

# Surveying and Virtual Reconstruction of the Castle Ruin Hohenburg

EUGEN DUTESCU<sup>1</sup>, CHRISTOF FLÜGEL<sup>2</sup>, OTTO HEUNECKE<sup>1</sup>,

<sup>1</sup>INSTITUT FÜR GEODÄSIE, UNIVERSITÄT DER BUNDESWEHR MÜNCHEN

<sup>2</sup>BAYERISCHES LANDESAMT FÜR DENKMALPFLEGE

## SUMMARY

Up to the fire of 1707, the Hohenburg - in its final building condition a baroque castle - throned over the river Isar near the small town of Lenggries, Bavaria. A copperplate engraving and a votive picture attest the former appearance. On site only a few relics of walls are recognizable of the remained ruin, presumably belonging to different building periods. The entire facility is in a condition, which could only be stabilized with significant financial means in such a way, that the area could be opened for the public. To depict the final building condition of the Hohenburg a concept for the virtual development was worked out by the Friends of the Castle Ruin Hohenburg in Lenggries, the Bavarian State Office for Preservation of Monuments and Historic Buildings and the Institute of Geodesy at the University of the Bundeswehr, Munich. A high degree of geometric authenticity and detail reliability of the computer model is one of the main objectives. The primary task was to record the few remaining walls in the castle plateau area and to generate a digital model of the entire site. Therefore, a tacheometric and satellite supported network was created. The recording of the site morphology was achieved by terrestrial laser scanning, in which the surface is scanned contact-free in the form of a raster. The virtual reconstruction of the castle site, as long as an alignment is possible, is accurately attached to the detectable layout structures and the digital terrain model. The virtual reconstruction is now available to the Friends of the Castle Ruin Hohenburg, in order to establish a show room at the museum of Lenggries. The virtual reconstruction of the Hohenburg will be here the central "exhibit" and the scarce findings are only of illustrative nature within the exhibition concept.

## ZUSAMMENFASSUNG

Bis zum Brand von 1707 thronte über der Isar nahe der Ortschaft Lenggries, Bayern, die Hohenburg, im letzten Bauzustand eine barocke Schlossanlage. Von dem einstigen Aussehen zeugen heute lediglich ein Kupferstich und ein Votivbild. Geblieben ist eine Ruine, bei der vor Ort nur noch wenige Mauerreste zu erkennen sind, die mutmaßlich unterschiedlichen Bauperioden angehören. Die ganze Anlage befindet sich in einem Zustand, der nur mit erheblichem finanziellen Aufwand derart zu stabilisieren wäre, dass das Areal der Öffentlichkeit zugänglich gemacht werden könnte. Um den letzten Ausbauzustand der Hohenburg anschaulich präsentieren zu können, wurde durch den Förderverein Burgruine Hohenburg in Lenggries, das Bayerische Landesamt für Denkmalpflege und das Institut für Geodäsie der Universität der Bundeswehr München ein Konzept zur virtuellen Erschließung erarbeitet mit dem übergeordneten Ziel, dabei einen hohen Grad an geometrischer Authentizität und Detailtreue des Computermodells anzustreben. Primäre Aufgabe der Vermessung war es zunächst, die wenigen Mauerreste im Bereich des Burgplateaus zu erfassen und ein digitales Geländemodell des gesamten Burgbereiches zu erstellen. Dazu wurde tachymetrisch und satellitengestützt zunächst ein Passpunktfeld angelegt. Die Aufnahme der Morphologie des Geländes erfolgte über terrestrisches Laserscanning, einem neuartigen Messverfahren, bei dem berührungslos die Oberfläche in Form eines Rasters abgetastet wird. Die virtuelle Rekonstruktion der Burganlage setzt, soweit eine Zuordnung möglich ist, passgenau auf die noch erkennbaren Grundrissstrukturen und dem DGM auf. Dem Förderverein Burgruine Hohenburg steht die virtuelle Rekonstruktion nunmehr zur Verfügung, insbesondere für die Gestaltung eines Schauraumes im Museum Lenggries. Die virtuelle Idealrekonstruktion der Hohenburg wird hierbei das zentrale „Exponat“ bilden, das spärliche Fundmaterial hat in der Ausstellungskonzeption nur illustrativen Charakter.

## 1. Hohenburg Castle, Lenggries, Bavaria, Germany

Up to the fire of July 7<sup>th</sup> 1707 during the so-called “Spanischer Erbfolgekrieg“, the Hohenburg - in earlier times also named Hochenburg - throned over the river Isar near the small town of Lenggries, Bavaria. The last ruler of the castle was the family of Maxlrain and Schellenberg. Today, an copperplate engraving by Michael Wenig, made closely before the fire disaster (Fig. 1), and a votive picture, which shows the castle with snow covered roofs in the background (Fig. 2), attest the former appearance of the site - in its final building condition a baroque castle. More details on the history of the Hohenburg can be found in Ulrich, 2001.



Fig. 1: Copperplate engraving by W. Wenig, approx. 1700 (south-west-sight of Hohenburg Castle)



Fig. 2: Votive picture (west-sight of the Hohenburg Castle in the background)

After the destruction and the abandonment of the site, the stones were used among other things for the new Hohenburg palace (Schloss Hohenburg, approx. 500 m south-west of the old castle). Only a ruin remains, where today some wall rests can be recognized on site (Fig. 3).



Fig. 3: Wall relics in the foreground and ruins of the donjon in the background (south-west-sight direction)



Fig. 4: Aerial photo of castle location (by courtesy of Bay. Landesamt für Vermessung & Geoinformation)

As it can be seen in Fig. 4, in meantime the location of the former castle is covered almost entirely by deciduous trees, thus an air-based surveying of the site is excluded. In order to allow access of the broader public, relatively high financial efforts will be necessary to facilitate the stabilization of the entire site. However, the interference to the archaeological monument substance should be minimized in

such a case. Furthermore, the access to the ruin through the former north pathway is burdened by the exposed topography (e.g. endangerment by falling rocks). Thus, a visualization of the past at the original location, as it is frequently aimed at other sites, is improbable at the moment.

In order to illustrate the former castle and to point up its historical importance in the upper Isar valley, a concept for a virtual reconstruction was elaborated by the "Friends of the Castle Ruin Hohenburg" (Förderverein Burgruine Hohenburg) in Lenggries, the Bavarian State Office for Preservation of Monuments and Historic Buildings (Bayerisches Landesamt für Denkmalpflege, BLfD) and the Institute of Geodesy at the University of the Bundeswehr, Munich. The main objective was to achieve a high degree of geometric authenticity and detail reliability of the computer model. The whole project is a pilot for similar objects in Bavaria.

## 2. Surveying Tasks

The primary task of the surveying was to identify the remaining wall fragments, plateau edges, recognizable slide-rocks and outbreak pits within the range of the castle plateau and to provide a high resolution digital terrain model of the entire site. For this purpose a geodetic network with a total number of 22 points was surveyed using tachometry and GPS equipment. The connection of the surveyed network to the official reference system is realized via the SAPOS service (SAPOS stands for SatellitenPOSITIONUNGSDienst der deutschen Landesvermessung). This allows the connection of the surveying data with official deliverables like the digital cadastral map (digitale Flurkarte, DFK), digital aerial photographs and also digital topographic maps, e.g. TOP50 Bayern Süd.



Fig. 5: Impressions from the geodetic measuring campaigns at the plateau area of the Hohenburg; left: GPS receiver Leica System 500, right: tachometer Leica TCR System 700

An other advantage is to work in a north oriented system and to receive the elevation data with a sufficient approximation as heights above mean sea level. Even if the connection to the ordnance

network is ensured only with a standard deviation of about 3 - 4 cm due to the substantial coverage and the rather far distance to the nearest SAPOS station in Bad Tölz (about 10 km away), an accuracy on mm level of the internal geometry within the network is achieved. Such a geodetic network available, the surveying of the wall relics by tacheometry and the acquiring of the site morphology by terrestrial laser scanning can be performed.



Fig. 6: Laser scanner Leica HDS 3000 at the western flank of the castle bedrock

The terrestrial laser scanning is a rather new measurement technique that allows to digitally capture the shape of an object in form of a three dimensional point raster, the so-called point cloud, with additionally recorded intensity values. In order to obtain a suitable (manageable) amount of data, a raster of about 2 cm was used to capture the plateau area and about 10 cm for the bedrock area. To capture the entire site, the laser scanner Leica HDS 3000 was installed in a total number of 25 positions. After the registration of the data (the combination of all scan data into one local coordinate system) and the geo-referencing to the official coordinate system using the software Cyclone, a data volume of about 3 GB was obtained.

The next phase of the project was the point data “cleaning” in order to eliminate all unwanted data from the acquired point cloud. As to be seen in Fig. 5 the surface was easily distinguishable at the plateau, other than at the flanks of the bedrock, see Fig. 6. All the disturbing regions in the point clouds had to be cleaned manually before the digital terrain model can be created by triangular meshing. An intensity based segmentation of the point cloud provided only partial results.

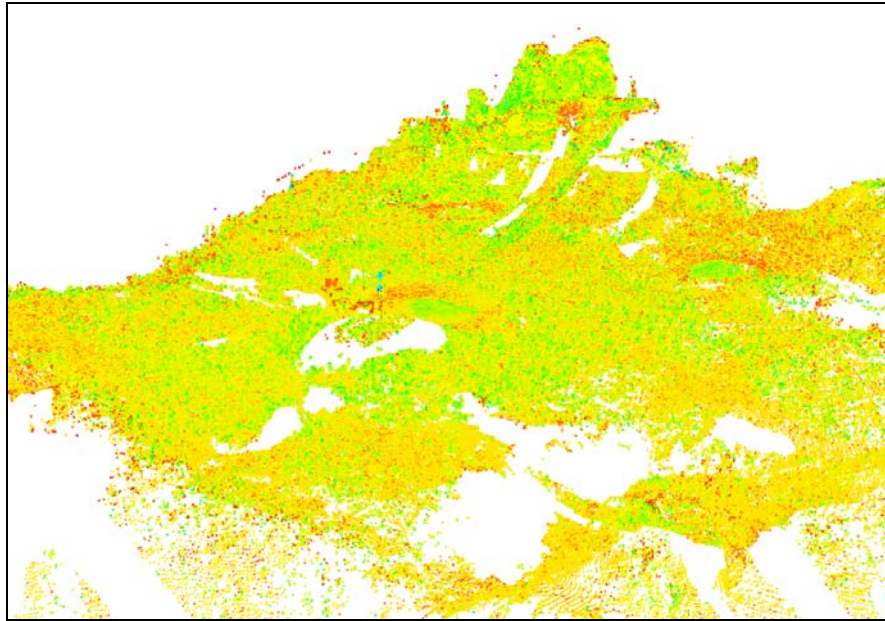


Fig. 7: Intensity colour map of a point cloud at the plateau (raster about 2 cm x 2 cm); screenshot Cyclone with the donjon in the background. The green colour denotes regions with a good reflectivity level and the red ones defines points with a lower level.

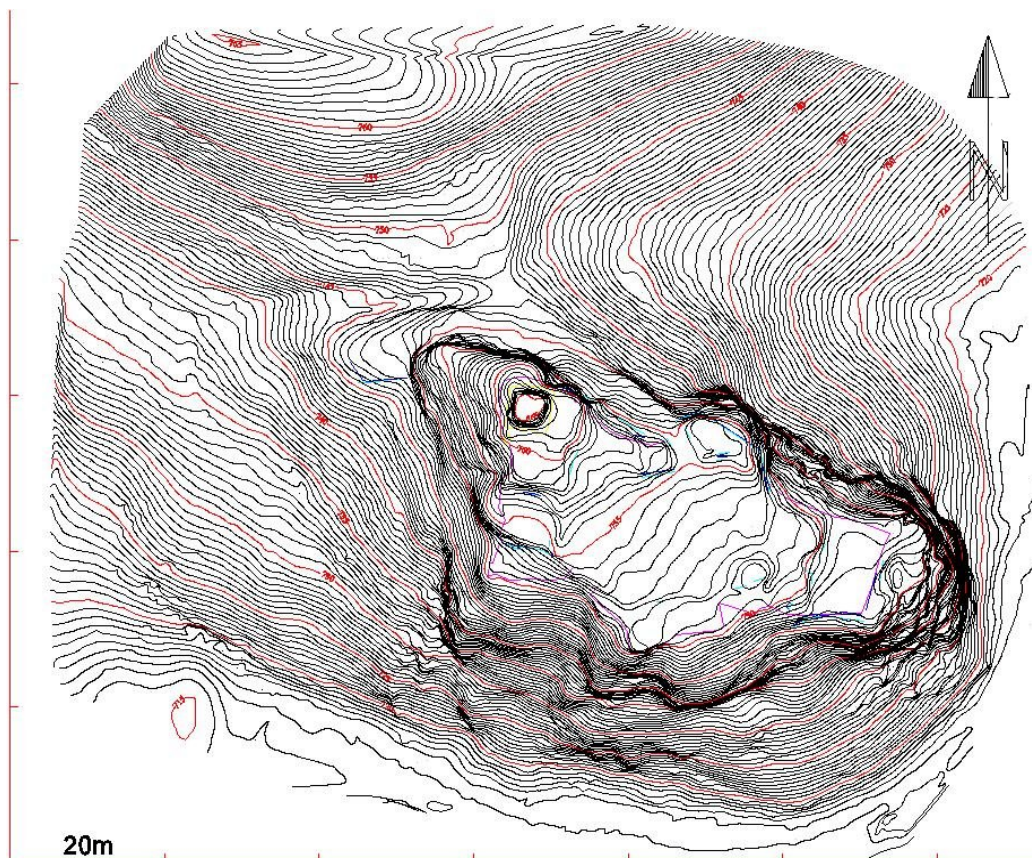


Fig. 8: Castle bedrock with contour lines (equidistance 0,5 m) and ground plot of walls relics (blue)

Fig. 8 shows the contour lines of the castle bedrock with an equidistance of 0.5 m, obtained after exporting the triangulated scanner data from the laser scanner software Cyclone to AutoCAD. Beneath in Fig. 9 the surveyed wall relics and plateau edges are illustrated in a perspective view. Although it is spoken of a “plateau” it has to be annotated that height differences up to approx. 10 m are present. For all the daily work and activities at the comparatively small court yard with about 20 m x 40 m in dimension this surely was an appreciable restraint (Förderverein Burgruine Hohenburg, 2006).

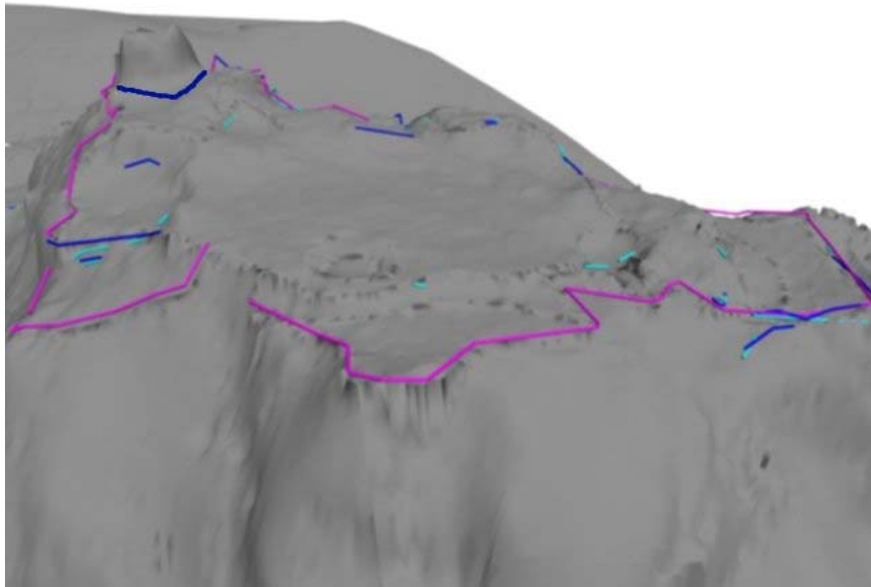


Fig. 9: Perspective sight of the plateau with walls rests (blue) and plateau edges (pink)

### 3 Virtual Reconstruction

The next steps of the project was the virtual reconstruction of the castle site. All buildings are as accurately as possible attached to the detectable layout structures and the digital terrain model, as long as an alignment was possible. In some places, a correspondence between the topographic survey and the two delivered sources (see Fig. 1 and 2) was possible only with the appropriate guidance from the Bavarian State Office for Preservation of Monuments and Historic Buildings. The differences between the results from the surveying campaign and the two illustrations probably can be explained by different building phases of the castle. However, there are some dissimilarities between the current terrain model and the one illustrated in the copperplate engraving. Presumably the reproduction of the natural site situation was not essential for the artist. Looking at Fig. 1 and 2 some differences related to the windows and chimneys can be seen. In such situations the reconstruction is done with respect to the copperplate engraving. Apart from the necessary geometrical information such as the approximate building heights deducted from the copperplate engraving, the so-called semantic knowledge is also

essential for the virtual reconstruction. This for instance is related to the shape and colour of the roof tiles given by some site findings. To complete lacks of knowledge, a set of illustrations with comparable buildings from the 13<sup>th</sup> to 18<sup>th</sup> century was supplied by the Bavarian State Office for Preservation of Monuments and Historic Buildings (see Fig. 10). In this way details of items like windows, doors, brick-work, etc. could surpass the quality of the original source images (Fig. 1. and 2). Moreover, some digital images are used directly as texture maps in the virtual reconstruction, see Fig. 13 and 14. Furthermore, following the available details from the illustrations in Fig. 1 and 2 objects like oriels, arcades, windows, doors and even a sun-clock are modelled and positioned using the software 3ds Max by Autodesk. More details for a typical virtual reconstruction process are described in Dutescu, 2006. The general appearance of a medieval castle site in present time is illustrated in Fig. 10, left side. However, in case of the Hohenburg Castle the virtual reconstruction should provide the appearance of a castle with defence purposes as it appeared in the 17<sup>th</sup> century.



Fig. 10: Digital images provided by the Bavarian State Office for Preservation of Monuments and Historic Buildings for the virtual reconstruction. Left intended impact of the complete site, roofs and chimneys in the middle, entrance door on the right.



Fig. 11: Virtual reconstructed Hohenburg Castle, technical model (compare votive picture in Fig. 2)



Besides the geometrical and semantic information some further inputs are needed in the virtual reconstruction. The initial aim of the project at the beginning was to create a more technical oriented but preferably authentic model of the castle site as is depicted in Fig. 11. Here the bedrock is taken directly from the laser scanning survey, e.g.

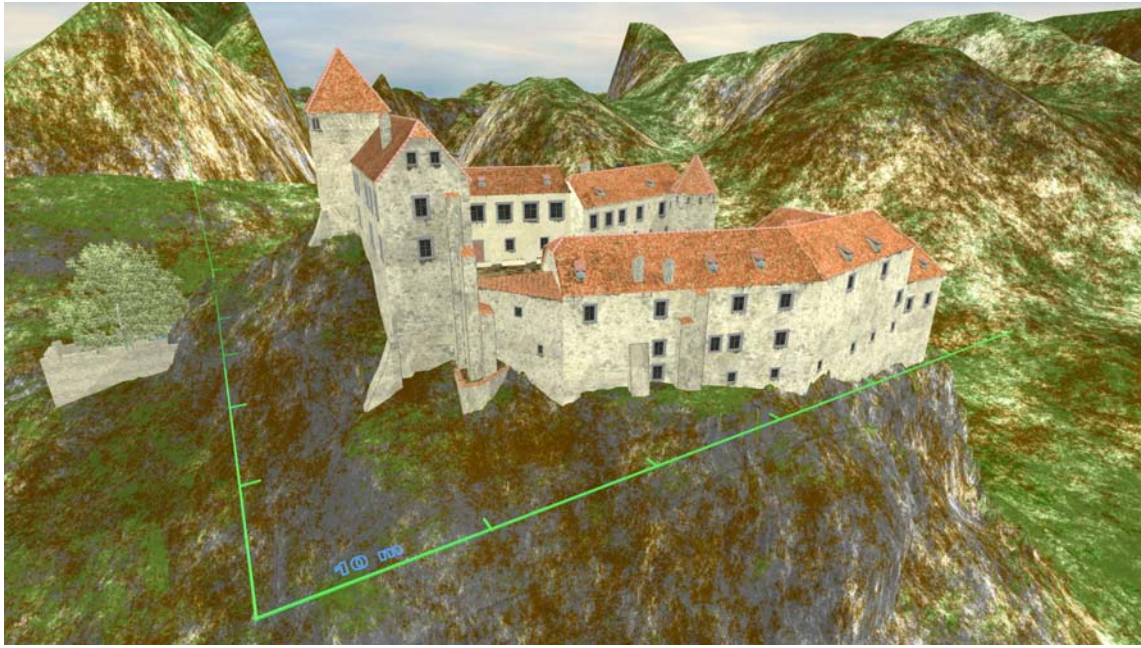


Fig. 12: Virtual reconstructed Hohenburg castle (compare copperplate engraving in Fig. 1)

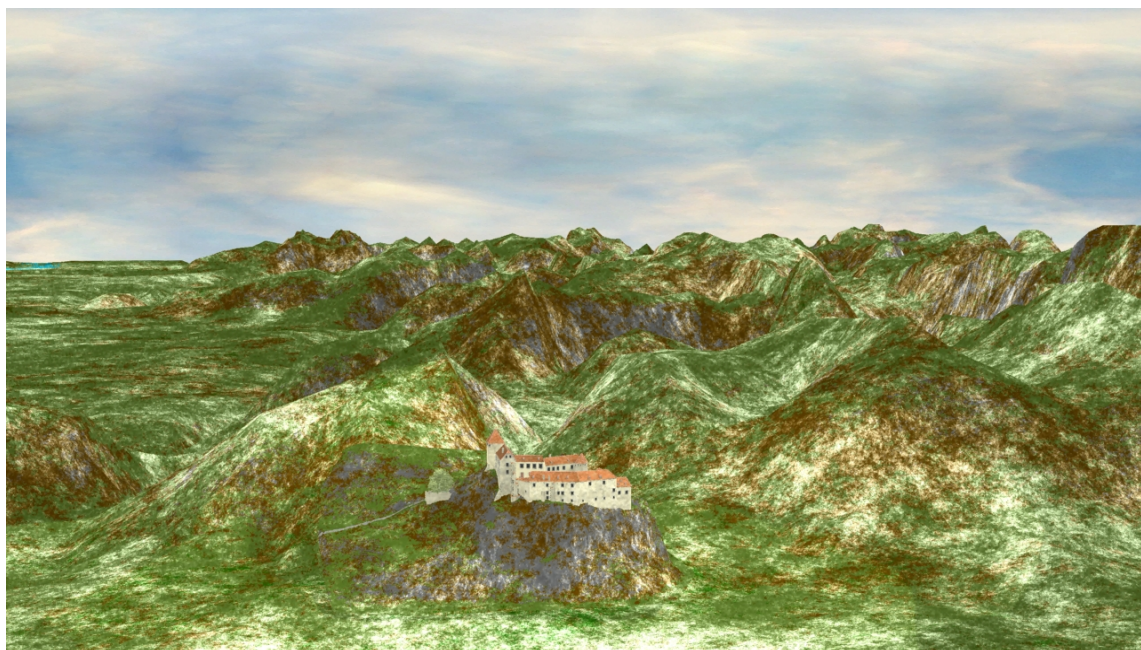


Fig. 13: Virtual reconstructed Hohenburg castle embedded in the surrounding of the alpine mountains



Fig. 14: Virtual reconstructed Hohenburg, detailed view at court entrance on the north side



Fig. 15: Virtual reconstructed Hohenburg, detailed view at the east building from the court yard

However, the project evolved by-and-by to a more photo realistic model due to the wishes of the “Friends of the Castle Ruin Hohenburg” with regard to the intended utilization in a museum. A purely technical reconstruction (simple volumina model without high sophisticated texturing) however will not satisfy the visitors’ eyes, as it remains (notedly) behind today’s well established museums standards. Among others, an aim was to give an aged, weathered appearance to the virtual castle and the lime formations of the bedrock. Finally, the complete location is embedded in the 3d panorama of the alpine region by use of the available digital topographical map of Bavaria, scale 1:50000. This is to give a background to the model. Only the landscape texture for the morphology is changed here.



Fig. 16: Virtual reconstructed Hohenburg, top view at the castle and surrounding bedrock

Fig. 14 and 15 depict some detail views at the computer model and the data sources used to generate the model details. Fig. 16 gives a top view on the site. The bastion in the west and the pathway at the north of the castle are to be seen. Based on the digital model animated films enriched by text and music can be produced. This is made also within the project due to the requirements and wishes of the “Friends of the Castle Ruin Hohenburg”.

#### **4 Actual stage of the project**

The surveying and the virtual reconstruction concept used here for the Hohenburg Castle has a pilot character within the Bavarian State Office for Preservation of Monuments and Historic Buildings (Dutescu et al., 2006). A new concept for the assessment to a monument for a broader public using the possibilities of computer techniques is elaborated, and the original monument keeps untouched as it is. This form of presenting a monument provides information for different parties such as tourists, school

classes from the region etc. and also can be used as a base for a physical model, such as a Diorama – if still needed. The virtual model can be modified easily at any time in order to meet new requests or target groups. Nearly no technical limits are given, however. Moreover, with the help of geodetic measurements it is possible to obtain a high degree of geometrical authenticity for such virtual reconstructions. This could also be a basis for further, more scientific works on such kind of projects.

The virtual model created within this project will be used by the “Friends of the Castle Ruin Hohenburg” and the community of Lenggries especially for a show room in the local Lenggries museum. This show room will be opened next year for the celebration of the centenary of the fire of July 7<sup>th</sup> 1707. Besides some other scarce findings and original documents, a “fly through” over the virtual reconstructed Hohenburg will be the central main exhibit. From point of the Bavarian State Office for Preservation of Monuments and Historic Buildings this is a completely new exhibition concept for minor archaeological museums, given that a virtual reconstruction at a computer is the nucleus and not only a facultative additive element to illustrate the scarce findings, which, according to prevailing museums standards are normally considered to attract the focus of attention. In the case of the Hohenburg show room, the choice of scarce findings therefore will be made with regard to the specific information each single piece can contribute to the understanding of the ruin and its virtual reconstruction. Thus, e. g. tiles or mortar fragments from the Hohenburg ruin are considered to be more informative than well-preserved objects having only art historic value. The fly-through of the Hohenburg Castle with about 3 minutes length will attract immediately the visitor’s attention. The story behind the fly-through, that’s to say the historical sources for the reconstruction and the “high-tech” used to achieve such a result will be confined to “flat ware” with texts and illustrations along the walls of the exhibition room. This is to avoid an informative overkill within the film itself.

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