Work Package 3

Digital survey and data processing
Task_3.1 Metric digital survey: development of digital survey campaigns for the acquisition of metric, qualitative and colourimetric data of the architectures identified as case studies to be deepened.
Task_3.2 Creation of a digital database: definition of the parameters and criteria for the structuring of a unitary archive for the collection of digital and analogue data.
Task_3.3 Data processing and development of digital media: elaboration of the data acquired during the surveys and realization of graphic works, representing plants, elevations and sections, and multimedia products of the investigated architectures, such as 3D models, photographs and videos.
Output O7 - Digital laser scanner surveys (3D point clouds), O8 - Digital Structure from Motion surveys (3D mesh models), O9 - Technical drawings of architectures (technical report), O10 - Multimedia material (photographs and videos), O11 - Survey activity report (report)

[O11] The purpose of the integrated digital survey activities carried out in WP3 was to combine traditional and innovative techniques to develop methodologies, protocols, and risk assessment tools, as well as to create user-friendly interfaces for the management and enhancement of Cultural Heritage, establishing a constantly updatable digital Database that could be used as a basis for the development of activities described in subsequent WPs.

The integrated digital survey campaigns were conducted in the following case studies, considered particularly representative for the project due to their architectural and landscape characteristics: Convento del Sacro Speco di San Francesco (Narni, Umbria, Italy); Convento della Porziuncola in Santa Maria degli Angeli (Assisi, Umbria, Italy); Convento di San Bartolomeo (Foligno (PG), Umbria, Italy); Eremo delle Carceri (Assisi (PG), Umbria, Italy); La Romita di Cesi (Narni (TR), Umbria, Italy); Convento Nossa Senhora da Ínsua (Caminha, Norte, Portugal); Convento Santa Maria de Mosteiró (Valença, Norte, Portugal); Convento Sao Francisco do Monte (Viana do Castelo, Norte, Portugal); Castell Monestir de Sant Miquel d'Escornalbou (Riudecanyes, Catalonia, Spain); Convento de San Francisco (Chelva, Valencian Community, Spain); Eremo de San Francisco (Chelva, Valencian Community, Spain).

The integrated digital survey campaigns enabled the creation of three-dimensional models of the convent complexes, with reliable metric and textural data. For these operations, LIDAR instrumentation such as terrestrial laser scanners, as well as photographic equipment such as drones and digital cameras, capable of providing accurate measurements and color data of the external surfaces and internal spaces of the architectures, were employed. They also captured the territorial contexts in which the convents are situated. Through the post-processing and interpretation of such data, it was possible to obtain both technical drawings of plans, elevations, and sections of the buildings, at different levels of detail, and navigable three-dimensional models. These supports were essential for conducting in-depth analyses of the architectures, their characteristics, and their state of preservation, useful for management by local administrations, for restoration and seismic prevention projects, or for remote access.

[O7] TLS surveys were typically conducted using two different models of laser scanners: a Z+F IMAGER 5016 and a FARO Focus M70, both utilising phase difference technology. The former was mainly used for external scans due to its particularly wide range, which made it suitable for capturing

portions of the landscape context as well. The latter was employed for internal environments, being smaller, more manageable, and lighter, with a smaller range compared to the former. The large amount of data obtained from the laser scanner survey campaigns was subsequently imported and processed within specific software for managing point clouds, such as Leica Cyclone. The main phases of filtering (i.e., noise reduction in acquired data), cloud-to-cloud registration (a procedure for visual alignment that exploits a series of rigid transformations), certification (i.e., verification of the reliability of the acquired measurements and correction of errors), and processing (i.e., obtaining raw data related to plans, elevations, and sections of the building that will form the basis for technical drawings) of the global point clouds were developed through this software.

Fig. 4: Point cloud showing the laser scanner acquisition positions and the corresponding control polygon of the Convent of San Bartolomeo in Foligno.

Fig. 5: Perspective view of the point cloud of the Porziuncola inside the Basilica of Santa Maria degli Angeli in Assisi.

Fig. 6: Point cloud of the Hermitage of the Carceri in Assisi.

[O8] Three different types of cameras were typically used for photographic surveys: a digital camera, a drone with a camera, and a 360° camera, to obtain different products that met various needs. The digital camera was used to take photographs documenting both the context and the most relevant details of the convent complexes, useful for integrating the cataloging sheets, as well as the workgroup's operations. It was also used to produce images that, through the Structure from Motion (SfM) photogrammetric technique, allowed the generation of three-dimensional mesh models of the architecture. The three-dimensional mesh models, properly scaled thanks to comparison with the laser scanner point cloud and textured, provide reliable geometric and chromatic data. The drone allowed for taking photographs and shooting short videos of the complexes from above: these operations were useful for complementing close-range photogrammetry performed from the ground with digital cameras and for obtaining impactful photos and videos that were also used for promotional purposes

of the project. The 360° camera allowed for taking rapid shots that were processed to obtain Virtual Tours of the convent complexes, navigable by users even through the Web.

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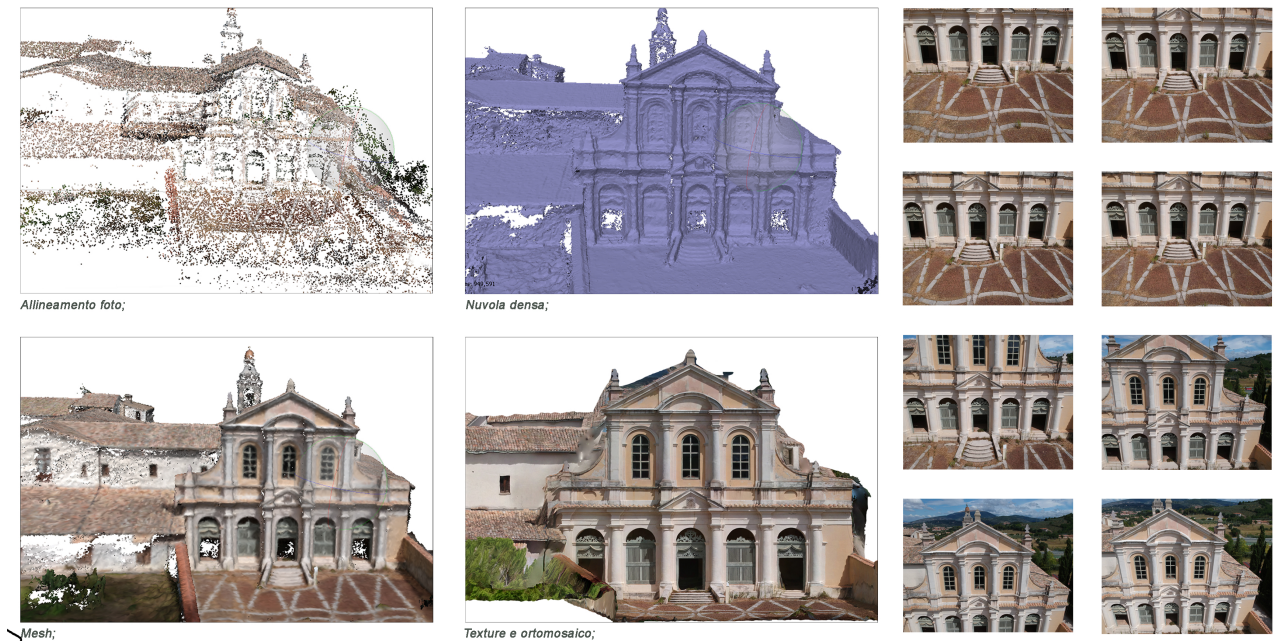
Texture e ortomosaico;

Fig. 7: Processes of Structure from Motion (SfM) photogrammetric survey processing for the development of the textured 3D mesh model of the convent of San Bartolomeo in Foligno.

[O9] The laser scanner point cloud can be used to obtain 2D drawings of plans, sections, elevations, and axonometric views. These images are imported into drawing and modeling software such as Autodesk AutoCAD or Rhinoceros to provide a metrically reliable support for the creation of dimensioned technical drawings or NURBS 3D models. The former can have a representation scale ranging from landscape to more detailed scales such as 1:50 or 1:20 – they are, for example, used to represent distribution schemes and maps of degradations and superficial lesions. The latter constitute an effective way to visualise the convent complex in three dimensions and to break it down into its essential volumes, for example, to represent the construction phases of the buildings. From the mesh models, orthomosaics of the facades of the architectural object can be obtained, i.e., orthorectified images of the wall surfaces. These images are used together with the point cloud data to create two-dimensional representations of plans, elevations, and sections, adding information regarding the color and texture of the facade surfaces.
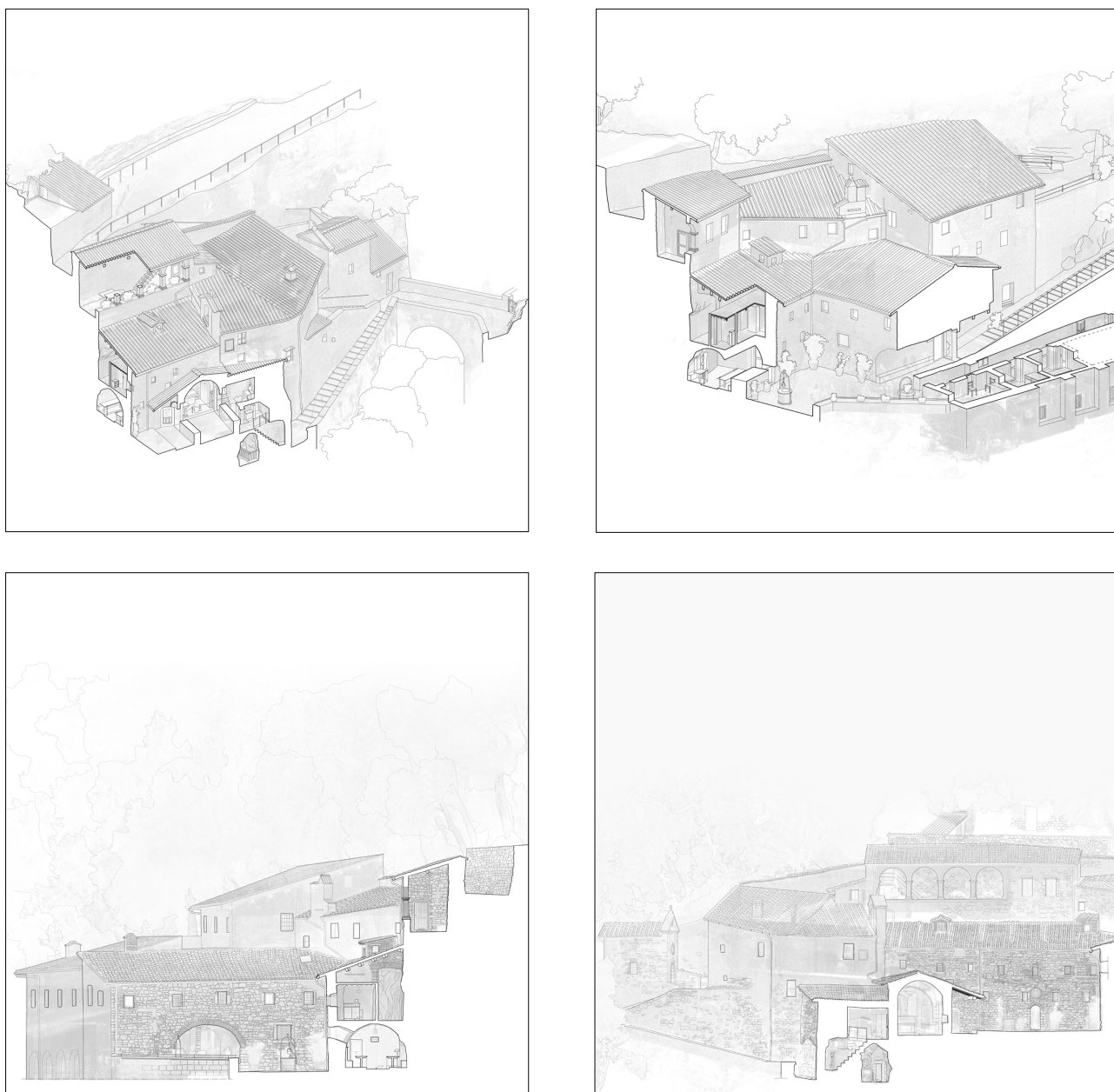
Fig. 8: Axonometric sections and environmental sections of the Hermitage of the Carceri in Assisi.

[O10] The multimedia materials (photos and videos from ground and drone, 360° photos) acquired during the on-site survey campaigns served both for the documentation of the convent complexes and as structural elements for communication, enhancement, and remote use of the sites, for tourist and educational purposes. These materials were structurally useful for the project site and social media utilization (detailed in WP9), enabling the construction of immersive experiences in various ways. The choice regarding the development and implementation of the main advanced communication media relied significantly on images and videos mainly for these aspects:

- Photographic data is formally the simplest encoding representation, as a descriptor of space, for all age groups, especially considering childhood and the elderly, allowing for easier and more immediate user/immersion experience.
- Raster content requires fewer computational resources, making them more suitable for use on mobile devices (tablets or smartphones).
- Greater simplicity and relative economy in the acquisition and authoring process.
- The possibility of immersive/interactive use of such content even from mobile devices without the need for an HDM (head-mounted device).
- The contents produced are easily portable to other and more common digital platforms usable for the communication project, such as the use of the Virtual Tour directly from the website.

Multimedia materials were acquired, for dissemination purposes, related to the following case studies: Convento del Sacro Speco di San Francesco (Narni, Umbria, Italy); Convento della Porziuncola in Santa Maria degli Angeli (Assisi, Umbria, Italy); Convento della Santissima Annunziata (Gualdo Tadino (PG), Umbria, Italy); Convento di San Bartolomeo (Foligno (PG), Umbria, Italy); Convento di San Damiano (Assisi (PG), Umbria, Italy); Convento di San Francesco del Monte o Monteripido (Perugia (PG), Umbria, Italy); Convento di San Francesco di Monteluco (Spoleto (PG), Umbria, Italy); Eremo delle Carceri (Assisi (PG), Umbria, Italy); La Romita di Cesi (Narni (TR), Umbria, Italy); Convento SS. Annunziata (Amelia (TR), Umbria, Italy); Santuario Le Celle (Cortona (AR), Toscana, Italy); Convento Santa Maria della Spineta (Fratta Todina (TR), Umbria, Italy); Convento San Salvatore al Monte (Firenze, Toscana, Italy); Convento San Pietro sulle Acque (Massa Martana (TR), Umbria, Italy); Convento di San Girolamo (Spello (PG), Umbria, Italy); Romita (Nocera (PG), Umbria, Italy); Convento SS. Annunziata (Norcia (TR), Umbria, Italy); Convento SS. Annunziata (Bevagna (PG), Umbria, Italy); Convento Santa Maria dell'Oro (Terni, Umbria, Italy); Convento Santa Chiara (Spello (PG), Umbria, Italy); Convento Santa Caterina (Spello (PG), Umbria, Italy); Convento Sant'Ubaldo (Gubbio (PG), Umbria, Italy); Convento San Girolamo (Spello (PG), Umbria, Italy); Convento San Girolamo (Gubbio (PG), Umbria, Italy); Convento San Francesco (Fiesole (FI), Toscana, Italy); Convento San Fortunato (Montefalco (TR), Umbria, Italy); Convento Montesanto (Todi (PG), Umbria, Italy); La Scarzuola (Terni, Umbria, Italy); Convento Farneto (Colombella (TR), Umbria, Italy); Convento Santa Croce (San'Anatolia di Narco (TR), Umbria, Italy); Convento Sant'Antonio Abate (Campello di Pissignano (TR), Umbria, Italy); Convento di Sant'Antonio di Monteluco (Spoleto (PG), Umbria, Italy); Convento di San Paolo Inter Vineas (Spoleto (PG), Umbria, Italy); Convento di San Giacomo (Todi (PG), Umbria, Italy); Convento di San Bernardino da Siena (Montefranco (TR), Umbria, Italy); Convento di San Bartolomeo a Brogliano (Foligno (PG), Umbria, Italy); Convento di Sant'Angelo in Monte (Città della Pieve (PG), Umbria, Italy); Convento di San Martino (Trevi (PG), Umbria, Italy); Convento Nossa Senhora da Ínsua (Caminha, Norte, Portugal); Convento Santa Maria de Mosteiró (Valença, Norte, Portugal); Convento Sao Francisco do Monte

(Viana do Castelo, Norte, Portugal); Convento São Paio do Monte (Vila Nova de Cerveira, Norte, Portugal); Castell Monestir de Sant Miquel d'Escornalbou (Riudecanyes, Catalonia, Spain); Convento de San Francisco (Chelva, Valencian Community, Spain).
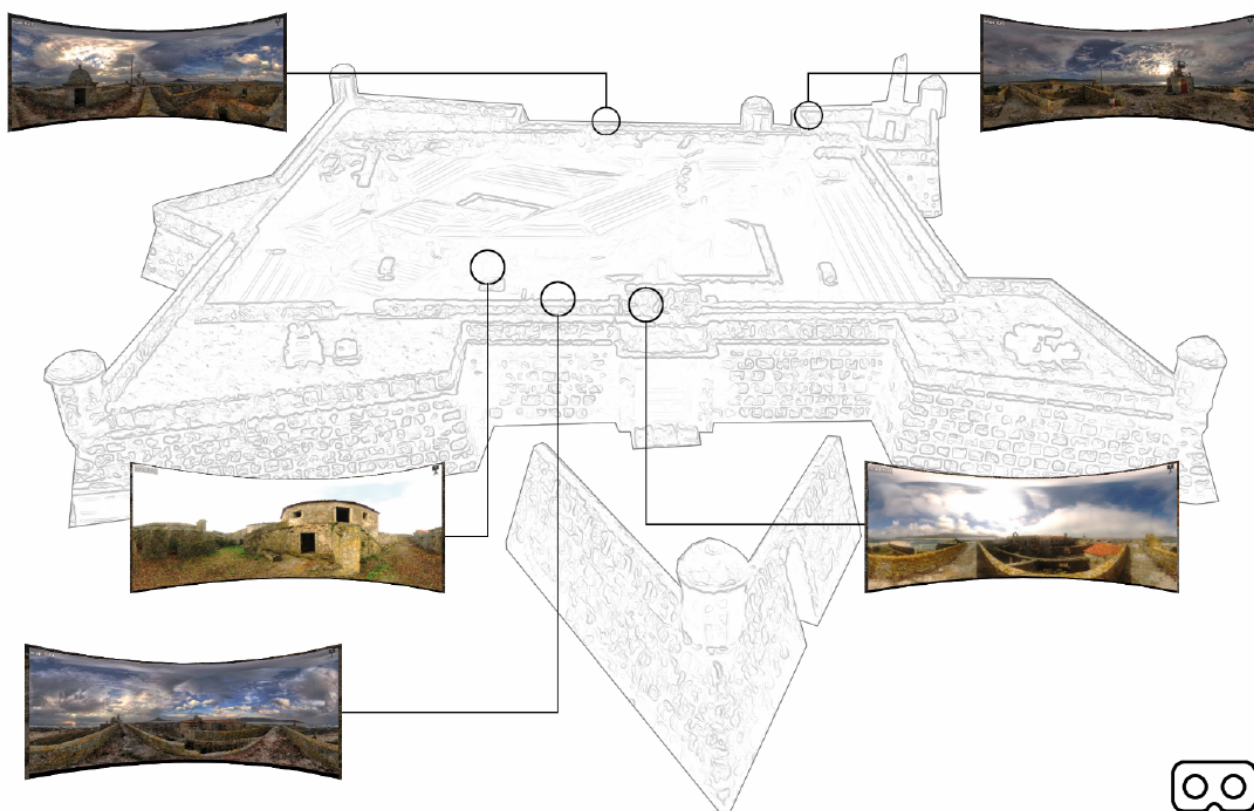

Fig. 9: Virtual Tour created using 360° spherical photographs of the Convent Nossa Senhora da Ínsua in Portugal.