

# MEASURED SURVEY AND DIGITAL PHOTOGRAMMETRY METHODS DURING THE RESTORATION OF THE MAIN DOME DECORATION IN THE PILGRIMAGE CHURCH OF ST. JOHN OF NEPOMUK AT ZELENÁ HORA IN ŽDÁR NAD SÁZAVOU

Jaroslav ZASTOUPIL <sup>1</sup>, Jiří VIDMAN <sup>2</sup>, Pavel HLAVENKA <sup>3</sup>

<sup>1</sup> Zastoupil a Král Land Surveyors, Thákurova 3, Praha 6, Czech Republic, zastoupil@zkz.cz

<sup>2</sup> Jiří Vidman, Národní Obrany 21, Praha 6, Czech Republic, jiri@vidman.cz

<sup>3</sup> PH Agentur, Buzulucká 426, Teplice, Czech Republic, phagentur@volny.cz

**Keywords:** Measured survey, photogrammetry, digital photography, cultural heritage, documentation, visualisation, restoration, surface geometry analysis

## Abstract:

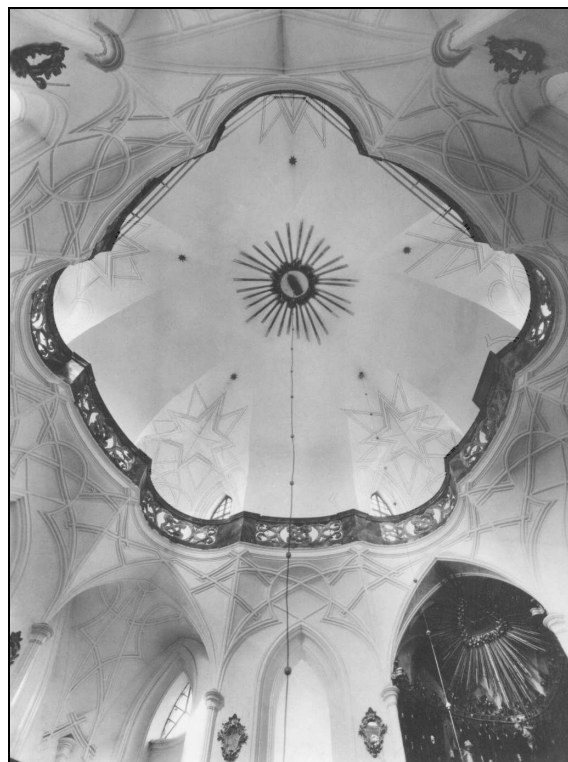
*The pilgrimage Church of St. John of Nepomuk at Zelená Hora in Žďár nad Sázavou is the unique work of Jan Blažej Santini-Aichel. During the restoration research in 2004, traces of this original decoration were found. Our first task was the measured survey of this finding, including the photo-plan. The analysis of art historians and conservationists followed. Thanks to the extent of our findings, the original ornamentation was recognizable. 3D visualizations were made for the result's presentation. As the final conclusion of the expert committee, the original decoration was fully restored. Because of the low-cost reconstruction of the dome in 1794 – 1802, the dome lost its ideal spherical shape. Consequently, the next task was the analysis of the deviation of the current surface from the ideal sphere, which was important for the restorers and stucco artists to assure the right final visual effect. The last part of the surveying work was the documentation of the final result. Restoration work finished in 2008. This report describes the total of all the surveying, photogrammetric and laser scanning methods used during the process.*

# 1. MEASURED SURVEY AND DIGITAL PHOTOGRAMMETRY METHODS DURING THE RESTORATION OF THE MAIN DOME DECORATION IN THE PILGRIMAGE CHURCH OF ST. JOHN OF NEPOMUK AT ZELENÁ HORA IN ŽD'ÁR NAD SÁZAVOU

## 1.1 The pilgrimage Church of St. John of Nepomuk at Zelená Hora in Žd'ár nad Sázavou

Construction of a pilgrimage church consecrated to St. John of Nepomuk was initiated by the abbot of the Cistercian monastery in Žd'ár nad Sázavou, Václav Vejmluva (1670–1738). The architect of the church was Jan Blažej Santini-Aichel (1677–1723), who produced a design now regarded as one of the crowning works of the 'Baroque Gothic' style. The church itself was built in 1719-1722; construction of the ambit continued through the following decades, ending only in 1769.

On July 16, 1784 a fire destroyed the church's roof. In the same year, the monastery itself was dissolved. Threatened with ruin, the church was only saved through the care of local residents, guided by Father Matěj Josef Sychra (1776-1830), who eventually succeeded in winning permission for the church to be revived as a cemetery chapel. The roof of the church was rebuilt in 1792, along with the vaulting. However, by this time the ornamentation of the vaulting had long since been destroyed, and because of the limited funds available, the restoration in 1794-1802 only repaired the most necessary sections. This fact remains evident even in photographs from the 1960s (Figure 1), in which the bare vaulting over the main interior contrasts with the rich ornamentation on all other surfaces.



**Figure 1:** Main dome, 1953 (Image: archive of the The National Institute for the Protection and Conservation of Monuments and Sites, Brno, Photo: Čestmír Šíla)

The pilgrimage church was inscribed in 1994 in the UNESCO world heritage register, as item no. 690.

In the period 2005-2008, a great quantity of documentary work was completed regarding the church, specifically documentation of partial repairs or examinations, and including the overall evaluation of the actual condition of the complex. Most interesting both for historians and surveyors was unquestionably the documentation of the ornament of the church vaulting, where it was necessary for this entirely unique commission to ensure documentation that would suit the needs of the participating experts: preservationists, art historians and restorers.

## 1.2 Dokumentation work for reconstruction of the ornament of the vaulting in the main nave

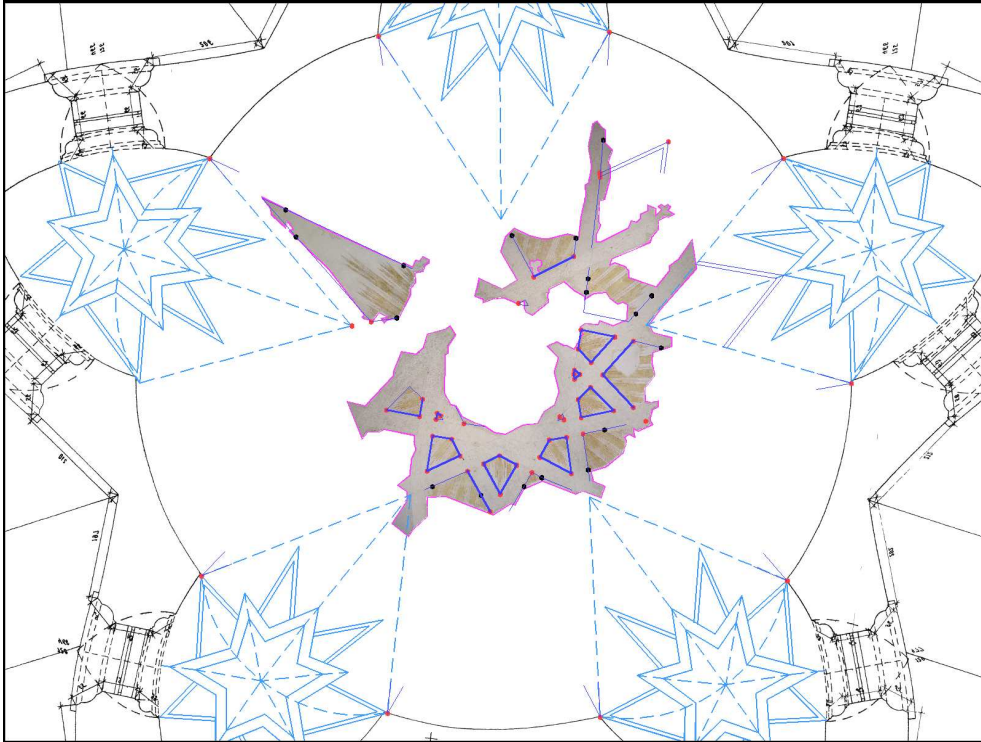
During restoration examination in 2004, traces were found in the cupola of the original ornament and even original stucco work from the period of Santini. These traces not only contained the outlines of the original ornament and fragments of the original frescoes, but even the original sketching lines in graphite (Figure 2). For the surveyors, the first task was to document these findings. Complicating the work was the fact that the space for measurements was divided into three sections by the surfaces of the scaffolding, between which there was only a gap of a few centimetres in width between the scaffold and the actual surface of the vault. A further complication was the impossibility of using tripods.



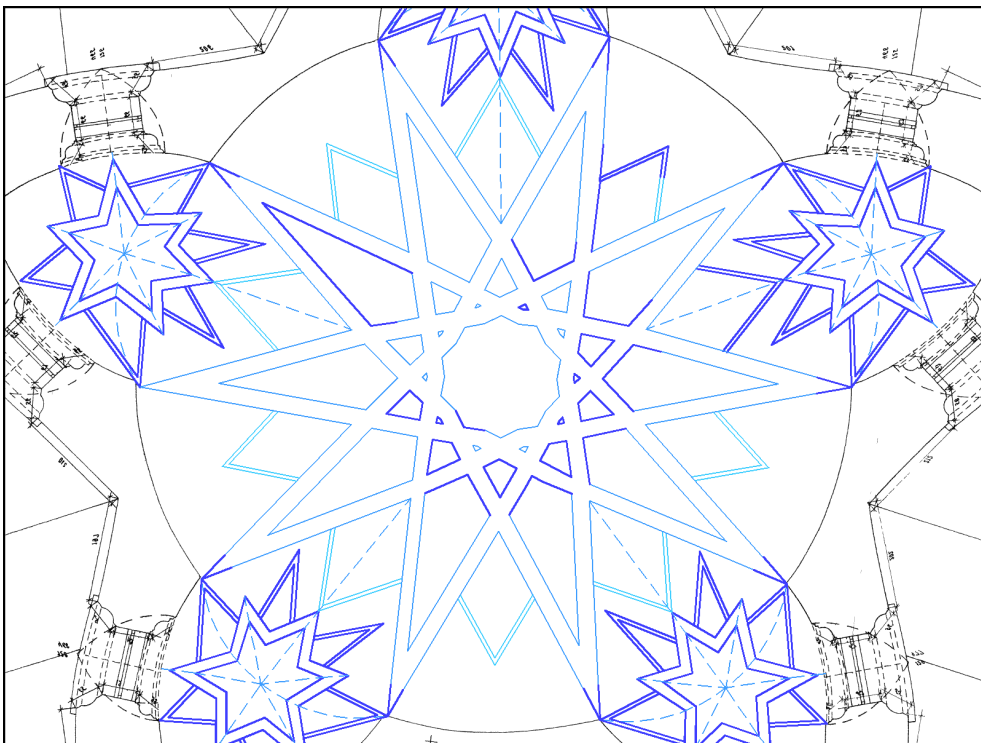
**Figure 2:** Part of the foundations of original stucco work from the period of Santini.  
(Photo: Jaroslav Zastoupil)

A spatial micronetwork was created, composed of fixed points stabilised by screws affixed to the stucco of the vaulting and free-standing points for the total station. Measurements were made with a Leica TCR. The network was rectified using the smallest-square method; the standard deviation was  $m_{xyz} < 3$  mm. From it, all of the discovered traces of the original ornament were measured. Additionally, a photographic plan was made of the findings, using the software TopoL.

The next step was analysis of the findings. Thanks to their extent, it was possible to undertake reconstruction of the original ornament of the cupola. For the final decisions of the art historians and preservationists, a visualisation was prepared of the extant state and the possible methods for reconstruction. On the basis of this data, it was decided to undertake a full reconstruction of the original ornament. (Figure 3 and Figure 4)

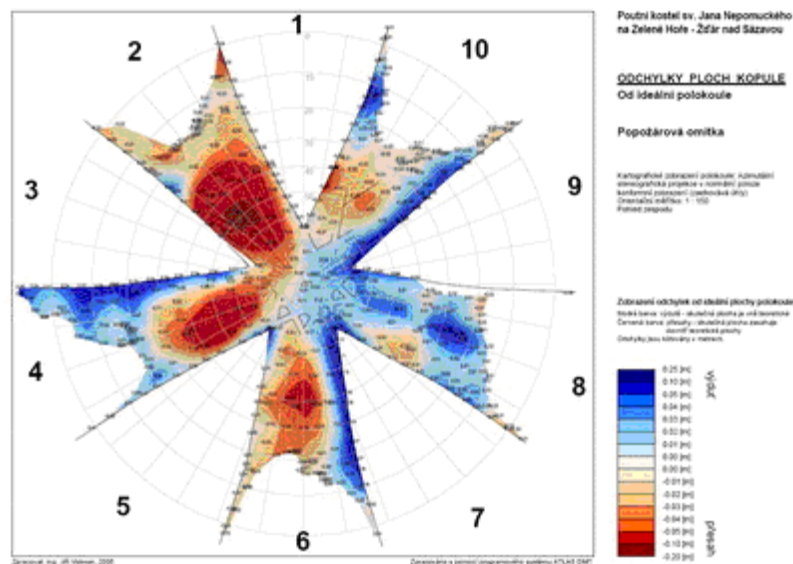


**Figure 3:** The foundations projected to the floorplan.  
(Image: Pavel Hlavenka)



**Figure 4:** Analysis and reconstruction of the original ornament based on the survey.  
(Authors: Jan Vinař, Zdeněk Chudárek)

Because the cheaply performed reconstruction of the cupola in 1794-1802 caused a deformation of its shape, for the work of the stucco artists it was essential to undertake an analysis of the current and actual form of the cupola, and determine its deviations from the form of an ideal spherical surface. This task was performed through the program Atlas DTM (Digital Terrain Model) and the deviations depicted using colour hypsometry. (Figure 5)



**Figure 5:** Analysis of the actual form of the cupola.  
(Author: Jiří Vidman)

On the basis of our documentation, reconstruction of the vaulting ornament was completed in 2005-2007. The resulting state was documented through the method of 3D scanning using a Leica HDS3000 scanner. The standard deviation of the point coordinates was  $m_{xyz} \leq 6$  mm. Scanning was undertaken by the company Gefos, a.s. Prague. The results of these measurements were eventually used in the documentation of the church in 1:50 scale in 2008-2009.

## 2. ADDITIONAL WORK

In addition to the aforementioned work, further documentation was also prepared:

### 2.1 Documentation of the balustrade of the 2nd gallery

After repairs in 2007, documentation was performed of the wooden balustrade in the 2nd gallery in 1:10 scale. The balustrade is composed of 10 sections, with sections of radius 1.78 m alternating with sections of radius 5.00 m. (Figure 6) The metric images were shot using a calibrated Nikon camera. Each section of the balustrade was projected onto the surface of a substitute cylinder and unrolled flat. The photographic plans were then subsequently colour-treated, bitmapped and cropped. The size of the pixels in the resulting photoplans is 1 mm.



**Figure 6:** One of the ballustrade segments.  
(Photo: Jiří Vidman)

Software used: PCI, TopoL, Atlas DTM a Adobe; the coordinates of the ground control points were determined geodetically, total station: Leica TCR.

## **2.2 Documentation of the current state of the complex**

In 2008-2009, measurement was performed of the actual state of the complex of the pilgrimage church. The last documentation of the complex dates from 1966, and is available in only one surviving scroll of paper blueprints. This state caused many complications for their usefulness:

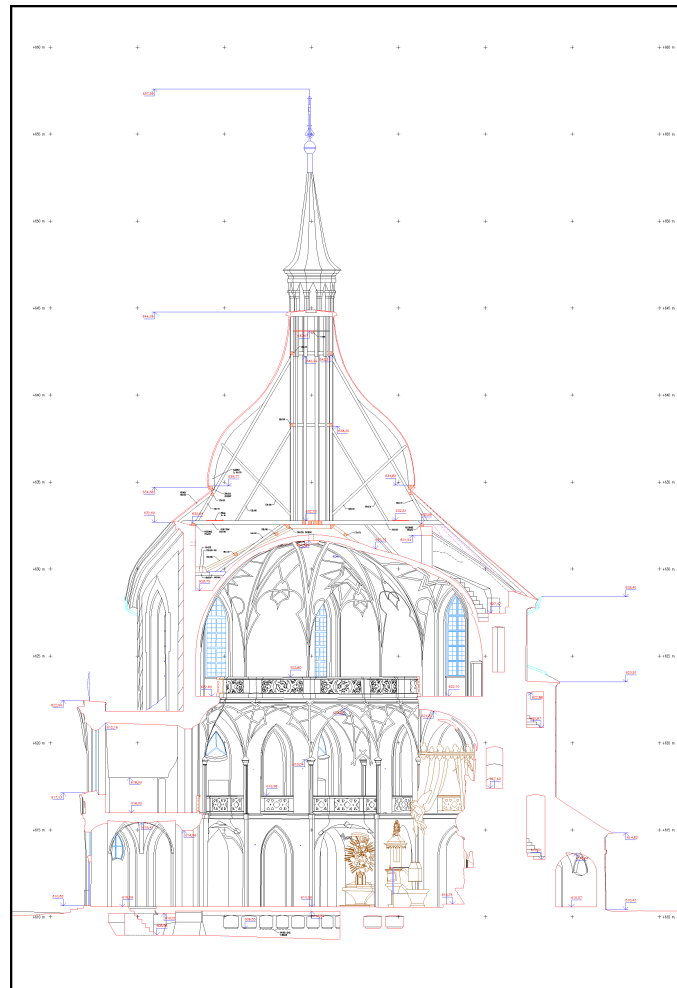
- The quality and precision of the documentation is limited by the technologies then in use.
- Since 1966, many changes, structural and landscaping alterations have occurred, so that the state depicted does not match that in reality.
- Because of the condition of the paper on which it is printed, the surviving scroll of blueprints is practically unusable.

A thematic map of the complex was created in 1:200 scale along with documentation of built structures in 1:50 scale. This documentation consisted of floor plans for each floor level, 4 cross-sections (Figure 7) and 5 elevations.

Survey was performed with a combination of geodetic and photogrammetric methods. The geodetic part was performed with a Leica TCR total station, detail measurement with a laser distance meter Leica DISTO and common direct measures.

Measurement views for the photogrammetric part of the documentation were performed with the following metric cameras: Zeiss UMK 10/1318 and UMK 6.5/1318, and Rollei Metric 6008. Vector evaluation was performed using the analytic plotter Zeiss Planicomp.





**Figure 7:** Cross section of the church.

### 3. CONCLUSIONS



**Figure 8:** The interior of the church after the reconstruction, 2008. (Photo: Jiří Vidman)

### 4. REFERENCES

- [1] HORYNA, Mojmír. *J. B. Santini-Aichel – Život a dílo*. Praha : Karolinum, 1998. ISBN 80-7184-664-3. p. 338-349
- [2] CHUDÁREK Z., JERIE P.: *Kopule poutního kostela*, in: *Kostel sv. Jana Nepomuckého na Zelené hoře*. Editors: Veselá, M., Šanderová, J., Vítková, M.. Telč : Národní památkový ústav – územní odborné pracoviště v Telči, 2009. ISBN 978-80-904240-0-5, p. 176-189
- [3] RAFL, T.: *Rekonstrukce štukové a malířské výzdoby kopule*, in: *Kostel sv. Jana Nepomuckého na Zelené hoře*. Editors: Veselá, M., Šanderová, J., Vítková, M.. Telč : Národní památkový ústav – územní odborné pracoviště v Telči, 2009. ISBN 978-80-904240-0-5, p. 194-201
- [4] CHUDÁREK Z., ŠACH M.: *Restaurování zábradlí druhého ochozu*, in: *Kostel sv. Jana Nepomuckého na Zelené hoře*. Editors: Veselá, M., Šanderová, J., Vítková, M.. Telč : Národní památkový ústav – územní odborné pracoviště v Telči, 2009. ISBN 978-80-904240-0-5, p. 208-213