PROGRAMMED CONSERVATION OF HISTORICAL AND ARCHITECTURAL HERITAGE. TOOLS FOR OPTIMISING A PROCESS BASED ON KNOWLEDGE AND INFORMATION

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ABSTRACT

In the field of conservation, maintenance technologies represent an instrument for guaranteeing a lasting future for historical-architectural heritage. This approach can be considered above all a tool for learning about and comprehending systems in relation to changing interactions with context. Interest in these technologies focuses on moving the field of conservation toward a process-based and systemic approach that shifts attention from the moment of restoration to the sequence of preventative measures, and from the single monument to all examples of heritage in a given territory.

The paper emphasises the importance of the phase of study and its instruments: the process of conservation must be supported by a system of learning and a constant flow of information that helps optimise choices. Identifying the forms, methods and times of intervention implies a constant process of analysis, monitoring, diagnosis and cataloguing of data. Programmed and periodic controls make it possible to evaluate the validity of measures adopted.

The study identifies BIM (Building Information Modelling) and HBIM (Heritage Building Information Modelling) as important instruments for providing measured, qualitative, reliable and complete descriptions. These tools can be considered fundamental to any conservation study thanks to their ability to condense the complexity of reality into a single model.

The creation of tools capable of establishing relations between the level of understanding of a building and that of its context are an important guide to research focused on constructing an effectively systemic process of conservation that includes the analysis of all possible risks.
Keywords: Historical-architectural heritage, preventive maintenance, maintenance technologies, HBIM.

1 INTRODUCTION

The '*programmed conservation*' of historical architectural heritage represents a fundamental, and now largely unavoidable, cultural and strategic choice. Still 'out of the ordinary', the time has come to consider it an effective tool for the informed conservation of heritage and part of the regular maintenance of buildings and their contexts. There is a growing awareness that the objectives of reducing/eliminating conditions of risk and controlling processes of deterioration – slowing the progression of natural decline and eliminating the factors that generate these pathologies – can be effectively pursued only by ensuring that care is provided consistently over time and supported by maintenance technologies.

Combining maintenance technologies with historical heritage conservation defines a new approach known as 'programmed conservation'. This highly innovative technology requires the definition – through research and experimentation – and implementation of methods and instruments derived from hybrids of know-how borrowed from maintenance and conservation. More precisely, these methods and instruments must be matched to the objectives of conservation.

Maintenance is regarded as an integral part of any conservation project and represents the fundamental methodological approach to decision-making. In the field of conservation, this

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innovation substantially takes the form of the desire to determine how the maintenance logics are acquired; logics that serve to plan and prepare projects for the correct conservation and safeguarding of heritage.

In the field of conservation, maintenance does not enjoy the same priority it has in the field of new construction, where it serves to guarantee the duration of the lifecycle of building performance. Historically relevant buildings have undoubtedly surpassed this threshold of 'life expectancy'. Similarly, their 'residual performance' is surely below normally acceptable levels. The aims of maintenance in the field of new construction are founded on rules extraneous to cultural heritage. This latter is dominated by the strategic principle of indefinite conservation, achieved by maximising the duration of materials and limiting transformations, demolitions and refurbishments to situations of demonstrated necessity.

The fundamental assumption of a conservational approach to maintenance is that a building that is the object of programmed conservation must be considered an unrepeatable *unicum* in all of its parts; it does not postulate refurbishment, but instead studies and integrally conserves this monument-document, which must be protected against any possible alteration because '*a historical conscience knows that any calculation and any human integration is susceptible to subjective error*.'[1].

This does not mean they are without importance, function or use – the best guarantee for the conservation of a monument – but, more simply put, that these aspects are subordinate to those of conservation. This requires that we define compatible uses for each building. It means accepting reduced levels of performance with respect to contemporary expectations, in the name of the conservation of something impossible to reproduce today.

Furthermore, the penetration of the culture of maintenance within the field of conservation comports an understanding of the importance of *maintainability*. Recognisable and reversible interventions make it possible, over time, to implement programmes of control, monitoring and maintenance. Indeed, *accessibility* is a fundamental component of maintenance and must be extend to all of parts of a building. Furthermore, accessibility facilitates the identification of signs of deterioration and allows for timely action. This is particularly true of roof assemblies, which represent the principal source of structural deterioration.

By explicitly codifying the relationship between the conservation and maintenance of architectural heritage, a conservational approach has begun to adopt the fundamental concepts and terms of technological culture, including, in particular, the control of 'process' and a systemic approach.

2 TOWARD PROGRAMMED CONSERVATION

From the earliest considerations of John Ruskin to texts by the authors who fostered a European culture of restoration, historical heritage preservation through maintenance has been considered the best match to the most precautionary approach to conservation – minimum intervention and maximum consideration of authenticity – characterised by a condivisible methodology. Conservation through maintenance is a vigilant and constant practice of care. It does not imply insertions and changes to building and structural components, but instead pursues the extension of useful life and the maintenance of residual performance and utility.

Since the mid-1900s, professional debate and theoretical reflections have repeatedly affirmed the necessity of including maintenance in the conservation of monuments, though without producing any concrete results; indeed, preventive maintenance is so often resolutely hoped for as part of the conservation of historical heritage, yet so rarely implemented in reality. While this position can be found in the work of various authors, the most well-known is

certainly that of John Ruskin. In The Seven Lamps of Architecture from 1849, he stated '*The principle of modern times (...) is to neglect buildings first, and restore them afterwards. Take proper care of your monuments, and you will not need to restore them. A few sheets of lead put in time upon the roof, a few dead leaves and sticks swept in time out of a watercourse, will save both roof and walls from ruin.*' He continues: '*Watch an old building with an anxious care; guard it as best you may, and at any cost from every influence of dilapidation. Count its stones as you would jewels of a crown; set watches about it as if at the gates of a besieged city; bind it together with iron where it loosens; stay it with timber where it declines; do not care about the unsightliness of the aid; better a crutch than a lost limb; and do this tenderly, and reverently, and continually, and many a generation will still be born and pass away beneath its shadow*' [2]. In 1893, Camillo Boito made very similar statements when he noted: '*as praiseworthy as the restoration of a building may be, restoration must always be considered a sad necessity. Intelligent maintenance should always prevent it.*' [3]. This position was regularly confirmed in the many charters on restoration that followed.

In 1931, the Athens Charter expressed a preference for operations of maintenance over activities of highly invasive restoration. Point I states: '*The Conference heard the statement of the general principles and doctrines relating to the protection of monuments. Whatever may be the variety of concrete cases, each of which are open to a different solution, the Conference noted that there predominates in the different countries represented a general tendency to abandon restorations in toto and to avoid the attendant dangers by initiating a system of regular and permanent maintenance calculated to ensure the preservation of the buildings*.' This document also indicated the critical elements of environmental issues that imposed suitable approaches requiring physical and chemical studies to implement suitable maintenance.

Italy's Istruzioni per il restauro dei monumenti (Instructions for the Restoration of Monuments), issued by the Ministry of Public Education in 1938, contains the following note under point 2: '*It is a fundamental necessity to prevent in the timeliest fashion, through attentive maintenance, anything that may cause the deterioration of monuments and works of art (…)*'.

Article 4 of the Venice Charter from 1964 states in no uncertain terms: '*It is essential to the conservation of monuments that they be maintained on a permanent basis.*' These recommendations were repeated in 1972 in the Carta Italiana del Restauro (Italian Restoration Charter), Addendum b. Istruzioni per la condotta dei restauri architettonici (Instructions for the Execution of Architectural Restorations). '*It is to be assumed that work of timely maintenance assures long life to monuments, avoiding the acceleration of damages. It is recommended that greater attention is paid to continuous surveillance of buildings so conservational measures can be applied before restoration work of a larger magnitude becomes necessary*' [4].

During the 1960s, Cesare Brandi, founder of the ICR, theorized the concept of 'Preventive Restoration'. This term referred to a sum of actions that made it possible to avoid or delay a true and proper restoration, a so-called work of rehabilitation. '(…) *preventive restoration is to be understood as all that aims to prevent the necessity for restoration, making preventive restoration no less important than effective restoration. We must direct all authorities responsible for the conservation of works of art toward preventive restoration. (…) It is clear, at this point, that to no lesser a degree than in effective restoration, preventive restoration must gather all results, discoveries and scientific inventions referred to fields interested in the subsistence of art: from research into lighting and its effects on the choice of light sources, as well as heat, humidity, vibrations, air conditioning systems, packaging, hanging and disinfestation. This list may never be exhaustive, but will require continuous updates*' [5].

The culture of maintenance began to spread following the affirmation of Brandian theories of prevention, and the adversity toward the invasive nature of traditional restorations. One of Cesare Brandi's pupils, Giovanni Urbani, later director of the Istituto Centrale di Restauro, also considered it indispensable to adopt strategies of conservation focused on safeguarding the material authenticity of the original work: setting out from Brandi's idea of preventive restoration, he defined an approach he referred to as 'Programmed Conservation': the systematic control of the conditions of the object of conservation and the environment in which it is conserved, '*to slow as much as possible the speed of processes of deterioration, intervening in time and, if necessary, with maintenance works appropriate to various types of materials*' [6].

In this sequence of Restoration Charters, the successive Carta della Conservazione e del Restauro degli Oggetti d'Arte e di Cultura (Charter for the Conservation and Restoration of Cultural and Art Objects) from 1987, as well as The Charter of Krakow 2000, reiterated the exceptional nature of restoration and the preference for conservation, to be implemented through environmental controls, inspections and monitoring.

3 PROGRAMMED CONSERVATION AS PROCESS

Maintenance intended not as action, but as scientific discipline, arose in the arena of war, and progressively extended into other fields: aeronautics, industrial production and, later, construction. It developed its own specific connotations in each field. The time has now come to affirm its importance also in the field of Cultural Heritage.

In the field of conservation, the primary aim of programmed maintenance – maintaining the efficiency of a system – is substituted by the preservation of the essential material and morphological qualities an object, its physical presence and significance as a monument-document inherited from the past and to be transmitted into the future.

In the Piano pilota per la conservazione programmata dei beni culturali in Umbria (Pilot Project for the Programmed Conservation of Cultural Heritage in Umbria), Giovanni Urbani provides a definition of programmed conservation: '*A similar technique, referred to here as programmed conservation, is necessarily aimed primarily at individual objects, toward the environment that contains them and which is the source of all of the possible causes of their deterioration. Its objective is thus to control these causes in order to slow as much as possible the speed of processes of deterioration, intervening in time and, if necessary, with maintenance works appropriate to various types of materials*' [7].

While the scientific community has recently begun to support the introduction of maintenance within the approach to preservation and conservation proposed by Giovanni Urbani, it has yet to be regularly applied *in situ* by the various actors involved in the conservation of historical-architectural heritage. On the contrary, they often disregard the methods of programmed conservation; there is a sense that the importance of the scientific organisation of the process of maintenance has yet to be acquired. It must not be intended, as often occurs, in reductive terms, as the simple implementation of technical-operative actions, but instead as the capacity to organise a complex process aimed at understanding and studying each single building and managing the sum of the heritage we have inherited over time. The idea is that this technology can open up the field of conservation toward an approach that shifts interest not only from the single restoration to the temporal sequence of preventive actions, but also from the individual architectural object to all objects. In other words, from the single monument to the entire patrimony of a territory. Or better yet, from simply correcting the deterioration of individual buildings to the complexity of their relations with factors linked to their context, whether anthropic or natural, at the small or large scale.

Programmed maintenance for conservation represents both a programmatic and operative approach that links each intervention to a system of actions coherent with the formulation of a broad technical and management programme. A programme that evaluates the conditions of an individual building and precedence and priorities of intervention in relation to the larger group of buildings and available financial resources. This approach aims to decisively overcome the culture of restoration as episodic events, focused exclusively on repairing known and consistent damages, in favour of a new systemic and process-based vision. A vision of continuous activities of conservation over time and with the pretence of creating conditions that guarantee the duration of a building's life by constantly monitoring its physical and functional evolution.

Preventive conservation is not simply a set of actions to impede damages and deterioration, but the vigilant monitoring of mechanisms linked to use and abandonment and the evaluation of suitable functions according to a logic of endless revalorisation.

The planned conservation of monuments is a process that must be aimed not only at monitoring and controlling the environmental mechanisms that cause physical degradation, but also at the adequacy of functional choices that can be implemented over time: the abandonment of the building, in fact, must be feared and avoided as much as incorrect use. Living and using the historic building properly is, in fact, the main guarantee of its survival.

Maintenance for conservation is implemented in the present but refers to a future. It is based on information that can change as time progresses; proposed as an organised process, its complexity is directly proportionate to the number of elements involved.

The indispensable passage from episodic to programmed conservation requires the implementation of a process strongly connoted by retroaction. The importance of the feedback from different phases depends on the fact that experimental verifications, and consequent reflections, permit a continuous refinement of analyses, decisions and interventions. In other words, the reiteration over time, with greater efficiency and efficacy, of a circular process of analysis, diagnosis, planning, programming, implementation, control and verification of results and feedback. The acquisition of knowledge plays an important cybernetic value during this process: data acquisition of data – pertinent, complete, correct and which does not exceed the objectives for which it has been gathered – serves to guide the decision-making process toward optimum choices: this comports a notable commitment to the immaterial dimension of study and observation focused on understanding, controlling and monitoring. Repair and restoration are avoided by diligent action focused on interrupting processes of deterioration and preventing possible damage.

Knowledge nurtures the process of conservation. It is indispensable to the permanent definition and implementation of a system of choices and decisions based on 'maintenance policies' related to specific objectives. Deciding whether to act before or after a problem arises with a component means deciding whether to adopt 'incidental maintenance' – intervention only after a problem has arisen – or 'preventive maintenance' – components are repaired/substituted before there is a problem.

For the most part, an attention toward the conservation of materials favours the implementation of policies for 'dealing with', rather than 'preventing' a problem. This is does not apply, however, when one problem produces a 'proliferation of problems', when a problem with one element leads to additional damages. A key role in a preventive approach is played by cleaning and small maintenance works repeated regularly over time to defend a building.

'Condition-based maintenance' CBM is the closest programming policy to conservation. Given the lack of statistics on the evolution of phenomena of deterioration, and having to

infer information from the building itself, CBM appears to be the most suitable conservation policy. That said, it requires an attentive understanding of the building that makes it possible to evaluate the programming of only strictly necessary interventions objectively and based on the results of specific studies.

4 PROGRAMMED CONSERVATION AS A SYSTEM

The adoption of a logic of maintenance in the field of conservation essentially means appropriating the process-oriented nature of this field and extending it to a duration coincident with that of the monument to be preserved.

This promotes a change in perspective that limits recourse to episodic and disconnected actions over time, or 'calamities', in favour of the introduction of an approach to conservation as prevention and diligent care. The gap between event and process in conservation marks a fundamental passage that is not only cultural, but also technological and organisational. It introduces a profound innovation to the means traditionally employed to study and understand a building and the relative interventions proposed.

Indeed, programmed conservation substantially describes a perpetual relationship with the heritage object to be cared for. The intention is to implement an on-going process of study and intervention with the final aim of identifying and implementing actions to slow processes of deterioration and prevent possible damage.

Another element of conservation, borrowed from the field of maintenance, is the prevalence of the management of knowledge and flows of information, with respect to the actual realisation of works. Programmed conservation minimises physical actions involving the material elements of the building. It assumes the prevalent connotation of a logic of constant organisation and the provision of services, using technologies matched to different phases of the management process. They must be coherent with the problems encountered and able to provide effective and lasting benefits in terms of knowledge and conservation. This means implementing a process that remains in a state of permanent evolution and specialisation. It also includes continuous innovations to the techniques and instruments used to document the physical state of the building, diagnostic technologies and those used to govern interventions.

To operate in this manner, it is no longer sufficient to simply develop projects. This new approach requires organised processes and shared management. Processes serve to establish procedures, operating instructions, forms and information systems for data management. This approach requires shared tools for the univocal governance of procedures of analysis, monitoring, diagnostics and the realisation and control of works. A similar approach should refer to a group of buildings. This is the only way to ensure the effective actions of a community of technicians, institutional operators, professionals and contractors operating in different territorial contexts who must share a common language, content and method.

What emerges is the necessity to work not only, as noted, in methodological and instrumental terms to optimise processes, but instead, and also, to define the characteristics and means of implementing the 'system' used to organise and manage them.

It is worth recalling what Reginald Lee had to say about building maintenance: '*programming maintenance means organising a complex system of interaction between technical, economical and procedural factors. To manage the functioning of this system, organise activities and, above all, assess costs, it is necessary to operate in different disciplinary areas. In practical terms, there is a need for knowledge and instruments that belong to the field of programming, criteria of financial resource planning, information management systems, organisational models used by maintenance contractors*.' [8].

His words reveal the twofold nature of programmed conservation: it is both a process and a system. Programmed conservation is implemented as a process that accompanies the life of a heritage building and postulates the activation of a system that guarantees its organisation/servicing. Organising and implementing this process requires a true 'System of Programmed Conservation', in other words, a socio-technological macro-system consisting of two permanently related systems: one, comprised of the sum of heritage buildings in a specific context, and the other consisting of the sum of organised human and material resources. The fundamental requisite is the capacity to respond quickly and effectively to the organisation and implementation of a process that involves heritage buildings that exist in a constantly evolving context that represents an endless source of new risks.

The implementation of this process must maximise the inclusion of local actors from areas where the objects to be conserved are located. They should be asked to share the content and methods of this new approach that governs the process of conservation. Their presence may also generate opportunities for the cooperative and synergetic management of programmed conservation. To achieve this, it is fundamental to permanently stimulate comparison and dialogue among institutional stakeholders and authorities responsible for heritage conservation around the methods and instruments adopted, or to be adopted.

To be sustainable and produce positive results in a specific environment, a conservation project must be tied to a specific local economy and productive situation. It must consider the abilities of local businesses and the presence of skilled craftsmen and contractors.

The intention is to trigger a virtuous cycle that connects territorial resources, entrepreneurial skills, craftsmen and the quality of what is realised.

While the management system's primary objective is to guarantee the survival and identity of heritage over time by identifying methods and priorities of intervention, while simultaneously optimising the use of human and financial resources, its secondary objectives can be said to include:

- improving the understanding of heritage;
- favouring the duration of original materials and components;
- improving systems of diagnosis and monitoring;
- defining and obtaining information about the vulnerabilities of heritage buildings;
- providing tools that support decisions about priorities and times of intervention;
- implementing interventions suitable to the characteristics of the building to be conserved;
- monitoring the results of interventions;
- improving the effectiveness of interventions;
- improving the archiving and cataloguing of data about physical-historical characteristics, diagnostic studies and monitoring and methods of intervention.

The creation of a similar system, evidently based on continuous improvement, requires the constitution of a new field that suggests the cultural evolution of all institutional operators, professionals and contractors. It requires the combination of consolidated technical know-how and organisational and managerial skills.

If the conservation of historical heritage includes the intention to promote an approach to programmed conservation alongside studies, it appears opportune to develop organisational models that optimise the management of the most suitable instruments and assist the governance of the maintenance process.

The current challenge to governing the programmed conservation of historical heritage is tied to the search for, definition of and experimentation with new organisational methods to be adopted by institutional bodies and businesses, together with specific tools for governing a complex process. These models, methods and instruments aid the selection of means and priorities in relation to available resources.

The foundation of this approach is a constant commitment to understanding all of the components of a system comprised of the environment, a building and its use.

The structure of this investigation is fundamental to the identification of the numerous components to be maintained and the constant programming, implementation and verification of forecasts and results, accompanied by an endless process of updating and refining tools of investigation and forecasting.

The propaedeutic and fundamental operations required to choose the forms, methods and times of intervention entail a constant practice of analysis, monitoring, diagnosis and archiving of data: programmed and periodic controls serve to assess the validity of measures adopted during the programming phase. Eventual transformations to the system though 'Building-Environment' interaction should be logged.

5 CONSERVATION PROJECTS AND KNOWLEDGE

Preventive and programmed conservation is a technical and managerial methodology focused on safeguarding the physical aspects of historical architectural heritage. It is founded on the attentive identification and prevention of situations of risk and the systematic planning of largely non-invasive maintenance works. The objective is to avoid/delay important restoration works and benefit from the evident economic and cultural advantages of this approach.

Programmed conservation defines criteria, methods and procedures for planning, programming and carrying out maintenance works involving monumental architectural heritage based on two fundamental dimensions: duration, linked to the maximum possible control of the processes responsible for the deterioration of a building and its physical components; safety, linked to the prevention of all possible risks that pose a threat to these monuments. This innovative technology consists in a systemic approach to the organisation of processes, referred equally to the territorial scale and the smallest component. The intention is to prevent all possible risks that may threaten a building. The pillar of this technology is the understanding of the building and its surroundings, and the updating of this knowledge in relation to the evolution and dynamics of deterioration or possible damage.

This assumption, already amply shared among the scientific community, received a significant formal approval with the issuance of the Codice dei Beni Culturali e del Paesaggio, the Code of Cultural and Landscape Heritage (the so-called Codice Urbani from 2004). Article 29 of the Code transposes and promotes an innovative and systemic approach to conservation that shifts attention from direct intervention in single cases to a comprehensive set of 'indirect' activities of studying, monitoring and diagnosis.

To ensure the development of procedures linked to the management of historical heritage, programmed conservation must necessarily adopt an approach capable of describing the complexity of phenomena and the network of relations between them; the regulation identifies a possible methodological-conceptual model in the so-called 'Systemic Approach', introduced by Von Bertalanffy in his General System Theory [9].

The problem of knowledge is thus of absolute importance. In a systemic approach, the early phases of the process of programmed conservation postulates, and cyclically repeats over time, the acquisition and progressive study of what we know about a building. Areas

explored include techniques, tools and materials utilised, evolutions over time and conditions of risk deriving from the urban and territorial environment.

As a process, the act of conservation postulates a critical judgment that is culturally and scientifically determined – a reading and interpretation of the building and the phenomena in which it is involved. The adequacy of this opinion is correlated to the quality of the knowledge on which it is founded; this act must be solidly and periodically repeated – in relation to the factors of evolution intrinsic and extrinsic to a building – to define/update the strategies and methods of intervention programmed as part of a conservation project.

The study and analysis of a building and its environment, and the control of natural or pathological processes of deterioration, are all elements of understanding. They are also indispensable information for any activity of maintenance/conservation. They serve to develop the capacity to forecast – and thus prevent – the evolution of deterioration or possible damage.

Conservation must be founded on scientific data acquired using the most suitable tools offered by evolving technologies. Projects must consider the multidisciplinary aspects of each problem and expand studies to the fields of chemistry, physics, biology, geology and computer sciences. The need to learn about and document historical heritage must confront the board spectrum of possible characterisations of different elements, parts, dynamics and relations. This presupposes multidisciplinary studies, whose results must lead to the sure identification of the necessary conservation works. These works must in turn be defined in relation to static and structural consolidation or the integrity of different components and building materials. Where possible, it is also necessary to consider the reduction/elimination of all possible risks linked to a specific context.

6 HBIM FOR CONSERVATION

Recent decades have introduced an on-going reflection in the field of restoration and conservation on how to represent information about the state of conservation and required interventions. The field has since taken a decisive step forward thanks to the development and affirmation of important advancements in digital technologies.

A reliable and complete description is fundamental to any project intent on acquiring the understanding necessary for conservation: it reduces the complexity of a real situation to a specific model. Digital photogrammetry and 3D scanning systems make it possible to create high resolution and three-dimensional surveys of buildings. These documents represent geometries as well as materials. To meet the objectives of conservation three-dimensional digital models are produced to integrate information about the morphology of a building with other information about materials uses, phases of construction and technical characteristics linked to environmental factors.

This evolution of three-dimensional models corresponds with a broader and international diffusion of BIM (Building Information Modelling) and HBIM (Heritage Building Information Modelling) systems, whose use in the field of conservation hints at interesting new developments. BIM is progressively gaining ground in the field of new construction; however, the methods of using and integrating HBIM are still in an early phase and linked to the use of databases tracking the conservation of historical-architectural heritage. There are substantial differences between the construction of BIM and HBIM models: while the former uses different three-dimensional models to coordinate and integrate the work of various specialists involved in the design of a building (etc.) and the spatial and temporal planning of the construction site, the latter is essentially a tool for understanding the morphology, materials,

phenomena and history of a building to be conserved (Fig. 1). As a tool for analysing and representing architectural heritage, BIM is increasingly more often also considered fundamental for understanding processes of transformation over time, for learning about a building, as well as an indispensable support to the development of a conservation project.

The application of Building Information Modelling to existing buildings and architectural heritage concentrates primarily on the phase of surveying and defining the state of conservation of sites and materials. This technology helps plan better informed interventions and expand the understanding necessary to implement opportune and effective conservation strategies. In this case, the BIM model is less a tool of representation and more an indispensable support to the planning of actions of conservation. BIM tools make it possible to create an environment of analysis and interpretation that reinforces the process of learning about a building. This process looks not only at geometric aspects, but also at the representation of the diachronic evolution of phenomena of deterioration/conservation.

The most relevant aspect to the optimisation of BIM as a support to the process of programmed conservation is precisely the possibility to 'fill' a three-dimensional model with a large quantity of information and data. Examples include: results of in situ and laboratory testing, specific conditions of deterioration, specific elements in need of specific interventions. Indeed, more than a three-dimensional representation of building, a digital model constructed in BIM creates a true cognitive system [10]. Research in this field is oriented toward determining the methods and instruments that assist the creation of digital data archives describing the geometry and morphology of a building, the articulation of the components used to construct it, all related information about materials, analyses and studies deriving from diagnostic processes.

This field is still largely unexplored, in particular in relation to the possible methods of creating functions and libraries for modelling historical architecture. The reconstruction of complex and non-standardised forms has yet to be optimised and remains a laborious undertaking. Current experiments proceed by adopting diverse applications to convert point cloud surveys into parametric objects to be associated with attributes. The current challenge in the field of modelling focuses on identifying simplified methods for obtaining BIM models for cultural heritage and guarantee an accuracy, precision and quality of representation coherent with the data acquired. At the same time there is a need to minimise the number of steps and

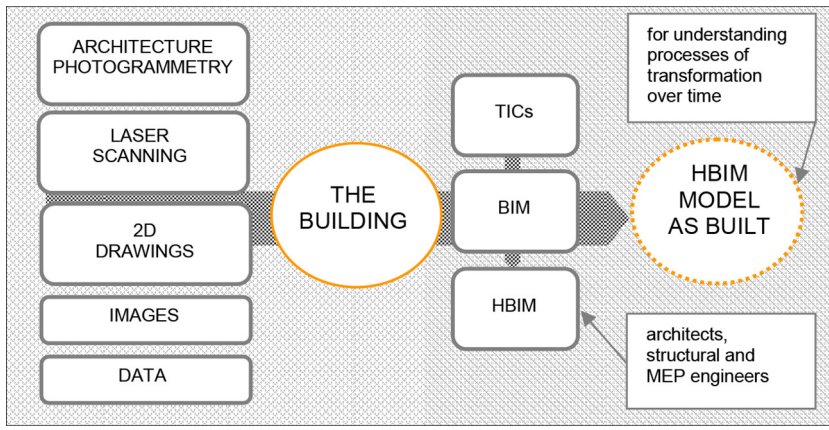

Figure 1: HBIM Approach. The model as support to the conservation project.

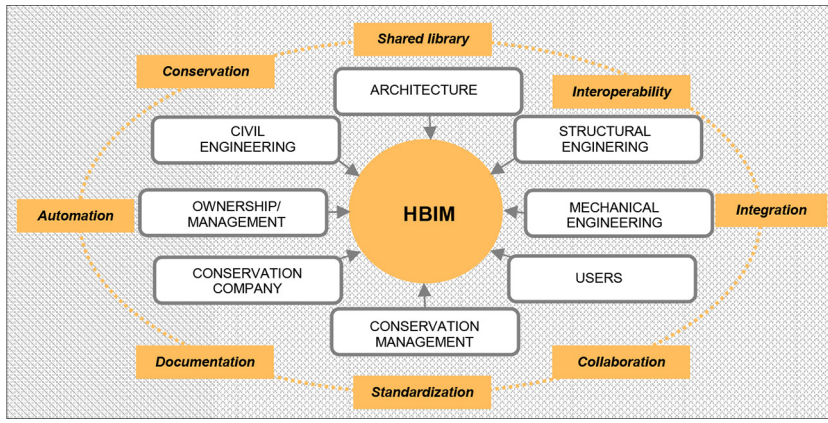

Figure 2: Integration between operators. Redrawn after (Naglaa A. Megahed 2015).

modifications to formats during the modelling process to avoid the simplification or loss of information.

A further area of interest is represented by the association and representation of information used to populate a database: other than historic iconographic sources, it is also possible to record images that document the evolution of phenomena of deterioration in order to facilitate the programming and planning of maintenance interventions.

One of the most interesting themes of current research focused on innovation in HBIM modelling systems is the creation of instruments that allow for the transfer of the management and control of the conservation process to interoperable platforms. This would further improve the capacity to programme heritage conservation by exchanging and sharing of data among territorial operators (Fig. 2). A similar result could be implemented through the creation of advanced and integrated design tools based on BIM and GIS systems. GIS can be used to extend the value of the design data provided by digital Heritage Building Information Modelling and allow for the visualisation and analysis of different structures within their context. The integration between BIM and GIS may in fact permit a more detailed and relational visualisation of phenomena of risk, generating a better decision-making process and improving the communication and comprehension of how to approach the conservation of monuments.

7 CONCLUSIONS

The concepts of maintenance and conservation as a process of constant care represent important cultural advancements. Their value lies in the objective to ensure a future for built heritage and environments of historical value that together define collective memory.

Conservation supported by maintenance technologies can be used to guarantee an even longer future for heritage that has survived to the present day. This approach constitutes first and foremost a fundamental instrument for learning about, understanding and re-appropriating the system being studied, not in the abstract or in isolation, but within the changing dynamics of the relationship with context.

The conservation of historical heritage, intended as the prevention of deterioration, is now recognised and accepted as an approach that ensures we are able to conserve the authenticity of cultural heritage. The adoption of maintenance technologies for the conservation of historical heritage opens up new operative perspectives for the creation of instruments designed to

support information gathering/decision-making. Instruments that provide new forms for organising and governing knowledge and information about historical heritage that serves to define, govern and control interventions.

This process requires the definition, for individual buildings and groups of buildings in a particular context, of a process for studying, observing and measuring levels of conservation, evaluating the efficacy and periodicity of maintenance works and for identifying and analysing all possible sources of risk together with corresponding forms of prevention and protection. For these reasons, research must continually focus on developing and optimising tools for governing systems of knowledge linked to processes of conservation. The aim is to improve the effectiveness and efficiency of choices and actions designed to ensure the future of historical architectural heritage. With this objective in mind, HBIM has the ability to represent an environment in which it is possible to obtain not only complete technical drawings for the conservation of historical buildings, including 3D documentation, but also for collecting information and analyses.

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