



Aerial view of the conventual complex. Credits: P. Becherini, 2021

Integrated investigation methodologies for architectural Heritage conservation and promotion: La Romita di Cesi (TR), Umbria, Italy.

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Abstract: This article presents research conducted as part of the European project F-ATLAS, which aims to study the convent complexes of the Franciscan Observance and their landscape context between Italy, Spain and Portugal. The research uses historical and archival sources and integrated digital survey methodologies to document and study the network of the Observance convents and the routes that connect them for their conservation, protection and valorisation. In particular, the text illustrates the preliminary phases of the study of the conventual complex La Romita di Cesi (TR) in Umbria, Italy - one of the Oratories given in concession to Paoluccio Trinci in 1373, suppressed in 1866 and brought back to light in 1991 by Fra Bernardino. Parallel to studying historical and archival sources, two integrated digital survey campaigns were carried out using TLS and photographic instruments. This work aimed to become a reliable support for the preservation of the Observant Cultural Heritage, for its promotion to insiders and the public, and finally, for the future management of La Romita.

Keywords: observant Architecture, Franciscan Observance, integrated digital survey, TLS, SfM photogrammetry.



Figure 1 | Aerial view of the conventual complex. Credits: P. Becherini, 2021.

1. Introduction

This article is part of the research carried out within the European Project F-ATLAS, one of the winning projects of the JPI-CH 2019 call. F-ATLAS aims to study the conventual complexes of the Franciscan Observance and their landscape context between Italy, Spain, and Portugal. The research uses historical and archival sources and integrated digital survey methodologies to document and study the network of Observant convents and the paths that connect them for their conservation, protection, and enhancement (Bertocci, 2021). The project is a collaboration between the University of Florence, the Instituto Universitario de Lisboa, the Universitat de Barcelona and the Universidade Catolica Portuguesa. It is a three-year project launched in 2020 (<https://www.f-atlas.eu>).

In particular, the text illustrates the preliminary phases of the study of the conventual complex La Romita in Cesi (TR), Umbria, Italy (Fig. 1). It is a case study peculiar from the historical point of view, as it is one of the Oratories given in concession to Paoluccio Trinci in 1373, suppressed in 1866 and brought to light in 1991 by Fra Bernardino (Di Giampaolo, 2013). From the point of view of architecture and landscape, the complex has

characteristics common to other convents analysed within the F-ATLAS Project: the presence of hermit caves, pre-existing Benedictine and even earlier settlements (at the times of the Umru and the Romans) possibly adapted to the needs of the friars, location of the complexes in the woods or close to cliffs, architectural aspect dependent on the specific characteristics of the place and ordered according to comfort and reason (Mussolin, 2012; Pellegrini & Paciocco, 2001; Salvestrini *et al.*, 2023).

Two integrated digital survey campaigns were carried out in parallel with studying historical and archival sources. During the first one, in August 2021, a laser scanner was used to detect the external spaces of La Romita, defining a closed polygonal around the convent's buildings. A digital camera and a drone were also used to make photogrammetric and documentation acquisitions. During the second campaign, in March 2022, a laser scanner was used to detect the interior spaces of the convent.

The data acquired during the survey operations, adequately processed, represent valid support for the study and analysis of the conventual spaces and the surrounding territory.

2. La Romita di Cesi

La Romita is located on a slope of Monte Torre Maggiore, along the route that connects the archaeological site of Carsulae to Spoleto, near Terni. There are traces of settlements in the territory of Terni already in prehistoric times, witnessed by finds of a necropolis. From the third century B.C., the area became a Roman colony.

La Romita is part of the Provincia S. Francisci (Fig. 2), which at the end of the thirteenth century is one of the Franciscan districts with the highest settlement density, along with those of Marchie Anconitane and Pennensis, which define the band of settlements that cross central Italy from south-west to north-east (Pellegrini, 1984). The predominant tendency of the Franciscan settlements in the thirteenth century was to be concentrated near the great centres of economic propulsion or in the surrounding territories, with a few exceptions. In the Umbria, Marche and Abruzzo areas, characterised by many small and medium-sized urban centres, almost half of the Franciscan settlements are rural or romitorial (Pellegrini, 1984).

2.1 Historical background

The archivist Rossi has reconstructed the historical events of the conventual complex (Rossi, 2022), in which it is said that St. Francis lived several times, starting from 1213. The presence of a Benedictine hermitage built around the seventh-ninth centuries is attested in honour of the SS. Volusiano and Procolo, next to which St. Francis had made a shelter with wood and clay. He also built a church dedicated to SS. Annunziata, with the same proportions as the Porziuncola in Assisi (Rossi, 2022). In the course of 1300, in the convent came the blessed Giovanni della Valle, Gentile da Spoleto and Paoluccio Trinci - to the latter, Gregory XI grants eleven Oratories, including La Romita (Bertocci *et al.*, 2023), in which to “live the purity of the Rule” as established in the Observant Reform. San Bernardino da Siena resided here in ‘400 and expanded the buildings by erecting twelve cells with wooden structures. The monastery complex also includes a sacristy, a refectory, a cloister, a library, a novice building and the surrounding forest with vegetable gardens (Rossi, 2022). In 1532, as the Wadding testifies, the Romita passed into the hands of the Reformed. The convent was unaffected by eighteenth-century Napoleonic suppression due to its isolated position. Still, in 1860 it was hit by the Pepoli Decree, and in 1867 the gendarmes forced the friars to abandon the place (Rossi, 2022). The complex was bought at auction by the Eustachi family of Cesi and was inhabited by settlers until 1956, then left in a state of neglect until 1991 (Frate Bernardino, 2020). In 1991 Fra Bernardino, from the convent of Montesanto in Todi, located the ruined buildings of the convent hidden by



Figure 2 | La Romita is located near Terni, inside the borders of Umbria (in grey) and those of the XIV century Provincia S. Francisci (in yellow). Credits: A. Cottini.

the vegetation of the surrounding woods and obtained the concession of the owners to begin the restoration (Rossi, 2022; Frate Bernardino, 2020).

2.2 The conventual complex

The intervention of the friar, as reported in the volume in which he gathered his own experience of life at La Romita, presupposes a deep knowledge of the local history and the characteristics of the architecture of the Franciscan convents. The volume mentions the presence of a cave of prehistoric origin near the convent, consecrated to the cult of fertility and still visitable, as well as a sacred path that connected Carsulae to the first Umbrian (sixth century BC) and then Roman (fourth century BC) temple located on top of Monte Torre Maggiore, whose remains are still visible. It is reported that the Benedictine chapel - part of the original nucleus of the convent, was built over a Roman temple. Not far away, inside the courtyard dominated by the cedar of Lebanon, there are still visible large worked stones that are supposed to be of Roman origin (Frate Bernardino, 2020).

Thanks to the reconstruction operations started in 1991, the Benedictine chapel, the church of SS. Annunziata of the fourteenth century, the cloister, the cells and the novitiate of the fifteenth century, the refectory of the eighteenth century, the system of cisterns and the surrounding gardens were restored (Frate Bernardino, 2020). The original materials found on site were recovered and used for rebuilding: the architectural volumes are visible in their essentiality, and the stones were left exposed without plaster.

Currently, the cells are used as lodgings, while the building of the novitiate serves as a kitchen and refectory. The complex welcomes both pilgrims passing through (La Romita is one of the stages of many local hiking trails) and people who want to spend weeks or months reciprocating the free hospitality with maintenance work of the structure.

3. Planning of the metric survey campaign

The digital survey of the Romita di Cesi complex provided for developing an acquisition methodology to guarantee its accuracy and reliability on an architectural scale. The need to investigate the sections of the area for documentation purposes determined the scale of territorial representation with centimetre reliability regarding its spatial location in the horizontal plane and, for the elevation, the interesting height differences to which the site is subjected. The need to describe the site's layout, not limited to the design of the built element alone, and the need for detailed profile analyses led to the use of massive acquisition instruments such as Terrestrial Laser Scanning. An aerial photogrammetric acquisition was carried out to complete the data of the top part of the structure, which was impossible to reach with the TLS. This also provided the possibility of creating, simultaneously with the laser survey of the conventual structure, a 3D model of the entire context, partly agricultural and wooded - a factor that expanded knowledge of the final product. In summary, the survey of this case study consisted of the integration of three different types of acquisition, mainly TLS survey and photogrammetric survey from the ground and aerial, with Structure from Motion (SfM) technique, which completed what was obtained through direct acquisition by taking precise measurements (Fig.3). For the simultaneous management of this information, it was essential to design a data registration method, fast and repeatable to allow rapid operations during the acquisition phase (Pancani, 2016).

3.1 Practical and operational considerations on survey and data processing procedures

The first step in setting up a survey with TLS consists in choosing the type of instrument: in an architectural survey, the required precision must be assessed, which will be determined by the size and shape of the object. Despite the possibility of dividing scanners according to their range, there are many criteria for choosing the type of instrument. Still, it is necessary to take into account various operational characteristics, among which also parameters such as the acquisition speed, the scanning resolution, the divergence of the laser beam, the entire range of the instrument concerning the materials from which the object is formed, the measuring range, the possibility of automatically recognising targets and homologous points, operational autonomy, and last but not least the software that is necessary for the control of the survey operation and the management of the point cloud assume great importance, in addition to the mandatory considerations regarding accuracy and range. Once the instrument has been chosen, it is necessary to conduct a preliminary analysis of the object, possibly with site supervision, to establish how many and which the acquisition points for the complete survey of the object of study are - without leaving gaps and hidden areas. It is therefore essential to consider that, while in the traditional survey accuracy is the predominant parameter, in a survey with the laser scanner technique it is necessary to take into account other characteristics, which can influence, sometimes even in a decisive way, the realisation and accuracy of the survey itself. In this case, as in the survey of Cultural Heritage, it is often necessary to combine the geometric shape with the material description of the object (Volzone *et al.*, 2022). The photographic image represents the best response to this need; for this reason, a Z+F Imager 5016 was used with an integrated HDR camera, as well as LED spotlights for dark environments and the possibility of a 360°x320° field of view, with a scan density up to 1,000,000 points/s. The characteristics above, combined with the acquisition range of 360 meters, made obtaining the entire hermitage complex possible. The campaign took place in two distinct phases of acquisition to be able to complete the data capture. The first mission was carried out in August 2021 and the second in March 2022, with scans performed in colour (RGB data) for the external spaces - to read the wall textures and the outer surfaces' state while in black and white for the interiors. The photographic acquisitions from the ground and aerial were completed in two days during the first mission for 2500 photographs. Among these, 1500 shot with a Nikon D610 SLR with a 24-120 mm lens for a 24-megapixel resolution, while for the aerial data obtained with a DJI Mini 2 drone, the

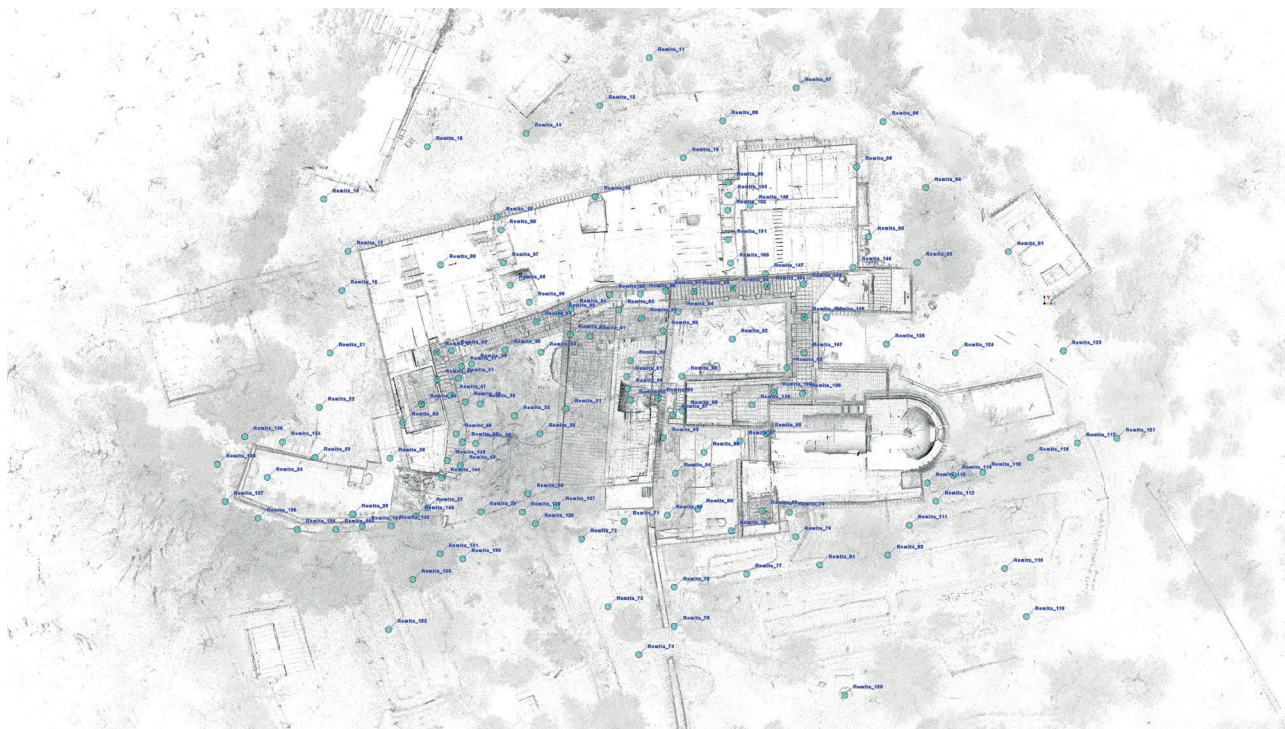


Figure 3 | Laser scanner positions in the external and internal spaces of the convent and the surrounding area.

resolution was 12 MP (24 mm lens). For the TLS survey campaign, the modus operandi followed a usual trend, firstly documenting the external spaces (August 2021) and then concentrating on the internal ones (March 2022). Following a careful study of the site and assessing the best conditions, weather and inclination of the sun's rays, an aerial photographic campaign was made to shoot single shots at the nadiral view, at 30° and 45°, to cover most of the conventual complex with the DJI Mini 2 drone. With a weight of less than 250 g (dimensions of 245×290×55 mm) and a battery life of about 30 minutes, it was possible to complete the necessary flights in just over two hours to achieve what was required. It was thus possible to obtain a complete description of the morphology and characteristics of our object of study (Becherini *et al.*, 2022). A considerable amount of data demonstrates that the survey of large structures requires a very long and well-designed acquisition phase to obtain a significant overlap between adjacent images for a complete object description. (Fig. 4).

3.2 Post Processing

Another crucial element for the profitable use of TLS is undoubtedly the software. A laser scanner tool is inseparable from a software package and a hardware tool, which can manage the data this instrument can detect.

In general, the essential functions of an ideal software for surveying Cultural Heritage are control and management of data acquisition, pre-treatment of acquired data (noise removal, filtering, recording of scans), treatment of filtered data (modelling), and integration with other information (digital image mapping). It must be emphasised that because of the enormous amount of data obtainable through a TLS, it is recommended that a representation can be obtained through a three-dimensional model, allowing exploration of the object and from which measurements and sections can be easily obtained. The object's 3D model, where appropriate photo-textured and navigable, is a readily available product. Still, it can be challenging for inexperienced users and requires powerful hardware support (graphics card equipped with a three-dimensional accelerator and adequate processor). The result, however, dramatically impacts the public and provides a detailed description of the object, from which it is possible to obtain accurate metric information. Another beneficial product for analysing the object in depth is the orthophoto, obtainable through integration between the images of the object acquired simultaneously or not with the TLS survey, through the acquisition of terrestrial and aerial photogrammetry, as in this case. Each of the two acquisition systems forms a point cloud in space - the goal, at the end of data elaboration with different software (such as Leica Cyclone for the laser scanner acquisitions

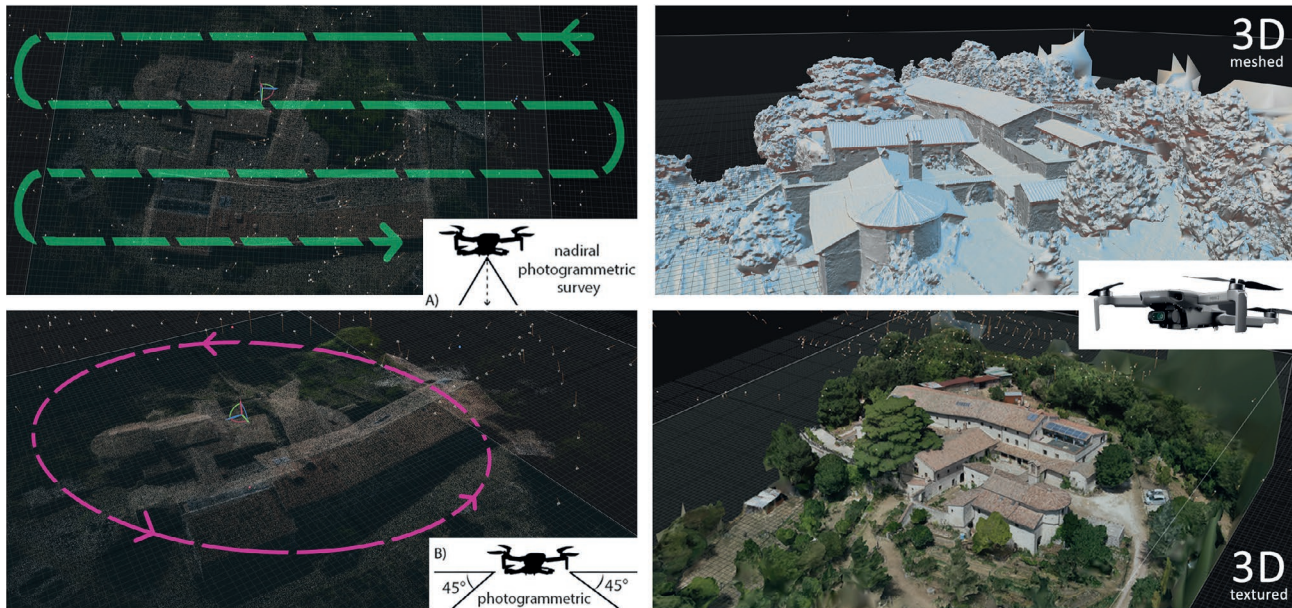


Figure 4 | On the left two of the types of UAV shots. On the top right the 3D mesh model, below the textured model. Credits: P. Becherini.

and Agisoft Metashape for SfM photogrammetry), was to maintain the exact coordinates. First, common points were determined between the two acquisition systems, so it was possible to rototranslate the photogrammetric model with the coordinates obtained from the software. Today, the international scientific community recognises the integrated use of the two techniques as the optimal solution for an accurate survey from the metric point of view and with the details necessary to describe an object fully. From the point of view of the extraction of geometric characteristics, a long phase of data processing is required and, despite the high degree of automation offered by the most modern software packages, many interventions by the operator. The two techniques are perfectly complementary: while photogrammetry produces a model that is easy to interpret using colour information, allowing a better reading of the wall texture and any degradation of the parietal surfaces, the laser scanner can describe the three-dimensional geometry of an object with high resolution.

4. Use and interpretation of data

Thanks to the integrated digital survey, it was possible to obtain a cloud of high-reliability points metric-morphological of the conventual complex and the surrounding landscape, as well as a textured 3D mesh model, which provides information about the colour and texture of the exterior wall surfaces. According to established operational methodologies, these models can be elaborated

to obtain two-dimensional and three-dimensional representations, such as plans, sections or axonometric splits, at different scales of detail (Becherini *et al.*, 2022; Bertocci *et al.*, 2023; Cioli & Cottini, 2023). The technical works prove to be a reliable support for further studies on the architectural and structural aspects of the convent, to study its distributive characteristics and to understand the relationships between the interior spaces, the outside and the surrounding landscape (Fig. 5). Of particular interest is the study of the distribution of the rooms in plan and section, through which it is possible to formulate hypotheses about the evolutionary phases of the architectural objects, looking for evidence in the bibliographic and archive sources (Bertocci *et al.*, 2023). The data obtained from the survey can also be used to compare with other Franciscan convents, for example, in terms of architectural characteristics, proportions or built-environment relationship. In Fig. 6, for example, data extracted from the point cloud of the Porziuncola of Assisi and the church of SS. Annunziata in Cesi were compared since they are correlated in the literature, as illustrated in paragraph 2.1. It is possible to notice how, despite minor differences in scale (as evidenced in the black and red metric scales, referred respectively to the Porziuncola and the SS. Annunziata), the proportions of the nave of the SS. Annunziata are superimposable in the plan to those of the Porziuncola. As for the section, both naves have an ogival barrel vault but with different arch proportions. In “Lo spirito e la pietra”, Verdolotti (2017) identifies the hesitation between the ogival arch and the round arch as an element of the influence of French architecture in early

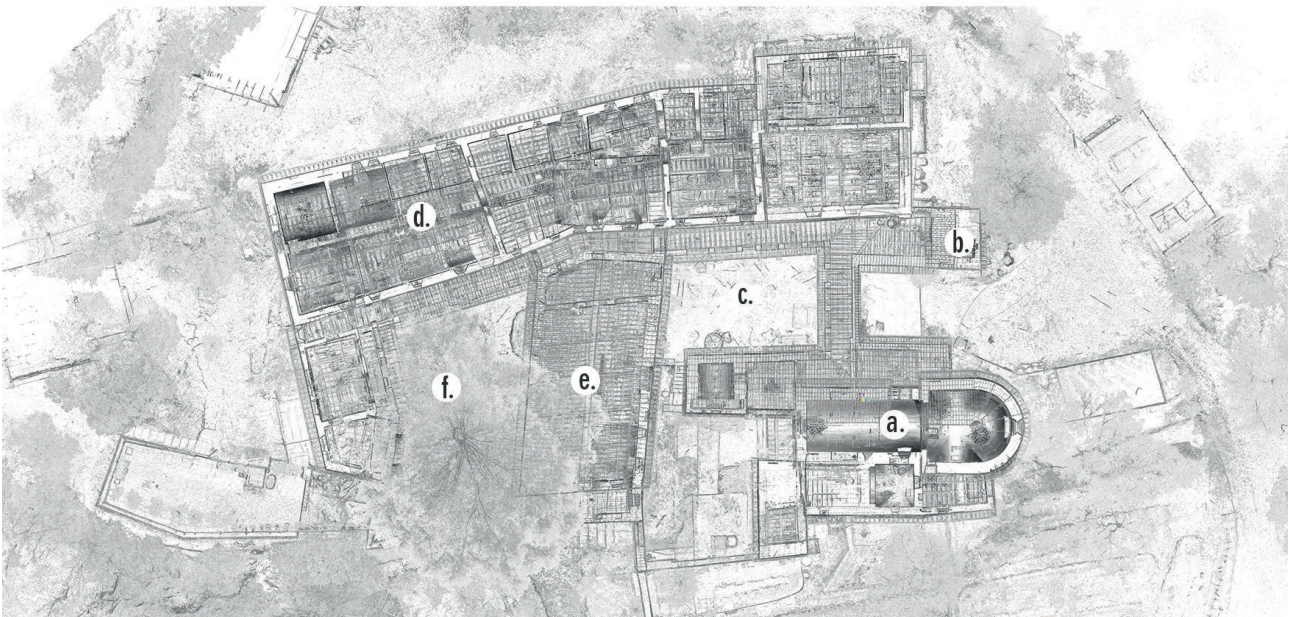


Figure 5 | Axonometric and plan views of La Romita and its surrounding landscape - point-cloud visualisation in Leica Cyclone. a. SS. Annunziata church, b. Benedictine chapel, c. Cloister, d. Cells (on the first floor), e. Novitiate (nowadays it is a living room with a kitchen), f. Courtyard with the cedar of Lebanon, where worked stones that are supposed to be of Roman origin are still visible. Credits: A. Cottini.

Franciscan architecture. The data obtained - in particular three-dimensional models, videos and photographs - offer exciting potential at the level of promotion of the Heritage, thanks to the dissemination through websites and social media dedicated to the F-ATLAS project to

attract a diverse audience of scholars and fans of the sector, but also tourists. They can also provide remote access to convents (via navigable 3D models and virtual tours), even if the buildings are hardly accessible or not accessible to the public (Cottini, 2022).

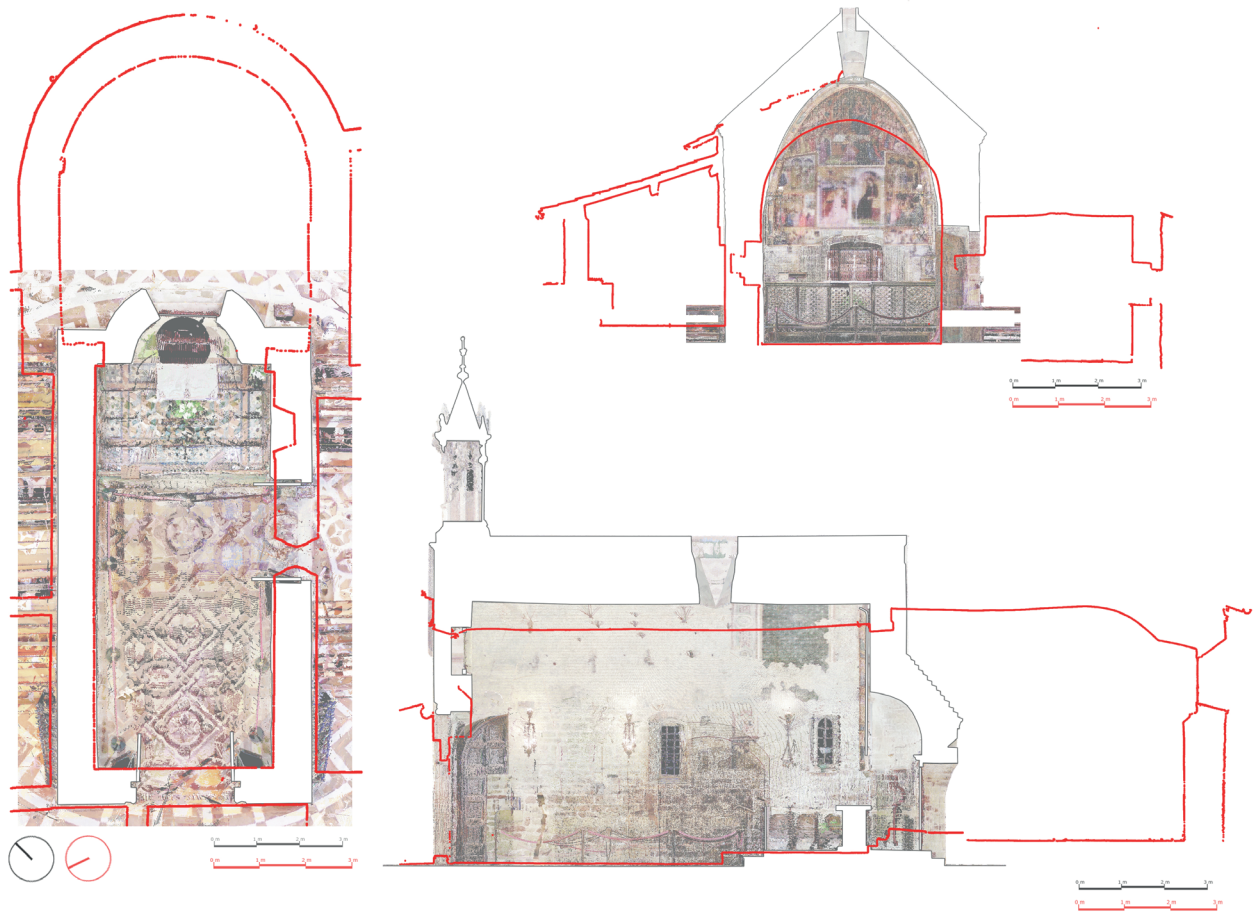


Figure 6 | Comparison between the plan and two sections of the Porziuncola of Assisi (coloured data) and the church of SS. Annunziata in Cesi (in red, raw data of the slice extracted from the point cloud). Credits: A. Cottini.

5. Conclusions

Integrating digital surveying techniques and studying bibliographic and archival sources constitutes reliable support for the architectural analysis of historical buildings. The data collected in La Romita convent have been entered into the database of information relating to the research project F-ATLAS. They will constitute a database that can be consulted and updated over time. The data of this database are different and significant in digital space; it is, therefore, essential to establish a priori the purpose of use and discretise the data accordingly. Thus, collecting data with digital survey methodologies assumes a crucial role in documenting the state of the conventual complex: the data can be updated in the future and used as support for architectural and diagnostic investigations or the promotion of Heritage. The project aims to preserve the Observant Cultural Heritage, promote it, and make it known to the public, considering the cultural contributions and historical-artistic-architectural characteristics. In this specific case,

the aspects related to the conservation of assets are of particular interest also for the future management of La Romita, having recently passed away Fra Bernardino, the leading proponent of the correct management of the conventual complex.

Acknowledgements

The project F-ATLAS is funded by JPI Cultural Heritage, which received funding from the European Union's Horizon 2020 research and innovation programme (www.f-atlas.eu). The consortium is composed of 4 principal investigators: University of Florence (PI Stefano Bertocci), University Institute of Lisboa (PI Soraya Genin), University of Barcelona (PI Maria Soler Sala), Portuguese Catholic University of Lisbon (PI Maria Filomena Andrade). The digital surveys were made in August 2021 and March 2022 by Anastasia Cottini and Pietro Becherini of the University of Florence. Paragraphs 1, 2, 4 and 5 are attributed to Anastasia Cottini. Paragraph 3 is attributed to Pietro Becherini.

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