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THE *PALAZZO DELL'ATENEO* IN THE UPPER CITY OF BERGAMO (*CITTÀ ALTA*): NEW DOCUMENTATION AND CONSERVATION STUDIES

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ABSTRACT:
The *Palazzo dell'Ateneo* is an impressive neoclassical building situated between the basilica of Santa Maria Maggiore and the cathedral of Sant'Alessandro, in the heart of the upper city of Bergamo. Erected to house the *Ateneo di Scienze Lettere ed Arti* – an important cultural institution founded by Napoleonic decree on 25 December 1810 – it stands on a large medieval cistern, the so-called *Fontanone*, partly underground. After many years of inactivity, the monument was restored at the end of the last century as a venue for temporary exhibits and public events. The University of Bergamo, on the occasion of the "Bergamo and Brescia: Italian Capital of Culture 2023", has launched a project to improve the knowledge of the edifice. A campaign of 3D surveys and diagnostic tests aimed at both restoring the real geometries to understand its evolutionary phases and historical stratifications, and at evaluating the state of health and the structural criticalities affecting the ancient construction. Based on this case study, this paper aims at debating the concept of survey and at underlining the fundamental role of the metric-material investigation within the knowledge process aimed at establishment of the conservation project. This is today an important issue because, due to the increasing simplification of instruments and software and the reduction of costs, the role of the surveyor is very often considered marginal. In fact, it is increasingly misunderstood that the machine operates autonomously and automatically and therefore does not need to be taught by trained and competent professionals. A contradictory situation as the quality of the documents and of the restitutions of the survey does not improve with technological progress but, on the contrary, becomes increasingly poor due to the improvisation and the lack of solid cultural and scientific background.

1. INTRODUCTION

The *Palazzo dell'Ateneo* is a building of historical and architectural interest, located in the heart of the Upper City of Bergamo (*Città Alta*), in the ancient Roman forum between Piazza Vecchia, the Basilica of Santa Maria Maggiore and the Cathedral of Sant'Alessandro. The site likely remained intact until the early Middle Ages because it was narrow and elongated, very rocky, very steep and with large height differences. In it was located a fountain (the so-called *Fontanone*) for the water supply of the neighbourhood, as confirmed by both the ancient documents and the recent discovery of a lead pipe still visible today under the sacristy of Santa Maria Maggiore. This is perhaps the reason that prompted the municipality in 1342, during the Visconti domain, to build a large cistern to guarantee a reserve of drinking water in the event of drought, war, or siege. The fountain was a large reservoir, partly underground, fed by the aqueduct coming from the Castagneta spring, north of the city. The water, before pouring into the cistern, flowed into a small settling tank on the western side towards the basilica; on the opposite side there was the intake area with the draft in the lower part and the bottom outlet (now buried and hidden). The cistern has not undergone major modifications over the centuries, apart from the restoration of plaster and the recent construction of a metal staircase to access it. Internally it is surmounted by a vaulted ceiling with ogival cruises, divided into five regular spans. Even externally, the emerging structure towards the cathedral and the *Mercato del Pesce* (the ancient fish market) has not undergone too many changes. The walls are still covered by the ancient two-tone rows of light and dark stone typical of Gothic architecture. At the centre of the northern wall there are the 'gripping mouths' hidden in the jaws of two marble lions (Angelini, 1955).
The construction of the *Fontanone* allowed for the creation of an overlying rectangular square on which a small building was later built. The famous bird's eye view of Bergamo by Alvise Cima from the end of the 17th century indicates the existence of a tiny structure above it. It was most probably a disused weapons depot. The walled south elevation is designed with three small doors; the north front, not visible in the representation, was most likely open and punctuated by columns. In 1743, the portico became the seat of the nascent lapidary museum, as the loggia of the *Palazzo della Ragione* was too small and not very suitable; the project was entrusted to the Veronese architect Alessandro Pompei. The works began in 1759 and ended in 1768 with the laying of a monumental access staircase. We are not aware of the original design, but it is possible to imagine an essential structure, perhaps an open loggia, where the ancient tombstones were placed internally. The division into modules proportional to the Veronese foot of the building – around 35 cm – has recently been confirmed. This has conditioned in metrical aspects all its subsequent functional

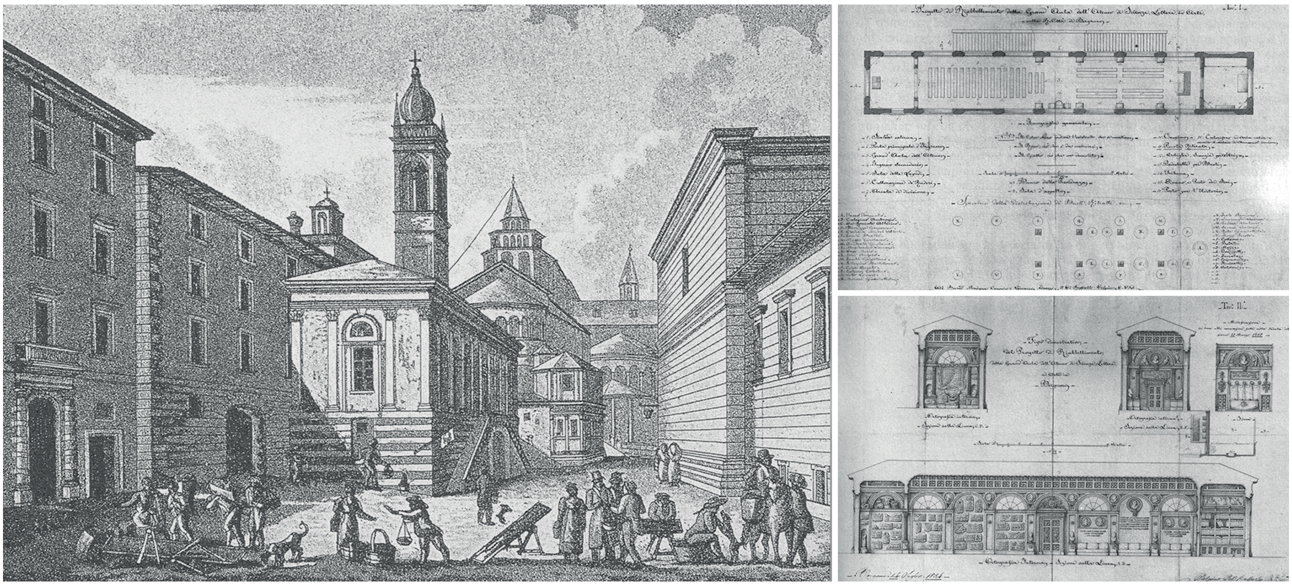

Figure 1. The *Palazzo dell'Ateneo* and the *Fontanone* in the 19th century (left) and the project by the architect Raffaele Dalpino, 1854 (right).

and stylistic modifications (the pilaster-arch sequence follows the ratio 1:3 and the width of each pilaster is equal to two feet).

On December 25, 1810, the *Ateneo di Scienze Lettere ed Arti* was established by Napoleonic decree. In 1818, the new institution was assigned the seat of the museum for the purpose of meetings of the three academic classes. The first project, aimed at adapting and making the place safe by Carlo Capitanio, architect in charge of the city's technical office, was not followed by construction works. Then the architects Luchini and Bianconi were charged with the adaptive reuse project (because they were members of the *Ateneo* which, in the meantime, financed the building).

The project – now lost – included the closing of the arcades with windows and the construction of two large rooms in the two opposite side bays. The first to create a large vestibule with a secondary entrance and the second for office and library use. The spatial distribution was maintained by the architect Raffaello Dalpino, to whom we owe a new design that was created and completed in 1859. Dalpino's project is a cultured and refined design, with a wise use of architectural orders and a rigorous respect of the modules adapted, in proportions, to the site and to the pre-existing buildings (Colmuto Zanella, 2001). An apparently simple and symmetrical space but, instead, strongly diversified in the two parts through a different characterization of the furnishings, functions, and arrangement of the tombstones (present only in the left part). A perfect combination of the museum function and the institutional role of the *Ateneo* headquarters. This configuration remained unchanged for about eighty years until 1935 when the building was given to the local fascist group Garibaldi; the collections were then removed, and the furnishings were replaced (figs. 1-2). After many years of inactivity, the monument was restored at the end of the last century to be converted into a space for temporary exhibitions and public events (Cassinelli, 2001).

The University of Bergamo, on the event 'Bergamo Brescia Italian Capital of Culture 2023' and in partnership with the City of Bergamo and the *Ateneo di Scienze Lettere ed Arti*, has launched a research on the building. A campaign of surveys and diagnostic

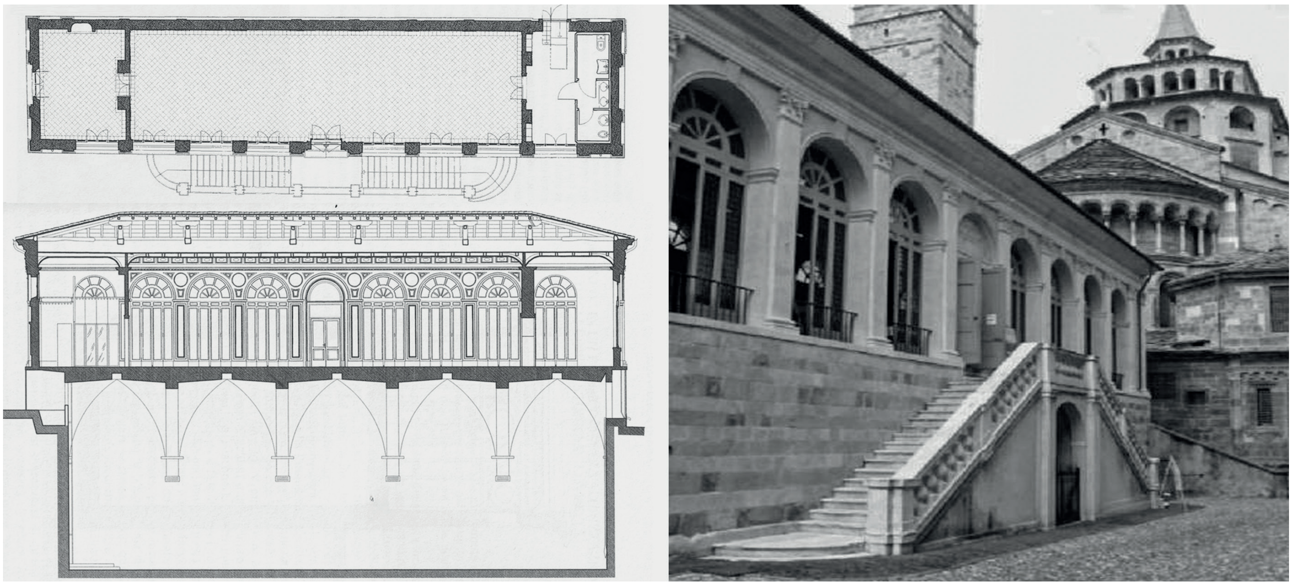

Figure 2. The restoration project by the architect Bruno Cassinelli, 1997 (left) and the *Palazzo dell'Ateneo* and the *Fontanone* today (right).

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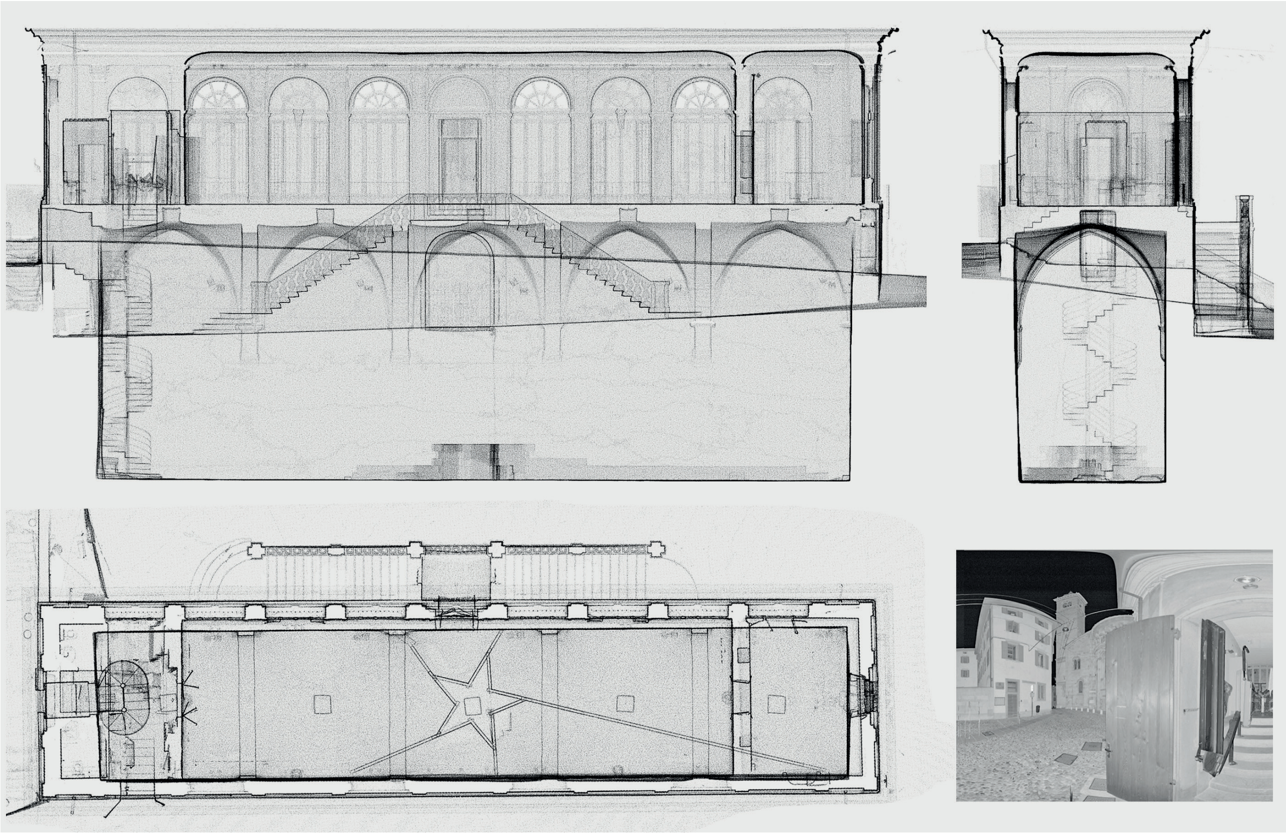

Figure 3. Overlap representation from 3D laser scanning survey (© Lab_S.A.B.E.).

tests aimed at both restoring the real geometries to understand its historical stratifications and at assessing its conditions (figs. 3-12). The research group, also made up of experts from other universities, has carried out integrated survey campaigns with different methodologies (direct, topographic survey and instrumental acquisitions with both active and passive sensors). Extensive use was also made of UAVs with on-board RTK positioning to survey the roof and other high parts. Subsequent processing has made it possible to build more models of the monument to produce orthographic images necessary for the graphic analysis and the mapping of decay and instability phenomena. The lighting conditions of the rooms (especially of the cistern) offered the opportunity to start an experiment of reconstruction of the clouds from different HDR processing to highlight the different surface treatments and understand the succession of interventions. The out-of-plane analyses of the surfaces allowed reading the deformations and differential deviations of both the walls and the vaults; they highlighted a possible failure (or plastic deformation) of one of the trusses of the structure for the coffered roof of the hall. Elements that need to be monitored soon to preserve the integrity of the structure and guarantee the safety of the users of the space.

2. THE INTEGRATED MODEL

Architectural survey is a process aimed at exploring the characteristics of built heritage and appreciate their relations. This is an essential activity based on observation, investigation and interpretation aimed at its knowledge. In Italian langage, the words *rilevamento* and *rilievo* are often considered synonymous, even though they have two distinct meanings (Docci & Maestri, 1993). The first is, in fact, the set of actions necessary for the measurement and representation of reality while the second is the drawing (understood as a graphic transposition) of the acquired data and information. The roots of the two words derive from the Latin *revelare* which refers to the notion of revealing, removing the veil, making known something secret and unfamiliar. Surveying is a learned voice valued in the medieval period for its high semantic stature in the context of the Christian religion, transcribed with a capital R because it is an indication of faith. Its use in the technical-scientific field is later and linked to the birth of modern topographical sciences in the Age of Enlightenment (Monti & Selvini, 2015). Today, the content of the noun has been expanded to the measurement, processing and analysis of the metric, physical and chemical parameters of the environment by means of the computer science and the use of electronic sensors: the contemporary “Digital Survey” (Bertocci & Parrinello, 2015).
The scientific community, despite being fully aware of the mistake, has in any case accepted the inappropriate use of the word. It has reconsidered it in current practice, also extended to design and methodological contents. Architectural survey is therefore a series of operations intended to understand the dimensional, morphological and material characteristics of a building and to evaluate its conditions. It is functional for many purposes: from the simple act of cataloguing to the conservation and valorisation project, and, nevertheless, for the reconstruction of a lost past of which only slight traces remain. In the physical space, in fact, everything is recorded in the form of superimposition of signs; they can be evident, buried, worn out or so tenuous as to be almost invisible or, again, they can be hidden or altered and even

Figure 4. The *Fontanone*: photographic acquisition and HDR image processing (© Lab_S.A.B.E.).

falsified. However, they are still present and only if we discover, read and decipher them, we are capable of penetrating the essence of physical space. The graphic representation (traditional or digital, static or dynamic) returns,ultimately, the geometry, the colours, the structure and the conditions of adulteration of a place. It helps in identifying and highlighting its stratifications, anomalies and dissonances. In the elaboration process, from the data acquisition to interpretation, it is always possible to find important elements on which to reflect to improve awareness.
The task of the survey is to operate a critical synthesis to transform the complexity of reality into ordered relationships of signs and symbols. The observation – today, as mentioned, increasingly digital – transposes information into virtual figures made up of points, surfaces and three-dimensional objects. It is not

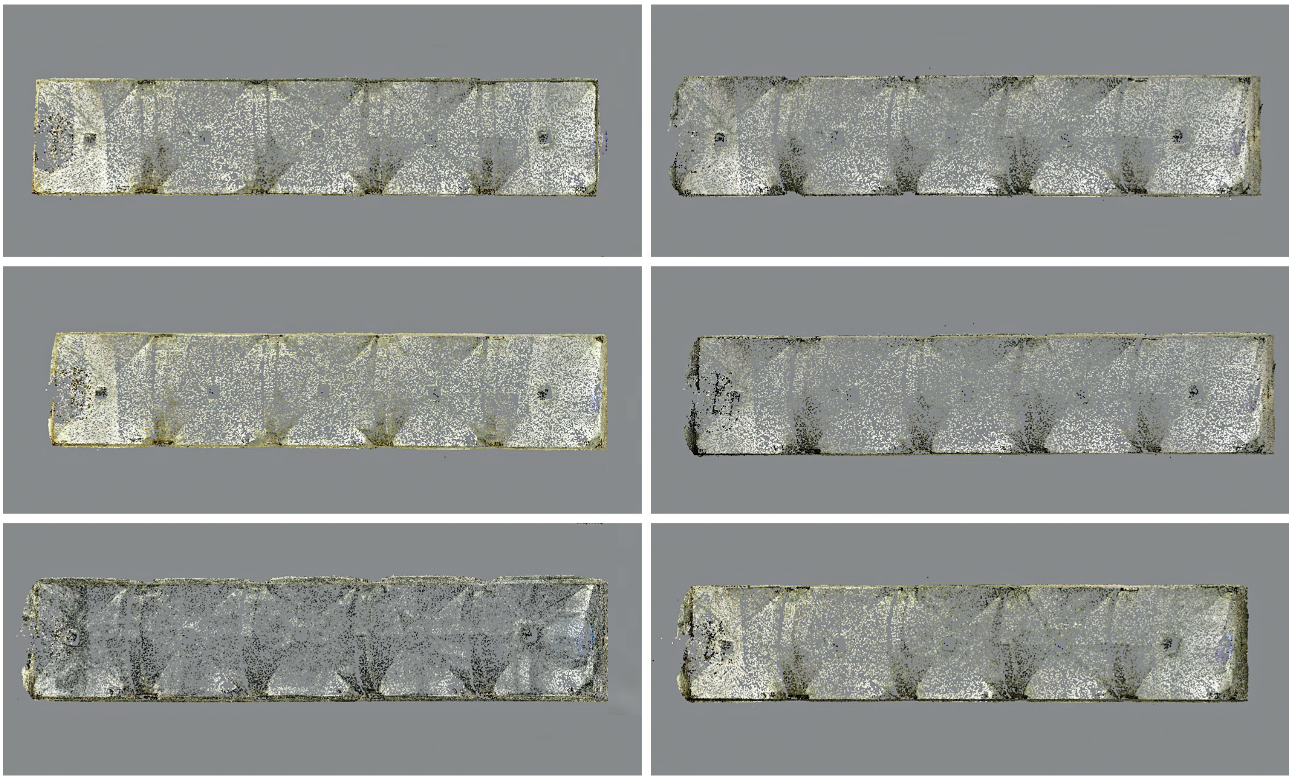

Figure 5. Models of the *Fontanone* from different sets of HDR images (© Lab_S.A.B.E.).

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only a tool for documenting the natural and built environment, but an expression of the critical thought of the ‘draughtsman’ as well as a testimony to his personal reflection on the world around him. In this regard, capture and representation are investigative and synthetic means of understanding the complexity of a territory (Bertocci & Bini, 2016). The distinction between the terms acquisition, restitution and interpretation therefore becomes fundamental also due to the implementation of the survey process in three distinct phases: the first to be carried out in a state of neutrality and values, the second to be understood as the elaboration and graphitisation of information and the third seen as the result of a judgment that implies the commitment of ideas and this in turn implies reference to values.

The digital revolution has significantly transformed the conception and operating methods of the act of surveying; the direct survey (the so-called architects’ survey) has been integrated with the instrumental one (the so-called engineers’ survey) thanks to the increasingly simplified use of electronic instruments equipped with both active and passive sensors. The Digital Survey is objective and is able to reveal details hidden to the human eye and mind. Unlike the direct one in which the interpretation begins during the acquisition phase (and it is therefore able to influence the objectivity of the subsequent phases), it delivers a final datum free of logical-deductive errors.The knowledge gained during the acquisition stage is supplemented during further processing by the creation of models. The meaning attributed to the noun ‘model’ is very different from the consolidated idea of a simple one-to-one scale reproduction of an architecture already built or still in the conception phase. A model cannot be regarded, as was the case in the last century, as a purely formal transcription of an object. Today, it should be considered as a container filled with all its geometrical, material and structural peculiarities (Mandelli, 2010). Three declinations are possible: physical, metaphysical and digital. The physical model – the so-called *maquette* – is the concrete one that can be touched, the metaphysical model is the conceptual one and the pure expression of an idea. The digital model – the result of digitization and the information revolution

Figure 6. Photogrammetric model of the *Fontanone* with accuracy value overlay (© Lab_S.A.B.E.).

– is the fusion of both, the thought that materializes in a virtual image representative of an existing work or project (Velo, 2010). The difficulty of collecting data coming from different fields and often incompatible with each other in a single corpus has now been solved by the new geomatics and computer vision.

The technological advances have therefore opened new opportunities; the advantage of virtually modeling our environment and visualizing it with the illusion of the third dimension has a significant impact on the management and enhancement protocols related to cultural heritage (Cardaci, Versaci 2018). Today, the surveyor that deals with the study of an environment has a vast range of devices and technologies available, both from the ground and from the air, each with specific characteristics. To transpose the complexity of a territory into numerical bits, an in-depth evaluation of the acquisition strategies is required; a planning that allows to make the right methodological and instrumental choices, in relation to the exploration object, the intervention time and the purpose of the data collection and archiving process. The awareness of the ecosystem is an indispensable condition for describing the dynamics of transformation of the elements that

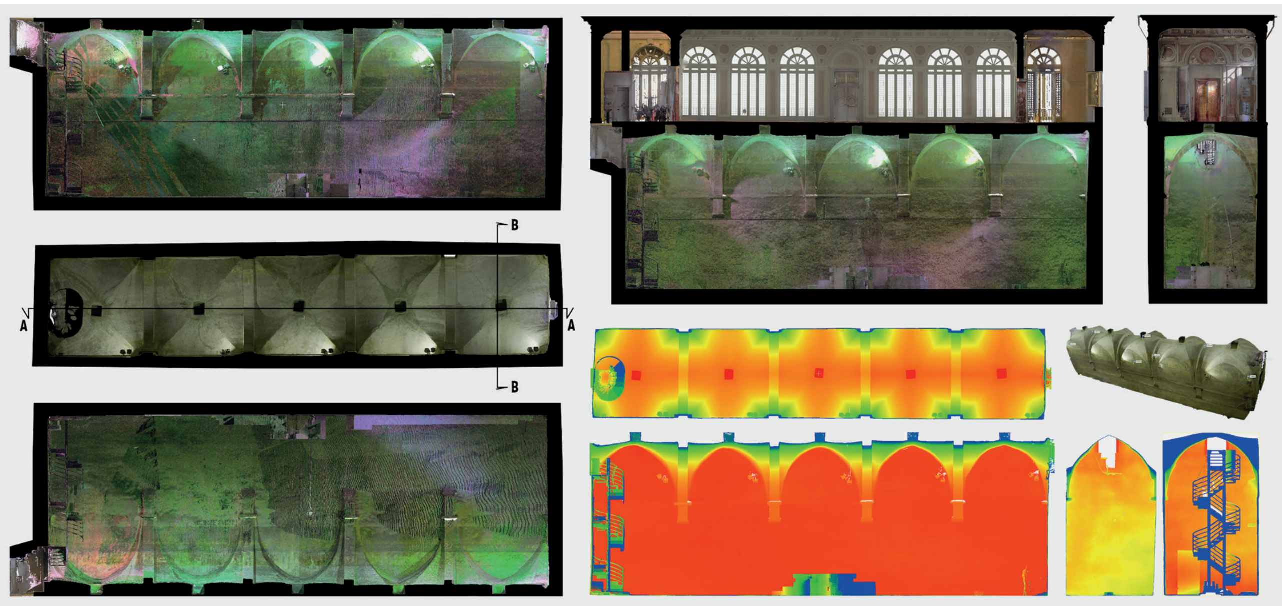

Figure 7. The *Fontanone*: orthographic projections from the integrated model (image and range based) and deformation analysis (© Lab_S.A.B.E.).

constitute it. This is possible by building a 3D database structured in multiple levels of information deriving from multi-source surveys. Landscape drawing and measurement are now possible thanks to Global Navigation Satellite Systems (GNSS), topographical instruments (total stations and auto levels), reality-based instruments with active (Terrestrial Laser Scanner) and passive (3D digital photogrammetry) sensors. The terrestrial survey (TLS and close-range photogrammetry) imposes an average long time for the data collection phase because it makes use of a static protocol (from fixed stations on the ground during photographic captures or laser scans). The new Remotely Piloted Aircraft Systems (RPAS) instead acquire information dynamically. Used at low altitudes (on average between 25 and 250 meters but, more and more often, even a few meters above the ground as substitutes for the traditional cameras), they ensure both a discrete metric accuracy (generally < ±1 cm) and a high resolution (the reduced flight height which allows particularly sharp and detailed nadiral images not obtainable with other systems).

RPAS have revolutionized the field of aerial observation, both because they are much more advantageous – in terms of economics, versatility and measurement accuracy – compared to traditional flights with helicopters and/or aircraft or satellite images, and because they have reduced significantly the costs and operating times of on-site activities. In addition, they offer the opportunity to make use of Light Detection and Ranging (LiDAR), Multispectral and Thermographic technology – increasingly used for mapping large areas – alongside the normal RBG cameras, specific sensors that are becoming increasingly smaller and lighter. The recent development of the real-time kinematic positioning (RTK) – much more consistent and accurate than normal GNSS – has introduced further advantages because it is able to place the sensors spatially and in real time in the Cartesian reference system. This, in addition to simplifying the computational costs of the Image-Based 3D Reconstruction process, allows model scaling without having to build a topographic support network. The issue of verifying and validating the geometric quality of the point cloud obtained fdrom drone is still a subject of discussion today. Many researchers do not consider it a substitute for terrestrial systems even if recent experiments demonstrate a continuous improvement in terms of accuracy, reliability and quality of the returns. RPAS data processing progresses rapidly towards obtaining complete and metrically reliable point clouds, from which to structure multi-scalar analyses; all this thanks to both the improvement of aircraft and sensors, and new algorithms for managing increasingly automatic and 'intelligent' flight plans.

In any case, the acquisition must always be integrated to obtain a database capable of returning precise information at different scales. RPAS and satellite survey systems (together with the traditional topographic validation) in fact allow geo-referencing in a single coordinate reference system the terrestrial information obtained by the close-range photogrammetry and those gotten form TLS acquisitions (widely used for geomorphological applications of areas of small extension). The information is returned in models with different densities (with markers for recording and verifying imprecisions). They are an optimal raw material for the documentation of complex heritage that responds to the need to obtain a final product on which to develop in-depth diagnostic analyses, divisible and reproducible in different duplicates.

Figure 8. 3D image-based reconstruction of the *Sala delle Adunanza* (© Lab_S.A.B.E.).

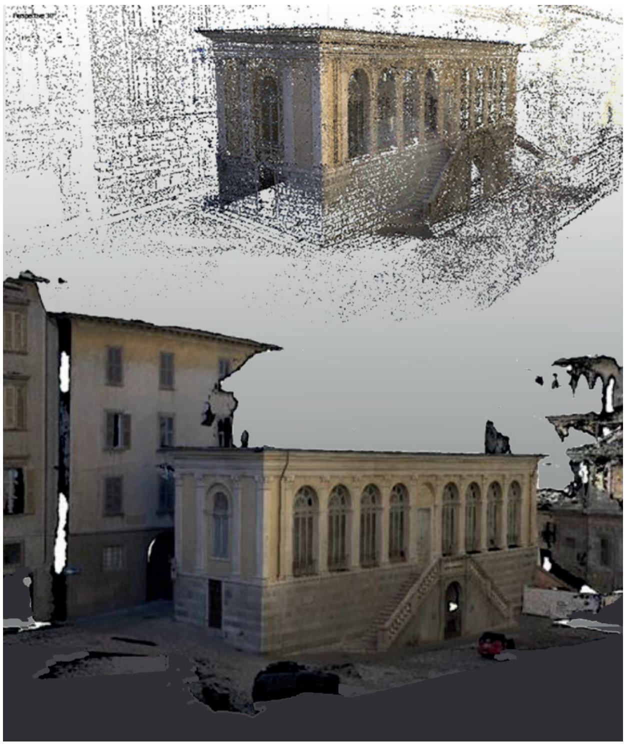

Figure 9. Image-based 3D reconstruction of the *Palazzo dell'Ateneo* (© Lab_S.A.B.E.).

Figure 10. The *Palazzo dell'Ateneo* and the *Fontanone*: orthographic projection of the facade (© Lab_S.A.B.E.).

A single register with too much information risks being overabundant for the graphic rendering on a territorial scale, as well as difficult to manage. It is therefore necessary to discretize, segment and decompose it (possibly duplicate and decimate it) to create partial products aimed at specific purposes. The multi-scalar documentation must therefore use an operating protocol capable of making a gradual choice of the Level of Detail (LoD) based on the graphic scale. The digitization of information on the built environment is an evolving theme that concerns not only thinking about new archiving solutions, but also the sharing of knowledge, both past and future, as related to the entire life cycle of the built. There is a growing need to use the Building Information Modeling (BIM) at the architectural scale and the Geographic Information System (GIS) at the urban scale.
The combined use of these tools will allow the creation of digital archives for the creation of applications aimed at the visualization, interrogation and analysis of the built environment. An information system able to collect and harmonize even very heterogeneous data in a single navigable platform, designed to support surveys at different scales and to include all classes of users.

3. CONCLUSIONS

Today, the survey is being enriched with new contents capable of restoring both the natural environment and the built heritage, the durability, the thermo-hygrometric characteristics, the degradation of materials, the structural and energy criticalities. All this is rendered in various forms, from traditional 2D drawings, to foreshortened views (conical and parallel) in 3D, from 4D video rendering up to the new 'interactive and immersive' frontiers of 5D.

Figure 11. The *Palazzo dell'Ateneo* and the *Fontanone*: parametric model after Scan to BIM processing (© Lab_S.A.B.E.).

Figure 12. The *Palazzo dell'Ateneo* and the *Fontanone*: photorealistic rendering of the parametric model (© Lab_S.A.B.E.).

The practise of survey is changing: it proposes restitutions not only of spatial geometries but also of information characterizing the materials. The traditional RGB models are now joined by thermographic and multispectral models capable of analyzing the morphology of the building integrated with information on temperature, humidity, the spectral signature and, in general, the physico-chemical characterization of the surfaces. Models created based on direct observation (because the stones speak and only the architect or the engineer can listen to the slight whisper of the built, certainly not a machine) integrated with data obtained by reality-based instruments with active (3D Laser Scanning) and passive sensors (digital photogrammetry), both terrestrial and aerial with UAVs.

Data restitution has progressively evolved from the traditional redesign of simple thematic maps towards 3D restitution and image analysis to quickly monitor changes in the built and green spaces, to also obtain quantitative data on vegetation and tree species, to investigate spontaneous mutations and biodiversity. The survey of the built heritage today is confronted, on the one hand, with the profound change brought about by innovation and the use of integrated digital documentation systems, on the other with the need for a multidisciplinary dialogue capable of promoting insights into specialized sectors. The combined use of traditional survey techniques and new technologies, in this case the RPAS, has opened new scenarios. Today the capture of images from the zenith and/or from a bird's eye view is allowed, while it was not possible with classical photogrammetry with airplanes and helicopters and/or with satellite remote sensing. These are aerial frames of great clarity and high resolution acquired by multiple sensors in the visible light spectrum (RGB) but also within the multispectral and thermal infrared bands. Surveying large areas would be an unthinkable operation if performed exclusively with ground instruments but it is rather easy with aerial surveys with drones. Data taken 'from the sky' that have to be integrated with those taken 'from the ground' and geo-referenced in a single reference system necessary for the integration of the built environment operated with 3D laser scanning and close-range photogrammetric terrestrial techniques. The case study of the historic headquarters of the *Ateneo* is thus an example of a new method of investigation to understand the built.

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