubt can be seen.

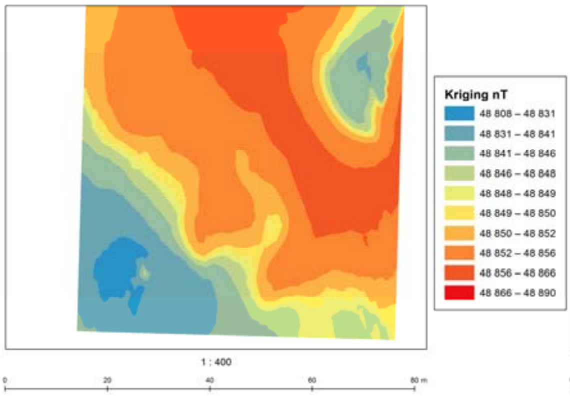

Fig. 2: Interpolation of magnetometer data using a kriging method for magnetic field intensity

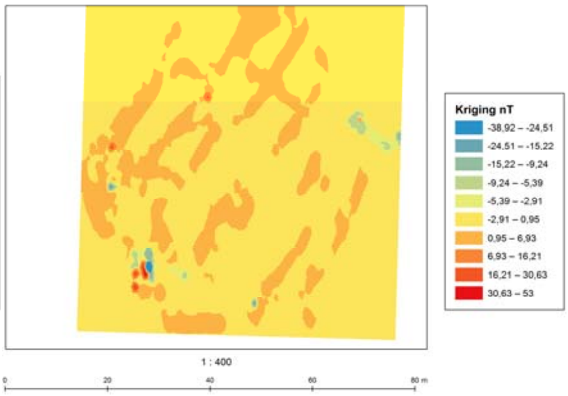

Fig 30: Interpolation of magnetometer data using a kriging method for magnetic-field-intensity gradient

CONCLUSION

Using more technologies to obtain results is very beneficial because of a several-side look at the issue. An interdisciplinary approach associates science disciplines, such as cartography, archaeology, environmental sciences, cultural heritage preservation and non-invasive exploration methods, with each other. At present, archaeological excavations are falling a little behind remote sensing and other methods. The issue is that this method delivers the largest amount of information, but at the cost of large financial expenses, energy, and time spent. Last but not least, it also involves having a large number of skilled people available and managing them properly. The most beneficial but also the most challenging is the research based on a combination of all methods and approaches.

The article presents detailed documentation of a probable redoubt by means of RPAS and a magnetometer. Both technologies confirm the presence of an object. The redoubt outline is also visible in the Shaded-Relief Terrain Model (available at the Czech Office for Surveying, Mapping and Cadastre). The RPAS technology, combined with geophysical devices, enables documenting and confirming the presence of archaeological objects. By combining these technologies, we confirm the finding of an archaeological object and thus it is possible to detect subsurface structures of objects. The combination of these methods seems to be an appropriate alternative when considering cost / work / performance perspectives.

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