New methods for building archaeological documentation and analysis process

Report of work 2012
A project funded by the Swedish National Heritage Board, R & D funds

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A workshop was held at the Lateran-baptistery in September. In the picture, from left, Hanna Menander, Anders Kaliff, Nicolò Dell'unto, Barbro Santillo Frizell, Gunilla Gardelin, Mats Anglert, Olof Brandt, and Agostina Appetecchi. Håkan Thorén took the picture.
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Introduction

"New methods for building archaeological documentation and analysis process" is an international research project funded by the National Heritage Board, Heritage Board’s R & D funds since 2011 (Appetecchia et al 2012). The project is a collaboration between the Swedish National Heritage Board, Contract Archaeology Service, UV, The Pontifical Institute of Christian Archaeology in Rome, The Swedish Institute in Rome, Kulturen in Lund, Department of Archaeology and Ancient History, Lund University and the Vatican Museums. The overall aim of the project is to strengthen the building archaeological perspective so that in the future it forms an integral and important part of cultural resource management. We want to achieve this by developing new practices and methods for documentation, analysis, interpretation and communication of results from building archaeological investigations. The goal of our studies is also to generate a deeper knowledge and a result that brings life to the buildings and the people who lived in them for the user of today.

This report is a presentation of our work in 2012. The campaign has meant that we during two weeks in September in 2012 have processed the three-dimensional documentation from previous campaigns (see Implementation). The result means that we can analyse different phases of the Baptistery in three dimensions, which also results in an entirely different idea of the space in the room during different periods. Furthermore, the processed and analysed three-dimensional documentation means that we now have scientific data for several reconstructions of the Baptistery. The field campaign also included laser- and photo scanning of the attic and interior of the Baptistery. This means that we now have documented all the octagonal core of the Lateran Baptistery in Rome in three dimensions.

During our fieldwork we held a meeting with the reference-group and we also conducted a workshop at the Swedish Institute in Rome. In late autumn, the project and part of the reference-group conducted another workshop in Lund.

Project background, aims and objectives

“Building Archaeology” and its research field in Sweden today represent a comparatively small and rather insignificant part of the cultural heritage. This is despite a number of efforts that have been made both from universities and through previous grants from the National Heritage Board’s R & D funds (Eriksdotter et al 1998, Sundnér & Jönsson 1999). The reasons for the stagnation are several but the overall problem is that few surveys are done and that the resources often are very limited. It is therefore difficult to develop the building archaeological field both in practice and in theory.

The significance of the building archaeological perspective for our cultural heritage obviously needs to be highlighted and its role in cultural heritage management needs to be clarified. In order to increase its relevance it requires that we broaden our perspectives and recurrently discuss which
kinds of questions can be asked to the source material and how these can be related and communicated to the research community as to the society. We need to develop both our scientific questions and results. But we also need to develop how we communicate the results. This requires not only that we develop and discuss new methods, analyses and issues but also that we seek dialogue and discussion with researchers and practitioners in other countries, but also in related disciplines.

For building archeology, digital technology has meant opportunities to further develop methods for both documentation and new types of analyses. Today we have the ability to create models and "whole" room by using three-dimensional documentation techniques, such as laser scanner and photo scanning. This means that the space of the building but also how the building has been used and how this has changed over time can be discussed in a more profound way than before (Eriksdotter 2005). This type of documentation also has great potential to be processed into visualizations and models of the building that can be advantageously used in order to convey its history. But perhaps most important of all is that we through these reconstructions can start to discuss the people “behind the walls”, those who built and those who used the building. Several researchers have shown that through the study of the architecture of buildings, the shape and space of the rooms and the interior decoration makes it possible to discuss prevailing social conditions, but also contemporary ideologies and mentalities (Graves 2000, Eriksdotter 2005, Nilsson 2009). By “reading” and interpreting the various elements of the building and trying to understand what significance they have had we can get closer to people, the users of the room. This kind of empathic analyses, actually dealing with the intellectual properties of the room, has therefore a great potential to make people’s experiences and intentions visible. Analysis and simulated experiences of this kind can advantageously be carried out in virtual models where selected visual positions can be reconstructed and visualized (Eriksdotter 2005, 2009). A three-dimensional documentation makes it easier and can thus be a first step in this type of analysis.

Against this background we, in 2008, initiated the research project “The Lateran Baptistery in three dimensions” in order to develop and test new documentation methods. An important aspect of the project was also to create a platform for Swedish and Italian building archeologists. In 2010, a pilot study was funded by Gihls fund where parts of the Lateran baptistery was laser scanned in order to evaluate the method (Menander et al 2010). The results showed that there were great potential and good opportunities to use the laser scanner as a tool. An important lesson learned from this first attempt, however, was that a three-dimensional approach meant a whole new way of thinking, both in practice and in theory. The work was then, as now, to bee characterized as work in progress. It was also clear that the development must be gradual. This means that we first have tried to examine, develop and evaluate three-dimensional documentation methods. Further work on the process of interpretation, visualization, and a model of the building was saved for a later stage.
In 2010 we applied for funding from the National Heritage Board’s R & D funds. The project “New methods for building archaeological documentation and analysis process, pre-study” was granted funds in 2011 with the intention to further develop the work of using three-dimensional documentation methods. An important objective was also to continue the cooperation on an international level. Therefore the Lateran baptistery in Rome was chosen again as an object and experimental workshop. The campaign in 2011 meant that we laser- and photo scanned the entire outside of the baptistery. The report “New methods for documentation and analysis in building archaeology – pre-study” provides a detailed description of our work (Appetecchia et al 2012). The results also meant that we have developed new methods and techniques for building archaeological documentation but our work also shows that a three-dimensional digital approach allows new kinds of presentations, analysis and interpretation of the building (http://www.arkeologiuv.se/cms/arkeologiuv/publikationer/rapporter.html).

The purpose of the 2012 campaign was to develop the next step in the building archaeological working-process; processing, analysis and interpretation of the three-dimensional documentation. How to process, interpret and analyse a three-dimensional documentation in practice? What kind of new questions will we be able to ask and how will it affect our interpretations? These were some of the issues that were prominent in our work. The aim was also to create a three-dimensional basis for the next step in the work-process; reconstruction and modeling. Furthermore, we have attached great importance to continuously evaluate both the technology and the way we work.

The Lateran-baptistery in Rome

The Lateran baptistery in Rome, chosen as object of this project, is an exceptionally well-preserved late antique building with important parts dating to the fourth and fifth centuries. The main changes, which have determined how the building looks today, were made in the 16th and 17th century. But the general late antique and early medieval shape was not changed, only the roof, the decoration and the windows.

The late antique and medieval complex consisted in a central, octagonal hall built by the Emperor Constantine in the fourth century, surrounded on five sides by chapels and other buildings from the fifth and seventh centuries. The fourth-century building probably had doors on all sides and small, arched windows above the doors. The shape of the roof in this earliest phase is unknown. In the fifth century a major reconstruction lasted several decades (Brandt & Guidobaldi 2008) and gave the building more or less the shape it still has today: The walls of the octagonal hall were raised with new, higher and bigger windows. Inside the building a baldachin with eight columns in two stories carried an inner octagon, probably covered by a small dome. Most surrounding rooms were added in this fifth-century reconstruction: two small, cross-shaped chapels towards south west and north east, a vestibule to south east, and towards north west a portico which connected the
baptistery with another, bigger, cross-shaped chapel. Only one of these three cross-shaped chapels is still preserved in its ancient shape. In the seventh century an older hall east of the baptistery was transformed into a chapel.

The Renaissance reconstruction began in the early 16th century with a new roof, both above the circular corridor and the central baldachin. In the later part of the same century the portico and the chapel to North West were demolished. In the 17th century the marble decoration of the inner walls was replaced with paintings depicting scenes of the life of Constantine. In the 18th century the cross-shaped chapel to south west was replaced by a new, oval one.

The only important change in the aspect of the baptistery after that was when the plaster was removed from the outer walls in 1966, revealing the late antique brick walls which are the main research object of this project. Earlier archaeological research has not concerned the standing structures but only the remains which were excavated below the floor of the baptistery in the 1920s and around it in the 1960s.

Implementation

The aim with this year's work was planned to allow the completion of the reconstruction of the building, an essential operation to provide a thorough high precision three-dimensional geometric database for our archaeological and historical researches. A detailed basis, including geometric information, color parameters and visual aspect of the building, could be used, in fact, not only to document or monitor present conditions of the monument and its real dimensions, but also as precious instrument for individuating or discovering previously unnoticed archaeological elements; in this sense we had excellent results on this building.

We will start from the data capture methods used, and then continue with the evaluation of the post-processed 3D model. The first part of the "laser scanning chain" includes, as is known: selection of appropriate equipment, data acquisition, as well the registration of different sensor positions. Each target has its particular, local coordinates, but it is possible to include it into one global coordinate system, using a simple total station. This step cannot be avoided, it was crucial to realize a perfect close range data collection.

Problems during the fieldwork are also being discussed. We firmly believe that the presentation of a practical example, with all possible difficulties or problems, gives the opportunity to implement our knowledge about these innovative techniques and suggestions for other researchers who face with similar operative processes of 3D restitution.

This year, as noted above, the aim of the survey was to complete the 3D documentation of the Baptistery in order to identify, more clearly, the second phase of the building, dating at the fifth century.
We surveyed, in particular:

- The so called “Internal Octagon”, where large shreds of masonry ascribed to the V century are preserved;

- The interior of the octagon (except the surrounding chapels), the baldachin with porphyry columns and the vestibule, as well.

To do this it was decided to combine 3D laser scanning technology (using a Leica Laser Scanner) together with new photo scanning technique. We chose both techniques, as in previous campaign, because of the excellent results we had in 2011 and considering the particular characteristics of the parts of the building on which we focused. The photo scanning method can reduce operating times and costs and still produce almost the same quality of acquired data. The situation in the internal octagon created also arduous conditions for the successful use of only 3D surveying approach.
The work was carried out by a team of two persons that worked for 7 days, for a total of 56 hours, using the LeicaHDS 6000 with excellent results. The surveying of targets was done using the total station Leica TPS FlexLine 06.

**Laser scanning, attic and in-side**

The operating process, as mentioned above, which aimed at obtaining the three-dimensional representation of the building, began with the planning and execution of a preliminary survey of the structures united to the arrangement of appropriate procedures for data acquisition and post-processing.

As in previous campaigns, the main steps of our work with Laser Scanner technology and photo-scanning technique have been articulated in the following moments:

- **The instruments: selection of the equipment**
- **Planning the work: preliminary Survey on the current conditions of the building**
- **Data Acquisition**
- **Post-processing**
The instruments: selection of the equipment

Since we don’t have scanning equipment of our own and it is inconvenient to transport surveying- and scanning equipment from Sweden we decided to rent the equipment in Rome. The local Leica dealer kindly supplied us with a Leica TPS06 total station and a Leica HDS 6000 laser scanner.

The Leica HDS6000 is a phase-based, high speed, high precision and “low noise” laser scanner. A disadvantage with phase-based scanners is that they have a shorter range in comparison to for instance time-of-flight scanners, but in this case the range of approximately 80 m with an accuracy of 4 mm at 50 meters was more than sufficient. The laser scanner system allows full horizontal 360° and up to 310° vertical, in a single scan. Measurement rates up to 508,000 points/sec are possible. The scanner is equipped with a lithium battery that provides enough power for an eight hours work-day.

The targets employed were so called 6” black & white, tilt & turn target (Leica Geosystem 2012:2), the newest Leica standard targets. The v-block magnetic mount was included in the equipment. Both types of targets were carefully placed on the walls of the structure during each scan session, and then photos were taken; they were perfect and simple to recognize during the measurement with their patterns of very high contrast.

<table>
<thead>
<tr>
<th>LEICA GEOSYSTEM HDS6000</th>
<th>Modeled surface precision (noise)</th>
<th>Field of view (for each scan position)</th>
<th>Lighting</th>
<th>Class protection (IP)</th>
<th>User interface</th>
<th>Power supply</th>
<th>Communication</th>
<th>System performance</th>
<th>Spot size</th>
<th>Operating temp.</th>
<th>Range</th>
<th>Scan rate</th>
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<tbody>
<tr>
<td></td>
<td>2 mm at 25 m; 4 mm at 50 m for 90% albedo</td>
<td>Vertical 310° (maximum) - Horizontal 360° (maximum)</td>
<td>Fully operational between bright sunlight and complete darkness</td>
<td>IP 54, High level protection against dust and rain</td>
<td>Onboard touch panel or external notebook or Tablet PC or PDA with web browser, IPhone</td>
<td>24 V DC; integrated Li-ion battery (1.5 hrs) and/or optional external DC power supply (4 hrs) or AC supply</td>
<td>Lan Ethernet Cable; Bluetooth, WiFi</td>
<td>Precision for each point</td>
<td>3 mm at exit (based on Gaussian definition + 0.22 mrad divergence)</td>
<td>-10° to + 40°</td>
<td>79 metri @ 90% riflettività</td>
<td>Up to 508.000 points/sec, maximum instantaneous rate</td>
</tr>
<tr>
<td></td>
<td>3 mm at 25 m; 7 mm at 50 m for 18% albedo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Distance</td>
<td>≤2 mm at 90% albedo up to 25 m; ≤3 mm at 18% albedo up to 25 m; ≤3 mm at 90% albedo up to 50 m; ≤5 mm at 18% albedo up to 50 m</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Position</td>
<td>5 mm, 1 m to 25 m range; 9 mm to 50 m range</td>
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<td></td>
<td></td>
<td>Angle horiz./vert.</td>
<td>125 μrad, one sigma</td>
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<td></td>
<td></td>
<td>Spot size</td>
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<tr>
<td></td>
<td></td>
<td>Operating temp.</td>
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<tr>
<td>Scan resolution</td>
<td>Pts/360° (vert., horiz.)</td>
<td>Scan time (full dome)</td>
<td>Point spacing at range @10 m</td>
<td></td>
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<tr>
<td>&quot;Preview&quot;</td>
<td>1250</td>
<td>25 sec</td>
<td>50.6x50.6 mm</td>
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<tr>
<td>Middle (4x)</td>
<td>5000</td>
<td>1 min</td>
<td>40 sec 12.6 x 12.6 mm</td>
<td></td>
<td></td>
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<tr>
<td>High (8x)</td>
<td>10000</td>
<td>3 min</td>
<td>22 sec 6.3 x 6.3 mm</td>
<td></td>
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<tr>
<td>Super High(16x)</td>
<td>20000</td>
<td>6 min</td>
<td>44 sec 3.1 x 3.1 mm</td>
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<tr>
<td>Ultra High (32x)</td>
<td>40000</td>
<td>26 min</td>
<td>40 sec 1.6 x 1.6 mm</td>
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Figure 3. Leica Geosystem HDS6000
Images were taken using the digital camera Nikon D7000, a 16.2 MP digital single-lens reflex camera model (fig. 5). The digital image-system acquisition is fast and also allows, it’s known, to transfer the images immediately to a computer and to judge their quality or to immediately process them. This camera was chosen, in particular, for the high-resolution capability, fundamental for a detailed documentation of the structure.

The HDS6000 scanner supports an external camera kit: digital photographs were acquired by mounting the camera directly to the scanner, using a bracket system set available from Leica, fitted on the tripod after removing the scanner.

A Nikon Fisheye lens was used during the entire survey. The Nikkor 10.5mm f2.8 DX lens (Fig 6) has a viewing angle of 180° and a 10.5mm focal length.

An extreme wide-angle lens allowed the possibility to capture a large area without having to take numerous pictures, with an evident reduction of time in recording images. This was extremely useful at the Lateran Baptistery, as we are detecting a large building, with high vertical walls. This applies, in particular, for the interior space of the octagon, at the ground floor. The inside building is approximately 19 by 19 m with a 7 by 17.5 m vestibule.
The ceiling height is 11.6 m high, while the ceiling of the vestibule is 10 m. So, the Baptistery is a perfect example of high architecture, and recording its high-ceilinged inside and the vestibule was a difficult but possible challenge, using an extreme wide-angle lens camera just from a standard laser scanner tripod. The fish eye lens was capable of capturing the wall’s full height and length from all angles, in their entirety.

Calibrating the camera and lens to the digital 3D software (Cyclone 7.4, see below) that was to be employed, before acquiring images, was crucial for a good final result. It was necessary, mostly, to remove the extreme distortions that are on the edges of the lens so it was decided to make several tests deciding the best way of capturing images for the virtual reconstruction of the building.

The second step was to acquire the images, and the third was to post-process them in the appropriate software. Concerning the acquisition of pictures, the camera, as noted above, was mounted with its bracket on the tripod after removing the scanner. The photos were taken sequentially: a total of 9 pictures for each scan position were realized; the images had to be overlapping to allow a precise reconstructing process, so it was decided to put the camera on the bracket and take pictures moving it, horizontally, for 360°, considering a range of 45° between each photo shoot (for a total of 8 images) and capture a last one, putting the camera 90° respect of the bracket, to be sure to have sufficient details for the ceiling.

The digital images were then downloaded to a laptop and elaborated into Cyclone 7.4.1 software.

Concerning the total station, a Leica FLEXLINE 06 was used (Leica Geosystem 2012:2), as in previous campaigns: it is ideal for mid to high-accuracy applications and offers complete flexibility (Fig 7). The accuracy of this total station measurement is 3 mm, the range is about 150m. The station was equipped with two batteries, each one lasting for one day of work. The number of points taken per working day was between 20 and 30. It was necessary to define a grid of fixed points and geo-reference them after the scan work. We placed new ones, but at the same time we also used others already placed last year. Problems occurred with the recording: some targets already measured with the total station would not be visible from the scan-position. A fundamental step was the data fusion between the data/measurements collected by total station and the scans into a common geo-referenced system, to register the point clouds and to orientate the images taken. Practical considerations about this step of the survey will be detailed further below.
Preliminary Survey

In the case of a complex building, as the Lateran Baptistery, good planning is indispensable in order to avoid having data redundancy or deficiencies during the survey.

After a preliminary inspection to determine the current status of the building, scan-positions have been identified:

- 16 in the internal octagon (upstairs).
- 10 in the interior space of the octagon (ground floor).
- 3 in the vestibule (ground floor).

On surveying the baptistery, problems were found with the modern accretions, which have created some operative and logistic difficulties and with “everyday life” at the baptistery. For what concerns the first aspect (accretions), the internal octagon was restored during the 20th century, creating a “forest” of iron bars/poles supporting the ancient wooden ceiling and a metal catwalk all around, allowing the passage (Fig 8). The limited breakneck mobility on the metal catwalk affected our activity: walking on it, trying to move and fix the scans with all the survey equipment (tripod, cables, and power supply devices) was not a simple work! Another problem was the limited visibility of the walls, due to the density of the iron “forest” and to its intrinsic complexity! So, the surfaces were difficult to measure with a high detail level.

Figure 8. “Forest” of iron bars in the Internal Octagon
Regarding the second aspect, the Baptistery is open to public every day: tourists, masses, marriages created long waits between each scanning session on the ground floor!

**Data acquisition and geo-referencing**

Each of our scanning session consisted of:

1. Choosing the scanning area;
2. Taking a mid or high resolution panorama scan measuring, in the meanwhile, the target’s location and identifying and acquiring them;
3. Geo-referencing the targets with the total station;
4. Recording images with the digital camera, after removing the scanner from the tripod;
5. Removing the targets from the scene, after acquisition of images.

The whole procedure took between 30 and 40 minutes, depending on the circumstances the survey took place. During each scanning session, two people were required to operate the scanner and the total station. It was decided to create point clouds with large overlapping areas; then the scanner was setup and the targets acquired. For each scan, the point distance did not exceed 15m, this permits that the accuracy of the model would be nearly 2 mm. The number of scans and points collected during the survey, as well as the amount of pictures taken by the digital camera are listed in Table 2.

<table>
<thead>
<tr>
<th>LATERAN BAPTISTERY 2012 - DIGITAL DATA</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Number of scans</td>
<td>29</td>
</tr>
<tr>
<td>Number of points</td>
<td>About 317000000</td>
</tr>
<tr>
<td>Pictures</td>
<td>About 1000</td>
</tr>
</tbody>
</table>

To completely cover the entirety of the *Internal Octagon* (upstairs), the area was scanned from 16 positions. At each one, a 360° panorama scan (mid resolution) was performed. Due to the overall complex structure, as mentioned above, some areas cannot be acquired without effort. So, some small data gaps had to be considered. Before data capturing targets were located on each corner of the octagon and somewhere in the central area, on the iron bars, as markers for the scans and the images. We carefully placed them, so that at least three of them were visible in every scan, covering the whole of the area. Photos were taken, as the scans, at two meters interval, more or less; this distance allowed enough overlap between images for the post processing. The total duration of all operations (considering also time requested for resolution of problems encountered) was 20 hours (two working days and a half), of which 20–30 minutes were taken for each scanning session.
On the ground floor, in the octagon and the vestibule, laser scans and pictures were taken from different places: in the octagon on each of the inside corners, between the wall and the baldachin; in the vestibule at two ends of the structure and one point in the middle, near the main door: a total of 11 scans were required to cover the inside of the rooms. All scans were performed as 360° panorama (medium-resolution), documenting surface characteristics of the walls: this was due to the presence of frescoes as well as of the baldachin with porphyry columns.

Targets, even in this case, were carefully placed: it was decided to put them on the marble balustrade of the baldachin and after the scan was finished, photos were taken using the fish eye lens; each of the pictures captured the wall in its entirety, covering the 11.6 meter height. A number of additional shots were necessary, however, to capture every detail, frescoes in particular and process them using photo-scanning method. We took 265 pictures in the octagon, using a Canon Powershot G1 X in order to have enough overlap between images.

The acquisition time for each station was different: the work took about 8 hours (1 day of work, divided into different days, considering the possibility to scan only when the baptistery was closed to public).

The second step, in both cases (octagon upstairs, octagon and vestibule), after data acquisition, was the geo-referencing of each scan. Each scan had its own reference system but the individual point clouds could be transformed into a global reference system, an external one, already existing (we created it since the first time we used the 3D laser technology at the baptistery), so that, merging the point clouds, all points could be processed collectively. We estimated their location, as usual, acquiring the spatial coordinates (position and orientation) of the special retro-reflective targets with a total station. For each scan, at least three of these targets were used. Other marks in the scene were also used (with unknown coordinates) and located automatically by the system during the merging process.

Post-processing

The post-processing of data includes several steps in different software. In our case we used:

- **Leica Cyclone** (ver 7.4. 1 Build 3087).
  - Registering and geo-referencing of point clouds

- **MeshLab** (ver. 1.3.2, 64-bit)
  - Remove duplicated points
  - Merge close points
  - Merging point clouds
  - Mesh decimating
  - Meshing (poisson filter)
• **Agisoft Photoscan Professional** (ver 0.9.0 Build 1586, 64-bit)
  - Aligning photos
  - Building mesh
  - Mesh decimating
  - Texturing
  - Editing

The first step of the post-processing was to register the scans. The registering can be done with at least two methods. One method is to align point clouds to each other by selecting common points and then let software with a good aligning algorithm do the work, i.e. MeshLab. Another method is to register the point clouds with scanned control points that are within the same coordinate system. The latter method is easier to use if scans in several rooms should be registered and combined. In our case the registering was done in Leica Cyclone. The point clouds were registered one by one or two by two together with control points and then each scan was exported to PTX-format.

The last campaign (2011) we divided the photo-scanning of the building into eight parts, one for each wall. We felt like it was a good division and decided to also divide this year’s post-processing into parts that corresponded to the walls/sides A-H. The different exported PTX-files were imported into MeshLab, where the first step was to remove duplicated points and merge close points. Each point cloud contained eleven million points from the beginning but that amount of points was hard to handle and was more than enough to get a good model. After merging close points we had a point cloud where the distance between the points were about 5 millimeters. The next step was to reconstruct the surfaces, in other word build meshes. In the inner octagon three scans was used to build meshes of each walls. Three point clouds with scan positions closest to each wall were used and edited to include only points that had hit the wall. The three point clouds were then “flattened” into one. After the flattening the new point cloud needed a bit of cleaning again so duplicated points were removed and close points were merged. After this process the resulting point cloud of each wall contained about 3 million points. These points were used to build the geometry, the mesh. The meshing was done with the Poisson filter in MeshLab and the resulting mesh contained about 6 million faces.

The most complicated part in the creation of a realistic 3D-model is usually the texturing. In our case we found an easy way to do it after a hint from a colleague (thanks to Carolina Larsson, Humanistic Lab, Lund University). The solution was simple since we had both laser-scanned and taken photos for photo-scanning. We imported 265 pictures from the inner of the octagon into Agisoft Photoscan, aligned the pictures and built the geometry. After that we geo-referenced the Photoscan model with coordinates taken from the registered laser-scanned point clouds. The geo-referencing made it possible to import the meshes from the laser scanned data and create their texture from the photo-scan photos.
Concluding remarks

The present research has already produced numerous results concerning not only the knowledge of the monument but also the use of these advanced techniques. This year, in particular, the laser scanning and photo-scanning techniques have contributed to the aim of completing the model of the Baptistery!

Combining 3D Laser Scanning data together with photo-scanning data, still seems to be the best solution for the production of high-resolution textured model of the Lateran Baptistery.

This campaign was also fundamental to refine the choice of an efficient equipment, suitable to our needs and to identify a standard procedure, optimizing time and resources, during the work.

Our work in MeshLab

The project members were involved in working with the scanned data in the program MeshLab, an open source software for processing and editing unstructured 3D triangular meshes. MeshLab provides tools for editing, cleaning, healing, inspecting, rendering and inverting meshes. The development of MeshLab started in 2005 as a part of the FGT course of the Computer Science department at the University of Pisa, Italy. The system is continuously developed (http://MeshLab.sourceforge.net).

Our goal this year was to make phase models, which means making a model for each main phase of the building. The phases had already been interpreted in 2D elevations (Brandt 2012:fig 12) that we used as a base for the work creating phase models in MeshLab.

The process of scanning the building focused on one wall at a time. This made it possible to work with single walls in MeshLab and later put them together as a model. The single walls where edited in a mesh and the model was put together in a project. A mesh can be defined as a single object (consisting of a network of vertices) or model and a project can be defined as several meshes linked together.

When scanning a wall two files are created. One file contains the texture and one file contains the vertices (triangles) which creates the model. It is important to keep the texture and the triangular model in the same folder otherwise you will lose the texture of the model.

When you have opened MeshLab you start with importing the mesh. When the scanned wall appears you can turn and twist it around in any way that you want. There is also a possibility to use a zoom to get close to the object, which is necessary when working with the scanned data. To save the mesh you use the tool Export mesh as.

Our principal task was to remove information that did not belong to a specific phase. There were two main tools that you could use. One was a brush that you could use to select and delete the information that you didn’t want. There was a possibility to decide the size of the brush, which was useful. The other tool made it possible to select and delete faces in a rectangular region. If you made a fault it was possible to regret the work.
done by using the tool Reload. If you were happy about what was selected you used the tool Delete the current set of selected faces.

When we had deleted the parts that didn’t belong to a specific phase on each wall we imported the edited mesh into a project where the different walls were linked together automatically into a model. In total we made four phase models.

Workshops in Rome and in Lund

In Rome 17–18 September
In connection with the field work we organized a workshop for the project and the reference-group. The meeting intended to be the first step in the work with the three-dimensional model and the reconstruction of the baptistery. The workshop began with a meeting at the Swedish Institute in Rome where the project results achieved so far was presented. This was followed by a discussion of about analysis of space and how different researchers have worked with these kinds of questions, both in two- and three-dimensional context. The second day of the workshop was held in the Lateran baptistery and aimed primarily to place further discuss on how and which time periods we can reconstruct. Nicolò Dell’unto also presented various examples of models and reconstructions, including from his work in Pompeii and from Catal Hüyük.

In Lund 26–27 November
The workshop took place in Lund during 26–27 November 2012, where the group members met. During the first day two of the members, Agostina Appetecchia and Olof Brandt, presented papers at Lund University, the department for archeology and classical archaeology. In the afternoon we had arranged a meeting with Stefan Lindgren and Carolina Larsson at the Humanistic Lab at Lund University and members of Digital Heritage Forum at Lund University. They are working with digital data in connection with digital heritage and make 3D-models and virtual reality projects. We had a guided tour where we were able to see their equipment and their possibilities to work with 3D data. A number of examples of 3D models were shown to us by them and by Nicolò Dell’unto from the department for archeology and classical archaeology. One of the examples we saw was a scanning of the crypt of Dalby church in Scania, Sweden, and another example was the scanning of a block in Pompeii, Italy. After that we had a discussion about our future work and what possibilities there could be for us to develop a reconstruction of one phase of the Lateran baptistery and also the possibilities to work with Stefan Lindgren and Carolina Larsson at the Humanistic Lab.

The next day we went to Ingvar Kamprad Design Centrum (IKDC), the Virtual Reality Laboratory (VR Lab), where we again met with Nicolò Dell’unto from the department for archeology and classical archaeology, Lund University and also with Joakim Eriksson from the VR Lab. They showed us an example of a virtual Reality made with the ruins in Pompeii.
as a base. After that we went to the Dalby church, situated outside of Lund. A research project focused on the church and several articles dealing with different aspects of the church have been gathered in a book. Parts of the church have been scanned and we saw some examples of that at the Humanistic Lab the day before. During the summer of 2012 the church underwent a restoration, and in connection with that a buildings archaeological investigation was made. The research, scanning and buildings archaeology of the church in Dalby is an example that was discussed in connection with the research of the Lateran baptistery in Rome. In the afternoon we had a meeting about our ongoing report work and our next step in the project.

**Results**

The aim of this year’s campaign was to process and analyse the three-dimensional documentation and explore new approaches and issues that the documentation entails. In practice this meant that we have been working with the photo and or laser scanned facades in MeshLab (see Implementation). In order to achieve measurable and achievable results, we chose to focus on three distinct building phases: baptistery of Constantine- fourth century, baptistery of pope Sixtus- fifth century and the baptistery during Renaissance and later periods. The stratigraphic work carried out in previous campaigns and processed further by Olof Brandt (Brandt 2012:33-85 with references to earlier publications) has been the basis for the “contents” of
each phase. The selection is based on the fact that the baptistery has changed and/or looked different during these periods, which means that we will have the opportunity to examine how the current style ideals but also the liturgy and rituals is reflected in the architecture. Furthermore, we have made the choice based on variations within the source material between the different phases. The first phase, 4th century, is in principle only based from archaeological and building archaeological source material, while for the 5th century, phase two, both archaeological and written sources are available (see below). The youngest building phase we have chosen, the Renaissance, means that there are plenty of written sources, but also a large and diverse visual material to work with. The processing and interpretation of each phase is therefore partly based on different source material which also should have implications for the reconstruction, which is the next step in our work.

Below we present our processed three-dimensional “MeshLab images” with an explanatory text and also a table of characteristic of the masonry for each phase we have chosen to work with. The result means that we have laid the foundation for a “scientific” model and the reconstruction of the baptistery, which also shows the source material we base the model on. The images illustrate the process of critical interpretation of the source material, which is rarely seen in the finished models/reconstructions. A further result is that the images can be advantageously used for an antiquarian purpose of conservation and restoration, showing how much of the masonry remains of different phases. To conclude we can say that to publish and present “MeshLab-images” is thus an educational value both for those who look at the finished model and reconstruction and for the antiquarian authorities.

The first phase: Baptistery of Constantine, 4th century

Enough remains of the first phase to get a general outline of the original building, but too little to make a detailed reconstruction. The most striking, but not the only, remains of the first phase of the baptistery are certainly the lower parts of the brick walls of the octagonal hall, which is the core of the building. These original walls are preserved up to a maximum level of circa nine meters above ground level. These remains tell us about an octagonal hall with a diameter of 19 meters and rather thin walls, only 80-90 cm thick. These remains of the walls show that the hall was perforated by many openings which connected it with the surrounding areas or with other rooms which have disappeared. All visible walls show evident traces of doors, circa 2,5 meters high, beneath arched windows, almost three meters high, which begin four meters above ground. They can be distinguished from the upper parts of the same walls both through small differences in building technique and through the presence of windows in the upper parts which could not exist together with the windows of the lower part. This octagonal structure stands on a thick, circular foundation wall, which may originally have been intended for a building of different shape. Small rectangular foundations correspond to the eight inner corners of the octagonal hall and indicate that corner columns were part of the original project.
This is what we know about the original phase of the octagonal hall. It leaves many questions without answer. These questions concern mainly the upper part of the building, and the surrounding structures. How high was the building, and was it covered by one single roof, which rested on the outer walls of the octagonal building? Or was there a higher, central part with windows which illuminated the centre of the hall? Presumably, the baptismal font stood at the centre of the room, but it is not certain that it corresponded to that, 10 meters broad, which has been excavated and which may belong to a later phase.

But the complex did not contain only the octagonal hall. Although the vestibule was added in the second phase, but in the same place where the vestibule later was built, remains of earlier buildings where left standing as annexes and were completed with new reconstructions. Most important was a great rectangular hall, of which one part was demolished for the building of the baptistery but the rest was used as an annex, corresponding to today’s chapel of San Venanzio. The hall itself was built in bricks, but the parts which connected it to the baptistery were built in “opus vittatum” of bricks and small tufa blocks. The same technique can be seen in a fragment of a wall preserved in the west side of the vestibule, which was added in the second phase. It was realized in the final stage of the preparation of this report that this wall fragment most probably belongs to the first phase of the baptistery. It must however be further analysed and documented before it can be included in the graphic documentation. That wall fragment indicates that in the original phase, there was a rather important complex of smaller and bigger rooms to the south-east of the octagonal building. Another smaller room was left standing to the northeast, and was transformed in the second phase into the chapel of St. John the Evangelist.
This original phase is attributed to the Emperor Constantine (312–337) by later sources like the 6th century Liber Pontificalis. The building technique of its brick walls fits well in the early or mid fourth century and could hardly belong to the fifth century.

**Technical details**

**Phase I (4th Century)**

<table>
<thead>
<tr>
<th>Wall type 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building technique:</strong></td>
<td>Brickwork</td>
</tr>
<tr>
<td><strong>Phase:</strong></td>
<td><strong>Phase I</strong></td>
</tr>
<tr>
<td></td>
<td>Phase I is unanimously recognized as the moment of the construction of the octagonal building by Constantine.</td>
</tr>
<tr>
<td><strong>Date:</strong></td>
<td>Early 4th Century</td>
</tr>
<tr>
<td><strong>Location of the sample wall (S.U.):</strong></td>
<td>B Side, lower part. (S.U. 3002)</td>
</tr>
<tr>
<td><strong>Structure type/Form:</strong></td>
<td>Outer perimeter wall of the octagon.</td>
</tr>
<tr>
<td><strong>General description:</strong></td>
<td>Brick-faced concrete. The brickwork is well preserved, formed by horizontal and regular courses of bricks.</td>
</tr>
<tr>
<td><strong>Height of bricks:</strong></td>
<td>2.5-4 cm</td>
</tr>
<tr>
<td><strong>Modulus</strong></td>
<td>29-31.5 cm</td>
</tr>
<tr>
<td><strong>Height of 5 courses and 5 mortar joints</strong></td>
<td>Mortar. Pinkish, very hard, with frequent inclusions of tile flakes and pozzolanic fragments. The joint beds, oscillating from 2.5 to 3 cm of thickness, present a particular smooth pointing, slightly to slide, with the lower edge just uncovered that, in some cases, can become flush, overlapping the bricks. This pointing type, pretty common in Rome during the 4th century, ([Apollone Ghetti et al. 1944-1945; Bertelli et al. 1976-1977]), could be recognizable, in this sample, in the first courses of bricks, certainly less exposed to the corrosive action of atmospheric agents.</td>
</tr>
<tr>
<td><strong>Modern restorations</strong></td>
<td>Apparentely not visible</td>
</tr>
</tbody>
</table>

**The second phase: Baptistery of pope Sixtus, 5th century**

The same source, the Liber Pontificalis, mention two reconstructions in the fifth century, under the popes Sixtus III (432–440) and Hilarus (462–466), but probably they were part of the same project, which meant that the octagonal hall was raised and that it was surrounded by new structures on four of the eight sides, in a cross-shaped plan: the vestibule and the three cross-shaped chapels of Saints John the Evangelist and John the Baptist, and of the Holy Cross. The vestibule and the chapel of St. John the Evangelist are still preserved; that of John the Baptist was completely rebuilt in oval shape in the early 18th century. The vestibule is a rectangular hall with apses on the short ends. Its outer long side was open, with two huge porphyry columns carrying an architrave. It is possible that the height of these columns determined the new height of the building. This may also explain why the baldachin added inside the octagonal hall itself needed two storeys of columns in order to reach the same height. This baldachin, formed by eight columns carrying an architrave with a theological inscription, carries
an inner octagonal brick structure, which probably originally was covered by a small dome, similar to the present one. In the outer walls of the octagonal hall, the windows of the first phase were replaced by new, bigger, arched windows, which began where the earlier windows ended. Also important parts of the decoration of the complex are known: mosaics remain on the vaults of the chapel of St. John the Evangelist and of the vestibule, and the vestibule also preserves remains of coloured marble slabs on the walls. 16th and 17th century drawings document the marble slabs on the inside of the walls of the octagonal hall, replaced in the 17th century by fresco paintings.

This phase is relatively well known. The main open questions are two. The first is the function, in this as in the original phase, of the hall which only in the seventh century became the chapel of San Venanzio. The second is if the highest part of the octagonal structure, from 12,20 m above ground, was added in a third phase, and if that hypothetic phase was added soon after the second. The recent documentation campaigns have revealed a couple of features which seem to confirm this hypothesis. On the inside of the outer walls, a kind of shelf has been documented, above which the wall continues thinner than below. On the outside, the 3D documentation reveals a slight irregularity in the wall surface which is present at exactly the same level as the “shelf” and on all sides of the building. Interestingly, the walls of the inner octagon, carried by the central baldachin, have square openings which may be explained as windows only if the outer walls were only 12,20 meters high. The 3D documentation of the inner octagon will now for the first time make it possible to make an exact comparison between the positions of the various features of the two octogons, and thus to understand better how the roof of the building was structured in the different phases.
Technical details, phase 2

 Phase II (5th century)

<table>
<thead>
<tr>
<th>Wall type 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Building technique:</td>
<td>Brickwork</td>
</tr>
<tr>
<td>Phase:</td>
<td>Phase II. Phase II belongs to the fifth century. In this period two reconstructions are known, under the popes Sixtus III (432-440) and Hilarus (461-466), but they were probably part of the same project: the octagonal building was surrounded by new structures: the vestibule and the three cross-shaped chapels.</td>
</tr>
<tr>
<td>Date:</td>
<td>5th century</td>
</tr>
<tr>
<td>Location of the sample wall</td>
<td>A Side, upper part/beneath the roof</td>
</tr>
<tr>
<td>Structure type/Form:</td>
<td>Outer perimeter wall of the new octagon</td>
</tr>
<tr>
<td>General description:</td>
<td>Brick-faced concrete. The brickwork is well preserved, formed by horizontal and regular courses of bricks.</td>
</tr>
<tr>
<td>Height of bricks</td>
<td>2.5-4 cm</td>
</tr>
<tr>
<td>Modulus Height of 5 courses and 5 mortar joints</td>
<td>Circa 35 cm</td>
</tr>
<tr>
<td>Bonding material</td>
<td>Mortar. Pinkish/grey, very hard, with inclusions of small tile fleks and pozzolanic fragments and nuclei of slaked lime, rather consistent. Joint beds: 2.8 to 3.5 cm.</td>
</tr>
</tbody>
</table>

The Renaissance and later periods

The baptistery was the object of several reconstructions during the middle ages, but the reconstructions in the 16th and 17th century were particularly important in determining today's global “look” of the building. The centrally-planned structure of the baptistery with its inner baldachin met the refined taste of the Renaissance and its love for the central plan. It is quite striking that, while other important early Christian churches were demolished or completely transformed, the baptistery was only partially re-decorated, and its roof was repaired. Repairs and reconstructions of the roof and of the central dome began in the 16th century, but most of these reconstructions were made by the popes Urban VIII (1623–1644) and Innocent X (1644–1655). The marble decoration of the inner walls was replaced by frescoes. Also the vestibule was re-decorated. The big, arched windows were replaced by smaller, rectangular ones. In the 16th century the chapel of the Holy Cross was demolished, creating today's entrance from the Piazza. In the 18th century the small, cross-shaped chapel of St. John the Baptist was replaced by a new, oval one, which is still standing. After that, little have changed in the baptistery.
Evaluation

Laser-/photo scanning, technical evaluation

After working with both laser-scanning and photo-scanning on the baptistery in two campaigns we have got a nuanced attitude to the techniques. When we began to plan this project four years ago not many people would have come up with the idea to make a 3D-model of a building from photographs. Today it is an easy task to produce a photorealistic model of a building from a couple of photos but the photo-scanning technique is not always the obvious choice. In this campaign we decided to make a combination of the two methods in order to get a good result in a short time.

The aim with this project is not to compare laser- and photo scanning techniques but to try using three dimensional methods in building archaeology. Within the project we haven’t done any detailed comparison between the two techniques, but our opinion is that both techniques give us a result suitable for our purposes. More detailed comparisons between laser- and photo scanning have been done with results that show that the resulting accuracy from both methods is comparable (El-Hakim et al 2008). We also experience good results when we geo-reference photo scanned models with control points surveyed by total station. When we apply texture from geo-referenced camera positions calculated by Photo scan on geo-referenced meshes reconstructed in MeshLab the result is also good.

The goal of the campaign 2012 was to scan the inside of the attic of the octagon, to get information about the roof construction to later be able to reconstruct the upper part of the building. With the knowledge about the metal truss in the attic we thought that it could be a problem to use photo scanning to model the walls behind all steel beams, so we planned for laser scanning. The result after making models from both types of scanning is that the resulting mesh from the laser scan is better, but it is definitely possible to get a reasonably good result with photo scanning. To get a mesh from both techniques was quite easy but when it came to texturizing of the meshes the problem with the steel beams became obvious. Since we wanted to be able to model as large portion as possible of the wall behind the metal truss we had to take pictures and laser scan from different directions with the metal truss in front of the wall. Since some beams of the truss are very close to wall it’s a tough job to get a texture free from disturbing beams, it’s a lot easier to cut them out from the mesh.

During the 2011 campaign we learned a lot about the pros and cons of scanning techniques, and our knowledge has grown during this campaign. We immediately regret our decision to laser scan the attic of the octagon when we had to carry all the equipment there. It had been much more pleasant to just bring the camera. Together with the size of the equipment the differences in hardware cost between the two techniques are considerable. The cost for laser-scanners has indeed fallen in the last year but it is still
a significant investment to buy a scanner when you can achieve a similar result with a camera. The demands on computers and software are big when you are creating photo scan models but you also need a powerful computer and good software to be able to handle large amount of laser scan data. A camera is small and it is easy to take a lot of photographs in different positions and every photograph is actually comparable to a scanner position when laser scanning. This makes it easy to take a lot of overlapping photographs that can be processed into a highly detailed 3D-model without too much effort. To catch the same amount of details with a laser-scanner might require a lot of scan positions (Appetecchia et al 2012:20f). It’s also possible to take photographs from different kind of extendable poles or even from drones. A drawback for the camera is bad light conditions, it can even be hard to align photographs taken in daylight with differences in sun/shadow or aligning photos taken during periods with different vegetation. Other problems that you can run into when photo scanning, can be caused by shiny and reflective surfaces. Images with little or discernible structure and also repetitive structure can be a problem (Ducke et al 2010). Also the situation that prevailed in the attic of the baptistery octagon is an example when photo scanning techniques can fail. The large number of beams in front of the motif sometimes causes the image aligning algorithm to make errors. During this year’s campaign we also found out that we didn’t have to choose one of the techniques but that instead it could be a good idea to combine both techniques to easily get a good texture on the model. But if you use both techniques you also get all their shortcomings at the same time.

Archaeological evaluation

If an archaeologist shall be able to use laser- or photo scanning and different software to make edition work on a daily basis it needs to be user-friendly. Therefore the technical equipment and software needs to be evaluated from an archaeological point of view.

Laser-/photo scanning

From the point of view of the archaeologist, when comparing laser scanning and photo scanning for producing a 3D documentation of a building, it is evident that photo scanning presents several advantages. No expensive equipment is needed, nor is the help of a specialised operator. The archaeologist can make the documentation independently. The only real challenge when working with standing buildings is that you have to take the photos from a more or less frontal position also of the upper part of walls, so it may be necessary to use a sky lift, a platform or some other structure. To take the photos is a fast process, but to edit the data takes time, which means that the whole process is not as fast as you might first think. The editing process can speed up, when you get more used to it.
Experiences of working with MeshLab

3D models were created with photo scanning and the software Agisoft Photoscan. In order to get a high resolution but not to make the model too heavy, one separate model was created for each wall of the building. These models have been object to elaboration in MeshLab as part of the archaeological analysis of the building.

Stratigraphical wall analysis in 3D

With the help of a stratigraphic analysis of the same walls produced in 2D at an earlier stage of the project, the 3D models were elaborated with MeshLab. Two versions were created which illustrate what remains of two particularly important phases. This elaboration was made by simply removing those parts which are believed to belong to more recent periods. This work was done by a man team working together. The simultaneous observation of the details of the 3D model by the team members made it possible to check and in some cases to correct details of the earlier stratigraphic analysis. This showed how important it can be with a continuous dialogue during the work between different persons with various backgrounds and experiences.
Technically, this was done by first selecting the parts to remove with the selection tool, and then deleting them with the tool “Delete selected faces and vertices…”

In a technical evaluation of this method, it can be noted that this work highlighted a particular feature of the software. The model is composed of vertices (triangles) – the 3D model itself – and texture – a photographic image. The experience showed the importance of a good quality of both the texture and the triangles. Usually the archaeologist identifies the parts to delete with the help of the image of the texture, but the exact shape of the selection depends on the shape of the triangles of the 3D model; the selection does not follow the precise outline traced by the archaeologist, but the shape of the triangles. This means that the precision of the cut depends on the size and number of the triangles – the more and the smaller triangles, the more precise is the cut. If the triangles are large, it can give a rather disturbing result, where parts are deleted which was meant to be conserved. On the other hand it is evident that the higher is the number of the triangles, the heavier the model will be.

While the procedure described above was simply a way of illustrating in 3D an analysis which had already been done, the question arose whether it is possible to do this the other way around, creating first a model of the whole building, making the stratigraphic interpretation using the model at the site as a help to interpret the walls. Is there any risk if one speeds up the process by for example cutting out the phases during the fieldwork, registering descriptions and interpretations on digital forms?

It is important to show the phase models to make the conditions clear for further revisions and reconstructions. It is not satisfactory just to show the final result. It is important to separate collected data and stratigraphic analysis in relation to reconstruction, but also to stress the process of the work. Working with a 3D documentation highlighted particular possibilities added by the third dimension.

Traditional stratigraphic wall analysis is most often based on a 2D image. The 3D work offers a new possibility to use the 3D model to highlight the lines which distinguish wall parts belonging to different periods. This can be particularly efficient if the texture is turned off and the light/shadow is moved around in different directions. This offers the possibility to distinguish features which are not normally visible unless the sunlight falls in a very particular direction. Again, this works best if the triangles are small and the 3D model has a high precision. This need must of course be weighed against other considerations. The most interesting methods are those which can be used by archaeologists and without too specialised equipment. A detailed 3D model of a huge building requires a very powerful computer, not only for the creation but also for the elaboration, selection etc. It has also been observed that Agisoft Photoscan is good at producing the texture, less good at producing the vertices/triangles. If this is correct, it is a drawback of the software, which must be weighed against the fact that it is very easy to use and produces the texture automatically.
One could argue that a 3D documentation could make a good base for interpretations, since you can see both the inside and outside at the same time (at least sometimes). This makes it easier to see if a feature on the outside is corresponding with something on the inside and vice versa.

At the end of these short considerations it can be useful to point out some things which the participants in the project did not have the possibility to do and some thoughts about the future development of this kind of work. These considerations have more to do with the reconstruction work which will dominate the next step of the project. In this context, it would be helpful if there was a possibility to make or insert drawings in MeshLab in order to show the probable outlines and the volumes of the phases of which perhaps only few small parts remain.

It will be particularly important to consider the idea of space in the further development of the work. It is important to develop the analysis in order to include more than the construction. The space is as important as the construction: it is self-evident that the use and function of a building take place in the empty space. Maybe one can make more profound interpretations about the construction by analyzing the space. What happens if one would make a model of the empty space? Would that open up for other interpretations?

**Dissemination**

An important goal with the project is to disseminate the results of our work in a variety of contexts. Therefore we have also considered it important that to produce a report after each year’s campaign (see Menander et al 2010, Appetecchia et al 2012). This report, like the previous, is published both as a paper copy and as a pdf file on the National Heritage Board’s UV’s website. A link to the report is also available at the following institutions websites: Swedish Institute in Rome, Pontifical Institute of Christian Archaeology in Rome and Kulturen in Lund. As in previous years’ reports, this report will be distributed to different groups within the fields of culture heritage management.

During 2012, the project has been presented at several seminars and conferences. In January 2012 in Rome Hanna Menander and Olof Brandt presented the project at the seminar ”Kulturav, tradition, förmdling. Romerska fallstudier in situ”. In early May, Olof Brandt presented some of the experiences of the project in the lecture “Laser scanner e Structure from motion nel rilievo e nell’analisi delle strutture murarie” at the university of Tor Vergata, Rome, and later the same month he presented some of the results in the keynote lecture “Understanding the shape of early Christian baptisteries” at the annual meeting of the North American Patristic Society in Chicago. At the end of May Hanna Menander and Håkan Thorén held a lecture, “Från Läckö till Lateranen”, at the doctoral seminar in Lund. In June, Olof Brandt presented the project at the conference “Subterranean Archaeology in Italy” at the British School at Rome under the title “3D documentation and analysis of the Lateran baptistery” and at the Vatican
museums under the title “I disegni di un battistero straordinario. L’alzato del Battistero Lateranense dagli architetti rinascimentali ai rilievi 3D del terzo millennio”. In October, Hanna Menander was in Visby to present the project to National Heritage Board, F- department. In connection with the projects workshop in Lund, at the end of November, Olof Brandt and Agostina Appetecchia made presentations that partly were based on issues that we are working on in the project but also other experiences and results from three-dimensional documentation.

In 2012, the project wrote an article, “New methods for building archaeological documentation and analysis process” (Menander et al in script), for the National Heritage Board’s forthcoming publication of the results of R & D projects.

**Coming work**

On the prospect of a possible coming and final season of the project we are planning to make deeper analysis of the 3D documentation with phase models, develop reconstructions of some phases of the Lateran baptistery and make analysis of the use of space.

**About making reconstructions**

The creation of reconstructions can have more than one purpose. One reason for creating a reconstruction is to mediate a story to the public about how the building was used during different eras - to make the history about people’s lives come alive. It is possible to make the reconstruction to come alive like in a computer game where you can choose to be a character and follow how that person has used the building and what that person has experienced in the building. The making of reconstructions is a very important part in an archaeologist’s work, to make the results understandable to a broader audience. Another reason is that the reconstruction can be a way for the archaeologist to examine the results.

In the process of making a reconstruction all sorts of problems about how the building might have looked will arise. This means that the argumentation you need to do when creating a reconstruction actually can improve the result. Questions might come up that you would not have found out if you had not made a reconstruction. The reconstruction puts the archaeological results to a test, what have the building looked like?

In order to show how a building has been used during different periods you need to do reconstructions. To make the reconstructions you need to have enough information about how the building may have been designed during a specific time period.

The 2012 season made an important step in showing how we as archeologists and other historians that use buildings as a source material, can use the 3D documentation for gaining more knowledge about a building’s different phases and how the constructions have worked. It is important to identify how the 3D documentation can form a base for better implementations.
The phase models that we have created are important in more than one way. The phase models are important for making the knowledge about how much of a building phase that is preserved more visible. The final results are usually presented in projects involving 3D modeling but the process before the final results is never visible. The process of implementation is important to stress and one way is to show the phase model before a final model is presented. It is important to offer the possibility to criticize the sources, the basic documentation and the process from the basic documentation to the final result.

In order to create reconstructions of some of the phases in the Lateran baptistery we will use the phase models as a base. For some phases we have quite a lot of information about how the building has been designed both on the outside and inside. For some phases though, especially the two oldest phases, the information about the design is limited. We know quite a lot about how the exterior has been designed concerning the outer walls and openings, but we don't know so much about the construction of the roof, although we have some clues to use for making a reconstruction. We know very little about the interior in the two oldest phases and we need to use comparative materials to be able to make a reconstruction.

Each reconstruction should be followed by a clear description of what has been the base for the reconstruction made.

**Analysis of space**

To make a deeper analysis of the building and in the longer term be able to mediate how people have used it, you need to examine the use of space. The action has taken place in the empty space and therefore you need to examine it on a deeper level. To show why and how this could be done, in a next and final step of the project, one can put up some questions to discussion. The questions that can be formulated and put to a 3D documentation is infinite. By putting up a few questions it is possible to discuss some issues, without claiming to cover every angle of the subject. Here we have chosen a few questions to put some light on specific angles that deals with what we can gain from making analysis of the use of space.

**How can a 3D documentation influence the analysis of the user of a building?**

By identifying the empty space, the volume, which the users have found themselves in when the use of the building has taken place, there is a possibility to study the space. A 3D documentation can form a base for large improvements on this area. To be able to study the actual volume when making this type of analysis is preferable, because if you don't have the volume you will have to imagine it and there is limits to the imagination. It is important that the 3D documentation not only deals with the construction but also deals with the empty space. Gunhild Eriksdotter has made models of the empty space in a building and has stressed the importance of making analysis of the volume (Eriksdotter 2005, s 210ff). Maybe it is possible to make a model of the empty space and study it and see if the result of the analysis differs from a traditional way of making an analysis of space, like
those made of for example Pamela Graves (Graves 2000). Pamela Graves have worked with 2D documentation presenting interesting analysis of space in churches in medieval Norfolk and Devon. She has been studying the visibility of altars in churches, and the visibility depending on were you where seated in the church (Graves 2000). By making such analysis with a 3D reconstruction as the base the results can be presented in a much better way and the result might also be different when you have the third dimension.

**How has the user experienced the room?**

By identifying the climate with warmth–chill, light–darkness, sound–silence etc you could make a study of how people might have experienced the room. How people experience their environment is very subjective and has to be taken into account. One might argue that a change of the height of a building by lowering or heightening of the roof might have effect on the acoustics of the building. The time of year is affecting how much light there would be in a room and on what time of the day there would be light. The light could be used in the liturgy. The light cast from a window could be used for marking the position of an altar (Graves 2000, s 198). Gunhild Eriksdotter has worked with building virtual experiences of a room, where the story she creates focuses on the use of the building. The structure of the story is formed around the relation between the user and the building, which room the user had access to etc (Eriksdotter 2009).

**Is it possible to analyse the pictures, like paintings and sculptures, in a building and by doing that gain understanding of the use of different parts of a room?**

Paintings, sculpture and other decorations in a room correspond to the room in different ways. Depending on where you are situated in a room you can see different parts of the decoration or the sight can have been limited from another position in the room or maybe not visible at all (Nilsson 2012, s 232). One example could be a church where different people have access to different rooms and parts of the church. Depending on whom you are and which part you have access to, you can follow the liturgy well or not well and you can see decorations well or not well and so forth. This can be a key to better knowledge about people’s life. If this type of analysis can be applied to a 3D documentation of a building new knowledge can be gained about the experience of different people of the building and of what has been going on in the building.

**How can individual experience of a building be identified?**

By identifying openings in the building, which has influenced the movements in the room, there is a possibility to get closer to finding out how people moved around in a building. This must be done in combination with for example identifying the furnishings of the room which has been a part of the liturgy, ceremony or ritual and has affected the movements made in the room. But most important, the identification of the empty space must be done. Together with identification of which persons have had access to
different parts of a building and also where these people can have been situated in a building one can try to get closer to more personal and individual analysis of persons lives. It is not always easy to identify what the interior has looked like during different periods, since decoration and furnishing from later periods can hide or even have destroyed older decorations and furnishing. If we want to understand the use of buildings there is, although, a need for this type of analysis. To be able to study what people might have seen during the liturgy, you will have to try to put different characters into action in the building. By trying to be a specific character and see what happens when that character makes access to a room, what that person might have seen and experienced, even what action that person might have taken part in, and one can start to analyse people’s lives at an individual level.

**What is the building’s accessibility?**
To try to understand the accessibility of the Lateran baptistery in Rome you have to start by identifying openings that has affected the movements. The openings for doors can give the key to how the access was made from the inside of the Lateran area or from the outside from the town during different periods of time. This can form a base for a comprehensive reflection about the accessibility of the building during different eras. In a more theoretical angle one might stake that the church, with all its different parts and symbolic decorations, can form a map over the Catholic religious world with its values. The church has and has had an important role in society and it is important to try to see the churches not as isolated objects but as a part of the society. By this approach the study of churches is very important to be able to understand people’s lives.

**What is the use of the building today?**
It might be interesting to study how the Lateran baptistery is used today. There is both a religious use and the use of the building as an interesting architectural object visited by many tourists. There can be different ways to analyse this. One method is called “Deep hanging out”. The anthropologist Clifford Geertz coined the term Deep Hanging Out in 1998. The anthropological research method can be described as “…immersing oneself in a immersed in a cultural, group or social experience on an informal level”. Observations picked up from deep hanging out may end up in intense and deep insights compared to practices of conducting short interviews with subjects or observing behaviour. “…deep hanging out is as form of participatory observation in which the anthropologist is physically or virtually present in a group for extended periods of time or for long informal sessions” (http://cyborganthropology.com/Deep_Hanging_Out). Another type of observing movements in a building could be by filming, but that involves some problems getting permission to do that. Making a film makes the researcher invisible and there will be a distance between the researcher and the group observed. The method deep hanging out involves the researcher and it is possible to build up a trust between the researcher and the group being studied.
The questions that are discussed above shows a direction for the next step in the project towards a deeper analysis of the building. The questions should be seen as examples of what type of question you could put towards a 3D documentation, there could of course be other questions that would be interesting to add. The discussion also shows the importance of examining not only the construction but also the empty space and how a 3D documentation makes that possible.

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**Acknowledgments**

Thanks are due to Dr. Antonello De Amicis and Arch. Valentina Albano by *Leica Geosystem*, for their precious support and assistance during the field work.
Administrative data

Country: Vatican State
Location: Extranational area of San Giovanni in Laterano, the Lateran Baptistery, Rome, Italy
Coordinate System: Local
Height System: Local
Riksantikvarieämbetet, Verkssekretariatet, FoU-medel, (Swedish National Heritage Board, FoU-funds) dnr: 353-3512-2012
Project number: 12156
Report Number: UV Rapport 2013:106
Project group: Mats Anglert (RAÄ, UV), Agostina Appetechia (Dr. PIAC), Olof Brandt (Prof. PIAC), Nicolò Dell’Unto (Dr. Department of archaeology and ancient history, Lund University), Gunilla Garde-lin (Kulturen in Lund), Hanna Menander (RAÄ, UV), Håkan Thorén, (RAÄ, UV).
Administrative Coordinator: Swedish Institute in Rome
Responsible antiquarian authority: Vatican museums, Maria Mari, Paola Benetto
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Investigation time: 10–22 September 2012 in Rome, Italy, 26–28 November 2012 in Lund, Sweden
Archive Documents: -