USING 3D MODELING TO PROMOTE RAILWAY HERITAGE. THE RAILWAY STATION OF CURTEA DE ARGEȘ MUNICIPALITY AS CASE STUDY

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ABSTRACT:

The characteristics of the industrial heritage (antiquity, architectural, cultural, technological value) determined its inscription in the category of historical monuments. In recent years, non-invasive digital technologies have been used in studies focused on documenting, digitizing, preserving elements of industrial heritage. Also, another objective of digitizing the industrial heritage is to facilitate its promotion as a cultural resource among the general public. The purpose of this study is to promote the railway station of Curtea de Argeș through non-invasive technology. The analyzed industrial monument represents a symbolic building of the neo-Romanian architectural style. The building is also associated with a remarkable historical value: the railway station was also used by the Romanian royal family. Based on the use of terrestrial photogrammetry (versatile GNSS RTK GS18 I sensor) and aerial (photogrammetric flight), the authors created the 3D model of the station, obtaining a high-resolution modeling. The results of this study reflect the usefulness of modern technology for documenting, 3D modeling and promoting an industrial monument inscribed on the list of national cultural heritage. The accuracy and optimal performance of the measurements made, using GNSS technology and aerial photogrammetry, allowed highlighting the remarkable architectural and volumetric characteristics of the railway station of Curtea de Argeș Municipality.

1. INTRODUCTION

The inclusion of the railway transport elements in the sphere of cultural heritage was made relatively late (in the second half of the 19th century), as a result of belonging to the industrial field (Hecker, 2008). The main obstacle of classifying the elements of railway heritage as cultural goods was represented by the lack of recognition of its cultural and technological values, which results from its perception as an element of infrastructure with ordinary qualities (Hecker, 2008).

Against the background of deindustrialization, many elements of railway transport have been decommissioned, an issue that has come to the attention of the international community since the 70s of last century (Bazac, 2021). In this context, in order to maintain the functionality of the old railways and to preserve the engineering structures, urban regeneration projects with economic, environmental, social and cultural implications were started.

For the implementation of industrial sites regeneration projects, high-level cooperation between various stakeholders is needed, which takes the form of collaborative management (Popoviciu, 2012). Railway elements have been reused for cultural purposes (museums, exhibition spaces) (Bazac, 2021; Cano Sanchiz et al., 2020; Dorobanțu, 2020; Ekimci et al., 2019; Merciu et al., 2014; Michniack, 2016), tourism (tourist railways, hotels, restaurants) (Bazac, 2021; Michniack, 2016; di Ruocco et al. 2017), as office spaces for activities in the field of creative industries (Ekimci et al., 2019), etc.

The large size of industrial buildings and heritage sites, as well as their strategic location (usually in the central or peri-central area of cities), also generates an approach from the perspective of economic profitability of urban regeneration projects. (Merciu et al., 2014; Merciu, 2020). Preservation of cultural heritage is often seen as a factor limiting the development of the cities (Merciu, 2020; Messaoudi et al., 2021; Nae et al., 2019; Taloș et al., 2021).

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Adaptive reuse is also an action to highlight the elements of industrial heritage (Merciu et al., 2014) that allows the general public to be aware of the historical and cultural significance of industrial monuments.

In recent years, modern technology has been used more and more frequently as a tool for documentation, accurate monitoring, digitization, conservation and promotion of cultural sites among the general public (Jo and Hong, 2019; Herman et al., 2020; Martín-Lerones et al., 2021; Nistor et al., 2011; Rădulescu et al., 2021; Tache et al., 2019).

2D and 3D virtual representations are also useful for interactive presentation and promotion of industrial heritage elements: 3D models made with laser scan (Corso et al., 2013; Herner, 2019; Monego et al., 2017), the Building Information Modelling (BIM) technology (Carnevali et al., 2019; Wu et al., 2015) or Global Navigation Satellite System (GNSS) (Monego et al., 2017), aerial photogrammetry based on state-of-the-art technology (drones, LiDar) (Piras et al., 2017; Opitz et al., 2015), GIS storytelling (López and Cruz, 2021; Merciu, 2015).

This paper aims to promote the railway station of Curtea de Argeş Municipality, an industrial monument of national importance, using non-invasive technology (versatile GNSS RTK GS18 I sensor and photogrammetric flight).

2. DESCRIPTION OF THE CASE STUDY

The need for this study results from the cultural importance of the railway station of Curtea de Argeş municipality, which is a symbolic building of the neo-Romanian architecture, to which is added the historical value: the railway station was used by the Romanian royal family (Curtea de Argeş was the royal residence, with important Voivodship and royal necropolises) (Brie, 2005). The railway station was built between 1896 -1898, under the coordination of the engineer Elie Radu (Mănescu et al., 2003).

The railway station is individualized by architecture of a "domestic" monumentality, which combines in a balanced way elements and proportions specific to Romanian architecture. (windows in full arch, marked by the polychrome glazed ceramic frames of level 1 of the side bodies, twisted girdles present on the entire contour of the building, visually separating the two levels) with neo-Gothic decorative elements concentrated on the pediment of the central body, marking the cornice and the twin windows of level 1 of the pediment (Mănescu et al., 2003, pp. 106-107). The promotion of the national style was established as a priority at the end of the 19th century, in literature and arts, a movement supported by King Carol I (Mănescu et al., 2003, p. 107). The two towers mark the centrality by symmetry (Figure 1. a and b).

Figure 1. Picture of railway station
(a main façade, b. Northeast view)

Due to its architectural, historical, cultural and aesthetic plurivalences, the railway station of Curtea de Argeş Municipality is classified as a historical monument of national importance (code AG-II-m-A-13627) (List of Historical Monuments, 2015). The building occupies an area of 507 square meters.

3. METHODOLOGY

In this paper are used some of the main geomatic methodologies for obtaining the 3D model, from classic topography and the versatile GNSS RTK Leica GS18I sensor, to aerial photogrammetric flight.

Leica GS18I is an RTK GNSS rover, a dual frequency receiver, which allows the measurement of topographic points, with the help of images. To measure points, the sensor uses innovative virtual positioning technology based on the integration with the Global Navigation Satellite System (GNSS) and Inertial Measurement Unit (IMU) of a video camera (Leica ARO 135). When the chosen point is identified in consecutive images, the 3D position of the point is constructed using the forward intersection. In order for the measurement in the images to have an optimal accuracy and performance, the railway station was captured from a distance of 8m.

The rover uses real-time positioning (RTK) services that involve the transmission of information called differential corrections via the Internet. These services are provided by the Romanian Positioning System (ROMPOS). In order to measure points, the GS18I sensor must receive signals from the satellite. Using satellite data, the 3D coordinates of the ground point are measured with an accuracy of less than 1 centimeter (Monego et al., 2017).

The processing of the captured data was performed by the authors in the Leica Infinity program (Figure 2).

Figure 2. Graphic view of the data processing measured in the Leica Infinity program

The data processing also resulted in the creation of point clouds resulting from the measurements with versatile GNSS RTK Leica GS18I sensor, which were processed, aligned and georeferenced in the reference system of the topographic network (Figure 3).

Figure 3. Creating point clouds from data captured on the ground and building the 3D model

It was also necessary to use photogrammetric flight to scan the roof of the building. For data processing, the UltraCam Eagle M3 photogrammetric system used on a Beechcraft 200 Super King Air was used on an aerial platform. The software suite allows workflows for digital photogrammetry production, including automatic creation, orientation and triangulation of aerial images. Following the calculation of the exterior orientation, a dense point cloud was created for the roof of the building.

4. RESULTS AND DISCUSSIONS

In order to create the 3D model of the railway station of Curtea de Argeş Municipality, the points of interest were measured with the Leica GS18 I sensor during a field campaign in March 2021. The sensor was used with a measuring staff, held upright or tilted, due to the integrated IMU sensor, to measure the building footprint. Thus, 5,913,872 points were collected. Positioning the camera towards the building, the field operators walked along the main and side facades, while the camera automatically captured 989 images. The building was captured up to a height of 12 m.

The images were processed automatically by the application associated with the sensor. The Leica Infinity application automatically processes, positions and orients the captured images, thus ensuring the preservation of the quality of the measurements performed in the field.

The end result was a point cloud that defines the entire building (Figure 4). By capturing images on the same object, point cloud alignment takes place. The 3D model was processed to obtain a complete set of data that were classified into several categories, according to: point intensity (Figure 4. a and b), point density (Figure 4. c and d), by elevation (Figure 4. e and f), RGB model (Figure 4. g and h). The point cloud resulting from measurements performed with the versatile GS18I sensor is of high density (Figure 4. a and b).

Figure 4. Results obtained from data processing (a, b. Intensity of points; c, d. Dense cloud of points; e, f. Elevation - symbology according to the height from the ground; g, h. RGB 3D model visualization of tiny details rendered in color on the structure of 3D objects; the information is stored in a digital format and kept in separate color bands (red, green and blue)

The accuracy and optimal performance of the measurements made with the versatile GNSS RTK Leica GS18I sensor allow highlighting the remarkable architectural and volumetric characteristics of the building (Figure 4. g and h).

Similar results were obtained in other studies based on the use of the same technology (GNSS) (Monego et al., 2017) or laser scan (Corso et al., 2013; Herner, 2019).

Research in the field of cultural heritage is proving to be more and more complex, increasingly using knowledge from other fields, which reflects its interdisciplinary nature. Modern technology, which proves a very fast and wide development, is extremely useful in the field of cultural heritage research because it offers a permanent technological support in the activities of documentation, conservation, 3D reconstruction, promotion (Betti et al., 2021; Carnevali et al., 2019; Herman et al., 2020; Martín-Lerones et al., 2021; Nistor et al., 2011; Rădulescu et al., 2021; Sun et al., 2020; Xiao et al., 2018; Xu et al., 2021).

The particular characteristics of buildings and industrial heritage sites, such as their age and very large size, impose a number of difficulties in the process of their conservation (Nistor and Buda, 2013; Opitz et al., 2015; Wu et al., 2015). Modern technology offers multiple solutions to meet the challenges of conserving industrial heritage. Thus, in recent years there has been an increase in the number of studies focused on the use of modern technology, both for the conservation and promotion of industrial heritage (Corso et al., 2013; Herner, 2019; Merciu, 2015; Monego et al., 2017; Piras et al., 2017). The results obtained based on the use of non-invasive technologies (3D models, storytelling) can be easily used by third parties to promote the industrial heritage on computers or on the Internet (Corso et al., 2013; Herner, 2019). Digitization is a tool increasingly used by

technical museums to protect and promote elements of industrial heritage (buildings, collections) (Herner, 2019).

The digitization of the industrial heritage is also used for educational purposes, due to the fact that it can contribute to the assimilation of its characteristics, as well as to its fixation in the consciousness of the general public as a cultural resource.

5. CONCLUSIONS

Non-invasive technology contributes to the promotion of industrial heritage elements, as well as to the understanding of their importance and significance.

Realization and analysis of 3D models, of industrial sites or of the collections of industrial objects within the technical museums, are used for documentation, monitoring, conservation and promotion of industrial heritage elements. These results can be obtained using multiple modern non-invasive technologies: terrestrial photogrammetry, aerial photogrammetry, laser scan or a combination thereof. The selection of a certain method or the combination of several methods depends on several factors such as: complexity and size of industrial sites, ensuring high resolution accuracy, location constraints, technical characteristics of the tools, purpose of using the method (promotion among specialists or among general users), etc.

Along with 3D laser scanning, terrestrial photogrammetry is increasingly applied in the field of cultural heritage, including for the digitization of industrial buildings classified as historical monuments. In recent years there has been a very rapid development of computer technology and specialized software necessary for processing the obtained data. For example, the versatile GS18 I sensor is part of the new technology, which allows measuring points in a shorter time.

The current difficult situation generated by the COVID-19 Pandemic has considerably limited the conservation of industrial heritage elements, the most affected being the small technical museums that are based on visitors' incomes and members' volunteer actions.

It can also be appreciated that 3D modeling is very useful for the promotion and conservation of industrial heritage which is less known as a cultural resource among the general public compared to other cultural assets (architectural heritage, churches, museums).

This study focuses on creating a 3D model of an industrial monument with multiple valences (architectural, historical and cultural) using the versatile GNSS RTK GS18I sensor and photogrammetric flight. This study highlights the usefulness of 3D modeling in promoting the railway station of Curtea de Argeș Municipality, classified as a historical monument of national importance.

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