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From Plan to HBIM in Zaragoza to Canfranc Passenger Buildings

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Abstract

Graphic Expression, specifically architectural drawing, allows for the expression of the construction model and process, transitioning from the blank, two-dimensional plan to the actual constructed model.

Drawing is a tool in architecture to represent ideas, solutions, or projects we want to carry out. When studying Architectural Heritage, the potential of graphic expression to represent the existing, analyse its condition, and propose possible actions is undeniable.

Architectural heritage and other historical documents and objects from historical archives must be preserved to maintain history and culture.

The use of increasingly sophisticated tools and techniques allows for efficient optimisation of the level of detail of each graphic document for each situation.

Nowadays, we have tools and technology that enable new ways of working, facilitate data acquisition, representation of existing models, and preservation of existing documentation.

This document presents the different techniques for digitisation and the study of railway architecture from Zaragoza to Canfranc, focusing on passenger buildings at some stations.

Specifically, it refers to the work carried out, from the study of the documentation consulted in the AZAFT historical archive, the digital scanning of plans, redrawing of these plans, 3D surveys, photogrammetry work, and generating point clouds from laser scanning.

Keywords: *railway, Canfranc, stations, passenger buildings, architectural drawing, graphic expression, 3D modeling, photogrammetry, scanning, laser scanner, HBIM, heritage.*

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1. Introduction

The Zaragoza to Canfranc railway project, as a cross-border communication with neighbouring France, has been a long-standing aspiration advocated and defended by the Aragon region since the 19th century. Among other publications, these demands were recorded in 1853 in the text "Los Aragoneses a la Nación española" (Aragonese to the Spanish Nation).

This project was not without controversy due to technical, geographical, and orographic difficulties, different political and economic interests, and others beyond the scope of this document.

The study focuses on the final layout, specifically on the existing structures today, which allow us to trace the passage of history, which we can visit and touch, particularly in studying passenger buildings at train stations. "The passenger building is undoubtedly the most representative element of the architectural and logistical complex known as a railway station" (Martínez-Corral, 2019).

In the final layout, we can distinguish four sections. The first runs from Zaragoza to the town of Tardienta, connecting to the existing line to Barcelona. The second section extends from Tardienta, connecting to a branch line to Huesca, the provincial capital, and extending the line to Jaca. The third section reaches Canfranc, where the international station is located. The last section responds to French obligations to shorten the line, linking the Zuera station to the Turuñana station, bypassing Huesca and reducing the route by more than 40 km. The route crosses the border through the Somport tunnel to connect with France but is outside the scope of this study.

In the context of conserving and managing architectural heritage, the Canfranc Line presents a unique challenge. With its vast expanse, numerous structures, and rich history, preserving this masterpiece of the past for future generations requires a deep respect for its legacy and innovative tools and approaches that adapt to the demands of the present.

At this point, the convergence between the past and the future arises in the transition from traditional drawings to Heritage Building Information Modeling (HBIM). This article will explore how this technological evolution is transforming how we understand, preserve, and study the buildings between Zaragoza and Canfranc. From delineating their initial layouts to implementing advanced digital solutions, we will examine how HBIM has become an indispensable tool in preserving architectural heritage. Through concrete examples, detailed analysis, and reflections on the future, we will delve into the fascinating world where the past meets technological advancement, all in the unique context of this railway line.

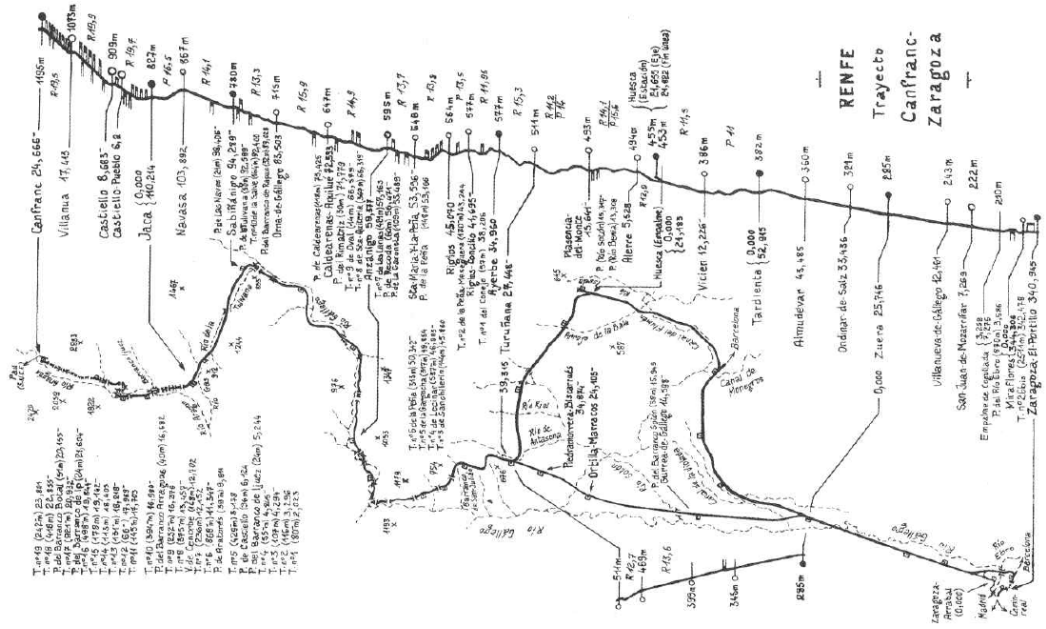

Figure 1. Layout and Section of the Zaragoza-Canfranc Railway Line. Source: Parra et al. (2005)

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2. Study of Plans: Digitization and Redrawing

"With architectural drawing, we can surpass the flatness of a two-dimensional surface and represent three-dimensional ideas in a clear, understandable, and convincing manner. Developing this skill requires experience both in the execution and interpretation of the graphic language of drawing. Drawing is a matter of technique and a cognitive act involving visual perception, good judgment, and logic of dimensions and spatial relationships" (Ching, 1974).

The plan represents an essential graphic document in work and, therefore, in studying architectural or heritage work. Spaces, structural systems, construction systems, and other solutions that will be carried out and executed in the work are reflected in the drawing. They also serve us to depict and study existing spaces.

Plans become graphic documents in themselves, with the ability to express. To understand them, learning to read and interpret them is necessary. Each stroke on a plan has rigour; it has a way of being and speaking in its graphic language.

In an initial approach to this study of the railway line between Zaragoza and Canfranc, access is available to original documentation of the layout, construction, and projects of the line, as well as of the stations, specifically the passenger buildings. The Zaragozana Association of Friends of the Railway and Tram (AZAFT) preserves in its facilities an archive with plans, scrolls, and other graphic documents, texts, letters, etc.

The condition of these documents, their preservation, the history of these documents, and this archive are the subject of another study. With the affection and value they have, not only as a document but also as heritage in themselves, they have been consulted and studied, preserving their condition.

Figure 2. Photo of the Consulted Plans. Source: Author.

The original plans consulted and studied were in a delicate conservation condition, and after consultation, they were catalogued and preserved. To facilitate the consultation and study of the found graphic documentation, as well as to preserve the condition of the original documents, digitisation was carried out through scanning as they were studied. The digitisation of plans "aims to:

- Increase citizens' access to archive documents through the use of the internet;
- Disseminate historical heritage;
- Safeguard original documents by avoiding manipulation;
- Create backups of unique and valuable materials;

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- Create a common repository for the dissemination and preservation of historical heritage" (Generelo, 2017).

Scanning historical plans from the 19th and early 20th centuries is not easy. It is truly an exciting task because it involves handling historical documents. However, their manipulation must be careful due to their delicacy and conservation status. The format of the plans, with large dimensions, also presents certain challenges when handling and digitising the documents. Likewise, the logical intention of AZAFT's archive property to preserve the documentation in its facilities to avoid the loss of any copies does not facilitate solutions for moving the plans for digitisation. The same applies to the lack of economic resources allocated for this purpose.

Given all these circumstances, the decision was made to acquire a scanner for plans with guides, which allows scanning by successive passes over the surface of the plans to be digitised, as well as assembly and editing of the images afterwards.

The characteristics of the Senniao Track Scanner for plan digitisation are as follows:

Table 1. Laser Scanner Characteristics

Model number	SN900STA0H	**Colour depth**	other
Scanner amplitude	A4	**Type**	Escáner de superficie plana
Interface type	USB 2.0	**Scanning element type**	CIS
Scanning speed	600*600dpi <6cm/s	**Optical resolution**	300 x 600
Brand name	LZHZXY	**Origin**	CN(Origen)
Product Model	SN900STA0H	**with English Manual**	Yes
File Format	JPG & PDF	**canner size**	265X42X24.5 mm
Product weight	1.6KG	**Standard battery**	2*AA alkaline five batteries
Resolution	900 * 900dpi | 600 * 600dpi | 300 * 300dpi	**Memory**	Micro SD card, up to 32G
Scan track length	A0H (a scan length of about 1.5 meters)	**Product number**	DL0158

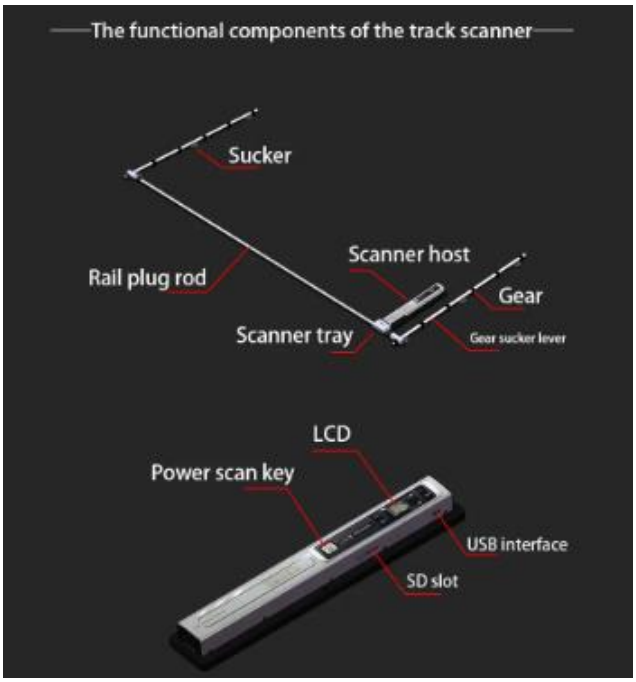

Figure 3. Photo of Plan Scanner. Source: Aliexpress.

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"As a reference, we will consider that an appropriate resolution for opaque graphic supports will be between 300 ppi and 600 ppi" (Generelo, 2017).

Table 2. Minimum Suitable Resolution Levels for Each Support. Source: General, 2017

Support	Type	Resolution (PPI)
Opacity	Up to 18x24 cm	600
	Above 18x24 cm	300
Celluloid Transparent	35 mm and 16 mm	2,600 - 4,200
Glass or Celluloid Transparent	4x5 cm, 4.5x6 cm	1,800
	6x6 cm, 6x7 cm, 6.5x9 cm	1,200
	9x12 cm, 10x15 cm	800
	15x20 cm and larger sizes	600

Due to the dimensions of the plans and graphic documents, the scanning resolution is set at 300 dpi. The IMADARA document is taken as a reference.

"The purpose of this document is to establish a protocol of action and standardised guidelines for all Archives of the DARA system that are easily assumable by all centres, whether or not they have specialised technicians in digitisation, thus unifying criteria and facilitating the dissemination and conservation of historical documents. Although DARA allows the incorporation of documents of all types, such as moving images or sound documents, the present recommendations will focus only on still images of textual documents. Some guidelines for graphic documents (photographs, engravings, drawings, cartography, etc.) are included. It should be noted that these recommendations are aimed at digitising documents of a historical nature and/or declared to be of permanent conservation, as well as documents of an exceptional nature" (General, 2017).

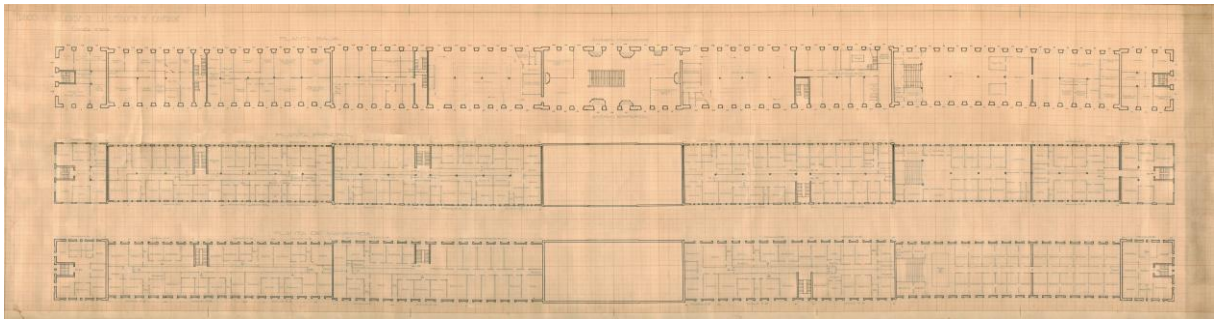

Figure 4. Digitised Plans of the Passenger Building at Canfranc Station. Source: Author.

The digitisation of the original plans enables quick, secure, and easy access to the sources while preserving the document. However, the digitised document does not serve as a working document, allowing direct modifications. Instead, it serves as a basis and reference point to gather the necessary documentation and information to accurately represent spaces and construction elements using drawing techniques in computer-aided design programs.

During the digitisation process, a sufficient approximation for documentary work is achieved. However, despite meticulous scanning and subsequent image assembly and editing, there is always some loss of definition and precision. Therefore, it is considered beneficial and necessary to create precise drawings where measurements, spaces, construction solutions, and all kinds of details can be verified.

"A drawing is a two-dimensional static document responsible for communicating and transferring information to a recipient. In the field of architecture, drawing can serve various intentions. Within an analytical, descriptive, or design process, there may be developmental stages where drawings have different expressive and informative levels: more abstract, synthesised, and geometrised, emphasising colour, shape, composition, luminosities, details, movements, etc. The final drawings (those that conclude the ideological stage and offer the possibility of

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construction) are the ones that meticulously guide the 'faithful' construction of a work, based on a vocabulary and syntax of architectural graphic expression" (Gomes et al., 2017).

Figure 5. Floor Plans, Elevations, and Sections of the Passenger Building at La Peña Station. Source: Author.

The detailed and meticulous drawings allow for much greater precision and observation of details and construction elements. Furthermore, they serve as a basis for subsequent work in various fields that may arise, whether it be study, analysis, conservation, or even intervention.

Referring to the original documentation also allows for comparing what was projected with what was executed. It also enables the observation of the condition of existing elements and the status of what has been preserved. Redrawing the plans using CAD methodology based on the original plans and comparing them with the existing conditions provides a valuable working document.

3. 3D Model

3D modelling has become an essential tool in the preservation and management of architectural heritage, allowing for the creation of precise and detailed digital representations of historic structures.

The process of 3D modelling begins with collecting data about the building to be represented. Once the data is gathered, 3D modelling software is used to create a digital model. Specifically, 3D models have been developed using SketchUp software, a dynamic and powerful architectural 3D modelling software that enables the creation of scenes and geometric models with comprehensive information agilely. Using a 3D modelling tool allows for the transition from two-dimensional plans to three-dimensional, obtaining a digital model of any building or architectural and heritage work.

"Increasingly, SketchUp is being used to significantly enhance spatial perception... In the technological world we live in, innovation and communication are fundamental, making it essential to draw in three dimensions" (Calle, 2016).

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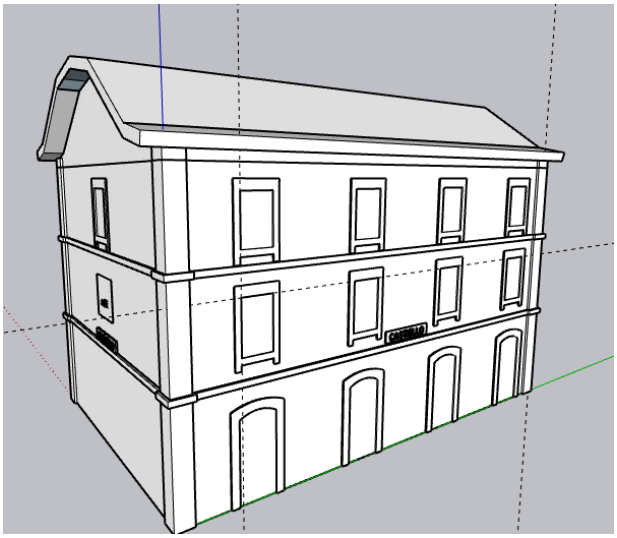
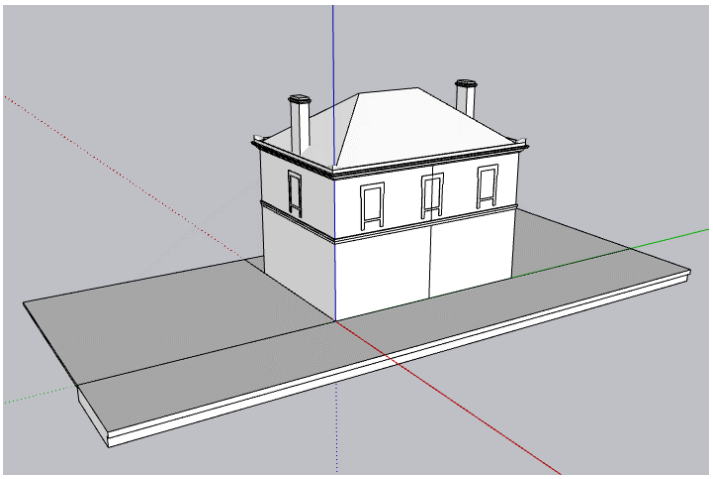


Figures 6 - 7. 3D Model of the Passenger Building at Castiello Station. Source: Author.

These models can be manipulated and edited, adding additional details and refining the geometry to create an accurate and realistic representation of the original structure or landscape. Additionally, 3D modelling allows for creating interactive virtual models that can be explored and analysed from any angle, providing a new way to interact with the history and architecture of the Zaragoza to Canfranc Railway Line.

3D modelling has been used to document various buildings along the route between Zaragoza and Canfranc, focusing on the passenger buildings of some of the stations on the line. These digital models provide a precise visual representation of the line in its current state and serve as a tool for planning restoration and conservation projects.



Figures 8 - 9. 3D Model of the Passenger Building at Caldearenas Station. Source: Autor.

Additionally, 3D modelling allows researchers and conservators to simulate the evolution of structures over time, anticipate potential conservation issues, and efficiently plan future interventions.

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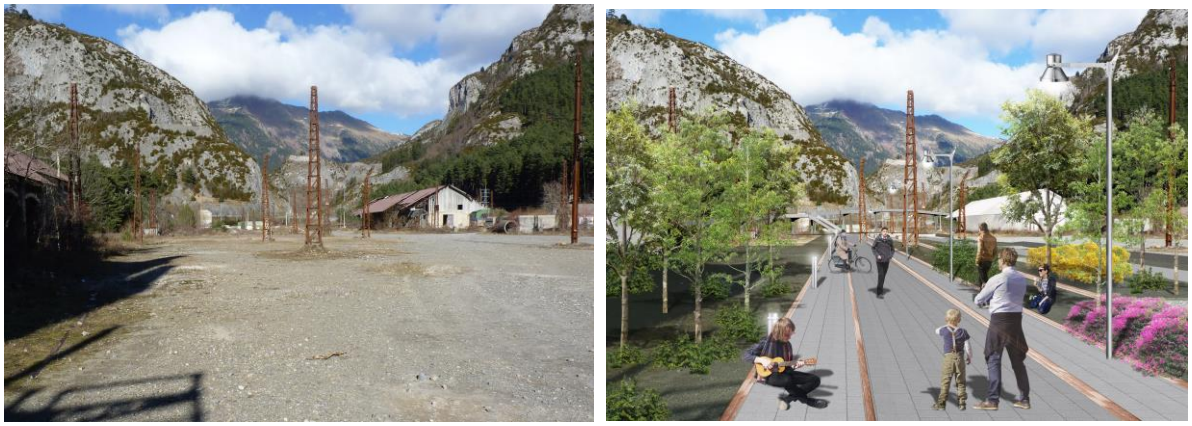

Figures 10 - 11. Proposed Urban Development Infographic for Canfranc Station. Source: Urbanism Department, School of Engineering and Architecture, University of Zaragoza.

4. Photogrammetry

Photogrammetry has become an indispensable tool in the conservation of architectural heritage. It allows for precise capture of historical buildings in their current state. Photogrammetry uses high-resolution photographs to create accurate three-dimensional models of objects or environments. This involves taking detailed photographs of buildings and their architectural features from different angles and perspectives.

These photographs are then processed using specialised photogrammetry software, which employs advanced algorithms to identify common reference points in the images and calculate the three-dimensional geometry of the scene. The result is a detailed and accurate digital model that captures the essence of the observed buildings. It is possible to quickly generate a point cloud as the basis for further work and study.

In addition to being a quick process, photogrammetry is relatively inexpensive because we can capture the snapshots using a digital camera, even those incorporated into our mobile phones, for subsequent production using specific software. Specifically, we have worked with RECAP from Autodesk.

Figures 12 - 13. Point Clouds Obtained through Photogrammetry of the Passenger Buildings at Castiello and Plasencia Stations. Source: Author.

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5. HBIM

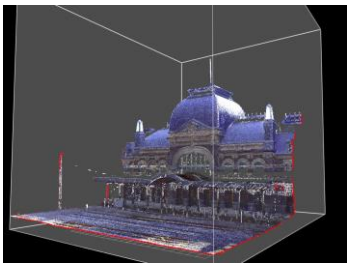
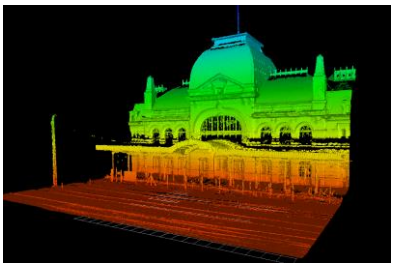
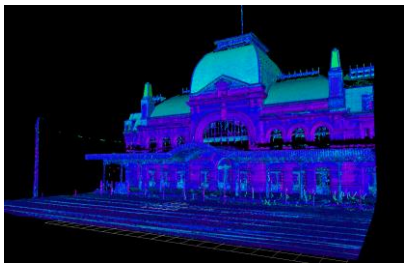
Building Information Modeling for Heritage Management (HBIM) represents an innovative approach to conserving and managing historic buildings. Unlike traditional models, which primarily focus on the visual representation of architecture, HBIM incorporates detailed digital information about the geometry, structure, materials, and other relevant aspects of a building, structure, or detail etc.

This wealth of information allows visualising the structure in its current state and simulating its evolution over time, anticipating potential conservation issues, and planning interventions more efficiently. Additionally, HBIM facilitates interdisciplinary collaboration and interconnectivity by providing a common platform for architects, engineers, conservators, and other professionals involved in heritage preservation.

Among the advantages offered by this working methodology are (VVAA, 2018):

- Real-time interoperability of all users;
- Workflow optimisation;
- Greater precision in measurements and budgets;
- Enhancement of visualisation and dissemination.

The digital models created using this technology provide an accurate representation of existing structures. Furthermore, integrating historical information into these models provides a more comprehensive understanding of the line's past, enriching our understanding of its cultural and historical significance.

Figures 14 – 15 - 16. Point Clouds were obtained via laser scanning of the passenger building at Canfranc Station. Source: Mora.

6. Conclusions

The railway line between Zaragoza and Canfranc remains a symbol of connection and encounters between cultures and eras. From a collective standpoint, it is essential to protect and preserve this legacy for future generations. Preserving what exists and disseminating the history and architectural heritage is necessary in architecture. By consulting existing sources and documents based on the AZAFT archive, we have compiled an important catalogue of reliable documentation of the originally projected plans and contrasted it with what exists today. This study provides a repository where we have:

- Original documents;
- Digitised documents through scanning;
- 2D plans;
- 3D modelling;
- Point clouds from photogrammetry;
- Point clouds obtained through laser scanning.

As is the case in most situations, heritage management faces a series of challenges. Among the most prominent are limited funding, lack of specialised human resources, and the need to reconcile heritage preservation with contemporary demands for development and tourism.

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However, the future of heritage management on the Canfranc line is full of promises and possibilities. Using new technologies and work methodologies, such as HBIM as a fundamental tool, is expected to enable effective heritage management, thus guaranteeing the preservation of architectural heritage.

The transition from traditional plans to the HBIM methodology, through other digital design, modelling, and information management tools, marks a significant milestone in heritage preservation. When we look to the future in terms of development, sustainability, and prosperity, there must be a commitment to heritage preservation, in this specific case, the architectural legacy provided by the passenger buildings of the railway stations between Zaragoza and Canfranc, ensuring that it continues to be a symbol of connection and encounter throughout the centuries.

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