3D RECORDING OF CASTLES

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Architectural remains of castles are quite distinctive compared to other types of buildings regarding the degree of preservation and the landscape in which they are located. Both factors significantly influence the digitisation strategy. As already stated in the case of 'standard' architecture, the spatial organisation and height considerably increase demands on the digitising techniques. This applies even more to castle architecture. The remains of castle buildings are often found in various stages of destruction and thus structures have complex forms. Given the predominantly vertical elements, the effective collection of data is even more complicated, especially in terms of recording upper floors. Moreover, the majority of castle ruins is situated in an environment characterised by irregular terrain and often with dense low or high vegetation. This creates natural obstacles and shadows in the photo-documentation and can be a highly limiting factor for the performance of techniques and tools used in the collection of data, such as an UAV.

Two castle complexes were selected as case studies within the framework of the CONPRA project. They are different, especially in terms of the natural landscape in which they are situated. The environment of Čachtice castle is composed of relatively open space with small areas under forest and a relatively regular terrain around the castle premises. On the contrary, Dobrá Voda castle is situated in a densely forested area with marked elevations of the terrain underlying different parts of the castle complex.

All case studies were processed in a workstation with the following parameters: Intel Xeon CPU E5-2620 v2@ 2,10 GHz, RAM 128 GB, GPU NVIDIA GeForce GTX 780 3GB, OS W8. In the case of TLS application, the resolution was always set to 6 mm per 10 meters. For IbM, Agisoft Photoscan software was used with the following parameters set for the batch processing workflow: step – align photos (high accuracy with the key point limit of 40,000

and the tie point limit of 20,000 points); step – refinement of alignment (decreasing of global re-projection error to max. 1px); step – build dense point cloud (medium quality, aggressive depth filtering); step – build mesh (arbitrary surface type, dense point cloud as source data, interpolation enabled, custom face count: various values); and step – build texture (generic mapping mode, texture from all cameras, blending mode Mosaic, texture size 4096, texture count 1, and no colour correction). In case of CapturingReality RC, the parameters were as follows: step – align photos (max. feature per image 80,000, pre-selector feature 40,000, image overlap medium, detector sensitivity medium, max. re-projection error 2px); step – reconstruction (normal detail); step – build texture (Guter 3, texture resolution 8192, large triangle removal threshold 10, maximal texture count style, visibility based texture style).

Čachtice, Castle

Site type:	Castle
Location:	Čachtice, Nové Mesto nad Váhom District, W Slovakia
Dating:	13th-16th century
Recorded parts:	Complete castle area
Recording technology:	IbM
Recording equipment:	Camera Sony Nex 7, UAV
Software:	CapturingReality RC, CloudCompare 2.7
Record:	Scaled 3D model (mesh) (Figs. 75, 76)
Short description:	The Čachtice castle is situated on the top of a limestone peak in Malé Karpaty mountains. The former frontier castle served as a control point at the border between the Myjava and the Váh valleys. The oldest part of the castle, dated to the 13th century, is the main pentagonal tower situated at a prominent point of the terrain. During the 14th and the 15th century, intensive building activity resulted in a new built area north of the main tower. New fortification features (cannon bastions), parts of the lower ward and some wall sections were added to the construction at the end of the 15th century. The final major building activities are dated to the 16th century when a complete reconstruction of the upper part of the castle was conducted and new architectural features were added to the lower ward (Plaček, Bóna 2007, p. 91-93). The project's aim was to digitise the complete historical landscape setting before the reconstruction works commenced (in 2013). The recording was carried out by IbM, which was facilitated by the relative openness of the area, with only few obstacles to the visibility of the architecture. The raw data was collected with an UAV (light sailplane equipped with a camera).

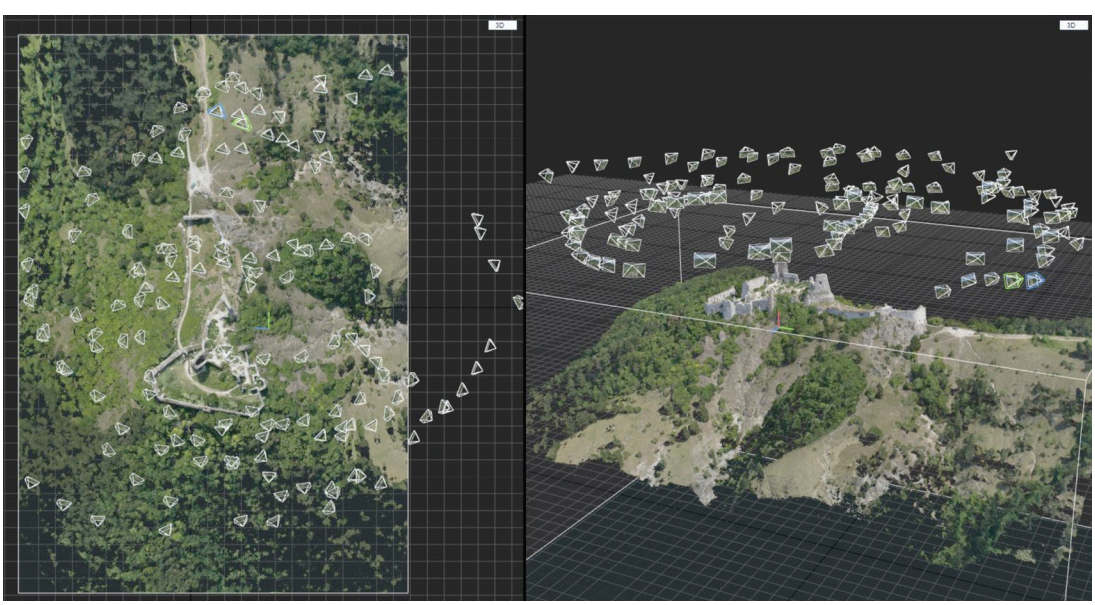

Figure 75. Čachtice (Slovakia). Castle, 13th-17th century. IbM (148 photos 12Mpx). Distribution of cameras during photo taking.

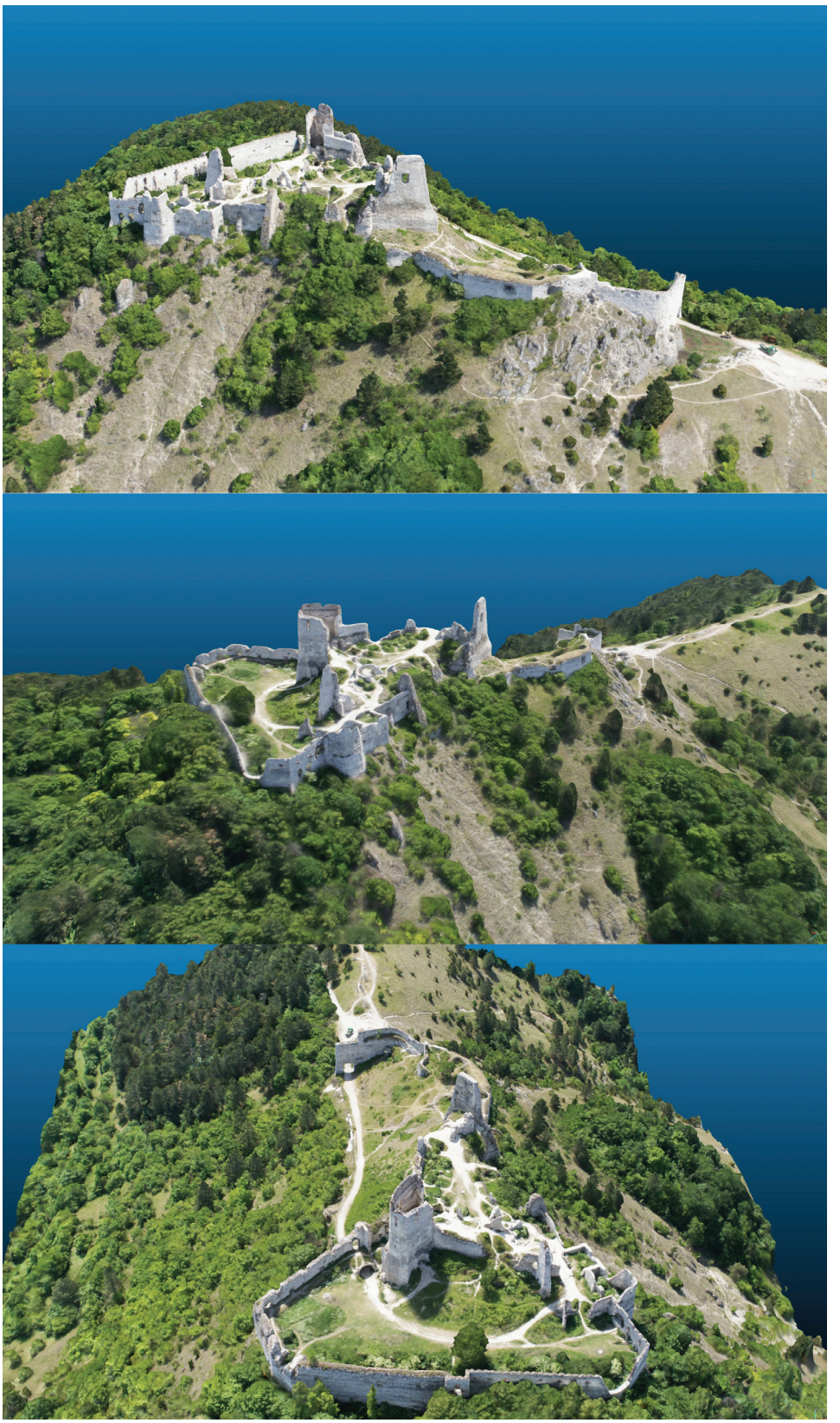

Figure 76. Čachtice (Slovakia). Castle, 13th-17th century. Isometric views of the textured 3D model.

Dobrá Voda, Castle

Site type:	Castle
Location:	Dobrá Voda, Trnava District, W Slovakia
Dating:	13th-17th century
Recorded parts:	Complete castle area
Recording technology:	TLS, IbM
Recording equipment:	TLS Leica C10, camera Nikon D5200 (optics AF-S Nikkor 16-85 f/3.5-5.6 ED VR DX), TS, GNSS Rtk Rover (differential GPS)
Software:	Agisoft Photoscan 1.1.0, CloudCompare 2.7, Microstation V8i trial version, Cyclone
Record:	Georeferenced 3D model (mesh), georeferenced orthophoto plans and cross-section views (Figs. 77-79)
Short description:	The castle is situated on the top and SW slopes of a limestone ridge. The oldest part (13th c.) is represented by two towers and a palace in between. Two late medieval extramural settlements are located to the east and the west from the core area of the castle. The far end of the eastern settlement marks a polygonal building (chapel?). At the southern edge of the western settlement lie a tower gate and cylindrical bastion. The third settlement was built in the 16th c. south from the castle, with walls connected with the castle and three cylindrical bastions and and entrance gate. The entire castle area was recorded. The terrain configuration has significant ondulations; also, dense forest cover created shadowed many parts of the architecture. Individual castle buildings were in various stage of degradation. In such circumstances, TLS (Leica C10) was used as the main recording equipment, occasionally completed with IbM for more complex architectural elements. Data from TLS and IbM were registered separately and subsequently merged in CloudCompare. Georeferenced GCP measured by TS were the basis for common registration.

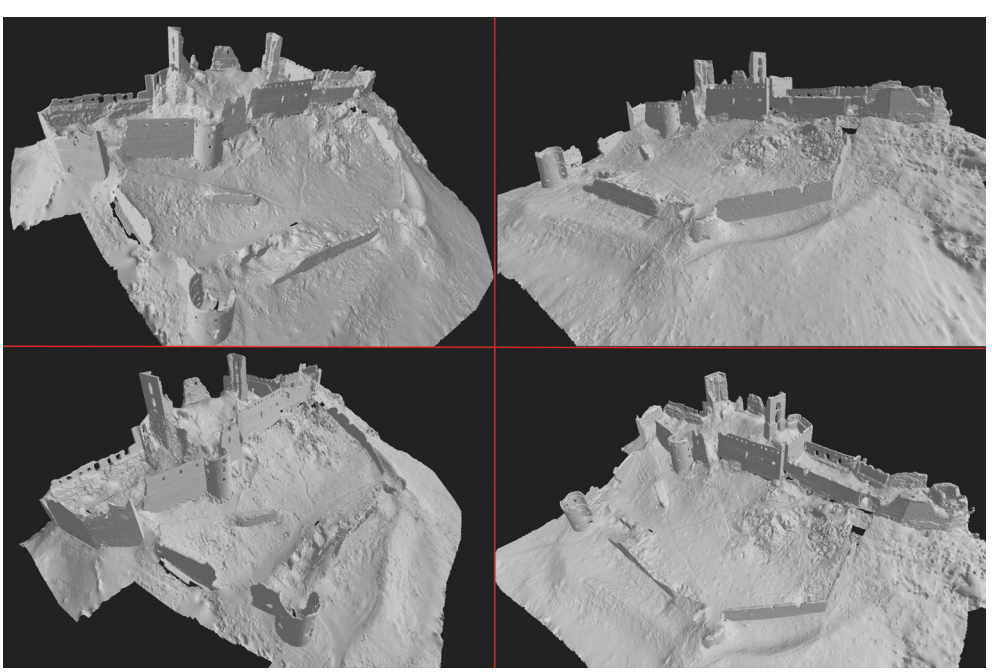

Figure 77. Dobrá Voda castle, 13-16th century. TLS (150 TLS stations). Isometric views of the shaded 3D model.

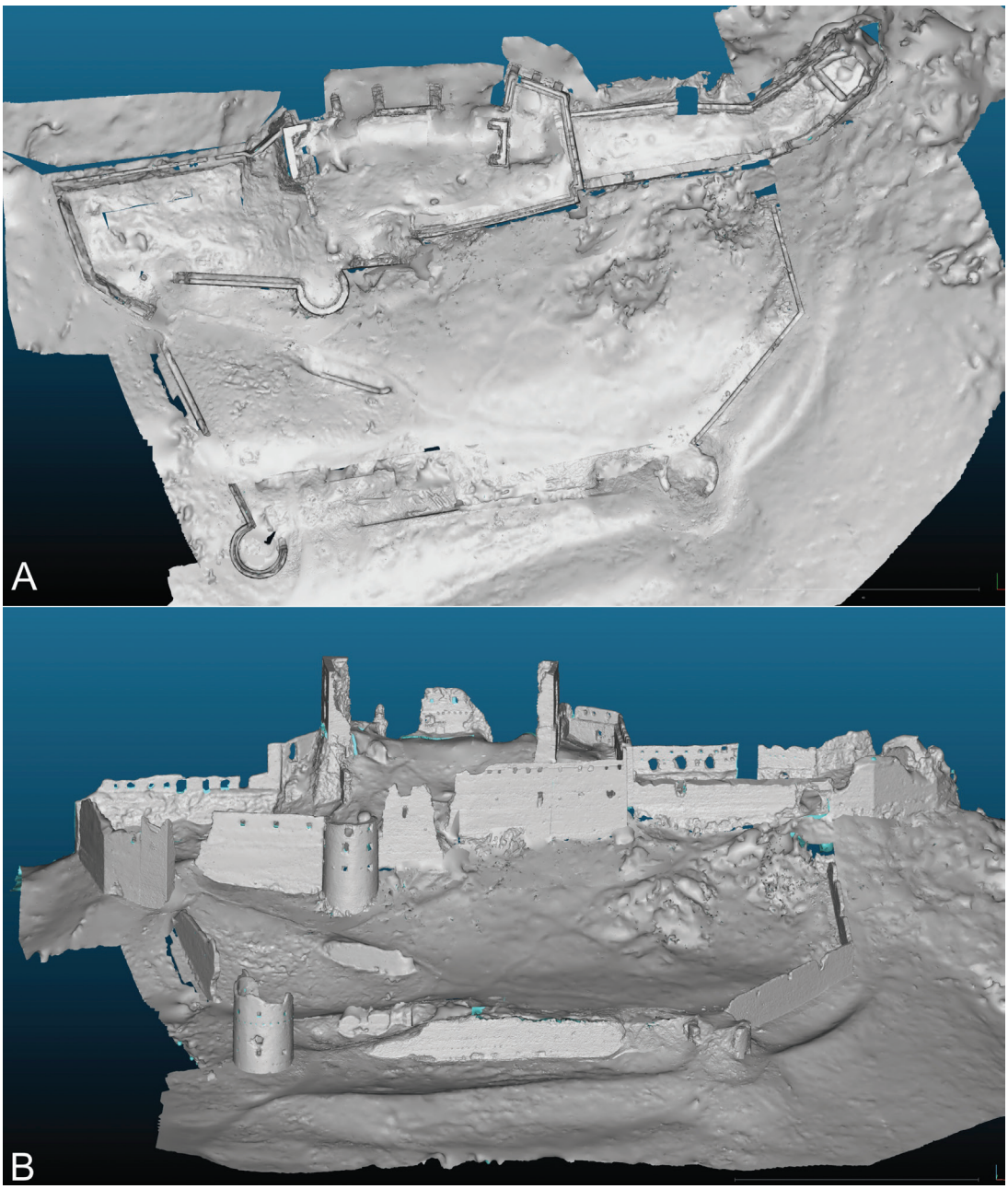

Figure 78. Dobrá Voda (Slovakia). Castle, 13-16th century. TLS. A: nadir view of the 3D model of the castle's ground plan, B: isometric view of the model of the castle complex.

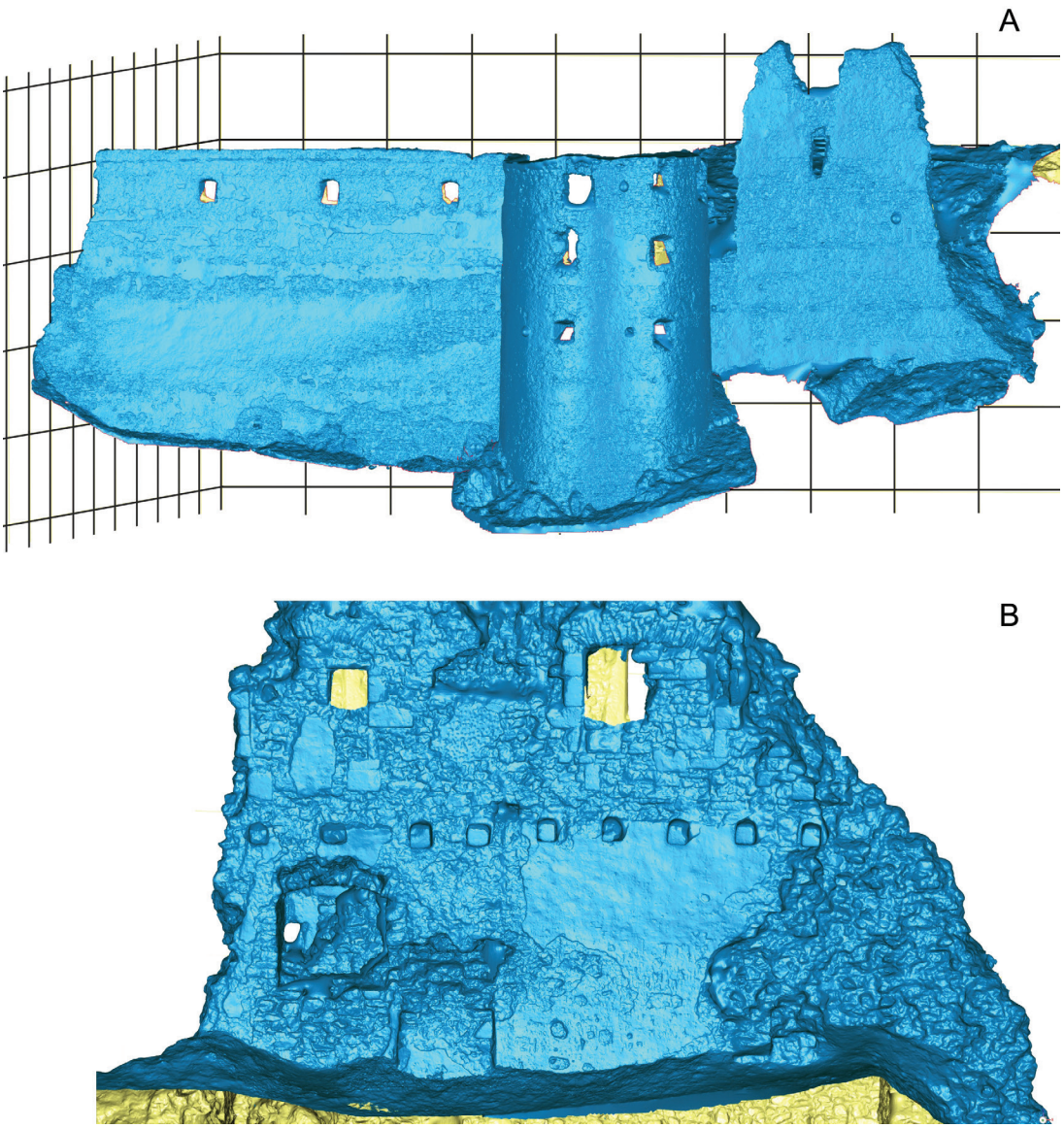

Figure 79. Dobrá Voda (Slovakia). Castle, 13-16th century. TLS. A: isometric view of the 3D model of the outer walls of the upper castle, B: view of the inner facade of the upper palace.

DISCUSSION

Castle architecture represents a special category of buildings determined by the landscape context and the nature of their construction; this places specific requirements on the digitisation process. As in the case of 3D documentation of building structures, documenting the remains of castles requires thorough reconnaissance of the terrain and an elaborate digitising scenario as well as a thorough plan of the work procedure. It is likely that a castle cannot be processed within a single set, especially in the case of more extensive complexes. Therefore, the collection and processing of the data should focus on smaller sections or individual structures of the castle complex. This places high demands on the general data management.

It turns out that the key determinant for the choice of digitisation strategy is the degree of elevation (terrain configuration) in different parts of the castle area and the extent and density of forest around the castle. Dense forest represents a substantial limiting factor to the application of basic IbM tools. This is especially true in the case of use of an UAV, which is necessary for the collection of data on vertical architectural elements. The example of Dobrá Voda castle shows that an UAV cannot be fully substituted by a high monopod stand in complex terrain with significant elevation variations combined with high structures. High density of trees made the use of TLS also difficult. The shadows created over, and by, the architecture required frequent change of scanner positions, as well as GCP, used for the registration of individual scans and their general georeferencing. Moreover, the positions of the surface scanner caused digitisation shadows on higher floors of individual structures, especially in areas of windowsills and linings of the windows or gun port openings. These elements usually cannot be captured by laser signal sent from the surface of the surrounding terrain.

Since UAV cannot be used for the photo documentation, most of the images were made from the ground level; the upper parts of the structures are thus captured from a highly oblique perspective. The lack of a sufficient number of perpendicular or almost perpendicular photos devalues the resulting texture, as the texture map is created by defining GCP between the 3D model (mesh) and the individual images. If part of the architecture is, in this work procedure, captured only at a very oblique angle, false perspective is created after such images are layered in the 3D model.

The situation is considerably simpler in the case of castles located in environments with little forest vegetation. Depending on the size and complexity of the castle area, only IbM or IbM in combination with TLS can be used. The potential of an UAV can be used in full, which is indispensable for the documentation of extensive castle ruins. Rough masonry (without any surface treatment) is characterised by a high degree of plasticity and texture structuring. This enables generating sufficient number of SIFT points in the process of bundle adjustment, which is the basic condition for a clean 3D model without much noise.