edited by

SANDRO PARRINELLO

FRANCESCA PICCHIO

Architectures along James I itinerary in the Valencian Province

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Persistent forms in Valencia Cathedral. © Sandro Parrinello

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Introduction

THE ROUTE AS A PRETEXT
PLACES OF JAMES I AND THE TRANSFORMATION OF LANDSCAPE

Sandro Parrinello

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Side page, Fig. 01
Out of scale
The Monastery of Puig in a play of correspondences between the historic settlement and the new one in the background.

The cultural route is a tool that, over the years, has transformed into a virtuous pretext for enhancing the historical, artistic, and landscape heritage of a territory. This function is noticeable in how the route serves as a bridge between the past and the present. It engages communities, institutions, and visitors in a meaningful dialogue about collective memory and the various elements that capture the essence of a place. To fully understand why the cultural route assumes this function, it is necessary to analyse its intrinsic features and the context in which it develops, starting a multitude of actions that combine the project dimension with the cognitive one during their development. Project-oriented approach, after all, is present at every moment of the cognitive process, aimed at idealising, visualising, and contextualising—in a near or distant future—events, episodes, and elements of a specific historical heritage. Therefore, these two dimensions coexist in every action undertaken to develop knowledge, but in the context of a route, understood as a path scattered across a territory, they must be clearly distinct or distinguishable in the logic and structure of research. This allows the route to establish a connection with the cultural models it draws upon.

In the architectural dimension, these cultural models focus on a variety of historiographic and technological aspects that link a product or a work, born from a specific culture, to a territorial dimension over a time span that, especially when dealing with historical or historicised heritage, is long enough to be traversed, contaminated, and influenced by additional cultural models and processes of habitation and transformation.

Documentation aimed at understanding a widespread heritage, which can be shaped into a cultural route, represents a complex but essential activity to create a representative and narratively critical synthesis. The cultural route is not merely a sequence of places or monuments, but a narrative and identity-based ecosystem shaped by profound and detailed knowledge. This type of documentation does not merely record data but operates as an interpretive and creative act, thereby revealing the in-depth connections that unite the different elements of the heritage.

Walter Benjamin, in his famous essay *The Work of Art in the Age of Mechanical Reproduction*[1], emphasises that documentation is never neutral but influences the way the public perceives a work or a place. Applying this principle to cultural routes, we can say that documentation creates the narrative

[1] Benjamin (1935), *Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit* (*The Work of Art in the Age of Mechanical Reproduction*).

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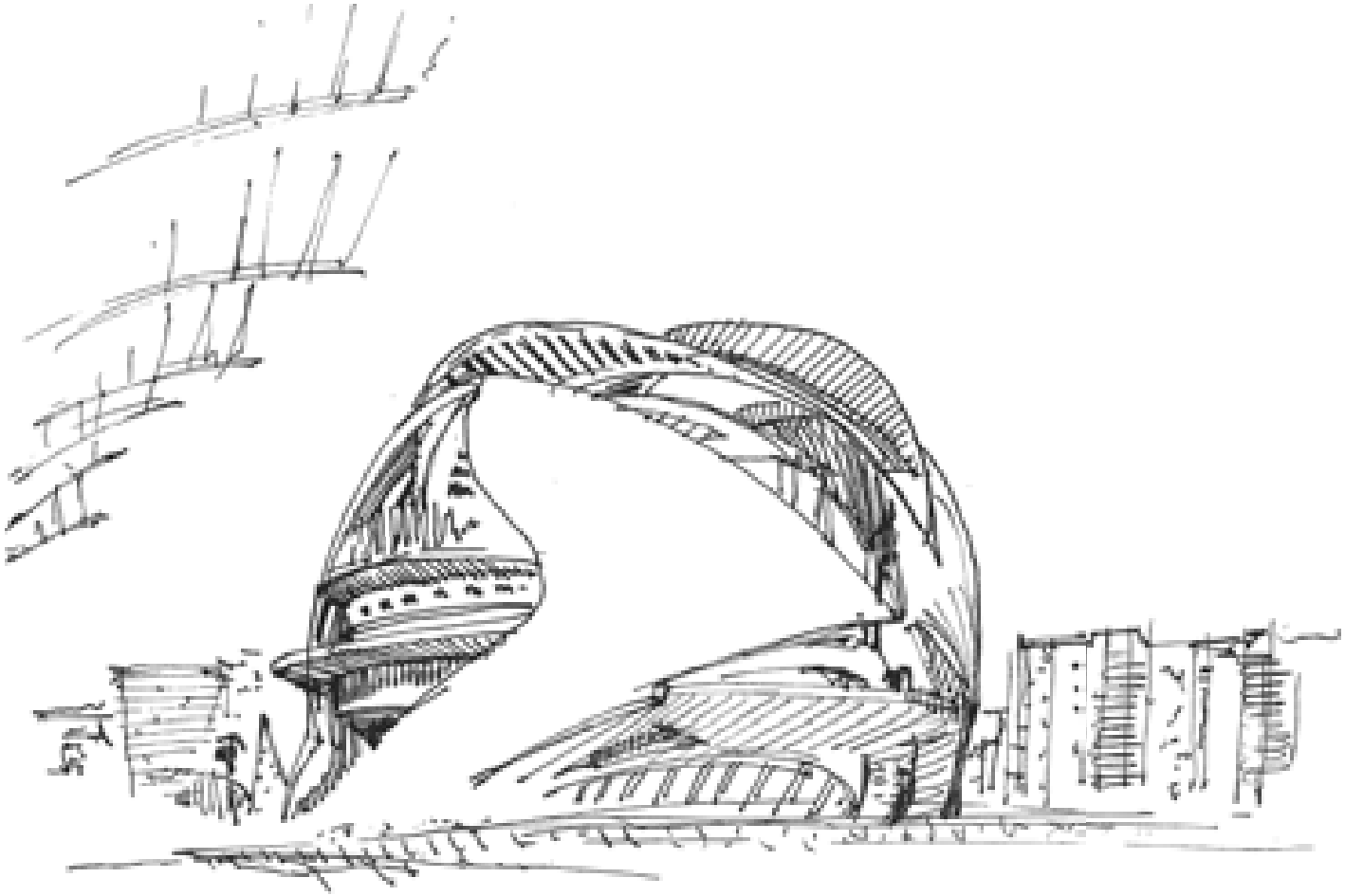


Fig. 02
Contemporary Landmark
The graphic sign interprets a contemporary landmark as part of the present urban landscape, providing a reference for the current spatial identity of the city. (Drawing credit: Sandro Parrinello)

fabric that allows a widespread heritage to be understood not as a series of isolated fragments but as a coherent and meaningful whole, working on a least common multiple that is articulated and identifies the route.

The scope of this operation, from a synthesis perspective, necessitates selecting certain aspects while forgoing various qualities or attributes. This is intended to enhance communication and highlight the reasoning that qualifies the route. In this sense, and with this necessary perspective, documentation procedures must be oriented toward two diametrically opposed objectives: to configure representative models that highlight specific attributes, emphasising the rationale and value aligned with the identification of the route; and to promote data collection that may enable future actions for the enhancement of qualities or for interrelations with the territory concerning specificities that, at the time of documentation, are not included in the analysis's scope. One of the crucial elements of the documentation process is the identification and mapping of resources. Every site, object, or tradition that constitutes the cultural route must be described not only from a physical and historical perspective but also in relation to its social, symbolic, and emotional context. This holistic approach allows us to capture the complexity of heritage and present it in a faithful manner.

Fig. 03
Historic Landmark
The drawn line reveals the persistence of the past within the urban fabric, translating layered histories into a readable sign that connects places, time, and collective memory. (Drawing credit: Sandro Parrinello)

In this sense, fidelity follows a logic of coherence, which is not tied to dimensional accuracy alone but to the perceptual association between a place and its model, between a place and its representation, in which even the metric and dimensional aspects—though physical and tangible—become part of the logical framework. For instance, an ancient bridge is not merely an engineering work but a crossing point that shaped economies, relationships, and collective narratives. Including it in a cultural route means recounting not just its past but also the way it continues to live in the present. Similarly, a fortification, a church, or any other place included in the route carries a plurality of meanings that must be translated. Another equally important aspect is the need to adopt digital tools and technologies, such as digitisation, georeferenced systems, and interactive databases, that facilitate the translation process of information and promote different forms of interaction with data as well as reinterpretation and transcription of signs. "Every documented memory requires interpretation because the past is never a direct replica of the present"[2].

[2] Ricoeur (2000), *La mémoire, l'histoire, l'oubli de Paul Ricoeur*. For an in-depth analysis of the concept of "being able to remember" (*pouvoir-se-souvenir*) in Ricoeur's philosophy, see Pacilè (2019), *L'escatologia di una memoria riconciliata. Paul Ricoeur tra memoria, storia e oblio*, where is emphasised: "the fundamental dimension of the human being, of the narrative construction of one's identity, both personal and collective, but above all of one's historical condition which, though aware of

Fig. 04
Simat de la Valldigna
The church within the Monastery stands out for the simplicity of its walls, animated by domes and towers that enrich its spatial form. (Drawing credit: Giulia Porcheddu)

In this sense, the documentation process is also an act of cultural mediation that seeks to balance data accuracy with the need to construct a narrative that is meaningful and engaging.

Documenting widespread heritage for the implementation of a cultural route also requires a strong component of interaction with local communities, which are the custodians of intimate knowledge, often hidden within customs and traditions passed down through generations.

A song, a legend, a story, or a technique orally transmitted and embedded in local products or works represent memories that rarely find space in official records but are essential to understanding the identity of a place. "Heritage lives in collective memory"[3] writes Pierre Nora, and the documentation process must include this intangible dimension of tangible heritage to provide a narrative that incorporates these complexities into its representation processes.

Side page, Fig. 06
A Landmark Along the Way
The Cruz Cubierta of Alzira, a Gothic octagonal structure, stands in the rural landscape as a historic marker of devotion and passage. (Drawing credit: Giulia Porcheddu)

If representation incorporates such suggestions, not just at the level of data within a hypertext or multidimensional drawing, but at an expressive level—through colours, lines, and forms—the outcome of the documentation, even in terms of technical outputs, will be more effective and capable of communicating the character, space, and time of a place. Cultural routes, to be effective, must

its own finitude, is called, through the continuous interpretation of its past, to rediscover within it an inexhaustible reservoir of meaning, necessary for the construction of a meaningful future.". Cf. also Ricoeur (1969), *Le conflit des interprétations*.

[3] Referring to that nebulous, vague, and ambiguous form of collective memory identified in the recollection or set of more or less conscious memories of an experience lived and/or mythologised by a community that identifies itself in the perception of a past of which it is itself an integral part. Nora (1978), *Mémoire collective*, in *La nouvelle histoire*, p. 398. See also Attruia (2021), *introduzione*, in *La memoria collettiva. Saggi di linguistica e letteratura*, pag. 13.

Fig. 05
Fortified Architecture
The Castle of Benissanó rises among the trees with towers and compact walls, shaping the landscape. (Drawing credit: Giulia Porcheddu)

be communicated in accessible and engaging ways. Their communication cannot be limited to an academic or specialist audience. This is why, in these studies promoted by the Prometheus project, the highly technical themes of databases, drawings, and narratives between landscape and architectural bodies oscillate between elaborative processes of information and activities that highlight their disseminative value.

The use of diverse languages in visual storytelling allows widespread heritage to become a shared resource, enhancing not only its potential for valorisation but also its preservation.

Thus, the documentation process is not a "simple" act of recording but an exercise in narration, interpretation, and participation, enabling the widespread heritage that constitutes the cultural heritage route to emerge with its values—not merely as a legacy of the past but as a tool for the future.

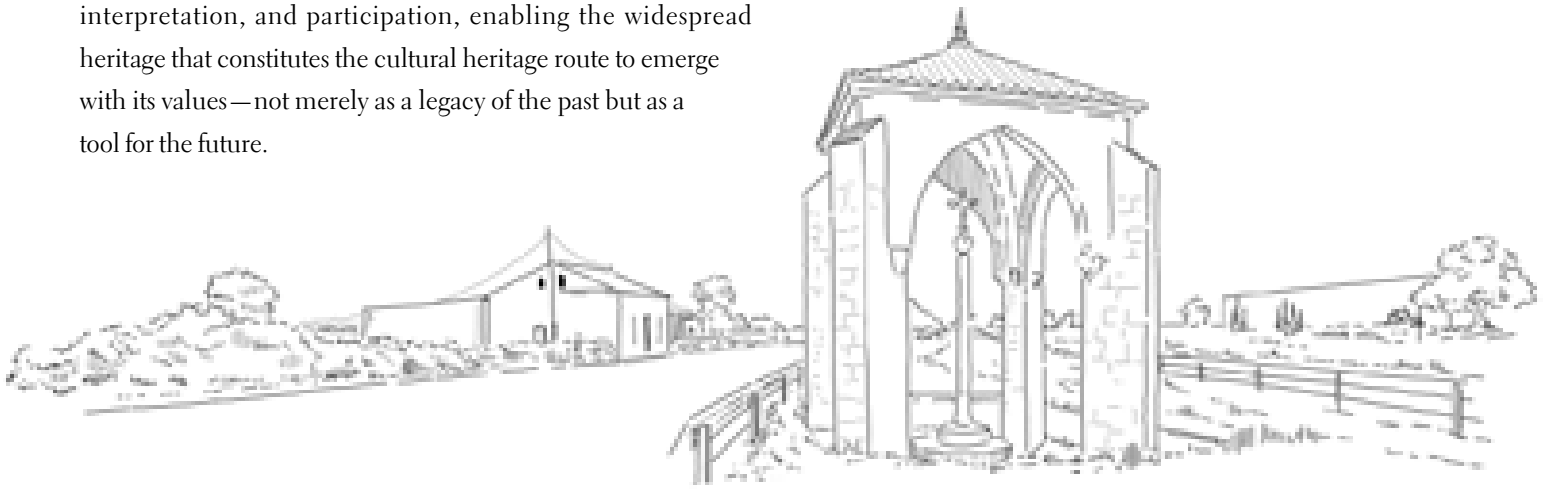
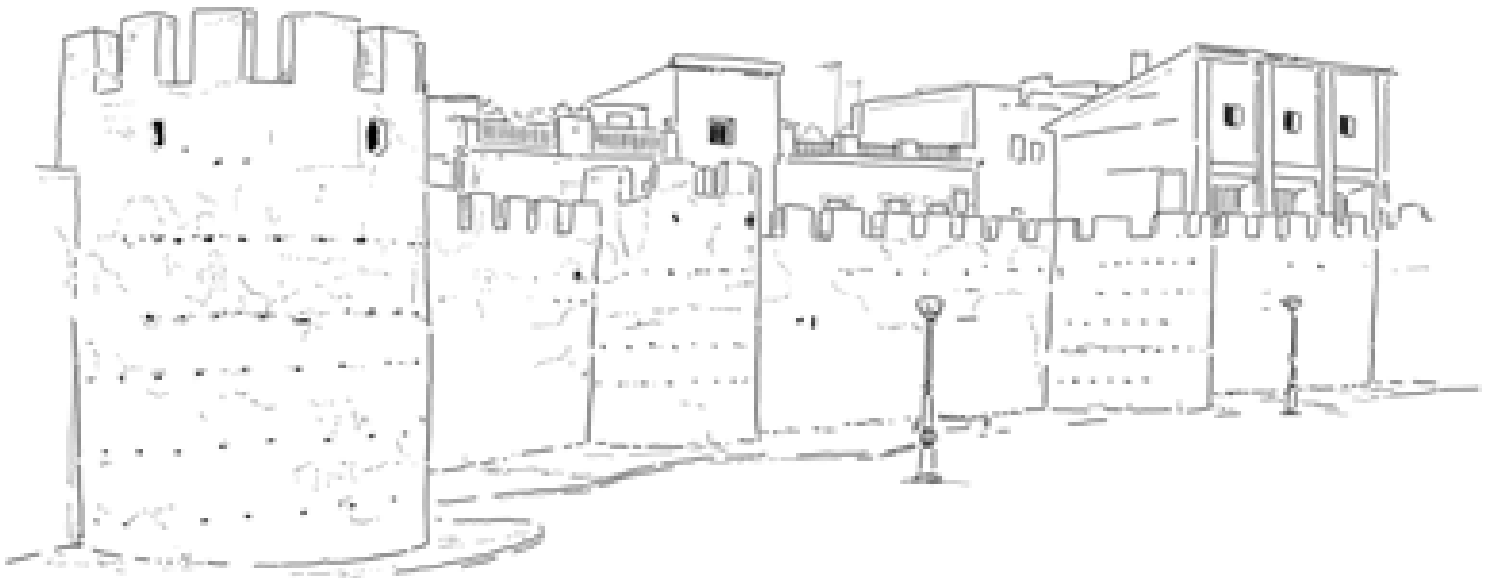


Fig. 07
Castle of Cullera
The Castle blends military fortification with religious architecture. (Drawing credit: Giulia Porcheddu)

Defining a cultural route and digitally transcribing it becomes more than just an acknowledgement of a historical dimension; it is an active endeavour, a fight for preservation.

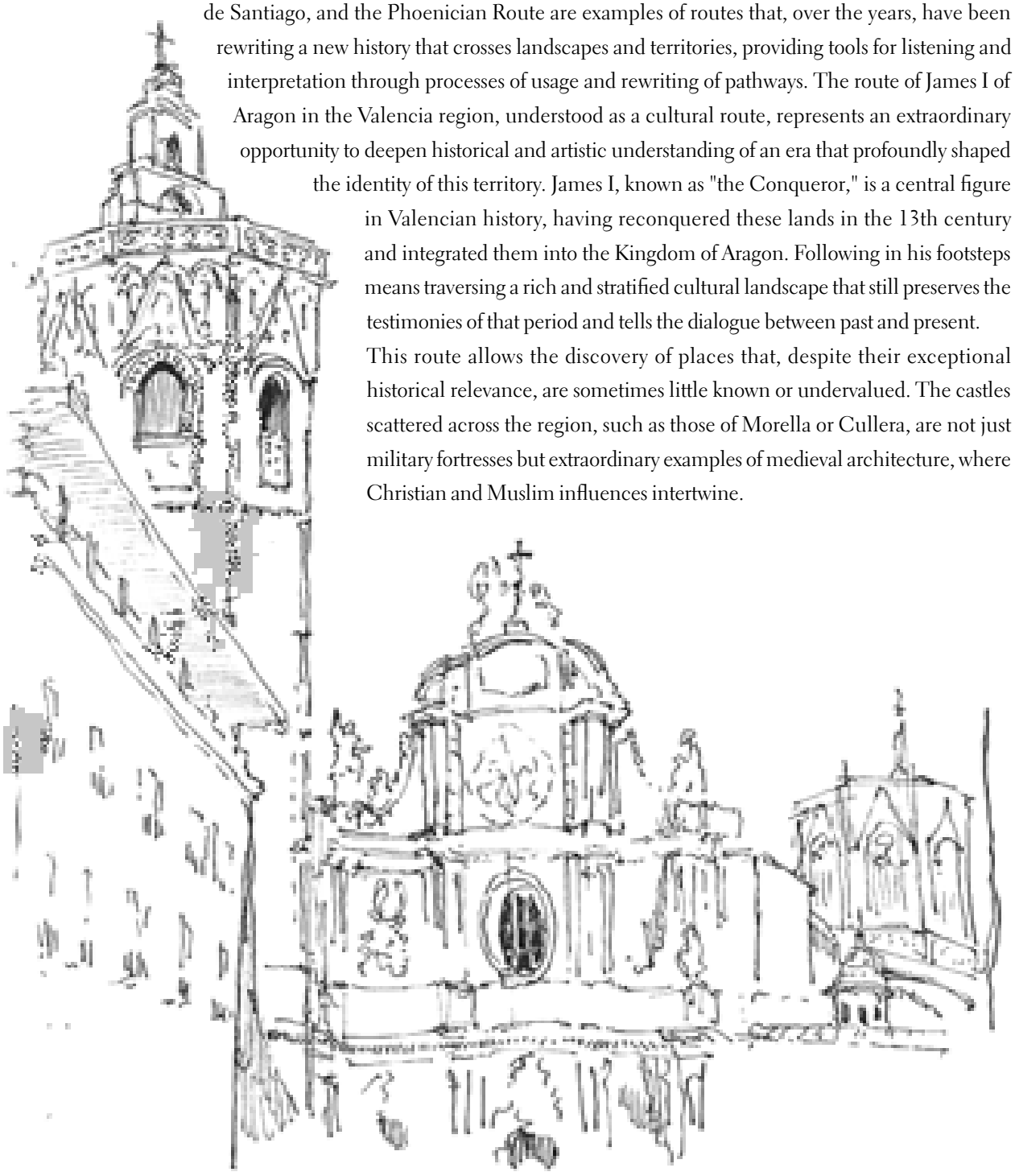
If, as Antonio Gramsci stated, history is always contemporary, then documenting a cultural route is a way to make the past an active interlocutor in our present, transforming researchers into active partisans for cultural heritage, countering the indifference and oblivion that peripheral cultural assets often face when not integrated into a system that promotes their understanding.

A cultural route is, therefore, a narrative tool for the territory, not merely a physical itinerary but a storytelling path that weaves together stories, traditions, and identities—an attempt to give voice to places by connecting them through themes that bridge past and present.



The narrative does not simply retell history as a static entity but as a living organism that evolves over time, transforming often-forgotten places into destinations of interest and discovery. However, valorisation does not end with restoration or tourism promotion. The Via Francigena, the Camino de Santiago, and the Phoenician Route are examples of routes that, over the years, have been rewriting a new history that crosses landscapes and territories, providing tools for listening and interpretation through processes of usage and rewriting of pathways. The route of James I of Aragon in the Valencia region, understood as a cultural route, represents an extraordinary opportunity to deepen historical and artistic understanding of an era that profoundly shaped the identity of this territory. James I, known as "the Conqueror," is a central figure in Valencian history, having reconquered these lands in the 13th century and integrated them into the Kingdom of Aragon. Following in his footsteps means traversing a rich and stratified cultural landscape that still preserves the testimonies of that period and tells the dialogue between past and present.

This route allows the discovery of places that, despite their exceptional historical relevance, are sometimes little known or undervalued. The castles scattered across the region, such as those of Morella or Cullera, are not just military fortresses but extraordinary examples of medieval architecture, where Christian and Muslim influences intertwine.



Side page, Fig. 08
City Wall of Alzira
A stretch of medieval fortification. (Drawing credit: Giulia Porcheddu)

Fig. 09
Traces of Continuity
The Valencia Cathedral reveals the persistence of architectural forms shaped within the evolving city. (Drawing credit: Sandro Parrinello)

Next page, Fig. 10
Castle-Palace of Benissanó
Detail of mullioned windows and crenellations, where defensive structure meets noble residence. (Drawing credit: Giulia Porcheddu)

Fig. 11
Valencia, Urban Fragment
A juxtaposition of architectural elements reflecting the coexistence of different temporal and spatial conditions within the city. (Drawing credit: Sandro Parrinello)

Their strategic locations and structures speak to an era in which territorial control was crucial, and every architectural element bears the marks of a conflict that was also cultural. However, these castles are not solely symbols of war; some have evolved over time into centres of civil power, reflecting the political and social dynamics of the region.

Likewise, the monasteries and churches along the route testify to the role of religion during the Reconquista and the subsequent reorganisation of the territory. The sacred art produced during this period—from mosaics to fresco cycles—not only demonstrates artistic mastery but also serves to understand the symbolic imagination of the time. The depictions of saints, biblical scenes, and decorative motifs in these buildings provide a window into the mindset of an era when faith and politics were deeply intertwined.

The route of James I highlights the complex relationships between Christian, Muslim, and Jewish cultures. Even after the Christian conquest, Muslim cultural influence remained evident—not only in architecture but also in agricultural techniques, place names, and certain traditions still alive today. This cultural plurality is one of the most extraordinary riches of the territory and an essential lens for understanding its history. Amin Maalouf reminds us that every identity is composed of multiple affiliations and that every culture is the result of encounters and exchanges[4]. It is this timeless coexistence of styles and rewritings, including those occurring in the present, that can promote an inclusive historical memory respectful of diversity. The symbolic value of James I, who is not just

[4] Maalouf (2021), *Identità assassine. La violenza e il bisogno di appartenenza.*

Fig. 12
Valencia, Street Fragment
A local urban scene where architectural detail and spatial enclosure shape the perception of place. (Drawing credit: Sandro Parrinello)

a historical figure but an identity reference point, allows us to recognise the weight of a collective memory that helped shape the territory. Places of memory become such when a community attributes to them a meaning that goes beyond their mere historical dimension, transforming them into symbols of its past and roots. Art and architecture are part of a heritage that the route allows us to rediscover and valorise—pieces of a larger mosaic that reconstructs the image of a complex and ever-changing society. Documenting and interpreting these elements mean restoring their rightful role within the historical narrative, offering travellers not only information but an immersive cultural experience. This project helps build a bridge between past and present, assisting local communities in rediscovering and valuing their heritage. Retracing the route of James I of Aragon, exploring and experiencing its monuments, is a journey that unites history, art, and identity. It is not only a way to better understand a crucial period in Valencian history but also to rediscover the value of a heritage that, while rooted in the past, continues to speak to the present with a strong and vibrant voice. In this sense, the route is not merely an itinerary but an experience that invites us to see the indissoluble link between places and the people who inhabit them with new eyes.

Side page, Fig. 13
Cruz Cubierta di Alzira
On-site drawing sessions during documentation activities. (Drawing credit: Sandro Parrinello)

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James I of Aragon's historical itinerary in the Valencian community

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The Iberian Peninsula was invaded by the Arabs in the year 711, thus beginning a long period of eight centuries of Muslim domination over the so-called Al-Andalus. Its political and social importance increased exponentially until the constitution of the Caliphate of Córdoba (929-1010). This period can be considered the "golden age" of Arab domination, becoming a military and cultural power. After the fall of the caliphate, it formed several kingdoms or taifas. The taifa of Valencia was created in 1010, occupying the territory between the taifas of Zaragoza, Toledo Albarracín, Tortosa and Denia. At the same time, the Christian kingdoms that had remained independent in the north of the peninsula never stopped considering the reconquest of the territories won by the Arabs. In this way, a reconquest began in terms of a crusade in Spanish territory itself, causing the borders between the Muslim and Christian kingdoms to alternately vary[1]. This circumstance promoted tolerance between different ethnic groups and commercial relations, regardless of the violent confrontations that occasionally occurred.

The kingdom of Valencia was conquered in 1094 by Rodrigo Díaz de Vivar, although it did not last long since in 1102 it was taken again by the Almoravids[2]. Between 1110 and 1120 the Aragonese took over most of the Ebro basin, including Zaragoza (1118) and Tarragona (1116). The weakness of the Almoravid army, due to the fights with the Almohads (new invading ethnic group from North Africa), was taken advantage of by the Christians to reconquer new territories[3] such as Tortosa (1148) and Lérida (1149) located in the Upper Mark of the peninsular East.

At the beginning of the 13th century, the archbishop of Toledo obtained from Pope Innocent III the proclamation of the Crusade and the union of the Christian kingdoms of the north. In this way, the allied forces of Castile, Aragón and Navarra, helped by Portugal, León and France, definitively defeated the Almohad troops in Navas de Tolosa in 1212[4].

In this climate of reconquest and crusade, King James I of Aragon was born in 1208. He is a kaleidoscopic character. All facets of his life and works are surprising and astonishing. He excelled in all those enterprises he undertook. His human temperament was forged from his earliest childhood. He was born in Montpelier and, according to what he himself tells in his autobiography, his mother,

Side page, Fig. 01
King James I of Aragon
Graphic re-elaboration of Manuel Boix's illustration for the 750th anniversary of L'Alcúdia (Museu del Cartell, Valencia).

Fig. 02
Visage of the Sovereign
Detail from Jaume I el Conqueridor, attributed to Gonçal Peris Sarrià and Jaume Mateu, 1427. Tempera on wood (Museu Nacional d'Art de Catalunya, Barcelona). Source: Wikimedia Commons / Google Art Project.

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[2] Arié (1984), *España musulmana (siglos VIII-XV)*, p. 32.
[3] Levi-Provenzal (1947), *Islam d'Occident. Études d'histoire médiévale*.
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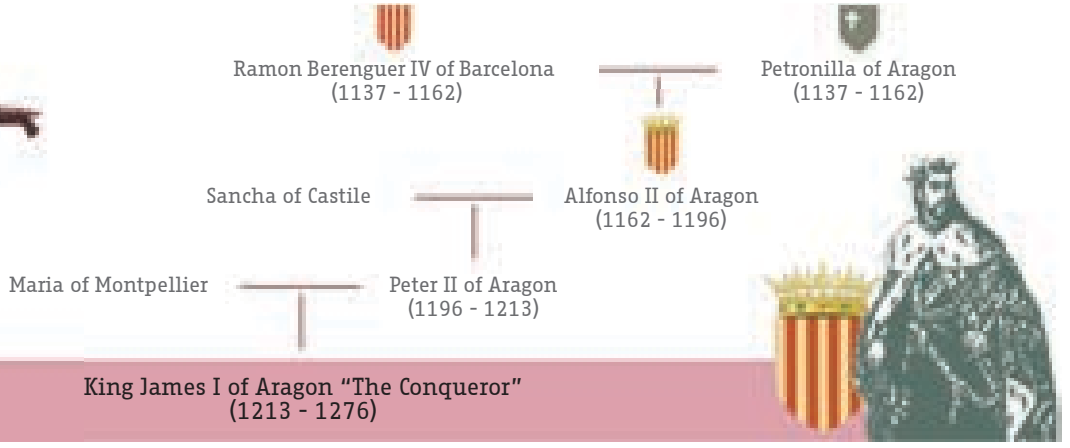


Fig. 03
Monument of "Rey Jaime I"
Equestrian statue located in Alfonso the Magnanimous Square, Valencia.

Side page, Fig. 05
The main phases of the Catholic reconquest

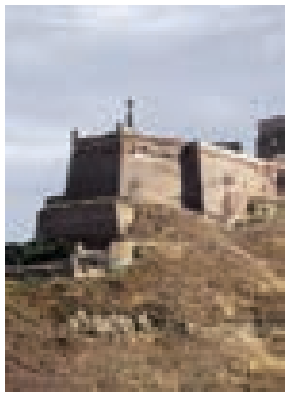
granddaughter of Emperor Manuel of Constantinople, had twelve identical candles lit, with the one with the name of Saint James being the last to burn out[5]. Shortly after he was born, his father, King Pedro of Aragon, gave him to Simón de Monforte, lord of Carcassonne and Beziers, so he spent his early childhood in Caracasanne. Upon the death of King Pedro, he was claimed as king by the nobles of Aragon when he was 6 years old. He was entrusted to Guillermo de Monredón, master of the Templars of Aragon who welcomed him in the castle of Monzón. At this early age he found himself presiding over Cortes Generales before bishops, nobles, knights and rich Aragonese men. They all swore an oath to him. With the Templars he was educated for two and a half years. He had meager economic means and a kingdom in turmoil due to quarrels between nobles. At the age of 9, he left the castle of Monzón, accompanied by several knights he trusted, wearing a borrowed coat of mail, to participate in his first battle. Thus he arrived in Zaragoza, the capital of Aragón.

From that moment on, he took on the great responsibility of appeasing his own kingdom and conquering new lands from the Saracens. The internal wars between Aragonese nobles were increasingly bloody, being forced to reconquer multiple places and lordships that were positioned on the side of his uncle Fernando, brother of his father and claimant to the throne.

The kingdom of Valencia was coveted by both Muslims and Christians due to its fertile agriculture and commercial activity as it was a link to the Mediterranean. The Castilians had tried to conquer it on several occasions[6]. James I reacted strongly against Castilian interference[7] by undertaking the conquest of Albarracín, without success, when he was only 11 years old. His maturity was early in every sense, since at the age of 13 he married Doña Leonor, sister of the Queen of Castile. After which he received the order of chivalry in Santa María de Huerta of Tarazona.

He was 17 years old (1224) when he proposed the conquest of the kingdom of Valencia by summoning the rich men of Aragon in Teruel, although it would be later, when the Master of the Order of Saint John, Hugo de Folcalquier and Blasco de Alagón proposed to him, in Alcañiz, undertake this important undertaking[8]. In this castle, some magnificent paintings are preserved in the diaphragmatic

Fig. 04
The Castle of Monzon
It was within these walls that the King spent his childhood under the protection of the Knights Templar. Graphic reworking from the Wikimedia Commons image, public domain.



[5] Flotats, Bofarull (1848), *Historia del Rey de Aragón Don Jaime I, el Conquistador.*
[6] Zurita (2003), *Anales de la Corona de Aragón.*
[7] Sanchis i Guarner (1965), *Época musulmana* in *Història del país valencià.*
[8] Flotats, Bofarull (1848), *cit.*

711: After the invasion, between 716 and 725, Muslims conquered Septimania, ending the Visigothic kingdom of Hispania. This opened the Islamic period in the history of Spain and Portugal.
721-750: The situation of the Iberian Peninsula after the end of the Muslim conquest, the deposition of the last Visigothic Kings of Narbonne and the formation of the Kingdom of Asturias.
981-1005: After an initial breakthrough of the Christian Kingdoms into the territory of the Cordoba Caliphate, the border is brought back to the Ebro River.

1031: After the fall of the Caliphate of Cordoba in 1031, Muslim Spain fragmented into the Taifa kingdoms, independent territories that often fought each other for power. These kingdoms came to be more than thirty.
1157: The Almohads took control of the Moorish principalities in the Iberian Peninsula from the Almoravids. Within twenty years they conquered most of Al-Andalus and moved the capital from Córdoba to Seville.
1210-1238: Following the victory of Las Navas de Tolosa there was a rapid reconquest of most of the territories of Al-Andalus and the final formation of the Christian states. The Kingdom of Aragon conquered Valencia and Majorca.

1252: Christian King Ferdinand III of Castile and Leon, after conquering Cordoba (1236) and Jaén (1246), following a long siege took Seville, and left only the Kingdom of Granada in Arab hands.
1360: The Kingdom of Granada continued to prosper. Nevertheless, political conflicts were constant, and this weakness was exploited by Christians, who gradually conquered small territories in the kingdom.
1492: After a ten-year long military campaigns, the Catholic Monarchs Ferdinand of Aragon and Isabella of Castile concluded the reconquest of Spain on January 2, 1492 with the taking of Granada.

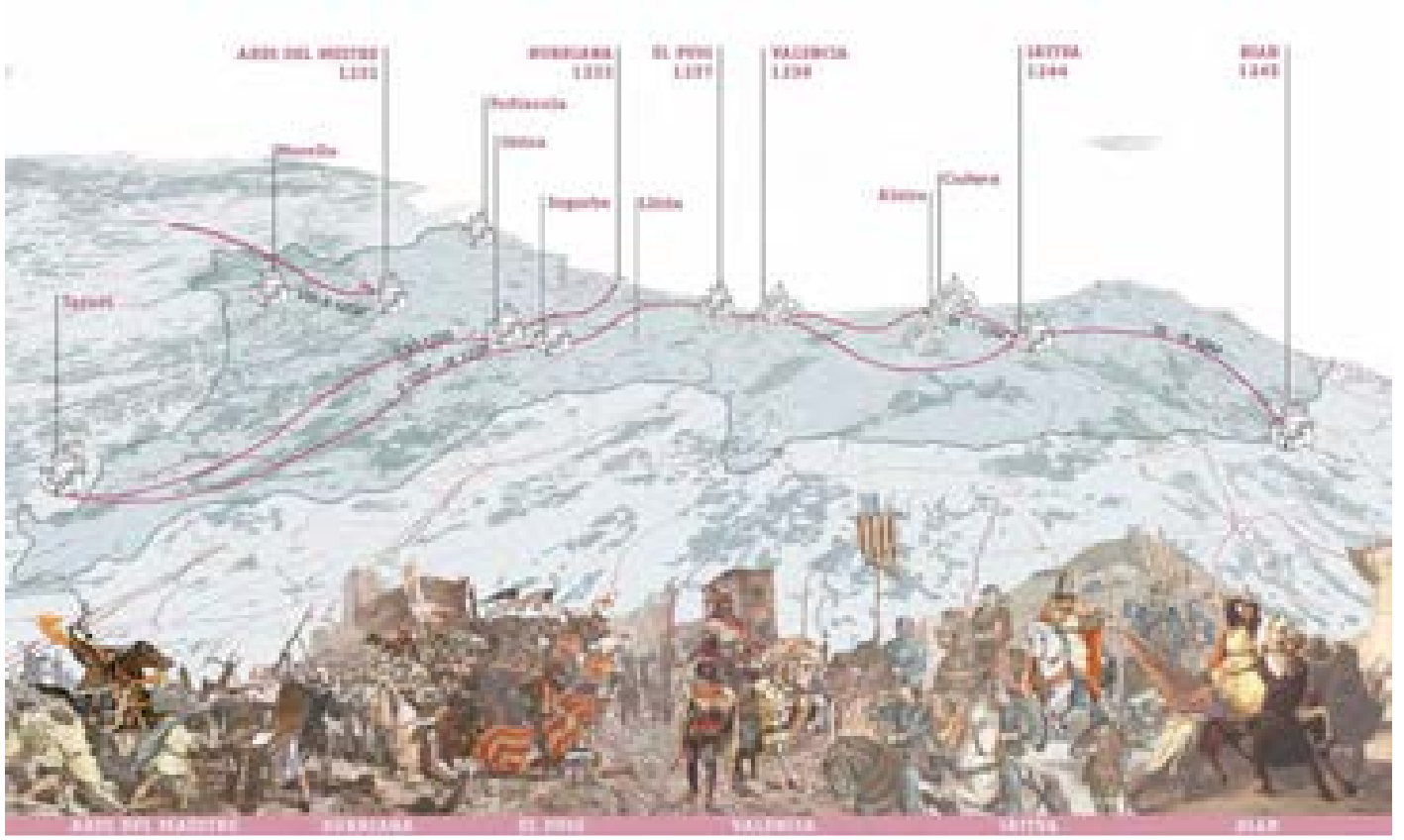


Fig. 06
Conquest of Valencian Kingdom
Routes followed by James I in 1233, 1235 and 1238. (Drawing credit: Alberto Pettineo)

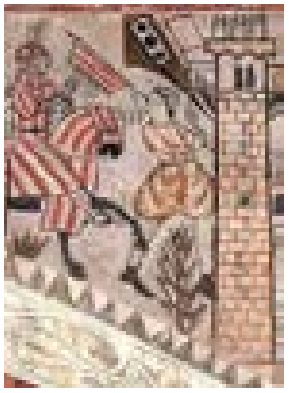


Fig. 07
James I enters Valencia
Fresco in the Castle-Convent of the Knights of Calatrava, Alcañiz.

arches of one of its rooms, where you can see the king's knights and James I himself besieging and taking the city of Valencia. In 1226 the Mallorcan Almohads captured two Aragonese commercial ships, which has traditionally been assumed to be the trigger for the conquest of Mallorca. Madina Mayurqa was conquered on December 31, 1229 [9]. The king of Valencia, Saiyid Abu Zayd, aware of the conquest intentions of James I, declared himself a tributary, concluding the pact in 1226. From that moment the Muslim governor was at the service of the expansionist policy of James I[10]. The conquest was not immediate. Initially, the castles and towns of Jérica, Viver, Segorbe and Torres Torres were conquered until reaching some hills near Sagunto. Later, the castles of Morella, Cervera and Chivert were taken, until reaching Peñíscola. From here they conquered the coastal towns until they reached Burriana in 1233, being the first place they took from the kingdom of Valencia[11]. He was 25 years old. It would be 5 years before he conquered the city of Valencia. All the castles and towns conquered were donated as a sign of gratitude to the knights and Military Orders that accompanied him in the conquest. These donations had a double strategic meaning: the king was exempt from maintaining the conquered places, given his meager income, and, furthermore, these donations served to encourage new conquests. Important border posts were often granted to the Military Orders, mostly of the Temple and Saint John of Jerusalem, a very opportune tactic to keep the border protected and well defended.

[9] Flotats, Bofarull (1848), *cit.*
[10] Sanchis i Guarner (1965), *cit.*
[11] Gual Camarena (1949), *Reconquista de la zona castellonense*.

Fig. 08
The King victoriously enters in the city of Valencia
Painting from the late 19th century by Fernando Richart Montesinos (*Museu de Belles Arts de Castelló*). Graphic reworking from the Wikimedia Commons image, public domain.

After the capture of Burriana in the north, they advanced to the conquest of Alzira and Cullera in the south without fighting in many of the farms they were passing through, since most of them surrendered in advance. Finally they settled in the so-called Puig de la Cebolla (Puzol), 19 km from Valencia, while the siege of Valencia lasted.

The taking of Valencia took place when the main towns and castles around it had already been conquered. This strategy helped the Saracen King Zaen surrender the city without a battle. The conquest of Valencia would have been more costly and violent without the strategic and military capacity of King James. The city was surrendered on September 29, 1238 and the armies entered the city on October 9, leaving twenty days of margin so that the Saracens who wished could abandon the city with all their belongings[12]. He donated to the Order of the Temple and the Saint John of Jerusalem and palaces located next to the two main gates of the city so that the defense would be assured.

Muslims who wished to do so remained in the city, forming a neighborhood specifically designated for them. The Jews also had an aljama. In both cases their uses and customs were respected, reflecting a policy of tolerance on the part of the Christian monarch.

The conquest of the kingdom of Valencia introduced into the conquered territory a new feudal political organisation similar to that existing in the Christian kingdoms. Muslim society had been, until then, a "lordless" society, with paid officials (alcaydes) in command of the most important fortresses[13].

[12] Flotats, Bofarull (1848), *cit.*
[13] Guichard, Bazzana (1980), *La sociedad musulmana valenciana en vísperas de la conquista de Valencia.*

Fig. 09
The Conquest of Mallorca
Fresco from the Palace of Aguilar and conserved in the National Art Museum of Catalonia in Barcelona. Graphic reworking from the Wikimedia Commons image, public domain.

The feudal system brought with it changes in the economic organisation, in the structuring of the territory and in customs, in addition to the obvious changes in language and religion.

There were also legislative changes. At the beginning of the conquest, James I improvised laws and regulations to solve military and repopulation problems. He initially used the Fuero of Zaragoza for the northern geographical areas that were first conquered. Once Valencia was conquered, he took new measures, thus creating the Fueros and Customs of the kingdom of Valencia[14]. These Fueros were sworn by the king in 1261, constituting the conquered territory as an independent kingdom belonging to the Crown of Aragon. The Fueros served as the legislative framework for the kingdom of Valencia until 1707 when they were abolished by King Felipe V.

The first measures implemented were aimed at strengthening Christianity and repopulating the city of Valencia: He handed over to the archbishop of Tarragona all the existing churches and mosques in the city to start the Valencian diocese and made donations of houses, rahales, workshops and lands to the knights and people who helped him in the conquest, to promote the repopulation of urban centers. The census is recorded in the *Llibre del Repartiment*[15]. Likewise, he freed the city's residents from taxes; He granted a license to transport construction materials, and handed over all the city's irrigation ditches to facilitate irrigation day and night. He granted Jews who wanted to be able to settle in Valencia while maintaining their traditions and customs. All the measures taken are included in the Book of Privileges[16]. These provisions led to a population change, with the replacement of the bulk of the Almohad population, based on a continued demographic contribution from the Christian areas of the Aragonese Crown. The important cities and richest or most strategic agricultural areas were distributed directly by the king among those who had collaborated in the conquest according to their social condition and degree of merit[17].

Side page, Fig. 10
The Valencian Territory: past and present
Left: The Kingdom of Valencia at the time of James I illustrated through territorial expansion (1233 to 1245).
Right: Administrative divisions of the present-day Valencian Community overlaid with the conquests of James I.
Today's borders have remained almost unchanged.

[14] García i Sanz (1979), *Els Furs*.
[15] Ferrando i Francés (1979), *Llibre del Repartiment*.
[16] García Edó (1988), *El Llibre dels Privilegis*.
[17] Cabanes Pecourt (1977), *El "Repartiment" de la ciudad de valencia*.

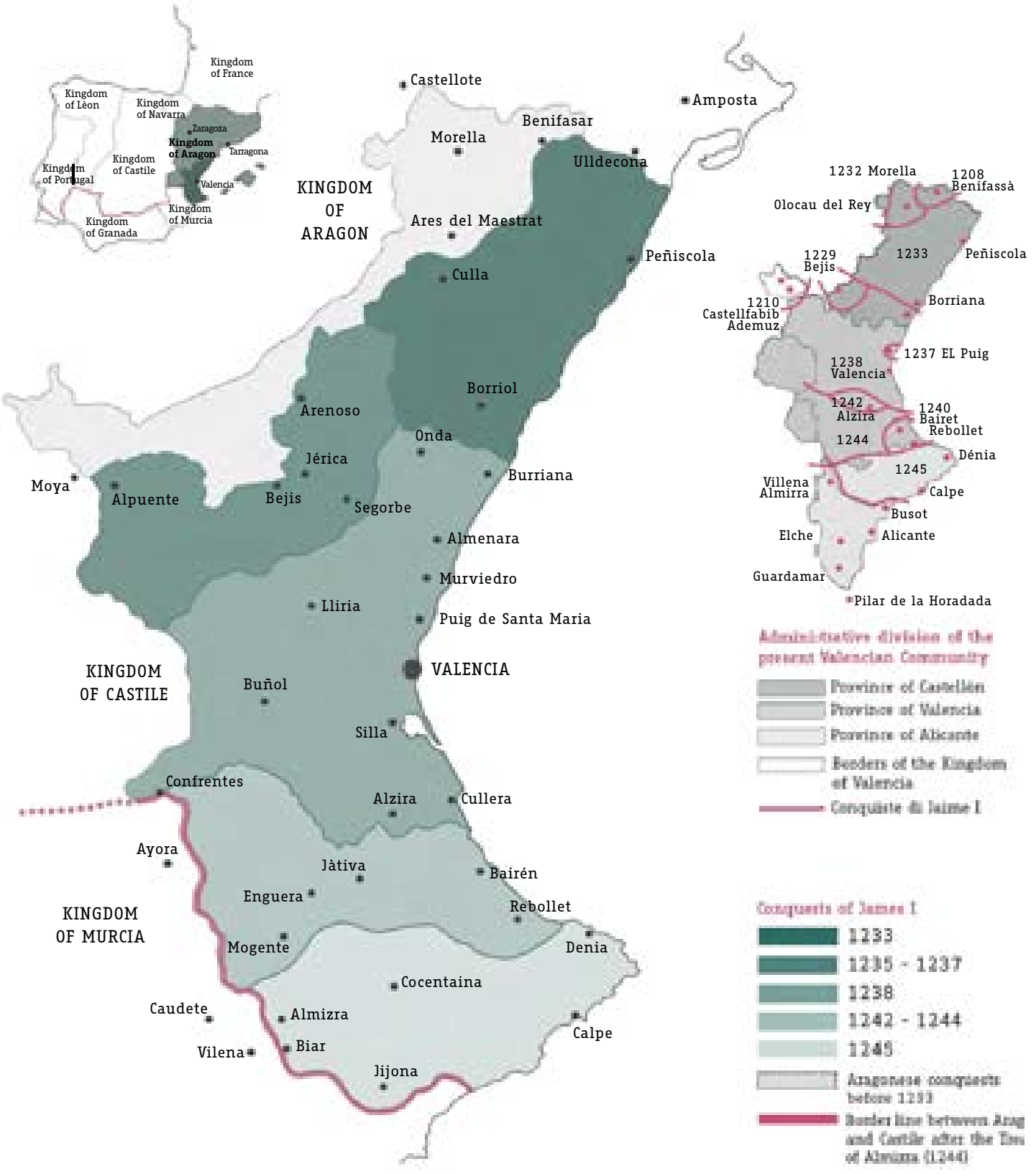

Kingdom of France
Kingdom of Lèon
Kingdom of Navarra
Zaragoza
Kingdom of Aragon
Tarragona
Kingdom of Portugal
Kingdom of Castile
Valencia
Kingdom of Murcia
Kingdom of Granada
KINGDOM OF ARAGON
Castellote
Amposta
Morella
Benifasar
Ulldecona
Ares del Maestrat
Peñiscola
Culla
Borriol
Arenoso
Onda
Jérica
Burriana
Moya
Alpuente
Bejis
Segorbe
Almenara
Murviedro
Lliria
Puig de Santa Maria
VALENCIA
KINGDOM OF CASTILE
Buñol
Silla
Confrentes
Alzira
Cullera
Ayora
Jàtiva
Bairén
Enguera
Rebollet
KINGDOM OF MURCIA
Mogente
Denia
Cocentaina
Caudete
Almizra
Calpe
Vilena
Biar
Jijona
1232 Morella
1208 Benifassà
Olocau del Rey
1229 Bejis
1233
Peñiscola
1210 Castellfabib Ademuz
Borriana
1237 EL Puig
1238 Valencia
1242 Alzira
1240 Bairet Rebollet
1244
Dénia
1245
Villena Almirra
Calpe
Busot
Elche
Alicante
Guardamar
Pilar de la Horadada
Administrative division of the present Valencian Community
Province of Castellón
Province of Valencia
Province of Alicante
Borders of the Kingdom of Valencia
Conquiste di Iaime I
Conquests of James I
1233
1235 - 1237
1238
1242 - 1244
1245
Aragonese conquests before 1233
Border line between Arag and Castile after the Treaty of Almizra (1244)

Fig. 11
The tomb of the House of Aragon
Located in the Monastery of Poblet, inside rest the mortal remains of King James I.

Also in rural areas there was a massive repopulation of Christians in response to the great concern of James I to transform the recently conquered lands into Christian territories. The legal instrument that expedited the process was the so-called "Puebla Letters" in which lay or ecclesiastical lords offered great tax advantages and even donations of houses and land to groups of Christian settlers who settled there. The first densely repopulated area was in the Maestrazgo[18]. Among the royal donations to the church, it is worth highlighting the repopulation work to the Cistercian Order. That is why their monastic settlements were located in the Upper Mark, a border location.

After the conquest of Valencia, King James I undertook the conquest of the taifas of Denia and Murcia. He was the monarch who conquered the most territories from the Muslims, becoming king of Aragón, Valencia, Mallorca, Denia, Murcia, Count of Barcelona and Urgell, Count of Rossellón and Cerdanya, lord of Montpellier and Viscount of Fenolleda. James I died in 1276, leaving an extensive conquered territory in which the Kingdom of Valencia was consolidated as a Christian kingdom, belonging to the Crown of Aragón. His body rests in the Monastery of Poblet (Tarragona) along with other great kings of the Aragonese Crown. The Kingdom of Valencia maintained its legislative independence until 1707 and the name until 1833, when the territorial division by provinces took place.

[18] Guichard (1977), La rrepoblación y la condición de los musulmanes, pp. 43-82.

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RELIGIOUS ARCHITECTURES

1_ **Church of the Blood,** Iglesia de la Sangre, Llíria. 39.6258333, -0.5941666.

2_ **Basilica of Saint James the Apostle,** Basílica de San Jaime Apóstol, Algemesi. 39.1889105, -0.436509.

3_ **Church of Saint John of the Hospital**, Iglesia de San Juan del Hospital, Valencia. 39.4743215, -0.3730151.

4_ **Monastery and Church of Santa Maria**, Monasterio y Iglesia de Santa María, El Puig. 39.5891447, -0.3037397.

5_ **Monastery of Santa María de la Valldigna**, Monasterio de Santa María de la Valldigna, Simat de la Valldigna. 39.0426639, -0.3051000.

6_ **Monastery of Sant Jeroni de Cotalba**, Monasterio de San Jerónimo de Cotalba, Alfauir. 38.9406556, -0.2461444.

7_ **Church of Santa Caterina**, Iglesia de Santa Catalina, Alcira. 39.1516500, 0.4408166.

8_ **Covered Cross of Alzira**, Cruz cubierta de Alcira, Alzira. 39.1685111, -0.4452277.

9_ **Covered Cross of Almassera**, Cruz cubierta de Almàssera, Almassera. 39.512225, -0.3634416.

10_ **Covered Cross of Mislata**, Cruz cubierta de Mislata, Mislata (Valencia). 39.4727889, -0.4094694.

11_ **Covered Cross of S. Vicente Street**, Cruz cubierta de San Vicente, Valencia. 39.4479833, -0.3857527.

12_ **Covered Cross of Jérica**, Cruz cubierta de Jéerica, Jérica. 39.8984861, -0.5564138.

CASTLES AND FORTIFIED SYSTEMS

13_ **City Walls of Alzira and House of James I**, Murallas de Alcira y Casa de Jaime I, Alzira. 39.1526361, -0.4435861.

14_ **Ruins of Puig Castle**, Ruinas del Castillo del Puig, El Puig de Santa Maria. 39.5910028, -0.304875.

15_ **Castle of Benissanó**, Castillo de Benisanó, Benissanó. 39.6258333, -0.5941666.

16_ **Castle of Cullera**, Castillo de Cullera, Cullera. 39.1659333, -0.2497222.

17_ **Castle of Almonecir**, Castillo de Almonecir, Vall de Almonacid. 39.9046000, -0.4469166.

18_ **Castle of Morella**, Castillo de Morella, Morella. 40.6198056, -0.1019583.

PLACES AND EVENTS OF THE ROUTE LINKED TO JAMES I
THE DEFINITION OF SITES

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Despite Valencia being a city founded in Roman times (138 B.C.) and serving as the capital (cap i casal) of a territory of approximately 23,000 square kilometers that bears its name in eastern Spain, its essence cannot be fully grasped without the presence of James I. He, after the Reconquista in 1238, granted special laws to the entire region and bestowed upon it the title of the Kingdom of Valencia. Thus, Valencia transcends being just the name of a city. The influence of a king with such a libertarian and modern vision solidified a distinct culture.

Even though the abolition of the rights ("Furs") occurred in 1707 following the Decree of New Plant issued by the Bourbon King Philip V after the Valencians' defeat in the Battle of Almansa, in 1982, the Autonomy Statute was established, and the region became known as the Valencian Community. However, the historical organisation of the Valencian people as the Kingdom of Valencia remains evident, preserving the same culture promoted by James I. To this day, the authentic historical sentiment in Valencia views the Bourbon monarchy as the one that abolished their rights, granted five hundred years earlier, including their own language (Valencian). The Museum of Xàtiva even displays a portrait of Philip V upside down, symbolising his role in the burning of the city for supporting his opponent (Archduke Charles) and renaming it San Felipe.

James I of Aragon, inheriting significant lineages from the House of Aragon and the emperors of Byzantium, the latter through his mother. He was the king of Aragon, Valencia, and Mallorca, count of Barcelona, count of Urgell, lord of Montpellier, and other fiefs in Occitania. Among his notable conquests are the Balearic Islands, Murcia, and Valencia, the latter supported by the Order of St. John of the Hospital. What James I established and had significant importance was the normalization of law and the transformation of the Courts into a representative body of the kingdom's will, the dictation of the Llibre dels Feits (the chronicles of King James I)[1], the promotion of trade and North African policy including the drafting of the Llibre del Consolat del Mar, and the refinement of the Tribunal de las Aguas (Intangible Cultural Heritage of Humanity), the oldest existing justice institution in Europe, which can be witnessed every Thursday at 12:00 at the Gothic door of the Cathedral of Valencia.

If we consider its cultural heritage over these eight centuries, there is a multitude of buildings and architectural typologies that have constructively evolved their techniques, in addition to functionality.

Side page, Fig. 01
The sites part of James I Route
Identified sites for the study and catalogued from a typological point of view.

Fig. 02
The reverted King
Detail of the portrait of Philip V de Bourbon by Josep Amorós, 1719 (Almodí Museum Xàtiva). The painting is displayed upside down as the king was guilty of burning the city in 1707. Graphic reworking from the Wikimedia Commons image, public domain.

[1] Vinas, Vinas (2008), *Llibre dels fets de James el Conqueridor*, (critical edition of the original 1343 manuscript).

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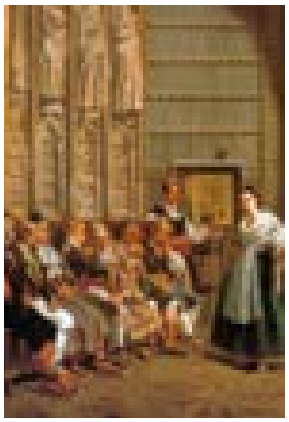

Fig. 03
Tribunal de les Aigües de Valencia
Fragment from Bernardo Ferrándiz, 1865 (Palau de la Generalitat, Valencia). Graphic reworking from the Wikimedia Commons image, public domain.

Fig. 04
The Battle of Almansa
Fragment from Ventura Lirios and Filippo Pallotta, 1709, (Prado Museum, Madrid). Graphic reworking from the Wikimedia Commons image, public domain.

Organisation of survey activities and operational methodology

Having established the lack of the only official source on the cultural route associated with James I, defining an authentic route where King James I traveled would be a challenging task. It's worth remembering that he was born in Montpellier (France), moved indiscriminately throughout the Crown of Aragon, including Valencia, and experienced failures in his expeditions to the Holy Land during the Crusade, landing in one of them in Aigües-Mortes near Montpellier. There is even uncertainty about the place of his death, with disputes between Valencia and Alzira. Only in Valencian territory, according to the Ruta Cultural James I the consideration involves 129 towns or municipalities.

However, in the Llibre dels Feits, James I does establish his personal vision of his conquests, which could serve to define the route of the conquests and the creation of the Kingdoms of Valencia and Mallorca. This could even be defined as the "Ruta dels Feits," opening upw a potential path in this European research project. Following this working hypothesis, examples from other routes, such as the Camino de Santiago, the quintessential European route, can be followed. This involves planning accommodations and other cultural and gastronomic alternatives. Therefore, in the obligatory reflection after each step in research is when ideas mature and concepts settle as different aspects and ideas interrelate, giving rise to new ideas and proposals. The Route, as it has been defined, is not a linear path, but follows and is connected to the morphology of the Valencian territory, retracing the emblematic places of the province's history, which bear witness to the conquest of the territory by James I. Starting from the definition of the sites, several monuments were selected for more in-depth documentation, with field survey activities organised at different times. In particular, an extensive

survey campaign was conducted in July and August 2022, followed by a phase of site implementation and bibliographic research in May 2023, and concluding with the completion of the survey activities in August 2023. This work flowed, in some cases, into Summer Schools and International Workshops jointly organised by the Polytechnic University of Valencia and the University of Pavia[2].

The survey activities took place in different phases and the work schedule was coordinated with the permissions obtained from the monument owners, both public and private, allowing the team to document several buildings over the course of the missions.

It is worth noting the complexity of establishing a versatile work schedule, i.e., being able to make changes to itineraries, and this was made possible thanks to the cooperation of the owners. In some cases, these are buildings with opening hours for the public, and during those hours, the team partially closed off the area to obtain the data properly. In other cases, full access was granted to the monument.

The documentation activities were carried out using digital survey equipment such as laser scanners, DSLR cameras and drones, under the constant supervision of a coordinator.

Selected Case studies

There was some complexity in deciding which buildings to analyse, as the goal was to document the maximum number of buildings related to the Route in a relatively short time.It's important to keep in mind that this was a digital construction in order to subsequently open different paths and levels: at the tourist, constructive, etc., levels. In this listing and for this first phase, no building from the city of Valencia was chosen because, a priori, they are well-studied or part of another research project, such as the case of the Cathedral[3] or the church of San Juan del Hospital[4], the main religious buildings of the medieval period. In other phases, an exhaustive list should be made, and the most representative ones of their typology should be chosen to form the idealised example, such as the palace of the Admiral.

For this initial approach to defining a route of James I and the digital representation of its monuments, the project has been based on digitally constructing a series of representative buildings of their existing typologies. Among these typologies, we basically have religious or defensive (strategic) buildings, as well as various construction typologies solely associated with this historical period, highlighting techniques such as earth rammed-wall or polychrome *alfarjes* (wooden coffered ceiling) in the execution of floor structures. Outside of these architectural typologies, there are also other architectural elements, such as covered crosses, which serve as landmarks to delimit the populations. In fact, during the celebration of San Vicente Mártir, the patron saint of the city of Valencia, it is said that the festivity is only "inside the crosses".

[2] In parallel with the main field survey campaigns, two summer schools were organised in July 2022 and July 2023, as well as several didactic workshops on the topic of documentation of the James I's Route.
[3] Cortés Meseguer (2014), *La construcción del proyecto neoclásico de la catedral de Valencia*.
[4] *Ibidem*.

Fig. 05
Signs and signifiers
Features and peculiarities of architectural heritage associated with the Route of James I.

Religious Architecture

The documentation and survey of churches covered all the three Valencian Gothic types. In particular, more detailed studies were conducted on the *Reconquest church* and the *Hall-type church*[5], more closely associated with the time of James I. Examples of the *Languedocian-Catalan type*, the third typology of Gothic churches, such as San Juan del Hospital in Valencia, are analysed in less depth. On the other hand, although there are different typologies of convents, monasteries, or charterhouses, only the most significant in the Valencian lands according to the Autonomy Statute (2020) has been surveyed. Also included within the religious complexes were the Cruz Cubiertas and the Cruz de Termino, although their function was mainly that of demarcating boundaries and signaling routes, they hold a profound religious significance of delimiting Christian territories. The religious buildings and complexes under study within the project are:

- Church of San Juan de l'Hospital in Valencia was founded by the Hospitaller Order after the conquest of the city in 1238, on land granted by King James I. The church, dates from the 13th century and follows the pattern of the Valencian Gothic churches of the Reconquista, although some classify it as late Romanesque or early Gothic. The original complex included a church, a hospital, a cemetery, a chapel in honor of James I, and housing for members of the order. The church has a single nave and side chapels separated by buttresses.
- Church of the Blood: Reconquest churches are the simplest example and arise from the need to have Christian places of worship during the period of reconquest by James I. They are single-naved with a rectangular plan and are constructed with diaphragm arches shaping the two slopes and covered with wooden framework. In this case the Church preserves a magnificent polychrome wooden coffered ceiling[6].

[5] Magro Moro, Marín Sánchez (1999), *La construcción en la baja edad media.*
[6] Zaragoza Catalán (2004), *Arquitectura gótica valenciana: siglos XIII-XV.*

• The Church of Sant James, located in the center of Algemesí, is a basilica building with a wide nave and chapels alternated by buttresses. Inside are remains of the ancient church dating back to the Reconquista. The original temple, probably the present chapel, dates from the 13th century and was built during the conquest by King James I. The chapel, Gothic in style, reflects the architecture of the Reconquista. Later, over the remains of the old church, the communion chapel was built, which retains elements of the original building.

• The Church of Santa Catalina in Alzira is an important religious building dating back to the 13th century, constructed after the Christian conquest of the city. Originally Gothic in style, it has been modified over time with Baroque influences. The church is dedicated to Saint Catherine of Alexandria and is known for its impressive façade and richly detailed interior. Some Gothic elements remain, such as buttresses, arch remnants, pointed arches, oculus, main chapel, and bell tower.

• Church of Santa María del Puig: El Puig was the place from where James I planned the entry to Valencia in 1238, subsequently ordering the construction of a monastery. The church is associated with the miraculous discovery of the image of the Virgin of El Puig by King James I and Saint Peter Nolasco, founder and grand master of the Order of Mercy[7]. The church has a hall-type plan, and its construction resembles that of the Valencia Cathedral.

• Monastery of Santa María de la Valldigna: This monastery originated from a concession by James II to the Cistercian Order of Santes Creus (Tarragona). Although it has undergone numerous modifications and additions over the centuries, with notable features such as the Baroque church or the chapter house (15th century)—commissioned by Abbot Rodrigo Borja, later Pope Alexander VI—it represents the quintessential Valencian monastery[8].

[7] Badenes Almenara (2009), *Jaime I y la Virgen del Puig*.
[8] Martínez García (1998), *Guía del Monasterio de Santa María de la Valldigna*.

Fig. 06
Religious complexes
Left, Portal of the Church of Santa Catalina in Alzira; top left, Monastery of Simat de La Valldigna; top bottom, bell tower of the Church of San Juan de Algemesi.

• The Monastery of Sant Jeroni de Cotalba, located near Gandia, built between the 14th and 18th centuries, shows influences from five architectural styles: Mudejar, Valencian Gothic, Renaissance, Baroque, and Neoclassical. The monastery stands on the remains of an Arab fortification, and the towers at the corners testify to the size of the original building. Some walls of the old city wall have been integrated into the monastery.

• The Cruz Cubiertas of Alzira and Jerica and the Cruz de Termino in the city of Valencia are examples of medieval constructions that were placed at village entrances and along roads as symbols of Christian devotion. Usually, these monumental stone crosses reached a height of between two and three meters, but in some cases they could exceed five or seven meters.

Castles, Palaces and Fortified Systems

In the buildings associated with a defense system, the residences of nobles or kings are also included, as they only had certain quarters for themselves within the entire castle. This section also include Palaces such as the House of James I in Alzira and Fortified Systems in a broader sense such the city boundary walls of Alzira and Cullera or stratified Fortress and Castles.

Fig. 07
The modern and the ancient
One of the towers of the defensive system of Cullera, now in dissonance with the new town.

• City boundary walls and the House of James I in Alzira: the city was granted to James I in 1243 after the Christian conquest of the Taifa of Balansiya. The first Christian settlement in Alzira was built on the foundations of a Muslim fortress after the expulsion of the Mudéjar following a revolt shortly after the conquest. Over time, the urban layout changed, affecting the preservation of the walls. Near the walls are the remains of the ancient palace used by King James I during his stays and of which only sections of the building remain today, including two large perpendicular walls.

• Castle of Vall de Almonecid: it represents an example of a fortress built in the 12th century by the Muslims, losing its military and administrative character some time later after being conquered by the Christians. It is located at the top of the valley to obtain a broad view of the territory and to have better defense.

• Castle of Benissanó: although built in the 15th century, this structure is a clear example of the evolution of the castle-palace, where the fortress and the lordly residence are combined. These constructions could not have arisen without the donation of lands by the king to his nobles. In this building, there are precious examples of architecture and also of construction elements, such as the technique of decorated gypsum vaults, with the Valencian territory having very few examples of this.

Fig. 09
Signs in the landscape
Towers of Morella fortified walls.

• Cullera Castle: although it has undergone numerous renovations throughout its more than a thousand years of history, it was a strategic landmark in the conquest of James I because it meant having total control of the Gulf of Valencia and overseeing the coastline of Cullera and the mouth of the Júcar River, which passes through Alzira and Sueca. In the 16th century, it served as a defense against the Berber pirates who ventured up the river.

• The Puig Castle, located on a hill overlooking the town of El Puig, is now a public park that still retains some sections of its walls and towers. Built by the Moors around the 11th century, it was captured by James I's forces in 1237. During their retreat, the Muslims destroyed the fortress to prevent James I from using it to conquer Valencia. It was later rebuilt by the conqueror, but in 1365, Peter IV of Aragon ordered its destruction.

• The Castle of Morella, is a fortress with a strategic position, using the rocky terrain for an expansive view. Construction began after Alfonso I's conquest in 1114 but was later looted and abandoned. It was restored in 1232 under Blasco de Aragón and then permanently occupied by James I. The castle features three circular levels. Despite damage from fires in the 19th century and subsequent restorations, it remains a significant historical and architectural landmark.

The conclusions of this initial phase of building along the Route of James I are very satisfactory, given that there is a convergence of aspects to consider in its preservation, enhancement, as well as in the dissemination of heritage. The first is that a considerable number of constructions can be carried out in a short period, also serving as an experience for other monuments and territories facing emergency situations, such as armed conflicts or natural disasters.

Side page, Fig. 08
Castles and defensive systems
Top, Morella Castle; bottom right, Benisano Castle and the remains of Puig Castle; left, fortified walls of Morella.

Fig. 10
The architectural legacy of James I and his time
Stylistic and constructive peculiarities.

It is also relevant that there is direct observation by experts in building/construction, allowing for an initial assessment of pathology or risks to the monument. Digitising monuments is important because it opens up a wide range of possibilities for work, ranging from fields like maintenance, conservation, to dissemination, for example. Once there is a database with all the buildings representing this route, conclusions can be drawn at another level, such as architectural and construction aspects: defining all building typologies, construction techniques, metric and geometric studies, etc., in addition to their evolution.

Finally, it represents the revaluation of the culture and history of a people with a figure who had a vision of freedom and modernity for his people in the midst of the Middle Ages, as well as promoting a cultural heritage route, the Route of James I.

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Religious Architectures
Places of worship and spiritual conversion

REGISTRATION AND DATA INTEGRATION
STRUCTURING OF MULTILEVEL DATABASES

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Side page, Fig. 01
Multisource Database
Integrated point cloud of St. Mary Church in the Monastery of Simat de la Valldigna.

Operations related to the structuring of 3D databases applied to the study and documentation of architectural heritage today rely on well-established methodological practices that use continuously evolving instrumentation[1]. The implementation and management of databases are not limited to defining the structure of a vast data system within a more or less complex context. More specifically, it involves a cognitive filter through which it becomes possible to read and interpret the architecture of objects and space[2].

In the research for expressive languages applicable to the Cultural Route in a broader sense, the graphic product emerges as an expressive vehicle for information, redefining the relationship between "sign and meaning" in the digital dimension[3]. Technological progress and the push toward digitisation have shifted all forms of documentation systems within the cultural heritage field toward the creation of digital platforms[4]. These interfaces gather descriptive tools useful for the development of new methodological protocols applicable to the management of heterogeneous information. Similarly, the science of architectural surveying, in all its variations, from the survey of historical buildings to the urban landscape, has embarked on an innovative path aimed at creating digital environments structured as point clouds and three-dimensional models, conceived as databases of spatial coordinates. This transformation from spatial data to digital code does not end with mere acquisition but involves a process of elaboration, structuring, and information management, aimed at ensuring the usability, interoperability, and long-term preservation of such complex data.

The structuring of digital databases within the context of James I's Route

One of the aims within the project actions was to establish protocols for acquiring data that are replicable, with a focus in developing descriptive three-dimensional models and information systems for connecting architectural objects. In this regard, particular attention was given to the survey activities

[1] Moyano et al. (2022), *Operability of point cloud data in an architectural heritage information model*; Vital, Sylaiou (2022), *Digital survey: How it can change the way we perceive and understand heritage sites*.
[2] Parrinello (2019), *Preserving memory through image: landscapes and digital databases for documentation*, pp. 18-33.
[3] Parrinello (2023), *Documentare una rotta culturale tra procedure di rappresentazionee di materializzazione del paesaggio*, pp. 1806-1823.
[4] On the development of information platforms and data organisation for the structuring of information encoding systems, cf. *ex multis*: Parrinello, Porcheddu (2022), *Sistemi informativi dinamici a supporto della documentazione archeologica per interventi in emergenza*, pp. 48-65; Soler, Melero, Luzón (2017), *A complete 3D information system for cultural heritage documentation*, pp. 49-57.

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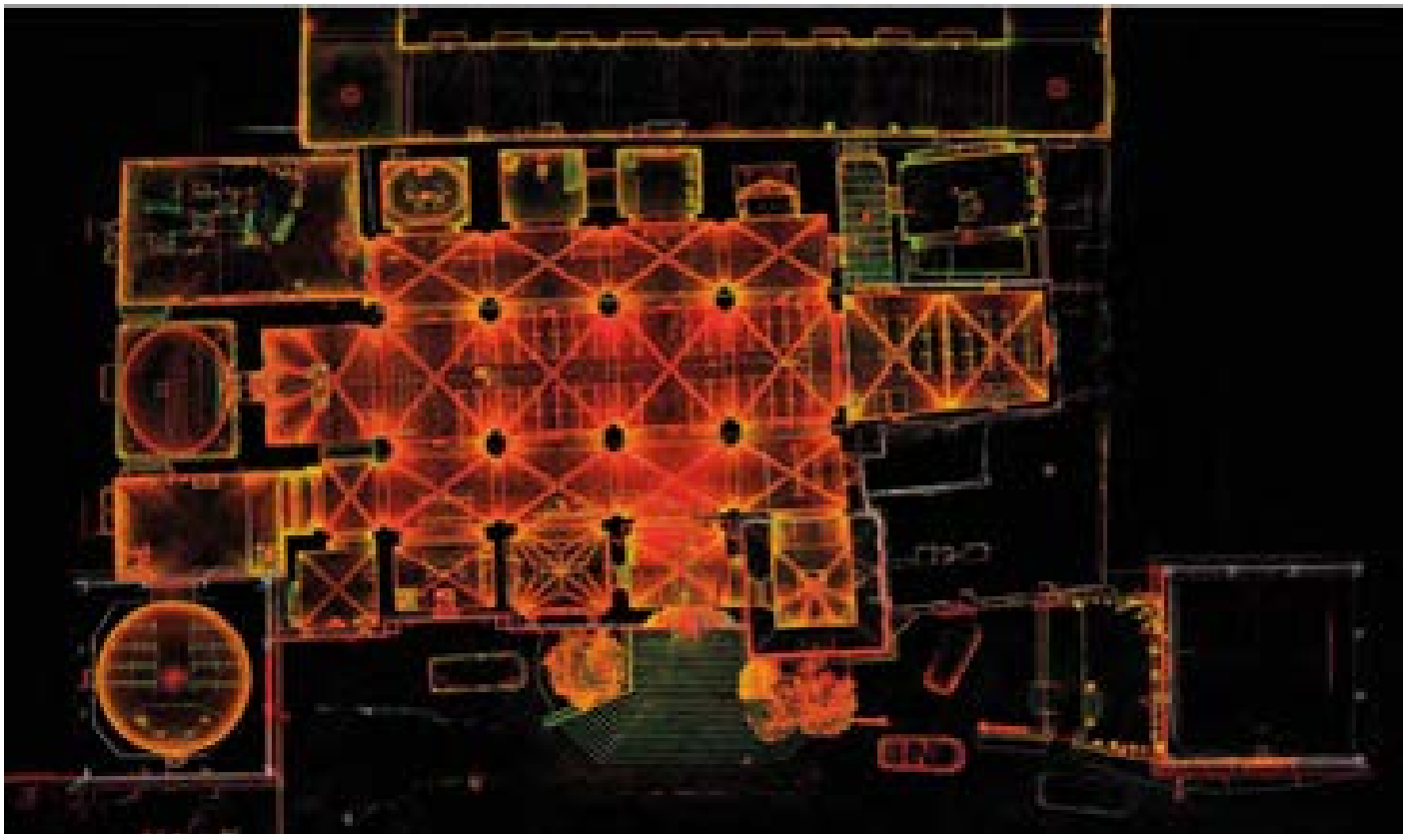


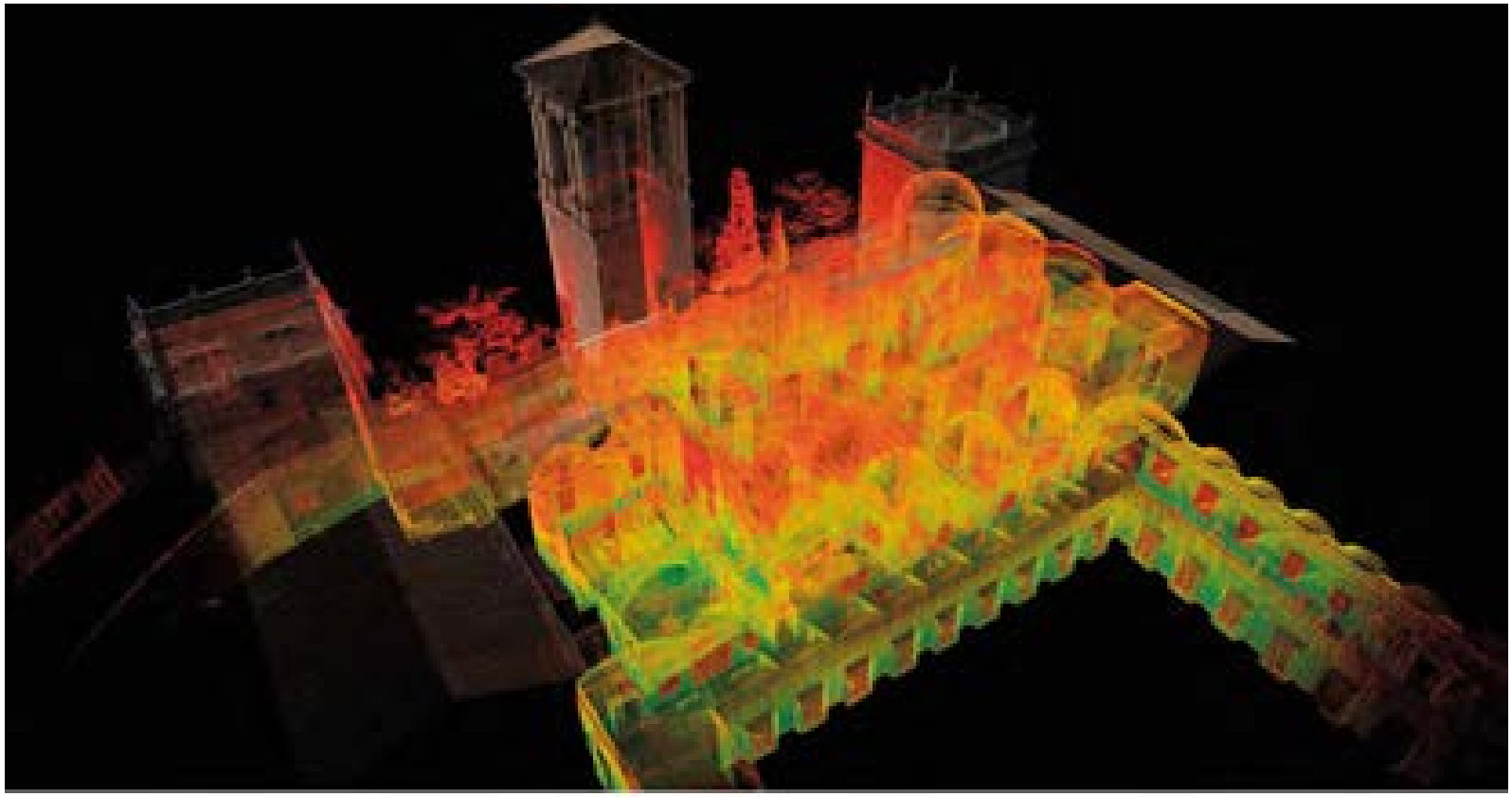
Fig. 02
Inside the building's limbs
Planimetric view of St.Mary Church inside the Monastery of Puig.

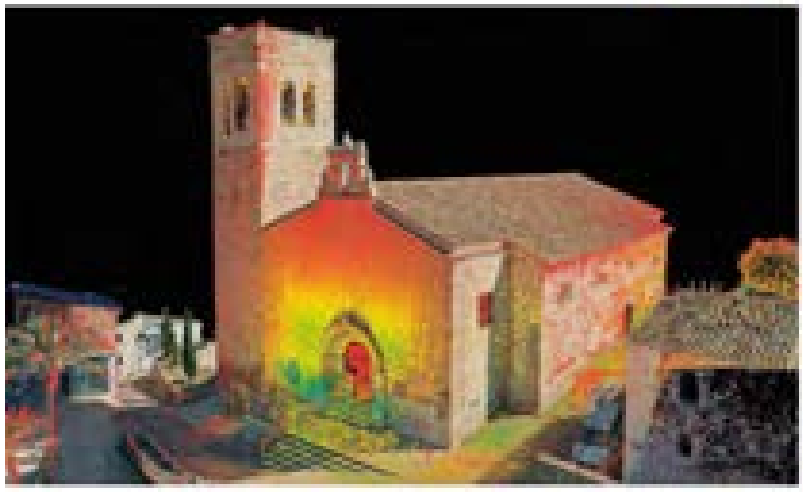
necessary for structuring multi-scale digital databases. The databases were used both as investigative tools for the morphometric understanding of the sites and as essential elements for creating digital outputs that describe the architectural heritage of the James I Cultural Route. In particular, the project actions involved experimenting with fast-survey methodologies through the combined application of *image-based* and *range-based* instrumentation, whose data, appropriately integrated, contributed to the production of multi-scale 3D databases, ranging from the architectural element to the building and up to the complex system of relationships at a territorial scale[5].

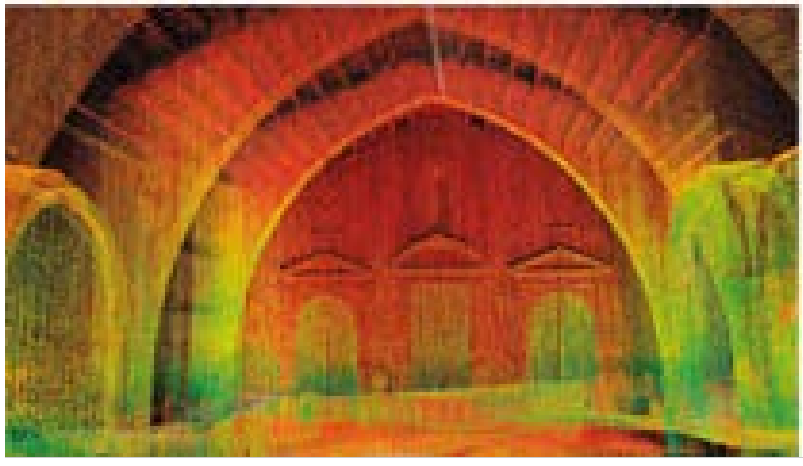
A significant area of experimentation that influenced the development of digital surveying methodologies, inside the project, was religious complexes[6]. In order to comprehensively document the heterogeneous characteristics and expressive richness of these architectures, the definition of surveying operations followed a protocol outlined in its general lines, but applied with different nuances for each case study analysed. The tangible differences in the characteristics of the analysed religious complexes, related to the varying focus on specific themes and the acquisition timelines defined during the planning phase, led to the establishment of surveying campaigns where photogrammetry techniques predominated, integrated, depending on the case study, with mobile and/or terrestrial laser scanner instruments.

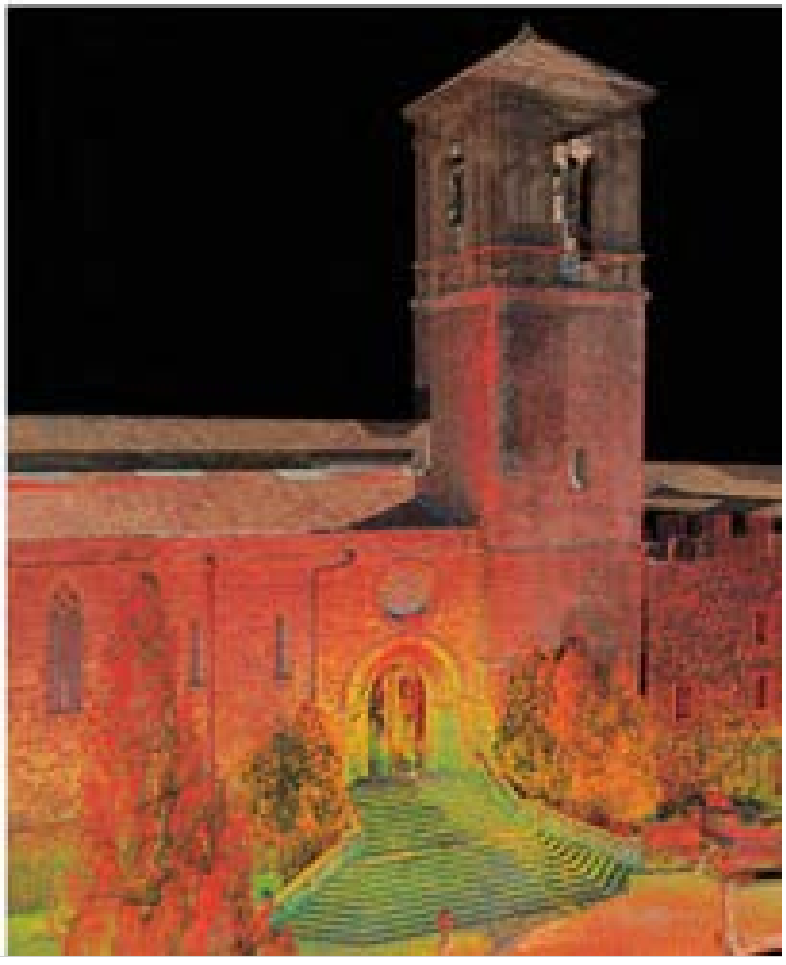
Side page, Fig. 03
Religious Complex 3D database
Examples of multi-source databases from selected case studies along the Route.
Top and bottom right: Church of the Monastery of Puig.
Bottom left: Church de la Sangre (Llíria), exterior view and interior nave.

[5] Parrinello, Picchio (2023), *Digital strategies to enhance cultural heritage routes: from integrated survey to digital twins of different European architectural scenarios*.
[6] The development of databases related to the second area of interest of the route, the fortified heritage, has followed, in its general definition, the methodology proposed here for religious architectures.









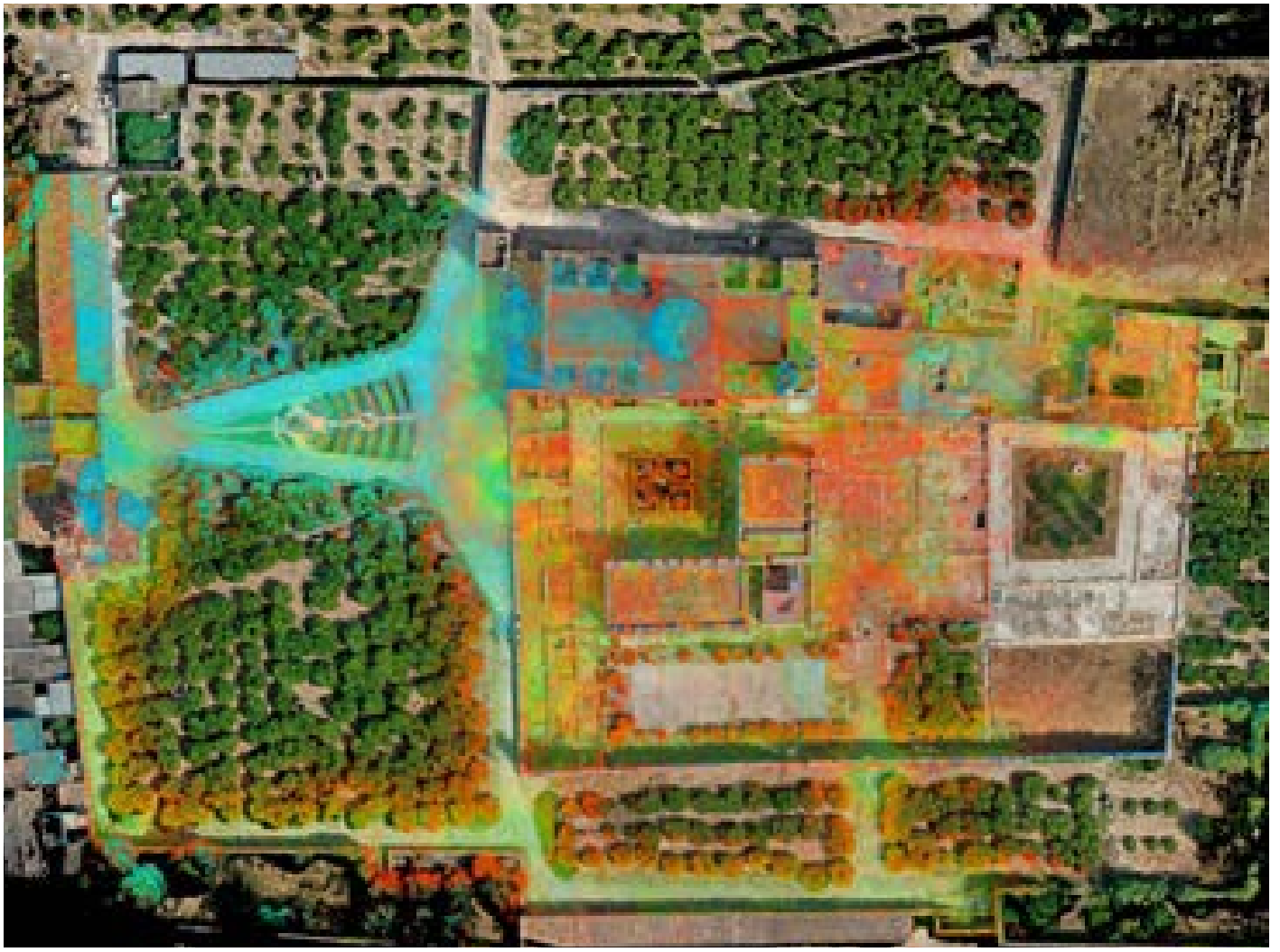


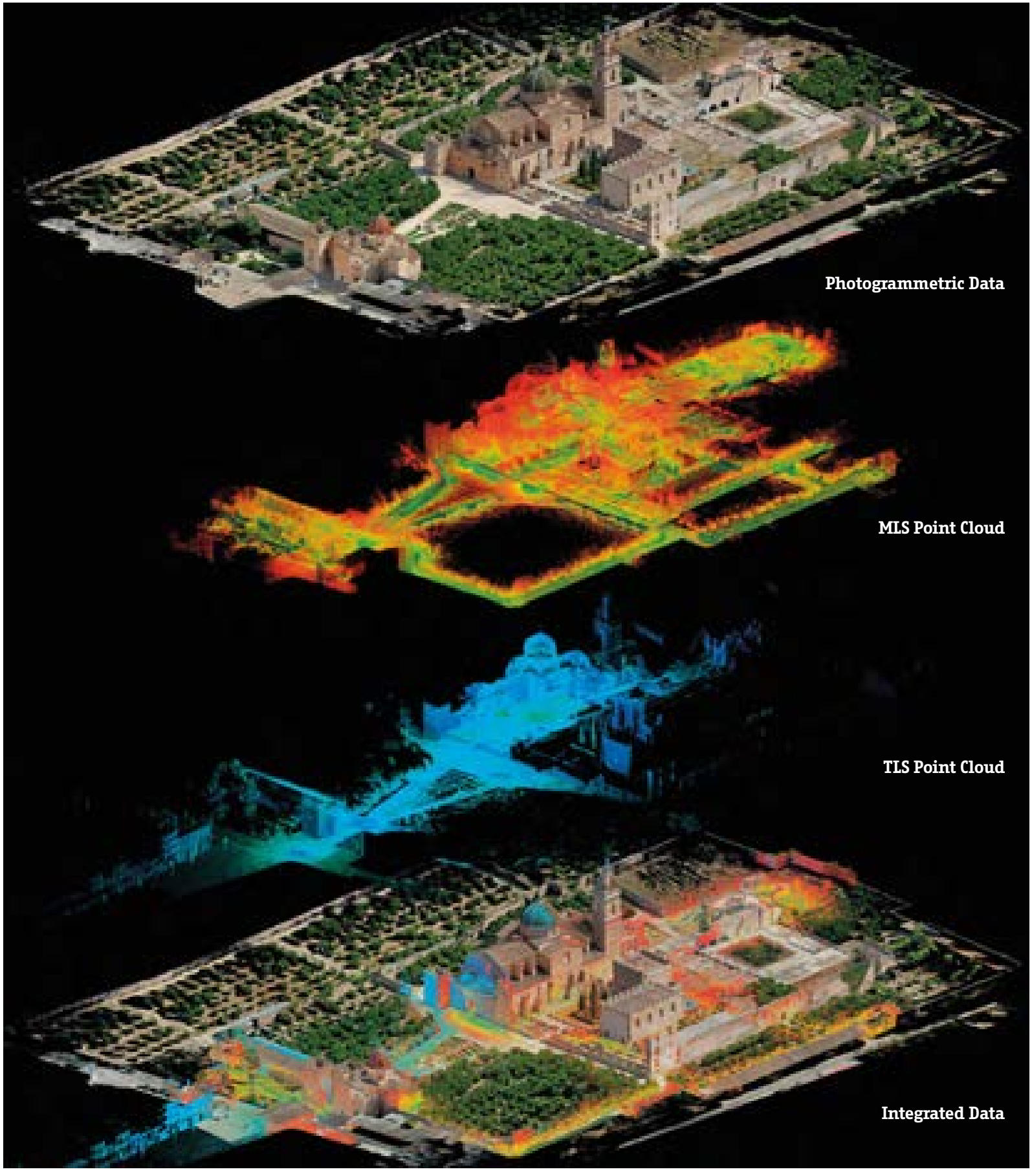
Fig. 04
Broad ensembles
Planimetric view of the point cloud of simat de la valldigna monastery.

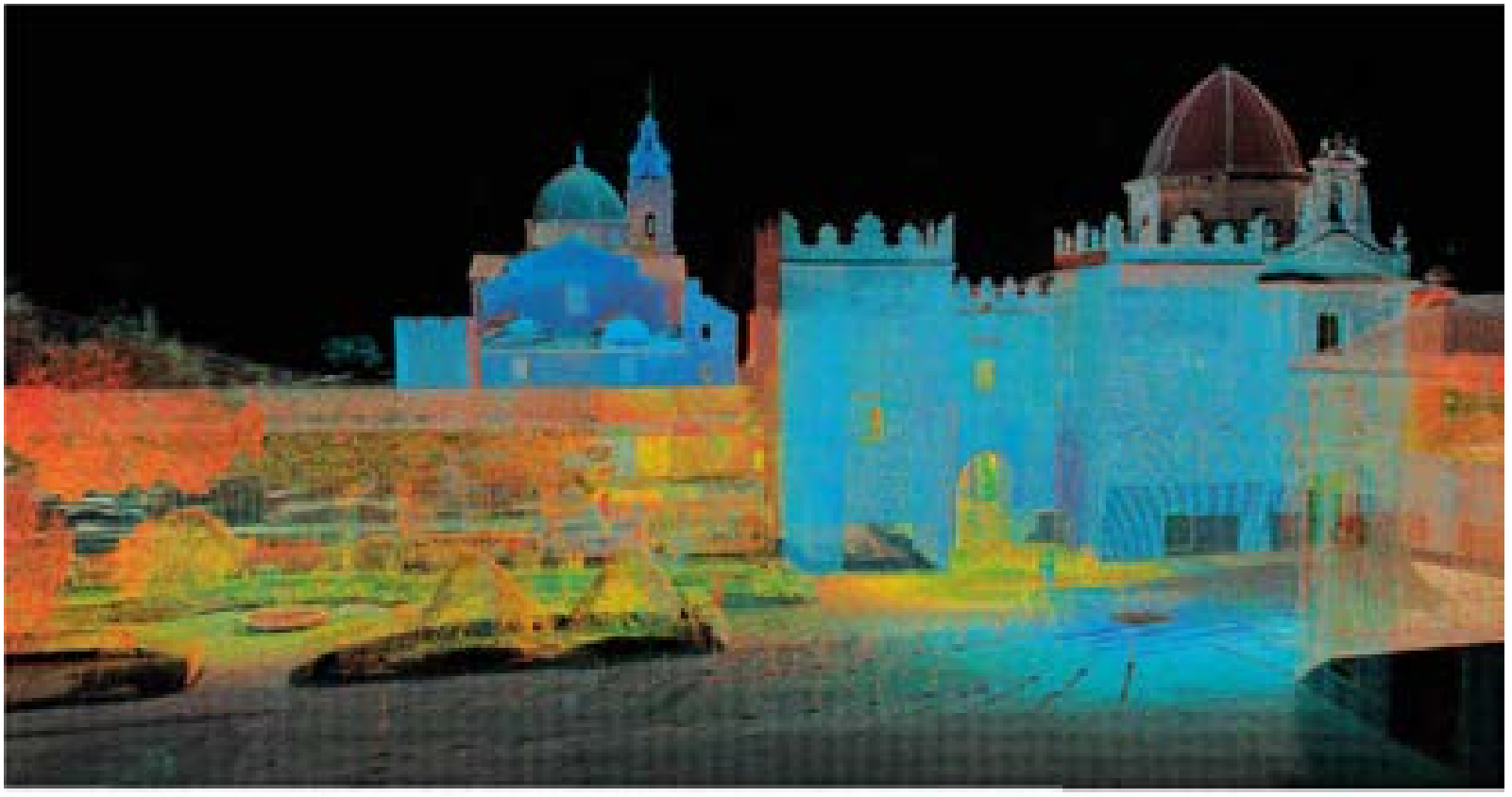
Side page, Fig. 05
Survey data integration
Axonometric diagram of the monastery's integrated database.

The varying levels of detail defined and the need to work within limited timeframes led to the creation of databases with different resolutions and detail levels. For case studies such as the Iglesia de la Sangre and the Church of Santa Maria del Puig, the photogrammetric acquisition was complemented by mobile laser surveying to ensure the morphological accuracy of the ensemble.

In other cases, such as the Cruz de Termino and the decorative elements of the Church of San James Apostol (Algemesi), photogrammetry was the predominant and, in some cases, exclusive tool for surveying operations. In these instances, the quality of the acquired images and the consolidated methodologies of photogrammetric survey[7], both on the ground and at height, resulted in databases

[7] The Structure-from-Motion photogrammetric surveying practices followed a methodological process already tested in various research projects. Similarly to the acquisition phase, the processing phase followed a consolidated workflow, from image alignment to the structuring of dense point clouds and mesh models, appropriately referenced and scaled based on direct measurement tools and laser scanning. For further insights on this topic, see Parrinello, Picchio (2019), *Integration and comparison of close-range SfM methodologies for the analysis and the development of the historical city center of Bethlehem*, pp. 589-595; Porcheddu, Picchio (2022), *Close-range photogrammetry for the production of models and 3D GIS platforms for archaeological rescue excavations*, pp. 112-121.


Photogrammetric Data
MLS Point Cloud
TLS Point Cloud
Integrated Data



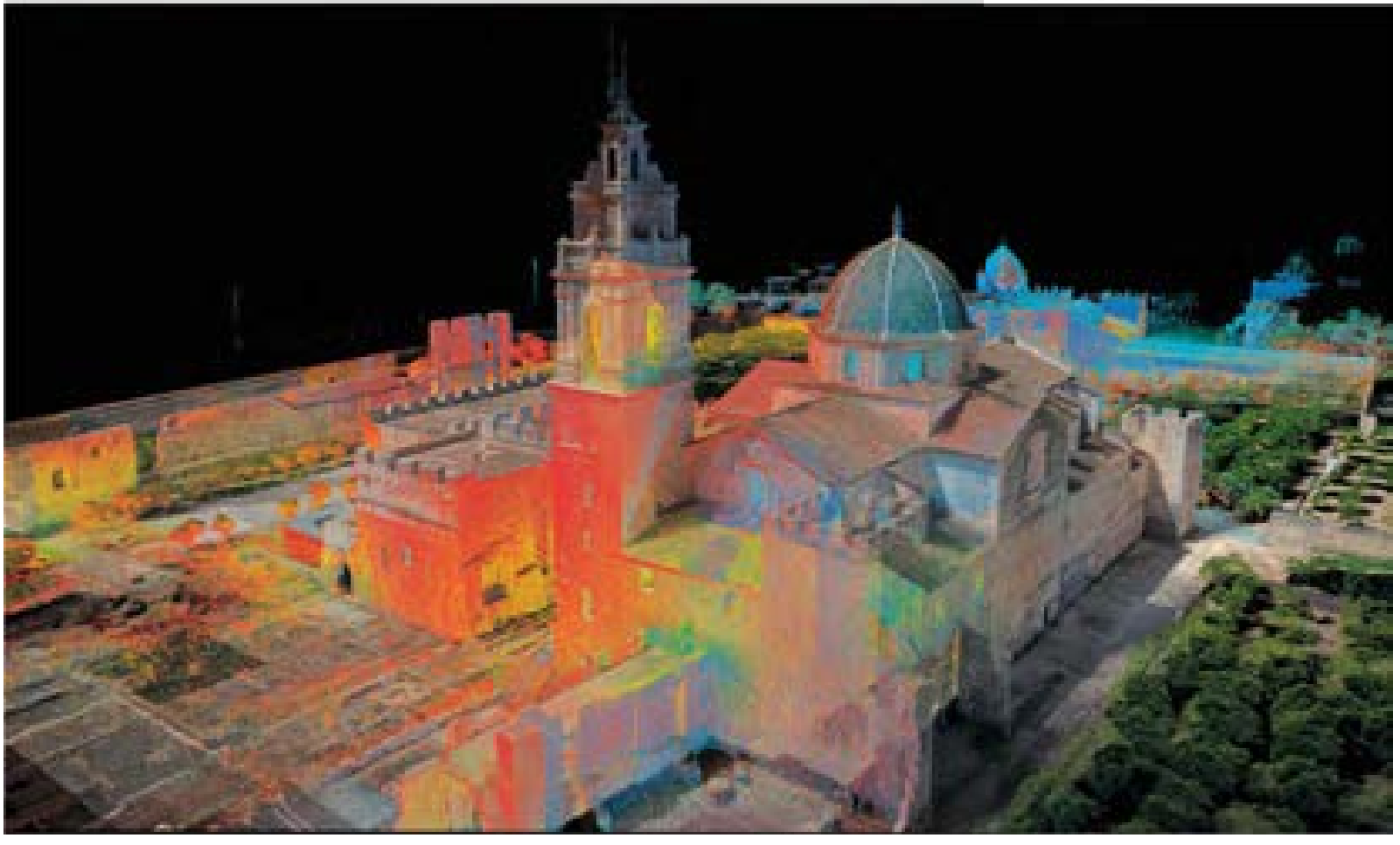


Fig.07
Church of St. Mary
Graphical editing of the integrated point cloud.

that were less competitive from a metric perspective but suitable for studying morphological features and conducting territorial-scale analysis[8].

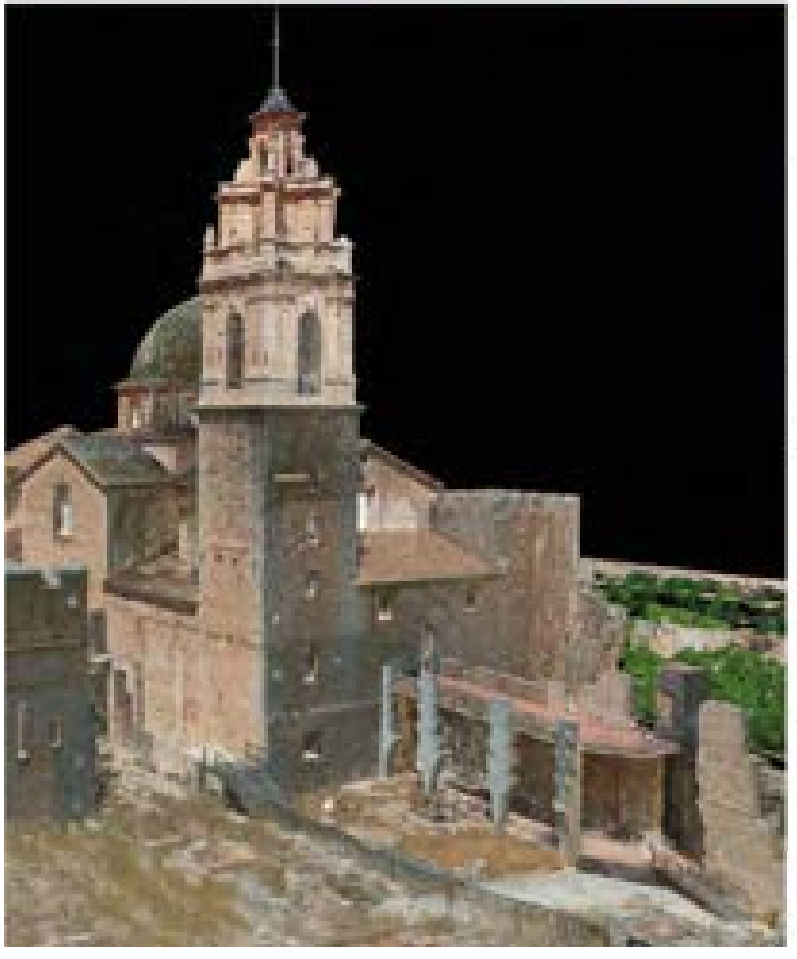
In more complex contexts, such as the Monastery of Simat de la Valldigna case, the experimental approach used for defining the digital database involved the integrated use of three measurement instruments. Surveying activities were carried out by combining terrestrial laser scanning (TLS) and mobile laser scanning (MLS), alongside close-range photogrammetry techniques from the ground, using DSLR cameras, and aerial photogrammetry with UAV technologies.In this context, the terrestrial laser scanner was used to ensure the morphological accuracy of the digital database and to provide higher resolution data for specific areas. These areas include the interiors of the church, which feature a complex decorative apparatus, as well as the entrance building and the cloister.For secondary-interest areas and the open spaces around the main complexes, the acquisition was carried out using mobile LiDAR systems capable of quickly detecting and mapping.

In parallel with the structuring of the laser scanner survey, the use of UAV equipment for aerial photogrammetric acquisition was tested. The aim was to produce point clouds that were effectively integrated to describe each investigated monument comprehensively[9]. Ground-based photography

Side page, Fig. 06
Survey data integration
Perspective views of the integrated point cloud of Simat de la Valldigna Monastery.

Next pages, Figs. 08,09
Digital Database
Perspective views of the colorimetric point cloud of Simat de la Valldigna Monastery.

[8] The use of the photogrammetric tool alone was limited to case studies at a detailed scale or to architectural complexes of small dimensions, where metric accuracy was ensured by direct measurement of the main elements of the case studies.
[9] While using UAV equipment was useful for covering missing data on inaccessible surfaces, it also allowed for the description and representation of each analysed complex as a whole, thanks to the possibility of structuring georeferenced 3D models.



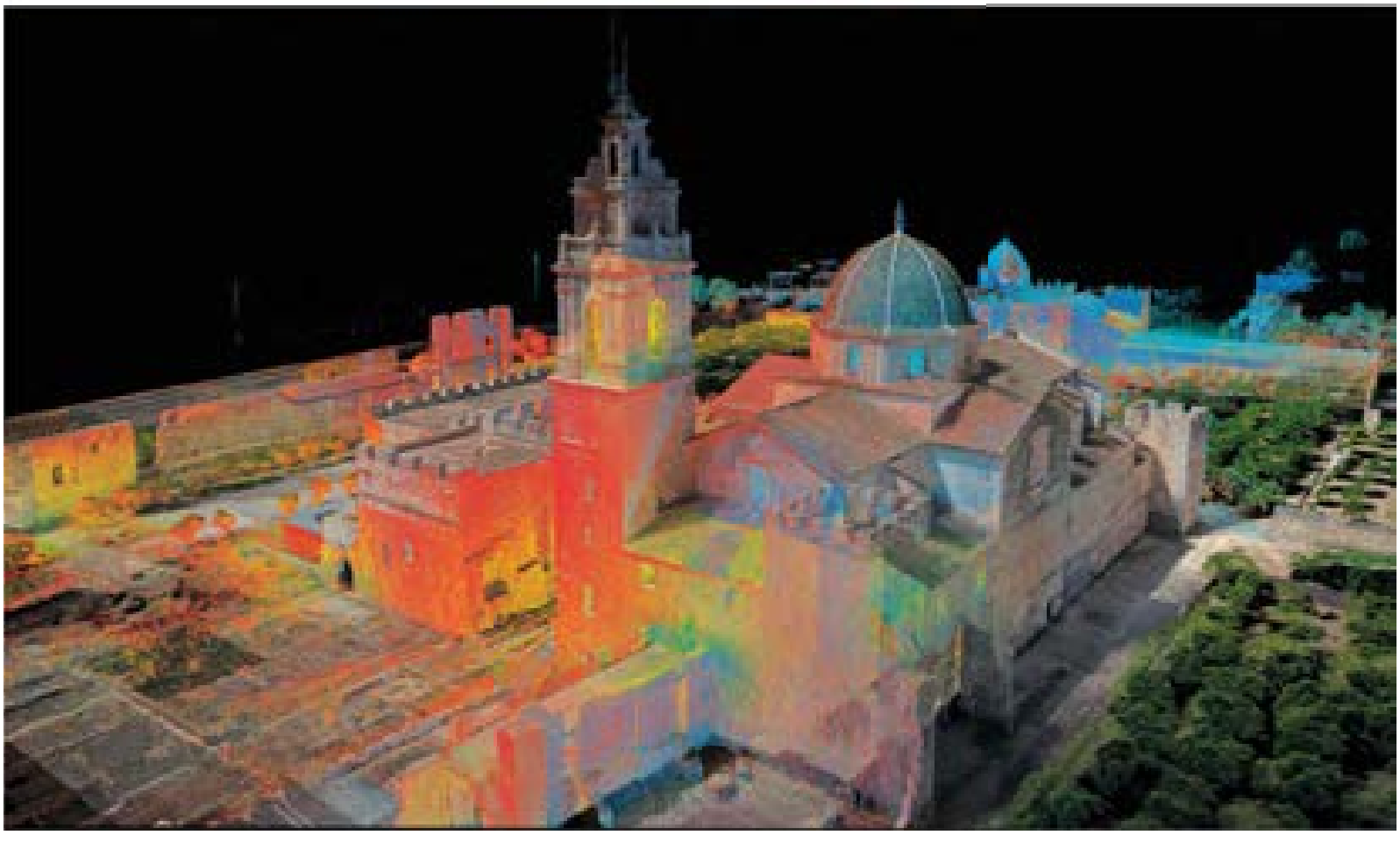


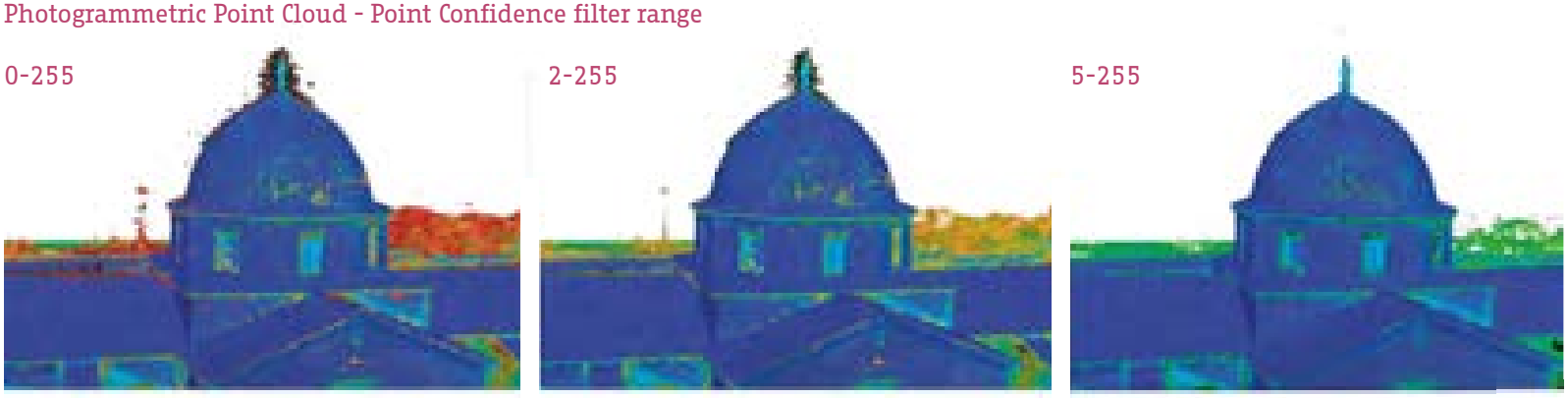
Fig. 10
UAV Survey data
Material and morphological quality of the photogrammetric data.

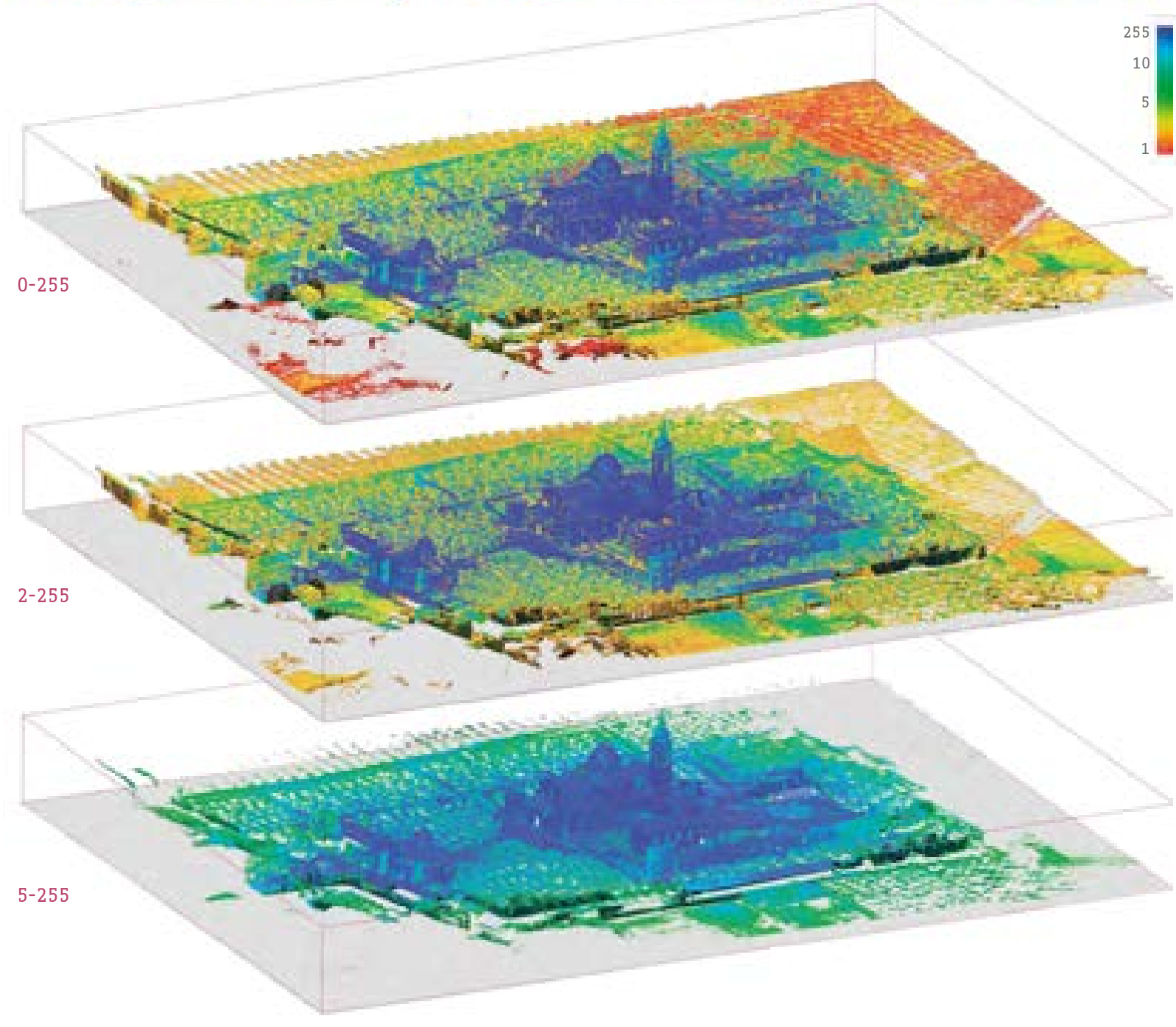
Side page, Fig. 11
Point cloud filtering
Schematic overview of photogrammetric point cloud filtering in Agisoft Metashape. Using the Point Confidence tool, the point cloud is filtered by setting a normalised value range between 0 and 255. Point Confidence expresses a relative reliability index related to the number of depth maps contributing to the reconstruction of each point, and is visualised using a colour scale.

was carried out to complete the documentation campaign, with particular attention given to surfaces that, due to their masonry texture or state of preservation, required higher resolution in the acquisition to be accurately described. The field data collection phase enabled the subsequent structuring of data organisation and synthesis processes by implementing digital databases for the analysed case studies. The implementation operations followed a methodological process in which the raw, heterogeneous data from the different instruments used were defined into individual instrumental datasets, which were then integrated and referenced to a common UCS.

When available, the laser scanner data, recorded through semi-automatic *cloud-to-cloud* processes, was used as the morphometric base for structuring the multisource databases. The result of these operations is a system of digital databases that provide the morphometric characteristics of these architectural complexes. These 3D databases serve as valuable tools for spatial analysis and understanding and a rich data source for subsequent implementations in digital modelling and structuring large-scale information system representation.

Photogrammetric Point Cloud - Point Confidence filter range





From 3D Databases to Systems for accessing Architectural Heritage

The methodology applied across different contexts enabled the acquisition of the multiple spatial and morphological configurations of the sites along the Route of James I, combining the morphometric reliability of the survey with the speed of field data acquisition. Digital surveying techniques allowed the collection of a large amount of geometric and informational data, providing an articulated and multiscale representation of architectural assets and their territorial context. Within this framework, three-dimensional databases assume the role of the primary structure for data integration, organisation, and analysis, enabling continuous comparison between real objects and their digital representations[10]. However, the informational richness of such databases may, in some cases, exceed the actual needs for documentation, interpretation, and enhancement of the sites along the cultural route. An excessive amount of data derived from digital surveys can lead to information overload, compromising readability and interpretative clarity if the data are not adequately selected, reworked, and discretised according to specific communicative goals[11]. Point clouds represent the foundation for an initial critical synthesis of spatial and metric information. They constitute the structural basis of the data, from which processes of selection, integration, and interpretation can be initiated. Photogrammetric data, when properly integrated and normalised with respect to metric data derived from laser scanning, provide a reliable basis for the construction of descriptive three-dimensional models. Although these models exhibit a lower level of geometric detail compared to reverse modelling directly derived from laser scanner point clouds, photogrammetry nonetheless allows for effective outputs in the enhancement of cultural routes, enabling immediate and integrated readings of different types of information.

At the same time, this representational synthesis may result in an excessive simplification of the forms and geometries of the digital duplicate compared to the real object, reducing the model's capacity to visually support certain categories of associated data. For this reason, the relationship between the real and the digital should not be understood as a simple transposition, but rather as a binary and dialectical relationship. The survey must provide a solid morphometric basis for the constructed model, while the model itself must be conceived as a structured tool capable of organising and conveying the collected information. Since the three-dimensional model represents the primary vehicle through which data are communicated, its structure must exhibit a level of complexity consistent with the nature and variety of the information to be managed. Appropriately segmented and semantically categorised models thus become interpretative supports for a wide range of historical, geographical, technological, and documentary content related to each case study along the route[12].

Side page, Fig. 12
From Building to Landscape
Conceptual outline of the information system and the possibility of relations.

[10] De Marco, Parrinello (2021), *Management of Mesh Features in 3d Reality-Based Polygonal Models to Support Non-Invasive Structural Diagnosis and Emergency Analysis in the Context of Earthquake Heritage in Italy*, pp. 173-180.
[11] Picchio, Cortés Meseguer, Porcheddu (2023), *Disegnare un sistema informativo 3D per la promozione della rotta culturale di Jaime I a Valencia*.
[12] Franczuk, Boguszewska et al. (2022), *Direct use of point clouds in real-time interaction with the cultural heritage in pandemic*


Landscape
Monastery of Simat de la Valldigna
Building
Abbot's Palace
Refectory
Element
Bell Tower
Boundary Wall

Fig. 13
From Real to its representation
From photogrammetric point cloud to textured model.

The organisation of elements within the cultural route, through effective strategies of segmentation and data management, whether based on point clouds or three-dimensional models, defines a structured framework for data archiving, consultation, and interpretation[13]. This process results from a conscious design action involving the integration and transformation of physical elements into their digital counterparts, where each digitised element may form part of a broader information system or constitute an autonomous, complete, and queryable database.

The need to make research results accessible to a wider audience through open-access platforms has guided the development of web-based information systems capable of associating optimised three-dimensional models—developed using BIM, NURBS, or Mesh modelling tools—with related multimedia and iconographic content[14]. The architectural elements composing the cultural routes, diverse in typology, territorial location, and historical evolution, are thus conceived as autonomous yet interconnected databases, capable of revealing relationships, meanings, and values that would not easily emerge through isolated interpretation.

and post-pandemic tourism on the case of Kłodzko Fortress; Picchio, Cortés Meseguer, Porcheddu, (2023), *Disegnare un sistema informativo 3D*, *cit.*

[13] Picchio et al. (2024), *Repositorio 3D para la puesta en valor de la Ruta Cultural de Jaime I en Valencia*, pp. 299-309.

[14] Cf. Beck, Borrmann, Kolbe (2020), *The need for a differentiation between heterogeneous information integration approaches in the field of "BIM-GIS Integration": a literature review*.

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CRUZ CUBIERTAS AND CRUZ DE TERMINO IN THE VALENCIAN LANDSCAPE

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The considerations made about the development of the Route Route of James I itinerary led to the identification of some monuments of significant cultural value: the Cruz Cubiertas and the Cruz de Tèrmino, medieval structures that spread especially during the 13th century in the midst of the expansion of the Aragonese empire. The Cruz played an important role within the cultural and religious context of the time, even though their function was not limited to a mere expressions of devotion. Placed close to urban centers and along roads, these architectural elements were meant to legitimise and to topographically mark the re-conquest of territories from Muslim rule[1].

Side page, Fig. 01
Cruz Cubierta of Alzira
TLS Point Cloud.

Cruz de Tèrmino and Cruz Cubiertas

The Cruz de Tèrmino and the Cruz Cubiertas are architecturally similar constructions, possessing a common and well-codified basic structure. The main elements making them up are: the pedestal or base, circular or quadrangular in shape, developed on two or more steps; the base, often enriched by epigraphs or inscriptions; the shaft, which can be decorated or smooth; the capital, often adorned with representations of Saints or floral patterns[2]. At the top of the structure, crowning it, a cross traditionally made of stone is placed, always showing the Crucified Christ on one side and either a representation of the Virgin or various depictions of Saints on the other[3]. It is not entirely clear whether the stylistic differences between the various elements are determined by chronological reasons, that led to different evolutions, or by purely aesthetic factors that allowed various types to coexist.

Due to the presence of iconographic representations carved on them, these monuments lent themselves as places of devotion along the main routes of communication[4], where the faithful were called to prayer before the figure of Christ, as a sign of repentance and purification. For this reason, the Cruz de Tèrmino are also known by the name of *Humilladero*, meaning humiliation. This important role played within the cultural and religious context of the time is closely linked to their function as true symbols of faith and spirituality[5].

Fig. 02
Cruz Cubierta of Valencia
Embedded within the urban development, Cruz Cubierta of the Cami de Quarta is now a mere decorative element inside the public space.

[1] Bayarri (2013), *Las cruces de término del Reino de Valencia*, pp. 9-10; 29.
[2] Zaragozá Catalán (2000), *Arquitectura gótica valenciana. Siglos XIII-XV*, p. 198.
[3] Cf. Bayarri (2013), *Las cruces de término*, *cit.*, p. 13; Mocholí Martínez (2008), *Xàtiva en la encrucijada. La cruz del camino de Valencia*, p. 21.
[4] Mocholí Martínez (2008), *Xàtiva en la encrucijada*, *cit.*, p. 20.
[5] Bayarri (2013), *Las cruces de término*, *cit.*, pp. 32-33.

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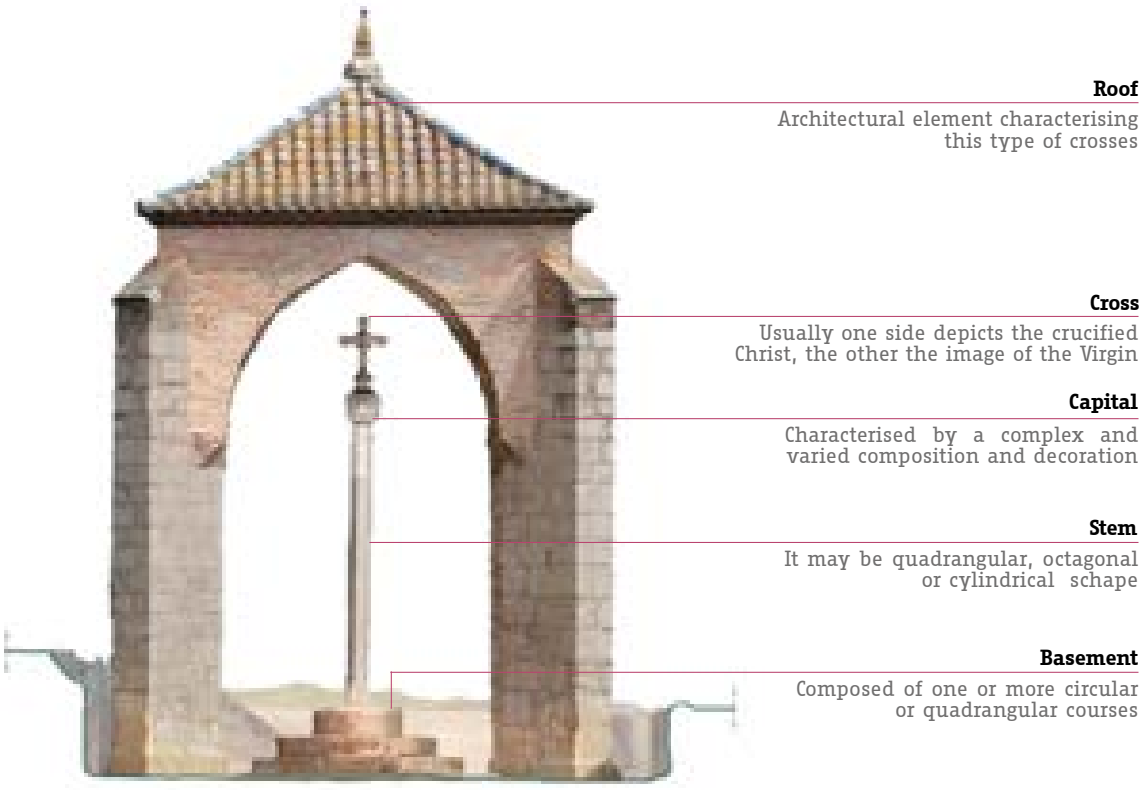


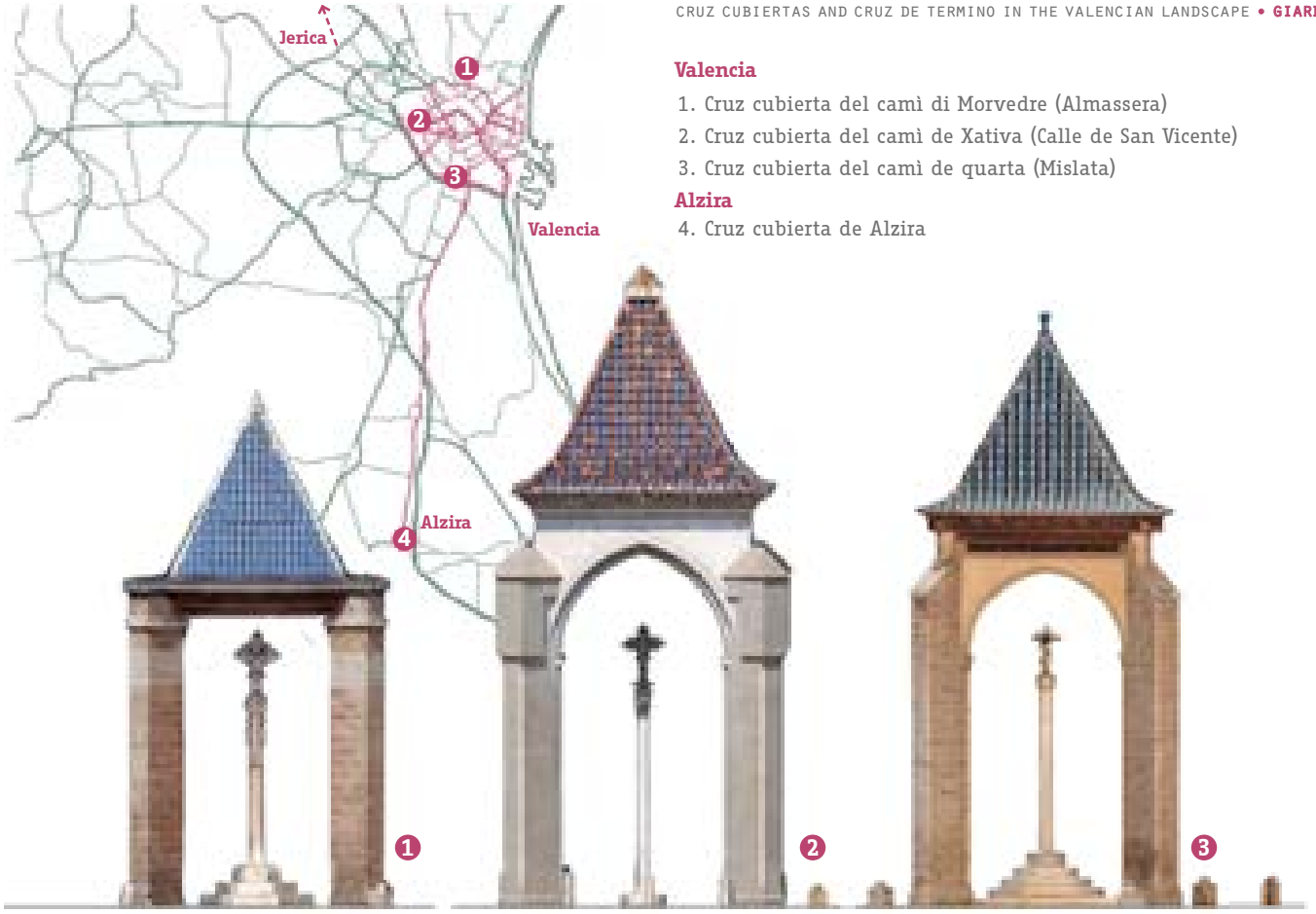
Fig. 03
Cruz Cubierta
Compositional scheme and main distinguishing elements.

It has also been suggested that such crosses may be the transposition into stone of metal crosses, used during religious processions and closely linked to popular devotion[6]. It was believed that the sight of the representation of the body of Christ crucified brought benefits, as much as the adoration of relics[7].
The Cruz Cubiertas are distinguished from the simpler Cruz de Tèrmino for the addition of an architectural structure with a four-sided sloping roof, in some cases conical in shape, to protect the monumental column and for their spread almost entirely in the territory of the city of Valencia.
The Cruz Cubiertas are also successive since they began to codify and develop only from the end of the 14th century, first with simpler wood coverings and finally in the 15th century with vaulted roofs and masonry pillars[8].

Cruz the termino in Valencia and Cruz Cubierta of Alzira and Jerica

The Cruz Cubiertas, built along the main roads of Valencia in the years following its re-conquest, had the primary purpose to encourage passersby to purification, through prayer, before entering the urban area. The closest to downtown are the Cruz Cubierta d'Almassera, the Cruz Cubierta de la calle de San Vicente and the Cruz Cubierta Mislata, while the Cruz Cubierta de Alzira and the Cruz Cubierta de Jerica are located further away, in the area of the Valencian territory.

[6] Mocholí Martínez (2008), *Xàtiva en la encrucijada*, *cit.*, p. 20.
[7] Mocholí Martínez (2017), *La significaciòn eucarìstica de las cruces de término en Valencia a finales de la Edad Media*, p. 492.
[8] Zaragozá Catalán (2000), *Arquitectura gótica valenciana*, *cit.*, p. 198.



Valencia

1. Cruz cubierta del camì di Morvedre (Almassera)
2. Cruz cubierta del camì de Xativa (Calle de San Vicente)
3. Cruz cubierta del camì de quarta (Mislata)

Alzira

4. Cruz cubierta de Alzira

Fig. 04
Markers and signs
Placed near urban centres and along roads, these architectural elements were intended to legitimise and mark the territory topographically.

The first three, built respectively in 1372-1373, 1376, and 1381, in addition to their religious and worship role, most likely had to topographically define the area of the jurisdiction of the city.

The Cruz Cubierta d'Almassera (*Creu Coberta del Camí de Morvedre*), the oldest in Valencia, displays a rich sculptural apparatus. Biblical scenes are represented on the capital, including the Annunciation, the Nativity, the Epiphany and the Ascension, while the representations of various ecclesiastical figures can be seen of the shaft. The Cross, in perfect Gothic style, is showing the Crucifixion on one side and Mary with the child on the other.

The Cruz Cubierta de la calle de San Vicente presents a transitional style between Gothic and Renaissance, with a stone Cross that, in addition to the usual representation of the Crucified Christ, introduces the image of the Eternal Father on the other side with praying figures at his feet. The ceiling of the architectural structure is characterised by a ribbed vault, between whose spaces linear decorations yellow and blue are painted. The tradition links the construction of this monument to a prodigy: it is said that a young man - who was actually an angel - knelt at the passage of a priest who carried consecrated hosts with him[9]. This story thus highlights a link of the Cruz also with popular adoration for the display of the Eucharist.

The Cruz Cubierta Mislata was the most difficult to survey, due to the closeness of surrounding buildings as well as the presence of a protective net for the wooden roof; suffered various damages

[9] Mocholí Martínez (2017), *La significaciòn eucarìstica de las cruces de término*, *cit.*, p. 491.

Fig. 05
Cruz Cubierta Alzira
Today, as in the past, it is located along the road axis connecting Alzira to Valencia.

and reconstructions over the years, that led to the preservation of only few original elements. Certainly worth mentioning is the capital, in which it is possible to distinguish the figures of Mary and Saint John.

Quite interesting is the story that tradition ascribes to the construction of the Cruz Cubierta de Alzira, closely linking it to the place where it stands[10]. Located today along the CV-42 highway, at the gates of the city of Alzira, according to legend, it was erected at the precise site where James I died on his way back to Valencia on July 27, 1276. Although this story is considered implausible by historians, it is possible that such a legend contributed to give to this monument a particular solemn and devotional aspect. This Cruz Cubierta presents a circular pedestal plan that develops on two steps, on which rests the base - also circular and without any decoration or epigraph - that supports the smooth shaft with octagonal section. The capital, also with octagonal section, is enriched by an ornamental apparatus showing four Aragonese coats of arms. The Cross presents, according to the tradition, the figure of the Crucified Christ on one side and the representation of the Virgin Mary on the other. The covering, a ribbed vault formed by pointed arches covered by a coffered wooden ceiling, is supported by four pillars with polygonal section radially placed.

Side page, Fig. 06
A recurring pattern in the Valencian territory
Top: Cruz cubierta of Almassera; bottom left: Cruz cubierta of Calle San Vicente and below Cruz cubierta of Jerica; right: Cruz Cubierta of Mislata.

The Cruz Cubierta de Jerica is the most recent one amongst the scanned monuments. Erected in 1511, it stands out from the others for its size and location, north of the Valencian area, close to the city of Jerica[11]. Initially erected as a simple Cruz de Tèrmino, it was equipped with the architectural covering apparatus in 1550. The small dimensions are due to the later addition of the roof.

[10] Bayarri (2013), *Las cruces de término, cit.*, p. 96-97.
[11] Ivi, p. 98.

Elaboration

Point filtering

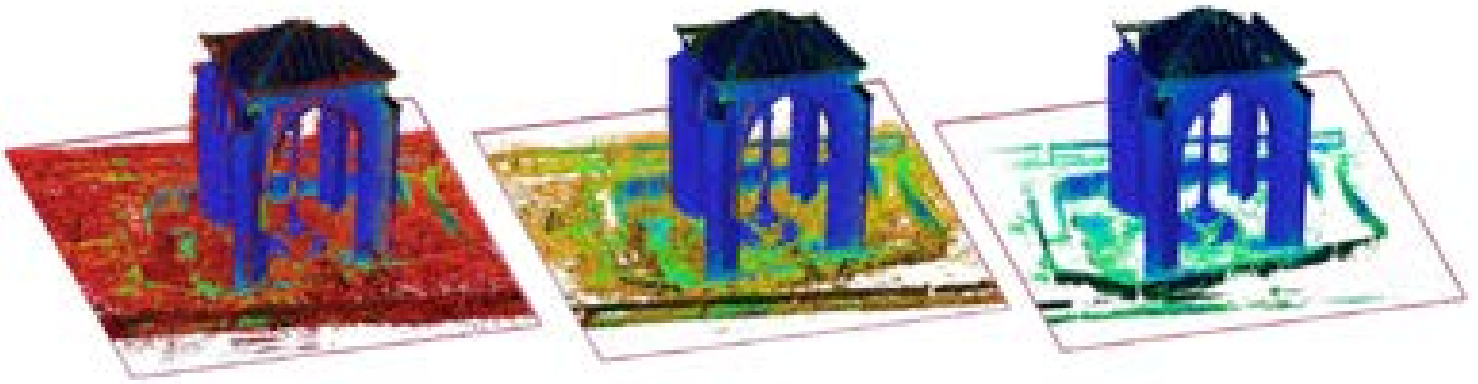


Fig. 07
Photogrammetric processing
For each case study, the process of restitution of digital models involved elaboration and filtering operations.

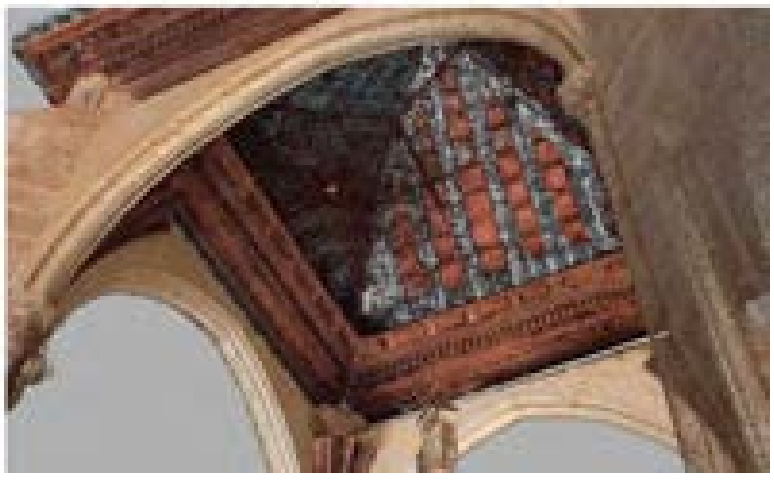
Developed Methodology and Results

The documentation of the selected case studies was structured through a defined methodological framework and a replicable workflow, designed for future extension to the Cruz de Término[12]. The survey campaign was carried out using close-range photogrammetry, integrating aerial and terrestrial image acquisition[13]. Aerial imagery was collected using a DJI Mini 2 UAV, enabling the documentation of upper elements—particularly roof structures—characterised by heights of up to approximately 15 m. Terrestrial data were acquired using a Panasonic Lumix S5 (full-frame mirrorless camera). The two systems, equipped respectively with a 1/2.3" CMOS 12 MP sensor and a full-frame CMOS 24.4 MP sensor, allowed the acquisition of high-resolution imagery (up to 4K), suitable for generating detailed and metrically reliable 3D models.

The image acquisition protocol adopted a structured multi-scale approach. A first circular sequence was performed at a distance sufficient to capture the entire structure. This was followed by three additional circular paths at progressively closer distances, focusing on the lower, middle and upper portions.

Side page, Fig. 08
The restitution of architectural features
Some detail views of the photogrammetric models.

[12] Picchio, Pettineo 2023, *Digitalizzare, ricostruire e fruire il Castello di Montorio. Un tassellonella definizione della rotta culturale dei castelli scaligeri*, pp. 1123-1130.
[13] In order to structure metrically reliable databases, the photogrammetry process was supplemented, in the case of the Cruz Cubierta of Alzira, with a TLS survey, while direct surveys were employed in the other cases.



Further image sets were acquired around the base of the column to document both geometric details of the shaft and the internal configuration of the vaulted ceiling. UAV acquisition completed the dataset, ensuring full coverage of the upper roofing elements through circular flight trajectories.
The survey of all the structures lasted a week, taking 1,662 photos. The acquired data were processed through Agisoft Metashape Pro photogrammetry software. The processing of each individual model was completed by importing the images, duly reprocessed, performing photo alignment, dense cloud, mesh, and texture. The output of this process was a 3D model for each single Cruz. The models consist of an average of 300 photos, with dense clouds ranging from a minimum of 19,509,317 to a maximum of 44,558,298 points, generating a total weight of 69.8 GB.
The use of the photogrammetric technique was chosen due to a logistical problems. Despite the expansion of the city over the centuries, the Cruz Cubiertas have not yet been incorporated into the urban area, but are located at its gates along heavily busy roads. Their location in chaotic and crowded areas required a fast and precise acquiring survey method, such as photogrammetry[14].
Only during the survey of the Cruz Cubierta de Mislata, a structural obstacle was found that made the survey difficult and inefficient. The presence of a protective net to prevent birds from nesting under the roof covering, generated a poor 3D model, that required heavy post-production for mesh correction and refinement. In all other cases however, thanks to high-definition images, the point clouds and 3D models obtained, were useful for analysis and digitisation.

Due to the excellent features and high definition of the processed files, it was possible analyse in detail the architectural aspect and the sculptural apparatuses of the surveyed Cruz, being able to ascertain, through the comparison of different models, the presence of a recurring base structure. Although many Crosses have been destroyed over the centuries, incorporated into urban areas, or damaged due to lack of preservation, many are still surviving to the present day. The 3D models and the collected material can thus be a starting point for the knowledge, valorisation and protection of these assets[15]. The survey methodology, developed and applied during this research, has indeed traced a possible path for the study of these monuments. It would be interesting to survey all the Cruz located in southern Spain and to enter them into a geo-referenced system so that it could be possible to understand the directions of their diffusion. A preliminary mapping has indeed shown a precise expansion area that roughly coincides with the area of the influence of the Aragonese kingdom. An attempt could also be made to reconstruct the road network of the kingdom from the 13th century onwards. A precise localisation would also provide valuable and concrete help to the preservation and enjoyment of such monuments.

[14] Parrinello, Picchio (2019), *Integration and comparison of close-range SfM methodologies for the analysis and the development of the historical city center of Bethlehem, pp. 589-595.*
[15] Gomes, Bellon, Silva (2014), *3D reconstruction methods for digital preservation of cultural heritage: A survey*, pp. 3-14.

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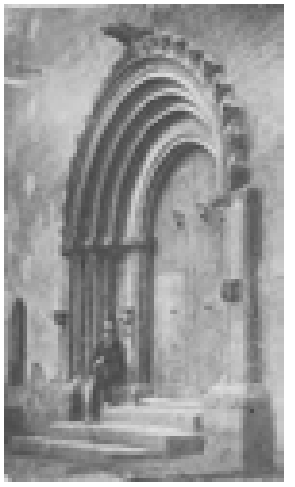
The Church of the Blood (*Iglesia de la Sangre*) in Llíria is perhaps one of the most representative buildings within the framework of the defined Cultural Route. The church is located on the hill in the old part of the urban nucleus of Llíria, on whose slopes once stood the Arab village, which later developed into the medieval town and the present-day city[1]. Administrative centre of the district that bears its name, Llíria is located, about 30 km east of the city of Valencia, near the course of the Turia River. Its location, between the plain of Albufera and the hills of the Serranía, gives it a distinctive atmosphere, where the typical houses of the Valencian landscape blend with the surrounding rural environment, ranging from vast agricultural fields to hilly areas, passing through lush green and wooded zones.

Under Arab occupation, the city, known as Lyria, became an important fortified center compri-sing a medina and citadel, which occupied the upper part of the present urban layout. Moorish Lyria was conquered by James I in 1239, and in 1253 he granted it the status of a city[2]. The construction of the church takes place in this temporal juncture and within the broader context linked to the events of the 13th century, related to the repopulation of territories con-quered by the Aragonese sovereign[3]. In the early stages of urban development and the repopula-tion of the area, existing Arab buildings were utilised, leading to the initiation of new construc-tions. A notable example of this is the main mosque, which served as the foundation for the Church of La Sangre, built and expanded in several phases over time[4]. It was the first and main Christian church of Llíria until the mid-17th century[5], when the Church of La Assumpció was built. From that year onwards, its use was limited to the Brotherhood of the Blood, which had been based in the church since 1574.

In 1919, the building was declared a national monument, and in 1985, it was designated as a Site of Cultural Interest[6]. The interest of this church lies in its construction system, whose most significant

Side page, Fig.01
The Church and the Landscape
The church dominates the high ground overlooking the town centre of Lliria.

Fig. 02
Church Main Gate
Early 20th century photograph of the current main portal of the church (from *Geografía general del Reino de Valencia*, Sarthou Carreres, vol. III, t. II, p. 534).



[1] Escrivà Torres (1995), *La vila vella de Llíria: reflexions sobre el desenvolupament urbà a l'època medieval*, pp. 91-102.
[2] García (2011), *Llíria durant els segles XIII-XIV, en Llíria, història, geografia i art: el nostre passat i present*, pp. 129-138.
[3] On the topic of the repopulation of the conquered territories and the process of establishing and building a feudal society in the occupied lands, see: Iradiel (1990), *Cristianos feudales en València. Aspectos sobre la formació del territori i de la societat*, in *España-Al-Andalus Sefarad: síntesis y nuevas perspectivas*, pp. 49-67; Guinot (1997), *La creació de les senyories en una societat feudal de frontera: el Regne de València (segles XIII-XIV)*, pp. 79-108; Rodríguez (2012), *La construcció d'una nova societat feudal: la repoblació del regne de València al segle XIII*, pp. 367-391; Pecourt (2017), *La repoblació dels aragonesos a València, en Baixar al regne: relacions socials, econòmiques i comercials entre Aragó i València, segles XIII-XV*, pp. 13-30. Particularly in the specific case of Lliria cf. Llibrer (2003), *El finestral gòtic. L'Església i el poble de Llíria als segles medievals*.
[4] Escrig (2003), *De la mesquita a l'església: la construcció de l'església de la Sang de Llíria*, p. 9.
[5] Cf. Sarthou Carreres (1900-1915), *Geografía general del Reino de Valencia*, vol. III, t. II, pp. 528.
[6] Escrig (2003), *De la mesquita a l'església*, *cit.*, p. 9.

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Side page, Fig.04
Architectural Features
Some recent images of the church reveal its massive and austere character, typical of the architecture from the Reconquista period.

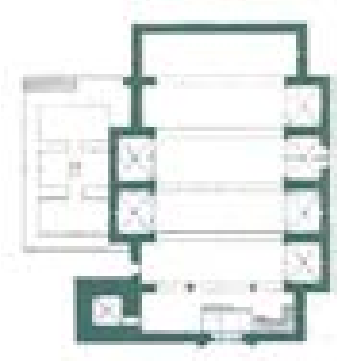
elements have been preserved to this day and which can be perfectly traced back to a specific type of religious temple known as *Iglesias de la Reconquista*[7]. One of the characteristics of the original church was that it was an isolated building. Except for the bell tower, no other structures were adjacent to or nearby. Neither custom nor law – whether civil or canon – allowed it. A royal decree established in 1249 granted newly built churches in the cities of the recently conquered kingdom the privilege of keeping the perimeter around each church free, and the surrounding spaces had to be "*clear, with wide streets and without bridges*"[8].

The church, at least in its original configuration, had a simple rectangular plan, with a massive, undecorated front and access on the side façade. The interior was characterised by a single, wide nave, although in the back of the building there are foundational remains that draw a trapezoidal outline indicating perhaps the former presence of an apsidal space[9].

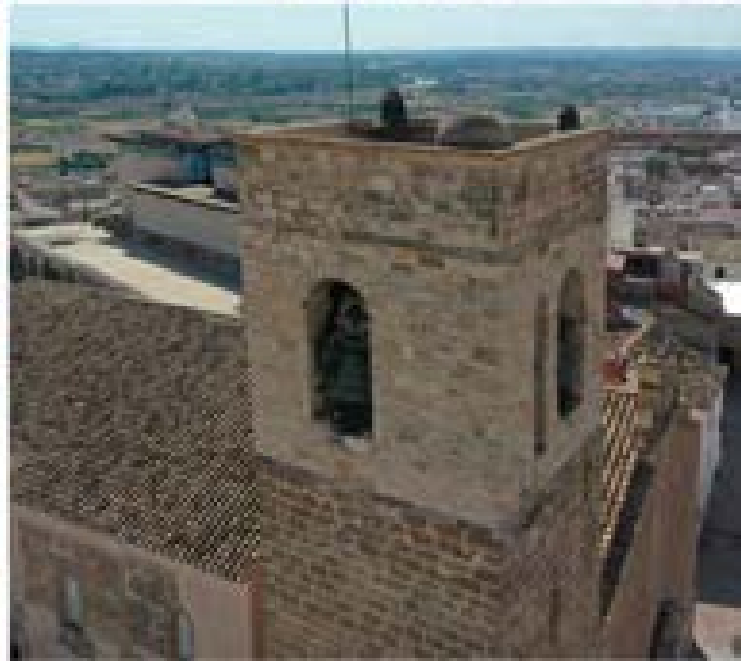
The single nave, whose origins coincide with the church's construction in the second half of the 13th century, is 15 meters wide and 30 meters long[10]. The church's plan is divided into five pointed diaphragm arches, which support a roof of Mudejar tradition and are decorated with chivalric scenes, mythological figures, and heraldic and vegetal motifs. The wooden roof, externally a double-pitched structure, consists of three internal planes or panels: the two larger inclined panels correspond to the external slopes, while the central panel, or *almizate*, is positioned where the two meet. The wooden beams, purlins, and roof boards rest on the five diaphragm arches. The original building included buttresses within the single nave, with the perimeter wall aligned with the outer edge of these supports. The arches rest on the buttresses, defining six longitudinal bays. The materials used for these arches are mainly stone, which was also used for the tower and the building's corners, while the rest of the structure was built with more straightforward local materials, such as adobe and mortar. These rhythmic interruptions on the lateral facades created small usable spaces but did not affect the perception of the nave's unified appearance[11].

The bell tower, located on the left side of the main façade, has a square plan, with no decorations or projections on the walls, crowned by a round arch for bell systems and a walkway. This feature was in harmony with the tower's original function, which served as an observation point for monitoring the territory and shelter for the inhabitants in case of enemy attacks[12].

Fig. 03
Planimetric view
Floor plan of the current layout of the church.



[7] These churches, whose typical features are rigor and simplicity in construction, consist of a rectangular nave with a basilica-like plan, a rectangular presbytery in most cases, and a two-pitched roof with a wooden ceiling, supported by a simple series of transverse or diaphragm arches. This type of church, with its naves defined by diaphragm arches, represents the most extensive chapter in Valencian medieval architecture. Cf. Catalán (1996), *Naves de arcos diafragma y techumbre de madera en la arquitectura civil valenciana*, p. 21.
[8] Cf. Escrig (2003), *De la mesquita a l'església*, *cit.*, p.10; Burns (1967), *The Crusader Kingdom of Valencia*.
[9] On the actual existence of an apsidal space contemporary to or subsequent the construction of the church and its typological implications related to the churches of the Reconquista cf. Escrig, (2003), *De la mesquita a l'església*, *cit.*, pp.15-16.
[10] Escrig (2003), *De la mesquita a l'església*, *cit.*, pp.5-17.
[11] Cf. Mas (1984) , *Arte en Llíria. Iglesia de la Sangre*, pp. 73-77; Escrig (2003), *De la mesquita a l'església*, *cit.*, pp.5-17.
[12] Cf. *Ibidem*.



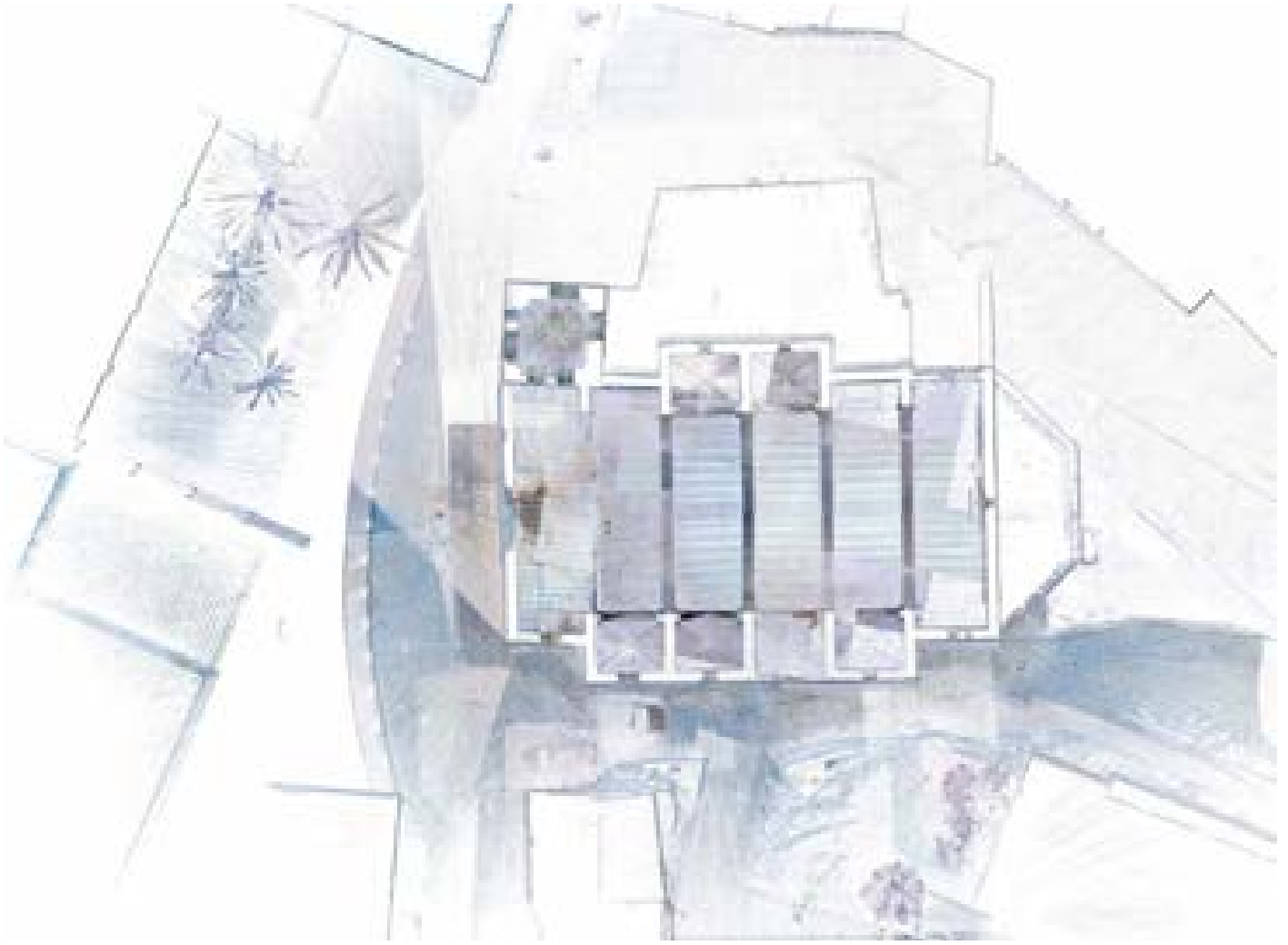
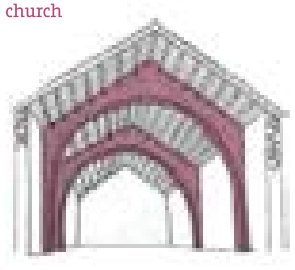


Fig. 05
Digital Database
Planimetric view of the integrated point cloud of the Church Complex.

Fig. 06
Diaphragm arches
Compositional diagram of the *arcos diafragma* structure of the church



The tower's wall equipment presupposes a construction or extension that occurred in later stages. It is also documented is the construction at the top of the tower of a sail-shaped belfry (espadaña), which took place in the 18th century[13]. This feature is no longer present, as it was removed during restoration work in the last century due to structural issues[14]. The appearance of the church that the citizens of Llíria could admire between the 16th and 17th centuries was already very different from that conceived by its builders. On the exterior, the massive perimeter of the building was modified by the addition of protruding chapels, a new choir, a sacristy, and an updated portal[15]. Starting from the 14th and 15th centuries, the church underwent a general renovation that altered the spatial configuration of the building. Five side chapels and a gallery for the local authorities and the choir were constructed. The chapels feature ribbed Gothic vaults and columns attached to the walls. In the 16th and 17th centuries,

[13] Cf. *Martí Ferrando (1974), Crónica de la Iglesia de Santa María o de la Sangre de Liria.*
[14] García (1997), *Restauración de la iglesia de la Sangre en Llíria (Valencia)*, p.68.
[15] Cf. *Martí Ferrando (1974), Crónica de la Iglesia de Santa María, cit.*

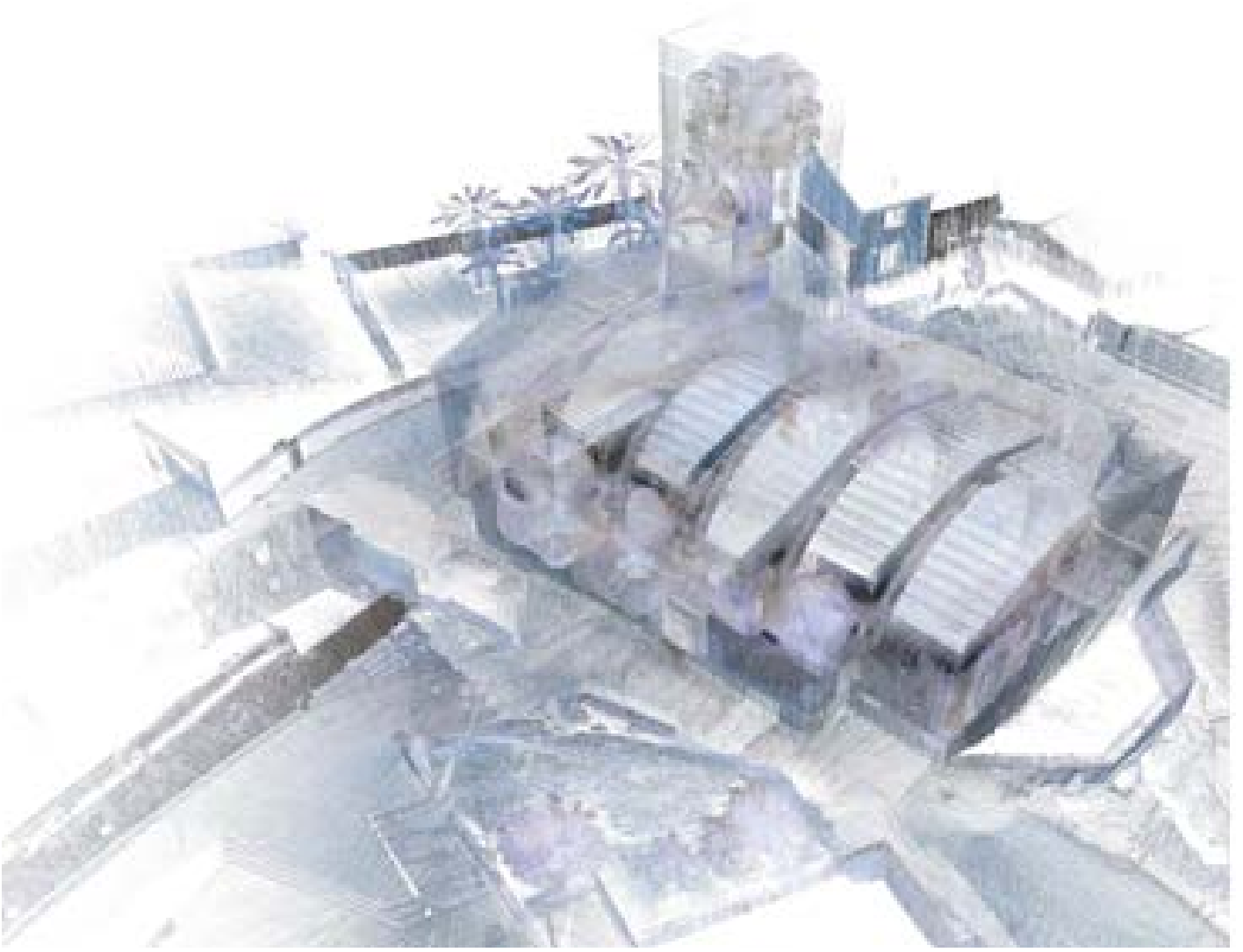


Fig. 07
Digital Database
Perspective view of the integrated point cloud of the Church complex.

significant changes were made to the interior. Some chapels and walls were painted, new altars were installed, and the bases of the altars, as well as the steps leading to the chapels and the chancel, were covered with tiles[16].

Despite these changes and later ornamental additions, the church was finally abandoned in the 18th century in favour of the Church of *Assumpció*, which was built during that period. The building we see today, despite the last restoration carried out at the end of the last century, which strived to respect the original structure as much as possible, is the result of the transformations that took place between the 14th and 17th centuries. Internally, the back wall, is decorated with floral motifs of classicist historicist style[17]. Externally, the main façade, built in rammed earth (*tapial*), features an entrance portal with a full arch of Gothic inspiration, formed by a triple archivolt decorated and enriched at the base with a bust wearing a ruff. Slender columns, typical of Catalan Gothic, support the arches.

[16] *Escrig (2003), De la mesquita a l'església, cit., p.13.*
[17] Cf. *García (1997), Restauración de la iglesia de la Sangre en Llíria (Valencia), cit., pp. 64-75.*

Fig. 08
Sanctuary back wall
The rear wall of the sanctuary features a flat composition with three decorative niches framed by painted architectural motifs, highlighting a later intervention within the medieval stone structure.

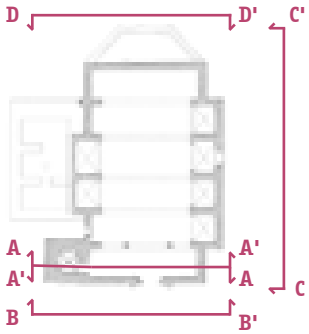
Another entrance is located on the southeast façade; it is in Romanesque style and does not correspond to the original entrance of the church. It is topped by a simple round arch made of well-squared ashlars and framed in stone. On the opposite northeast side façade stood the abbatial house, the ruins of which are still visible. The façade itself is entirely flat, except for a central pointed window, which internally marks the focal point above the altar[18].

The entire church is practically devoid of openings. The overall structure conveys a sense of solidity, characteristic of massive constructions, which define the distinctive features of the earliest pioneering churches, forming a model based on diaphragm arches.

Within the actions related to the cultural route and the defined project objectives, the study of the church's features, accompanied by a documentary analysis, was complemented by a phase of digital surveying of the building, representing a fundamental step in understanding and documenting the structure[19]. This approach made it possible to collect data and information useful for identifying the church's main morphometric and material characteristics, providing a clear view of its features.

Side page, Fig. 09-13
2D Drawings
Technical and descriptive documentation of the church.

[18] *Ibidem*
[19] Parrinello, Picchio (2023), *Digital strategies to enhance cultural heritage routes: from integrated survey to digital twins of different European architectural scenarios.*



Section A-A'

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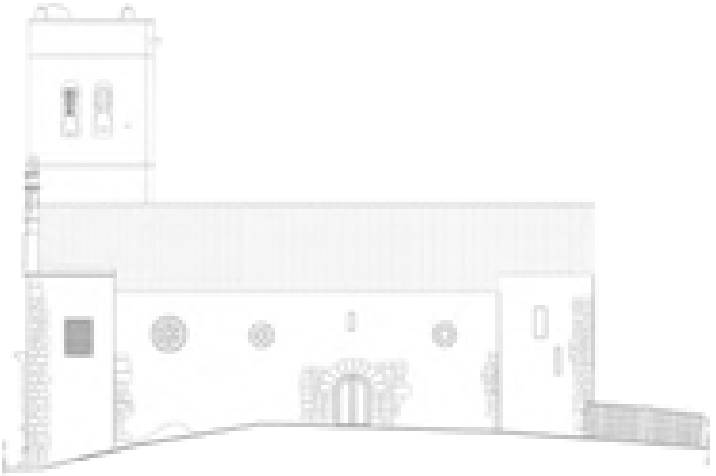

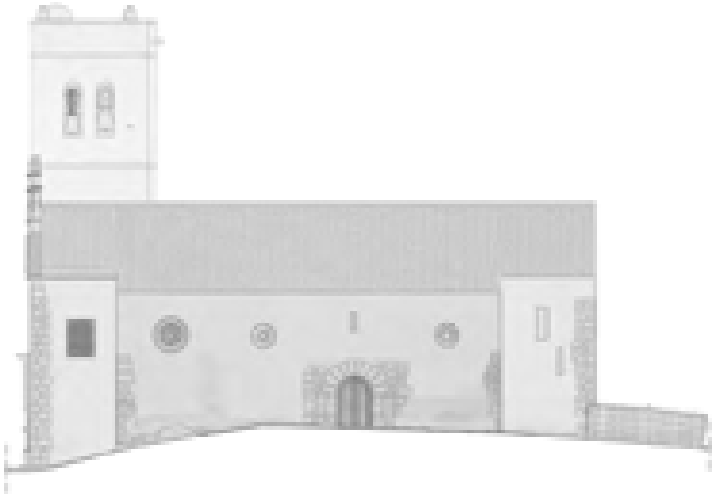

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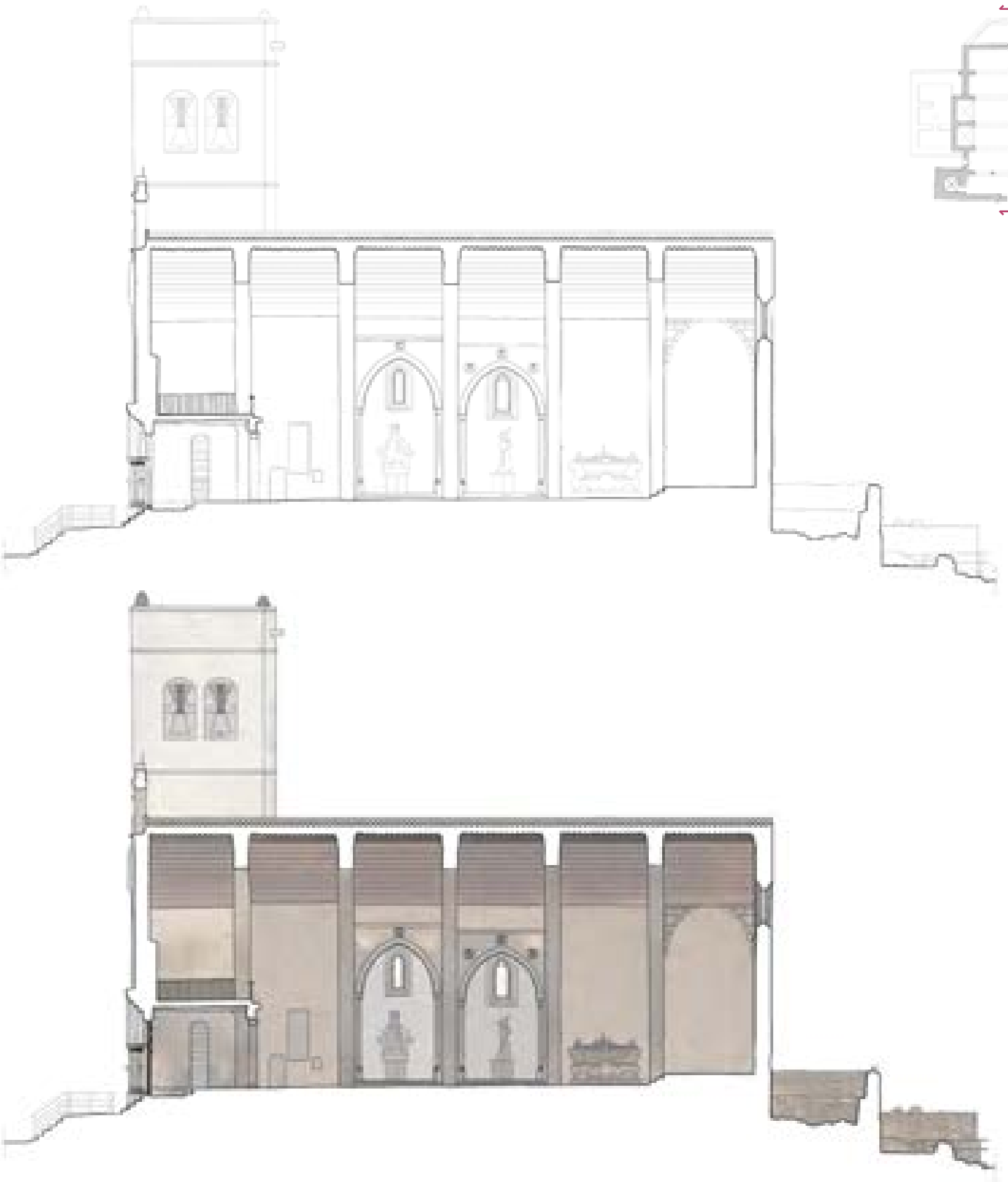

Section E-E'

Section E'-E'

Fig. 14
Traces of lost element
Early 20th-century photograph of the church, showing the sail-shaped belfry (*espadaña*) at the top of the bell tower, which is no longer present today.
(from *Geografía general del Reino de Valencia*, Sarthou Carreres, vol. III, t. II, p. 525).

This enabled the development of critical insights through the comparison of data derived from digital survey activities, the corresponding two-dimensional outputs, archival documentation, and the most recent scientific literature on the church.

The three-dimensional database should not be understood merely as a representational tool, but as a structured environment for the organisation and interpretation of information. Its morphometric accuracy supports a multi-level reading of the building, from masonry structures to spatial configuration, while also enabling the identification and documentation of specific elements, such as the remains of the apse, which contribute to defining the architectural value of the structure.

In the transition from the three-dimensional database to drawing, a process of selection, synthesis, and interpretation takes place, through which geometric information is reorganised according to representational and communicative logics.

Drawing thus assumes a central role, as it is not limited to being a means of representation, but acts as a critical and interpretative device, capable of encoding, selecting, and communicating architectural knowledge[20]. Through the integration of digital models and graphic outputs, drawing becomes a space of interaction between interpretation and representation, enabling a deeper understanding of the building and its components.

[20] Parrinello (2024), *Forma e linguaggio. La comunicazione nell'interazione grafica*, pp. 4-11.

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Side page, Fig. 01
The Church of Santa Maria
The monastery blends with the landscape of Valldigna.

The monastery is in a place whose origins date back to the Palaeolithic, with archaeological remains in the Cova del Bolomor and in the mountains of Umbria. Mesolithic flint has been found in the Cova del Vell, and the Cova de les Foietes or Cova del Caçador, with a collective Eneolithic burial, stands out for its richness. In Els Castellets and Penya del Migdia there are remains of Bronze Age settlements that were superimposed by other Iberians, and even Romans, in Els Castellets. It is in this Iberian period when it must have been called Marinyet, more advanced in the times of the Roman and Arab empires, being known by the names of Taverna and Gebalcobra[1].

The transformation of Taverna into Tavernes probably took place after the erection of the monastery of Nuestra Señora de Valldigna, when James II donated the valley of the river Vaca to Fray Bonanat de Vilaseca of the Cistercian order. Thus, Tabernes was under the jurisdiction of the Abbot of Valldigna, from 1297 until 1811, when it was incorporated into the Crown.

Chronological facts of the story

The following chronology is extracted from the document Memoria de protección del entorno urbano al Monasterio de Sta. María de la Valldigna, Normas Subsidiarias del Planeamiento municipal (1987).

- *In August 1240, Anendedrall, mayor of the Castle of Bairén, surrendered the fortress with the castles and arches of the Vall de Marinyet to the King. James I the Conqueror.*
- *On July 15, 1238, King D. James I made the first donation to his uncle D. Nuño Sanz, of El Llibre del Repartiment de València (1237-1252).*
- *In the year 1262, King D. James handed over his jurisdiction to the Infante D. Pedro.*
- *King D. James died on July 27, 1276, passing the crown to his son Pedro III.*
- *King D. Pedro III granted to Doña Constanza II of Hohenstaufen (1230-1307), Augusta Roman Empress of the East, Empress of the Greeks, estates, and revenues of Alfadech and Marinyet.*
- *In 1290 Doña Constanza named James II the Just of Aragon heir to her property and rights.*
- *In 1297 King D. James II, returning from his campaigns in the lands of Almeria and Murcia, and passing through the valley of Alfandech (Marinyet), commented to Fray Boronat de Vilaseca, Abbot of Santas Creus, "Vall-digna per a un monastir de la vostra religió", to which his senior chaplain replied "Senyor, Vall-digna, a phrase*

[1] Cf. Martínez García (2001), *El monasterio cisterciense de Santa María de Valldigna. Arqueología y cronología de sus Arquitecturas*; Brines Segarra (1998), *Conoce el Monasterio de Santa María de la Valldigna 1298-1998.*

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that changed the name of Alfandech to the Valldigna, and when he arrived in Valencia on March 15, 1298, the document of donation of the Valley for a monastery of the Cistercian Order in perpetuity to build a Monastery called "Santa María de la Valldigna" was drafted.

- *March 15, 1298, the date of foundation.*
- *The monastery was ruled for 538 years by 74 abbots during 98 terms of rule. The occupied area amounts to 52,912 m2 and the construction units of which it is composed are the following: Exterior walls, Portal Nou, chapel of N^{a}. Sra. De Gracia, Almácera, cloistered walls, church, sacristy and bell tower, cloister of the silence. Chapter House, Refectory, Abbot's Palace, Guesthouse, and adjoining rooms.*

The extensive and rich territory entrusted to the Royal Monastery of Santa María de Valldigna as a lordship allowed the monastic community to achieve a very prominent role in Valencian society, economy, politics, and culture during its almost six centuries of existence.

Fig. 02
The Monastery and its main elements
Floor plan representation of the monastery complex.

1 New Gate
2 Chapel of the Virgin of Grace
3 Ancient Olive Mill
4 Fountain ot the Tritons
5 Defensive Tower
6 Church
7 Cloister
8 Refectory
9 Chapter House
10 Bell Tower
11 Inner wall
12 Abbot's Palace

Fig. 03
The Church of St. Mary
Main facade of the Monastery Church.

A fortress that left its mark on the set of buildings and facilities with which the monks of Valldigna equipped themselves over the years[2]. This is how the works of the church, and the monastic dependencies began in the fourteenth century, although throughout its history it would need to be rebuilt due to earthquakes. The first at the end of the fourteenth century and the second in the middle of the seventeenth. After the confiscation of 1835, the monastery was abandoned, and its site was used as an agricultural estate. The buildings quickly deteriorated through neglect and looting, and it arrived in the 20th century in a sorry state of ruin. Fortunately, in 1991 the Generalitat Valenciana bought the ruins of the monastery and began an ambitious plan to rebuild and enhance what remains.

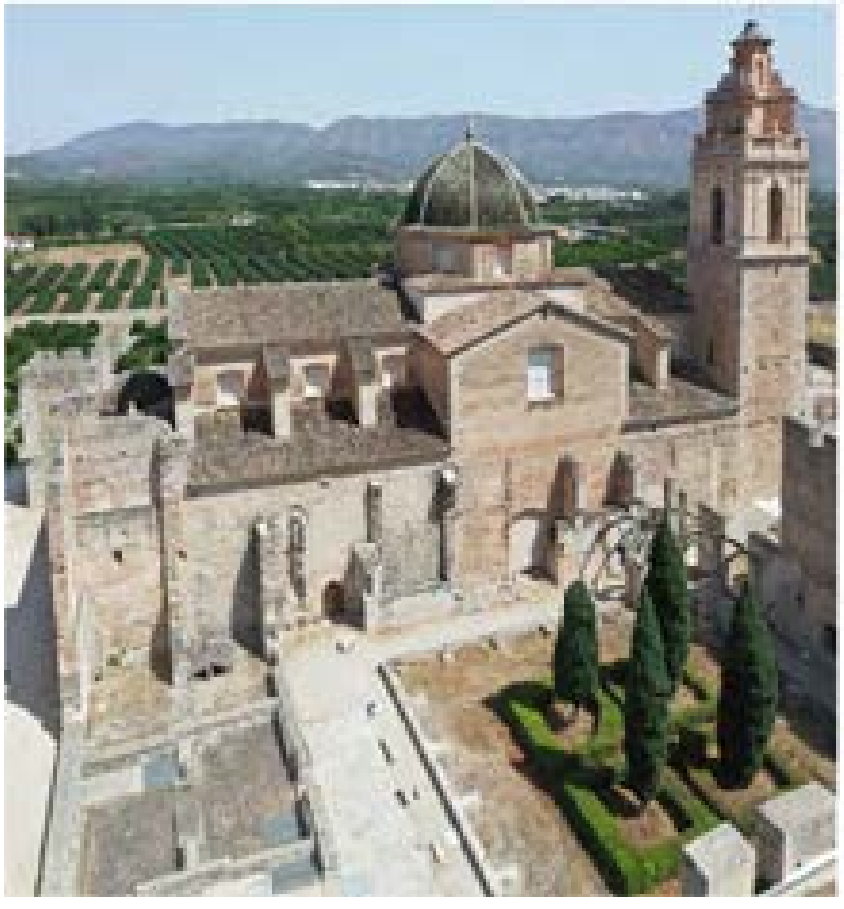
The church of Santa Maria

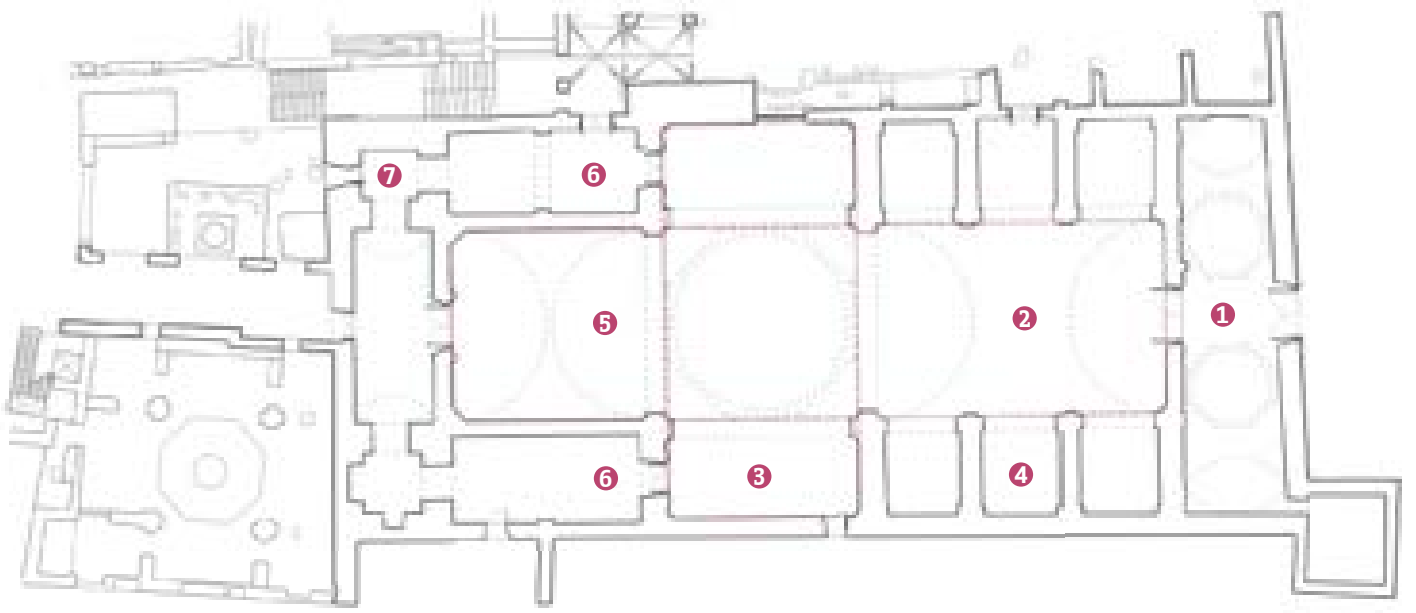
From the study carried out by Martínez García[3], and presented at the symposium on the Cistercian Movement, Valldigna (1298-1998) explains the origins and construction evolution of the monastery church. The first temple was built in the 14th century, following the canons of the Cistercian order, a church with a single nave modular from diaphragmatic arches.

The closest reference can be found in the monastery of Santa María de Benifassà[4]. The church was destroyed on December 16, 1396, by an earthquake. A second Gothic-style church was built in the 15th century and was destroyed again on 26 June 1644 by another earthquake, with Fray Francisco de Talavera y Castellet (abbot between 1640 and 1644) as abbot. The current church that we see today was the initiative of Abbot Rafael Trobado in 1648 and was completed around 1700. In the transept there is a dome that is not spherical but pointed inside.

Side page, Figs. 04, 05
Characteristics and Peculiarities
Representative images of the Monastery where its main features and state of preservation can be appreciated.

[2] Zaragoza Catalan (2000), *Arquitectura gótica valenciana*.
[3] Martínez Garcia (2001), *El Monasterio Cistercense*, *cit.*
[4] Martín Lloris (2013), *El Monasterio de Santa María de la Valldigna: símbolo en la organización territorial del Antiguo Reino de Valencia*.





1 Narthex
2 Central nave
3 Transept
4 Side chapels
5 Presbytery
6 Sacristy
7 Bell Tower

Fig.06
The Church and its main elements
Floor plan representation.

On the outside it is covered with greenish glazed tiles. The arches were also to be pointed, although they are covered. The entire interior of the dome is painted with Churrigueresque style decoration consisting of plant ornamentation and countless small angels. We also find stucco decoration in the form of leaf litter. On the pendentives we can find carved four coats of arms corresponding to the Spanish monarchy, the Cistercian and the Valldigna. In the center of the dome, the large central canopy stands out[5].

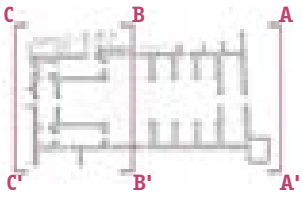
Therefore, the church of Santa María de Valldigna is a voluminous Baroque temple with a single nave, with three pairs of deep side chapels (which makes it externally simulate having three naves), an unmarked transept, a dome over the transept and a bell tower attached to the presbytery[6]. The choir was located at the head of the flat head. On each side were the sacristies, and behind it the back choir, which was accessed through a central door. At the top was the revolving throne of St. Mary and the Virgin's dressing room. The image of the Virgen de la Valldigna has been lost.

In 1697 an atrium or galilee was attached to the foot of the church for the converts, which was separated from the temple by iron bars as a gate. Inside we can find three fresco paintings, two of them on both sides of the access door to the temple and a third located on the lintel of the entrance door. The atrium is very curious, because it is covered by a transverse vault with two small domes at the ends and pendentives. The vaults are decorated in Churrigueresque style.

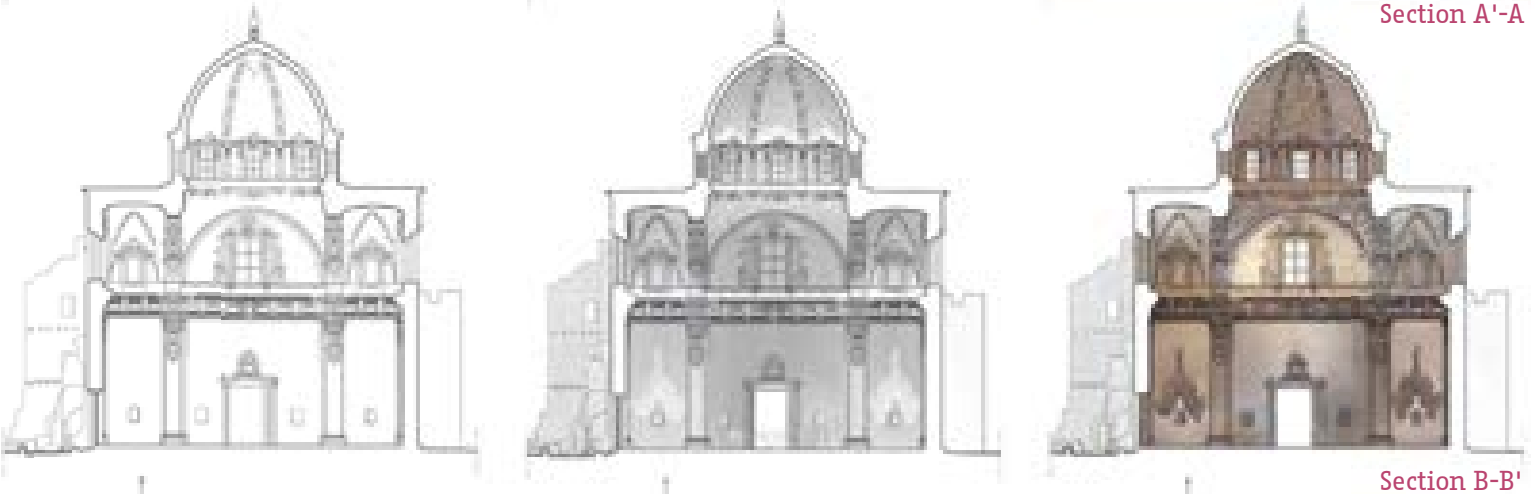
Next to the chancel we have the bell tower built in 1657. It consists of three bodies, the first corresponds to one of the angular towers that protected the 15th-century temple, the second is the body of bells, and the third is the crown as a temple that usually covers the Valencian bell towers of the Baroque period[7].

Next pages, Figs.07-13
Inside the Chruch
Significant sections and elevations of the Church.

[5] Martinez Garcia (2013), *El monasterio, cit.*
[6] Zaragoza Catalan (2000), *Arquitectura gótica valenciana*, cit.
[7] Martinez Garcia (2013), *El monasterio, cit.*



Section A'-A



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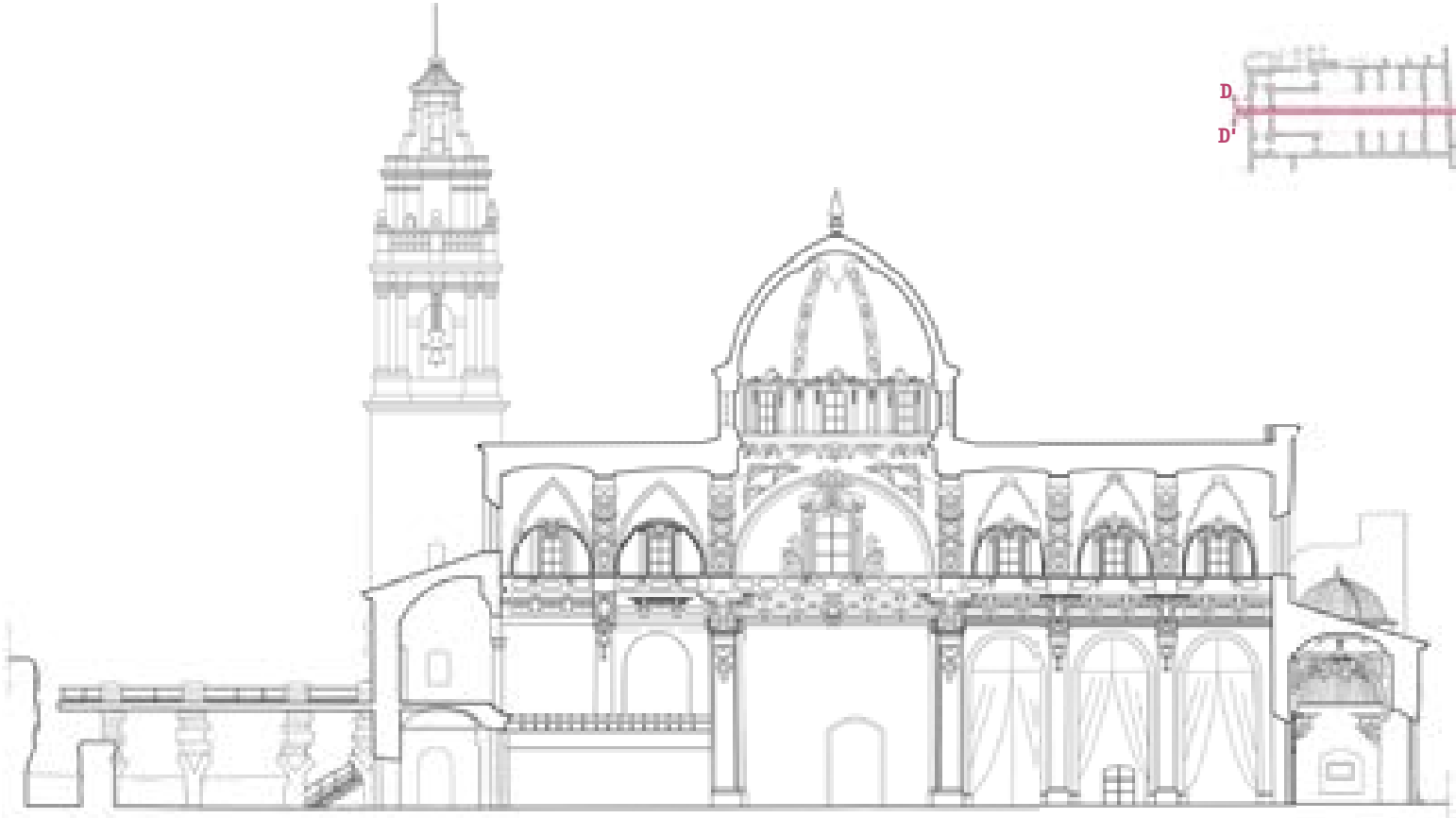
Section C-C'



Section D-D'

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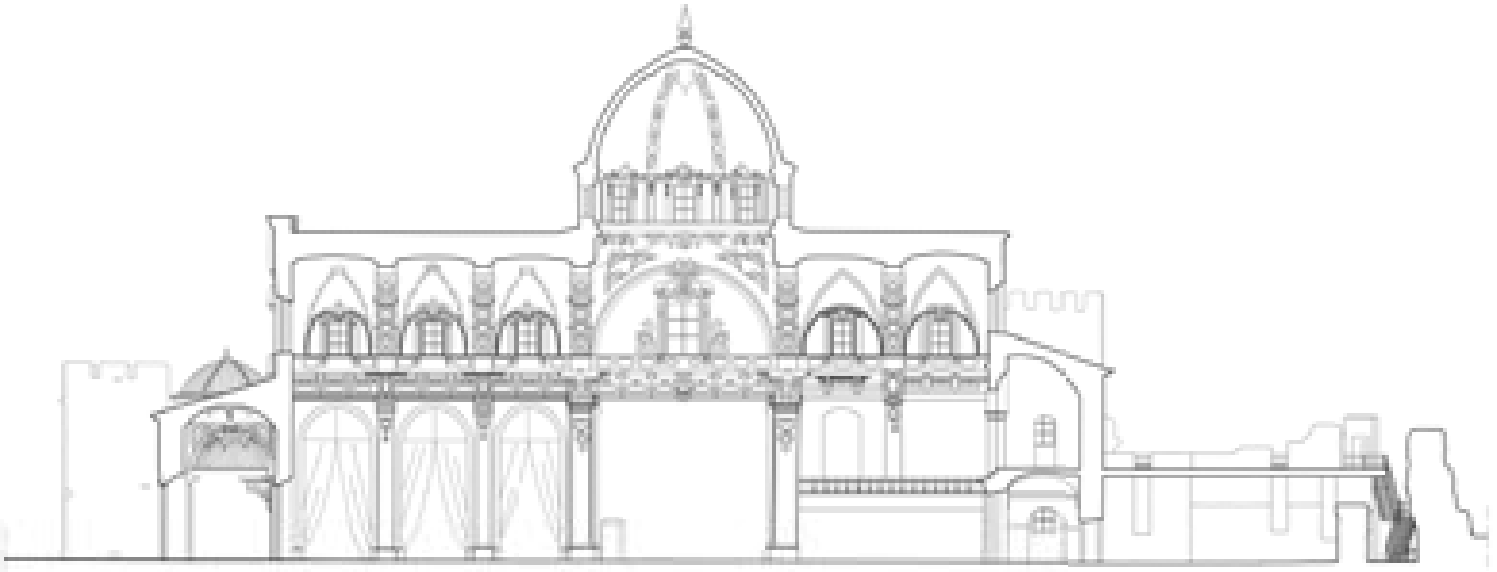

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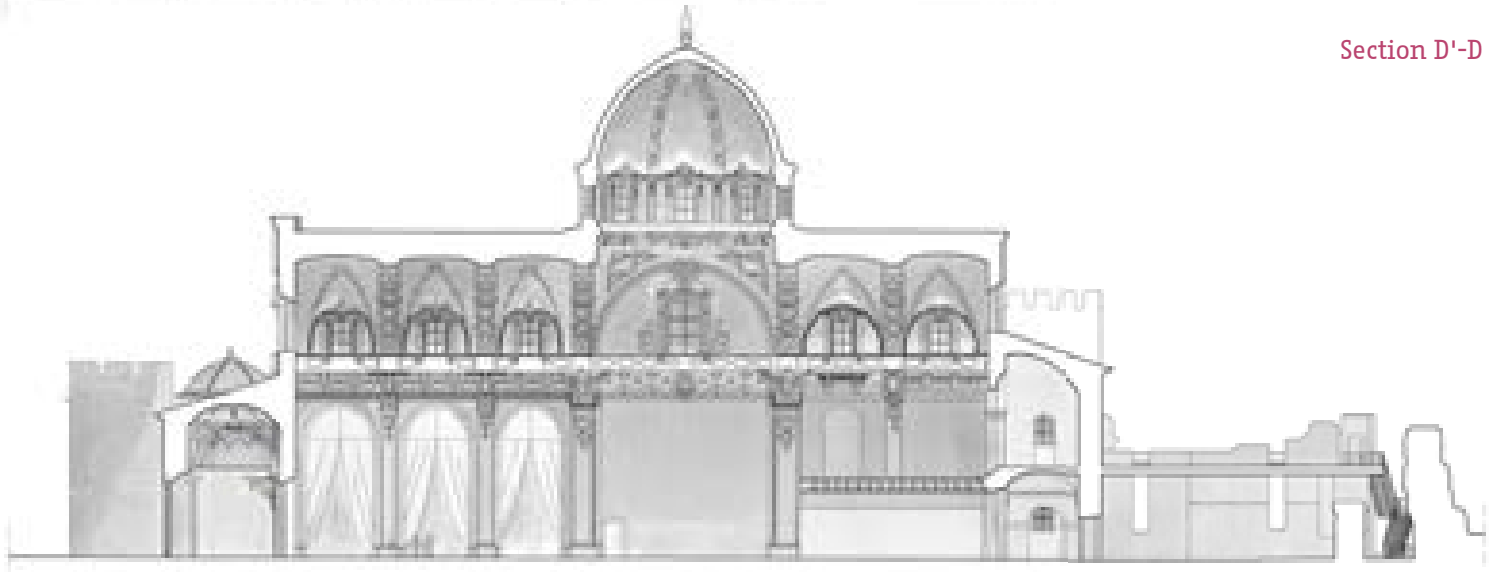

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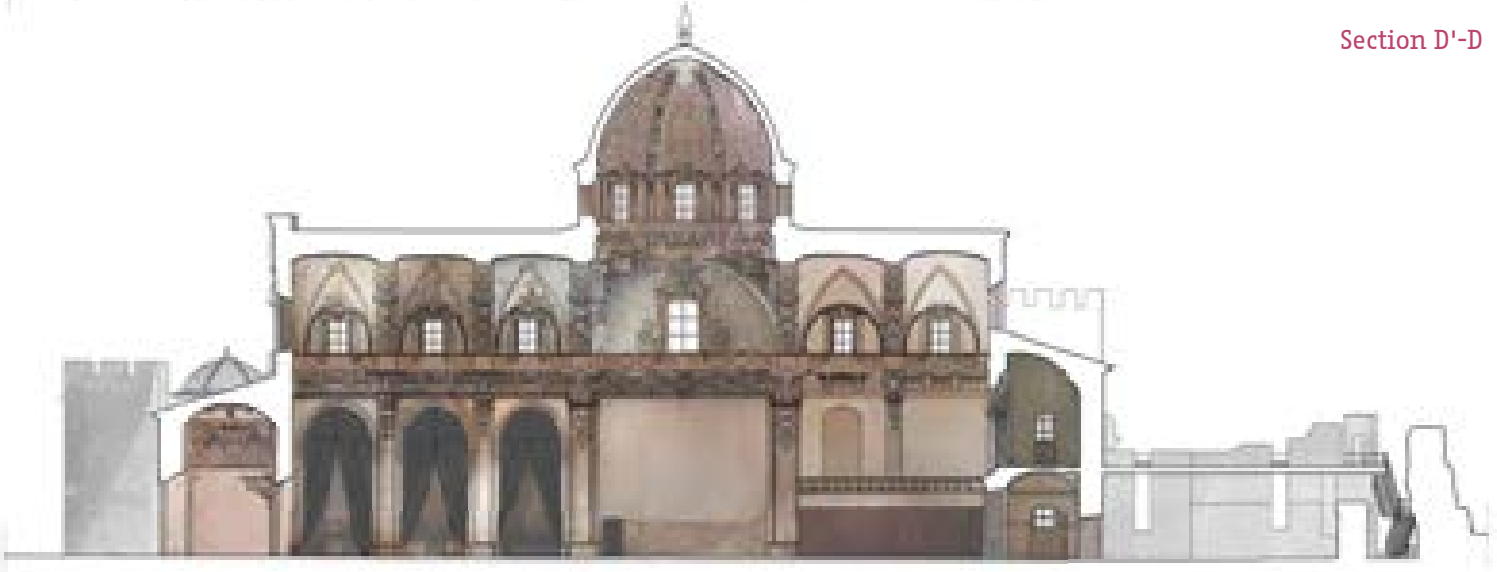
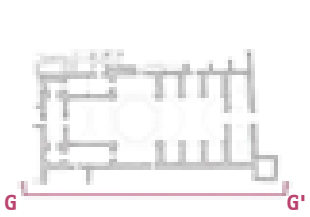
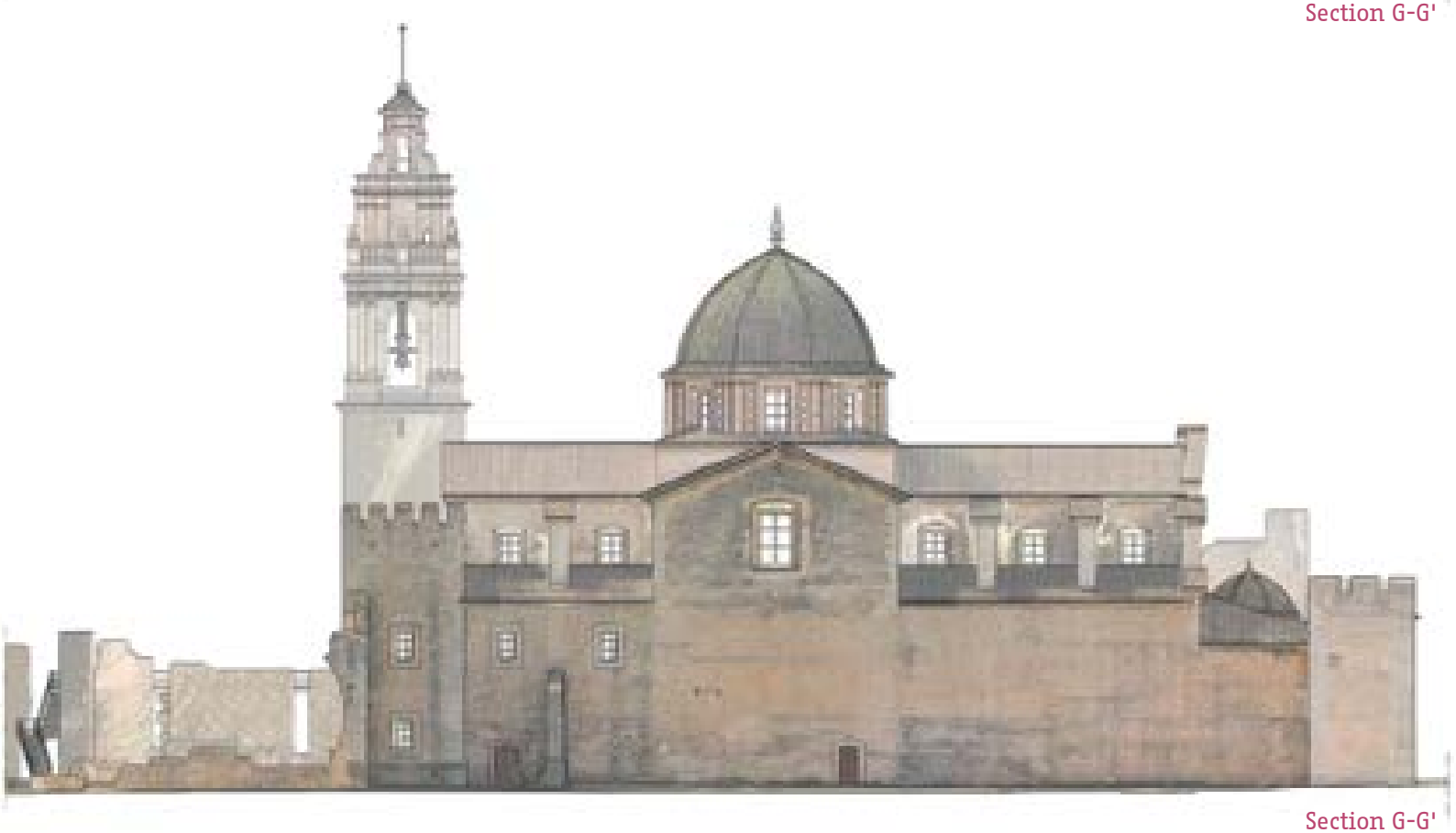


Section D'-D

Section F-F'



Section G-G'



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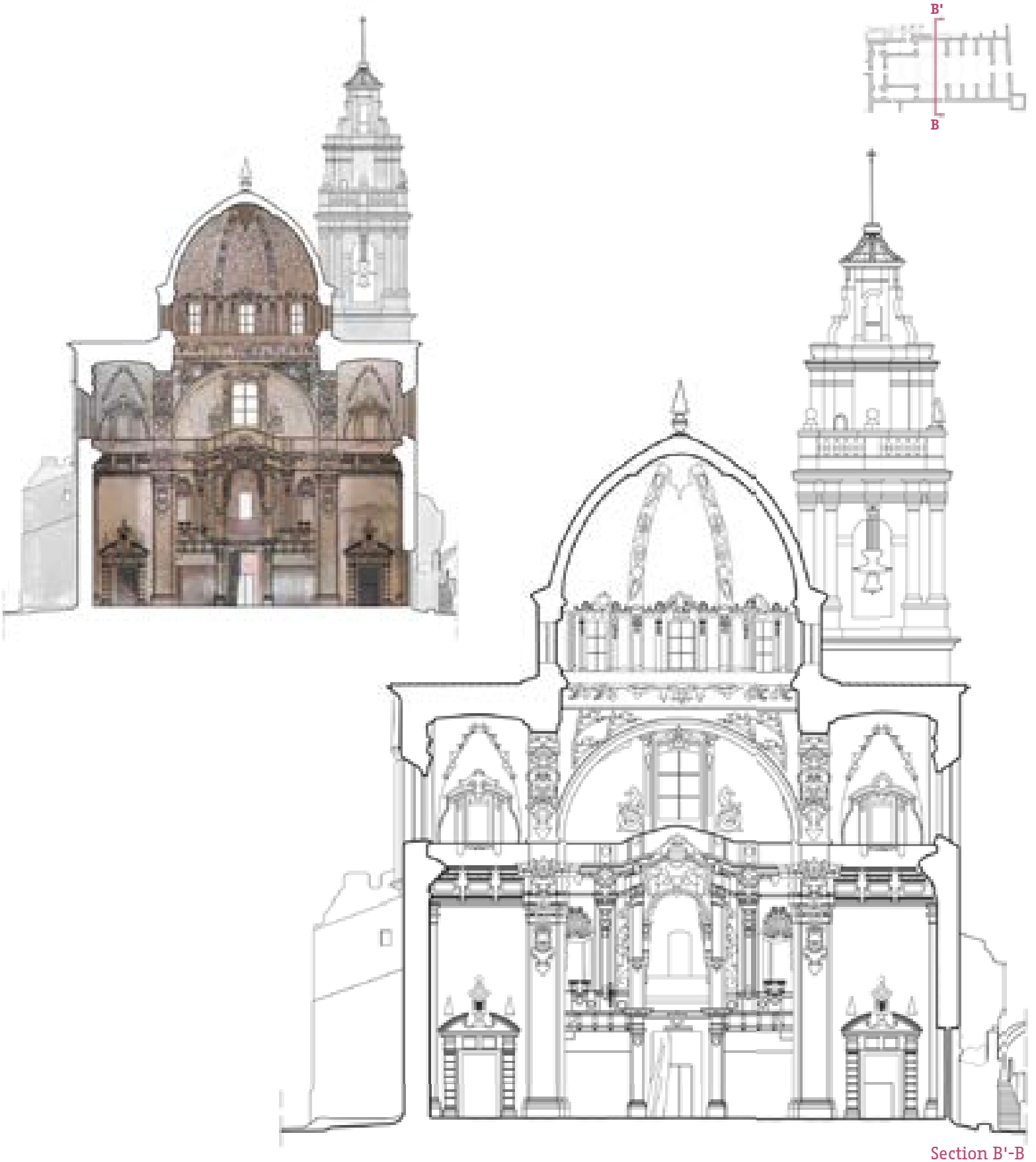

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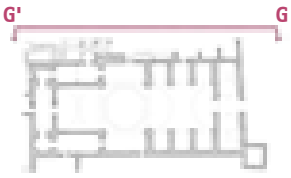

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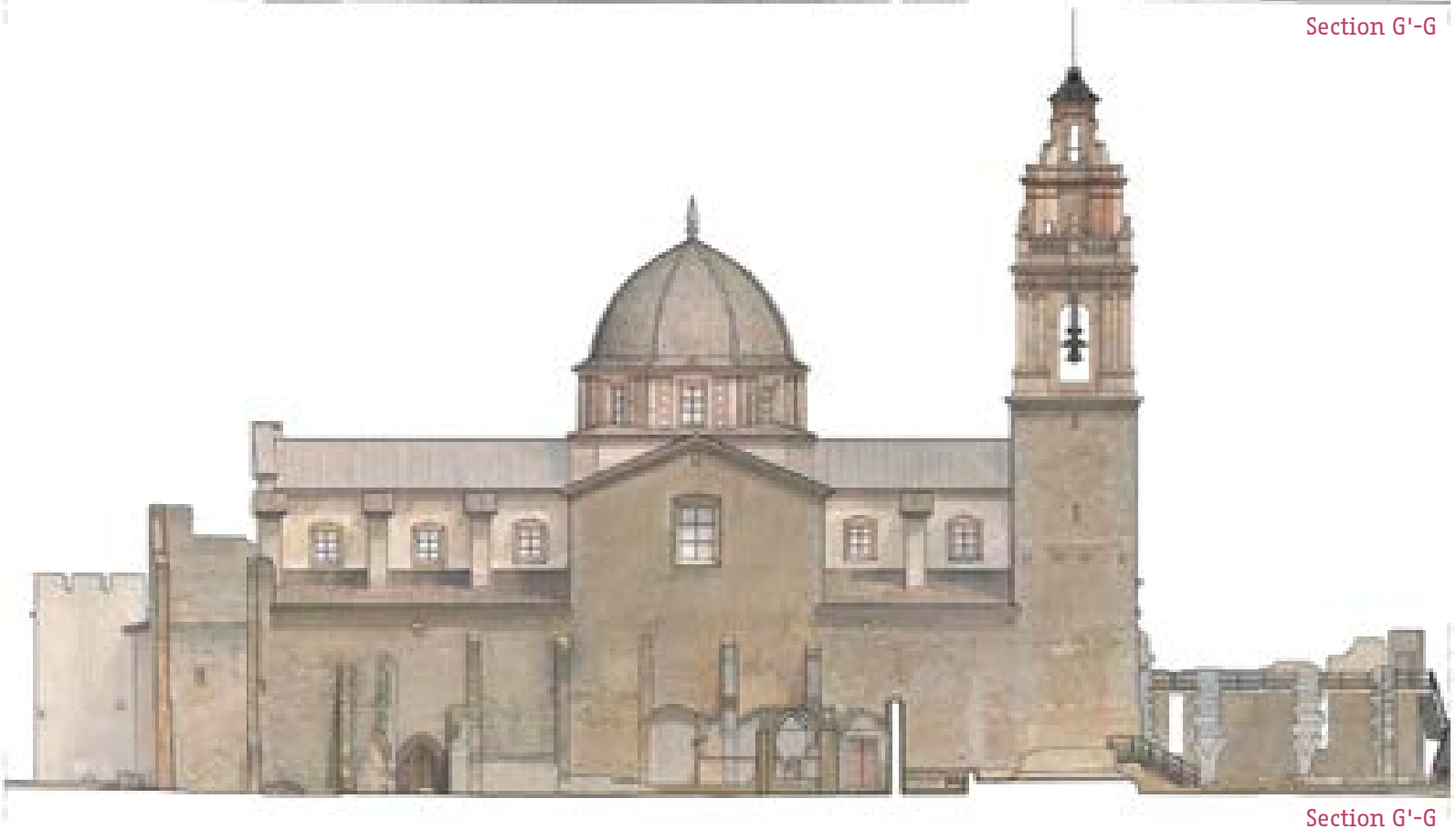

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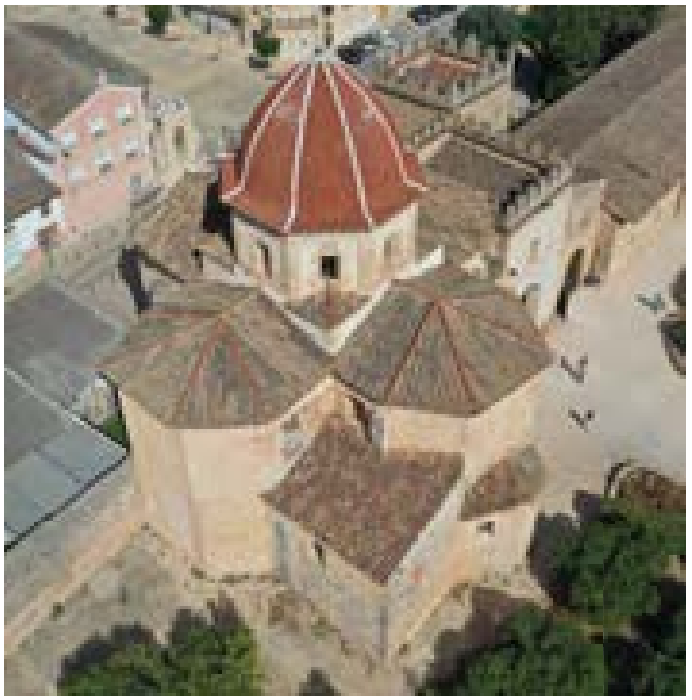


Fig.14
The monastic complex and its main elements
Left, Top view of the entrance building, in the foreground the dome of Virgen de Gracia Chapel; Right, remains and behind the refectory and the chapter house.

The Royal Gate or "Portal Nou"

The Royal Gate is built in the 14th century and is located to the west of the walled enclosure. It is the access of the wall to the monastic space that was used on important and solemn moments. It has a semicircular arch with three coats of arms (that of the Crown of Aragon and that of the abbot Arnau de Saranyó, its promoter). The sheltered space has a ribbed vault in perfect condition.

This modest gate is flanked by two towers that must have been crenellated and restored in the eighteenth century. The usual access door to the monastery, however, is located on the south wall and is called Puerta de la Xara[8].

The Cloister

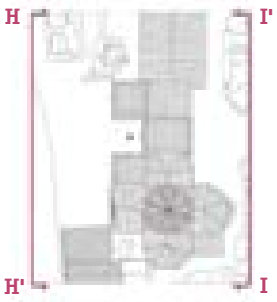
Unfortunately, little remains of the cloister, known as the "cloister of silence", the vital heart of the Benedictine monastery and the meeting point between its most important dependencies (Figure 5). Its plot is located to the south of the church, as usual. Its floor plan is square, and its pandas must have been vaulted with ribs (some ribbed corbels are preserved) and open to the courtyard by pointed arches[9].

The Chapter House

The Chapter House is located on the east side of the cloister. It is, without a doubt, the best-preserved medieval room of the monastery of Valldigna. During the fourteenth century, under the inspiration of the canons of Cistercian Gothic, a set of spaces was designed and erected around a large cloister

Side page, Fig.15
The Royal Gate
Significant elevations of the Building.

[8] Navarro Fajardo (2004), *Bóvedas valencianas de crucería de los Siglos XIV al XVI.*
[9] Cf. Pérez de los Ríos, Zaragozá Catalán (2013), *Bóvedas de crucería con enjarjes de nervios convergentes que emergen del muro en el área valenciana, ss. XIV - XV*; Zaragozá Catalán, Gómez-Ferrer (2008), *Lenguajes, fábricas y oficios en la arquitectura valenciana del tránsito entre la Edad Media y la Edad Moderna.*



Section H-H'

Section I-I'

Side page, Fig.16
Chapter House and Refectory
Significant sections of the Building.

that, even so, had an ephemeral life: in 1396, due to an earthquake, much of what had already been built collapsed, to the point that the first church had to be rebuilt ex novo a few decades later. Almost three centuries later, a new seismic movement would force a profound renovation of the complex, which adapted, on this occasion, to the Baroque aesthetic, especially visible still visible in the church and in the chapel of the Virgen de Gracia.

At the end of the 15th century, a new building was built on the site of an earlier building in the time of Abbot Roderic de Borja – the future Pope Alexander VI – and was completed at the beginning of the 16th century. It is an almost cubic room, topped by battlements, which is accessed from the old cloister through a much-destroyed Gothic-flamboyant door flanked by two windows with scarlet arches. Inside, it has a reconstructed starry vault. The vault is crossroads with two corbels depicting angels carrying shields. Above this are two narrow, flared windows. Abbot Pere Baldó (1499-1502) made the ogee arch of this oratory[10].

Refectory

Its construction dates to the 15th century, during the time of Abbot Joan d'Aragó (1460-1475). It is a large rectangular building, located to the south of the cloister, of which only three of the original perimeter walls are preserved, of great thickness and topped with battlements from the sixteenth century. A pointed arched door connected it with the cloister. Inside, you can clearly see the large corbels that collected the ribs of the ribbed vault that covered it and that disappeared completely.

A recent restoration has made it possible to close the space by reconstructing the western wall and it has been vaulted with ribs, simulating the original[11].

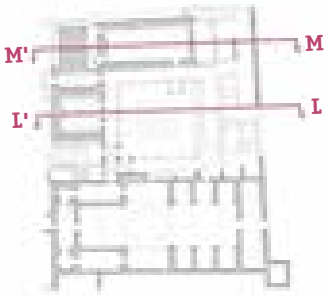
Parlor

It is a small rectangular space, like a corridor, located between the chapter house and the refectory and open to the cloister, which had the function of conversation between the monks. The entrances were two small doors pointed at their ends.

Abbot's Palace

It is located at the eastern end of the complex and, like other rooms, has disappeared; It's somewhat isolated from the rest. It was built by Abbot Arnau de Saranyó during the third quarter of the fourteenth century, but its final construction is a set of different periods, from the century to the eighteenth century. The abbot resided here, and it was also used for audiences with illustrious people. The upper cloister is made up of ten pointed arches on columns whose capitals are sculpted with the coats of arms of Abbot Saranyo and the Crown of Aragon[12].

[10] Cf. Capilla Tamborero (2008), *Graphic Representation and Geometric Analysis of the Springers of the Star Vault of the Chapter House of Santa María Monastery in Simat de Valldigna (Valencia, Spain)*; Navarro Fajardo (2005), *Bóvedas valencianas, cit.*
[11] Gómez Martínez (1998), *El gótico español en la Edad Moderna. Bóvedas de crucería., cit.*
[12] Zaragoza Catalan A (2000), Arquitectura gótica valenciana, cit.



Section L-L'

Section M-M'

Fig.17
The monastery today
In dialogue with the urban centre and surrounding hills, the monastery is still a tangible trace of the cultural and stylistic richness of the time.

Period of Decline, Ruin, and Recovery

In 1835 the decree of confiscation of the property of the clergy led to the dissolution of the monastic community of Valldigna and its lordship, the exclaustration of the monastery and the sale of all its property. The departure of the monks, the looting and plundering of the monastery, as well as the subsequent transformation of it into an agricultural exploitation, contributed, as much or more than the earthquakes suffered, to put an end to the former splendor of the Royal Monastery[13].

Most of the monastic buildings were demolished, and the pieces with which they had been erected were sold as building material. The movable goods and documentary collections that had been treasured by the community were dispersed in the footsteps of the ancient, cloistered monks.

A group of Valencian intellectuals and historians took an interest in public opinion on several occasions about the danger of the complete disappearance of the remains of the old Royal Monastery. All this allowed the group of buildings to be declared a Historic-Artistic Monument in 1970. And today, the monastery of Santa María de Valldigna, which is no longer used for religious use, has been prepared for visits and is a place increasingly known by those interested in Valencian art and history.lowable condition.

[13] Delicado (2000), *El Monasterio Cisterciense de Santa María de la Valldigna tras las desamortizaciones del siglo XIX.*

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Castles and fortified systems
Places of frontier and cultural exchange

Angriulena,ó Fesa Villa de
azas de Campo, una de Bla
antes era Conuento de Des
, yla otra de Marques Villa
no por si yotro por la Alque
linos, con los nombres, unc
s, des Arreras, ydra Arrezer
Cabanes, otro de Madraman.

tra Arrezera, que mu
ardls, otro de Salazar,
e de dicha Fesa de
la Mata, con dos
a Fesa de Tarragona,
con una muela
rantes escorribles
; ydl otro, de Ba
ns yotra Arro:
Fesa de
n

Traste, como queda dicho, de manera, que dicho
Comun y Consejo General de la
expresada Real
Azequia.

THE CITY WALLS OF ALZIRA AND THE HOUSE OF JAMES I

Agustí Ferrer Clari

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Side page, Fig.01
An 18th-Century Layout
Mapa de la Sequia Reial del Xúquer by Juan de Roxas, 1765, Museo Municipal de Alzira.

The Casa Reial or de l'Olivera is a Cultural Heritage Site by virtue of the additional provision of Law 4/1998, dated June 11, on the Cultural Heritage of the Ministry of Culture (R-I-651-0011038). It is located in the historic center of the Vila d'Alzira, which was declared a Cultural Heritage Site by Decree 126/2004, dated July 30, from the Consell de la Generalitat, with the category of historic ensemble, DOGV no. 4,811 of August 3, 2004.

In Alzira, it has been passed down through oral tradition, from parents to children and from generation to generation, about the existence of the so-called Casa Reial, where James I resided during his stays in this royal town, at a specific location known popularly as the Casa de l'Olivera.

Originally, it was a large tower that served as the Casa dels Jurats de la Vila until the late 15th century when they decided to move to the central area of the town, to what is now the current Casa Consistorial. The construction of the new building began in 1540 and was completed in 1603, marking the end of the old house-palace. From then on, it was presumably used as residential housing, with the space being divided into single-family properties anwd doors and windows being opened, which over time distorted the external and internal appearance of this noble and significant building. This transformation process continued until the late 20th century, when the building was acquired by the Town Hall.

> *Tradicionalmente, se ha conservado la denominación de la "Casa de la Olivera" donde se encontraba la ubicación de las estancias reales.... En este primitivo inmueble se albergaba la administración de la Vila, personificada por las figuras del Batlle, Justicia, Jurados, Racional, Síndicos, Escrivà y Mustafá. Estos decidieron a mediados del s. XVI adquirir y reformar una casa solariega - la denominada comúnmente de Santiago- para ubicar allí las dependencias municipales*[1].

Calle Major Santa Maria is part of the central axis that runs through the historic center of the ancient island of Xúquer (Al-Jazira), an isolated and fortified meander structured in two parts: a smaller area where the al-Kassar was located, and a larger area where the Madina was situated. Between these two nuclei was an empty zone serving as an albacar (a defensive enclosure). It was in this area that James I chose to settle when he agreed to the transfer of the town.

[1] Montagud (1990), Alcira, *Estudios Artísticos*, vol. I.

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Historical Background

During the Almohad period (12th-13th centuries), Al-Jazira Suqar was a splendid town where some of its inhabitants excelled in the arts, literature, sciences, and politics, as reflected in the description by Al Zhuri in 1147, who highlights the high social status: "...between Murcia and Valencia, to the east, flows a great river called Xúquer, from the city of Conca. In its midst is an island called Al-Jazira. The most splendid construction there is a great bridge with three arches, an ancient and excellently made work. The people of this island are refined and well-to-do".

Another piece of evidence is the solid walls that protected it. In addition to the archaeological remains preserved in the Museu Municipal d'Alzira-MUMA, which come from excavations of the Vila's underground, a notable fragment of wall was found on Calle de la Sang, featuring geometric and vegetal decoration with two Kufic inscriptions.

After the capture of Valencia, James I began preparations to advance further south of the Xúquer. Alzira was a stronghold that protected the river crossing, so after negotiations, an agreement was reached with the residents.

Fig.02
Fortified Layer in the Urban Landscape
Drone view of Alzira's medieval walls (2023), showing their integration into the contemporary city.

329. *E al torn que nos faem, lo Rayz D'algezira era exit Dalgezira per por que hauia de nos, e era sen exit be ab ·XXX· cauallers, e anaua sen a Murcia: e romas lo poder de la vila en los sarrains e en lo senyoriu. E enuiaren nos sos missatges que Algezira era bon loch e honrat, e dels meylors que fossen en lo regne de Ualencia: e si nos ho uoliem que ells sauenrien ab nos, nos lexant - los en aquell loch. E a nos plach nos molt la paraula quens enuiaren a dir, e dixem los quels penriem a merce, e quels rendriem en aquel loch, e els quens donassen poder daqueles torres que son a la porta de Ualencia. E els dixeren ques acordarien, e quens respondrien. E nos demanam los quant seria la resposta, e els dixeren que al tercer dia, e plach nos molt.*

330. *E uengeren al tercer dia a nos a Ualencia dels ueyls de la vila dels meylors que y eren, e foren ·IIII· per wtots los altres. E dixeren nos quens darien la torre que era maior que es prop del Pont de la Calçada que era a la porta que nos demanauem. E nos dixem los quens playa, car els tambe auenien en nostra fazenda, e quels amariem els fariem be. E faeren ses cartes ab nos con romasessen en Algezira ab aquels furs e custumes que eren en temps de los almohades: e que poguessen fer lur ofici en les mesquites aixi con solien, e que tot catiu sarrai que uingues a Algezira que fos alforro, e que nos nol poguessem cobrar ne nuyl hom per nos: e donaren nos dia que a ·V· dies que uinguessem cobrar la torre. E nos dixem los quey seriem a aquel dia, e que faessen exir tots los ueyls de la uila el altre poble, e quens jurassen faeltat, e quens serien leals a nos e als e als nostres, e als nostres homens.*

331. *E sobre aço nos uinguem al dia, e exiren a nos tots los ueyls, e juraren sobrel libre del Alcora quens serien bons e leyals, e que guardarien nostre cors e nostres membres, e els nostres homens quey metriem que tinguessen nostre loch. E quan nos haguem enparada la torre pregam los que els uolguessen quens dessen tro a la tercera torre, e nos quey fariem ·I· mur perço quels chrestians no entrassen als sarrains ni els sarrahins als chrestians, e quey fariem vna portela qui exiria a la Calçada per hon entrassen en la vila, e perço que ells no poguessen dir que dan los uengues de part dels crestians. E els dixeren que nons podien respondre menys de conseyl dels altres moros, e que tro a ·V· dies hahut conseyl nos respondrien. E nos pregam ne alguns dels sarrains dels majors queu conseylassen. E els dixeren que en tal manera ho farien que nos ne seriem pagats.*

332. *E quan uench a aquel dia responeren nos quels plahia, e atorgaren nos ho. E feem fer nostre mur entre nos e ells de ·II· parts, e fo aixi enclos lo castell e enfortit. E aixi haguem Algezira, e prenguem les rendes que solia pendre la Rais Dalgezira, ço es lo fenyor.*[2]

[2] Aguiló y Fuster (1873), *Chronica o comentaris del gloriosissim e invictissim Rey en Jacme Primer Rey d'Aragó, de Mallorques e de Valencia compte de Barcelona e de Montpesler.*

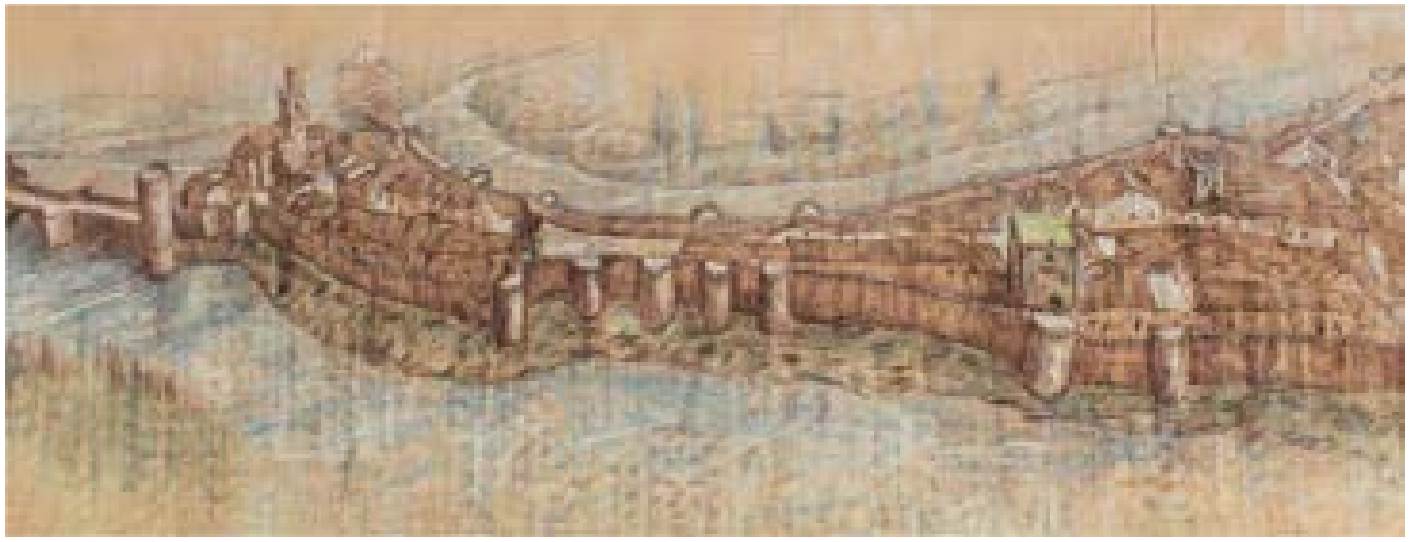

Fig.03
Visual Traces of Mediaeval City
This mural, located next to the Royal House of Alzira, through a vivid artistic representation, offers a glimpse into Alzira's historical structure, integrating architectural and landscape elements of the period.

In the Llibre dels Feyts: *Chronica o comentaris del gloriosissim e invictissim Rey en Jacme Primer Rey d'Aragó, de Mallorques e de Valencia compte de Barcelona e de Montpesler*, by Marian Aguiló y Fuster. It is important to highlight what is said after taking possession of this tower, which was the largest:

> *"... quens dessen tro a la tercera torre, e nós quey fariem I mur, perço que els chrestians no entrassen als sarrains ni els sarrains als chrestians..."*. Añadiendo a continuación: *"... E feem fer nostre mur entre nos e ells de II parts, e fo aixi enclos lo castell e enfortit"*[3].

It seems clear that James I closed and reinforced the Castle with a wall, thereby dividing the island into two parts, both physically and socially. Initially, it appears contradictory to close off a castle, which is already an enclosed space, unless it was previously open. We interpret that while the alcázar might have been open, the area between it and the medina, as noted, had an open space dedicated to the albacar, where there was a tower. It was in this area that the division and closure were implemented by erecting a separating wall.

Fig.04
Archaeological excavations
Photograph documenting the upper detail of a masonry structure. The stratigraphic context (UE 221) provides useful information on the construction phases identified on site.

In 2012, an excavation was conducted next to the façade of the old Santa Llúcia convent-hospital, located across from the Casa Reial. This excavation revealed a fragment of a wall running transversely to the street, cut and hidden beneath the sidewalk and pavement, which was interpreted as being the same as mentioned in the documentation.

James I, on one hand, in acknowledgment of the town's voluntary surrender under his promise of protection, and on the other hand, given the strategic importance of controlling this key point, retained control for himself, declaring it a Vila Reial. Within its walls, he established his residence. From there, he directed part of his campaigns, issued judgments, and even spent the final moments of his life.

[3] Aguiló y Fuster (1873), *Chronica o comentaris del gloriosissim e invictissim Rey en Jacme Primer Rey d'Aragó, de Mallorques e de Valencia compte de Barcelona e de Montpesler, cit.*

Fig.05
The Testament of the King
Detail of the painting *Últimos momentos del rey don Jaime I el Conquistador en el acto de entregar su espada a su hijo don Pedro*, by Ignacio Pinazo Camarlench, 1881, Oil on canvas, Senate Palace, Madrid.

560. E nos hoides estes nouelles quels chrestians eren desbaratats fom ne molt despagat, e haguem ab nos gran dolor. E per alguns dies aenant con fossem en Xatiua romasuts uench Linfant en ·P· fiyi nostre, ab Richs homens, e ab cauallers, e ab companya, al qual nos hauiem trames manament que uingues: e romas aqui en Xatiua ab tota sa companya per tenir frontera als moros. E nos pel trebayl que hauiem soffert, e car a Deu plahia, uench nos algun destemprament. E isquem nos de Xatiua, e uenguem nos en Algezira per trametre uianda al Infant e a sa companya: e aqui pujans e creschnos la malaltia, en axi que gracies a nostre senyor Iesuchrist en nostra bona e plena memoria nos confessam moltes uegades de bisbes, e de prehicadors, e de frares menors ab gran contriccio de nostres peccats, e ab grans lagremes: e depuys nos porgats dels peccats mundanals per rao de la confessio damunt dita, ab gran pagament reebem lo cors de nostre senyor Deus Iesuchrist.

561. E tot aço feyt, ueem nos esser agreujat per rao de la dita malaltia, trametem missatge al Intant en ·P· fiyl nostre que ell personalment uingues a nos a Algezira. E ell, demanat testament en que nos erem, pensa de partir de Xatiua per complir nostra uolentat, e uench a nos: e tantost fo denant nostra presencia lo uespre que uench e reebem lo, ell donan a nos reuerencia aixi con a bon fiyl deu donar a son pare.

562. E quan uench lendema lo dit fiyl nostre fo ab nos, e hoim nostra missa. E hoida la missa nos en presencia dell, e dels Richs homens, e dels cauallers, e dels ciutadans dixem li les paraules deius dites: Primerament en qual manera nostre Senyor nos hauia honrat en aquest segle, e especialment sobre nostres enemichs, e en qual manera nostre Senyor nos hauia feit regnar al seu seruiy pus de ·LX· anys, mes que no era en memoria, ne trobaua hom que negun Rey, de Dauid o de Salamo ensa, hagues tant regnat, e que ams sancta Esglesia: e en qual manera hauiem hauda amor e dileccio generalment de tota nostra gent, e con nos erem honrat ab ella. E tot aço regonexiem quens era uengut de nostre senyor Iesuchrist: e car nos per la major partida nos erem esforçat de seguir la sua carrera els seus manaments, e ell que degues pendre exemple de nos quant aço que era uia de be: e que aixi mateyx li pendria ell, complen e faen aço.[4]

[4] *Ibidem.*

Side page, Fig.08
Archeological excavation
Aerial view of the archaeological site within the medieval walls of Alzira, showing remains of the so-called Royal House and sections of the fortifications.

The meeting between father and son, in the presence of the other son Alfons and the entire military and ecclesiastical court, took place at the Casa Real of Alzira. It was a key moment in the reconciliation between the two protagonists, which was recreated and immortalised in a painting by the artist Ignacio Pinazo in the late 19th century.

It is sometimes difficult to understand our own history because it has been rewritten at different times. As previously noted, this is due to the transformations of the city and its surroundings, which have altered most of its cultural elements. Thus, Alzira has lost some of its historical foundations, such as the key features that gave it its name, the river and the walls that once surrounded and isolated wit.

Fig. 06
Façades nos. 3, 5, 7
View prior to demolition, showing structures containing medieval rammed earth walls and remains of the Casa Real.

Fig. 07
Façades nos. 7, 9, 11
Section of the monastic block with preserved party walls of archaeological interest, later integrated into redevelopment plans.

Recovery Projects

In December 1996, municipal architect Alfredo Andrés drafted the "Project for the Demolition of Buildings at c/Santa María nos. 3 to 13". Prior to the demolition, a wall survey was conducted to verify the historical background attributed to this urban space. As a result of the inspection, a report was submitted on February 25, 1997, titled "Elements of Archaeological Interest to Protect in the Demolition Project for Buildings at c/Santa María nos. 3, 5, 7, 9, 11, and 13". This report highlighted, among other significant elements: "... the existence of an exceptionally thick party wall between houses 1 and 3, which, running perpendicular to the street (N-S orientation), extends four meters from the façade line and reaches the two upper levels. Similarly, another impressive rammed earth wall was observed, serving as a party wall between houses 5 and 7, extending from the street to the city wall and rising to the building's roof. It is in relatively good condition, except for a fragment detached from the southern end, over what would be the courtyard adjacent to the wall, where there have been some collapses in recent years due to the abandonment of the houses and their progressive deterioration. Additionally, there was evidence of a brick arch at its base providing access to the walkway along the fortification. The space between the two walls corresponds to the so-called Casa Real. It is advisable to preserve these two walls as examples of medieval construction and integrate them into the new building project, thereby enriching our historical legacy". Point 5 stated: "... once the demolition work is completed, the resulting site is cleared and the structures are reinforced, an archaeological study will be conducted prior to the beginning of the new construction".

In February 2001, the houses were demolished, revealing the medieval structures, which were severely deteriorated due to the continuous adaptations they had undergone in subsequent renovations.

On May 31, 2001, the Territorial Directorate of Culture was requested to authorise an urgent archaeological excavation on the site. The work was carried out in several phases and study levels. One part of the work involved monitoring the demolition of the group of houses, particularly those between nos. 3 and 5, to uncover any potential historical elements hidden by previous renovations. As a result, the walls defining the perimeter of the tower were discovered.

In October 2005, it was reported that there was an urgent need for consolidation of the few remaining fragments, which were at risk due to their instability. Wall trenches were conducted to determine the dimensions of the formwork.

- Muro 1 (este): cajones de encofrado: altura 0.90 m. (dos tablas de 0'45); longitud de 1.80 m. espesor 1.50 m.
- Muro 2 (oeste): cajones de encofrado: altura 0.90 m. (tres tablas de 0'30); longitud, 1.80 m. espesor 1.50 m.
- Muro 3 (norte): cajones de encofrado: altura 0.90 m.; la longitud, 1.80 m.; espesor 1.50 m.

The studies indicated that the preserved structures belonged to a large building constructed during the Islamic period and enlarged after the Christian conquest, starting in 1242. It can be affirmed, according to the findings, that it was a large tower with a slightly trapezoidal plan.

In 2010, according to the project by municipal architect Ambrosio Ferrer, the structures were reinforced by closing door and window openings with formwork and consolidating the walls.

Fig.09
Dressed Dovetail
Close-up of a stone voussoir from an arched structure, showing precise ashlar work.

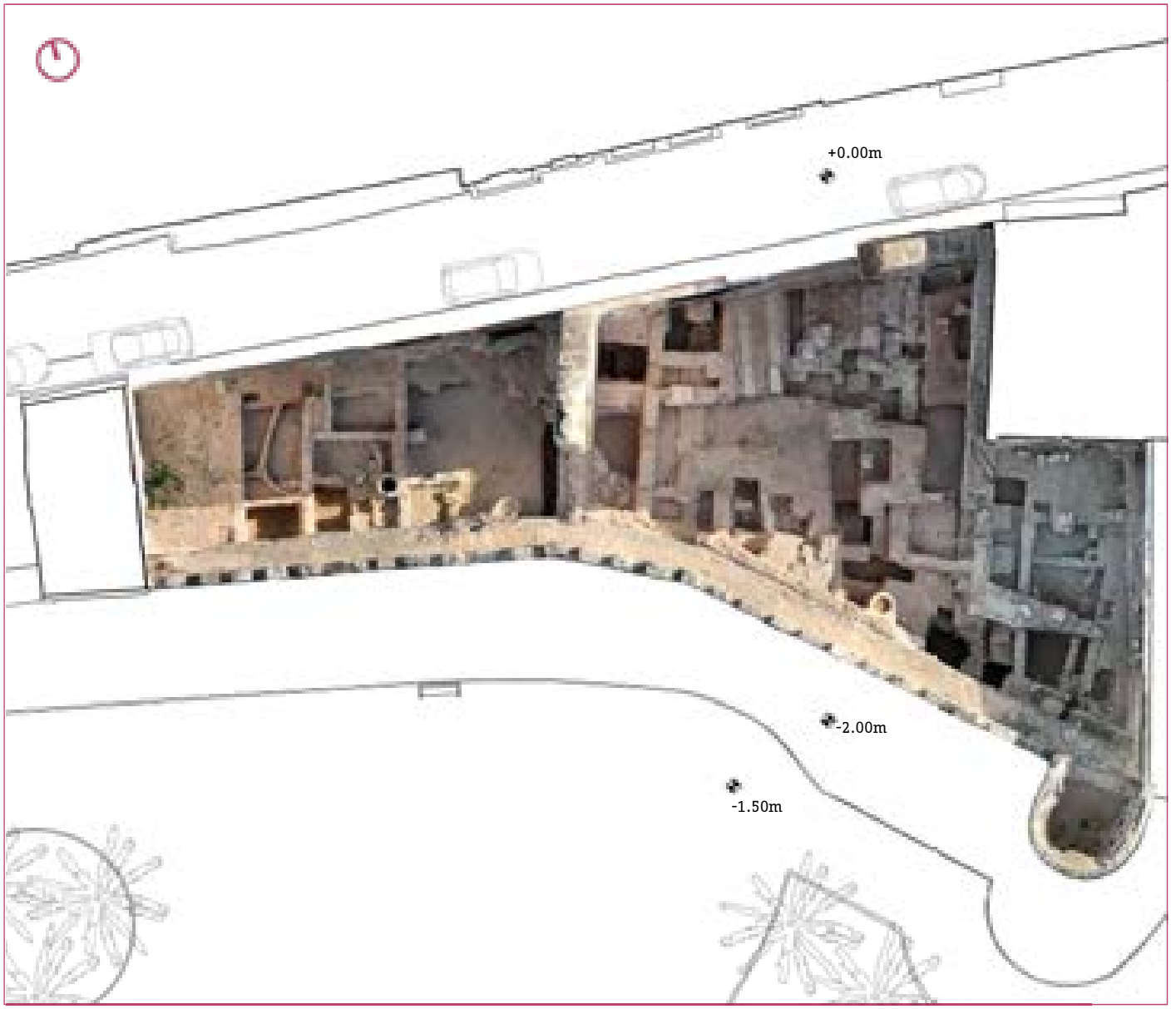

Fig.10
Archeological excavation
Planimetric drawing and orthophoto of the archaeological excavations within the medieval walls of Alzira, including the remains of the Casa Reial and adjacent structures.

Excavations were conducted in the central area and along the continuation of the eastern wall up to the city wall. Several occupation levels were identified, with the alternation of medieval and modern walls, removal and reuse of materials, and alterations caused by trenches dug for the drainage channels of the houses. A pavement in opus spicatum of solid brick laid in herringbone pattern was discovered in the central area.

One of the most notable finds was a mutilated ashlar arch uncovered when a door opening for a cart was created. Upon reviewing the stone pieces removed after the demolition, it was noted that one stone from the base of the door had inscriptions on its back that had been overlooked due to the dirt covering them. Once cleaned, it was found to be a reused Roman funerary slab, with the front cut to be embedded in the wall and the back facing outward.

On December 7, 2021, the Ministry of Industry, Commerce, and Tourism (BOE 8-12-2021 no. 293) granted a subsidy of €2,300,000 under the Recovery, Transformation, and Resilience Plan, National Tourism Plan Xacobeo 2021-2022, for the Project to Recover the Torre Real of James I of Aragón: creation of a cultural museum space, and €400,000 for the Restoration Project of the Almohad Walls: restoration of the curtain wall and towers, and reconfiguration of the old pedestrian path, according to the basic projects by architect Miguel Vila Donato.

Prior to the execution project, extensive archaeological excavations were conducted, directed by Maria Clausi and the undersigned, to uncover archaeological remains that could be integrated into the building for preservation and display, as well as to provide information about the different historical phases of this unique space. The musealization of the archaeological and architectural remains of the Tower and the wall will be of great significance not only for Alzira but also as a reference point and symbol of identity for all the towns of the former Crown of Aragon.

The excavations concluded in March, and it can be preliminarily anticipated that the Muslim rammed earth walls underwent various interventions. In some cases, such as the perimeter walls to the east and west, they were heightened, while in other cases, such as the southern closure wall parallel to the city wall, they were removed. The internal walls were subsumed under Christian structures and pavements. As the building lost its military function and became the town's administrative center, the Casa dels Jurats, it was adapted for functional use. Later, in the 16th century, reforms began to alter its appearance, as it was divided to acquire a more domestic character. The urban development of this part of the Vila involved demolishing part of the northern wall to widen the street, creating and blocking openings in the resulting wall.

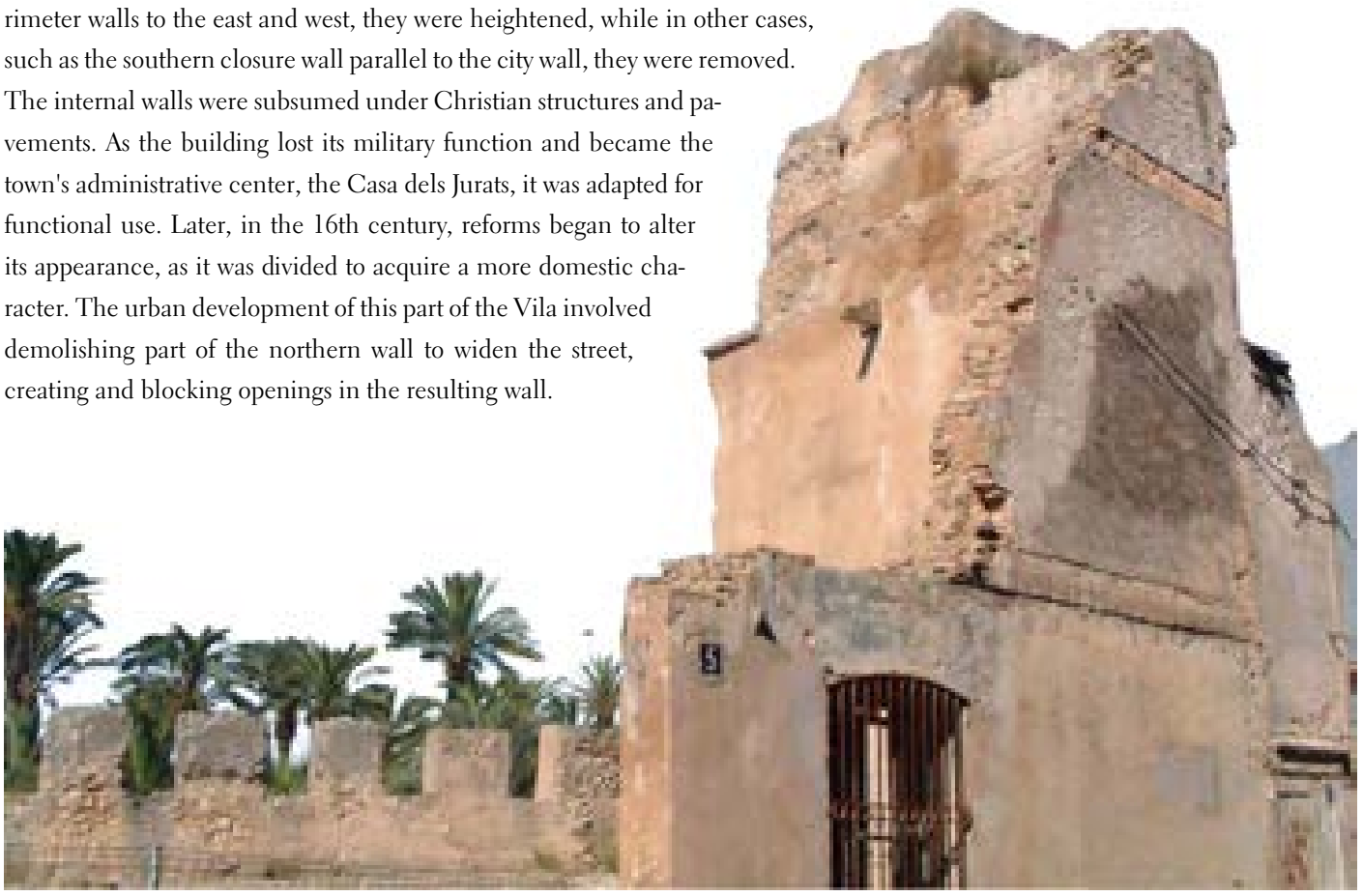

Fig.11
Remains of the James I's House
View from the street showing the preserved elevation and masonry of the so-called *Casa Reial*.

Fig.12
Consolidation of the Western Wall
The west façade of James I's House during consolidation works.

The building lost its tower-like appearance due to changes in functionality, becoming multiple residences that continued to undergo modifications, renovations, and repairs until the 20th century.
The numerous historical, social, political, military, religious, and economic events have made Alzira a city that has not remained static but has evolved with time, transforming into a modern urban center that has witnessed some episodes of its past with indifference or has been powerless to prevent its destruction.
The Xúquer River, at times an ally of the city and at others its enemy, has repeatedly ravaged the population, forcing it to rebuild with new buildings erected over the ruins of a historically beleaguered city. Consequently, there are few or no surviving buildings from each era that can refer to the history of Alzira, making it difficult for residents to recognise their history through these structures.
The continuous transformations of the city, driven by demographic growth; constrained by the city walls and the river; by natural disasters such as earthquakes or floods; sieges, or accidental or intentional fires; social or mental changes; expropriations or the Civil War; not to mention drastic environmental changes such as the removal of the surrounding river arm, have altered many cultural elements, either losing them entirely or transforming them for adaptation. Thus, Alzira has lost some of its historical roots, including the elements that gave it its name, such as the river and the wall, which surrounded and isolated it, hence the toponym "the island" (Al Yazirat).
For all these reasons and more, the recovery of the city's historical remains that are preserved or may emerge through archaeological studies of the subsoil is necessary, as they are constitutive, original, and relevant parts of the town's identity, such as the Casa Real and the city wall. Recovery will signify a reconciliation of Alzira with its history.
The cultural, social, and tourism valorization of these two Cultural Assets of Interest will revitalise the historic center of the Vila, improving a degraded urban and cultural space.
The Casa Real is one of the assets that has transitioned from being a part of local memory to becoming a cultural asset to be recovered, integrating among the few survivors of an era affected by the vicissitudes of time and urbanism.
After the demolition of the constructions attached to the preserved walls of the original building, hidden and degraded by successive renovations, it has ceased to be merely part of oral tradition and has become a reality. The appearance of the buildings that previously defined the space did not correspond to the presumed Casa Real, and repeatedly during visits by schoolchildren or tourists, they expressed skepticism about the accuracy of the claim that the King had lived in these houses, seeing only the limited architectural value of the structures before them. The archaeological excavations and the recovery projects for the Casa Real and the wall will dignify this space, which has great material and immaterial value, and thus significant identity sentiment as one of the most important in the history of the territories that comprised the former Crown of Aragon.

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3D DATABASE AS AN ELEMENT OF THE KNOWLEDGE PROCESS OF CITY WALLS

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Side page, Fig.01
The House of James I
TLS point cloud of the complex.

In recent years, the walls of Alzira have been subject of several academic studies that have delved into its origin and evolution over time. These studies, which represent a valuable contribution to the knowledge of the local historical heritage, have gathered a wide range of detailed information, providing an exhaustive overview of the transformations undergone by the city.

The history of the Alzira walls is indeed rich and complex, reflecting the different historical phases the city has passed through. According to scholars such as Bernat Montagud[1] and Augustí Ferrer Clarí[2], Alzira has Muslim rather than Roman origins, as evidenced by numerous ceramic finds from that era. During the period of Abderraman III and the subsequent conquest by El Cid in the 11th century, the city developed a fortification that surrounded the "villa". Built before the 10th century, the walls underwent various modifications and reinforcements over the centuries, adapting to changing defensive needs and urban transformations[3].

In the Christian period, the walls were maintained and repaired, with significant expansions and reinforcements between the 15th and 17th centuries to address the rising ground level due to river sediments[4]. During the War of Spanish Succession (1701-1714), the wall suffered severe damage due to the conflicts, but it was subsequently repaired and further fortified to ensure the city's protection.

From the 19th century onwards, Alzira experienced a period of economic prosperity that led to considerable urban transformation, with an expansion into new areas and the construction of new buildings outside the historic core, so the walls gradually lost their defensive function, becoming an obstacle to urban development. Starting in 1918, the walls became municipal property, and many sections were then demolished to allow for the city's expansion and improved traffic flow[5], and only in the 1960s an attention to the conservation of the walls and Alzira's architectural heritage began to manifest. In 1973, a restoration project for the walls was finally approved, and in the following years, various archaeological excavations were conducted to recover the remains of the fortifications[6].

The remains of the walls have been protected as a Cultural Interest Asset since 2003, but the

[1] Montagud Bernar, Lairón, Carrillo (2006), *Alzira, l'illa del Xúquer.*
[2] Cf. Ferrer Clarí (2020), *Les muralles d'Alzira, escut de la ciutat y clau del Xúquer*; Id., 2020, *L'illa del Xuquer (ss. VIII - XI).*
[3] Soler Molina (2000), *Alzira de Xúquer: gènesi urbana i urbanisme planificat a la cora andalusina de València (segle IX).*
[4] Fili (1935), *Inundaciones, terremotos, pestes y otras calamidades que ha sufrido Alcira.*
[5] Alba Pagán, Lairón Pla *(2020), Història d'Alzira.*
[6] Tabernes Pastor, Broseta Palanca (2017), *El plan especial de protección de la Vila de Alzira.*

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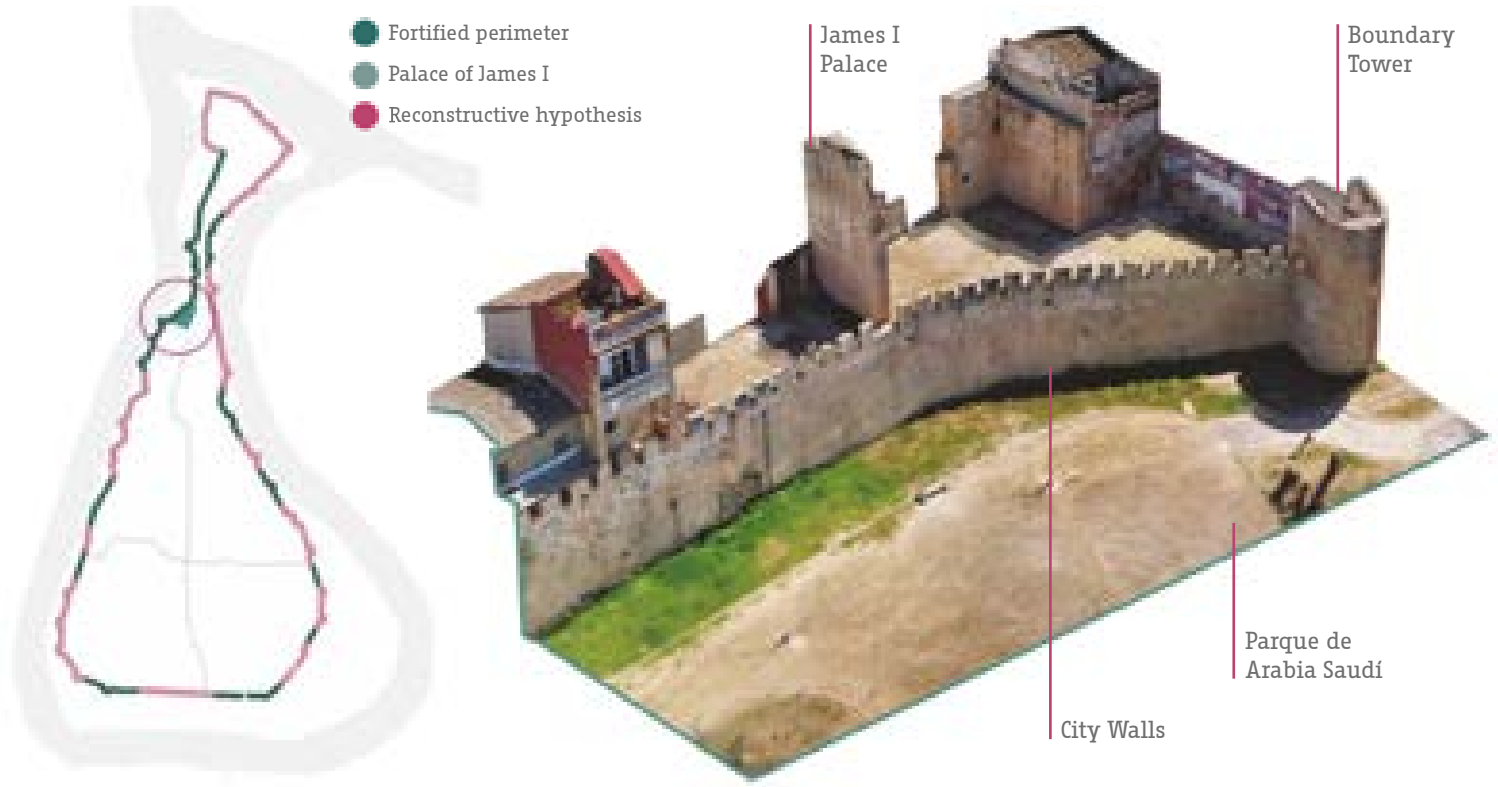


Fig.02
City Walls and James I's House
Diagram showing the fortified perimeter of Alzira with the location of James I's Palace (Casa Reial), alongside an axonometric view highlighting the main architectural elements of the palace and the adjoining city walls.

urbanisation of the 19th and 20th centuries has led to loosing many parts of the walls[7], and today only three large sections remained partially intact: the *Parque de Arabia Saudí*, the *Plaza del Mercado*, and the *Ronda de Algemesí*. Their conservation is crucial, so, as part of the Prometheus project, particular attention has been given to the section of the wall that overlooks the Parque de Arabia Saudí, located in the southwest part of the walled area of Alzira. This segment not only represents the most extensive and prestigious section of the wall, thanks to its integration within a public park, but also highlights significant needs for restoration and conservation. Of particular interest is the presence, over the walls and towards the inhabited historic center, of the historic *Casa de Jaime I*, currently in a state of abandonment. This underscores the crucial importance of knowledge and conservation operations, not only to preserve the historical and architectural value of the walls themselves but also to safeguard a cultural heritage of national relevance.

Heritage at risk: the walls of Casa de Jaime I

The section of the walls overlooking *Parque de Arabia Saudí* is characterised by the presence of eight towers, whose heights range from 5 to 10 meters, exemplifying the defensive architecture's capacity to adapt to the topographical variations. Strategically positioned, these towers were an integral part of the fortification's surveillance and defense mechanisms, providing defenders with a commanding view of the surrounding landscape[8].

Side page, Fig.03
The city Walls in the Urban Landscape
Aerial and street-level views of the preserved sections of Alzira's medieval walls, near James's House, illustrating their integration into the contemporary urban fabric.

[7] Alba Pagán, Lairón Pla (2020), *Història d'Alzira*
[8] Ferrer Clarí (2020), *Les muralles d'Alzira, escut de la ciutat y clau del Xúquer*, cit.

Fig.04
Documentation activities
Survey work along the city walls of Alzira.

The wall heights within this section exhibit considerable variation due to the uneven terrain: in the western segment, the walls attain a height of 3 meters, whereas in the central sections, they rise to 6 meters, mirroring the adaptive construction techniques employed to address and take advantage of the geographical conditions caused by the Jucar river.

The crenellations of the walls, with an average height of 40 cm, afforded defenders substantial cover while enabling them to observe and repel assailants. The walkway behind the merlons, the "paso de ronda," measures around 1.10 meters in width, facilitating the movement of soldiers along the wall for defensive maneuvers. This walkway extends for a total length of 300 meters, thereby creating a continuous defensive perimeter along this section of the fortifications.

The construction of these walls employed traditional *tapial* techniques, earthen structures with internal reinforcements: the *tapial* construction was reinforced with bricks and ceramic material, thereby enhancing the structural integrity and durability of the walls. Furthermore, the structure was fortified by brick pillars and masonry composed of bricks, ensuring resilience against both environmental elements and human attacks. The amalgamation of *tapial* techniques with brick and ceramic fillings signifies a confluence of local and imported construction practices, reflecting the cultural exchanges that transpired during the wall's development.

Side page, Fig.05
Integrated Point Cloud
Axonometric diagram of the integration of data from different survey instruments.

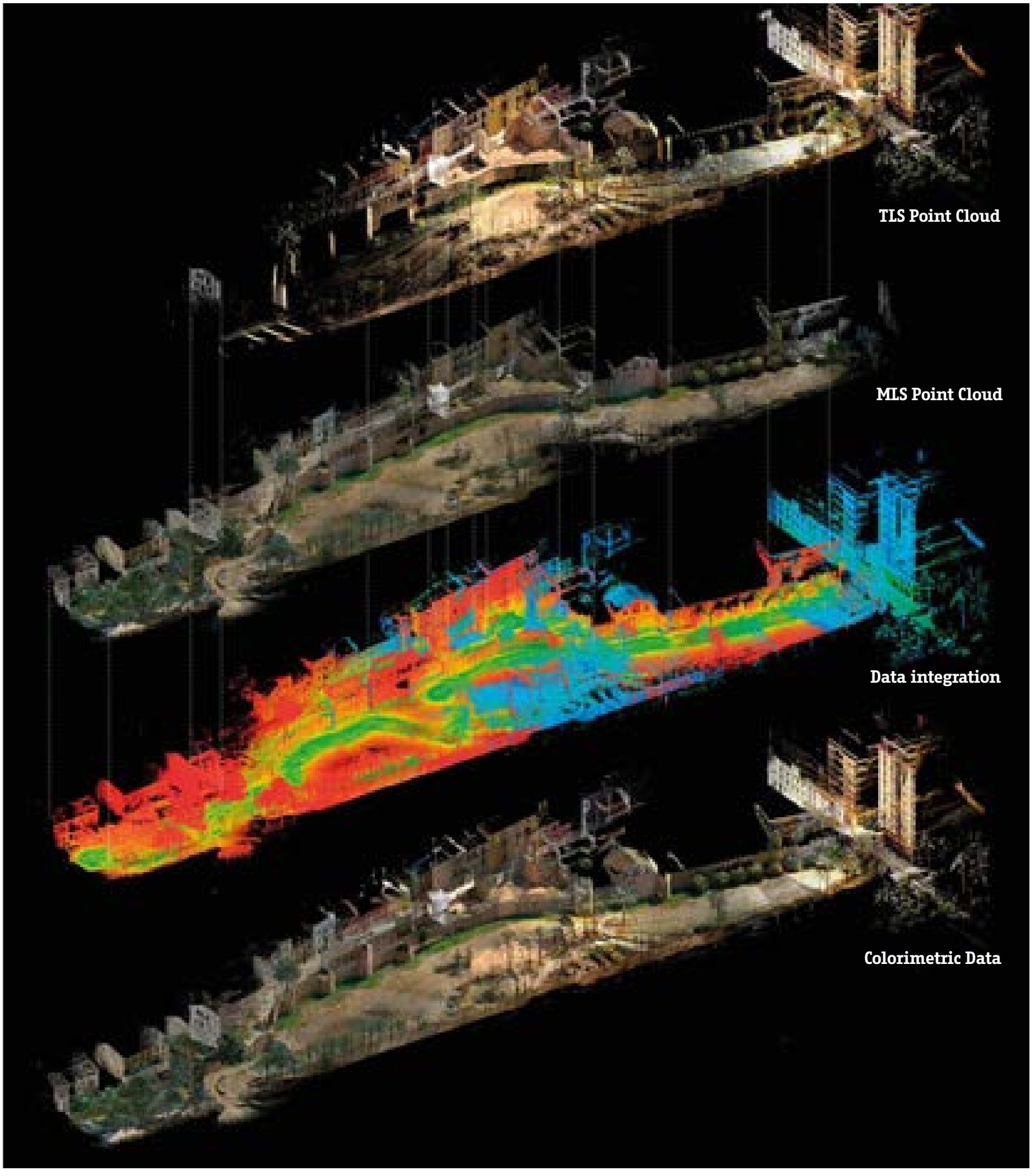

TLS Point Cloud
MLS Point Cloud
Data integration
Colorimetric Data

Fig.06
Digital database
Colorimetric view of the point cloud of the complex.

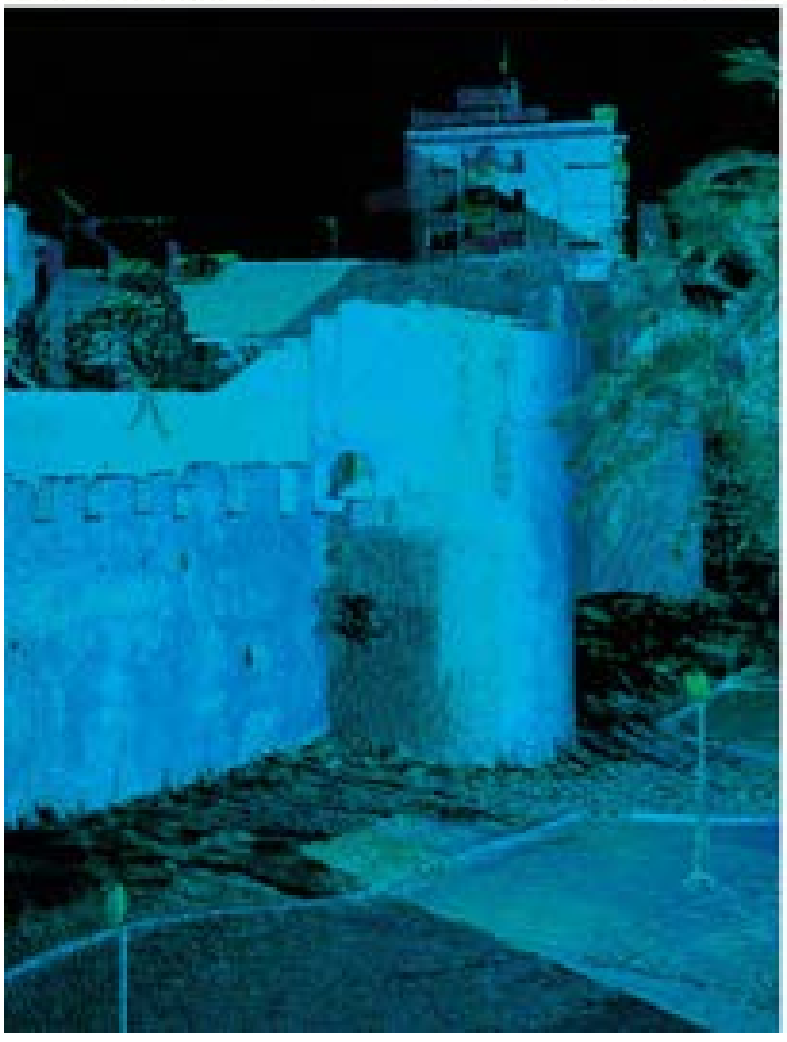
In the context of the fortifications, the *Casa de Jaime I* adds an architectural and historical dimension that enriches the understanding of Alzira's urban evolution. The structure itself, potentially dating back to the medieval period, complements the narrative provided by the walls. Together, they illustrate the living conditions, architectural styles, and urban planning of the time. Efforts to conserve and restore the *Casa de Jaime I* are then essential not only for preserving the individual structure but also for maintaining the integrity of the historical landscape in which it resides. Integrating the restoration of this house with the ongoing conservation of the walls enhances the historical narrative, providing a more comprehensive view of Alzira's heritage.

For this reason, the site has been designated as a green area and public park, reflecting a commitment to both preservation and community use and valorisation. Over the decades, the area has undergone several significant interventions[9]. In 1960, a cement coating was applied to the wall to presumably enhance its structural integrity. This was followed in 1975 by the comprehensive design and development of the park, which transformed the site into a space for public enjoyment[10]. Only in 2008, the remnants of the 1960s cement mortar were meticulously removed, a process aimed at restoring the wall closer to its original state and improving its historical authenticity.

With this perspective, in the context of conservation and valorisation projects, the digital acquisition of monuments plays a fundamental role, allowing for a detailed and accurate study of the walls, facilitating more effective restoration interventions thanks to a thorough understanding of the structure.

Side page, Fig.07
Digital database
Colour and Reflectance view of the Point Cloud.

[9] Mansanet (2019), *Las murallas de Alcira (Valencia)*.
[10] Tabernes Pastor, Broseta Palanca (2017), *El plan especial de protección de la Vila de Alzira*, cit.



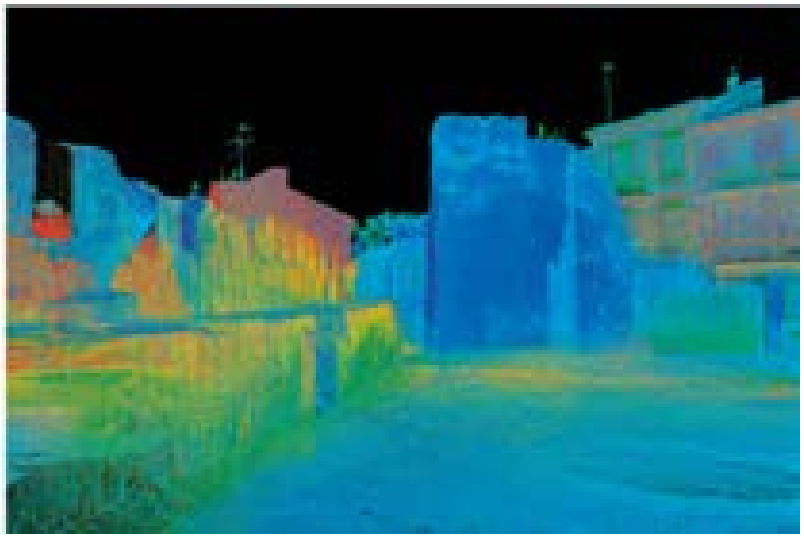


Fig.08, 09
Data Comparison
Comparative images of the data acquired through:
1. MLS;
2. TLS;
3. Data from drone;
4. DSLR surveys data.

Surveys and Integrated Databases for the Knowledge of the Walls

The survey activities, carried out in a single day during the August 2022 mission, employed various types of range-based and image-based instrumentation. The site's extent and morphological complexity, combined with continuous elevation changes and varying floor heights, necessitated a strategy to optimise the available resources and tools. In particular, range-based instrumentation was used to obtain a reliable metric baseline for referencing data from image-based acquisitions[11].

The laser acquisition campaign, involving TLS and MLS, was structured into two levels: the external level of the walls (along the park) and the internal level along the walkway (within the *Casa de Jaime I*). The TLS equipment (Faro Focus S150) was utilised for detailed surveying of the two levels, focusing exclusively on the central portion related to the *Casa de Jaime*. At the upper level, 17 scans were performed, 11 of which were conducted along the walkway near the merlature openings to align with the scans at the lower level. Along the lower portion, adjacent to the outer wall, 6 scans were carried out corresponding to those performed at the upper level. This approach allowed for the generation of two datasets that, when registered together, maintained an error margin of less than one centimeter, resulting in a metrically reliable database for integrating data from expedited acquisitions.

Given the site's morphology, which is fully integrated within the urban fabric, the MLS instrumentation (Leica BLK2GO) was employed to ensure broader data coverage, including not only the complete sections of internal and external walls but also the surrounding urban fabric[12]. Scanning paths were designed to connect the two fortified levels. 10 MLS scans completed the terrestrial laser survey, resulting in a morphometric dataset of the complex and its relations to the context, useful for understanding and analysing the stratigraphies and urban transformations that have occurred on the fortification.

[11] Costantino, Rossi, Pepe, Leserri (2022), *Experiences of TLS, terrestrial and UAV photogrammetry in Cultural Heritage environment for restoration and maintenance purposes of Royal Racconigi castle, Italy.*
[12] Dell'Amico (2021), *Mobile laser scanner mapping system's for the efficiency of the survey and representation processes*, pp. 199-205.


3

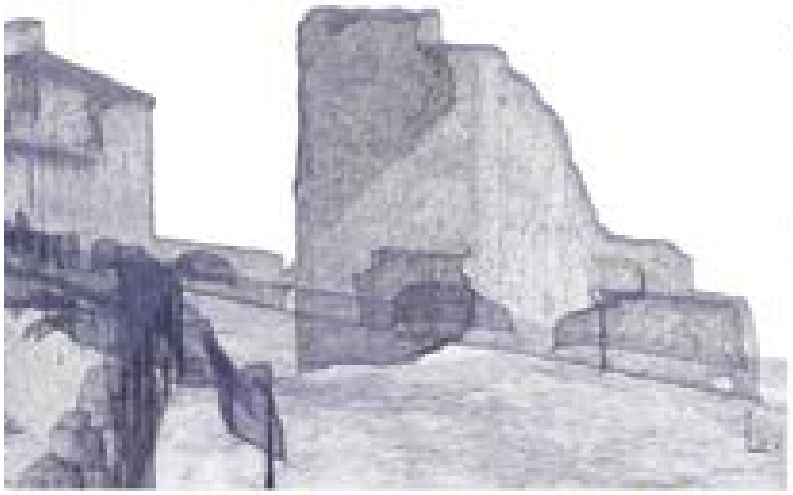

4

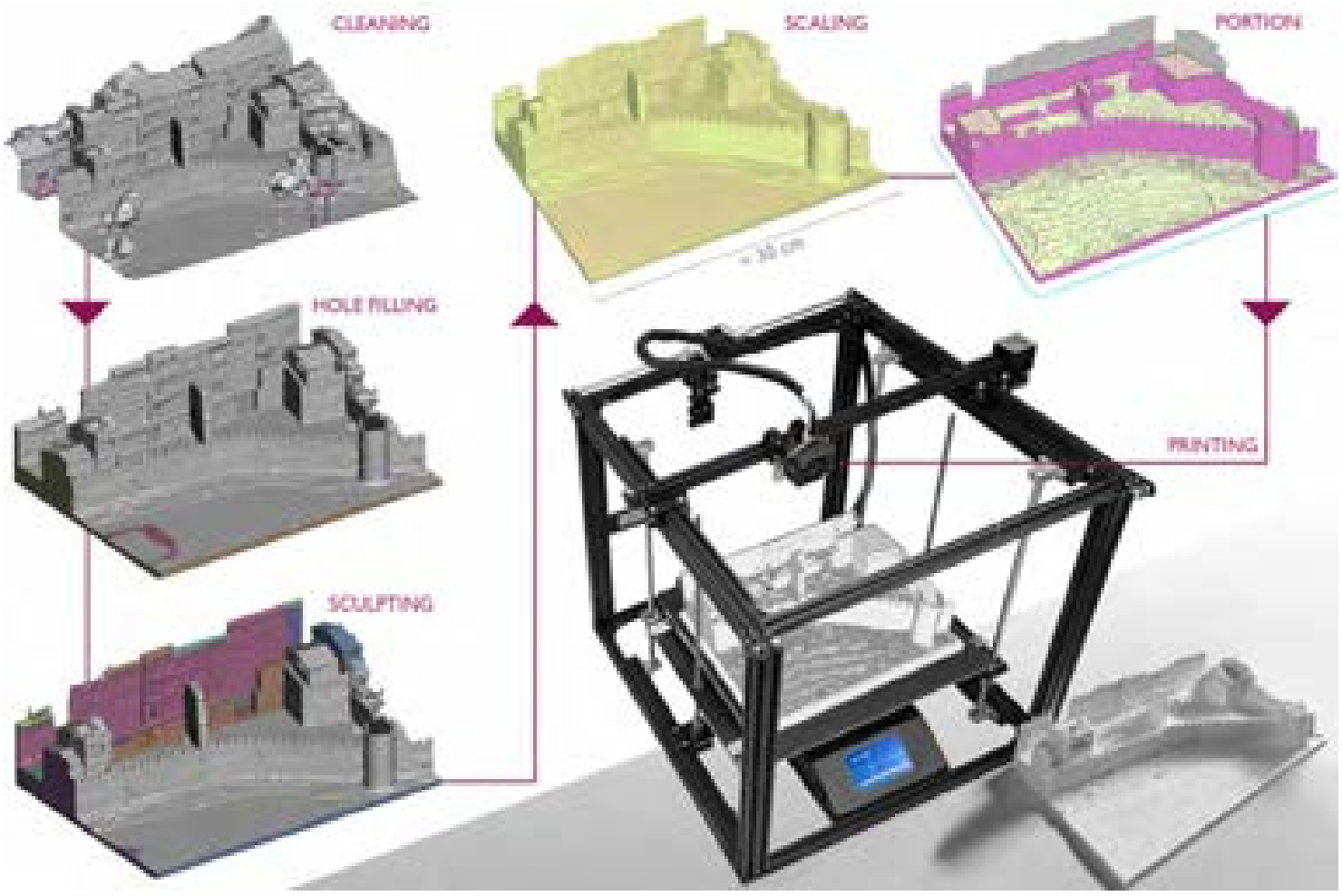
The laser database, consisting of 356.623.436 points, was integrated with data from photogrammetric acquisitions to enhance the metric data with more reliable and descriptive material and texture information. The photogrammetric acquisition campaign played a crucial role in completing and enriching the obtained data. Using a Canon 77D for terrestrial photogrammetry and a DJI Mavic Mini 2 for aerial shots, significant details of the walls and otherwise inaccessible areas were captured. Terrestrial shots documented fine details of the merlature and wall fronts, while aerial shots provided an overview of the roofs and upper portions of the walls, including defensive structures and walkways[13]. Two distinct flights were conducted: the first, with a radial point-of-interest flight plan, allowed for a detailed survey of the Casa de James, focusing on higher sections isolated from surrounding buildings; the second, with a grid flight plan, provided a comprehensive overview of the site and its urban context, filling in gaps from the MLS acquisition and offering an integrated view of the surrounding landscape. The processing of the photogrammetric datasets, including an average of 400 photos, led to the creation of high-resolution three-dimensional models, scaled according to the laser scanner coordinates and characterised by high precision in both material and colorimetric aspects. The datasets from the flights, were processed with photogrammetric software to produce point clouds and textured 3D models of the site, with sufficient resolution for augmented reality applications and 3D visualisation.

The final result is an integrated database combining point clouds obtained from TLS, MLS, and aerial photogrammetry, consisting of photogrammetric models and a wide range of data.

This database serves as a three-dimensional foundation for studies and enhancement interventions, enabling the development of innovative digital and physical products. The integration of augmented reality technologies has enabled the creation of 3D models for 3D printing and AR applications, offering new perspectives and scales of observation of the site and improving interaction with the cultural heritage.

[13] Rojas, Gomez (2021), *Levantamiento y documentación del patrimonio construido una experiencia en la aplicación de sistemas de registro*, pp. 27-44.





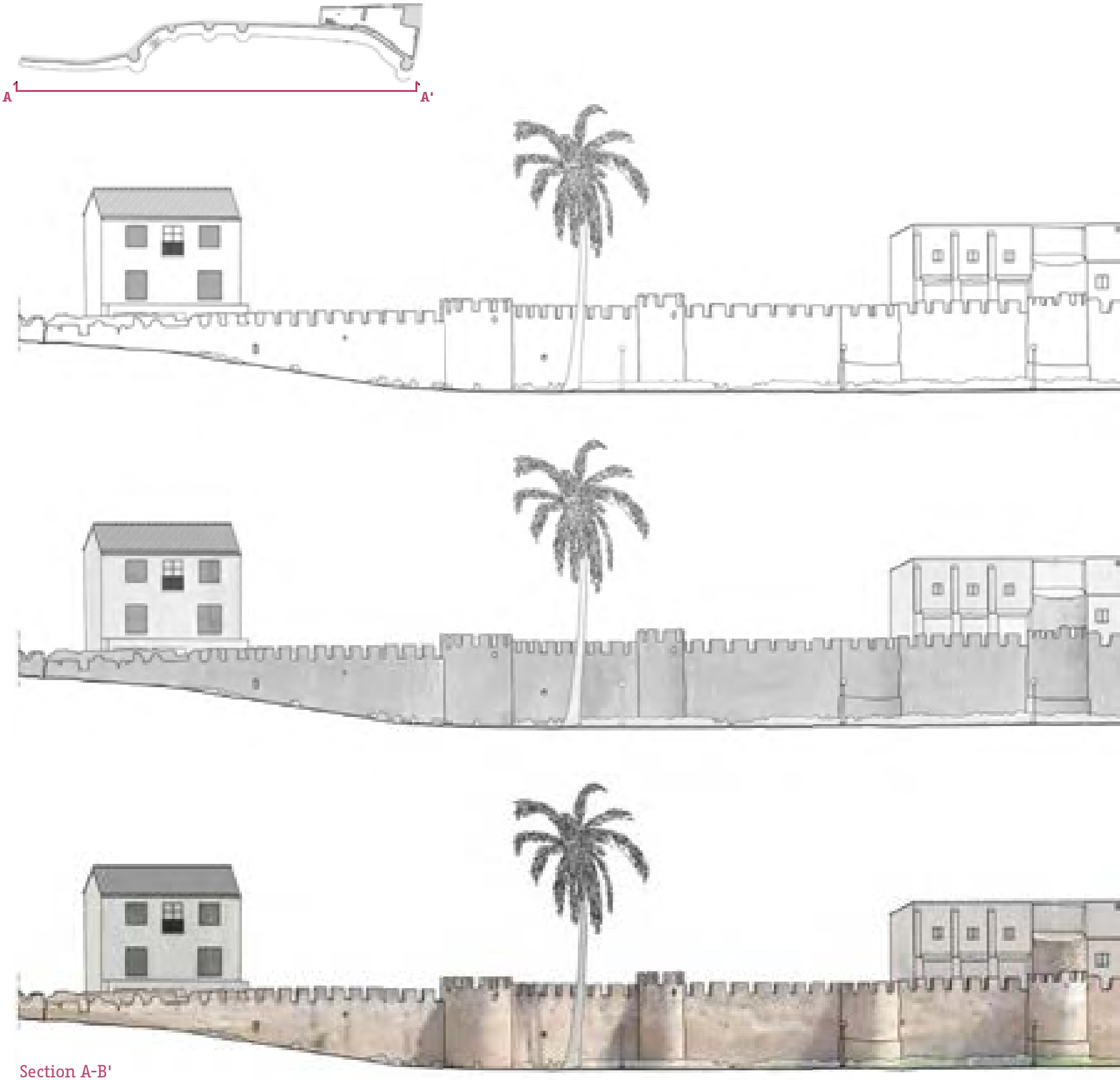
Advanced digitisation has not only provided a solid foundation for planning conservation interventions and monitoring the state of preservation but has also facilitated the creation of detailed two-dimensional drawings illustrating the site's morphometric characteristics, historical developments, and current conditions. These documents are essential for producing technical documentation and for conservation actions.

To promote and enhance these initiatives, the three-dimensional models have been prepared for 3D printing and incorporation into augmented reality applications, offering new perspectives and scales of observation that enrich the understanding and experience of the site. These efforts not only contribute to the physical preservation of the historic walls of Alzira but also to their enhancement as tangible testimonies of cultural heritage, ensuring that the heritage remains accessible and appreciated by future generations. The enhancement and preservation of the site not only keep the historical narrative of the city alive but also provide opportunities for cultural tourism and public education, strengthening the connection between historical memory and contemporary reality.

Fig.11
From model to 3D print
Process of preparing the mesh model for 3D printing.

Side page, Fig.10
Photogrammetric data
Results of the Processing Workflow.

Next pages, Figs.12, 13
Technical drawings
Significant sections and elevations.



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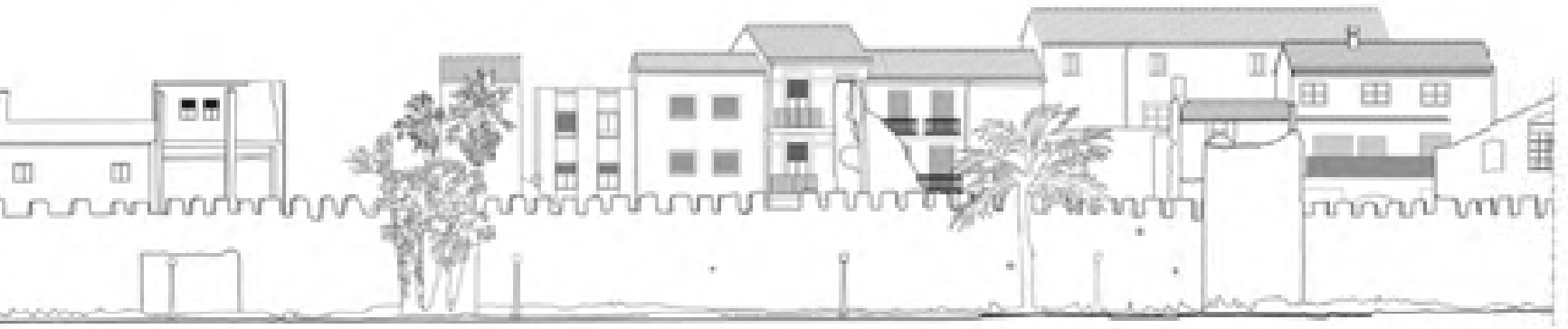

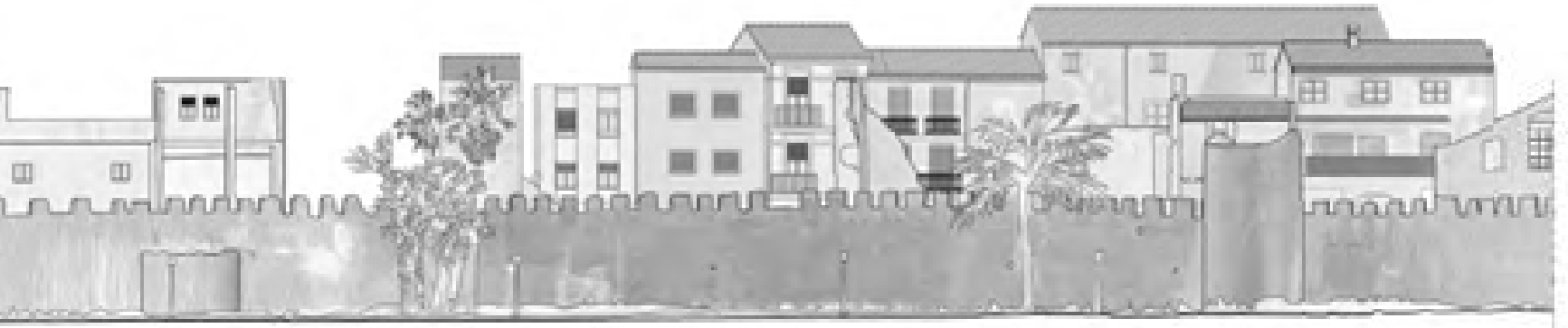

Section B-B'

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FAST SURVEY TECHNIQUES FOR THE DOCUMENTATION OF THE CASTLE OF BENISSANÓ

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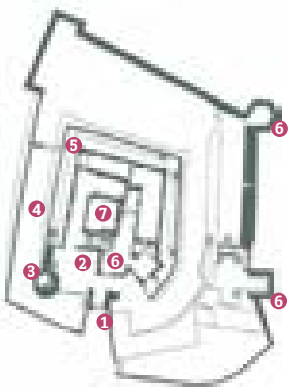
Side page, Fig.01
Benissanó Castle
View of the 15th-century castle of Benissanó, a fortified noble residence set between the Turia plain and the inland hills of Valencia.

The Benissanó Castle is located at the end of the narrow street that runs through the town's historic centre. Getting there is a journey, although short, through the intimate landscape of the Valencian countryside. Leaving the outskirts of Valencia and heading toward the hills, the town is a small urban nucleus perfectly defined in contrast to the surrounding agricultural land. The houses are low and colorful, and the streets are almost deserted due to the heat. The historic center is an example of a typical settlement, where historical layers blend with the quiet atmosphere of a rural village that retains the charm of its medieval origins. It features a simple yet functional urban layout inherited from past centuries. On the edge of the village stands the castle, the symbolic and architectural heart of the town, not only a defensive element but also a landmark that tells the historical significance through its walls and towers. The narrow streets are lined with buildings reflecting the traditional architecture of the Valencian province. The simple facades of mid-20th-century buildings alternate with ceramic decorations and the presence of churches and chapels, places that testify to the deep religiosity of the local community. One of the main attractions is the parish church, with its understated elegance and a bell tower that stands as another distinctive feature in the village's landscape.

The castle, which shares its name with the city, was originally developed during the Islamic presence in the region. The current configuration of the complex, resulting from successive transformations over the centuries, dates back to the 15th century and stands on the remains of an ancient *alquería* called Benixanut, a period in which it took on a noble residential configuration[1]. Benissanó has no direct connection to James I of Aragon, who granted this *alquería-castillo* to Íñiguez de Díaz Castelló[2], while the surrounding lands were distributed among several knights. By the 14th century, Benissanó had already become an independent estate and lordship, distinct from Lliria, and unresolved disputes

Fig. 02
Castle ground level
1. Main Access; 2. Place of Arms;
3. Poterna Tower; 4. Moat;
5. Patrol walkway; 6. Vestibule;
7. Homenaje Tower



[1] Cf. Rubial (1998), *Castillos de Valencia.*

[2] In the land grants made during the time of the Reconquista, documented in the Llibre del Repartiment, it is recorded that in November Íñiguez de Díaz Castelló received a tower and several buildings under the name of *Benizano*: *"P. Enneguez de Diacastello: turrim cum edificiis suis que vocatur Benizano et XIII jo. terre ibidem et domos contiguas domibus Dominici de Lombierre et quasdam domos pro stabulo contiguas muro ville et I ortum contiguum balneo. Kalendas novembris [...]"*. Coleccion de documentos inéditos del Archivo General de la Corona de Aragon, tomo XI, Repartimientos de los Reinos de Mallorca, Valencia y Cerdeña, Publicada de real orden por su cronista D. Próspero de Bofarull y Mascaró, Barcelona, 1856, p.447.
These lands would soon gain significant importance in the area, especially after the flight of the Arabs who were attempting to escape from the Christians. However, it was not until January 18, 1261, that James I confirmed Íñiguez de Díaz Castelló as the lord of the Benizano estate. From that moment on, Benissanó, which then consisted of a tower, surrounding buildings, a public bath, and a wall enclosing the village, would have its own jurisdiction; cf. Campos González, Herrero García, Alonso García, (1998), *El castillo de Benisanó.*

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Fig. 03
A glimpse from a Century Past
Evocative early 20th-c. view of Benissanó Castle, still standing proud amid open fields (from *Geografía general del Reino de Valencia*, Sarthou Carreres, vol. III, t.II, p.552).

Fig. 04
Noble residence
Early 20th-c. view of the inner Palace (from *Geografía general del Reino de Valencia*, Sarthou Carreres, vol. III, t.II, p.553).

over irrigation water culminated in an attack by the inhabitants of Lliria in 1408, during which the settlement was set on fire. It is therefore in the second half of the 15th century that Mossen Luis Villarrasa de Cavanilles, heir to this and other wealthier properties, built the Benissanó castle on the ruins of a previous fortification from the Islamic period of *Al-Andalus*. Its peak development occurred in the 15th and 16th centuries, thanks to the contributions of the Cavanilles-Villarrasa family, which shaped the current appearance of the building[3].

The structure is protected by two concentric walls, with the outer ring—connected to the city walls—being lower in height than the inner one. Today, only the castle and three of the city gates that once provided access to the walls remain.

From a typological perspective, the castle belongs to the category of palace-castles, combining the distinctive features of fortresses with those of medieval noble residences. Its architectural layout is based on a rectangular plan, with four internal levels, culminating in a crenelated terrace, which remains a prominent feature of the current structure. The most distinctive element of the castle is undoubtedly the central body, built upon the remains of a medieval Muslim tower, which serves as the keep of the fortress. The tower has a square base measuring 7.5 meters per side and was gradually transformed between the 15th and 18th centuries, with crenelations added during the last restoration in the past century. All the rooms are arranged around this tower.

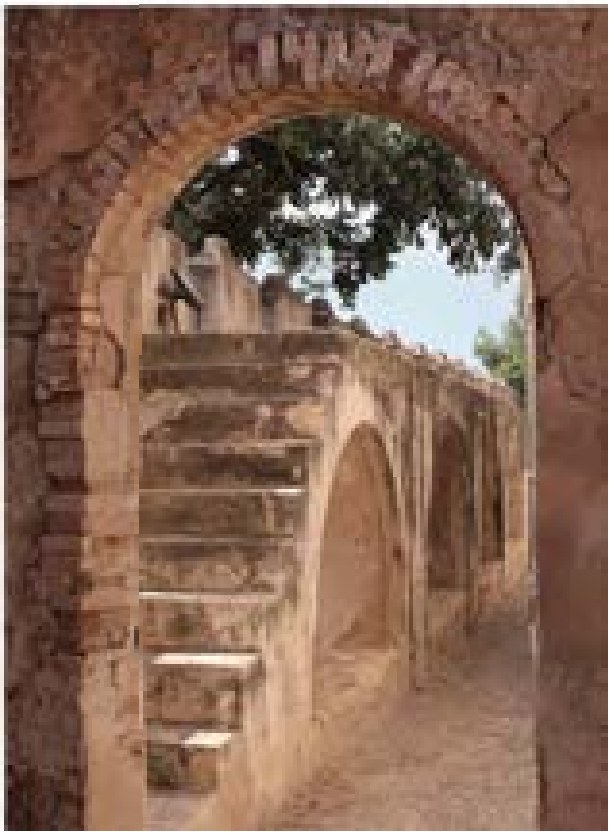
[3] Cf. Sarthou Carreres, (1910-1915), *Geografía general del Reino de Valencia*, vol. III, t. II, *Provincia de Valencia;* Campos González, Herrero García, Alonso García, (1998), *El castillo de Benisanó, cit.*

Fig. 05
The Castle today
Aerial view of the current state of the castle. Notable differences can be observed, particularly in the main tower's roofing system.

The complex exhibits a heterogeneous mix of styles, evident in the composition of its openings: Mudéjar with pointed arches, Gothic with delicate tracery, and Renaissance with round arches.
The castle has two entrances: one through a small passage connecting the stables to the vestibule, and another through a door in the parade ground, directly in front of the well, leading straight to the vestibule. Only a few original elements remain in the castle, with notable features including some coffered ceilings, sections of the flooring, and a Medieval Islamic passageway that is accessible from one of the rooms. The castle's current appearance, while evocative, obscures the charm of its former palace. By the early 20th century, the castle had already undergone significant modifications. In the section dedicated to the Castle of Benissanó in the *Geografía general del Reino de Valencia*, Carlos Carreres states: "*Deplorable transformations have disfigured the palace's original character. The disappearance of the bridge, the partial filling of the moat, the division and expansion of the halls, the overwhelming application of plaster and lime on the walls and ceilings (except for those spared due to their height), the perforation of coffered ceilings to build modern staircases, etc., have ultimately given the appearance of a farmhouse to what was once a noble residence*" [4].
The defensive wall forms an irregular polygon shaped by the rocky hill, while towers and gates follow a more regular layout, with entrances on each open side and corner towers at the ends of the curtain walls.

Side page, Figs.06, 07
The Features of the Castle
A selection of descriptive images highlighting the most significant fortified elements.

[4] Translation by the authors, the original text is provided: "*Lamentables transformaciones han desfigurado el carácter primitivo del palacio. La desaparición del puente, el rellenado de parte del foso, la división y aumento de los salones, la inundación de yeso y cal de los muros y techos (salvo los que por su altura se salvaron de ella), la perforación de artesonados para levantar modernas escaleras, etc., etc., acabaron por dar carácter de granja agrícola á lo que fué señorial mansión*". Sarthou Carreres (1900-1915), *Geografía general del Reino de Valencia*", vol. III, t. II, *Provincia de Valencia*, pp. 554.



Along the entire length of the wall, there are battlements, most of which are decorative, primarily resulting from renovations in the 20th century.

The castle originally had a moat, now disappeared, which explains the relatively low height of the outer wall. However, within the walls, there is a second line of defenses, featuring square and round towers, also crenelated, taller than the outer enclosure and attached to the palace itself. The current entrance is straightforward, but in the past, it was equipped with a drawbridge that spanned a second moat. The present gate leads to a small quadrangular courtyard, featuring the Poterna Tower and a well carved into the rock under Islamic rule. Beneath the parade ground, there are cisterns for water storage, the largest of which is covered by a large vault.

The decorative richness, combined with the complexity of its defensive morphology, led to the definition of an integrated research process, aimed at digitally reconstructing its overall image. The possibility of structuring a three-dimensional database of the site allowed for the analysis of the main defensive elements of the fortress, validating the hypotheses proposed on-site and defining an iconographic framework useful for its understanding[5].

Fig. 09
Inside the Palace
Views of some interior spaces on the ground floor, showing original structural elements and later architectural additions.

Side page, Fig.08
Inside the Castle
View of the castle's courtyard framed by the side arch of the main entrance, revealing original masonry textures and architectural details.

[5] Parrinello, Pettineo (2024), *Traditional Architectures Along the Cultural Route of James I of Aragon in the Province of Valencia*

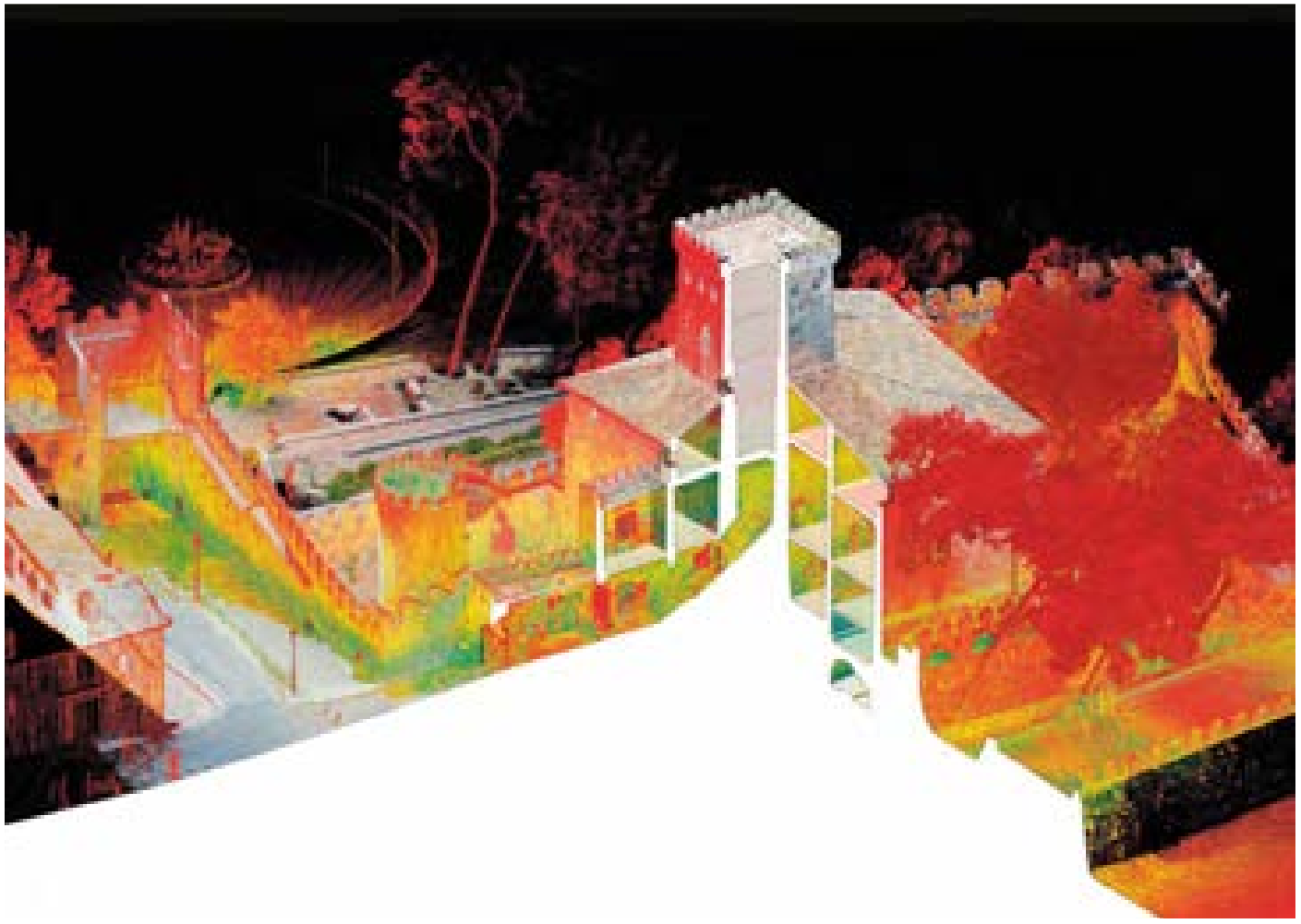


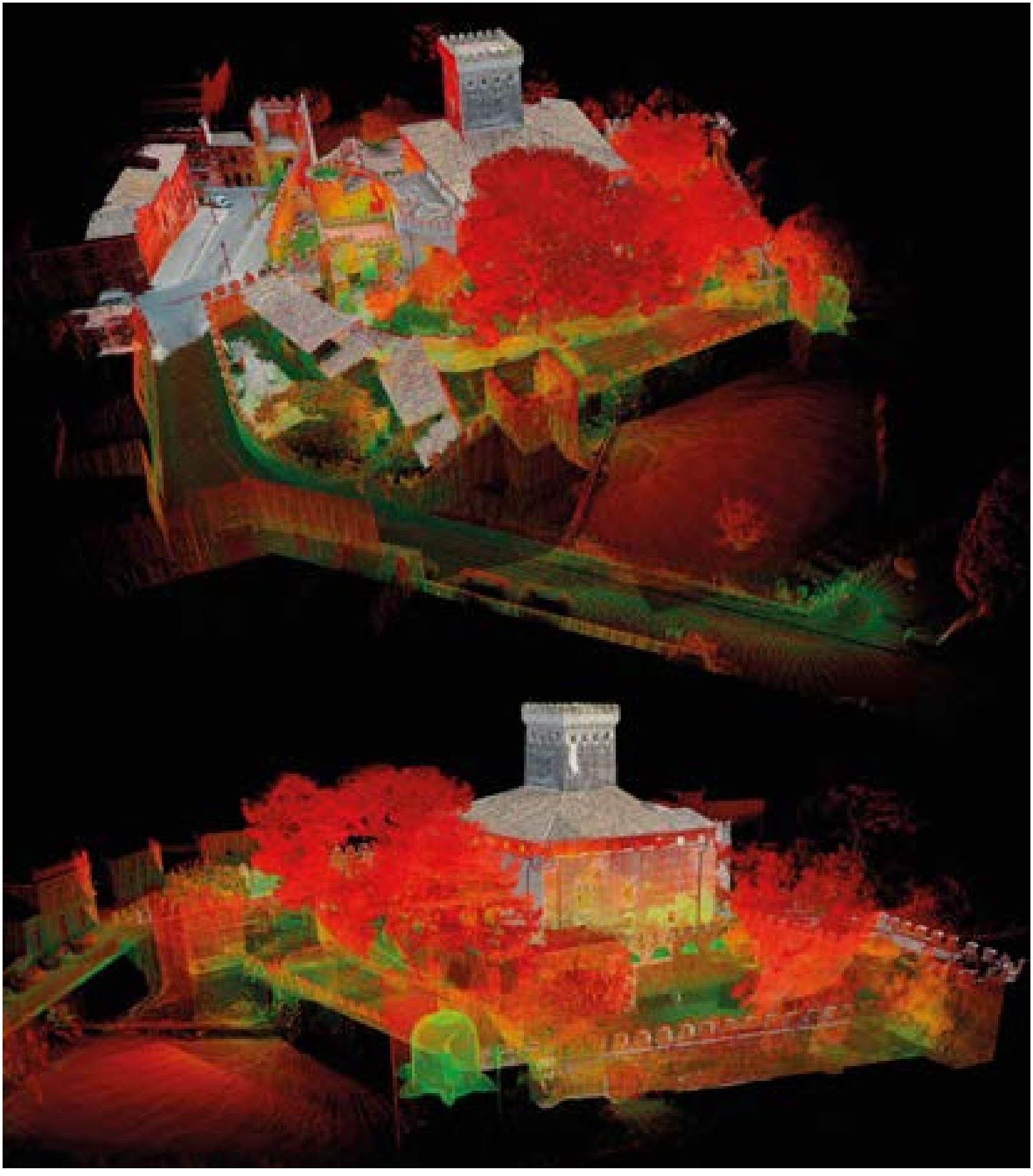
Fig. 10
Reading the Castle in Section
Axonometric cutaway view of the multi-source point cloud, illustrating the spatial complexity of the castle. (Drawing credit: Alberto Pettineo)

Side page, Fig.11
3D Database
Visualisations of the integrated 3D point cloud from UAV, and mobile mapping systems.

To achieve an adequate level of metric and colorimetric accuracy for each fortified element of the castle, a data acquisition methodology was defined, utilising SLAM-based LiDAR equipment integrated with UAV systems and DSLR cameras, leveraging image-based acquisition principles[6].

The castle was divided into macro areas to establish an organisational structure of the various environments, useful for the construction of a comprehensive digital archive. To gain an overall view of the external fortified space and relate it to the internal environments[7], a mapping of the entire complex was carried out using mobile LiDAR. The connection between the inner and the external spaces was ensured through the creation of linking pathways. Additionally, a mapping of the surfaces was integrated using image-based acquisition techniques, through: (i) UAV systems at a territorial scale to provide an overview of the surrounding area and capture the roofs, which were unreachable from the ground; (ii) DSLR cameras for detailed mapping of the main internal and external facades.

[6] Picchio, La Placa, Galasso, Dell'Amico, Fu, Porcheddu, Ricciarini (2025), *Metodologie integrate di rilievo per la documentazione di spazi urbani, da luoghi marginali a modelli dinamici di reuso*, pp. 244-255.
[7] The interior space was only partially captured due to the inability to access the upper rooms of the central tower, as they were closed to the public. However, this did not limit the overall understanding of the fortified space.



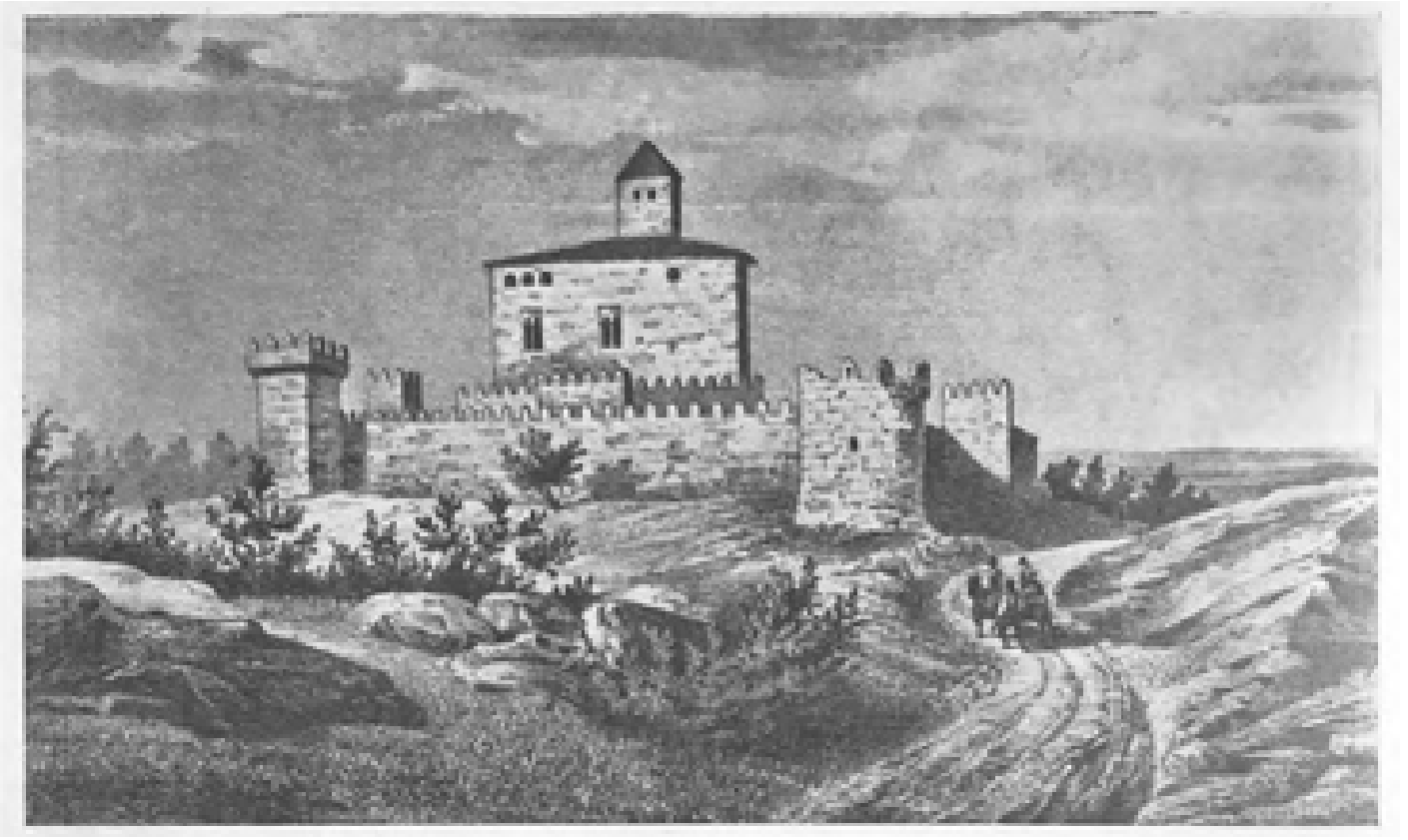


Fig. 12
A Romantic vision of Benissanó
View of Castle in an engraving by Isidoro Salcedo y Echevarría, from *Castillos y Tradiciones Feudales de la Península Ibérica*, José Bisso, 1870.

The breakdown into macro areas enableb the efficent use of the acquisition equipment and facilitated the creation of a comprehensive surface mapping, capable of describing the state of preservation and the structure of each area. The 3D database obtained from the developed methodology allows for the analysis of the complex from a different perspective, facilitating the understanding of the relationships between the various environments and between the construction elements. The accuracy of the metric data was ensured by mapping through LiDAR[8], proving effective for the mapping of the fortified complex. This aids in the analysis of the descriptive elements for the preservation of the Castle's image and the development of virtual systems for enhancing the complex within the Cultural Route. The management of data from the survey campaign and the organisation of information to create tools for digital access and understanding of the site are part of the activities outlined in the project[9].

The structuring of a data discretisation system, to reduce and manage the complexity of not only the morphological context but also the real-world context, produces a model-structure from which guidelines can be drawn to generate a cataloging and archiving system for the data and elements comprising the structure. Through the creation of a digital archive, it has been possible to preserve the current image of the castle along with its complex relationships with the surrounding landscape and the other sites of the Route.

[8] The average deviation of the photogrammetric data is 1-2 cm compared to the Mobile data in the integrated database.
[9] Picchio, Meseguer, Gonzalez, Valldecabres, Pettineo, Dell'Amico., Fu, Galasso (2024), *Repositorio 3D para la puesta en valor de la ruta cultural de Jaime I en Valencia*, pp. 299-309.

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Picchio F., Meseguer L. C., Gonzalez M. C. L., Valldecabres J. G., Pettineo A., Dell'Amico A., Fu H, Galasso F. 2024, *Repositorio 3D para la puesta en valor de la ruta cultural de Jaime I en Valencia*, in *Pensar dibujando: Proceedings of XVI International Conference of the Asociación de Profesores de Expresión Gráfica Aplicada a la Edificación APEGA 2023*, edUPV, Editorial Universitat Politècnica de València, pp. 299-309.

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The Almonecir Castle, located in the western part of the Sierra de Espadán, is a military construction of considerable historical and architectural relevance. Its isolated position from the main communication routes had a significant impact on the development of the surrounding villages, conferring it a strategic role in different historical phases. The relevance of the castle in the region underlines its prestige as an emblematic landmark within a complex defence system that spread to the entire territory of Sierra de Espadán. This defence system was established to preserve the security and integrity of the local communities over the centuries[1].

The Sierra d'Espadán region represents a territorial unit that shows its autonomous identity, both in terms of geographical and historical aspects. The mountain system constitutes an element unifying military works - such as castles, towers, and other fortifications – that provide its distinctive character and a peculiar identity[2].

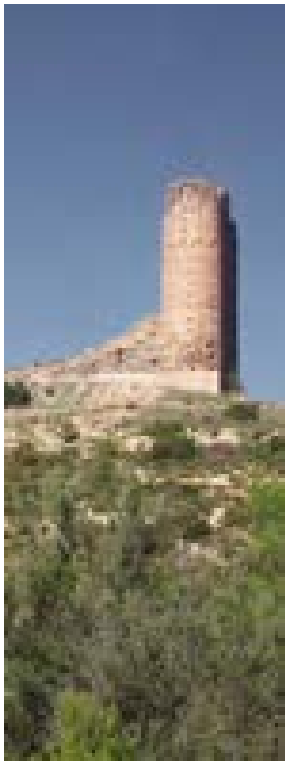
Taking into consideration the Almonecir Castle, a series of investigations took place to understand the construction technologies and be able to read the historical stratifications. On-field investigations were conducted to increase the comprehension of the castle to develop hypotheses on its original configuration and subsequent transformations. Through stratigraphic analysis of masonry structures, it was possible to obtain important information regarding the historical evolution of the complex. These visual surveys were performed to define the construction techniques used in the fortified elements of the castle and later integrated by archival research. The analysis helped to complete an informative framework necessary for a better understanding of the constructed fortified system, allowing hypotheses on the structure of elements that no longer exist.

Origins and History of the Castle

Providing an historical background it's crucial to properly contextualise the Castle of Almonecir and to outline its evolution over time, analysing the cultural, social and architectural influences that have contributed to its current form. The origins of the Castle are closely related to the Moorish conquest of the Iberian Peninsula and the origin of a new state known as Al-Andalus[3].

Side page, Fig.01
The Castle in the Landscape of the Almonacid Valley
Situated in an elevated position, the castle offers a broad visual command over the surrounding territory.

Fig. 02
Before the restoration works
View of the Homenaje Tower prior to the restoration works carried out in 2008.



[1] Selma Castell (2005), *El Alto Palancia en época islámica*.
[2] Forcada (2011), *Torre y Castillos de la Sierra d'Espadán*.
[3] Rodriguez (2005), *Historia del Castillo*.

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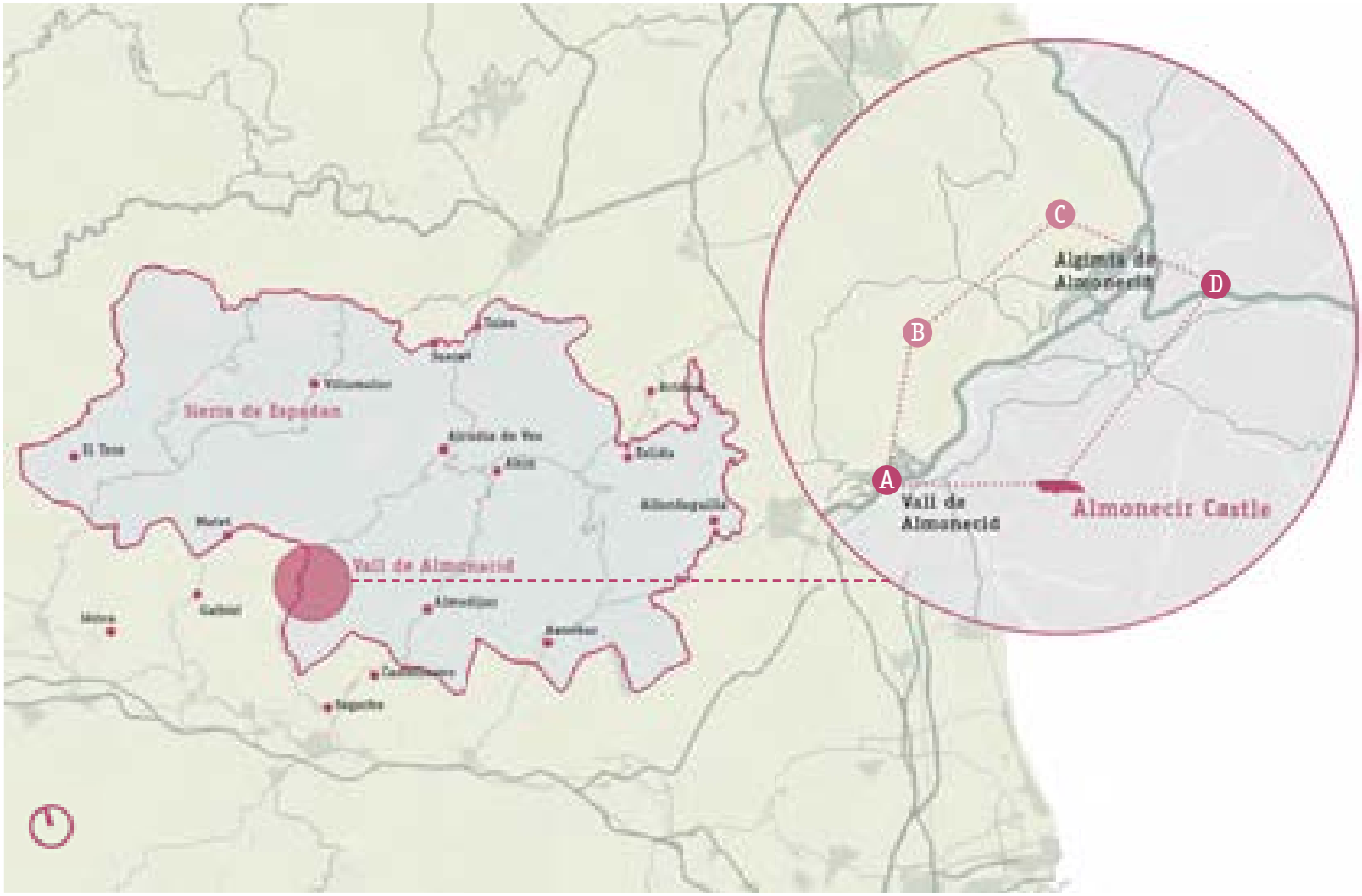


Fig. 03
The Sierra de Espadán and Its Network of Castles
Map showing the main fortified centres within the Sierra de Espadán. The inset focuses on Vall de Almonacid and its defensive system, highlighting the strategic position of Almonécir Castle.

Originally forming part of the Umayyad Empire of Damascus, Al-Andalus split off in 756 A.D. and reached the height of its power with the Caliphate of Cordoba (929-1035 d.C.)[4]. The castle of Almonecir in its early phase was probably a fortified monastery or ribat, inhabited by a community of Muslim known as Murabitin[5]. In the second half of the 11th century and the early years of the 12th century, administration and government inefficiency led to significant insecurity in rural areas of Al-Andalus, especially in Murcia and Valencia regions. As a result, peasants were forced to leave their homes and farms, seeking refuge in castles erected on hills and strategic locations, including Almonecir Castle[6]. Following the Catholic Reconquista of the Espedan area[7], King James I of Aragon granted Almonecir Castle to the royal chancellor Berenguer de Palou, Bishop of Barcelona, along with

[4] O'Callaghan (1983), *A History of medieval Spain*; Guichard, *Al-Andalus: 711-1492: une histoire de l'Espagne Musulmane*.
[5] For a more in-depth overview on this topic, see: Epalza (2004), *La Rápita islámica: Historia Institucional*; Martinez Salvadror (2004), *El ribat en al-Andalus. Enclaves militares y centros de transmisión mística (siglos IX-XI d. C.)*.
[6] Rodriguez (2005), *Historia del Castillo, cit.*
[7] For a more in-depth treatise on the events of Catholic Reconquista in Valencia and the formation of the Kingdom see: Arteta (1981), *Origenes del Reino de Valencia, cuestiones cronológicas sobre su reconquista*.

all the lands, villages, and inhabitants associated with it, as a reward for his contribution to the conquest of the Kingdom of Valencia[8]. During the 16th century, the castle played a central role in the Espadán War, which broke out following the 1525 decree by Charles V, mandating all Muslims in the Crown of Aragon to convert to Catholicism or leave the Iberian Peninsula[9]. Following the rebellion and the expulsion of the Moorish from the Espadán area[10], the castle of Almonecir gradually lost importance and its military functions became unnecessary. Today, the castle is evidence of the historical events that have shaped the region over the centuries. Its ruins stand as a tangible example of military art and fortified architecture over time, revealing the complexity of social, economic, and political relations that involved the castle throughout the centuries.

Fig. 04
Fortified Heritage and Its Territorial Context
Examples of the region's fortified heritage in relation to the surrounding landscape and urban centres. On the left: Castellnovo; top right: Castle of Artana; bottom right: Castle of Gaibiel.

[8] Llibre del Repartiment, donación del Castillo y Villa de Almonezir a Berenguer de Palou, Archivo de la Cathedral de Barcelona, sala 3, estancia 3, pergamino n°29, cf. Rodriguez (2005), *Historia del Castillo, cit.*
[9] Chabás (1890), *Los moriscos de Valencia y su expulsión*; Molero, Francisco, *La Guerra de Espadan, 1526: una cruzada en la Valencia del Renacimiento.*
[10] Rull Villar (1960), *La Rebeliòn de los moriscos en la Sierra de Espadán y sus castillos.*

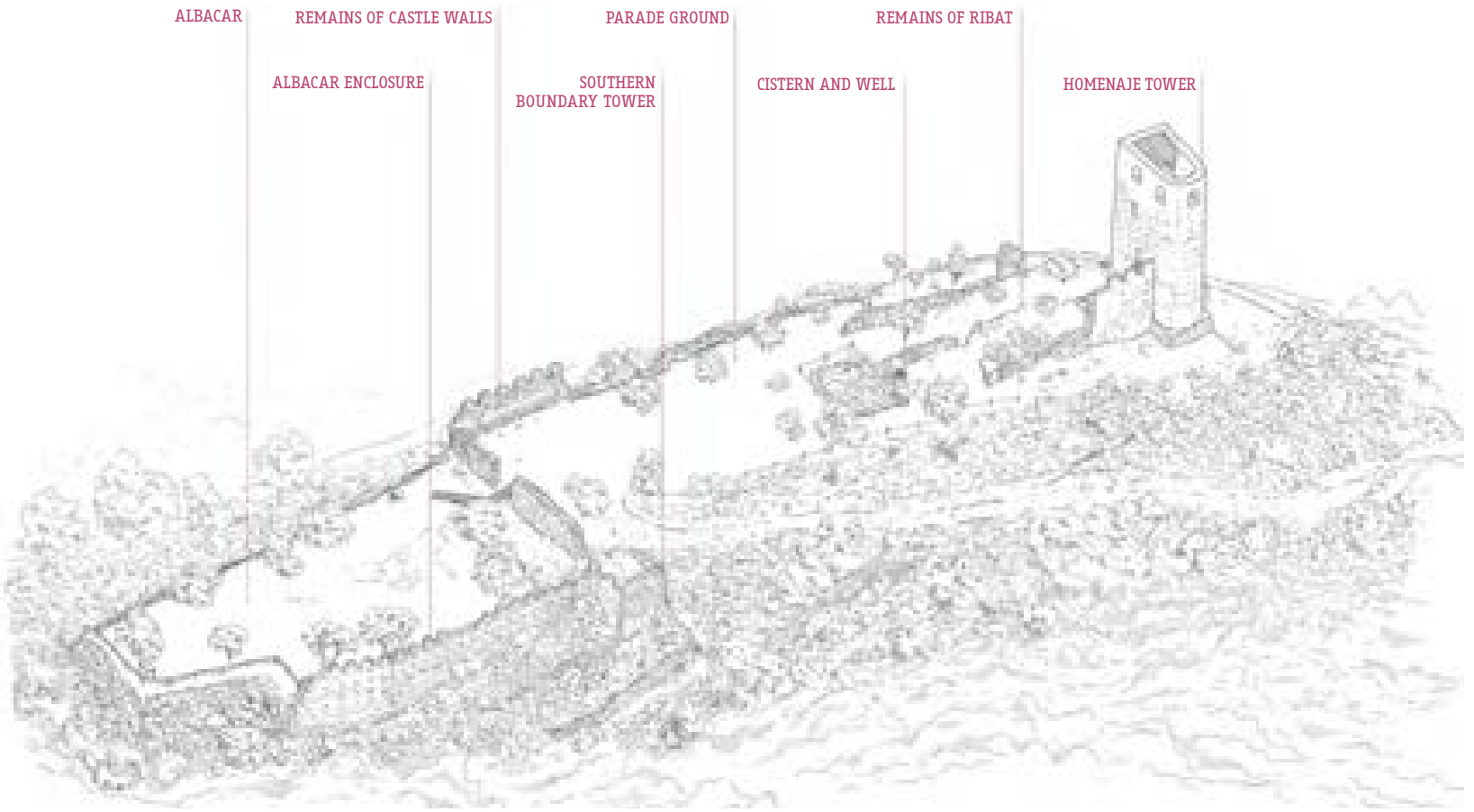


Fig. 05
Axonometric Drawing of the Castle Complex
Illustration of the castle showing its main elements. (Drawing credit: Giulia Porcheddu)

The current image of the Castle

The current appearance of Almonecir Castle is affected by the unavoidable passage of time, which has substantially altered the perception of its defensive systems. The castle has an irregular layout with terraced earthworks and an NE - SW orientation. Its walls cover an area of approximately 2,700 square metres and are internally organised into two main spaces separated by an inner curtain wall. The main defensive structures are placed in the first area, in the northeast portion of the castle, where are located the most well-preserved elements: the remains of the Homenaje Tower[11], the water system (well and underground cistern), and the common quarters[12].

In the second area, southwest of the first one, the complex extends to a lower enclosure, intended for non-permanent residential use, typologically identified as Albacar[13].

Side page, Fig.06
Geometry of a Stronghold
Illustration of the Homenaje Tower, highlighting its monumental character and recent reconstruction works on its upper section.

[11] *Torre de l'Homenaje* is the Spanish term, with a *Christians* significance, designated to indicate the keep. The origin of its name comes from the fact that inside was held the ceremony of homage where the lord gave to his vassal a feud in exchange of auxilium et consilium, i.e. help and advice. For a general discussion of the tower, see: De Mora Figueroa (1994), *Glosario de arquitectura defensiva medieval*.

[12] The remains of the masonry in these spaces was discovered during the archaeological excavations carried out in the 2000s and still partially visible today, c.f. Arandiga (2005), *Excavaciones arqueológicas en el Castillo de Almonecir*.

[13] The term *Albacar*, strictly referring to a specific late medieval defence system, consisting of a boundary wall used as a refuge for the inhabitants of a town or neighbouring territory, in case of attack. A broader meaning extends the term Albacar to any walled enclosure located outside a fortress, preceding and usually located at a lower level than the main one, and associating its use with the housing of livestock (Epalza (1984), *Funciones ganaderas de los albacares en las fortalezas musulmanas*; Elum (2002), *Los Castillos Valencianos en la Edad Media (Materiales y técnicas constructivas)*.

In this sector there are the remains of a boundary tower[14], probably the main one of the castle, intended to guard the outer walls. wThe tower, with a square plan, protected the southern portion of the castle's wall and the inner wall between the two areas of the complex.

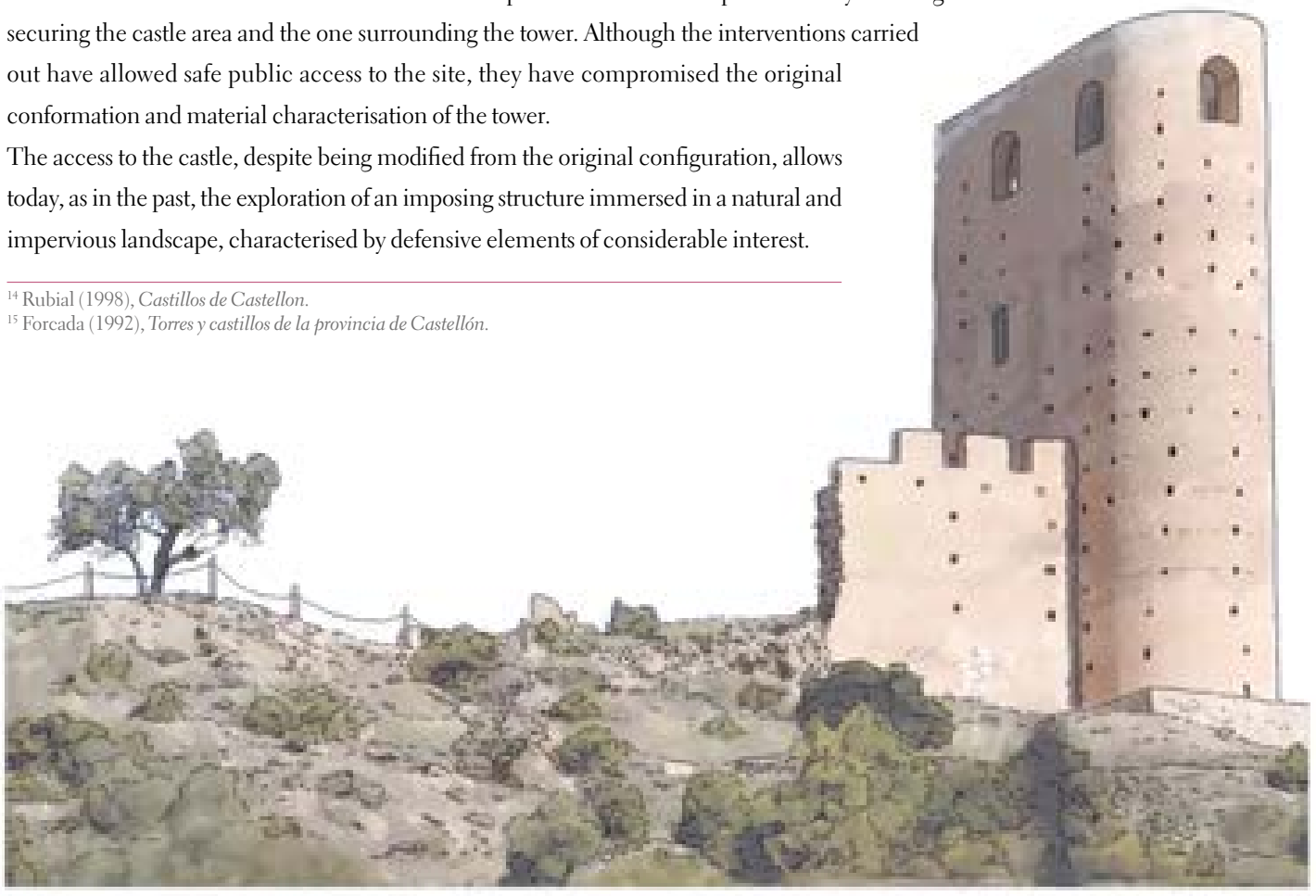
The most remarkable element of Almonecir Castle is its impressive Homenaje Tower. This tower presents an unusual layout plan, consisting of a rectangular shape with a semicircular side facing southeast. The tower is placed in the most vulnerable point of the castle's defence, near to what must have been the main access the complex. It may be possible that one could access the fortress by rounding the main tower from the outside, passing between its basement and an antemurale or barrier, a small wall lower than the main one, of which there are almost no remains[15].

Due to the advanced state of decay of the structures, in 2008 the Castle, and particularly the Tower, underwent restoration and consolidation works to allow its tourist fruition. The interventions involved the base of the Homenaje tower and the reconstruction of its upper part - with the insertion of wooden floors and internal vertical connections - and the improvement of the complex access by cleaning and securing the castle area and the one surrounding the tower. Although the interventions carried out have allowed safe public access to the site, they have compromised the original conformation and material characterisation of the tower.

The access to the castle, despite being modified from the original configuration, allows today, as in the past, the exploration of an imposing structure immersed in a natural and impervious landscape, characterised by defensive elements of considerable interest.

[14] Rubial (1998), *Castillos de Castellon.*
[15] Forcada (1992), *Torres y castillos de la provincia de Castellón.*

Next pages, Figs. 06, 07
The Features of the Castle
A selection of descriptive images highlighting the most significant fortified elements.



Study of constructive features and evolution of the fortified system

To investigate the evolutionary process of the castle's structures and defensive systems, a process of knowledge was crucial to understand its remains and, in particular, the wall equipment. Currently, two sections of the boundary wall are still clearly visible (12 m and 32 m long respectively) and well preserved. The wall section presents a difference in height between the outer and inner portions. The outer portion supports the battlements, while the inner lower portion served as a patrol walkway.

From a constructive point of view, these wall structures consist of two layers, not connected, partially made in rodeno, a red sandstone of the Sierra d'Espadan area.

The boundary wall as well as those of the massive Homenaje tower, were built using the *tapial* construction technique: built using formwork (*tapial* or *tapieras* in Valencian) filled with stone blocks of different sizes mixed with mortar, a mixture of lime, gravel and sand mixed with water or other filling materials[16]. Tapieras consisted of wooden boards that, placed vertically and parallel, formed the mould to shape the wall. These formworks were supported by transverse passing logs on which the scaffolds and tapieras themselves leaned.

Once the mould was filled with stones, gravel and lime mortar, the logs were removed and the moulds moved to the upper portions. The considerable size of the walls and the tower make the castle of Almonecir "one of the most significant examples built with this technique" [17].

The considerations made regarding the remaining defensive structures of the castle, in relation to historical documentation, have allowed for assessments of its evolution in shape over the centuries. Considering the current condition of the castle, it is difficult to make assumptions about its original configuration. Therefore, several hypotheses had to be considered in order to reach what would be the most logical and coherent layout.

The original configuration of the defensive complex was the Ribat (beginning of 12th century)[18]. To formulate hypothesis on this layout several elements have been taken into account: the existing wall remains in the vicinity of the tower and the presence of some typical structures of the time. Unfortunately, the Arabian texts from al-Andalus come down to us are not as meticulous and detailed as those from North Africa regarding everyday life in the Ribat, and archaeological remains from this period are few and far between[19]. For this reason, a background study of Ribat in North Africa has been carried out, although the differences between this region and Islamic Spain cannot be overlooked. On the subsequent extension of the complex, from the second quarter of the 13th century onwards, it is possible to refer to a Christian occupation of the castle, in agreement with historical data that mention the donation of the castle in 1238 to the bishop of Barcelona and chancellor Berenguer de Palou.

[16] Llopis García (2005), *Proyecto de rehabilitación de la torre del homenaje del Castillo de Almonecir*.
[17] Forcada (1992), *Torres y castillos de la provincia de Castellón, cit.*
[18] Jover Cerda (2010), *Los Castillos del Alto Palancia-Sierra de Espadán. Las incógnitas del Ribat de Almonecir*.
[19] Marin (2004), *El ribat en Al-Andalus y el Norte de África*.

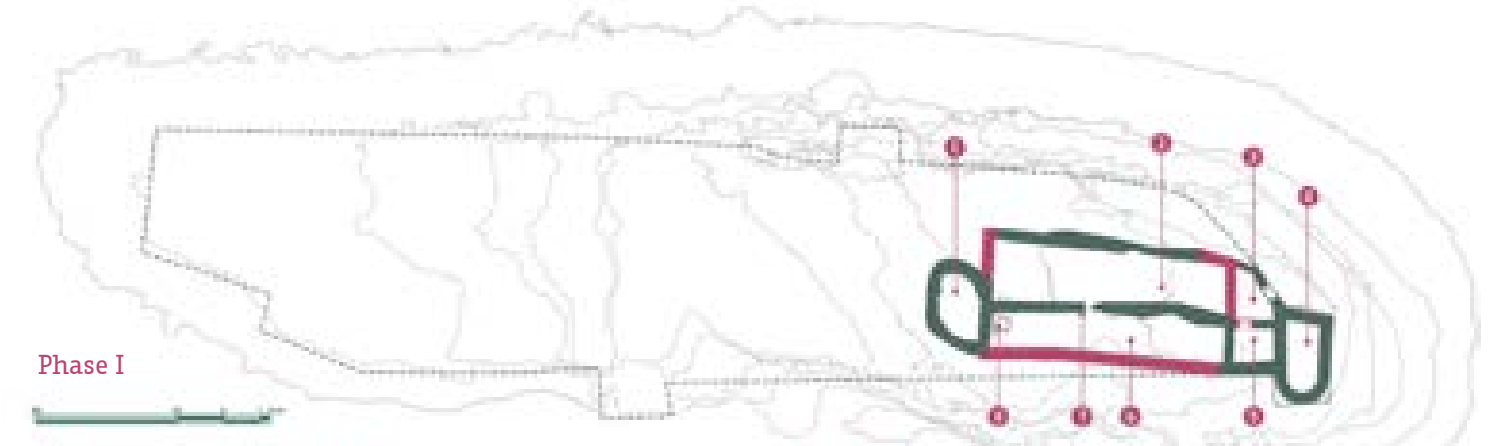
Based on these informations, it is possible to assume that the castle had already been built before this date, possibly completed between the 12th and 13th centuries by the Almohads[20], since it appears recorded in the *Llibre del Repartiment*[21].

Elements typical of Islamic building traditions can be seen in the construction of the walls, so it is possible to assume that it was built in the Almohad period. However, it must be emphasised that there are signs of reconstruction and improvements, likely occurring after the conquest and in later periods, which have contributed to changes in the original appearance. It can reasonably be inferred that the Christians did not change the layout of the walls, but made additions and consolidation of damaged parts, as well as the destruction of those that did not fulfil a strategic function.

Fig. 08
Documentation activities
Digital documentaion and survey operations within the Homenaje Tower

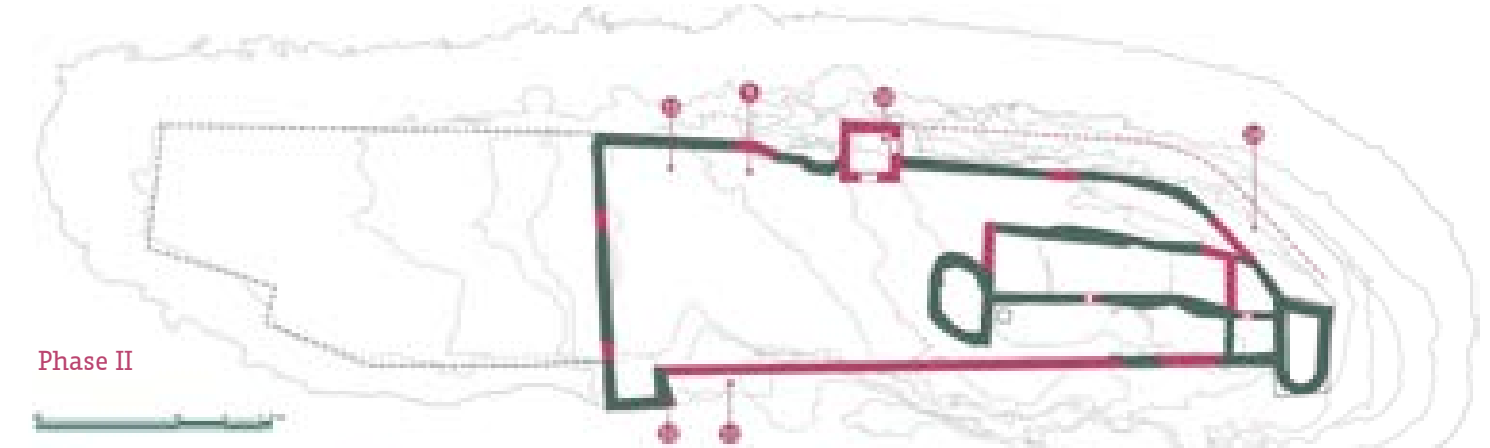
Next pages, Fig.09, 10
Castle's evolution
Phased plan illustrating a hypothetical reconstruction of the castle's development over time. On the facing page, the main archaeological and structural remains that support these interpretative hypotheses.

[20] Boan-Montenegro (2010), *Antecedentes Históricos del Valle de Almonecir.*
[21] Arandiga (2005), *Excavaciones arqueológicas, cit.*



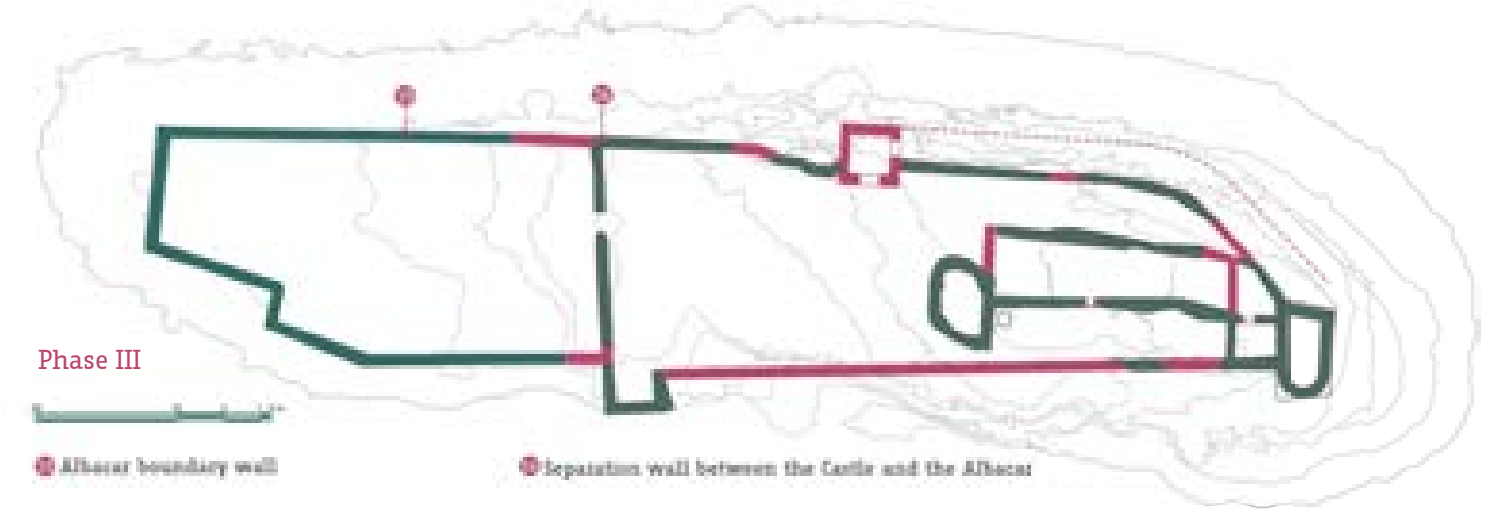
Phase I

1. Ribat tower
2. Ribat interiors
3. Access to Ribat
4. Homenaje Tower
5. Access antechamber to Homenaje Tower
6. Inner patio with water catchment system
7. Patio access
8. Well connected to the cistern



Phase II

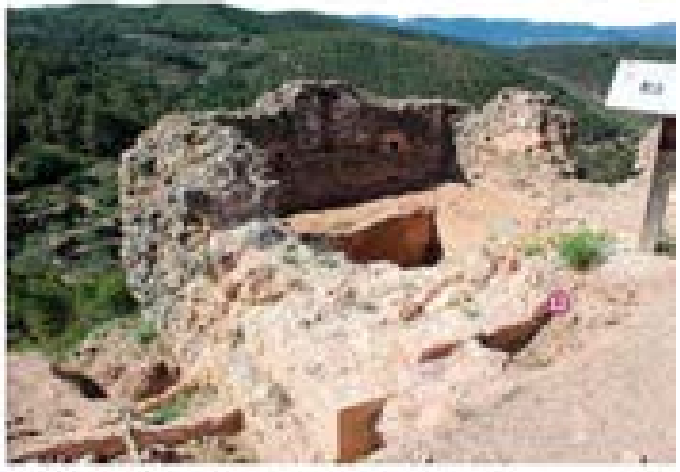
1. Castle parade ground
2. Castle access tower
3. Current access of the Castle
4. Southern boundary tower
5. Castle boundary wall
6. Former access path and entrance



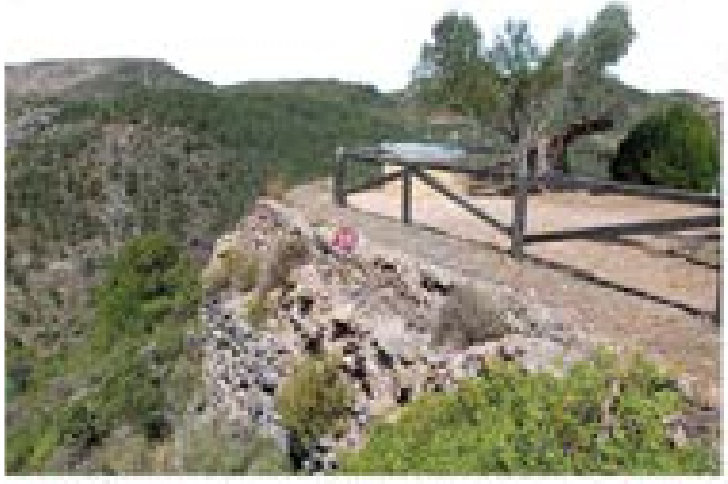
Phase III

1. Alhacar boundary wall
2. Separation wall between the Castle and the Alhacar

1 Foundational remains of a tower
2 Ribat interiors
3 Access to Ribat
4 Homenaje Tower
5 Access antechamber to Homenaje Tower
6 Inner patio with water catchment system
7 Patio access
8 Well connected to the cistern



9 Castle parade ground
10 Remains of the Castle Access Tower
11 Current access to the Castle
12 Southern boundary tower
13 Remains of the castle boundary wall
14 Former access path to the parade ground



15 Foundational remains of the alhacar boundary wall
16 Separation wall between the Castle and the Alhacar
17 Patrol walkway
18 Remains of the alhacar boundary wall

In the lower portion, identified as Albacar, the well-preserved wall sections have allowed for more reliable reconstructive hypotheses. The remains preserved in the southwest area of the castle (next to the foundations of the enclosure tower) led to reconstruct the battlements and obtain information on the height of the masonry. The enclosure has no openings to the outside and was presumably connected to the castle through openings in the cross wall that separated this space from the main enclosure[22]. From a compositional point of view, the battlements of the enclosure in this space are different from those in the other existing portions of the walls. This makes it plausible to place the Albacar at a different period, probably later, to provide shelter and protection for the inhabitants of neighbouring villages in case of attack.

The analysis of the castle and its architectural elements offers the opportunity to deepen the understanding of the construction techniques used, the materials employed, and the various transformations undergone over the centuries. This study provides a more complete and accurate view into the history of the castle, including the social, cultural, and political aspects that characterised its life and role within the society of the time. In addition, the study of the archaeological evidence provides valuable information, combined with a cross-analysis of documentary sources and existing studies[23], provides valuable insights, enabling an understanding of the stratification of different historical phases and the evolution of the castle within a broader historical context.

These actions provided a solid basis for the development process of valorisation and knowledge of the castle as a historical testimony of the territory. A process capable of making explicit those historical and cultural implications that contribute to the promotion and dissemination of knowledge of this important historical site.

[22] Forcada (2011), *Torre y Castillos de la Sierra d'Espadán*, *cit*.

[23] C.f. Rodriguez (2005), *El Castillo de Almonecir*; Piquer-Cases, Capilla-Tamborero, Molina-Siles (2015), *The virtual reconstruction of architectural heritage and its methodological application*.

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REVERSE MODELLING AND 3D DATA INTEGRATION
RECONSTRUCTING THE IMAGE OF THE ALMONECIR CASTLE

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Side page, Fig.01
Digital image of the Castle
Parametric model of the castle developed using scan-to-BIM.

Tracing the evolutionary process of a fortress, and reconstructing the characteristics of its defensive elements, requires a holistic approach that involves the comprehension of its different historical phases and the defensive structures adopted in each of them. What emerges, as an aspect of relevance, is the possibility of creating a digital repository capable of organising, archiving and analysing a heterogeneous set of information.

Thanks to the use of reverse modelling technologies through HBIM systems, it is possible, operating a synthesis of data, to create an information system capable of explicating these elements and allowing for a three-dimensional vision of an artefact that has undergone, over the centuries, notable transformations, and evolutions, stylistic and constructive. Scan-to-bim procedures applied to architectural heritage increasingly take advantage of the integration of historical, constructive, and technological information to produce comprehensive digital models that are both communicative and representative[1], thus interweaving the temporal and spatial dimensions. Moreover, if the stratigraphic complexity of the castle is associated with a considerable volumetric extension, it is necessary, to optimise the timings of in situ operations, to carry out survey campaigns using fast-survey acquisition technologies. These fast-survey solutions for the multi-scalar documentation of cultural heritage make it possible to approach complex operational contexts, taking into consideration problems related to limited accessibility, also in terms of time, and the wide extension of the environments and architectures investigated. The use in situ of increasingly faster and better performing technologies and methodologies from which data are obtained, often integrated, allows the creation of comprehensive digital heritage databases[2].

The development of digital databases from the integration of survey data provides a basis to enable the reconstruction of a semantically rich 3D model from the acquired data[3]. The use of the HBIM methodology for 3D reconstruction in the field of Cultural Heritage also offers a potential range

[1] Bruno, Musicco, Fatiguso, Dell'Osso (2019), *The Role of 4D Historic Building Information Modelling and Management in the Analysis of Constructive Evolution and Decay Condition within the Refurbishment Process*; Ferro, Lo Brutto, Ventimiglia (2023), *A Scan-to-BIM process for the monitoring and conservation of the architectural heritage: integration of thematic information in a HBIM model*.
[2] Parrinello, Picchio (2023), *Digital Strategies to Enhance Cultural Heritage Routes: From Integrated Survey to Digital Twins of Different European Architectural Scenarios*.
[3] Badenko et al. (2019), *Scan-to-BIM methodology adapted for different application*; Sampaio et al. (2021), *Analysis of BIM Methodology Applied to Practical Cases in the Preservation of Heritage Buildings*.

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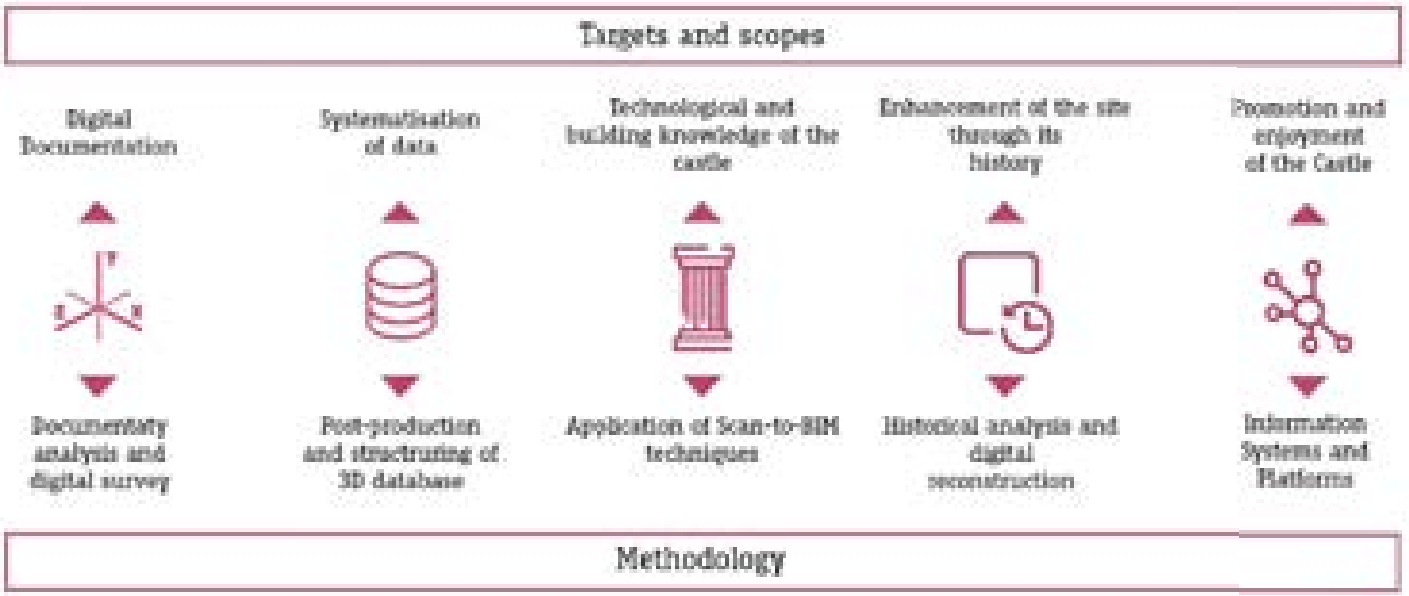


Fig. 02
Methodological Framework and Objectives
Diagram outlining the methodology and main objectives of the research, from digital documentation and data structuring to the historical reconstruction, technological analysis, and public dissemination of the Castle of Almonécir.

of applications, acting as an innovative element compared to traditional methods of managing, cataloguing and valorising architecture. A tool capable of storing and visualising geometric and documentary data together in a single database[4].

The potential of this tool has shown encouraging developments as a resource for the valorisation and communication of the architectural heritage, through specific virtual fruition applications that allow interaction with the information metadata associated with models[5].

In particular, research on the development of virtual scenarios has shown potential advantages related to the visualisation of BIM models and their respective information components[6], making it possible to describe the historical evolutionary aspects of the architectural artefact.

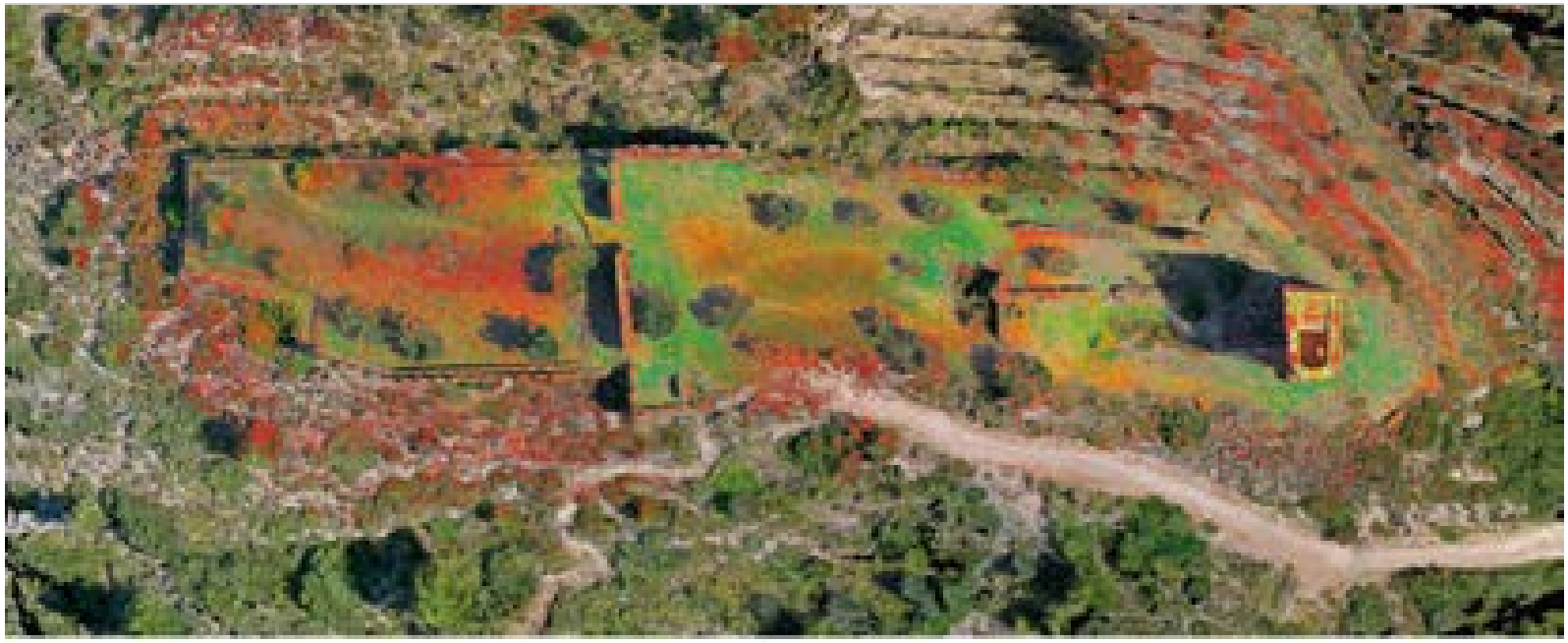
Digital survey and structuring of 3D database

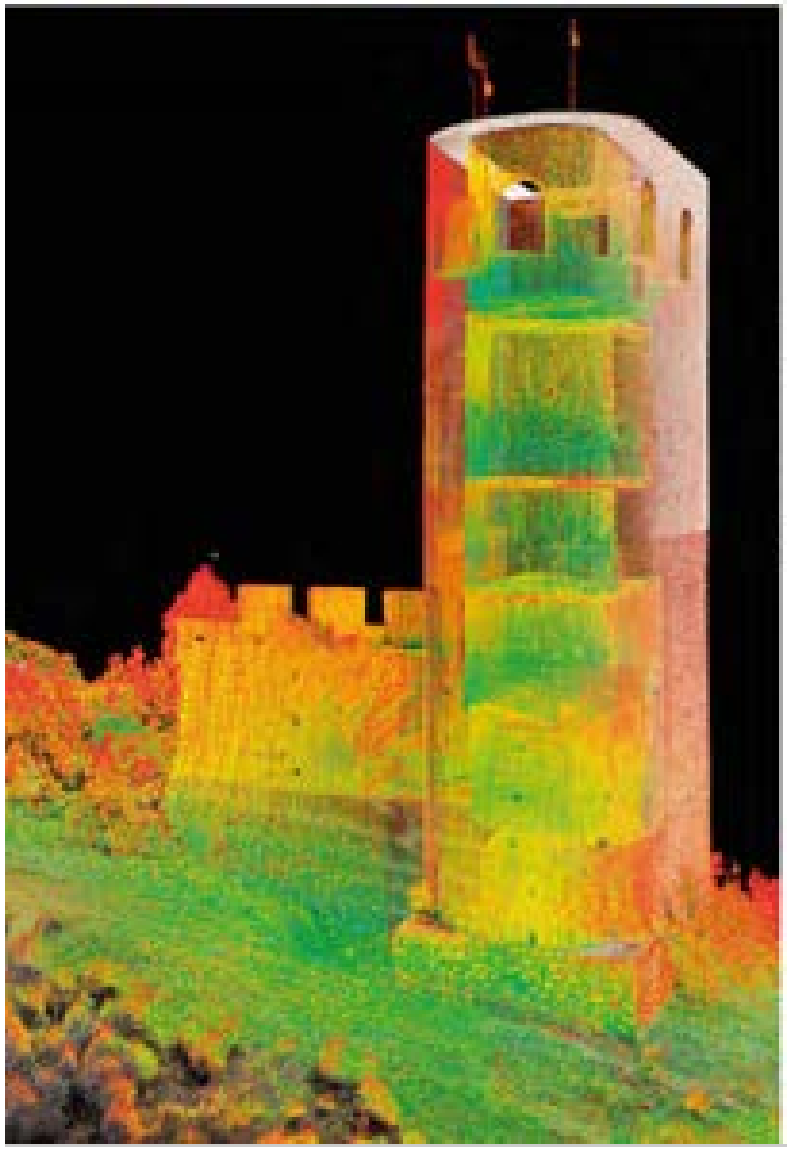
In the specific context of the Almonecir Castle, a methodological process of digitisation through fast-survey technologies was tested, using MLS (Leica BLK2GO)[7], integrated with UAV instruments and DSLR Cameras for SfM photogrammetry processes. This methodology, which is based on the use of instruments with different resolutions and reliability, was developed to represent the case study at different scales of detail: architectural and spatial.

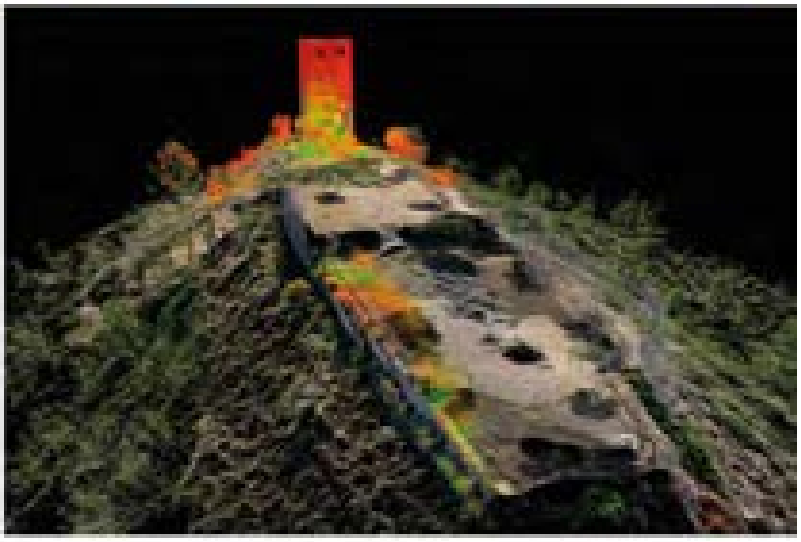
The documentation using the Leica BLK2GO Mobile Laser Scanner required a series of programming actions by the operator to structure the entire data acquisition campaign. The necessity of path planning, especially related to the morphological characteristics of the land and the architectural structure of the

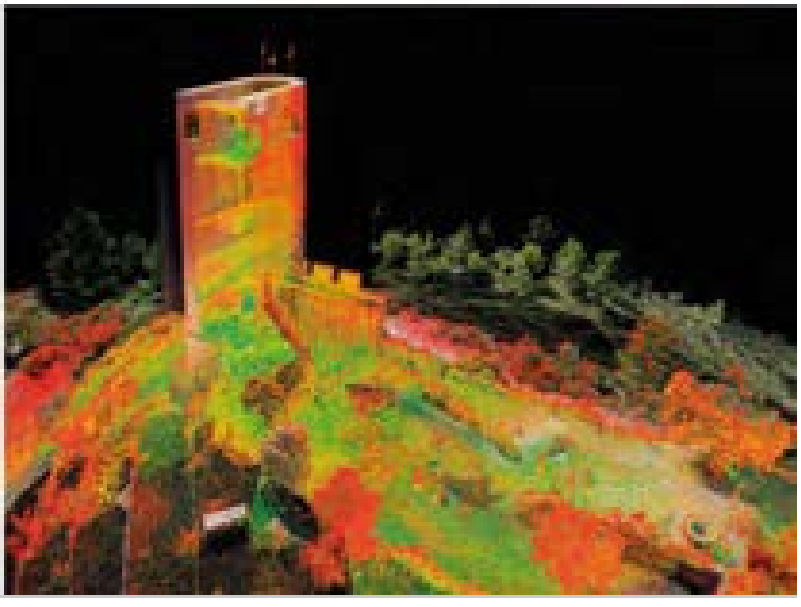
Next pages, Fig.03
3D Database
Visualisations of the integrated 3D point cloud from UAV, and mobile mapping systems.

[4] Martinez Espejo Zaragoza, Caroti, Piemonte (2021), *The use of image and laser scanner survey archives for cultural heritage 3D modelling and change analysis*.
[5] Sidani et al. (2021), *Recent Tools and Techniques of BIMBased Virtual Reality: A Systematic Review*.
[6] Li et al. (2017), *Mapping the knowledge domains of Building Information Modeling (BIM): a bibliometric approach*.
[7] The BLK2GO is a mobile laser scanner equipped with GrandSLAM technology: a combination of LiDAR SLAM, visual SLAM and IMU to orient itself in 3D space and scan in motion. It has a field of view of 360° horizontally and 270° vertically and a range of 0.5-25m. It has a built-in 12 MP, 90° x 120° rolling shutter camera and has an internal memory capable of storing 24 h of scan (compressed data) or 6 h of scan (uncompressed data).









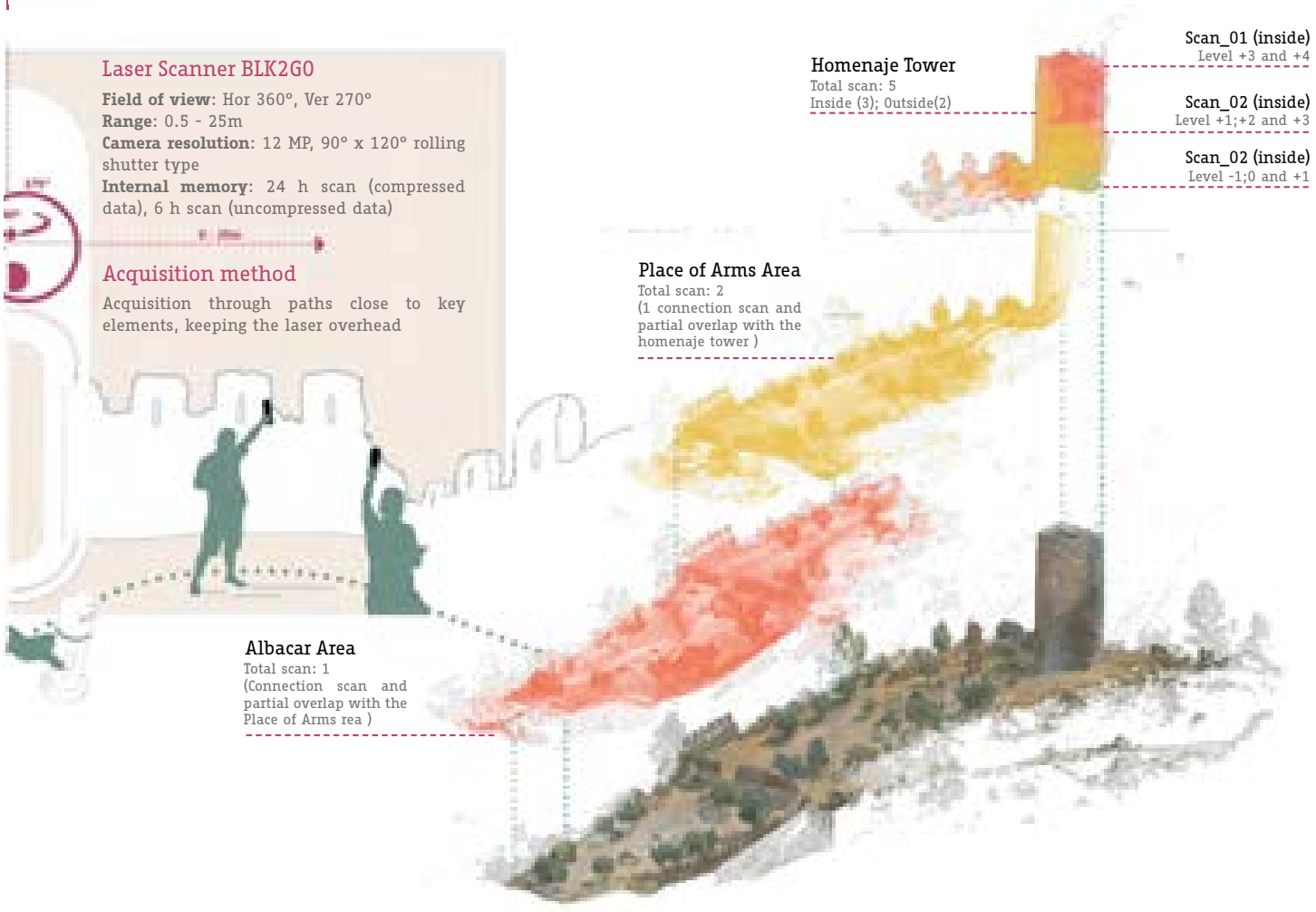


Fig.04
Mobile Laser Scanning Strategy
Diagram showing the data acquisition process using the BLK2GO mobile laser scanner.

Next pages, Fig.05
Photogrammetric Survey
Diagram presenting the acquisition methods using both DSLR and UAV systems. The image details the technical specifications, flight paths, and photographic datasets used to document the main architectural elements of the castle.

complex, becomes crucial when considering instrumental limitations. This instrumentation has an autonomy per single scan of approximately 15-20 minutes, beyond which signal losses may occur, resulting in mapping metric errors[8]. Another instrumental limitation, that affected the design of the paths, is the error produced by the formation of a drift angle, evident in the data post-production phase, and resulting from the union of linear paths. This error can be contained by splitting the areas to be surveyed into closed-loop paths that can compensate the derived error.

The entire fortified complex (in its accessible parts) was then subdivided into different acquisition macro-zones[9], whereby scans were planned for each of them according to the size of the area to be covered, internal rooms and/or vertical connections. The necessity to survey the castle using remotely pilot-controlled instruments (UAVs)[10] came from the need to document the upper portion of the

[8] Leica BLK2GO For Dummies, https://leica-geosystems.com/it-it/about-us/content-features/it_blk2go_dummiesguide

[9] The acquisition macro-zones were divided as follows: (i) *Homenaje Tower*, in which a total of five scans were carried out (interior/exterior); (ii) *Place of Arms*, in which two scans were carried out, structured in such a way as to allow for an appropriate distance between the instrument and the elements of interest (the remaining portions of the walls and the ruins of the tower); (iii) Interior space of the *Albacar*, in which only one scan was carried out. In this case, a certain degree of overlap was maintained with the previous scans by starting the route from the castle's parade ground. The total database thus divided consists of a total of 8 scans (average time per scan: 5 minutes, total number of points: 242.656.283, average number of points per scan: 30.332.035).

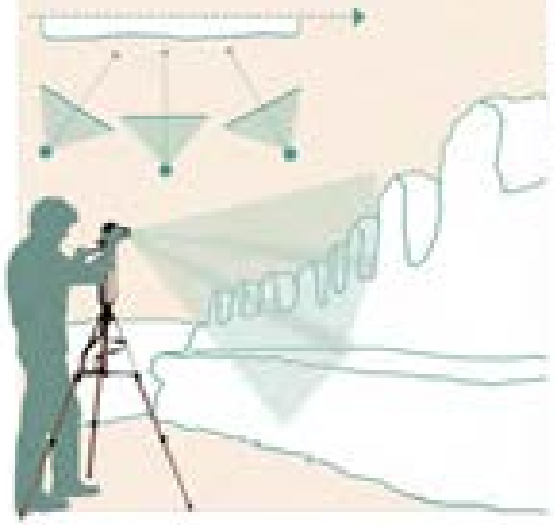
[10] The drone used for the photogrammetric acquisition campaign was a DJI Mavic 2 Pro which has the following characteristics: weight of 743g (with paraelic and battery); flight time of 27 minutes (at a constant 25 km/h and no wind); field of view of 78.8° 26 mm film (35 mm equivalent) f/2.2, a 1/2.3' CMOS camera sensor.

DSLR Canon EOS 2000D

Sensor: 22.3 x 14.9 mm CMOS
Effective pixels: 24.7 megapixels
Shutter speed: 30 - 1/4000 sec.
Lens: EF-S 18-55mm lens
Minimum aperture: 22 - 32 [2]

Acquisition method

The images were captured to ensure a proper overlap of frames (80 - 90%).



DJI Mavic 2 Pro

Weight: 734g
Flight time: 27 minutes (at constant 25 km/h and without wind)
Maximum flight distance: 13 km
Sensor: 22.3 x 14.9 mm CMOS
Effective pixels: 24.7 megapixels
Shutter speed: 30 - 1/4000 sec.
Lens: EF-S 18-55mm
Minimum aperture: 22 - 32 [2]

Acquisition method

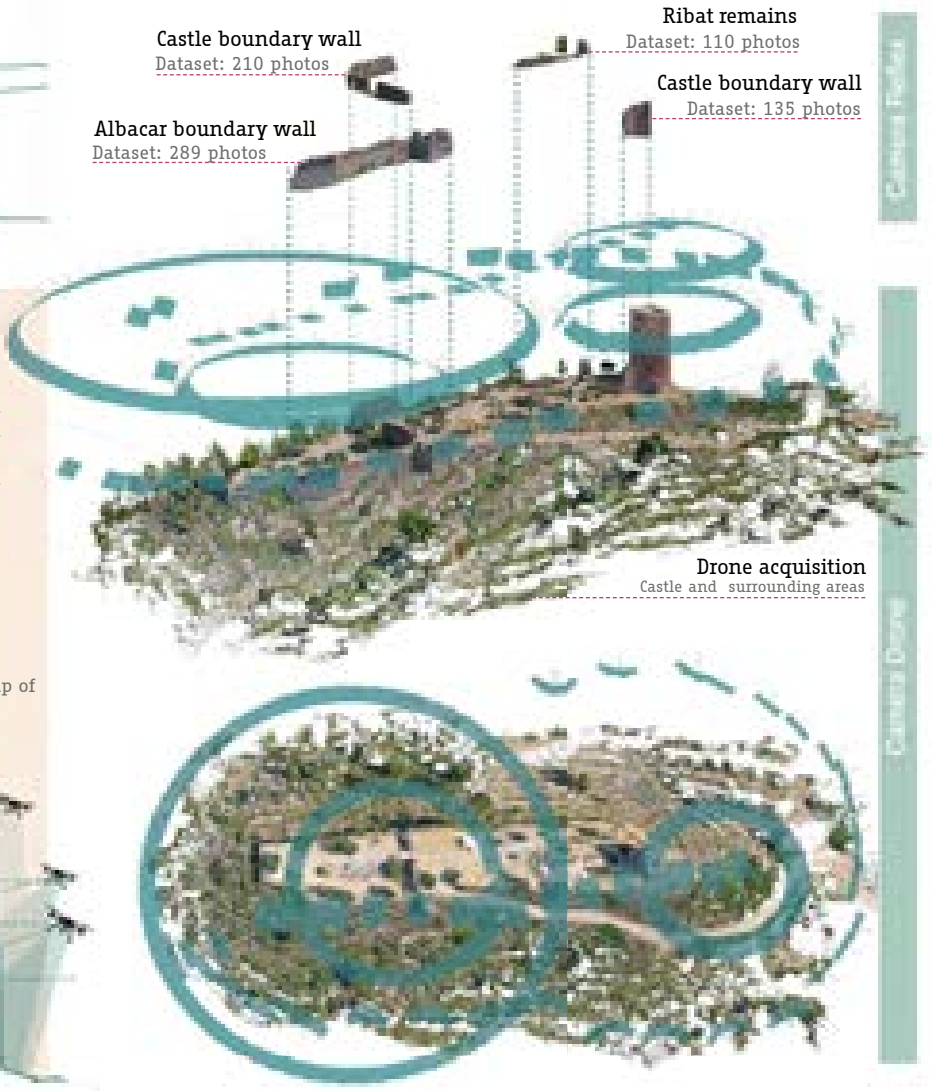
The images were captured to ensure a proper overlap of frames (80 - 90%).

DSLR Canon EOS 2000D

Dataset: 744 photos - **Image dimension** 6000x4000 - **Resolution:** 72dpi

Dataset: 276 photos - **Image dimension** 5472x3648 - **Resolution:** 72dpi

Photogrammetry and key areas



Photogrammetric process with Agisoft Metashape

Elaboration

Data Optimisation

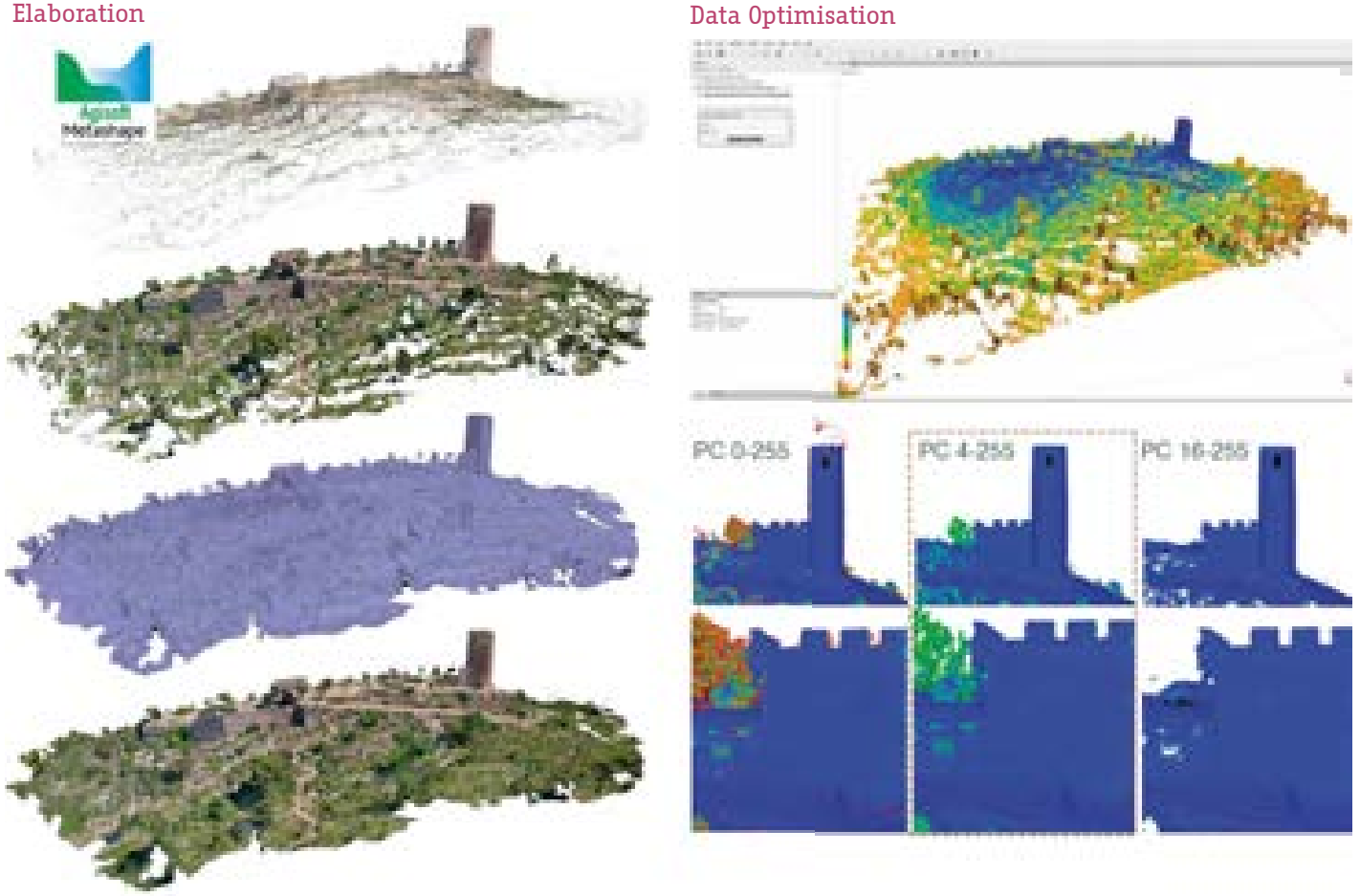


Fig. 06
Photogrammetric Workflow in Agisoft Metashape
Stages of the process, including point cloud optimisation. The images show the evolution from raw data to textured model, with examples of point classification thresholds used for data cleaning and accuracy enhancement.

Homenaje tower and the external areas of the boundary walls that are not accessible to the operator from the ground. The acquisition phase took place through the planning of several manual flights structured on two different scales: a punctual one around the Tower; and a territorial one involving the Castle, the Albacar and part of the surrounding space. For each flight, a radial path was performed with height variations for both scales of detail, architectural and territorial[11].

The data obtained from the survey campaign was processed and integrated to obtain a single 3D database into which all measurements and coordinates of the architectural elements could be merged. In particular, the photogrammetric data, aimed at obtaining a reliable point cloud to be integrated with the MLS point cloud, were processed with two different software solutions: Agisoft Metashape and RealityCapture[12]. This made possible a morphometric comparison, based on the MLS point cloud, to evaluate the geometric and formal reliability of the data. The point cloud from RealityCapture in general, which has been subjected to an automatic optimisation process, shows an improved morphological definition. In particular, the battlements processed in RealityCapture present

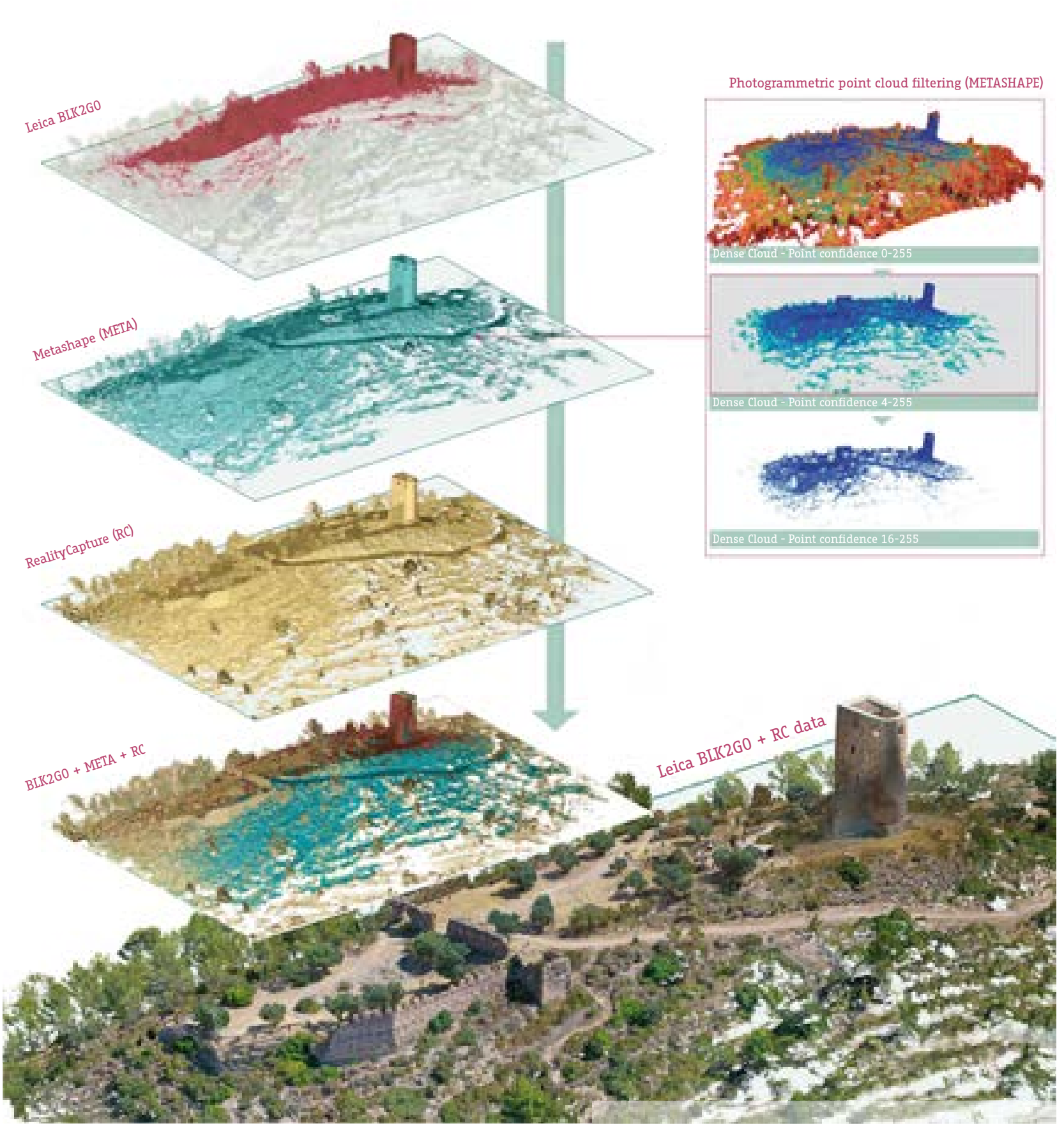
[11] A total of 744 photographs were taken (size 5472x3648, resolution 72dpi) with an overall overlap of 80/90%.
[12] Picchio, Pettineo (2023), *Digitalizzare, ricostruire e fruire il Castello di Montorio: un tassello nella definizione della rotta culturale dei castelli scaligeri.*

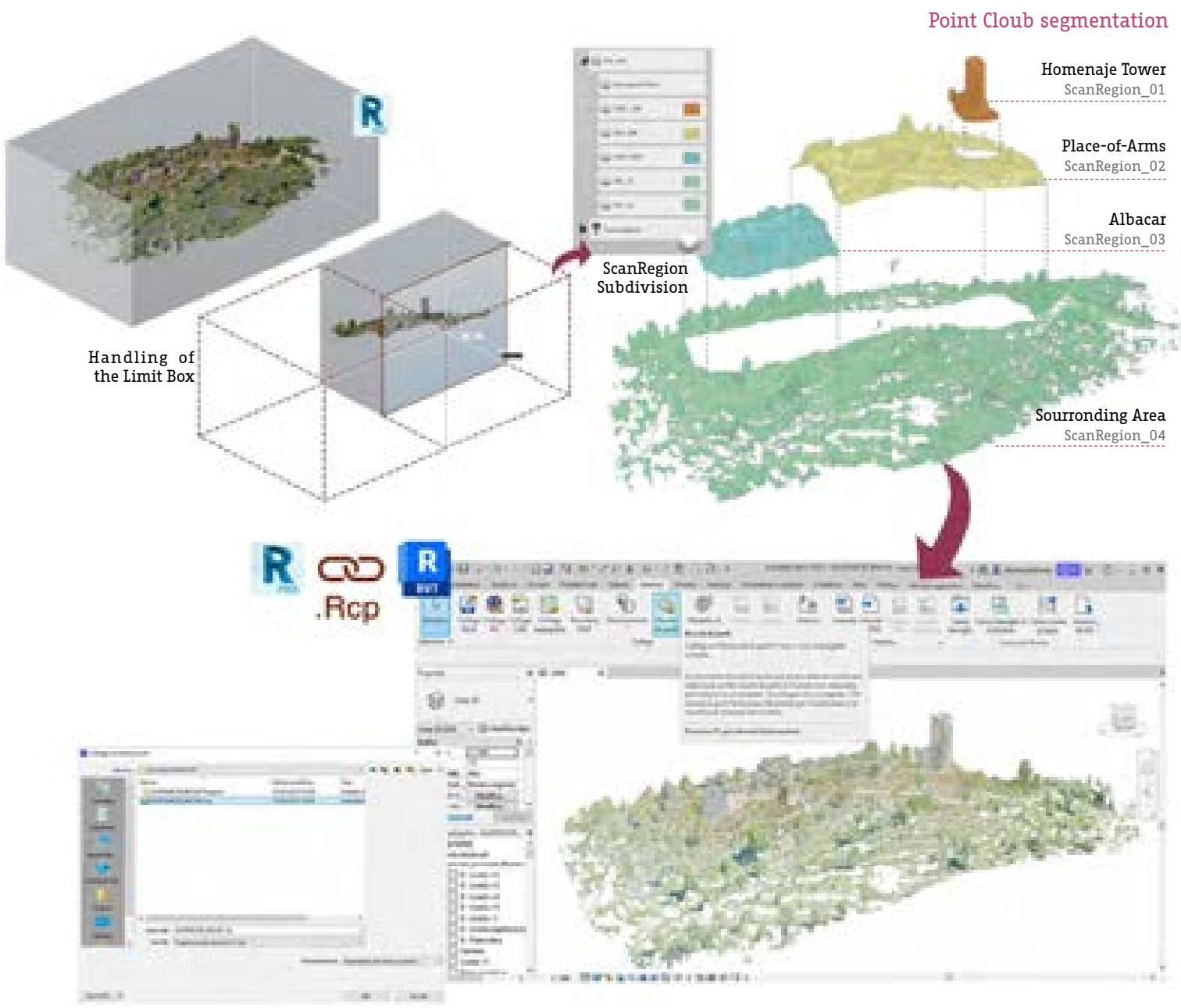
Photogrammetric data comparison

a more defined geometry, without the noise generated by the background/foreground elements in the photographs. In the model processed with Metashape, despite the semi-automatic optimisation with a discretisation from the operator, there is still noise around the battlement profile and the shape is not defined. Even for metal elements and thin profiles, such as the entrance staircase to the donjon, the quality of RealityCapture is visually and geometrically higher. In the process, the Metashape software has only partially reconstructed the staircase and railing, leaving a cone of shadow on the tower facade. This difference is also to be found in the numerical data gap: the RealityCapture point cloud has four times more points (168.8M) than that generated by Metashape (37.5M).

From a metric point of view, the following average deviations were found from the two photogrammetric clouds compared with the MLS data: (i) Average deviation between the BLK point cloud and the

Fig. 07
Comparison of Photogrammetric Outputs
Visual comparison of 3D models generated with RealityCapture (top) and Agisoft Metashape (bottom). The images highlight differences in texture resolution, mesh completeness, and the handling of problematic areas such as shaded zones and surfaces with low texture detail.


Leica BLK2GO
Metashape (META)
RealityCapture (RC)
BLK2GO + META + RC
Photogrammetric point cloud filtering (METASHAPE)
Dense Cloud - Point confidence 0-255
Dense Cloud - Point confidence 4-255
Dense Cloud - Point confidence 16-255
Leica BLK2GO + RC data



RealityCapture photogrammetric cloud is 4cm; (ii) Average deviation between the BLK point cloud and the Metashape photogrammetric cloud is 3cm; (iii) Average deviation between the two photogrammetric clouds is 1.5cm.

The three point clouds were therefore integrated into a single comprehensive database from which the most suitable combination of integrations could be selected for subsequent import into the Revit environment. The final database consists of the data from the mobile laser scanner and the photogrammetric cloud processed on RealityCapture. In general, the discriminating factor for the choice was better geometric quality and a higher point density, against a practically comparable accuracy and average deviation from the laser scanner cloud.

Fig. 09
Point Cloud processing
Workflow for managing and segmenting the integrated point cloud within Autodesk Revit.

Side page, Fig.08
Multi-Source Point Clouds
Visual comparison of point clouds generated from different sources and the integration of datasets for a complete and optimised 3D database.

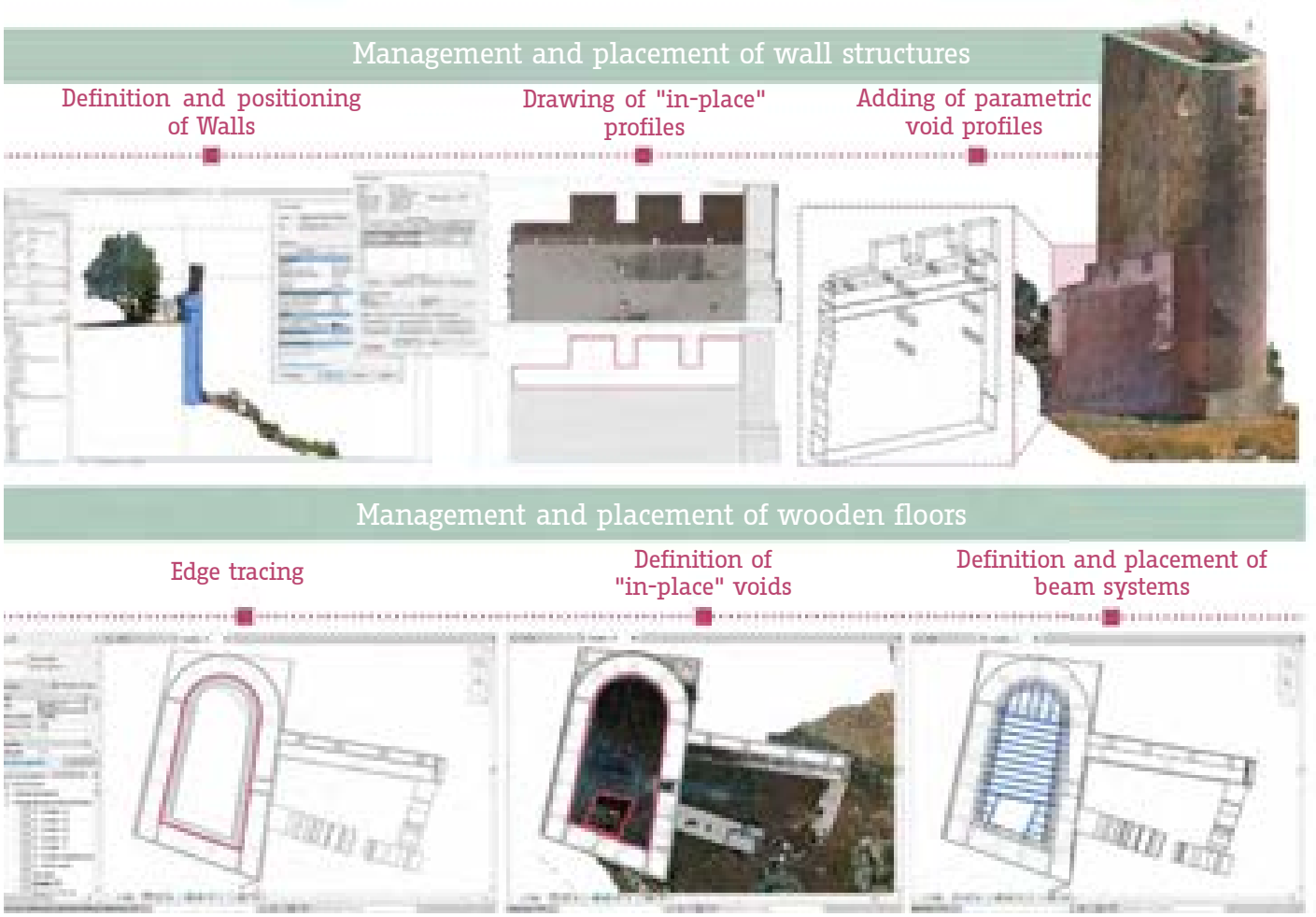
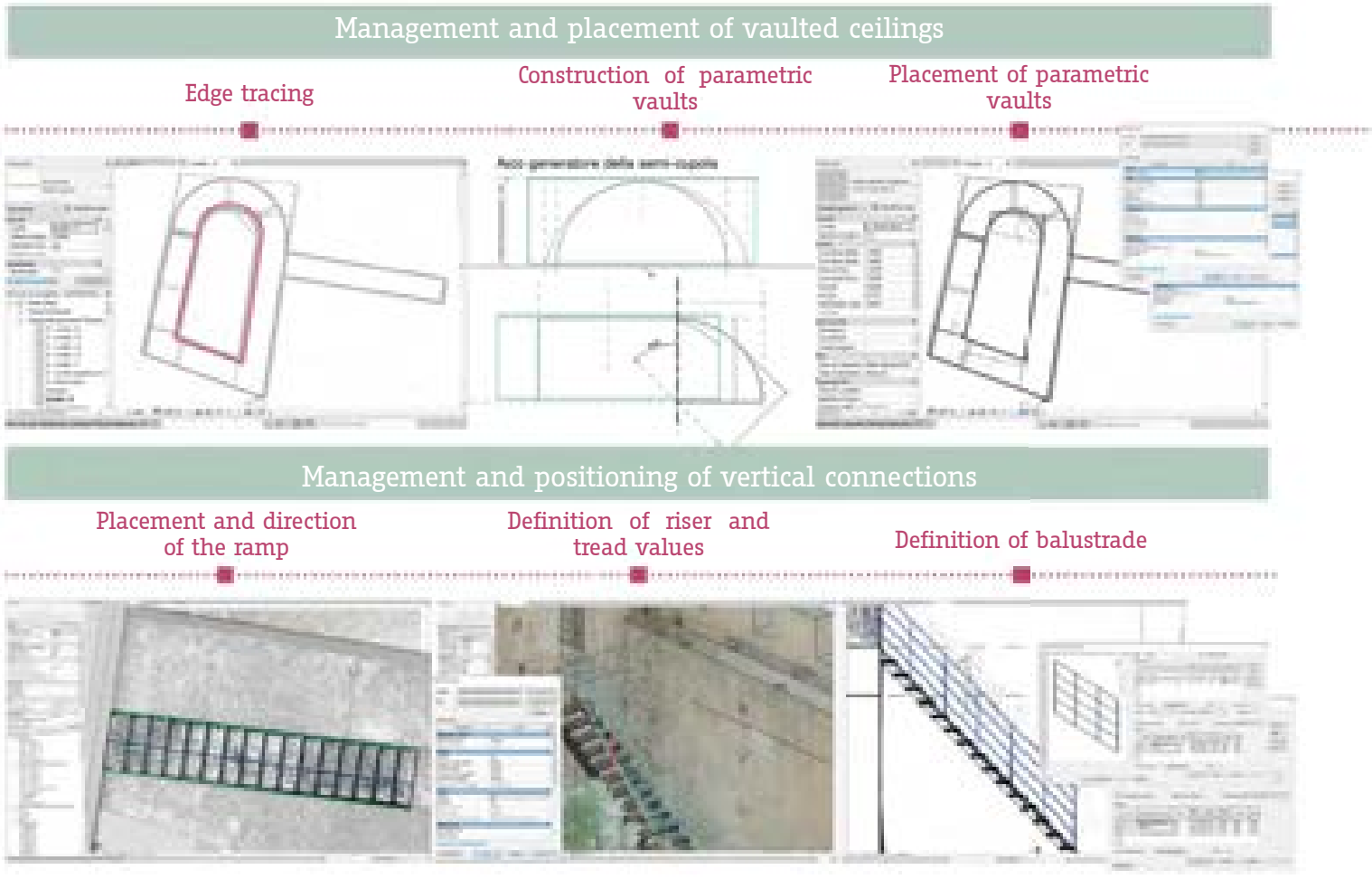


Fig. 10
Parametric Modelling of Walls, Floors, and Structural Elements
Modelling workflow of vertical and horizontal components within the HBIM environment. The diagrams show the generation of wall structures, voids, and wooden floors, including beam systems, based on the traced geometry from the point cloud.

HBIM project from data survey and management of Castle's historical phases

The castle of Almonecir, and more in general the fortified heritage, are the result of a series of transformations and technical adaptations occurring throughout their long history. Their essence is intrinsically linked to a time sequence that reflects the evolving nature of such structures[13]. These considerations are reflected in the choice of structuring the parametric modelling phase according to a twofold criterion: the typological subdivision of the individual building and formal elements on an architectural and spatial level (in relation to the orographic configuration of the hillside and the landscape system in which the castle is embedded); and hierarchical classification of the remains and historical information. Based on historical considerations and the aim of structuring an evolutionary model of the castle, before proceeding to the typological modelling of the individual formal components, 'work phases' were set up within the project file at which the evolutionary model of the castle was realised. One of the purposes of the experimentation was to test the ability of an HBIM system to include not only the metric data of the surveyed architectural heritage but also the chronological and evolutive information that has led the complex to reach its current conformation. On the other hand,

[13] Santoni, Martín-Talaverano, Quattrini, Murillo-Fragero (2021), *HBIM approach to implement the historical and constructive knowledge. The case of the Real Colegiata of San Isidoro (León, Spain)*.



in order to study the formal characteristics of the defensive structures, the architectural components of the castle were classified following a semantic typological division. The semantic classification of the castle's fortified elements took place through the structuring of a typological abacus in which a representative alphanumeric code was associated with each element. Starting from the current state of the castle, thanks to the metric and morphological support of the point cloud, the models of the architectural components were realised by modifying the parameters of the families present inside the Revit library, thus creating new components, specific to the case under study. In order to better represent several formal characteristics, typical of works realised with the tapial technique, and the irregular course of the masonry (with variable non-rectilinear cross-section) of the castle's current conformation, it was considered appropriate to also use an in-place modelling methodology, operating a subtraction between model solids. The restitution of evolutionary hypotheses within the software was carried out using various documentary sources, including scientific publications on the subject[14], supported by archaeological evidence visible in the point cloud and analyses conducted on site.

Fig.11
Parametric Modelling of Vaults and Vertical connections
Steps involved in the construction of vaulted ceilings and vertical connections, such as ramps and staircases. The images highlight the use of parametric tools to define vault geometry, riser and tread values, and balustrade profiles based on survey data.

Next pages, Fig.12
Semantic macro-subdivision
Axonometric view of the HBIM model showing main elements by type, material, and phase, representing both the current state of the castle and its configuration before restoration.

[14] C.f. Rodriguez (2005), *El Castillo de Almonecir*; Piquer-Cases, Capilla-Tamborero, Molina-Siles (2015), *The virtual reconstruction of architectural heritage and its methodological application*.

Semantic macro-subdivsion of the Castle's BIM model

Battlements 50cm (BW_Wll_BT_P7)
Creation phase: Actual State 2023
Material: Tapial

Boundary wall 115cm (BW_Wll_P7)
Creation phase: Actual State 2023
Material: Tapial

Albacar Boundary wall 60cm (AW_Wll_P1)
Creation phase: Actual State 2023
Material: Tapial

Albacar Boundary wall 70cm (AW_Wll_P2)
Creation phase: Actual State 2023
Material: Tapial

Boundary wall 105cm (BW_Wll_P6)
Creation phase: Actual State 2023
Material: Tapial

Albacar Boundary wall 60cm (AW_Wll_P3)
Creation phase: Actual State 2023
Material: Tapial

Albacar Battlements 50cm (AW_Wll_BT_P2)
Creation phase: Actual State 2023
Material: Tapial

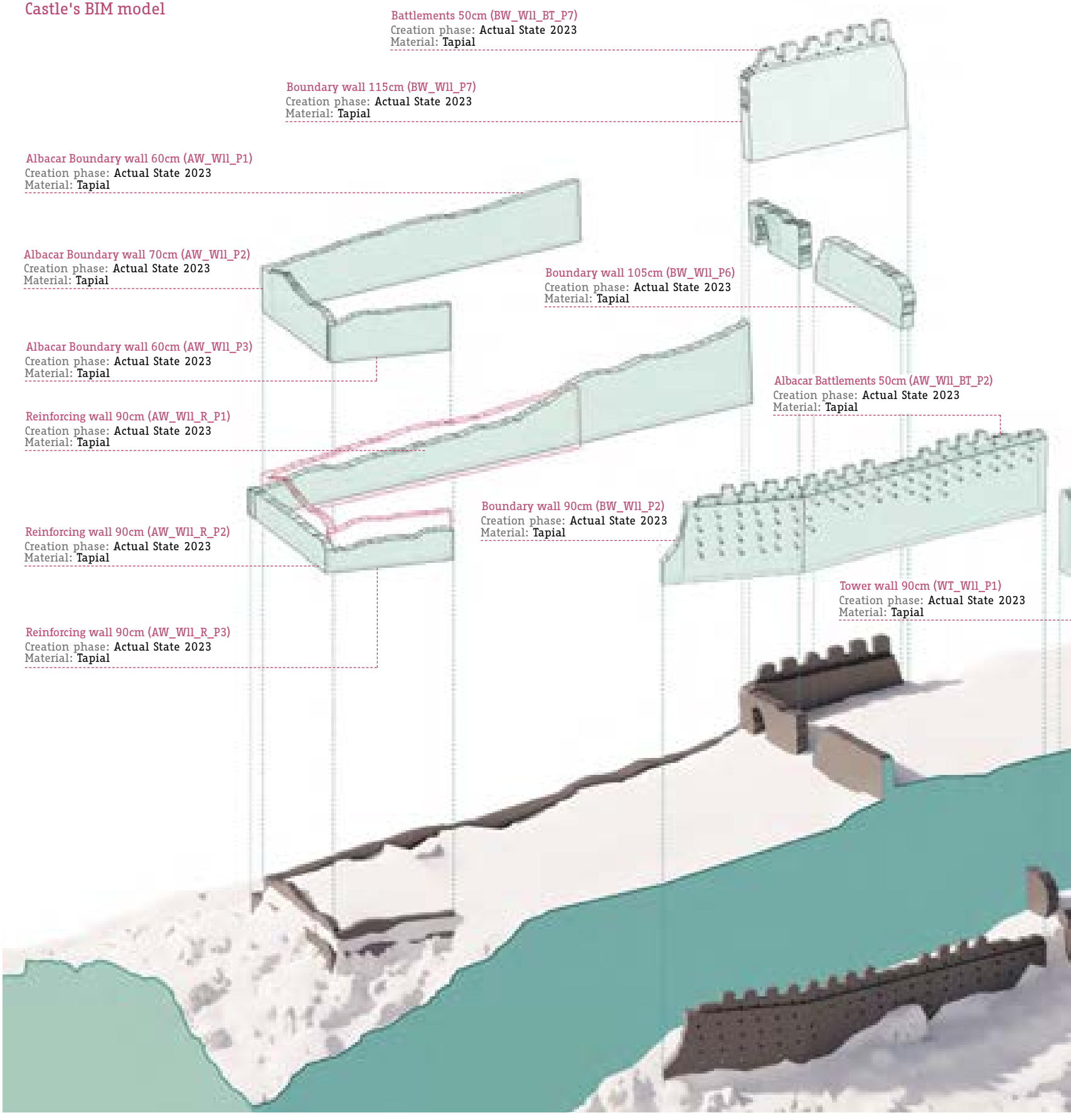
Reinforcing wall 90cm (AW_Wll_R_P1)
Creation phase: Actual State 2023
Material: Tapial

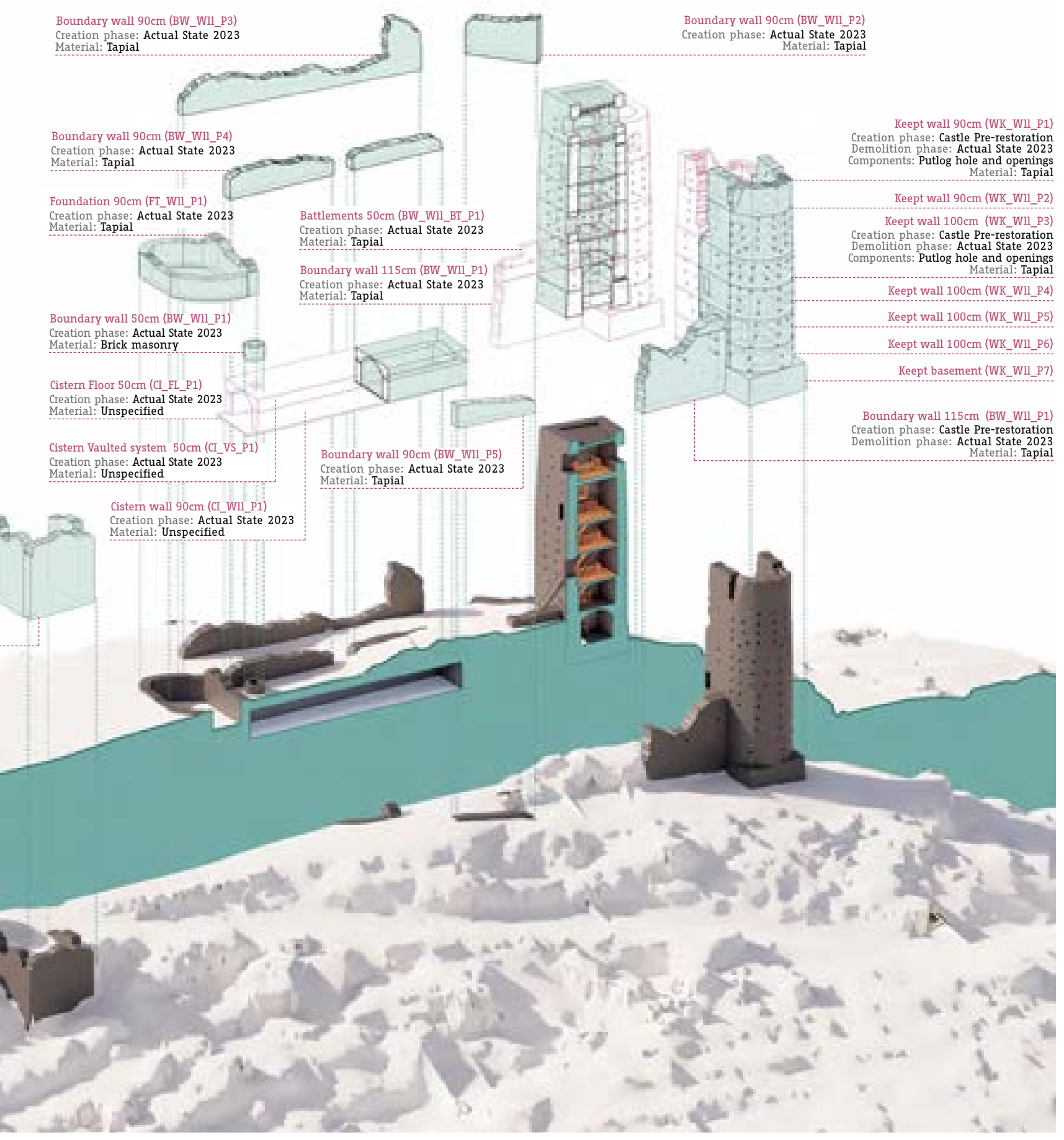
Boundary wall 90cm (BW_Wll_P2)
Creation phase: Actual State 2023
Material: Tapial

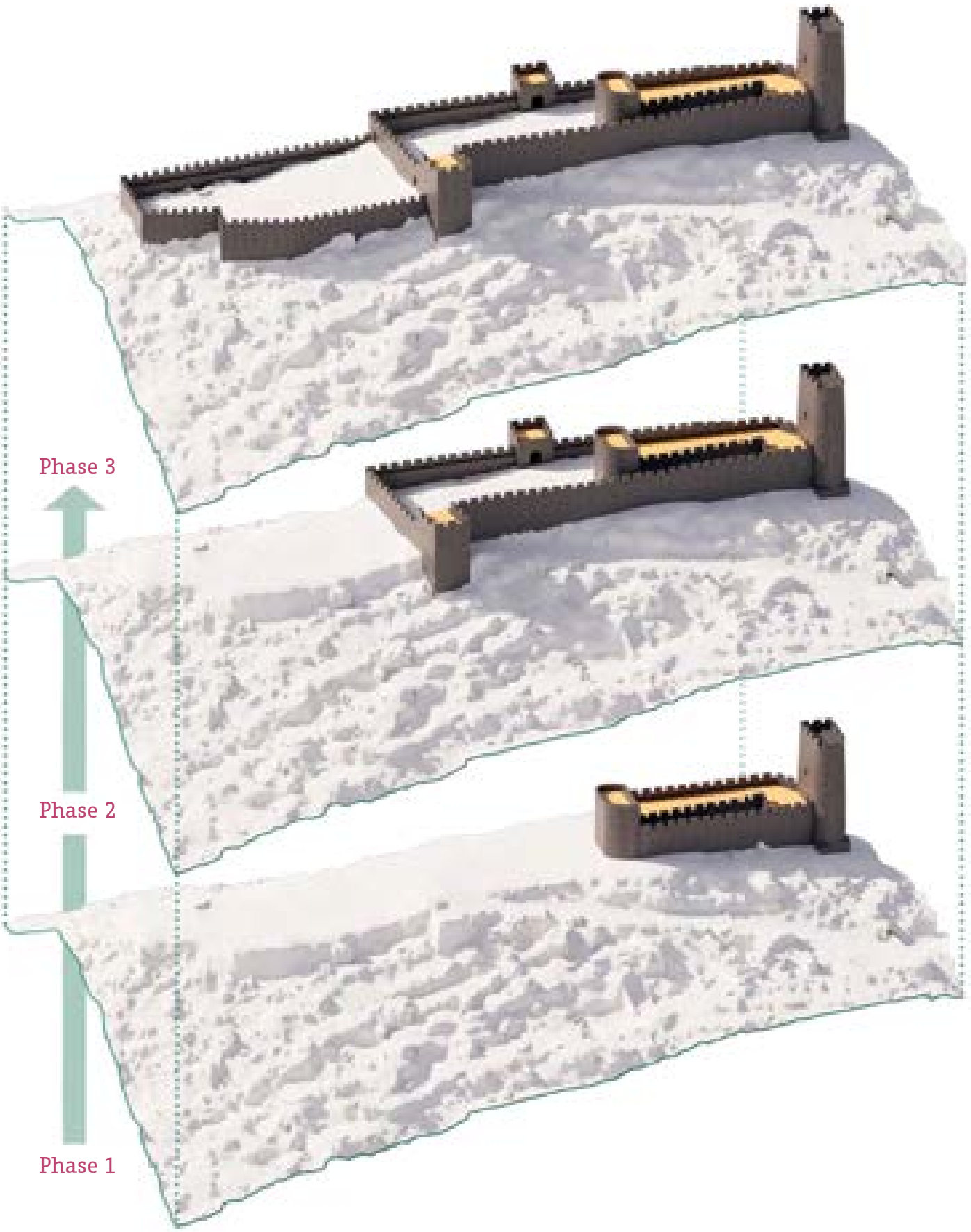
Reinforcing wall 90cm (AW_Wll_R_P2)
Creation phase: Actual State 2023
Material: Tapial

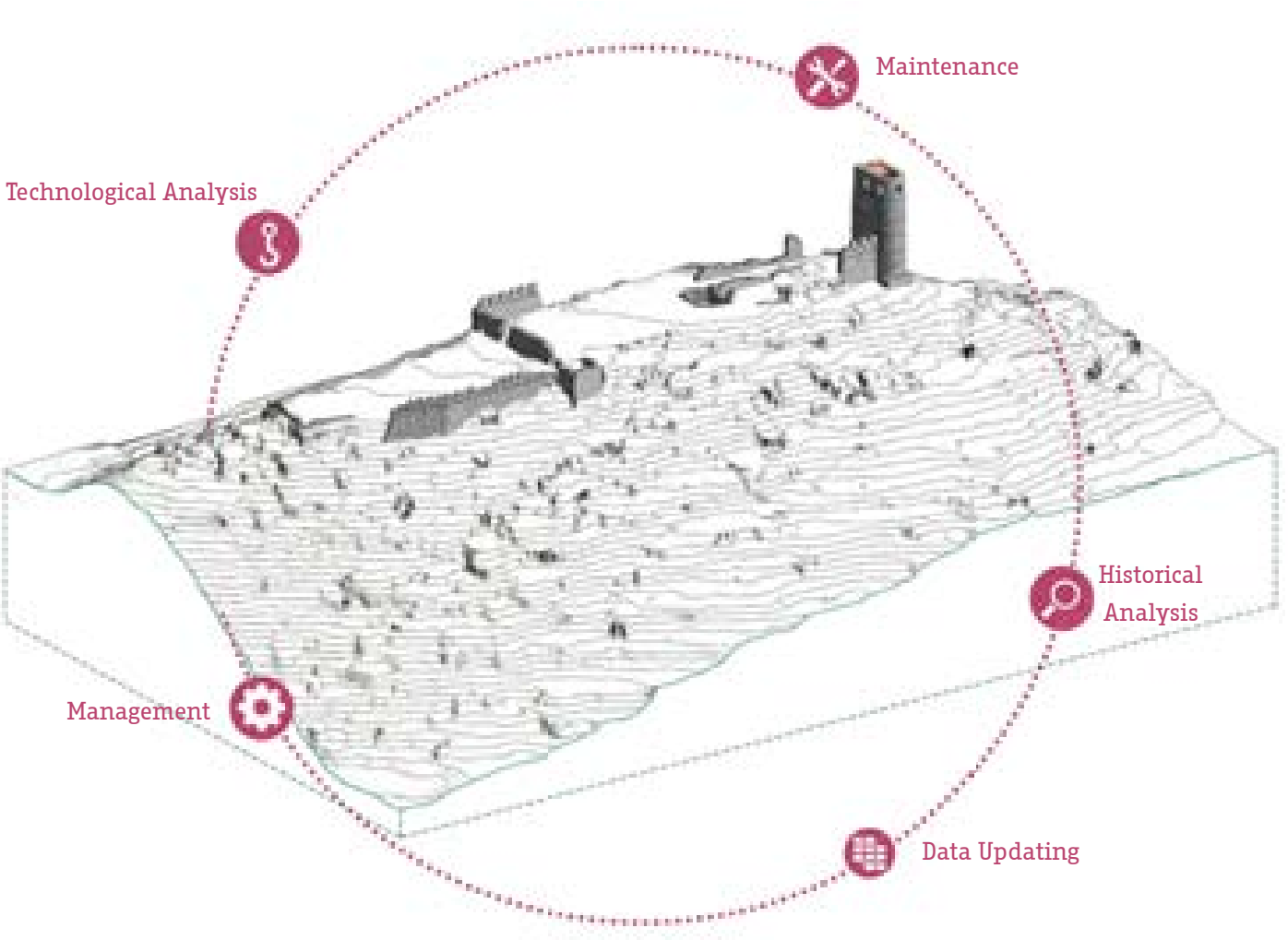
Tower wall 90cm (WT_Wll_P1)
Creation phase: Actual State 2023
Material: Tapial

Reinforcing wall 90cm (AW_Wll_R_P3)
Creation phase: Actual State 2023
Material: Tapial




Boundary wall 90cm (BW_Wll_P3)
Creation phase: Actual State 2023
Material: Tapial
Boundary wall 90cm (BW_Wll_P2)
Creation phase: Actual State 2023
Material: Tapial
Boundary wall 90cm (BW_Wll_P4)
Creation phase: Actual State 2023
Material: Tapial
Keept wall 90cm (WK_Wll_P1)
Creation phase: Castle Pre-restoration
Demolition phase: Actual State 2023
Components: Putlog hole and openings
Material: Tapial
Foundation 90cm (FT_Wll_P1)
Creation phase: Actual State 2023
Material: Tapial
Keept wall 90cm (WK_Wll_P2)
Battlements 50cm (BW_Wll_BT_P1)
Creation phase: Actual State 2023
Material: Tapial
Keept wall 100cm (WK_Wll_P3)
Creation phase: Castle Pre-restoration
Demolition phase: Actual State 2023
Components: Putlog hole and openings
Material: Tapial
Boundary wall 115cm (BW_Wll_P1)
Creation phase: Actual State 2023
Material: Tapial
Keept wall 100cm (WK_Wll_P4)
Boundary wall 50cm (BW_Wll_P1)
Creation phase: Actual State 2023
Material: Brick masonry
Keept wall 100cm (WK_Wll_P5)
Keept wall 100cm (WK_Wll_P6)
Cistern Floor 50cm (CI_FL_P1)
Creation phase: Actual State 2023
Material: Unspecified
Keept basement (WK_Wll_P7)
Boundary wall 115cm (BW_Wll_P1)
Creation phase: Castle Pre-restoration
Demolition phase: Actual State 2023
Material: Tapial
Cistern Vaulted system 50cm (CI_VS_P1)
Creation phase: Actual State 2023
Material: Unspecified
Boundary wall 90cm (BW_Wll_P5)
Creation phase: Actual State 2023
Material: Tapial
Cistern wall 90cm (CI_Wll_P1)
Creation phase: Actual State 2023
Material: Unspecified


Phase 3
Phase 2
Phase 1



The development of the model using the Revit platform has allowed the association, for each component, of metric, technological, historical-evolutionary, and conservation status information[15].
To developing a process of communication and dissemination of the results processed through information modelling, experiments were made to link the model to a platform that would allow fruition in a virtual environment. Through the software Enscape, it was tested the interaction of the information model through Virtual Reality (VR). The connection of the model within the platform takes place using a plugin that links the model to the rendering software in real-time. In order to allow easier use of the model by professionals and non-professional people, the Enscape software allows interaction with the information metadata associated with the various BIM components without the necessity of specific parametric modelling software. The software allows the information model to be exported in two different formats, the Exe Standalone, for offline visualisation, and the Web Standalone, for online use, thus creating a package that includes the entire virtualisation project within an executive compatible with Virtual Reality visualisation.

Fig. 14
HBIM model as a support tool
The digital model integrates functions for technological and historical analysis, data updating, maintenance planning, and heritage management.

Side page, Fig. 13
Historical development phases of the castle
Chronological reconstruction of the castle's evolution, aligned with the BIM model's phased structure.

[15] Castellano-Román, Pinto-Puerto (2019), *Dimensions and levels of knowledge in heritage building information modelling, HBIM: The model of the Charterhouse of Jerez (Cádiz, Spain).*

Fig. 15
Virtual visualisation of the HBIM model
Immersive exploration of the digital reconstruction using Enscape, accessible through both VR headsets and mobile devices.

The experimentation illustrated allowed us to make some considerations on the results obtained and possible implementations of the research. The 3D model, to which it is possible to associate other information layers, is a useful tool to follow all the operational processes necessary for the conservation and management of the architectural heritage. This methodology enables the preservation of selected information, facilitating data storage management processes and minimising redundancy and dispersion. The application of BIM provides the conditions for continuous updating and implementation in response to the needs and progressive evolution of digital systems. The most important result is the recognition of the need to think in terms of interoperability, working on structuring interfaces for communication and use of the parametric model. The proposed workflow highlighted the potential of visualising the BIM model through online applications and augmented reality systems is a workable solution for a better understanding of the architectural artefact and an efficient management of historical phases. This is even more tangible if one considers the increasing accessibility of technology costs to the public, and the technological development linked to the increase in computing performance of the instruments on the market[16]. This methodological development applied to the Castle of Almonecir opens the possibility of implementing and developing this operational flow through the replicability of the methodology on other case studies of the route, intending to enhance the territory and promote tourism within the Valencian Community.

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THE FORTIFIED CITY OF CULLERA, SYMBOL OF SIEGE AND RECONQUEST

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The strategic positioning of fortifications has always required continuous adaptations and renovations throughout history, aligning them with the evolving defense needs of each era or domination[1]. That is the situation in the Cullera Castle that, with its advantageous position - dominating a vast territory extending south to the Júcar river, encompassing both coastal and river areas - justified its use as a fortified stronghold from its foundation in the 10th century. With a wide historical chronology, this defensive system presents a multitude of architectural elements from different eras, exemplifying the architectural prowess of Andalusia during the 12th and 13th centuries[2]. Over the last decade, a series of studies and interventions have taken place leading to the consolidation and restoration of the various structures of the ensemble. Despite different remodeling in various periods, the remains from the Islamic period are well preserved and offer insights into the origins of the castle. The documentation of the buildings for the reading of the historical phases, but also for the valorisation of the castle, was one of the intervention approaches taken under the Prometheus project. An integrated fast survey was carried out allowing the production of 2D and 3D outputs useful for its preservation as a monument and at the same time contributing to its promotion.

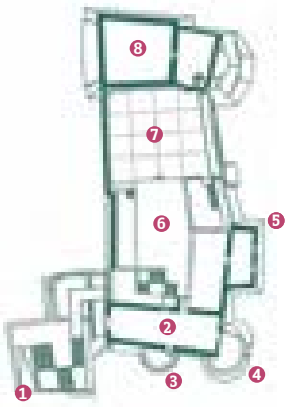
Side page, Fig. 01
The Castle in the Urban Context
The keep, one of the best-preserved elements of the complex, dominates the entire bay and is now integrated into the contemporary urban fabric, which has radically transformed its surrounding landscape.

A Chronicle of Defense Significance and Architectural Transformation

The Mountain of Cullera stands as a distinctive visual landmark, encircled by the Mediterranean Sea, the river Júcar's estuary, and expanses of rice fields. Perched on this elevated terrain, various defensive structures take form, ranging from natural features like caves and rock shelters to constructed elements such as a carlist fort and the Castle of Cullera[3].

The fortress since its origins served as a strategic element to defend and guard the coast and the mouth of the Júcar River. Initially subordinate to the interests of the caliphate, it also became a refuge for the local population during the Taifa era in the 11th century[4]. While maintaining its defensive role as a border, new structures were built during the Almoravid and Almohad periods due to Christian incursions and population growth. Indeed, the Cullera Castle complex extends beyond the fortress

Fig. 02
Castle main elements
1. Main Access; 2. Hall of Arms; 3. Support Tower; 4. Cap D'Altar Tower; 5. White Tower; 6. Place of Cistern; 7. Place of Arms; 8. Major Tower



[1] López González (2015), *Del castillo medieval al palacio-fortaleza*, pp. 191-198.
[2] Climent Simón, Giner García, Rodrigo Molina (2015), *El Castillo de Cullera. Adecuaciones del castillo islámico*, pp. 71-78.
[3] Furió Diego (1998), *De la societat islàmica a la feudal, la conquista i la colonització de Cullera*.
[4] Simón, Álvarez, García (2011), *Torres y murallas de la segunda albacara del Castillo de Cullera*, pp. 263-272.

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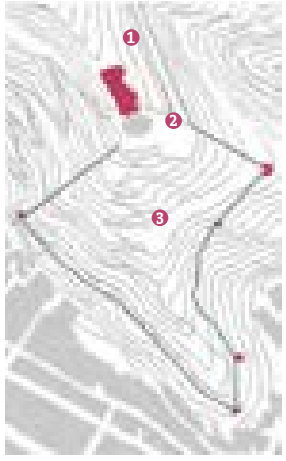
Fig. 03
The ancient defence systems
Defensive system of the castle along the mountain (1) with the two albacar enclosures (2, 3). Originally, the castle had multiple defensive tiers to shelter the population during a siege.



itself, encompassing a dual concentric walled enclosure known as *albacar*[5]: Albacar Vell and Albacar Segon. These enclosures served a threefold purpose: firstly, to assert the military and political authority of Cullera Castle; secondly, as a strategic gathering space for military forces in preparation for territorial defense; and lastly, to provide a refuge for the population and animals during times of danger[6]. During the Almoravid and Almohad phases in the region of Sharq al-Andalus, the typical and common policy was the construction and improvement of such defenses. The earliest mention of the lower *albacara* is found in the *Crònica de Jaume I or Llibre dels Feyts*: the account[7] describes an attempt in 1235 by the monarch to conquer Cullera, depicting the presence of Saracens, livestock, and inhabitants in the areas surrounding the castle.

What led James I to conquer *Hisn Qulayra*[8] was in fact its strategic position for the control of goods that were transported along the river Júcar[9]. As mentioned in the *Llibre dels Feyts*[10] during the conquest of

[5] From the Arabic "al-baqqâra" an albacara is a "walled enclosure on the outer part of a fortress, with an entrance to the square and an exit to the field, used for keeping bovine livestock".
[6] Estruch, Villa, Álvarez (2015), *Restes arqueològiques de l'albacar del castell de Cullera (Ribera Baixa, País Valencià): segles V aC-XIII dC*, pp. 59-66.
[7] de Gayangos (1883), *The Chronicles of James I: King of Aragon, Surnamed the Conqueror*, pp. 297.
[8] The Islamic settlement (*Hisn* means castle) from which Cullera would later develop.
[9] The river is navigable as far as Alzira.
[10] de Gayangos, (1883), *The Chronicles of James I*, cit., pp. 189-190.

Fig. 04
Panoramic view of the city of Valencia, 1563
View of Valéncia made by Anton van der Wyngaerde, offer a representation of the mountain of Cullera (in the background).

the castle, James I's troops, faced with the difficulty of attacking the fortress from the inside and opted to set up *fonèvol*[11]. However, they could not find suitable stones for the attack and were forced to call off the siege, retreating northwards. The Chronicles do not describe how James conquered Cullera, however in 1239, the castle is part of the new possessions of the Kingdom of Valencia, becoming a resting place for the troops that continued the expansion towards the lands south of the Júcar[12]. During this period, the castle rapidly changed its distribution: whereas the *hisn* fortress was a limited space for a few soldiers, it was transformed into the lord's residence, with the name of the main tower also changing, now known as the *Torre del Homenaje*[13]. The 13th century saw a duality between religious institutions and the crown for the contention of the area[14]. In 1240, the castle passed to the Order of the Hospital of Saint John, while the monarchy retained control over the city. After the dissolution of the Templars in 1312, the castle passed to the Order of Santa Maria de Montesa[15] and the crown began to take interest in the castle, ordering some works (partially carried out) in 1337.

[11] A *fonèvol* is a medieval siege weapon, similar to a *trebuchet* but smaller in size, used to destroy walls or throw stones at walls in order to knock them down.
[12] Hidalgo (2018), *Els castells de Corbera i de Cullera: de hisn musulmà a castrum cristià*.
[13] Font Borrás (2000), *Història i art. Evolució arquitectònica del castell de Cullera*, pp. 401-423.
[14] Arciniega García (1997), *El Castillo de Cullera. Informe histórico analítico*.
[15] Guinot Rodríguez (1985), *La fundación de la Orden Militar de Santa María de Montesa*, pp. 73-86.

Fig. 05
Historical Cartography
Left: cropped detail of Cullera Cape from the 1772 nautical chart Plano de la rada de Cullera; *right:* further enlarged detail of the same chart, showing the castle and the fortified system in relation to the landscape. Adapted from the Biblioteca del Instituto Geográfico Nacional, CC BY 4.0, ign.es.

Side page, Fig. 06
Historical photographs of Cullera, c. 1958.
Above: panoramic view of the beach and castle of Cullera; *below*: view of Cullera Castle from the urban centre. Photographs by Verdugo y Arranz, from the Archivo Fotográfico de la Dirección General de Turismo (1940–1992), Biblioteca de la Facultad de Empresa y Gestión Pública, Universidad de Zaragoza. Graphic composition from Flickr images, CC BY-SA 2.0.

In the 14th and 15th centuries, there is a lack of relevant information[16], the castle continued to belong to the Knights Hospitaller and, during the War of the Two Peters, it passed into Castilian hands before being reconquered by the Aragonese, being partially demolished and rebuilt[17]. In the 16th century, the fortress maintained its defensive importance, contributing to the security of the Valencian coast against pirate raids, the castle was "modernised" and a series of bastions and ravelins were built, the walls were reinforced with buttresses and artillery was placed in different towers[18]. During crucial events such as the War of Succession, Independence and the Carlist War, the fortress played a significant military role. However, after this last conflict, it was abandoned and remained in a state of disuse, entrusted exclusively to the care of the monks of the sanctuary[19] erected in its surroundings at the beginning of the 20th century[20]. In its current configuration, the castle is the result of multiple adaptations over time. Its excellent condition is also the result of significant renovation work[21] in recent decades and the presence of the sanctuary, which however has completely altered the original vision of the building[22].

[16] Arciniega García (2003), *Sistemas de defensa en Cullera: Castillo, murallas y torres.*
[17] Hidalgo (2018), *Els castells de Corbera i de Cullera: de hisn musulmà a castrum cristià, cit.*
[18] Climent Simón, Giner García, Rodrigo Molina (2015), *El Castillo de Cullera, cit.*
[19] In the 19th century, a community of Franciscans settled here, and a sanctuary was built right next to the castle.
[20] Hidalgo (2018), *Els castells de Corbera i de Cullera: de hisn musulmà a castrum cristià, cit.*
[21] For more details see: Climent Simon (2005), *Plan Director de actuaciones en el Castell de Cullera y su entorno.*
[22] Hidalgo (2018), *Els castells de Corbera i de Cullera, cit.*

Fig. 09
3D Database
Multi-source point cloud of the castle.

Previous page, Figs. 07, 08
The Features of the Castle
A selection of descriptive images highlighting the most significant fortified elements.

Documentation activities for an analytical reading of the fortified system

Several qualities, including history, architectural features and social importance, contribute to the value of Cullera Castle. The historical development, which has been briefly summarised, is fundamental to understanding how the fortified system acquired a formal and structural complexity, a consequence of successive overlapping phases.

A meticulous approach to representation and heritage documentation is essential for accurately recording these architectural features[23]. In this context, the representation of architecture in three-dimensional space becomes crucial not only to improve the visual and intuitive understanding of structures, but also to effectively define and clarify data[24]. This ensures that information is not only visually accessible, but also comprehensively articulated/integrated to convey an appropriate understanding of architectural complexities. This implies that in order to accurately assess the state of conservation of the existing heritage, it is necessary to collect detailed information. However, the amount of data is as much an asset as a bottleneck[25]: an excessive storing of data may be unnecessary in relation to the goals set. In cases where structures are in good condition, like in Cullera Castle, documentation can be streamlined, focusing only on those details essential for historical and architectural understanding.

[23] Morandotti, et al. (2019), *L'Università di Pavia. I cortili e gli ambienti monumentali. Un progetto di documentazione digitale e sviluppo di sistemi di gestione per la manutenzione programmata*, pp. 863–874; *Pettineo et al. (2025), From Integrated Survey to Semantically-Enriched Models: An H-BIM Pipeline for Developing Descriptive Systems to Understand Architectural Heritage.*
[24] Bertocci, Parrinello (2015), *Digital survey and documentation of the archaeological and architectural sities.*
[25] Parrinello et al. (2023), *HBIM modelling for the architectural valorisation via a maintenance digital eco-system.*

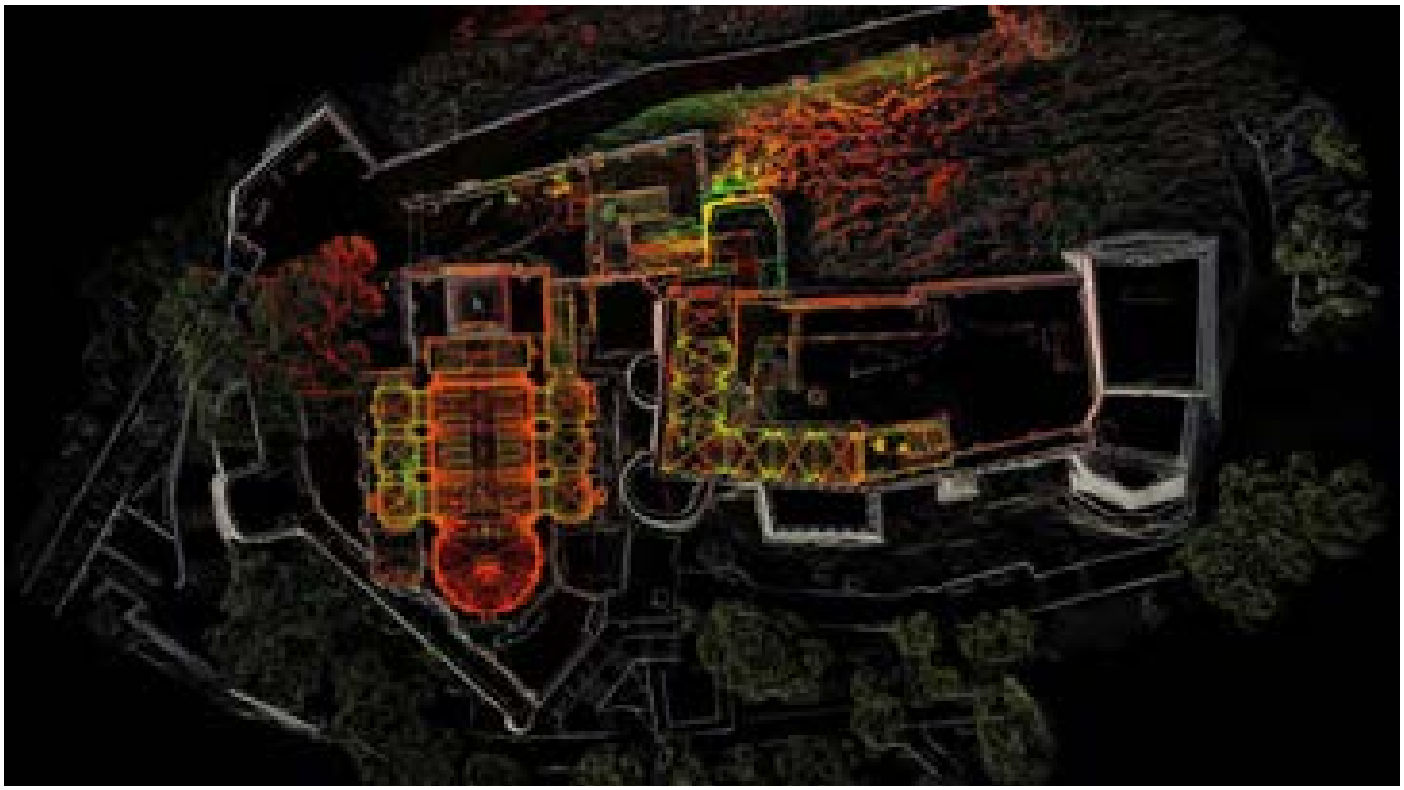
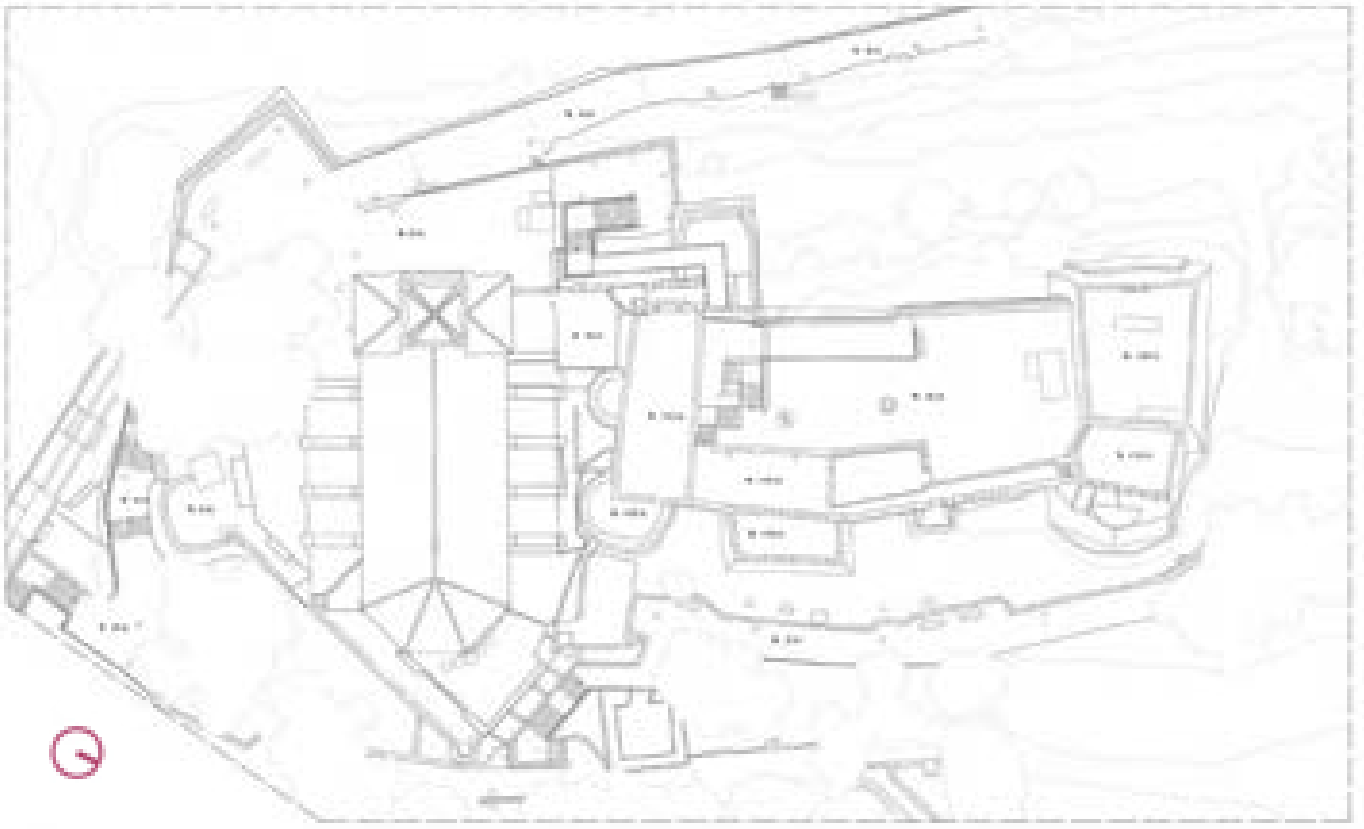


Fig. 10
3D Database
Planimetric view of the multi-source point cloud.

In order to balance the required accuracy with an efficient use of available resources, also in terms of time schedules, the documentation of Cullera Castle was carried out using fast survey methodologies, employing Mobile Laser Scanning (MLS) and photogrammetry from Unmanned Aerial Vehicle (UAV). The survey was carried out over the course of one morning, focusing on the acquisition of the castle, the sanctuary and the lower albacar system. The MLS instrumentation (Leica BLK2GO) was primarily employed to conduct interior surveys of the castle and sanctuary using a sequence of closed paths, featuring a 30% overlap for enhanced error control. Each scan, totaling seven in number, facilitated the survey of three interior rooms, except for the church interiors, which were surveyed in a single path (lasting approximately 10 minutes each). Additionally, the laser instrumentation was used to survey the tower system of the lower albacar. The scanning paths traced the route descending the mountain along the calvary, forming a closed loop that reconnected with previous scans in the church forecourt[26].

The drone survey (DJI Mavic Mini 2), on the other hand, enabled the acquisition of previously inaccessible areas, including rooftops and mountain slopes, providing a comprehensive overview of the entire complex. The flight was conducted manually, maintaining an altitude of approximately 30 meters, using a single set of batteries. Due to challenging weather conditions, particularly wind, and the extensive area coverage, it was not feasible to capture the mountain and lower tower system entirely.

[26] This strategy certainly reduced/compensated for the error, however due to the extension of the area and the lack of control points on the hillside, the resulting error was still quite significant.

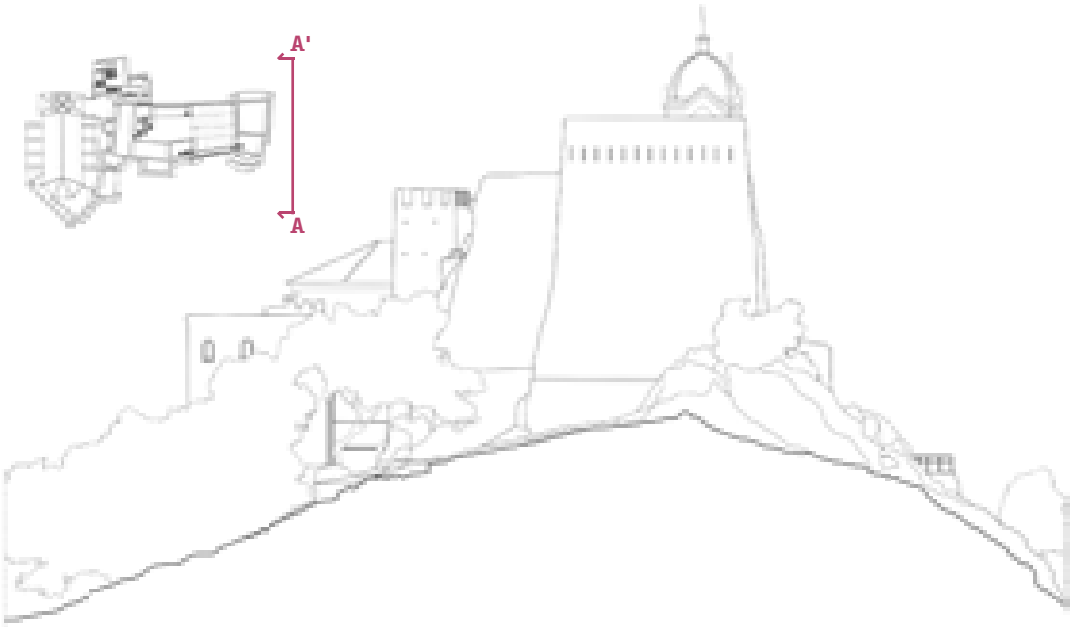


Nevertheless, a dataset consisting of 227 photos was successfully compiled, offering a holistic perspective of the primary albacar, the upper fortified system, and their connection to the sanctuary. Data processing enabled the integration of the dataset from MLS and drone photogrammetry in order to obtain a complete three-dimensional dataset.

However, the implementation of this methodology presents some challenges, including dealing with the problems of aligning MLS scans, processing the generated photogrammetric model and integrating them into a coherent system, incorporating detailed elements. The integrated database obtained from the acquisition campaign contains an overlapping configuration of metric and photographic information that can be analysed according to its intended purpose. Therefore, the survey data were first of all discretised through 2D vector representations to decompose and identify the architectural features of the fortified system. Through the drawing, the configuration of the fortified system is clearly revealed. A tangible example is the White Tower, crowned with battlements, which harmoniously integrates with the muslim wall, or the Major Tower, which has grown over the centuries to an impressive height of 16 meters, becoming the focal point of the entire defensive complex. Within the castle and the sanctuary, various rooms, including the armory and the refectory transformed into an evocative chapel, can be fully appreciated through the use of floor plans. The architecture of the fortress is evident and can be understood in the details outlined in these representations. In this way, the 2D drawing supported the identification of the fortified elements, as well as their construction characteristics, by searching for traces and signs in the masonry related to their construction conformation and their insertion in the context.

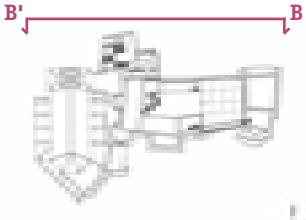
Side page, Fig. 11
Planimetric view
Drawing and photocomposition of the ecclesiastical and fortified complex

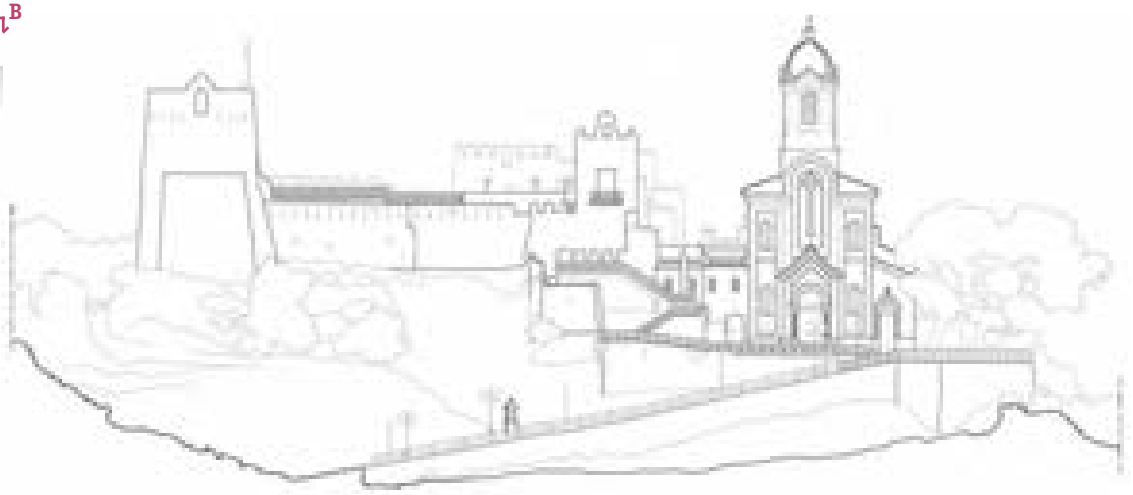
Next pages, Fig. 13, 14
Main elevations of the complex
Series of cross-sections illustrating the volumetric articulation of the architectural complex in relation to the landscape and site morphology.

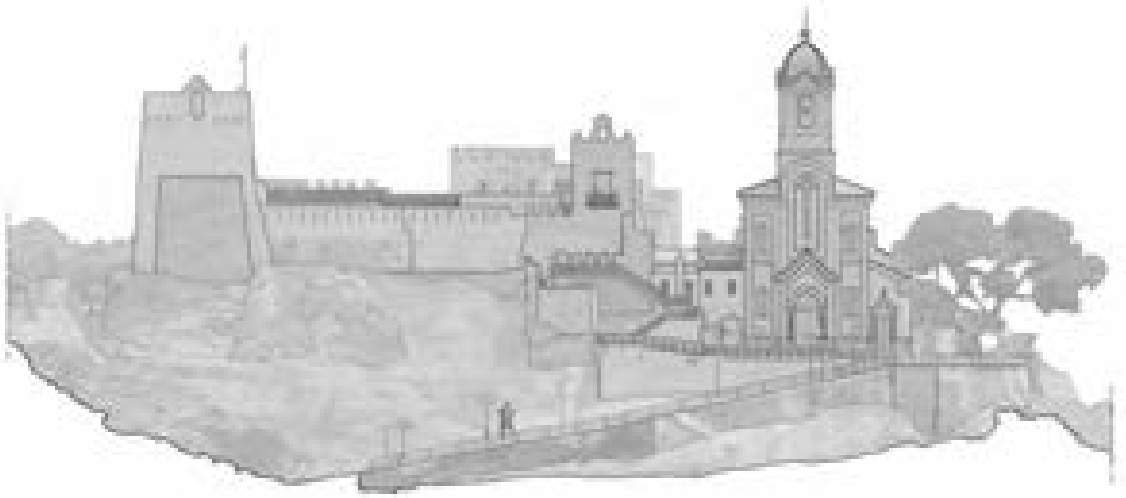


Section A-A'

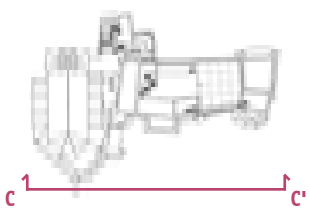
Fig. 12
Planimetric view
The drawing highlights the relationship between the built structures and the site's topography, with volumes adapting to the slope and culminating in the main tower.







Section B-B'



Section C-C'

The analysis of Cullera Castle has yielded profound insights into its historical trajectory and architectural evolution. The methodological approach, incorporating mobile laser scanning (MLS) and drone photogrammetry, not only captured the physical dimensions but also provided an understanding of the fortification's adaptive responses to changing political contexts. The 2D representations derived from survey data are, in this way, a valuable tool for revealing the intricate layers of the fortified system, unveiling defensive structures and offering an in-depth comprehension of their structural nuances. Furthermore, the processing of 3D models and their integration on platforms like Sketchfab provides an accessible and engaging avenue for public exploration.

This integrated approach, emphasising precision and accessibility, emerges as a methodological paradigm for the documentation and enhancement of fortified heritage. In this way, the digital representation of historical monuments not only preserves the past but transforms it into a dynamic and accessible scientific discourse for everyone, contributing to the preservation and dissemination of the richness of architectural history.

Fig. 14
Digital fruition system
The interactive 3D model offers a guided exploration of the architectural complex, highlighting its main historical and monumental features.

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DATA INTEGRATION FOR THE DEFINITION OF A DIGITAL DATABASE FOR MORELLA CASTLE

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Side page, Fig. 01
Multisource point cloud
Integration of terrestrial and aerial photogrammetry surveys, supporting geometric analysis and 3D reconstruction of the complex.

The Castle of Morella, located over 1,000 meters above sea level in the Spanish province of Castellón, is a remarkable example of strategic defensive architecture with origins dating back to Roman times[1]. Built mainly during Arab rule in the 8th century AD, it became a Christian stronghold during the Reconquista in the 11th century. Its importance became decisive, especially during Aragonese domain and the Wars of the Spanish Succession and Independence, resisting several sieges. Today, Morella's castle and historic center are important tourist sites that symbolise the region's complex history[2].

The structure of the castle reflects a strategic design that takes advantage of the geographical position and surrounding topography. Built on a hill, it offers a dominant perspective to guard access routes and takes advantage of the morphology of the terrain, characterised by hills and steep cliffs, for natural defense. In particular, the castle is an example of layered design with three distinct levels. The first, at the base, features a circular defensive wall to resist frontal attacks[3]. The second level, the functional center of the castle, has massive walls, semi-circular towers, and guardhouses for advanced and versatile defense. The third level, the defensive apex, includes the parade ground and the tribute tower, representing the safest point with the function of refuge and command. Between the castle and the city stretched the Albacara, a crucial open space in defensive strategies[4].

The monumental complex of the castle represents a tangible and irreplaceable testimony of Spanish history. The events that determined its cultural significance are reflected in its various evolutionary stages, from military fortress to historical icon, allowing a part of the Valencian territorial historical memory to be preserved over time in the framework of the route of James I[5].

[1] Segura Barreda (1868), *Morella y sus aldeas*.
[2] The castle became a National Historic Monument recognised by the Spanish State on 4 June 1931. For more details, see *Decreto de 3 de junio de 1931, declarando monumentos Históricos-Artísticos, pertenecientes al Tesoro Artístico Nacional, los que se indican*, *Gaceta de Madrid* (155), pp. 1181-1185.
[3] The circular layout allows effective deployment of defenders and armaments along the wall, providing uniform coverage and increased resistance to assaults.
[4] During times of danger, it served as a buffer zone, slowing down the besiegers and offering the villagers a strategic margin to organise their defence. The Albacara also served as a key point for communication and coordination between the castle and the city, ensuring an efficient exchange of information and the implementation of coordinated strategies.
[5] Although there is no specific information on the actions of James I in Morella, his figure remains relevant in the broader context of the history of the Reconquista and the formation of the Crown of Aragon.

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Fig. 02
Historical view of Morella
Engraved depiction of the city of Morella with the castle atop, showing dense urban fabric and monumentality enhanced in a symbolic manner.

Multi-scale 3D documentation of the fortified complex

The architectural characteristics and historical value of the site underline the importance of the castle as a place of Spanish culture and an identity symbol. It becomes an emblematic case of historical monumental multi-scalar architecture, so it becomes necessary to initiate actions aimed at the geometric and spatial knowledge of the artefact. The objective is to establish a knowledge base suitable for investigations and post-processing. Specifically focused on Morella Castle, the main training and methodological objective involve structuring an integrated documentation workflow employing suitable range-based and image-based survey techniques across all architectural levels[6].

The methods deployed for documentation activities are closely tied to the key features of the examined historical site. In the case of monumental complexes, the methodologies used responded to the principle of multi-scale data acquisition through multi-sensor systems, as well as meeting the requirements of data integration[7]. In this sense, he main features of the Morella fortress are large spaces and obligatory routes, marked by the presence of punctual architectural artefacts, such as gates, turrets or service buildings, and

[6] In the case of historical monumental complexes, it is often necessary to investigate the methods and tools to be used for the complete digital restitution of the complexities that characterise such contexts. For further information, see Picchio F. et al., 2020, *La costruzione di una banca dati tridimensionale per la Certosa di Pavia: sperimentazioni tecnologiche a confronto*.

[7] The integration of data from multi-sensor acquisitions is a topic of great interest in the current scientific debate (Galasso et al., (2021), *From excavation to drawing*; Parrinello (2021), *The wall of Santo Domingo*; La Placa, Picchio (2022), *Fast survey technologies*; Kowalski et al. (2023), *From archives sources to virtual 3D reconstruction*; Pérez-García et al. (2023), *Multiscale 3D Documentation of the Medieval Wall of Jaén (Spain) Based on Multi-Sensor Data Fusion*, as their potential affects both the survey operations themselves and their results. The choice of adopting a specific acquisition technology and a specific data processing process is strongly influenced by the characteristics of the building under study and the objectives pursued, which are often not only aimed at analysing its general characteristics, but also at assessing and verifying its possible critical conditions.

Fig. 03
Contemporary aerial view
Phtoto of the town and castle, showing the historic centre clustered around the rocky outcrop and the still well-preserved city walls.

continuous fortified systems, such as walls and walkways winding between rock walls and high slopes. In the field of three-dimensional digital documentation, site conditions present specific challenges, which must be addressed during both the acquisition and processing phases, for each level. In order to develop a geometrically reliable hybrid database, the workflow involved the integration of data from photogrammetric acquisition, aerial and close-range 360°, and from laser scanners, TLS (Terrestrial Laser Scanner) and SLAM (Simultaneous Localisation and Mapping).

Aerial photogrammetry was used to obtain an overview of the castle and its surroundings. One of the aspects that seriously conditioned the acquisition campaigns was the constant presence of wind. This required the execution of multiple trajectories over the top of the castle. Three acquisition campaigns were conducted with a DJI Mavic Mini drone, in manual mode, following a concentric trajectory around the monumental site, for a total of 493 images. The elaborations that were developed as a result of the acquisitions revealed a lack of photographic data in the vicinity of the northern walls, characterised by the presence of high rock walls. In fact, these acquisitions were not carried out due to the variable wind conditions on all sides that could have compromised the stability of the drone, increasing the possibility of a crash.

Close-range photogrammetry was carried out with Ricoh Theta, a 360° acquisition system, in order to evaluate the possibility of taking fast moving photogrammetric surveys. After manually setting the photographic parameters relating to ISO, focal length and snapshot time, two types of acquisition were made: the first by automatically taking one panoramic image per second, generating a total of 170 images, the second by recording three videos, from which frames were extrapolated during the processing phase.

Fig. 05
Survey techniques
Integrated survey techniques for the documentation of Morella Castle using terrestrial laser scanning (TLS), mobile mapping (MLS), drone-based (UAV), and 360° panoramic imaging.

The acquisition was conditioned by the presence of very intense sunlight, generating sharp shadows on buildings and walls and complicating the transition from very brightly lit spaces to lightless environments. For both acquisitions, it was necessary to proceed very slowly, so that the camera could automatically compensate for the change in brightness in real time.

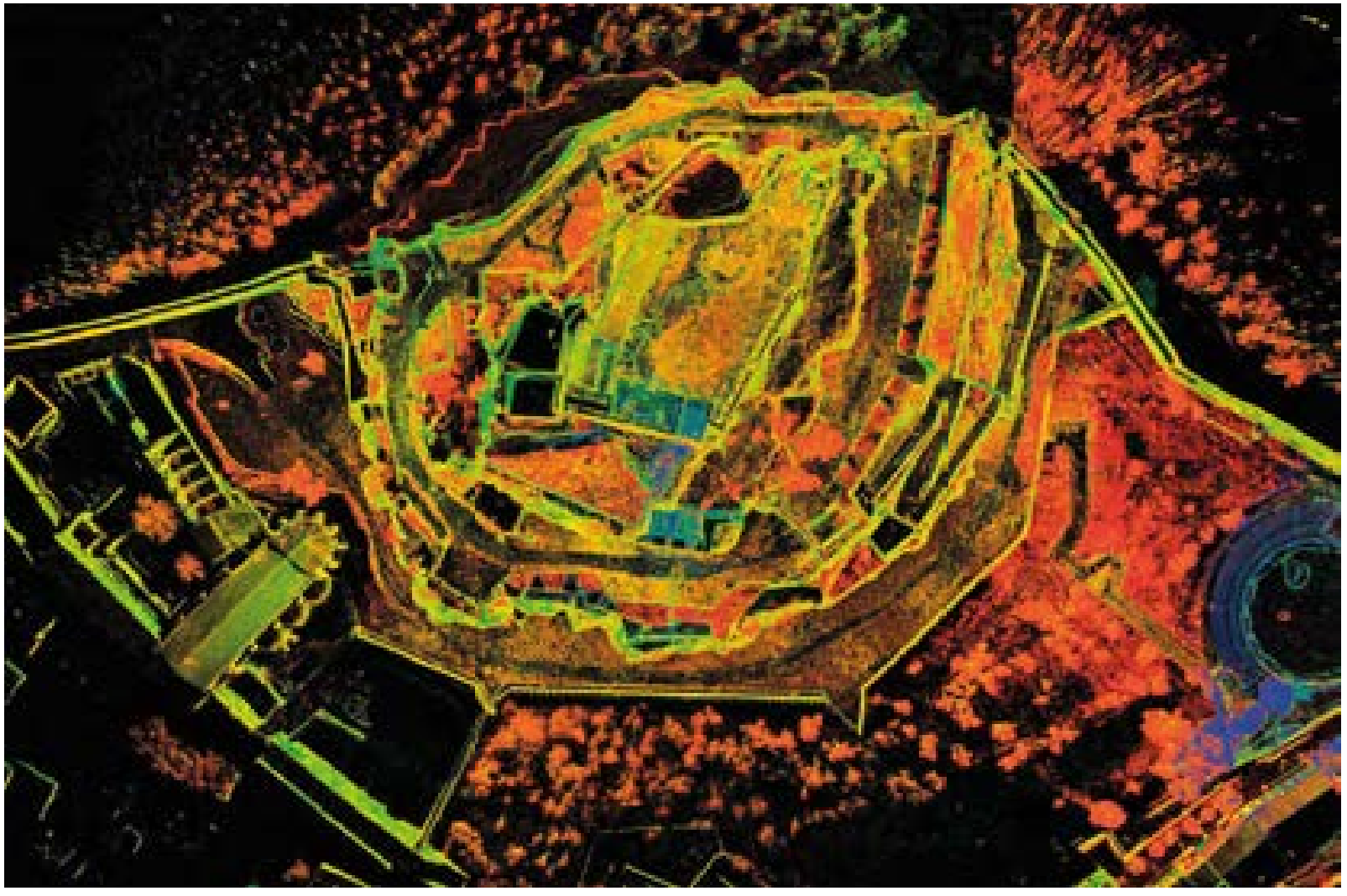
The survey using laser instrumentation was divided into three days, during which parallel documentation was carried out using Terrestrial Laser Scanner and Mobile Laser Scanner.

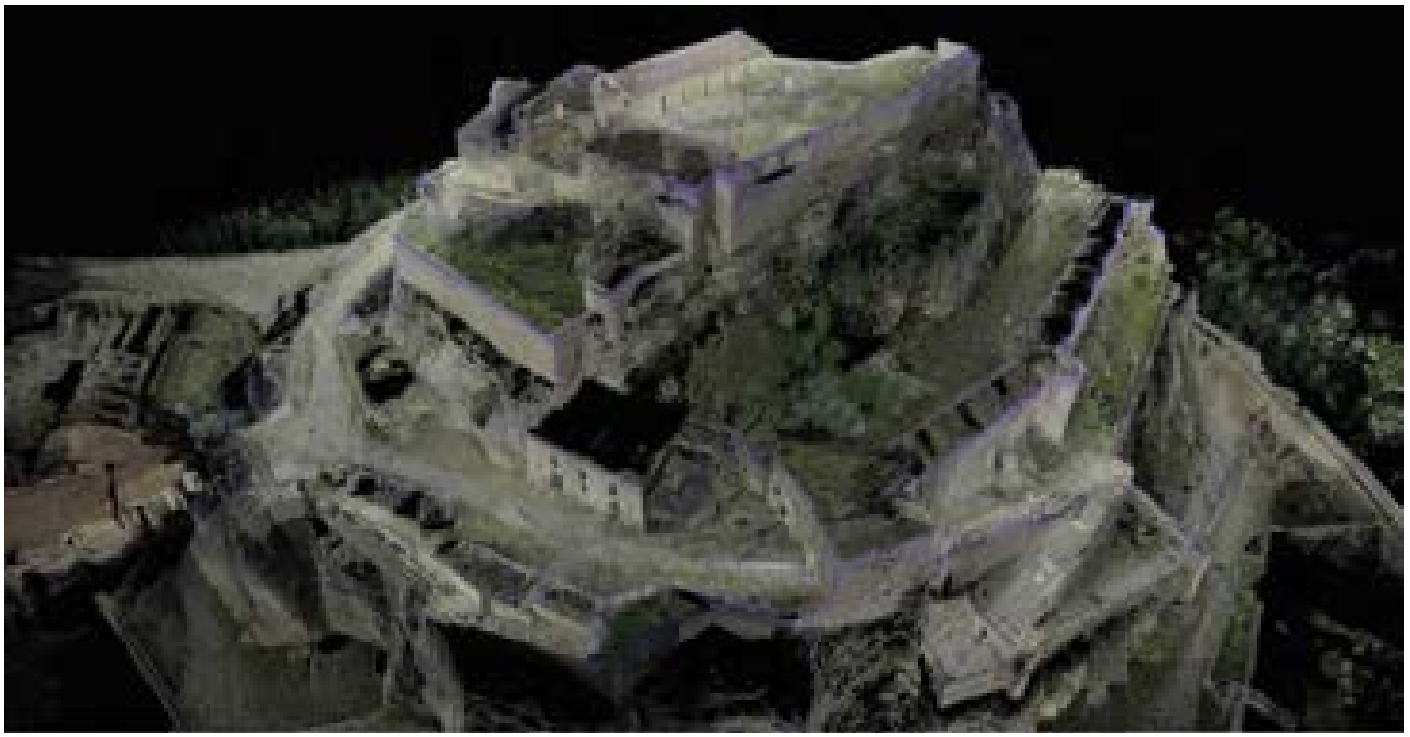
The documentation through TLS, using Leica RTC360 Laser, counted a total of 157 scans, executed at high resolution, for the acquisition of the entire castle and some buildings with accessible rooms. Due to the lack of closed paths to limit error propagation during acquisition, it was necessary to perform careful route planning on all architectural levels of the fortified site. Starting from the top of the castle, the scanning stations were distributed along the walkway leading to the first level, planning a good overlap between adjacent scans. Furthermore, the scans were carried out considering the architectural components of the walls, characterised by their high height and the presence of embrasures and small lookout areas. The aim was to document the castle in its entirety.

The survey by SLAM instrumentation, using a Leica BLK2GO, was developed according to closed loops and shorter paths. This type of approach depended mainly on the inner characteristics of the instrument, which works better if the acquisition is based on small closed survey paths. In this sense, the main issue is related to the drift error, evident in the post-production phase of the data, generated from the summation of the errors of the linear paths[8]. In order to contain these problems, 25 closed-loop scans were carried out, for a maximum of 15 minutes per scan. Considering the conformation of the site, the routes were executed starting from the highest level up to the Albacara, according to two different types of acquisition: extensive for connecting spaces, detailed at buildings and portals.

Side page, Fig. 04
The Features of the Castle
A selection of descriptive images highlighting the most significant fortified elements.

[8] Parrinello, Picchio, Dell'Amico, Malusardi (2020), *Le mura di Cartagena de Indias tra sperimentazione metodologica e protocolli operativi. Strumentazioni digitali a confronto per lo studio del sistema difensivo antonelliano.*





Data processing and integration for the construction of a global digital image

Starting from the digital products obtained from the various documentation techniques, the aim is to exploit the characteristics of each to develop a final database that is highly reliable from both a geometric and morphological point of view. Each dataset of information was processed according to usual techniques and procedures, and for each process an initial result with strengths and weaknesses was obtained.

Aerial photogrammetry was processed according to image alignment processing and generation of a dense point cloud and, subsequently, a textured mesh model. Regarding the model[9], as already anticipated, some portions of the castle are almost completely absent, generating some holes in the final result. As for the texture, despite the large number of images, the quality of the final digital product is fragmented in some specific points and many of the textural details are difficult to read, due to the large safe distance from which the photos were taken. Despite this, the final processed product is highly descriptive of the overall architectural layout of the castle.

For the close range photogrammetric product, the first dataset of images from the timelapse acquisition was processed, with one photograph per second generated automatically. The digital product obtained turns out to be completely fragmented and difficult to read, likely caused by the acquisition speed at which the photos were taken. The dataset obtained from the extraction of frames from the videos was processed in the same way. Thanks to the possibility of defining a priori the number of images to be extracted, it was possible to obtain a dataset of 500 images, which made

Fig. 07
TLS point cloud
View with colour mapping of TLS point cloud of the Castle

Side page, Fig. 06
Integrated point cloud
Point cloud views with colour mapping and reflectance data, derived from TLS, MLS and UAV photogrammetric surveys.

[9] Processing, conducted with high quality parameters, produced a dense point cloud of about 122 million points, a mesh model of about 60 millions polygons, amounting to a total of 8 hours of processing time.

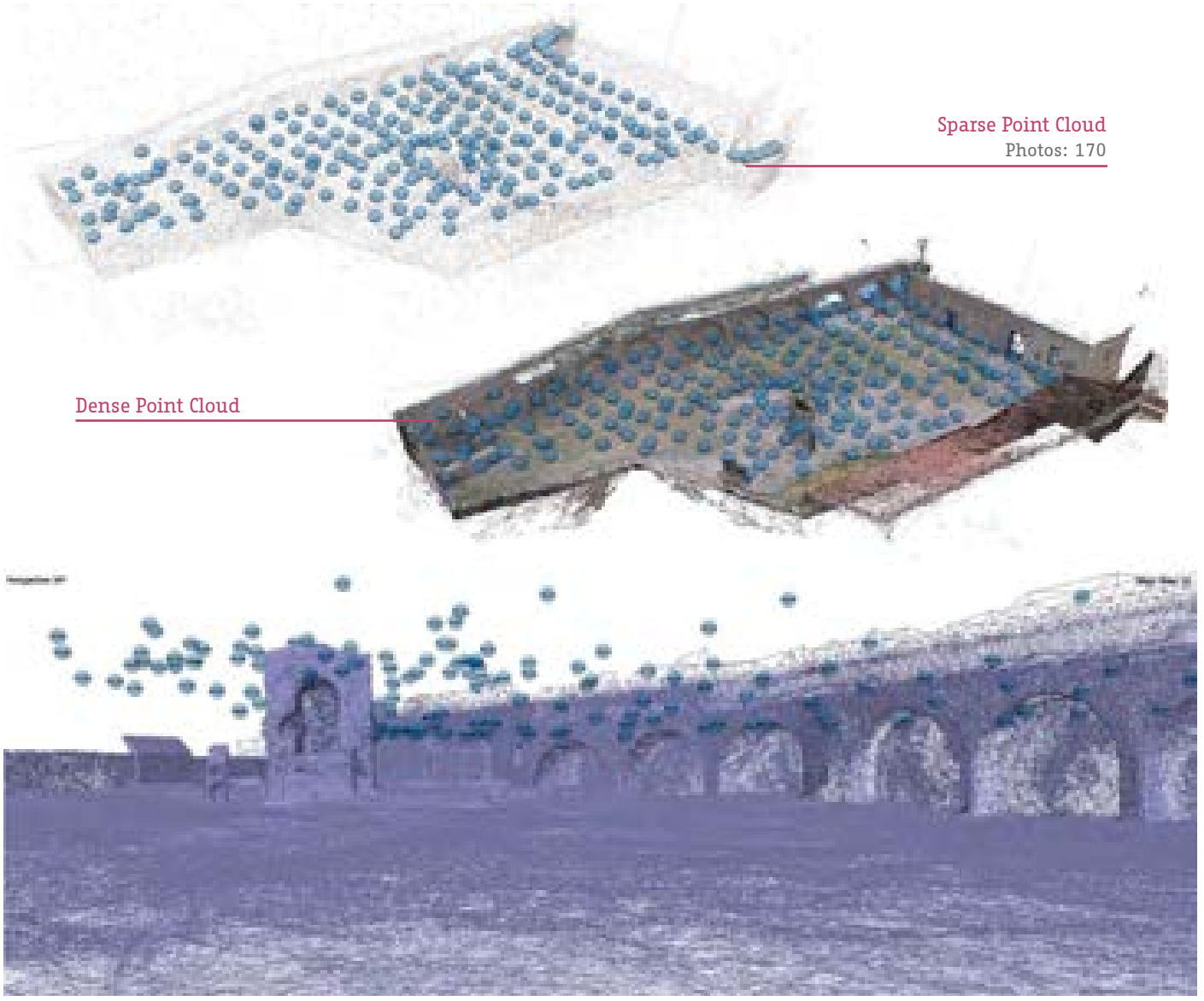
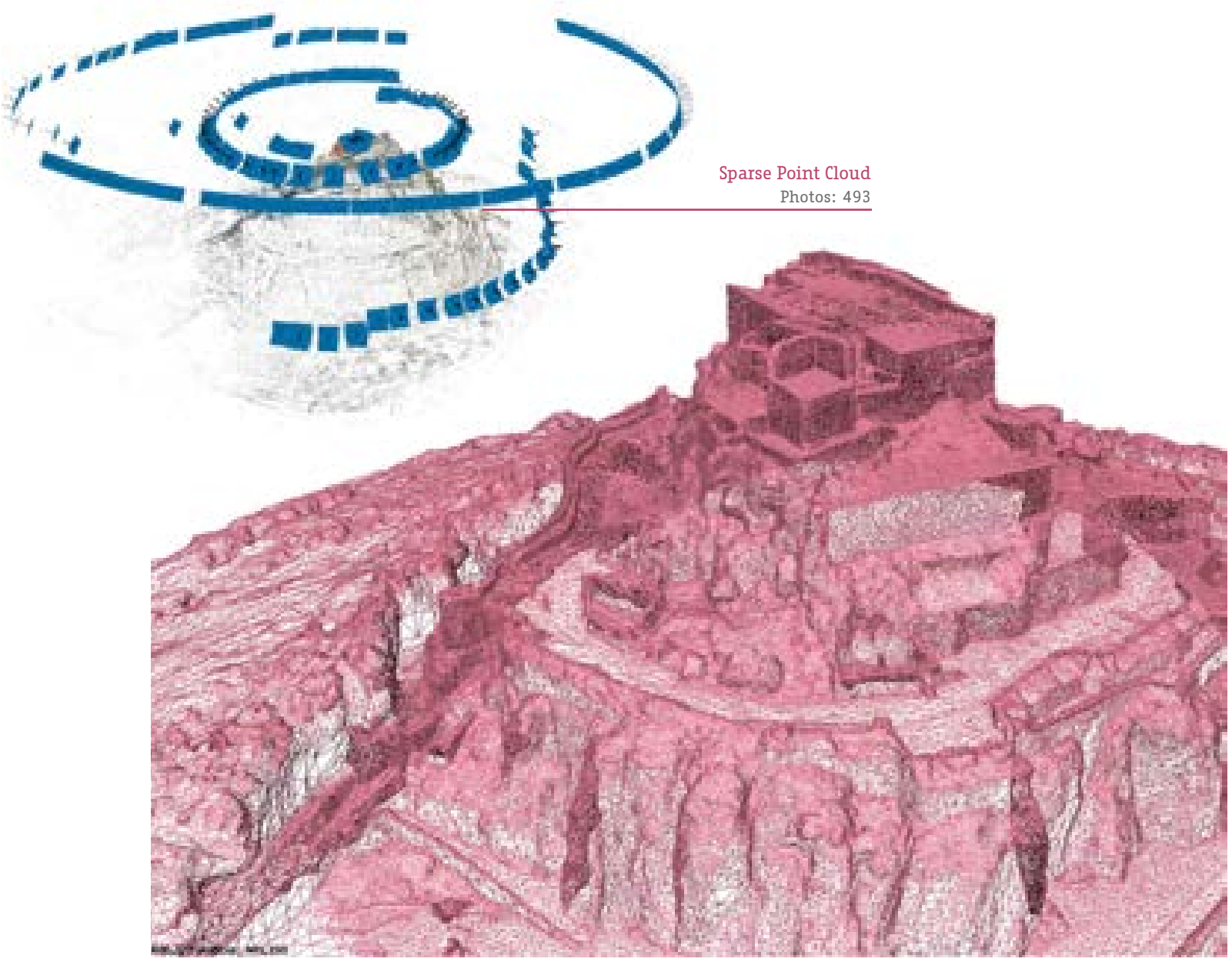


Fig. 08
Photogrammetric processing
Generation of sparse and dense point clouds from spherical images for photogrammetric reconstruction of the area.

it possible to produce a digital product that on balance extensively describes the morphological characteristics of the documented structures[10].

Regarding the digital data obtained from TLS and SLAM acquisition, a complete recording of all the point clouds obtained from the two different laser scanners was performed. The greatest difficulty was encountered with the data from the moving acquisition, as the starting data is less dense than that obtained from the stationary stationary laser. Despite this, for both types of point clouds, it was chosen to first record the data according to a Visual Registration, thanks to which it is possible to roto-translate a

[10] Processing, conducted with high quality parameters, produced a dense point cloud of about 103 million points, a mesh model of about 10 million polygons, amounting to a total of 8 hours of processing time.



scan with respect to a reference one until the total cloud is obtained. Finally, the database was optimised through Cloud to Cloud processing, reducing the average recording error and obtaining a geometrically more reliable database.

At last, all processed point clouds were integrated on the basis of homologous points, generating a final complete database. In particular, the TLS point cloud was used as the reference for the absolute orientation of the cloud derived from the Mobile laser processing and photogrammetric projects. Control targets were manually selected on the TLS point cloud on the parts where the photogrammetric result overlapped. Although this process was performed on the full resolution of the TLS data, additional errors in accuracy could not be completely cleared due to error spread.

Fig. 09
Photogrammetric processing
Elaboration of sparse point cloud and 3D mesh based on a set of drone-acquired images.

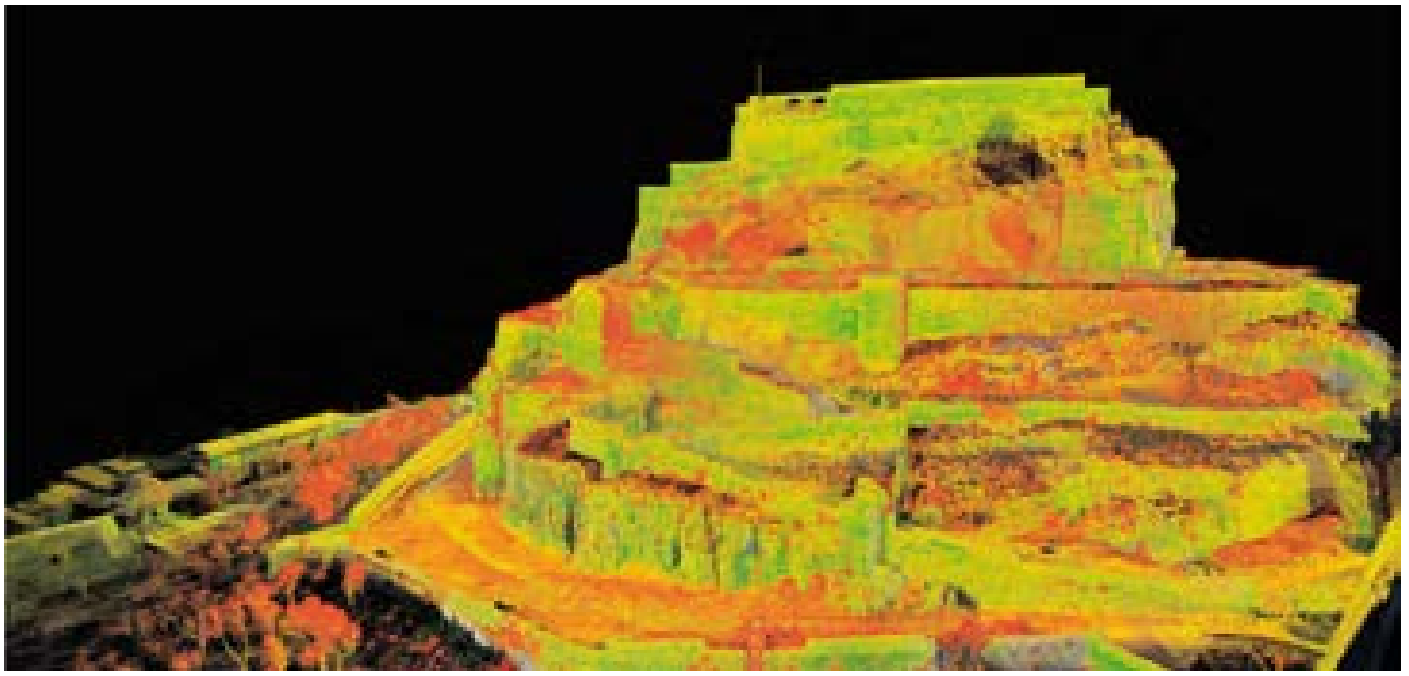


Fig. 10
Integrated point cloud
Point cloud view with colour reflectance data.

Final reflections and perspectives on multi-sensor documentation

The multi-scalar documentation experience carried out at the Castello di Morella shows how the geometric complexity and extensive scale of a historical-monumental site require integrated and carefully planned survey strategies. The combined use of photogrammetric techniques and laser scanner acquisitions made it possible to capture the overall morphology of the structure, enhancing both its topographical context and architectural details. However, the very nature of the survey paths, in some cases not closed or with little redundancy, increased the risk of drift errors, especially in the case of SLAM acquisitions. This underlines the importance of planning in advance both the scan paths (to limit error propagation) and the availability of overlap areas to be used as reference for correction. On the other hand, the effort to combine mobile sensors and static laser scanner stations made it possible to obtain a richer dataset, filling the gaps left by a single measurement method.

From a technical point of view, there is therefore a need for a careful balance between large-scale coverage and metric accuracy. In particular, the constant presence of environmental factors, such as wind, intense light and strong contrasts in brightness, and the orographic conformation of the site affected the acquisition conditions, complicating both the collection of aerial images and the colour rendering in the transition from well-lit areas to spaces without direct light.

The experience at Morella allows for further improvement of the integrated survey strategy. On an operational and methodological level, the case of Morella Castle confirms how multi-sensor solutions must be accompanied by a critical analysis of the limits of each system and a post-processing phase that privileges the validation of results through cross-referencing. Only in this way does it become possible to return a complete and reliable 3D database, functional not only to the conservation and study of the monument, but also to potential applications for tourist enhancement and interactive digital use.

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Description of the structure of Morella fortifications

Digitisation not only preserves cultural heritage, but also amplifies opportunities for sharing and learning. However, it is important to balance the adoption of new technologies with the preservation and protection of tangible and intangible heritage. The digital age has enhanced the possibilities for information acquisition and management in various fields, such as libraries, architecture, tourism, museums and education. In the European context, the importance of valorisation, or the "explication of the recognition of the value of a cultural or landscape asset with a view to its enjoyment in the present and, as far as possible, in the future," is recognised[1]. In recent years, Europe has expressed its interest in recognition of cultural routes, emphasising the desire to generate a system of management and recognition of the routes examined. To this end, the H2020 PROMETHEUS project aims to define and manage digital archives of Cultural Heritage Routes, developing "digital design" as a grammar of forms that allows the definition of an architectural language useful for communicating the heritage of the Itinerary[2].

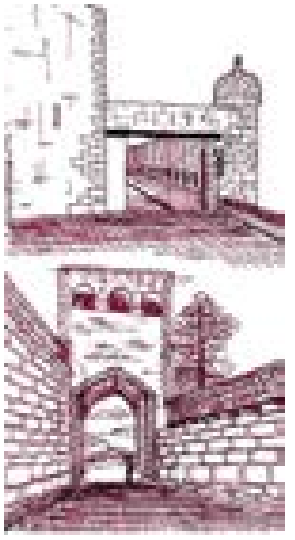
Within the H2020 PROMETHEUS project, the cultural route of James I is included as an itinerary, with the city of Morella, along with Alzira and Cullera, among the places studied. Morella is a medieval town, protected by walls and crowned by a castle, home to numerous historical and cultural heritage buildings. Located in a mountainous area, 1,000 meters above sea level, where topographical features condition the urban morphology and layout of the walls, the town is one of the few examples in the Iberian Peninsula that still retains the original defensive perimeter.

The current urban layout has stretches with an irregular street network enclosed within a wall and enough towers to adequately defend the city from all possible angles. It is therefore a unique heritage of great significance, both from a historical point of view and for the quality of its defensive architecture. In 1931, the Castle and Walls of Morella were declared Historical-Artistic Monuments, underscoring the exceptional role played by the Morella Defense Assets.

The citadel of Morella, situated in the north of the province of Castellón, traces its origins to the castle crowning the rocky ridge known as the "Mola," strategically positioned to dominate the entire valley.

Side page, Fig. 01
San Mateu Gate
Combined visualisation of the dense point cloud and mesh model of the San Mateu Gate

Fig. 02
City wall gates
Graphic representation of the Gate of Sant Mateu, the Portal de la Nevera and the Portal dels Estudis. (Drawing credit: Edoardo Gironi)



[1] Petraroia (2010), *Tutela e valorizzazione, in Musei e valorizzazione dei beni culturali.*
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Fig. 03
San Miguel gate
Monumental fortified entrance in the city walls, composed of two crenellated towers and a vaulted central passage. It was one of the main access points to the medieval town.

The foundation can be traced as far back as the Bronze Age when Iberian peoples inhabited the area. Subsequently, both the Greeks and Romans, beginning in the 2nd century AD, initiated fortification work on the castle. From 476 AD, the city was under the rule of the Visigoths until the 8th century, later being conquered by the Arabs in 714 AD, who renamed it "Mourelia."

In 1232, Don Blasco de Alagón conquered the castle of Morella and, later, King James I "The Conqueror" granted it the Municipal Charter ("Carta Puebla")[3].

Following the Christian reconquest in the 13th century CE, the urban morphology of the city began to take its present form by expanding and structuring itself outside the castle walls, following the natural slope of the mountain[4].

Morella's walls have a length of about 2,000 meters along which towers and gates are established: in total, the walls have ten towers (Pantó, Racó, Redona, Font Vella, Asperó, Alòs, Beneito, Fredes, Carraixet and Sant Francesc) and six gates to the city (Nevera, Sant Miquel, Sant Mateu, Forcall, Rei and Estudis). Within the city walls, the urban system sees the imposing presence of the castle, located at the highest point of the city, to which main stairways are connected, dividing the layout into neighborhoods and in turn subdivided as a result of the presence of main and secondary streets.

Within the historic center, in addition to buildings of worship such as the Archpriest's Church of Santa

Side page, Fig. 04
City wall gates
Views of the city of Morella depict the relationship between the urban system and the defensive walls. Elements such as towers and city gates are integrated into the walls.

[3] Dalmases Balañà, Pitarch (1983), *Morella: Ciudad de Morella.*
[4] *Ibidem.*

Fig. 05
Fountains in the historic centre of Morella
Views of some of the fountains still present and used by the people of the town of Morella.

Maria, the Convent of San Francisco, and the churches of Sant Miquel, Sant Joan, and San Nicolás, there are also several medieval Gothic palaces, such as the Palau del Consell (current seat of the Town Hall), the Ciurana House, the Cardinal Ram, the Piquer House, or that of the Marqués de Cruïlles. Additionally, there are buildings of more recent times such as the Escuelas Pías or the Bullring, all of which are preciously enclosed within the fortified enclosure.

The campaign to survey Morella's fortifications was born, therefore, not only to highlight the city's importance within the cultural routes of our interest but more importantly to document and show how the fortifications themselves identify the city's history. Indeed, they influenced its settlement pattern, defense practices, but, most importantly, they declare its historical image of the place.

Photogrammetric documentation of historic fountains in the city of Morella

Water, an essential and irreplaceable resource, multiplies its value for Morella society by being scarce and extremely difficult to obtain. For these reasons, since ancient times, all public authorities have kept in mind that to optimise its use and avoid abuse, it was necessary to articulate mechanisms for the management and use of water resources. The importance of water and its use is already evident in Morella's earliest historical documents: in the Carta-Pobla de Morella, granted by Blasco de Alagón on April 16, 1233, it grants them all the waters in the area, except those that are, or can be, used in the mills. Later, on September 14, 1273, King James I ratified the general conditions of the castle and the donations made by Blasco de Alagón, granting the use of water for the mills.

Fig. 06
Dense point clouds from photogrammetric processing
3D models generated from high-resolution photographic surveys of selected fountains in Morella.

Later, in 1318, the aqueduct of Sant Llucia was built under the authorisation of James II (still visible today along the defensive walls of the town of Morella). The purpose of building this structure was to transport water from the Font de Vinatxos to the Morella reservoir. Most of the population's water needs were covered by wells, cisterns, and several nearby sources; water was stored in the two existing reservoirs, "El Poll," located in what is now Plaça Colón, and "El Prat," located in the old soccer field. In 1689, the Font Vella reservoir was built and remained the only public water source for about ten years. In the following years, the new public fountains of Plaça Colón, Sant Joan, del Pes, Filato, Sant Miquel, "La Parra," La Cacha, and Sant Francesc were built to raise awareness and reconnect the Morellan population with the issue of water, which had now taken a back seat following the implementation of drinking water service in homes.

For these reasons, it was decided to highlight this heritage characteristic of the cultural route through the creation of photogrammetric models at a high level of detail. These models are intended to enrich the database and highlight how even simple urban elements, such as the city's fountains, actually represent a part of a city's history and identity.

The next phase of the photogrammetric survey of the historic center focused mainly on historic public water supply points. A photographic campaign was conducted to capture the historic washhouse and the main public fountains, including Font Vella, Font de Sant Joan, Font del Pés, Font purisima, Font de Sant Miquel, and Font Caxta.

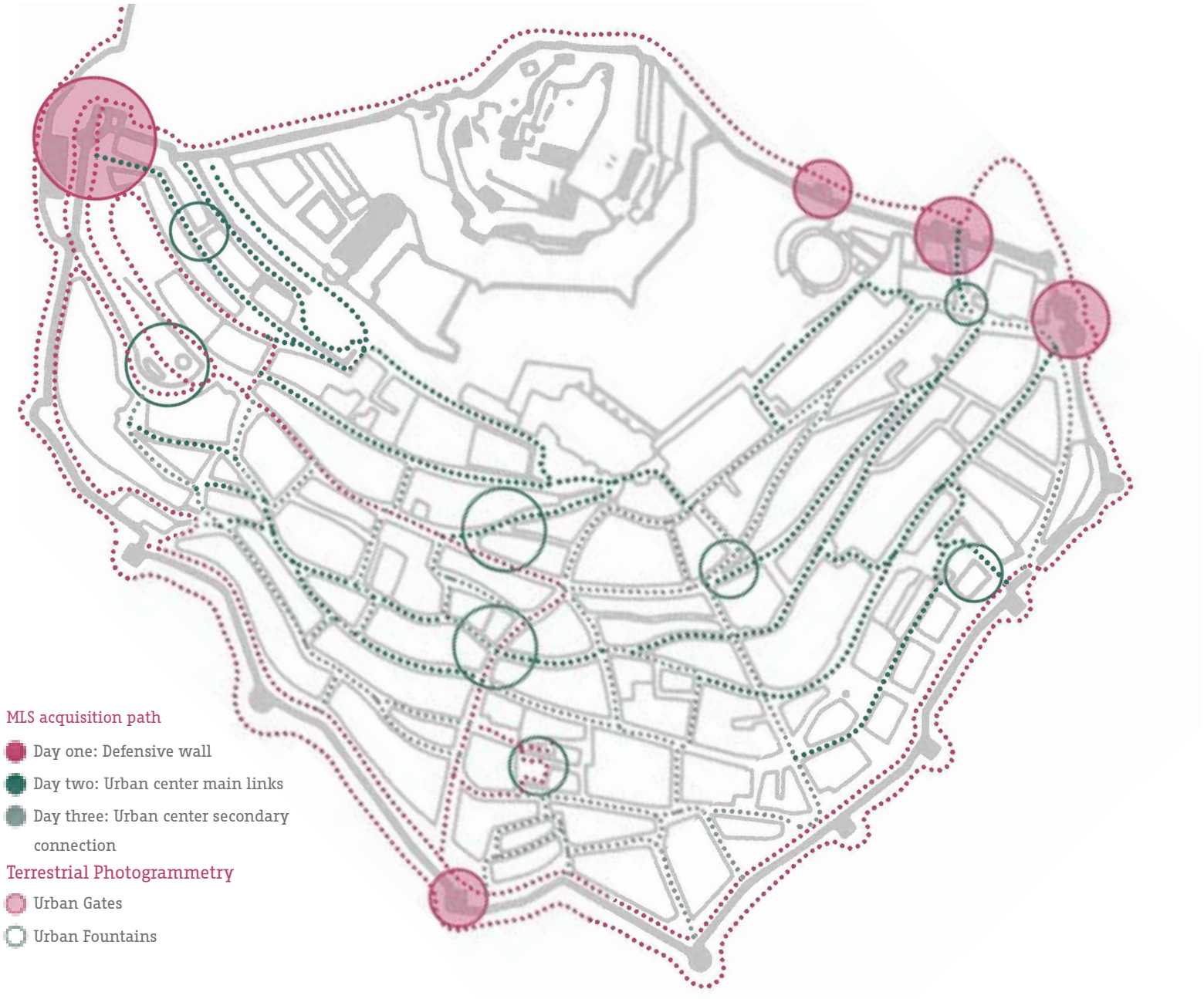


Fig. 07
Survey data acquisition
The simplified map of the town above shows the route followed with the KAARTA mobile laser scanner during the three-day survey, as well as the areas where ground-based photogrammetry was conducted on selected towers, gates along the city walls, and local water sources.

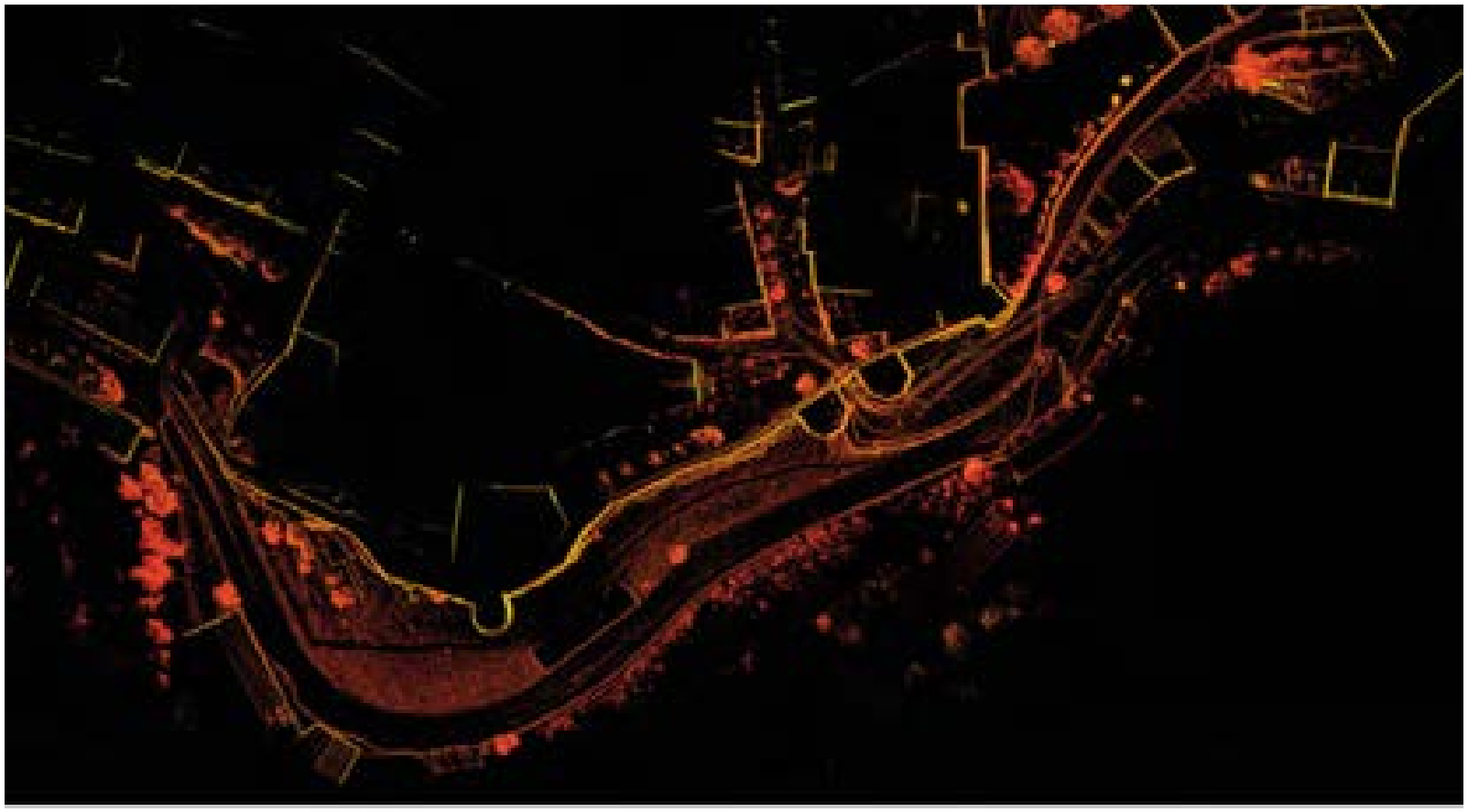
Designing Actions and Tools for Surveying: Fast Mobile Laser Scanner Surveys and Photogrammetric Acquisition

Based on the urban configuration and the geomorphological nature upon which the city of Morella was established, it was necessary to define the most effective acquisition protocols to obtain an optimal result capable of accurately describing and representing the territorial-architectural fabric within a few operational days. Among the available digital surveying tools, instruments were selected to adequately address the objective of acquiring the entire historic center in a limited time, utilising the rapid MLS (Mobile Laser Scanner) type acquisition system with the STENCIL KAARTA 2-16 Edition

laser scanner. Simultaneously, Canon EOS 2000D SLR cameras and Nikon D7200 cameras were employed for the photogrammetric shooting of the architectural elements.
The photogrammetric study, in particular, focused on creating 3D digital models to represent some valuable architectural and decorative elements, including gates and towers along the city walls, as well as historical fountains present in the historic center.
Before initiating the acquisition phases, it was necessary to break down the urban layout of the town of Morella into macro-areas and define the routes to be taken to obtain a comprehensive result while adhering to the available timeframe of three survey days. Thus, two macro-areas were defined: the first enclosing the city, encompassing the city walls, towers, and access gates; and the second including the urban center, further divided into micro-areas identified by main and secondary streets.

Route and data acquisition

Due to the configuration and complexity of the urban system, the initial phase of the survey campaign focused on the city walls and the defense system. For the documentation of the system, a series of short-duration scans were chosen to acquire the perimeter of both the inner and outer walls, using the Mobile Laser Scanner (MLS) acquisition system.
The city gates, situated within the defensive perimeter, were utilised as internal/external connection points due to the identification of homologous points during data recording. The obtained data allow for a clear understanding of the development of the city wall and how it connects not only with the surrounding area but, more importantly, with the city center.
Concurrently with the survey through the MLS system, a photogrammetric documentation campaign of the towers and access gates was carried out. This activity, conducted using Canon EOS 2000D SLR cameras and Nikon D7200 camera, enabled the integration of the data to obtain an accurate digital database for the digital representation of the city of Morella.
The second phase of the acquisition work involved the documentation of the entire urban layout within the defensive walls. The survey by the Mobile Laser Scanner was conducted with four- and five-minute scanning paths to acquire the main streets of the town. Each route considered strategic points of overlap between contiguous scanning slots and intersections with secondary streets, thus serving as connecting points between the various acquisitions. Subsequently, documentation by STENCIL KAARTA focused on secondary pathways. The latter, being more complex, required multiple scans of the same part of the pathway, each of short duration (2-3 minutes), and, when necessary, tilting the instrument to accurately acquire details, reducing the margin of acquisition error. The SLAM technology used has instrumental limitations related to the shooting angle. This implies more care during the acquisition phase as the quality of MLS point clouds is strictly dependent on how the operator maneuvers the instrument, the timing, and the paths chosen for the shooting.



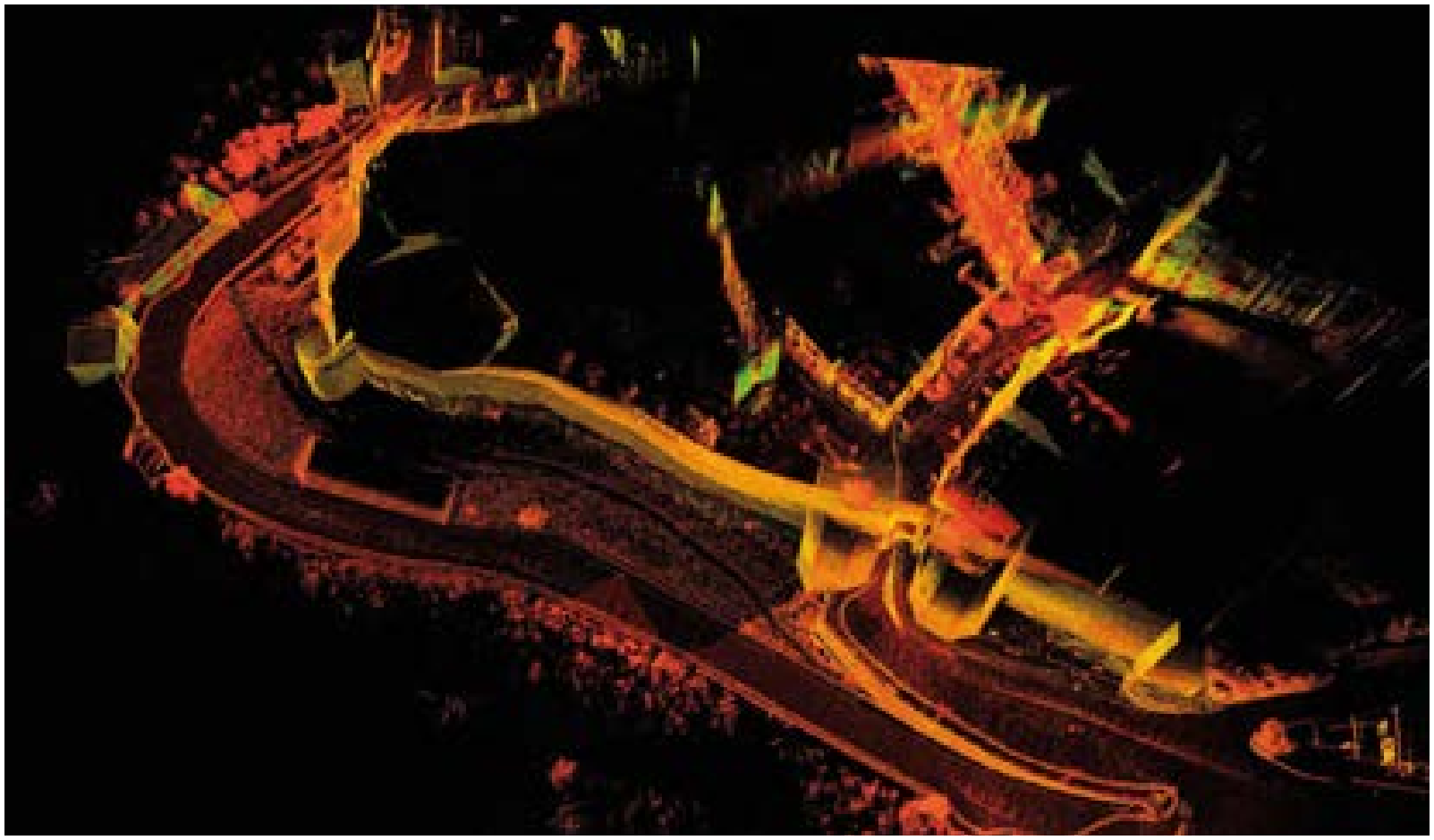


Fig. 09
MLS point cloud of the San Mateu Gate
High-density mobile laser scanner survey of the monumental gate along Morella's city walls.

To ensure successful shooting activities, the operator must maneuver the instrument with awareness and caution, tilting the instrument head thoughtfully according to the acquisition objective[5].
The duration of the scans was also influenced by the period in which they were performed: the town of Morella turns out to be one of the most important tourist spots during the summer period. To avoid noise within the acquired laser scanner data due to the unintentional "intrusion" of many tourists, which could have worsened the quality of the obtained data, it was preferable to plan the acquisition of the scans considering the tourist flows and minimising errors due to the presence of people.

Results with critical analysis

Following the survey campaign and a thorough check of the individual scans acquired, the point cloud was processed. Subsequently, the main errors identified during this control phase were attributed to:

- The presence of people who were visiting the city during the survey period, creating what is referred to as "noise";
- The morphology of the terrain, which made it challenging to keep the instrument completely stable, hindering proper acquisition of the terrain pattern;
- To the changes in light, which occurred especially when scanning the access gates.

Side page, Fig. 08
MLS point clouds of a section of Morella's city walls
Mobile laser scanner survey with top-down and perspective views of the fortified segments.

[5] Dell'Amico (2021), *Mobile Laser Scanner Mapping System's for the Efficiency of the Survey and Representation Processes.*

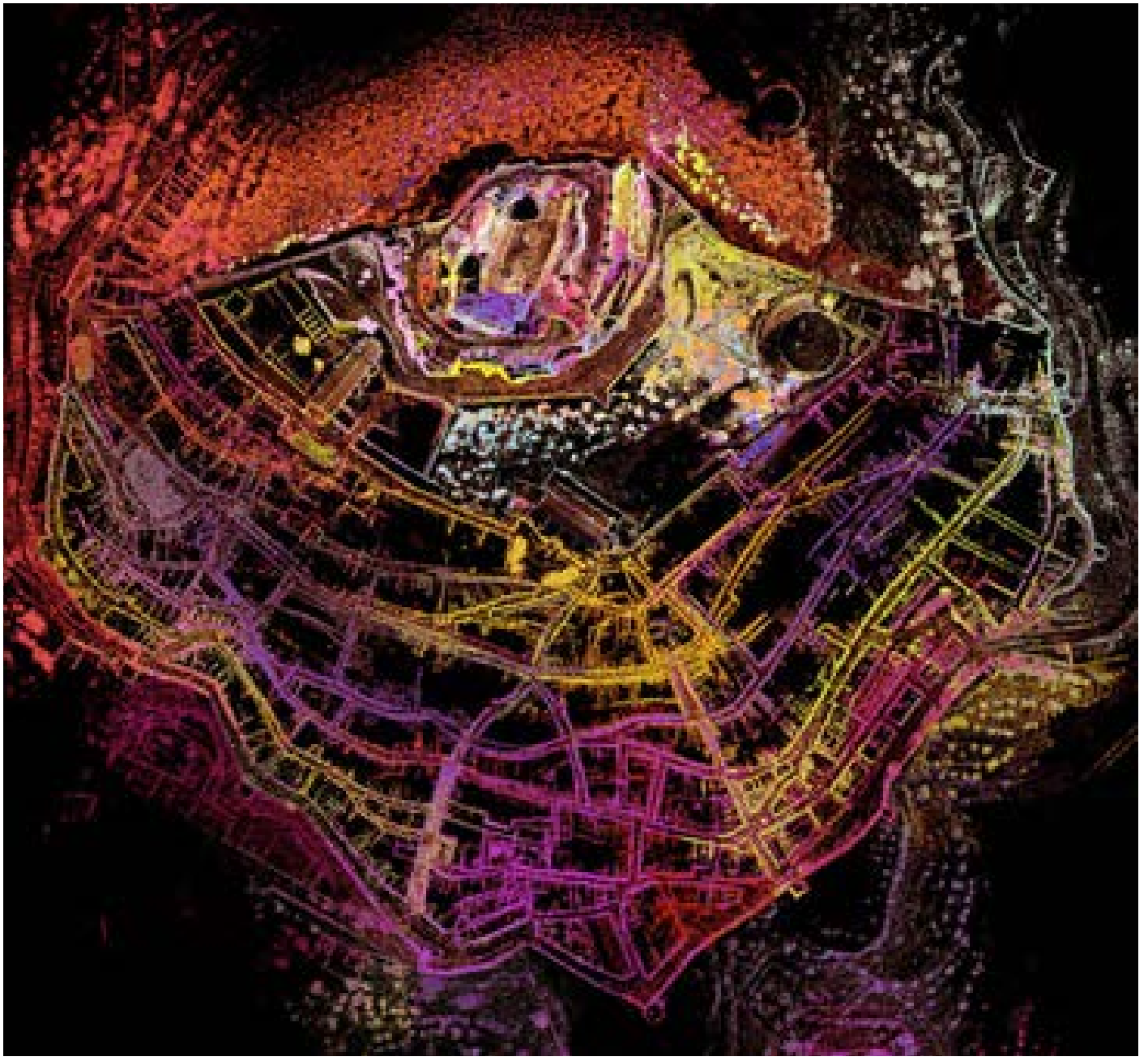


Fig. 10
MLS database of the entire city of Morella
Point cloud generated from mobile laser scanner survey along the urban street network and city walls.

The output files obtained are automatically cataloged in a folder in the computer's memory drive. This folder contains data about the laser sensors, information about the scan time, distance traveled, raw data of the images obtained with the feature tracker, and .ply files of the point cloud and the accomplished trajectory. The point clouds of the surveyed scene and the trajectory traveled were analysed using processing software such as CloudCompare, allowing for evaluations on the point clouds and their conversion into a compatible format (.e57 or .las) with the Leica Cyclone 2023 platform chosen for the next stage of database registration.

To achieve a complete and effective digitisation of the acquired point cloud through KAARTA technology, not only were the point clouds obtained through drone surveys of Morella Castle, towers, and city gates integrated, but also the point clouds obtained through the RTC 360 Laser Scanner during the post-production phase to control errors arising from MLS instrumentation.
For increased accuracy of the final database and greater completeness of the digital material, scans were carried out at the most complex and crucial points using the TLS (terrestrial laser scanner) system with the Leica RTC 360 Laser Scanner. This allowed for better management of the urban complexity of Morella, providing greater dimensional and final error control during the post-production and data recording phase.
Upon completion of the work, the achieved result enabled the visualisation of all architectural volumes in the historic center, entrance gates to the city (point clouds obtained through a photogrammetric survey), and water sources with high-quality data, despite the limited time available. The final database allows for a clear understanding of how the city walls are developed and how they connect not only with the surrounding area but, more importantly, with the city center and the castle.

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THE STRUCTURING OF AN INFORMATION SYSTEM FOR FORTIFICATION

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Side page, fig. 01
HBIM model of Morella Castle
Digital representation of the architectural complex integrated with the site's topographic surface.

The objective of the presented research activity is to outline a workflow to standardise the process of organising, parametric modelling, and information management, applied to the widespread fortified architectural heritage. Indeed, implementing parametric modelling processes via the HBIM methodology supports the setting up of a three-dimensional digital archive and the subsequent systematisation of archived data. However, this requires an initial effort to define the type and format of the related information and the set of rules to implement said strategies.

In addition to BIM technology, Geographical Information Systems (GIS) have proved extremely useful in recent years in the management and systematisation of heritage information. First developed to manage extensive areas in a 2D format, GIS now provides a robust data storage system, allowing the definition of topological and semantic relationships and the possibility of spatial queries, making it a suitable tool for the management of historic buildings[1]. Notably, the development of 3D GIS has improved the management of building data and site-specific information, as well as an in-depth understanding of its urban, historical and geographical context. In the field of AEC (Architecture, Engineering, and Construction), information systems have for quite some time been open to interoperability both with online monitoring and control systems through georeferenced platforms[2], as well as with advanced virtualisation systems oriented to the management and enhancement of CH (Cultural Heritage)[3]. To this end, it is essential to establish a digital ecosystem that allows access to all stakeholders involved in architectural processes[4], implemented through a user-friendly approach in order to attract the greatest number of users to inquire into the digitised heritage.

This paper analyses a workflow developed to integrate HBIM and GIS methodologies in structuring and managing a heterogeneous set of data, metadata, and paradata[5]. BIM-GIS integration represents a valid support for the design of an information system capable of managing a complex and heterogeneous architectural heritage[6].

[1] Doria, La Placa, Picchio (2022), *From Reality-Based model to GIS platform. Multi-scalar modeling for irrigated landscape management in the Pavia plain*.
[2] Matrone, Colucci, Iacono, Ventura (2023), *The HBIM-GIS Main10ance Platform to Enhance the Maintenance and Conservation of Historical Built Heritage*.
[3] Russo (2021), *AR in the architecture domain: State of the art*.
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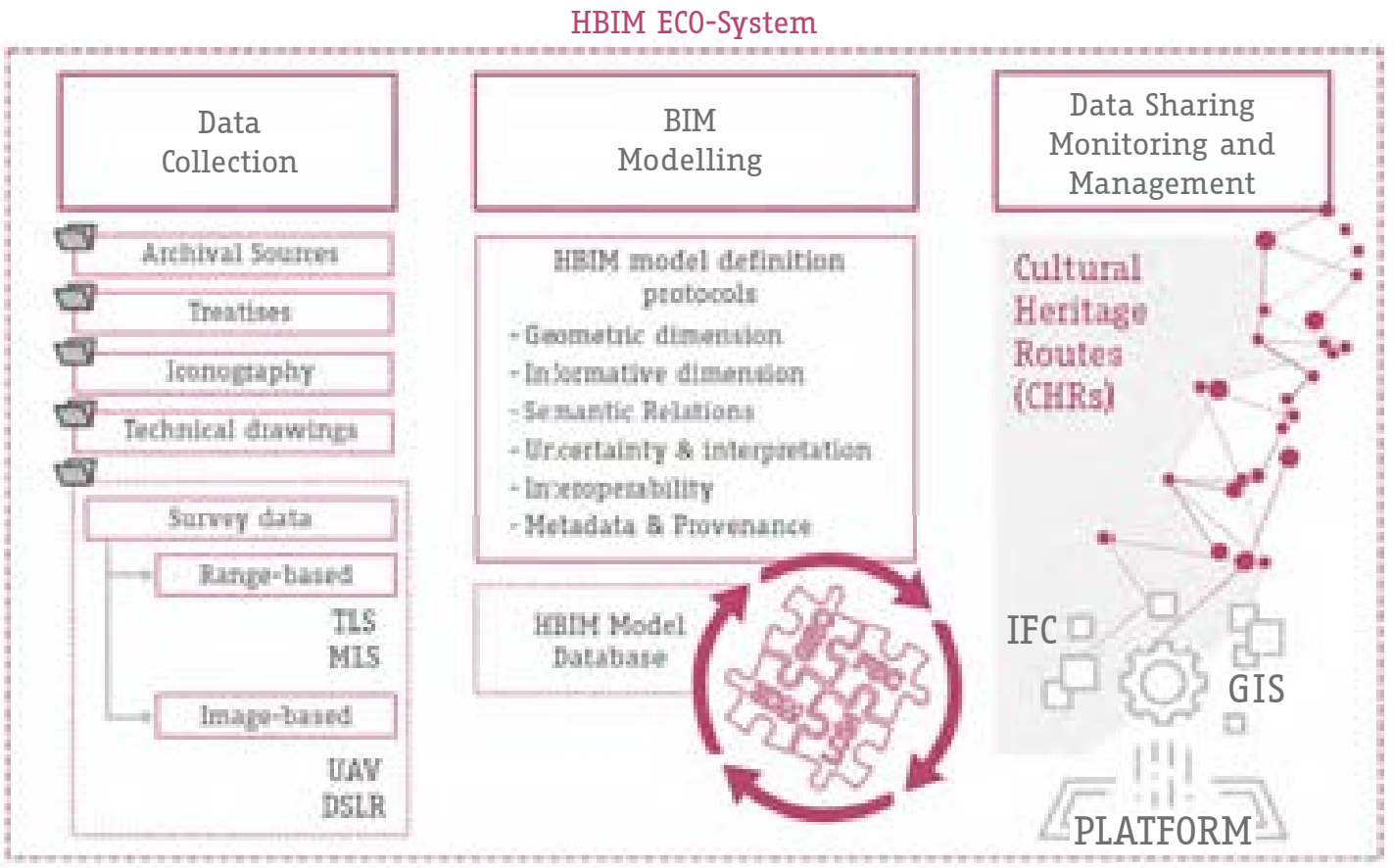


Fig. 02
Diagram of the HBIM system for built heritage management
From survey and data collection to BIM modelling, leading to sharing, monitoring, and management via interoperable platforms (GIS/IFC).

Interoperability between Information Systems

BIM-GIS integration is analysed from a complementary point of view; namely, BIM pieces of software allow for the generation of models capable of precisely describing the morphometric features of artefacts according to their temporal development, thereby providing information that can be later integrated into GIS systems to be visualised and analysed within a wider framework.

Combining both information systems makes it possible to link data and information, ranging from the territorial level to architectural detail, and allows their simultaneous reading by means of structured information layers. On the one hand, BIM advantages relate to the richness in geometric and semantic information, particularly with regard to their historical evolution; on the other hand, GIS supports decision-making processes based on geospatial display and modelling. Thorough information management of heterogeneous sources - documentation, surveys, and digital models - within GIS systems is a fundamental requirement for advanced historical analysis projects[7].

As a result, information exchange, now scientifically known as GeoBIM, contributes to blurring the boundaries between BIM and GIS[8]. Hence, a workflow for the efficient implementation of an HBIM

[7] Pettineo, Dell'Amico, Picchio, Parrinello (2024), *H-BIM e GIS per l'analisi e la ricostruzione filologica del castello di Almencir in Spagna*.
[8] Bortot, Borin (2020), *BIM a scala urbana, ricerche, analisi e interazione tra dati per l'organismo Venezia*.

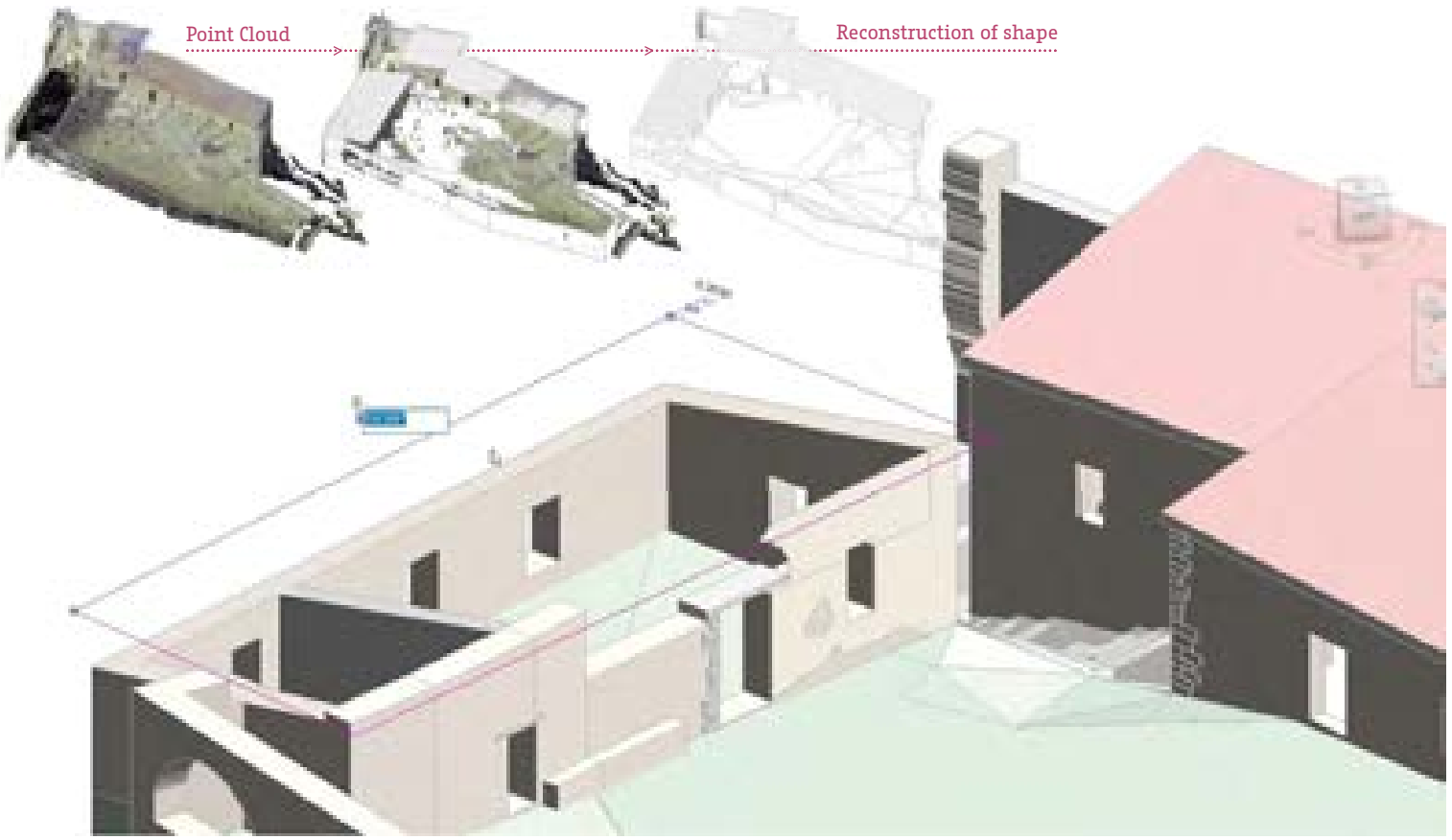


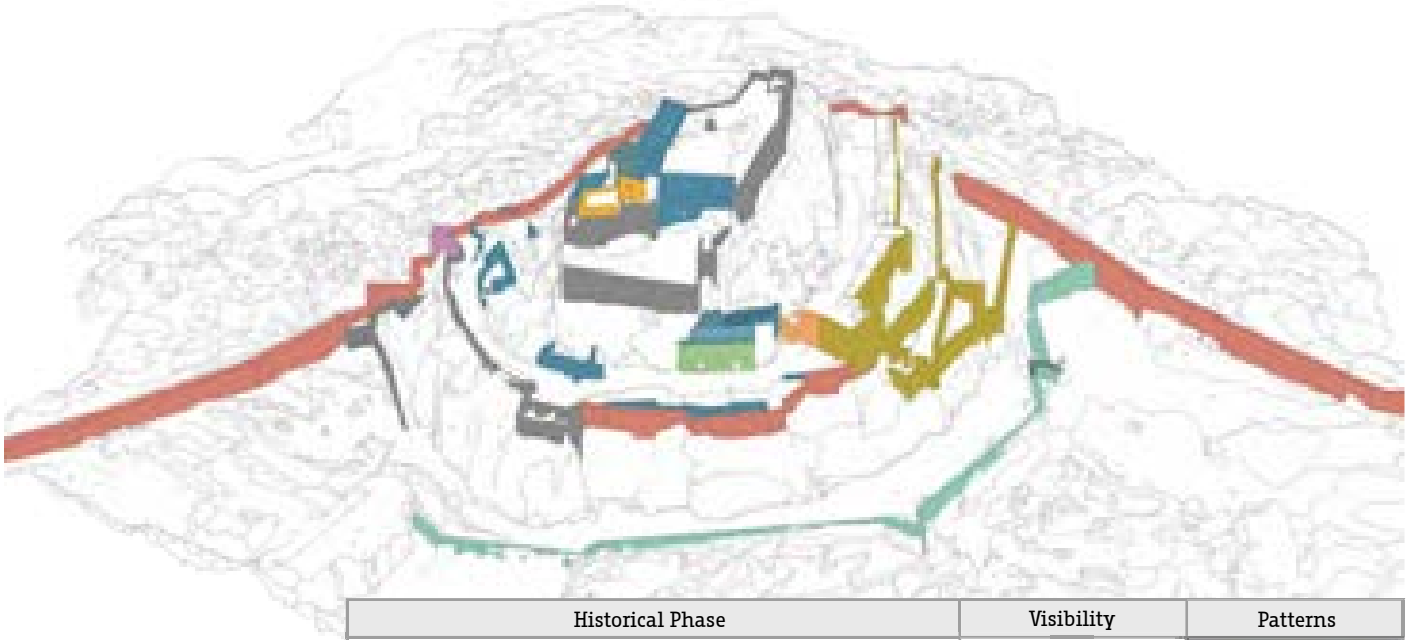
Fig. 03
Scan-to-BIM modelling process of Morella Castle
From point cloud to geometric reconstruction for the definition of the information model.

ECOsystem[9] is presented below, based on the so-called scan-to-BIM approach and comprising the following main phases: (i) Data collection; (ii) BIM Modelling, which consists of four iterative steps: Georeferencing (GEO), working in a federated environment where a common set of standards (FSC) has been defined, 3D Geometric Modelling (3DM), paying particular attention to the granularity of the information to be added, as specified by the current standard - European standard ISO 19650-1:2018, adopted through the Italian standard UNI EN 17412-1:2021 - in the definition of the "Level of Information Need" (LOIN); (iii) Data sharing for the management and to further the comprehension of architectural assets.

For the information ecosystem to work properly, these phases must operate synergistically, possibly requiring continuous iterations[10]; moreover, just like a physical ecosystem, a digital one must be designed to receive continuous external feedback and be capable of responding to such stimuli.

Through this methodological process, it is possible to structure and access semantically-rich objects in a GIS environment[11], where attributes can be easily merged with geometries, thus creating a proper relational database underlying the models.

[9] Parrinello et al. (2023), *HBIM modelling for the architectural valorisation via a maintenance digital ECO-System*.
[10] Lo Turco, Calvano, Giovannini, Tomalini (2021), *AIM! Algorithmic Information Modeling: New Strategies for a Fully Integrated Approach in the Field of Cultural Heritage*.
[11] Kolbe et al. (2005), *CityGML: Interoperable Access to 3D City Models*.



Historical Phase	Visibility	Patterns
Historical Phase_01_Uncertain	☑	
Historical Phase_02_XI_Century	☑	
Historical Phase_03_XII and XIII Centuries	☑	
Historical Phase_04_XIII and XIV Centuries	☑	
Historical Phase_05_XIV Century	☑	
Historical Phase_06_XV Century	☑	
Historical Phase_07_XVIII Century (year 1713)	☑	
Historical Phase_08_XIX Century (years 1835-1840)	☑	
Historical Phase_09_XIX and XX Centuries (years after 1840)	☑	

Fig. 04
HBIM model of Morella Castle with historical phase visualisation
The model identifies the construction and transformation phases from the medieval period to the contemporary age.

Information modelling of the Route Fortified Heritage

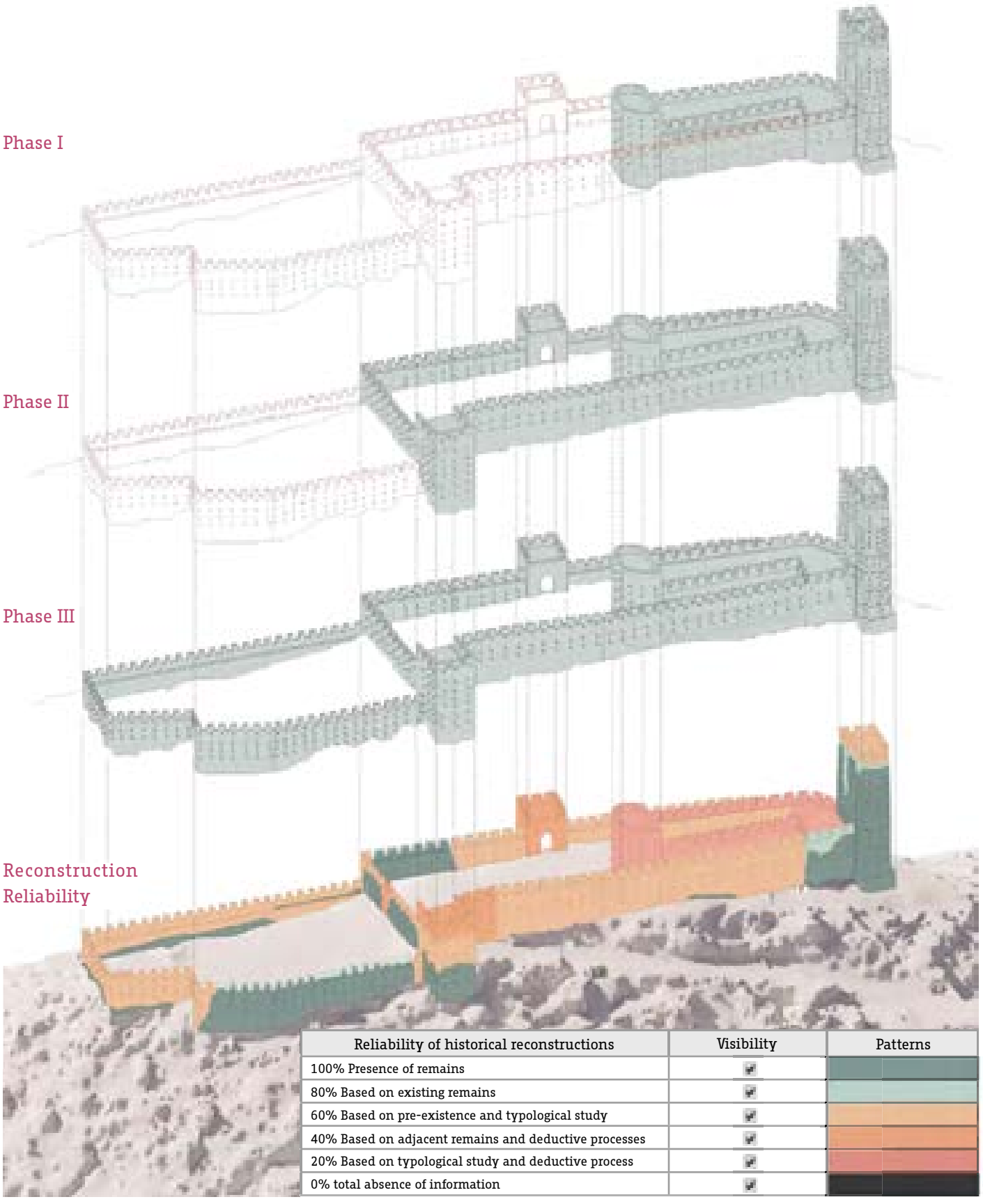
To develop the information platform and test its potential, this operational methodology was applied, focusing on different aspects, to two main fortified systems on the route: the Castle of Almonecir (see section 3.5) and the Castle of Morella.

The modelling process of the Almonecir Castle was structured according to an idealised and sequential typological representation of the evolutionary phases. The parametric modelling of the Morella Castle, on the other hand, followed a different approach, where the historical-evolutionary phases were represented simultaneously from a constructive point of view, presenting the entire masonry apparatus over different expansion stages.

The information modelling - in order to address the constructive-typological and historical-evolutionary representation requirements - involved, in addition to the integrated digital survey, a thorough documentary and archival analysis. This step is essential in determining the criteria that affected the historical expansion process of the identified sites, along with the chronological allocation of the remaining technological components. This discretisation phase is implemented into the BIM authoring tool environment (Autodesk Revit) via the 'Phase management' tool, thus allowing for a possible reconstruction of the original state of the buildings, as well as their subsequent modifications.

The definition of the historical phases is followed by the definition of a shared standard for the

Side page, Fig. 05
HBIM model of Almonecir Castle with hypothetical reconstruction phases
The reconstruction hypotheses are organised in phases and colour-coded according to a reliability scale, ranging from confirmed remains (100%) to total lack of information (0%).



Reliability of historical reconstructions	Visibility	Patterns
100% Presence of remains	✔	
80% Based on existing remains	✔	
60% Based on pre-existence and typological study	✔	
40% Based on adjacent remains and deductive processes	✔	
20% Based on typological study and deductive process	✔	
0% total absence of information	✔	

representation of the architectural elements. Autodesk Revit provides a quite comprehensive library for starters; however, one of the first drawbacks concerns the high specificity of historical components, such as those comprising fortified castles, which lack general standardisation and are usually not available in common databases, thus requiring case-by-case modelling. This process in the Revit environment is implemented through the generation of new families of components, requiring the definition of specific parameters and attributes, which is a time-consuming process; conversely, the careful design of new typological elements as parametric families lays the foundation for the structuring of a dedicated extensive library of historical elements, organised according to constructive technology and architectural style.

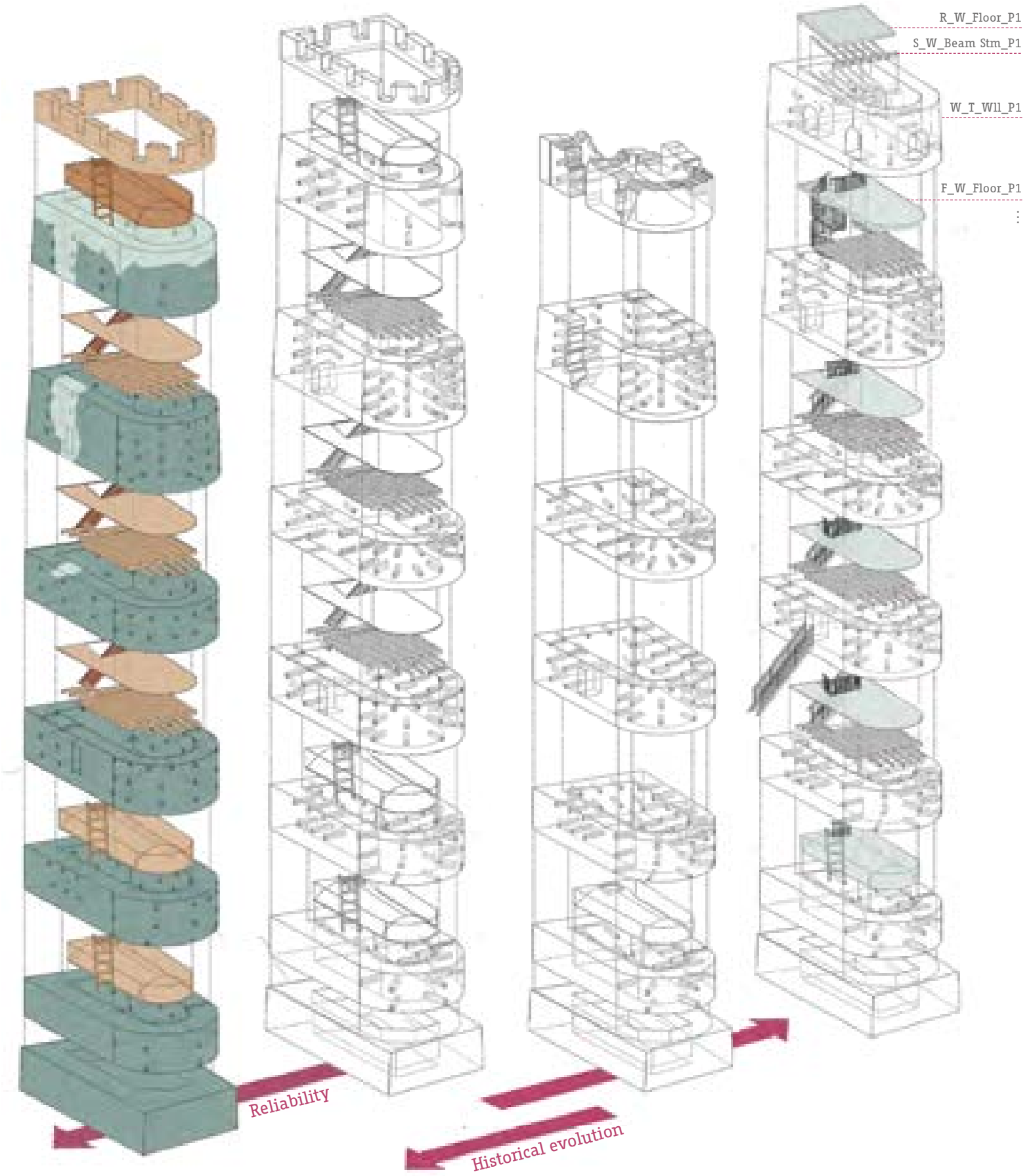
This digital archive - provided the necessary approximations are applied - could be used for the elaboration of further models of the defensive systems along the route of 'James I', by employing site-specific intelligent objects capable of describing the peculiarities and homologies of the various defensive building features. Indeed, the structuring of a technological database, necessary for modelling by typological elements, also facilitates the study and comparison from a historical-constructive point of view of the single components composing the investigated case studies, thus setting the basis for a cataloguing system of the historical artefacts and the subsequent implementation of a larger-scale management system starting from the selected pilot cases .

Implementation of the Spatial Management Platform

The idea of setting up a GIS-type information system arose from the imperative to improve understanding regarding the construction and defence techniques employed in the fortified heritage over the centuries, as well as to geographically link the various case studies. Therefore, the requirements for the selected GIS platform concerned the capability of integrating models realised in a parametric BIM environment, keeping the readability of annexed data and additionally providing the possibility of individually querying the modelled structural elements. For said reasons, we chose the ESRI ArcGIS Pro piece of software, as it enables an immediate and straightforward connection to the parametric BIM models preserving their proprietary RVT format, developed by Autodesk Revit.

To embed the models within the GIS platform, it was necessary to first georeference them within the BIM environment. An initial geolocalisation of the BIM models - in the lack of GPS points acquired on the field - was carried out using the GPS signal location metadata recorded by the UAS during the aerophotogrammetric acquisitions and integrated within the shots in JPG format. As a matter of fact, photogrammetric processing software, such as Agisoft Metashape, is able to automatically read the image GPS metadata, if present, and uses it to perform a rough georeferencing of the post-processed models; in this case, the resulting models were then scaled by integrating the metric data of natural points obtained from the laser scanner survey. Consequently, in the event of further measurement

Side page, fig. 06
Almonecir Castle, visualisation of phases and reliability scale
Explanatory diagram showing the historical stratification of the main tower and the level of reliability attributed to each stage, based on material evidence, indirect data, and reconstruction hypotheses.


R_W_Floor_P1
S_W_Beam Stm_P1
W_T_Wll_P1
F_W_Floor_P1
Reliability
Historical evolution

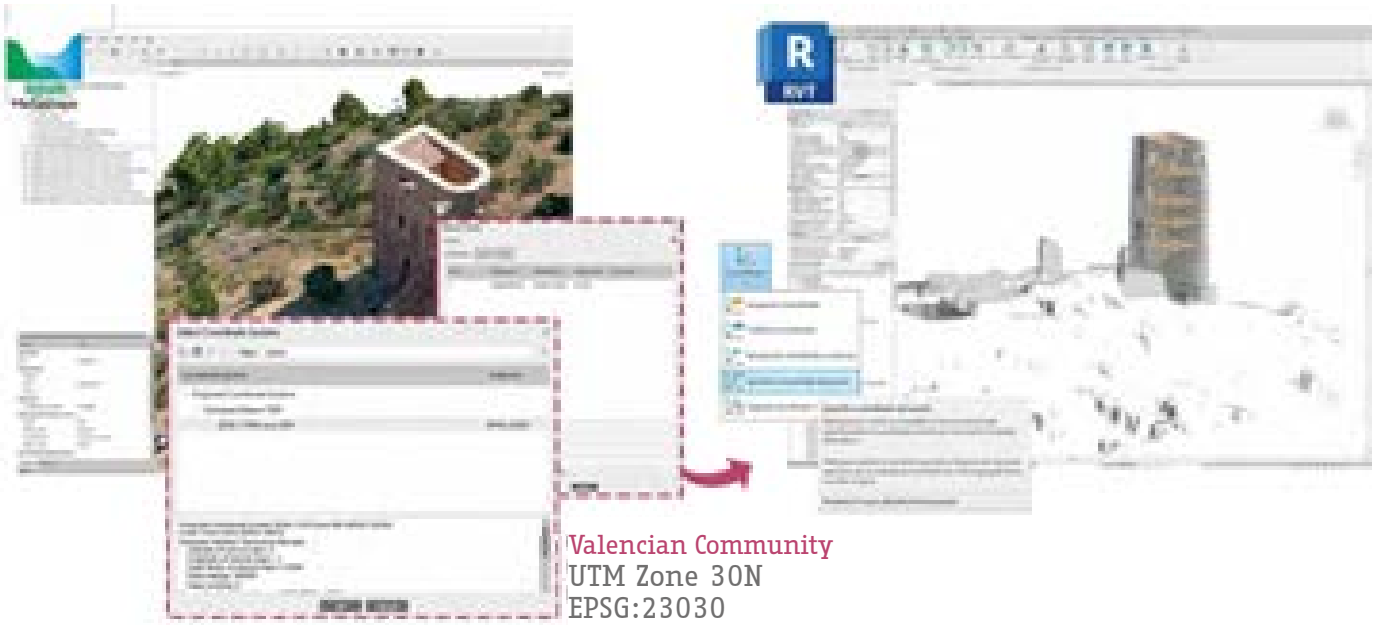
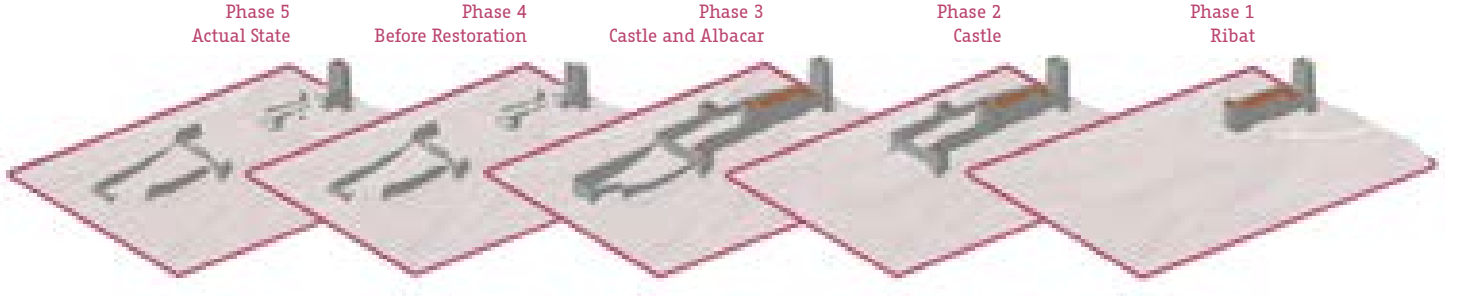


Fig. 07
Georeferencing and alignment of the BIM model
Setting of UTM coordinate system (EPSG:23030) and alignment of photogrammetric and BIM models within the territorial context.

and integration of more reliable topographic data, BIM software will allow the georeferencing of the models to be changed at any time by simply updating the shared coordinates of known points.
Before entering the location coordinates within the models, it was necessary, within the Metashape software, to convert the WGS84 geodetic coordinate system into a projected coordinate system (UTM), choosing the UTM corresponding to the Valencia Region. Then, for each model, a well-known point was selected, and the converted UTM coordinates were used for the homologous point within the Revit platform, by matching the "x" coordinate to the "E/W" direction, the "y" to the "N/S", and the "z" to the "altitude". The georeferenced BIM models were then linked to the ArcGIS Pro platform, where a base map was created and updated using the UTM30N reference coordinates (Valencia, Spain).
Finally, to manage the phases within the GIS, it was necessary to define a correspondence between its layers and the "phase" attribute property populated within the BIM environment. Upon activating the "SelectByAttribute" tool, which allows rule-based selection, it is possible to filter in or out various elements and accordingly copy them to other levels, offering a plethora of cataloguing options. In detail, the different BIM categories were filtered according to the specific historical phase determined during the documentation process. Each individual category (walls, floors, stairs, etc.) was then partitioned using the "ruled selection" in order to export the chosen components as "features" and

Fig. 08
Visualisation of historical phases of the model within the GIS
Reconstruction sequence of the site's architectural transformations, from the Ribat to the current state, managed within a GIS environment.



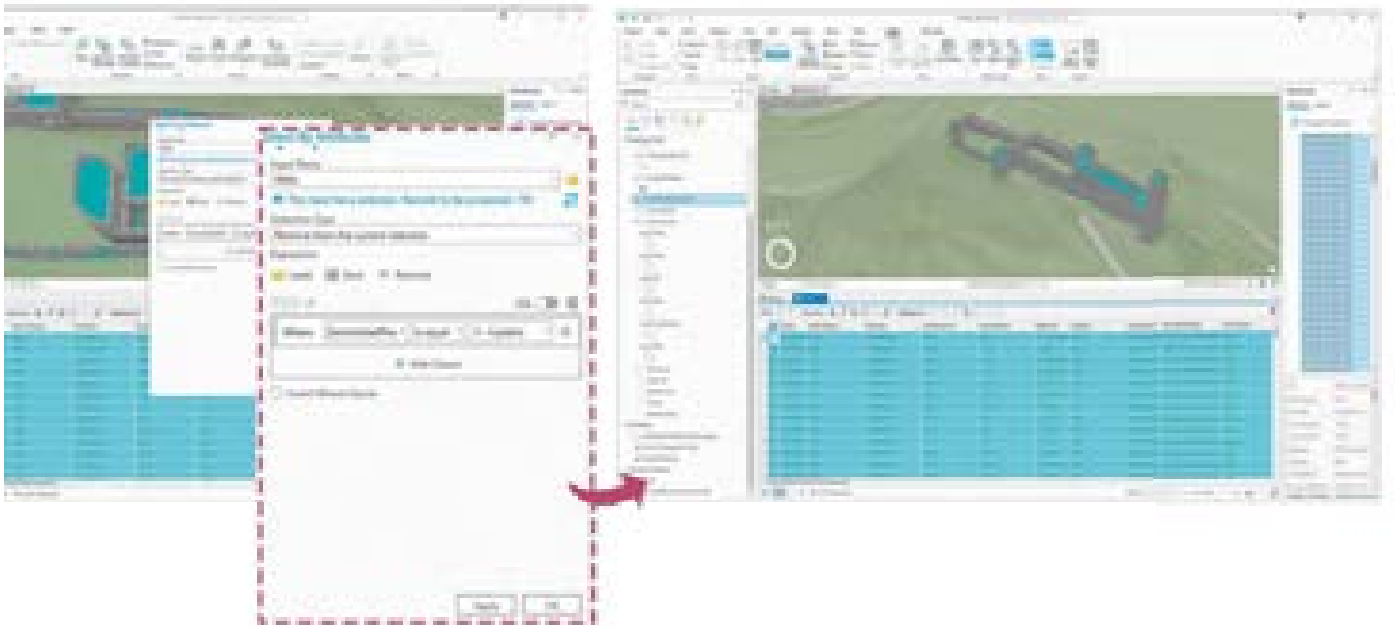


Fig. 09
Import and management of the BIM model in a GIS environment
Model export and attribute-based queries within a GIS platform for advanced analysis and management.

assign them to the corresponding layer, thereby ensuring that the specifics of the specific phase were displayed. The inclusion and validation of parametric models within the GIS platform opens up a range of opportunities and possibilities for the information enrichment of the model by extending its content to the territorial scale. Within the ArcGIS Pro software, it is also possible to create overlays on a spatial scale and to insert placeholders at selected locations. These tools will thus facilitate the connection between the different sites of a specific route, establish a relationship with sites belonging to similar cultural contexts and even support the definition of further thematic itineraries, through layered information organised according to a tree structure.

Conclusions and future developments

The presented application raises some closing thoughts on the results obtained and their possible further developments. Above all, it fostered awareness about the need for interoperability between information systems; in fact, while much has already been achieved in linking BIM and GIS, primarily thanks to continuous feedback from research activities[12], the full integration within different management platforms still has a long way to go.

Today's remarkable technological advances have gradually replaced two-dimensional digital cartography with three-dimensional multiscale GeoBIM models, which encompass highly descriptive and interactive types of representation. Operating-wise, the proposed workflow aims at promoting interoperability and accessibility for multiple parties, both in the form of open data formats such as IFC (*Industry Foundation Classes*) and Georeferenced BIM models managed through multi-scale monitoring platforms. Forward-looking developments include the potential development of similar information ecosystems via the presented methodological approach to other case studies of the "James I" route.

[12] Beck, Borrmann, Kolbe (2020), *The need for a differentiation between heterogeneous information integration approaches in the field of "BIM-GIS Integration": a literature review.*

Fig. 10
Textured model of Morella Castle in the BIM environment
Digital reconstruction of the fortified complex, integrated with photorealistic textures and managed within an HBIM environment for analysis and heritage management.

The twofold objective will be to both validate the methodology pursued and to attempt to make effective use of the GIS platform to devise dissemination and valorisation actions for the sites so as to increase the value of the territory and promote tourism within the Valencian Community. The virtual accessibility of the route could generate a significant growth of "informed visitors", spreading awareness about the value of these cultural routes. Namely, documentation plays a key role in this process of landscape re-development and in the preservation of the historical-architectural heritage, contributing to cultural appreciation within the European system.

In conclusion, this kind of interactive information system presents a unique opportunity to enhance the territory and its use for tourism. Through the multi-level gathering and interaction of information, this tool would allow integrated management and a clearer understanding of the area's architectural and historical features, thus contributing to preserving and passing on CH values to future generations.

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Credits

Research Project

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The scientific coordinator of the project is Prof. Sandro Parrinello.

The project involved collaboration among academic and non academic partners.

List of the academic partners:
University of Pavia (Italy)
Polytechnic University of Valencia (Spain)
Perm National Research Polytechnic University - until 2022 (Russia)
Gdańsk University of Technology - since 2022 (Poland)
University of Florence - since 2023 (Italy)

List of the non academic partners:
SISMA srl (Italy)
Ebime srl (Spain)
MetaHeritage srl - since 2022 (Italy)
Blesarq - since 2022 (Spain)
CTA srl - since 2022 (Poland)

Project Coordinators

Sandro Parrinello *(from January 2019 to May 2023)*
Francesca Picchio *(since May 2023)*

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A selection of the research outputs presented in this volume was developed through educational activities, including master and PhD thesis, academic courses, workshops, and international summer schools. These initiatives engaged students from the universities participating in the research programme and were conducted under the supervision and support of the project's researchers. The resulting materials, such as drawings, survey documents, and digital models, constitute an integral component of the scientific contributions published in this volume.

Architectural Survey and Representation Course

DICAr, University of Pavia
Academic Year 2022/2023
Course Coordinator: Francesca Picchio
Course Assistant: Elisabetta Doria, Francesca Galasso
Iglesia de la Sangre (Llira), pp. 81–85: Valeria Capelli, Beatrice D'Ovidio, Elena Lo Monaco.
Monasterio de Santa Maria della Valldigna (Simat de la Valldigna), pp. 90, 94–101, 103, 105: Anna

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Bergaminelli, Diego Dulbecco, Francesca Porretti, Alessio Bonaldo, Sofia Casile, Aurora Franchi, Greta Cozzi, Marika Garzone, Martina Rinaldi, Nadia Baroni, Enada Cela, Alice Krima Salsabil
Casa de Jaime I (Alzira), pp. 134–136: Edoardo Gironi, Mattia Ghisoni, Francesco Scarioni
Castillo de Cullera, pp. 192–195: Miriam Salvador, Andreu Conesa, Sergio Bermudez, Miguel Gracia

International Summer School 2022
The Route of Jaime I - Survey and analysis for evaluation enhancement and management of European Cultural Heritage Routes
(16-26 July 2022)
Scientific Responsible: Sandro Parrinello
Scientific Coordinator: Francesca Picchio, Luis Cortés Meseguer
Tutors: Anna Dell'Amico, Hangjun Fu
Participants: Alberto Pettineo, Giulia Porcheddu, Valeria Maria Ranieri, Francesca Villa

International Summer School 2023
The Route of Jaime I - Survey and analysis for evaluation enhancement and management of European Cultural Heritage Routes
(24-31 July 2023)
Scientific Responsible: Francesca Picchio
Scientific Coordinator: Anna Dell'Amico
Tutors: Anna Sanseverino, Francesca Galasso, Hangjun Fu, Giulia Porcheddu, Alberto Pettineo
Participants: Giuseppe Angileri, Madalina Elena Cantea, Dante Certomà, Laura Galesio, Edoardo Gironi, Edoardo Fina, Giacomo Tosini, Chiara Visconti

3D Models and 3D printings
All 3D models are authored by the contributors of the respective chapters, except for the model of Morella Castle, which was developed within the framework of the International Summer School 2023 - *The Route of Jaime I - Survey and analysis for evaluation enhancement and management of European Cultural Heritage Routes*.

3D printing models were produced at:
DAda-LAB, University of Pavia
Be More 3D, Polytechnic University of Valencia

Prototyping and processing of 3D printing models: Hangjun Fu, Dante Certomà

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Drawing on the collaboration of lecturers, researchers and students from different disciplinary fields, the project proposed an integrated approach to historical and architectural heritage, combining critical interpretation, digital survey, 3D modelling and information systems. In this framework, PROMETHEUS explored the challenges of applying BIM to heritage contexts, testing digital and cognitive protocols for the representation, management and enhancement of widespread cultural heritage within the European context.

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