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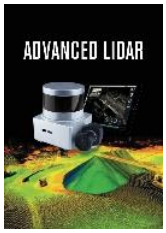


# Advantages and Disadvantages of Using TLS Techniques in Monumental Buildings; Darsiyak Yanartaş Monastery Archangel Michael and Gabriel Church Example

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**ABSTRACT**

Monumental buildings are considered as a building group that includes many different types of buildings, such as mosques, churches, madrasas, caravanserais, inns, and baths, built for public use. Each of these buildings has spatial characteristics that vary according to the type of building, periodical differences and regional character. However, it is seen that the majority of these buildings have a plan setup consisting of small spaces that are articulated to a large and central space. Among the monumental buildings, one of the building types that show this central place feature is the churches. While the use of terrestrial laser scanning method in the measurements of churches with central space provides many advantages, it also causes some disadvantages. In this study, measurements of the Yanartaş Monastery Archangel Michael and Gabriel Church, one of the 19th century Kayseri churches, was made with a terrestrial laser scanning system for documentation studies and the advantages and disadvantages of this measurement system were conveyed.

## 1. INTRODUCTION

Scientific and technological studies continue to develop in many fields in the world and in Turkey. This development has been included in the conservation of historical buildings with the use of laser scanning methods. Laser scanning methods give more detailed, accurate and faster results compared to traditional methods. More detailed and accurate data taken in the survey works is a very important element for better conservation of the historical building. By processing the data obtained by laser scanning methods, 3D models can be created and digital shares can be made. In addition, detailed analysis studies can be carried out through the data obtained by this method.

Although the studies carried out in the field of conservation have developed and increased in recent years, it is not possible to protect and document the destroyed buildings. For this reason, buildings that are on the verge of extinction should be protected or documented primarily. It is seen that the use of these techniques is preferred especially in the documentation of monumental buildings. Within the scope of this study, in order to investigate the advantages and disadvantages encountered in the use of TLS (terrestrial laser scanning) techniques in monumental buildings, the documentation studies of the Archangel Michael and Gabriel Church, which used terrestrial laser scanning technology in the survey measurement studies and the stages of the survey and the processes of transforming the obtained data into vector drawings for documentation purposes will be discussed.

Archangel Mikael and Gabriel Church in Kayseri, which had a very large non-Muslim population in the 19th century, is a building located in the Yanartaş Monastery in the village of Darsiyak (Kayabağ) in the Melikgazi district. The church, which is on the verge of extinction due to abuse and vandalism, contains many cultural and social data from the period it was built. In order to conserve this building, as one of the first stages, measurement and drawing studies were carried out with the Yanartaş Monastery Archangel Mikael and Gabriel Church within the scope of survey studies. [1]

[1]This study was developed and produced from the thesis titled "Darsiyak Yanartaş Monastery 'The Archangel Michael and Gabriel Church' survey-restitution and restoration project" completed in 2021 by Res. Ass. Melikşah Koca under the supervision of Assoc. Dr. H. Hale Kozlu at Erciyes University Institute of Science and Technology.

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## 2. METHOD

### 2.1. Terrestrial Laser Scanning

Terrestrial scanning systems, which continue to develop rapidly in the world, provide the most accurate transfer of the current state of the building to digital. With this system, which aims to minimize the margin of error, measurements can be taken with millimeter precision and detail in difficult and dangerous work areas without having to return later (Gümüş, 2010; Yılmaz et al., 2012).

In terrestrial scanning systems, if a building with a large surface area or a complex plan scheme is to be scanned, the scanning process should be done more than once from different angles in order to get the data more clearly and accurately. After a scan is finished, the secondary scan is continued from the adjacent surface of the first scanned portion. This process is repeated multiple times. In this way, all surfaces of the building/surface are scanned by arranging different stations. These stations create common scanned surfaces with the previously scanned surface (Kaya, 2020; Orhan, 2016 & Yakar, 2016)

Terrestrial laser scanning processes may not fully meet the purpose in some cases. In cases where it is used in simple projects, the desired results may not be obtained in terms of time and cost. In short, before starting terrestrial laser scanning processes, it should be clarified what the scanning will be done for and the problems should be examined accordingly (Kaya, 2020; Yakar et al., 2010).

#### 2.1.1. Pre-scan planning

Before starting the scanning process with terrestrial laser scanning, the scanning process should be planned. The planning of the scanning process in historical buildings is carried out by examining the spatial setup of the building. In addition, the scanning process is planned by evaluating door and window openings and surfaces that will cause reflection in order to prevent light bursts and reflections (Erdal & Hasan, 2021).

In the scanning process, point cloud data obtained from different stations should be brought together on a common coordinate plane. This common coordinate plane can be used as the coordinates used at the first station (Altuntaş & Yıldız, 2008; Alptekin et al., 2019)

In this study; The measurements taken by laser scanning method were used for the survey works of the Archangel Michael and Gabriel Church of the Yanartaş Monastery. The interior of the church consists of the naos, gallery, above the prosthesis and the diaconicon. In the exterior, there are narthex and facades. There are stairs that allow access to the roof from the place above the diaconicon in the church. In the interior of the church, light bursts occur in the laser scanning method, due to the collapse of the dome and too much natural light entering through the window openings. For this reason, the number of stations has been tried to be increased as much as possible indoors. Keeping the number of stations high also allows the accurate measurement of the naos, which has a large space. In addition, attention was paid to the establishment of stations on the stairs. The gallery surrounds the naos in a "U" shape. For this reason, a station has been installed in each nave of the gallery unit. Considering all this planning, it was deemed appropriate to establish 11 stations on the ground floor, 11 stations on the gallery floor, and 2 stations on the spaces above the diaconicon and the prosthetic. It is planned to establish 8 stations for the facades, 2 stations for the narthex, and 4 stations for the roof and terrace in the exterior of the church (Figure 1).

**Figure 1.** Stations used in scanning

#### 2.1.2. Scanning process and preferred software

The angles to be used in surface scanning and the frequency of scanning vary according to the scale of the project. The angle of contact of the laser beams sent with the laser scanning method on the building surface is of great importance in terms of being clearer and perceptible if the architectural elements in the building are concave or convex (Temizer et al., 2013; Yakar et al., 2019).

The FARO Focus M70 brand device equipped with GPS (global positioning system) was used in the documentation of the Archangel Michael and Gabriel Church of the Yanartaş Monastery. In this way, data could be easily transferred to AutoDesk software. Obtained point cloud data were first transferred to AutoDesk Recap software. Unnecessary point data is cleared in this software. Then, it was transferred to AutoCad software with the "Attach Point Cloud" command and made ready for vector drawing. This method eliminates the use of different interface programs and allows the data to be edited directly by the last user (Figure 2).


**Figure 2.** FARO Focus M70 brand device

Documentation and photographing were done at 360 degrees horizontally and 270 degrees vertically. When necessary, sensitive scanning and photographing processes were carried out on certain areas and surfaces. With the measuring device, measurements are made up to 70 meters at each station. However, this interval has been kept to a minimum in order to obtain more reliable

data. The measurement speed is 488000 points/second. The camera, which works integrated into the device, allows photography with a resolution of 165 megapixels. These photos can be obtained through the AutoDesk Recap program. It is aimed to make detailed measurements and photographs in and around the building by establishing 43 stations in total. AutoDesk Recap, Faro Scene and AutoCad software were used in the entire scanning process.

### 2.2. Yanartaş Monastery Archangel Michael and Gabriel Church Drawing Stage

The data processed with Faro Scene software were transferred to AutoDesk Recap software and unnecessary points were cleaned. Then this was transferred to AutoCad software with the "attach point cloud" command. The north-eastern part of the roof of the church building was measured with traditional measurement methods, as it was thought to cause problems in terms of security.

#### 2.2.1. Plan drawings

In the documentation studies, the plan drawings of the building are made by cross-sectioning the 3D point cloud of the building. AutoCad software was used for this. The sections were first taken as slices and the walls were drawn. Then, the drawings of the sections appearing on the ground were made over the plane section. This process is repeated for all floor plans (Figure 3, Figure 4).

**Figure 3.** Plan section lines taken over the 3D point cloud

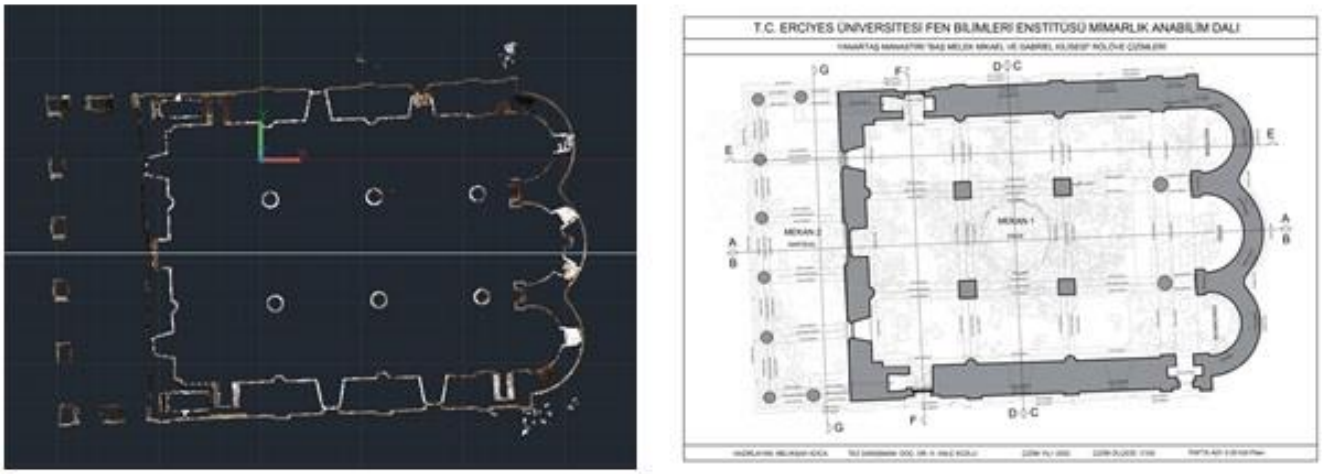


**Figure 4.** Point cloud slice plan section and drawing

#### 2.2.2. Sectional drawings

In the documentation studies, the cross-section drawings of the building are made by taking vertical sections over the 3D point cloud data of the building. For this, the points to be cross-sectioned are marked on the point cloud data transferred to the AutoCad software and the cross-section is performed with “2 points”. Then the “UCS” coordinate values are rearranged and the wall drawings are started by turning the slice into a section. The point cloud data is then made into a plane cross section to draw the visible segments (Fig. 5), (Fig. 6).

**Figure 5.** Section line over the 3D point cloud

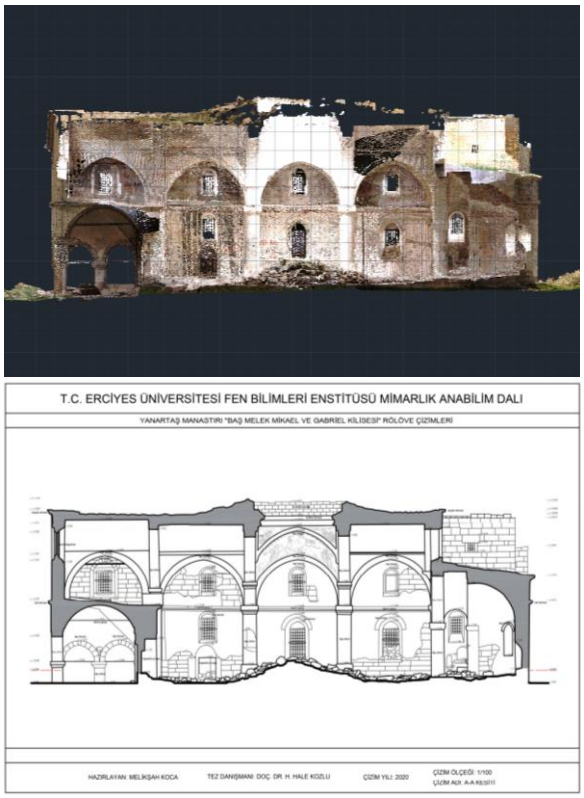


**Figure 6.** Point cloud plane section and drawing

### 2.2.3. Facade drawings

In the documentation studies, the facades of the point cloud data were studied in order to extract the facade drawings of the building. First, the point cloud is placed on the plane. Here, studies were carried out on the image that was optimized for the drawing by making changes on the point size, opacity and level of detail (Figure 7).

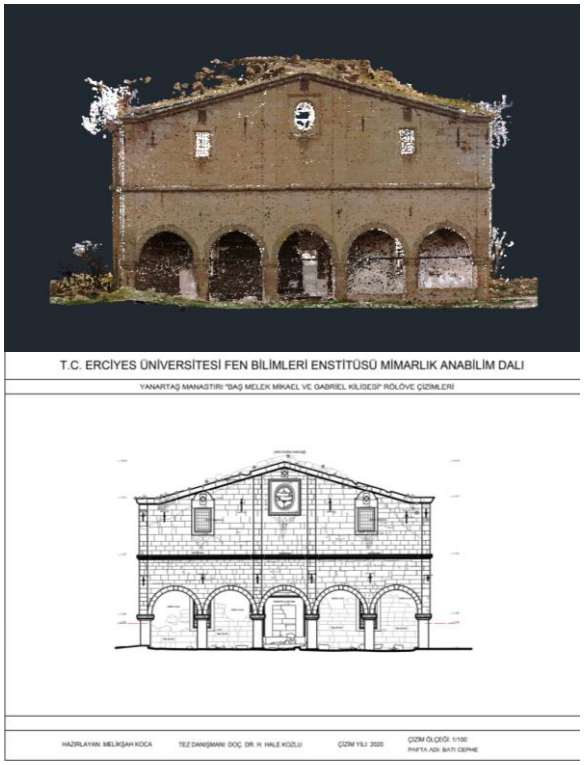


**Figure 7.** Point cloud facade and facade drawing based on this data

## 3. CONCLUSION

When the churches in Anatolia are examined, it is understood that central location feature is present in all churches despite their periodical or regional differences. The laser scanning method provides great advantages especially in indoor measurements, in such large spaces, and is preferred over traditional measurement methods in terms of time, labor, and detailed detection of structural elements and their deterioration. However, as in other monumental buildings, in other small spaces in churches, the subject of point shooting and scanning becomes difficult when the height and width of the space are very small. In such cases, it may be necessary to adapt the data obtained by different measurement methods to the drawing. In such measurement studies, the data obtained by traditional measurement methods can be easily integrated with the drawings extracted from laser scanning.

Another advantage of the laser scanning method is that it provides the opportunity to see and evaluate all the facades and spaces of the building together, thanks to the data obtained. Building details overlooked in the field can be easily read through point cloud data. In addition, it is possible to take a section from the desired point over the obtained point cloud data.

The fact that it contributes positively to the accuracy of the drawing by reducing the workload of documentation studies with the laser scanning method is an advantage that is valid not only for monumental buildings, but also for all types of buildings. In addition, measuring without touching the surface minimizes the damage to the historical building during the measurement. At the same time, these traditional buildings, which are under great destruction, pose a danger to those working in documentation studies. It has been experienced that the terrestrial laser scanning method is safer than traditional measurement methods. Many points are obtained with terrestrial laser scanning methods. The use of computers with high performance in the processing of these data will positively affect the data processing speed and the drawing stage.

In monumental buildings, where the structural integrity is conserved, the measurement process is more comfortable, in the event that some structural elements such as dome, roof and wall collapse, as in the church, which is taken as a sample, there may be too many light bursts around these openings. In this case, it may be necessary to supplement the building elements around these openings with traditional measurement methods. Again, as a disadvantage, if the FaroFocus device cannot be installed on the roof or in some upper floor spaces in case of structural problems, measurement may not be carried out by laser scanning method in these areas. Another disadvantage is that some wall paintings in the buildings do not give the desired result in orthophotos. In these cases, measuring, photographing and on-site drawing studies may be required by using equipment such as telescopic meters, binoculars, and ladders.

As a result, it is seen that the historical buildings that are our cultural heritage and that are not yet included in the conservation studies are rapidly disappearing. The ability to make fast and detailed documentation, especially in monumental buildings with terrestrial laser

scanning method is considered as an important technological development for such buildings that are under the threat of extinction.

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This study was developed and produced from the thesis titled "Darsiyak Yanartaş Monastery 'The Archangel Michael and Gabriel Church' survey-restitution and restoration project" completed in 2021 by Res. Ass. Melikşah Koca under the supervision of Assoc. Dr. H. Hale Kozlu at Erciyes University Institute of Science and Technology. Also, this study was supported by the Erciyes University Scientific Research Projects Unit with the project code FYL-2019-8667.

**Author contributions**

**Melikşah KOCA:** Case Study Survey, Software, Data curation, Writing-Original
**Hale Kozlu:** Conceptualization, Methodology, Writing-Reviewing and Editing, Investigation

**Conflicts of interest**

The authors declare no conflicts of interest.

**Statement of Research and Publication Ethics**

The authors declare that this study complies with Research and Publication Ethics

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