DOCUMENTATION OF THE BASILICA OF MAXENTIUS IN ROME - METHODS FOR PROVIDING FOUNDATIONS FOR MONUMENT RESEARCH

Gunnar Siedler, Matthias Hemmleb, Gisbert Sacher
fokus GmbH Leipzig
Gustav-Adolf-Str.12, D-04105 Leipzig, Germany
Phone +49-341-2178460, E-mail: home@fokus-gmbh-leipzig.de

KEY WORDS: Architectural photogrammetry, Building survey, Image maps, Image Unwrappings, Surveying service

ABSTRACT

Monument research and conservation requires in most cases an extensive documentation of the concerning object in a short time. With combined geodetic and photogrammetric methods the demanded map documents are of high quality and accuracy, especially in case of exact documentation true to scale. In view of the nature of the task and the financial frame, this requires the choice of adequate methods for surveying and documentation of the monument. Horizontal and vertical intersections were derived by geodetic measurements supported by laser technologies. By using predefined codes this method achieves results with high accuracy in an efficient way. Structured façades and special building details were recorded by stereo evaluation from metric images. In many cases the documentation or parts of it don't require a cost intensive stereo evaluation because the façade is nearly plain. Thus the rectification and montage of semi-metric images to image maps was performed. Besides, regular surfaces were recorded to image maps by unwrapping methods. The ruins of the antique Maxentius-Basilika at the Forum Romanum in Rome, were documented during two weeks in 1998. The derived products - image and graphical maps 1:25 - serve as map basis for building investigations and the documentation of the monument.

1 PLANNING AND IMPLEMENTATION

The request for the documentation of most parts of the Basilica of Maxentius with geodetic and photogrammetric methods occurred shortly before the beginning of the planned preservation work. Because this work was foreseeably accompanied by changes of the historical building substance, a detailed mapping of the façades and their damages was carried out by hand (DÖRING 2000). Graphical and image maps from the geodetic and photogrammetric survey serve as basis for this mapping.

Fig. 1: Basilica of Maxentius, 1998

Fig. 2: North nave of the Basilica, 1998

At the beginning of the work, scope and accuracy of the project were discussed. Details, like the joints of the bricks, should appear clearly in the image maps. Hence, a scale of 1:25 was chosen for most of the graphical and image maps. In relation to the recommendations for building documentation (ECKSTEIN 1990, new edition 1999) all measurements are in accuracy level 3-4. Following work and products were the aim of the project:

- definition of intersection height with level and rotating laser
- horizontal intersection in scale 1:25 with total station
- different vertical intersections in scale 1:25 with stereo evaluation
- image maps of all façades in scale 1:25 (inside and outside)
- overview image maps with gridlines in scale 1:100
- cylindrical image unwrapping of all the three vaults in scale 1:25
- cylindrical image unwrapping of all the three apses in scale 1:25 (inside and outside)

To reach this aim, a large amount of photogrammetric images was to be taken. The accuracy definition as already described, was basis for the planning of the image acquisition. But the images should not only serve as basis for the enumerated photogrammetric products, they also should document the whole monument and enable the evaluation of building parts, which are not object of the recent work. In order to get a mostly complete documentation of the monument with photogrammetric images, following acquisition techniques were used:

- image pairs for stereo evaluation with large format metric camera (UMK 10/1318)
- images for rectification and unwrapping with large format camera (Cambo Wide 58) and also with large format metric camera (UMK 10/1318)
- images for three-dimensional evaluation and further reference point determination with semi-metric camera (Rollei 6006 metric)
- small format images for documentation of measurements and planning purposes (Nikon FM2)

Fig. 3: Metric image of the north-east side of the basilica

Fig. 4: Large format image of the middle vault of the north nave

Altogether 30 image pairs with UMK, 110 images with Cambo and over 150 images with Rollei were taken. Additionally over 100 Rollei images were taken within the project from the Photogrammetric Department of the Technical University Berlin. Digital cameras were not used, because at that time, they did not provide the needed quality, resolution and efficiency, as metric and large scale cameras in connection with high resolution image scanning do. Another reason for the use of non-digital cameras is the necessity of film material for archive purposes.

The surveying work was performed in two measurement campaigns with a duration of one week each. Within the first campaign a geodetic basis was provided. This includes a triangulation network in and around the building and the measurement of photogrammetric reference points. All points were measured with total stations and calculated within a least-squares-adjustment in order to get a global reference system with a homogeneous accuracy for all further products. In parallel, the photogrammetric data acquisition started. After finishing the triangulation network the geodetic measurement of a horizontal map and selected vertical maps followed. The second campaign was used for field control and further detailed photogrammetric and geodetic measurements.

The geodetic calculation of network, reference points and intersections was already performed during the campaign. With the use of notebooks and large scale ink-jet-printers first plots of the resulting maps were possible. Most of the work was done between and after the surveying campaigns. For stereo evaluation an analytical plotter was used. Because image rectification and unwrapping was performed in a digital way, images had to be digitised with high quality film scanners (Kodak Pro Photo CD and Zeiss PhotoScan PS2). While rectification was done with a commercial software (Eddi 2D / metigo 2D) a self developed software was used for image unwrapping (metigo 3D).

2 RESULTS

2.1 Graphical Maps

The horizontal intersection of the existing parts of the basilica in scale 1:25 serves as basis for the following measures by hand. It was measured at a defined and signalised height at the building. All further graphical and image maps refer to the coordinate system of the horizontal intersection. Besides an overview map in scale 1:100 was derived. It serves for instance for the definition of the vertical intersections (Fig. 5).

Because of the use of special point and line codes during the survey, all measured elements and related vector information are grouped in layers. This makes it possible to produce several maps with different information level in an easy way. It is also possible to combine photogrammetric and geodetic measured graphical maps. Hence, the most suitable data acquisition has been chosen for the surveying of different monument parts.

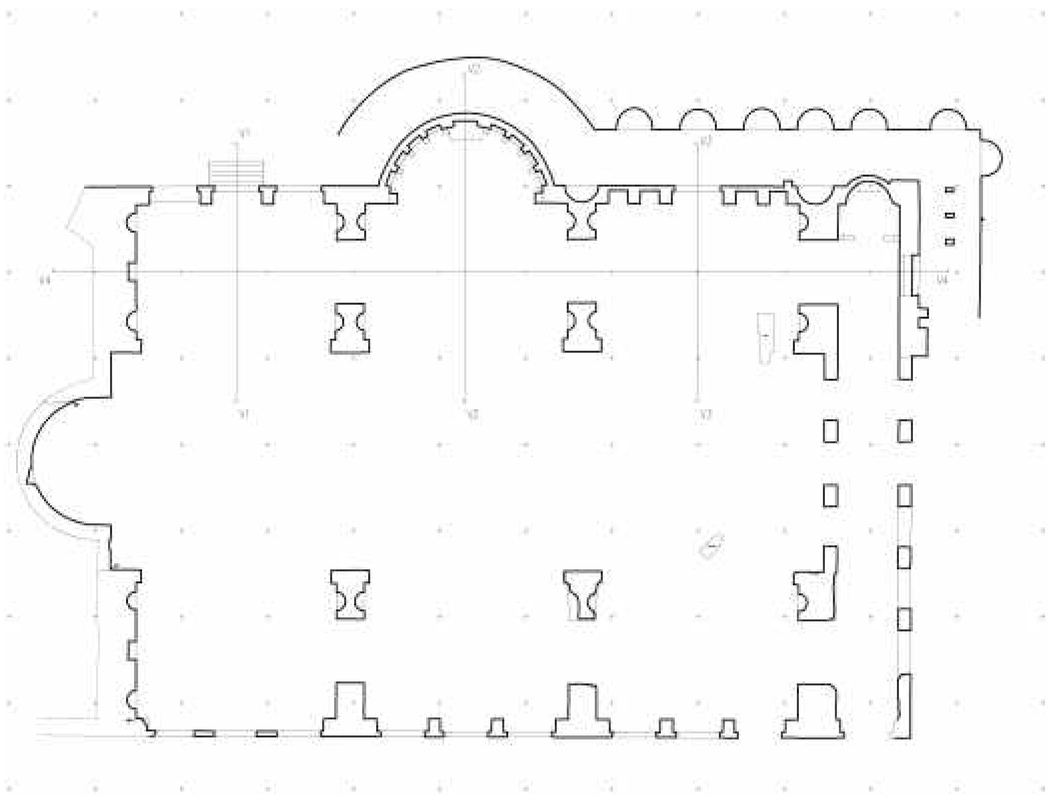

Fig. 5: Horizontal intersection with definitions of vertical intersections

2.2 Image Maps

The produced image maps in scale 1:25 serve as basis for the documentation and mapping of the façades and their damages. For overview purposes also image maps in scale 1:100 were derived. All image maps refer to a global coordinate system, which is visible as grid lines in the overview map (see Fig. 8). Every mesh contains a size of 7×10 metres on the façade, leading to image maps with a size of 28×40 centimetres which is well suited for further mapping work on A3 format. Fig. 6 shows a single sheet from the image map and Fig. 7 documents the high resolution of the rectified images.

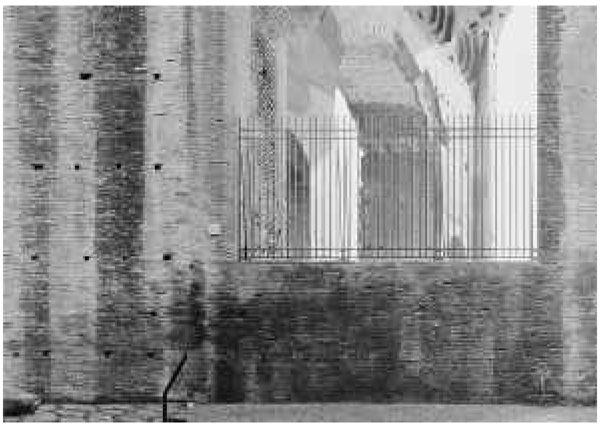

Fig. 6: Single sheet of rectified image map 1:25

Fig. 7: Detail of rectified image map 1:25

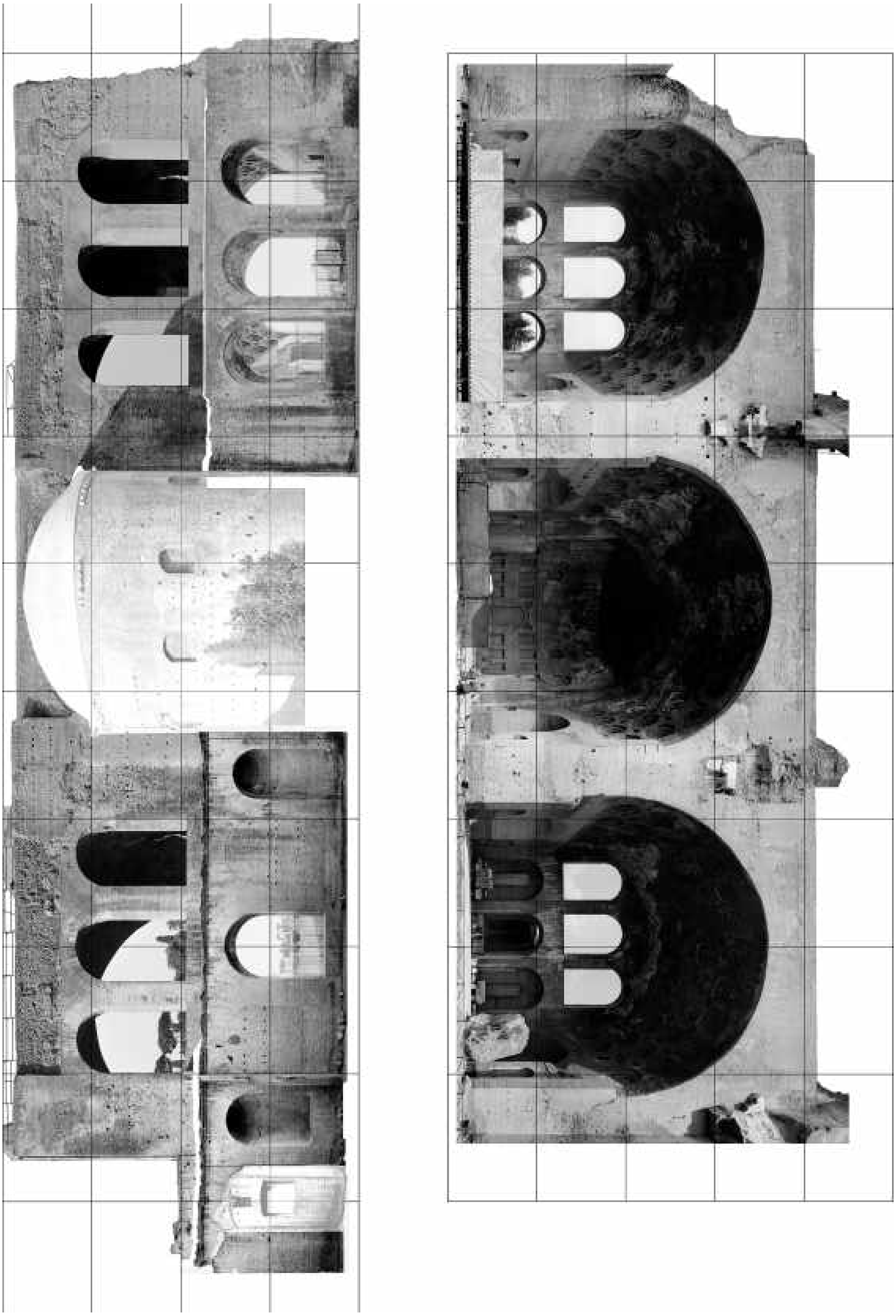

Fig. 8: Overview image map of the north and the south façade of the basilica (with grid lines)

The rectified image maps are based on a projective image transformation, which can be used, if the object surface describes sufficiently precise a plane. The images were processed with Eddi 2D / metigo 2D, a small, quick and efficient rectification software by the fokus GmbH Leipzig. While first results could already be achieved during the surveying campaign, the processing of the complete image maps was done afterwards. In order to achieve highest accuracy, each image has six to eight geodetic measured reference points, which were used in a least-squares-adjustment for the calculation of the transformation parameters. After processing, all reference points were overlaid with the rectified images for strict accuracy control. Because each image get it's coordinate origin during the rectification, geometrical image mosaicing was performed semi-automatically.

2.3 Unwrapped Image Maps

For special parts of the monument, unwrapped image maps were produced. This is possible, if the object can be described with a parametric body. For instance, some building parts have a cylindrical shape, which allows the application of a cylindrical image unwrapping. We used this method for the production of image maps from all the three apses (inside and outside) and the unwrapping of all the three vaults. This requires an extensive surveying of the concerning building parts which allows the determination of the cylinder parameters and the exact unwrapping with a parametrical photogrammetric approach. We use this approach for commercial applications since 1996. Together with some examples it was described already earlier in literature (HEMMLEB, WIEDEMANN 1997, HEMMLEB et al. 2000). But within the project it was the first time, that it was used for the combination of images with different interior and exterior orientation parameters for the production of one image map. That was necessary because of the difficult acquisition conditions on the monument, which require image acquisition with different camera types. Due to the needed high photographical quality, beside metric images also semi-metric images with a large scale format camera were used.

Fig. 10 shows the complete image map of the unwrapped inside of the north apse. As projection plane a cylinder with additional vertical profiles was derived from geodetic measurements. The upper part of the interior apse, which has nearly the shape of a calotte, was also projected on to the defined cylinder. Alternatively it is possible to choose a map projection for mapping of spherical shapes (SACHER 1999). Fig. 9 shows the large scale format images, which were used for the unwrapping of the interior apse.

Fig. 9: Large format images of the interior north apse

For the unwrapping of the outside altogether seven images were used, which were taken with UMK 10/1318 and Cambo Wide 58. As projection plane also a cylinder was used. The resulting image map is shown in Fig. 11. Brightness and contrast differences result from difficult acquisition conditions and the restricted time schedule, which did not allow to wait for cloudy weather.

As already mentioned, the three vaults of the still existing north nave were also unwrapped. The view into one of the three vaults from the ground (Fig. 2) gives an idea of the great demands on the photographic quality for the needed images. One of the used three images is shown in Fig. 4. The resulting image maps are referenced to the global three-dimensional geodetic coordinate system. Beside documentation and mapping purposes they were used for investigations of the building geometry, technical and static problems. Fig. 12 shows the unwrapped image map of the middle vault.

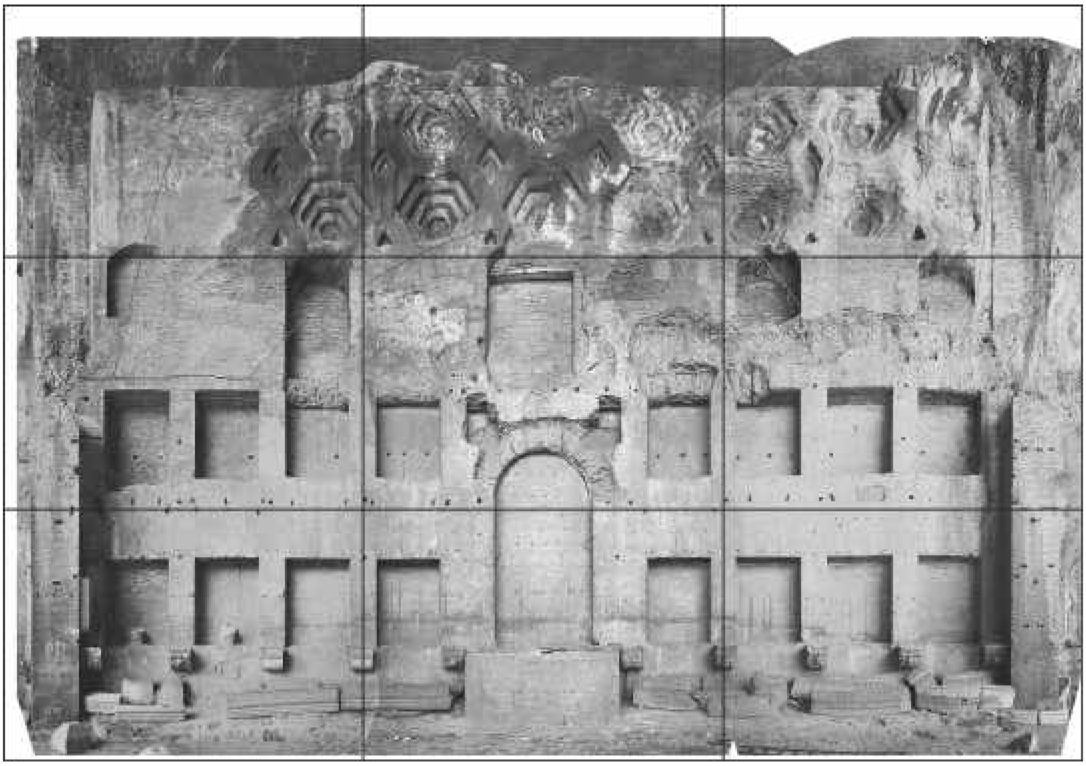

Fig. 10: Image map of the unwrapped inside of the north apse

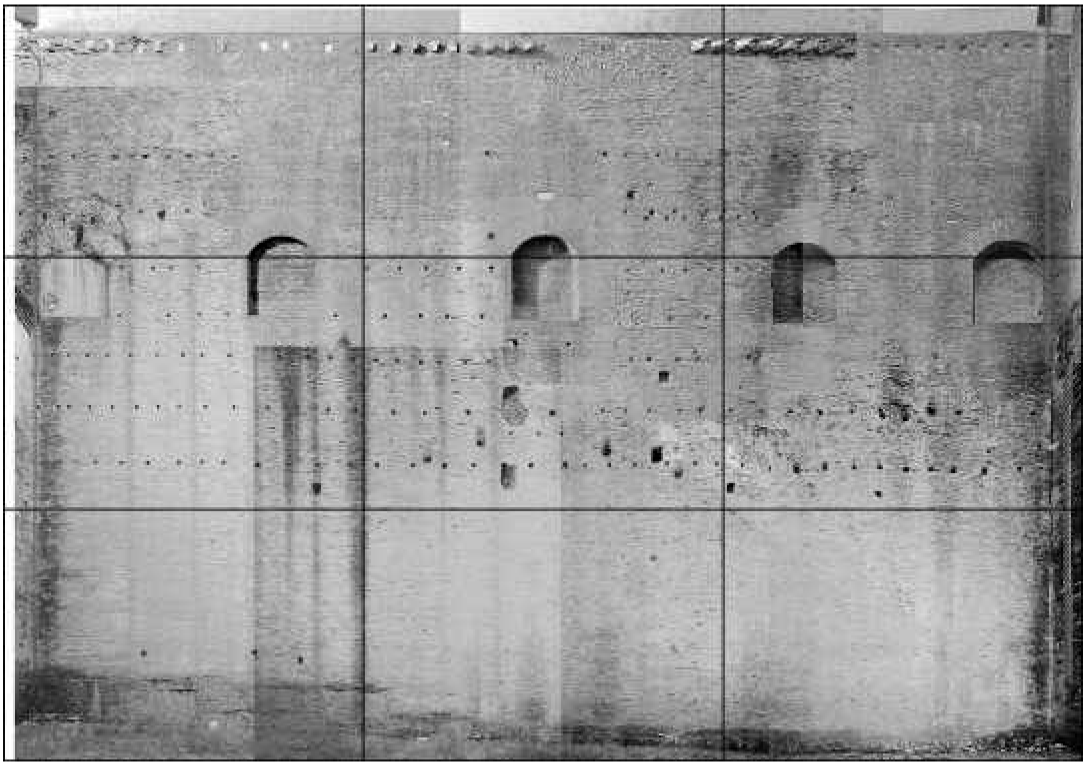

Fig. 11: Image map of the unwrapped outside of the north apse

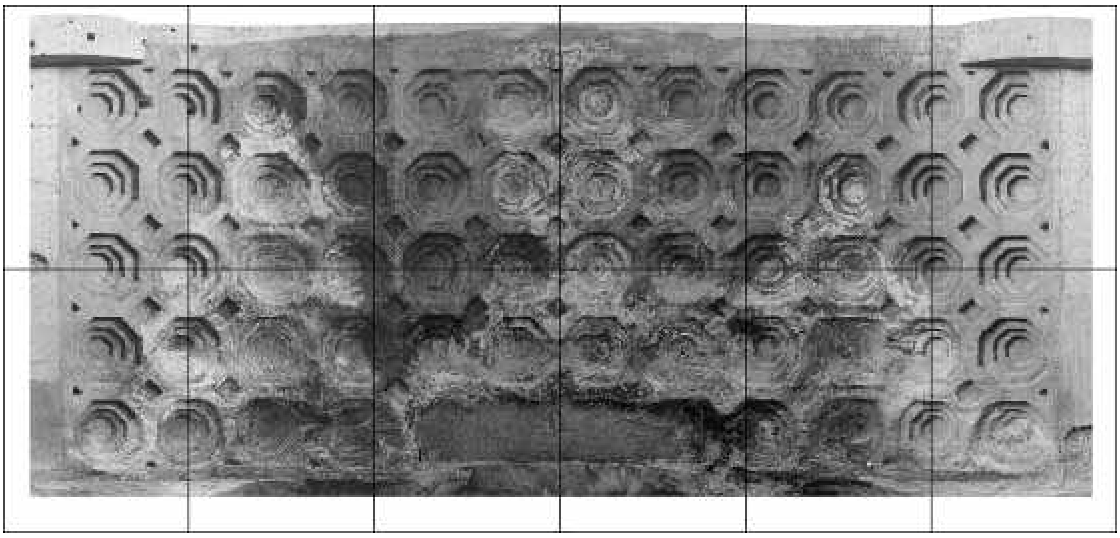

Fig. 12: Image map of the unwrapped middle vault

3 CONCLUSIONS

By the use of suitable photogrammetric and geodetic surveying methods it is possible to produce graphical and image maps true to scale with high accuracy in a short time and an efficient way. The needed map products and their accuracy level have to be defined in discussion with the customer, especially in case of the integration of his own measures and mappings. As the example of the Basilica of Maxentius shows, it is not always necessary to survey a complete 3D-model of the investigated object.

The documentation of the whole object with metric and semi-metric images is of very high importance. Moreover the accuracy level is to be defined with the customer. If these conditions are fulfilled, it is even possible to produce different map products and also a complete 3D-model subsequently.

In the case of the Basilica of Maxentius, the complete image acquisition and the measuring of geodetic reference information took merely less than two weeks. During this time also geodetic measurement of the ground and the production of first image rectifications could be done. The main focus of the introduced project was the production of image maps of all façades and vaults and stereophotogrammetric documentation. Altogether 39 image maps and 9 image unwrappings were produced during the project, which was finished after less than six months. The basilica of Maxentius was documented completely with metric and semi-metric images, which allows the evaluation of different further graphical and image maps up to a complete 3D-photomodel. These facts show the efficiency and the possibilities of the chosen combination of different surveying methods.

REFERENCES

M. DÖRING, 2000. Die Maxentius-Basilika - ein Arbeitsbericht. In: Von Handaufmaß bis High Tech. Dokumentation eines vom 23. - 26. Februar 2000 an der BTU Cottbus veranstalteten internationalen Kolloquiums. Verlag Philipp von Zabern, 2001, pp. 147-152.

G. ECKSTEIN, 1999. Empfehlungen für Baudokumentationen. Landesdenkmalamt Baden-Württemberg, Arbeitsheft 7. Konrad Theiss Verlag Stuttgart, 1999.

M. HEMMLEB, A. WIEDEMANN, 1997. Digital Rectification and Generation of Orthoimages in Architectural Photogrammetry. In: International Archives of Photogrammetry and Remote Sensing, Vol. XXXII, Part 5C1B, pp. 261-267.

M. HEMMLEB, G. SIEDLER, G. SACHER, 2000. Digitale Bildentzerrungen und -abwicklungen für die Anwendung in Denkmalpflege, Bauforschung und Restaurierung In: Von Handaufmaß bis High Tech. Dokumentation eines vom 23. - 26. Februar 2000 an der BTU Cottbus veranstalteten internationalen Kolloquiums. Verlag Philipp von Zabern, 2001, pp. 74-82.

G. SACHER, M. HEMMLEB, A. SCHEER, 1999: Mapping of Globe Surfaces into a Plane with Digital Photogrammetric Methods. In: Der Globusfreund - Wissenschaftliche Zeitschrift für Globen- und Instrumentenkunde, Vol. 47/48, Wien, pp. 305-320.