ADVANCED GEOMATICS AND CONSERVATION MANAGEMENT PLAN FOR PRESERVING 20th CENTURY ARCHITECTURAL HERITAGE

F. Allegretti [1], D. Del Curto[2], S. Mazza [1]

[1] Politecnico di Milano, Graduate School in Architectural and Landscape Heritage
[2] Politecnico di Milano, Laboratory of Analysis and Building Diagnostic, Department of Architecture and Urban Studies

KEY WORDS: Preventive Conservation, Modern Architecture, 20th Century, Conservation Management Plan, GIS

ABSTRACT:

This paper discusses the relationship between advanced geomatics and Conservation Management Plan (CMP), by deepening the case of a CMP dedicated to the conservation of the 20th century architectural heritage. A number of issues have already been discussed on how the advanced survey techniques contribute to the conservation field for the last decades (e.g. Laser Scanner, HDR, GIS, intelligence vs. abundance, B.I.M, VT/IM etc.). The authors analyse pros and cons of each technique with respect to the main purposes of a CMP: 1.knowledge, 2.value assessment, 3.data sharing and dissemination of results, 4.support for conservation and restoration activities, 5.support for the planned conservation of buildings / facility management over time. With respect to the research on the CMP for the National Art Schools of Havana, the conclusions focus on the need to share results to non-specialist stakeholders, and on the possibility to combine different scales of analysis and a plurality of buildings with various levels of interest and conservation needs.

1. INTRODUCTION

A Conservation Management Plan *"is simply a document which explains why a place is significant and how you will sustain that significance in any new use, alteration, repair or management"* (1).

The conservation planning process consist in: 1.knowledge, 2.value assessment, 3.data sharing and dissemination of results 4.support for conservation and restoration activities, 5.support for the planned conservation of buildings and the facility management over time.

Knowledge of the site is the key to a CMP, in order to assessing the framework of values to be preserved.

CMP is a work carried out by a number of professionals with different backgrounds, skills and working methods. A multidisciplinary approach clearly does not consist only in the wealth of information, but also in the ability to integrate different points of view and to provide clear guidelines and policies aimed at solving problems and preserving the site. The choice of the professionals to be involved depends on the features of each case study. For example, a historic garden and dwelling, requires the contribution of agronomists, botanists and geologists. Architects and historians, for istance, study the historical evolution of the site; engineers assess the structural aspects; sociologists may also contribute by investigating the role of the community as an active part in the use of architecture. Thus different joined skills allow to develop the early phase of knowledge of the site, even by integrating different points of view (the **first task** of a CMP).

The **second task** consists in assessing the historical, cultural and aesthetic value of the good. In fact, without this value, it would not be necessary to draft a CMP. The assessment of cultural significance and the diffusion of the research's results are two crucial steps along this path and they need to be shared with the various stakeholders involved.

The **third task**, also very important, concerns the sharing and dissemination of research results to the largest possible number of users who need to be made aware of how important is conservation. They also must be informed about both intermediate and final results obtained. The goal of this task is to identify vulnerabilities and critical issues of the site, to define the owners of the site and their duties towards conservation, to highlight the constraints and opportunities for the development and future use of the site, to identify and involve the possible stakeholders.

The **fourth task** concerns the development of conservation policies, in particular the development of general policies for the use, repair, maintenance of site structures and specific policies concerning the context surrounding buildings (pieces of furniture, landscape ...)

The **fifth task** concerns the setting up of management tools, the development of intervention and management policies. This task is based on the use of tools for territorial and architectural survey and on the graphic drawings produced thanks to these tools. The conservation policies and research developed in previous tasks con be coordinated within this last task. The fifth task also concerns the implementation and monitoring of the CMP over time. This includes a development plan where to foresee any further needs and evolution of the CMP, together with the need to train specialists to be charged for implementing and reviewing the CMP over time, even remotely.

The aim of this research paper is to identify a reliable information tool as a support to the development of the CMP of a specific case study: **The National Art Schools of Havana.** In fact, a CMP for the National Art Schools needs to manage such a wide complex on a double-scale level: a territorial scale, where you need to control the relationship among different buildings, paths, natural environments, and an architectural scale, where dealing with any specific issue of each building. In particular, the sinuous shapes of these buildings makes them not easy to be fully represented only with a traditional 2D representation.

The National Art Schools of Havana are considered an outstanding example of modern architecture in Cuba, since they translated the will for social renewal into an innovative project of architecture. The Schools were built just after the Cuban Revolution on a design by three young architects: Ricardo Porro (Cuban), Vittorio Garatti and Roberto Gottardi (Italians). Each of the Five buildings were designed to be devoted to a form of art (Fine Arts, Music, Ballet, Drama, Modern and Folkloric Dancing). They cover an overall area of approx. 37.000 m^2. Although each building is independent, they were all built with

(1) Heritage Lottery Fund, 2002-2007

the same materials and construction techniques. They are perfectly integrated in a 56-hectares park occupying the former golf course of Havana, in the residential neighbourhood named Playa.
The goal is to evaluate which survey techniques are most suitable to meet these needs within a CMP, by comparing pros and cons of different systems and models already developed or at an advanced stage of development.

2. GEOMATIC TOOLS FOR HERITAGE CONSERVATION AND MANAGEMENT

We here present the result of a bibliographic survey,aiming to seek, summarize and critically evaluate different methods and approaches which has been already developed for the data management of a specific architectural object in particular related to the conservation, maintenance and management of architectural heritage. Therefore, we here propose significant examples that deal with different side of the issue. These examples have been choosen both for their affinity with the present case study and, moreover, for the goals achieved through different field methods. For the authors, it represents a real guide to organize, integrate and evaluate published works, thus drawing attention to this topic in the current panorama.
Similarly to what happens in the construction sector, even in the field of heritage conservation, the actual tendency is towards 3D representation, in particular towards a BIM design approach.
2D representation as the only way to graphically reproduce the information is now outdated. Despite being less expensive in terms of time and money, it risks to simplify communication and, above all, it may not give a complete view of the whole object, especially in case of complex and irregular shapes (see, for instance, the domes of the National Schools in Cuba).
3D models can nowadays be obtained thanks to a number of techniques (e.g. LaserScanner+HDR, VT/IM etc.). They allow you to better investigate the building or the site during the phase of analysis and interpretation. Subsequently, they also allow you to control a higher number of information thanks to a BIM system and to better manage the design phases.
3D models can control the scale of the building as accurate as possible, but the need is also to have a system suitable for managing the urban/landscape scale to be assessed for the conservation and management of the entire area of Schools (es. references to Google maps, GIS, etc.) without which you would loose an important layer of the site.

2.1 Advanced geomatics for architectural heritage

The work begins with an overview on the application of geomatics as a support for preservation activities of the architectural heritage.
A very detailed survey of the mosaic floor of the S. Marco Basilica in Venice (2) was done with the aim to support an accurate restoration project. The geometrical and constructive complexity of such an object, the irregularity of shape and precious materials, required to assess a survey method suitable to represent such a level of complexity. A 3D model was done together with a 3D Digital Orthophoto in a 1:1 scale. It was developed by applying differential rectification of the photogrammetric images, made with a 16 million pixel Rollei DB44 Metric digital camera (1 pixel=900 nm), to which a 3D floor model (DSM) was associated, reproducing the complexity in an extremely effective and precise way. The software used were APEX PCI7.0, for the realization of the orthophoto and the 3D model, and ArcGIS 8.2 + ArcInfo 8.2 (ESRI) package for the display and management of the DSM information. 3D Digital Orthophoto allows you to document the layout and the state of conservation of each piece of the mosaic, providing information on the levels of the entire floor, directly obtained by restorers, specialized technicians and maintenance staff. The ArcGIS and ArcInfo environment, on the other hand, allows you to extract all the information concerning the contours. This combination of information provided a good basis for designing the restoration and maintenance operations. The restoration actions are the temporary removal and repositioning (or punctual replacement) of the damaged parts, respecting the typical irregular characteristics of the floor.

Figure 1. National Art Schools of Havana (Google Maps image)

Figure 2. National Art Schools of Havana (Del Curto, 2018)

(2) L. Fregonese, C. Monti, 2010

The main advantage of this method is that you get a three-dimensional, georeferenced image. It is the basis for building an information system that relates historical documents (research, previous drawings and maps) with modern surveys. It is also possible to perform global transformations, deformations and morphing (3).
The same method used for the floor of the Basilica of San Marco, was positively employed on an architectural scale for the survey of the building in Calle S. Ignacio 314, in Havana destined to be the seat of the RE(stauro).DI(segno) centre (4). Similarly, to the precious mosaic floor of Venice, also in this case the survey aimed at obtaining a 3D model immediately usable as a tool for the restoration work. The survey was performed with the ZandS Laser scanner technology, which allows to associate the 3D model deriving from the point cloud with the HDR spherical photos. The result is a 3D model that incorporates detailed photo images, thus allowing you to obtain very detailed information directly from the model (shapes, colours, proportions and measurements). In the executive design phase, this allows the designer to reduce the need to visit the building site and, in the case of a building so far away, it gives the chance to operate remotely.
Laser technology helps to obtain 2D or 3D models, which proves accurate to the building shapes, being thus a suitable base on which to design the executive details. The benefit of this technology consists in the possibility of reducing the duration of the survey campaign. It is particularly positive when it is necessary to reduce the number of the inspection days. Moreover, on this occasion the images were produced with the TruView software, creating a cloud of points taken from the machine thanks to the panoramic images, all done in two days of work. These have been used by Italian producers to create the windows of the REDI centre in the best way and with greater definition.
These methods are highly effective for the heritage conservation and management. In particular, the model obtained in the two cases above mentioned, proved to be a basis for developing a conservation project and for the management of the building site. Therefore, the results of the survey were relevant to the conservation project and to the execution of the works. The quality of the results was obtained thanks to the use of accurate surveying systems and high-skilled professionals. Moreover, such a detailed work was tailored to the specific case. It is therefore necessary to understand if such accurate systems can be successfully applied even in the case of larger objects or, in other words, how these systems can be adapted for application to the scale of the building and the territory.
Laser Scanner modeling is an effective tool for reproducing a single building and has proved useful both for research purposes and when it was applied in a professional job. With respect to the case study of the National Art Schools in Havana, we can ask whether Laser Scanner technology would be effective to create the geometric model of each building, and moreover if it would be effective even in the subsequent implementation and management phases of information. The advantages in terms of accuracy of the model would certainly justify the investment in terms of time and costs due to the use of accurate survey systems and specialized operators. On the other hand, however, the realization of a Laser Scanner model should be multiplied by the number of buildings present, considering the considerable size and complex shape of each. This increases the risk that a similar system is not used because it is too complex to manage locally, even though it is theoretically effective.

(3) R. Brumana, L. Fregonese, C. Monti, E. Vio, C.C. Monti, G. Monti, L. Taffurelli, 2006
(4) A. Raschieri, CUBA04, 2017, pp. 18-19

Figure 3. 3D Digital Orthophoto of the experimental area of the San Marco Basilica's floor (Brumana, 2010)

Figure 4. Laser scanner survey REDI centre, L'Havana (Raschieri, Cuba04, 2017)

Figure 5. 3D model, point cloud, REDI centre, L'Havana (Raschieri, Cuba04, 2017)

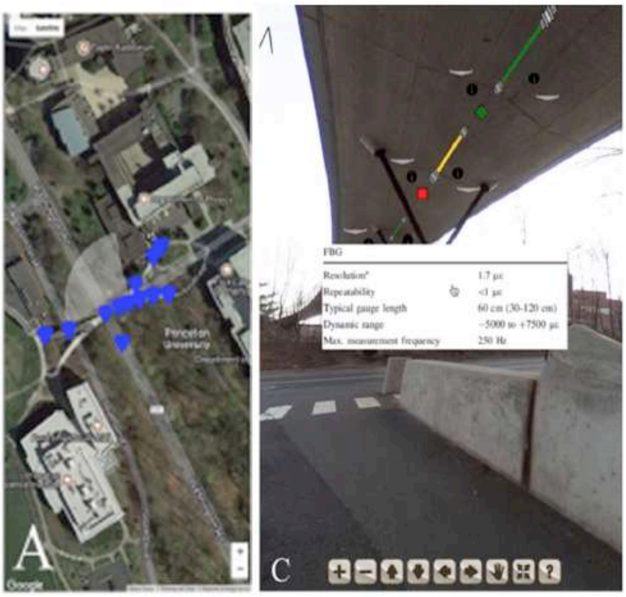

Figure 6. VT interactions (**A**) thermal change; (**C**) strain sensor metadata (R. Napolitano, G. Scherer, B. Glisic, 2017)

Figure 7. VT environment, Archeological area of Thann (M. Koehl, N. Brigand, 2012)

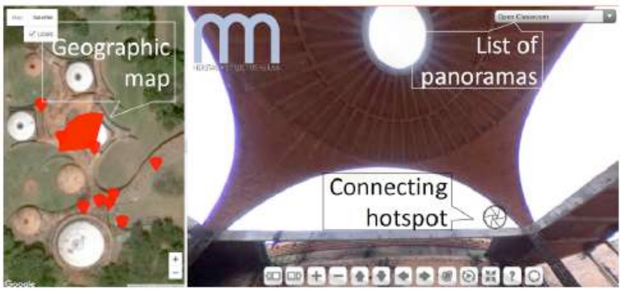

Figure 8. Interface for VT/IM environment (R. Napolitano, I. Douglas, M.E. Garlock, B. Glisic, 2017)

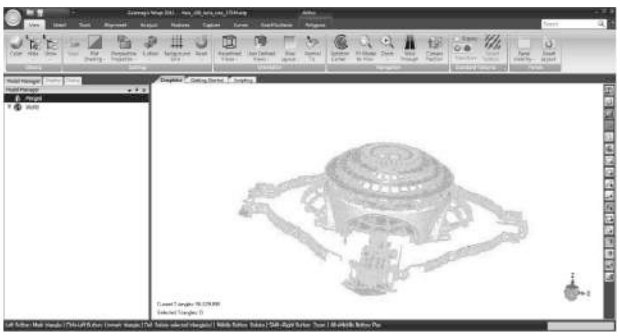

Figure 9. BIM model (Centennial Hall CMP, 2016)

VT (Virtual Tour) was developed for a complete 3D visualization of the object. They may thus represent a shortcut to overtake the problem of the realization of the 3D model from a Laser Scanner survey and point cloud. The VT was developed for tourism and educational purposes, to view a space to an audience in a simple and intuitive way. The VT is an engaging environment created with interconnected spherical panoramas starting from images obtained by specific cameras and software. 3D virtual tour technology has been increasingly used in the documentation and preservation of heritage buildings and sites. They are based on standard file formats (.obj format), and the use of a spherical camera. They have already proved to be valuable in the documentation phase and the results can be easily stored in digital archives for future research.

Princeton University has been working in this direction for a long time, developing VT as a support to the work of designing and analyzing structures of different types. As an example, the whole structure of the Streicker Bridge (5) was reproduced thanks to a VT/IM model(Virtual Tour linked to Informative Models) as a support to a SHM (structural monitoring systems). This system allows a user to virtually visit the structure, to visualize the sensors and to check the data network even without the need for a further 3D model. Streicker Bridge is a reinforced concrete structure dating back to 1964. The structure has been reproduced virtually, with the acquisition of spherical photographic images and their digital assembly. In the VT/IM environment, a user can access the tour to go through the structure, he can access the analyzed data, metadata (technical drawings, pre-compression scheme, etc.) and the information concerning the SHM system (color coding of the sensors, specifications of the monitoring system). The IM (Information Model) has the goal to keep and manage the information about the site and linked them direct on the virtual model. A user can also decide to limit the access to the tour for safety reason, i.e. to limit the data sharing just to the working group participating in the project.

This method is less expensive in terms of time and economic as it is not necessary to create a 3D model. A proper number of cameras and a management software are often enough and they are used for processing the photographic shots. They are then composed into a spherical image that allows the entirely vision of the object and allows you to virtually explore it.

This method proved to be interesting and immediate since you can feel exploring the structure in a way very similar to the one we are used since the street view function of Google Maps has been so widespread and used by a large audience. However, this example was developed on a single building, even if of considerable size. The research need to be extended towards the research of VT/IM developed not only on an single-building scale, but also on urban scale. This would make it suitable also for the case of the National Art Schools of Havana.

Further hints about how to apply advanced geomatics to the National Art Schools of Havana may derive from previous experiences already performed on some archaeological areas, since they are often similar in dimesions. The goal of the CMP for the National Art Schools is clearly different from a CMP for an archaeological area, since it is aimed at conserving and managing both the buillding and the site, and the educative function. Neverthelss a comparison proves interesting, as both cases aim at obtaining a double-scale level of conservation and management of the site.

A good example is the project developed by M. Koehl and N. Brigand in France for the archaeological site of Thann (6), a city in the north-east France. The idea was to strengthen Thann's

(5) R. Napolitano, G. Scherer, B. Glisic, 2017
(6) M. Koehl, N. Brigand, 2012

attraction by making cultural contents more available, thanks to a 3D archaeological experience of the site to be used as a platform where to share information and media contents. They used the VT environment as a basis for an archaeological knowledge and information system (AKIS). An accurate geographic information system (GIS) and a 3D model of the site were created. VT, 3D models, GIS and digital data have been combined to create an original 3D interface. If properly implemented, this will result into an useful platform both for specialist (archaeologists, historians, conservators) and not-specialist stakeholders, that is citizens and visitors.
The goal of the project was initially to collect data, build a GIS model and create a 3D model starting from the photographs and TLS techniques. The associated GIS system allows you to associate data in digital format to each element of the ruins: drawing, photography, assembly mode, drawing, collection of descriptive reports, hyperlink to Web page, etc. This structure is crucial to integrate the model into an information system of archaeological knowledge (AKIS), especially in 3D-AKIS. In the case of Thann, the analytical performances of 3D-AKIS combined with a high performance documentation management system were used to provide a tool for archiving and documentation, enabling a complete analysis of such a complex building structure. On a second step, the project aimed at integrating the site with a VT. This simple application was created with panoramas images and proved to be effective for viewing and understanding the site. The VT was finally combined with a 3D model that allows you to check the size of the site, by using a normal dimensioning tool over the picture. Thanks to a number of hotspots, it also allows you to consult further contents previously related to the model as digital documentation, video and georeferenced digital documents, e.g. archaeological reports, interpretation, research, collected objects, etc. A hotspot link always leads you to another scene, image, website, etc. A hotspot can be displayed as an animated point, a visible geometric shape, e.g. a point or a surface, so it can be easily recognizable and operable by the user.
Following this example, the Department of Civil and Environmental Engineering of the Princeton University have alreay made an early attempt to apply the same method to Vittorio Garatti's School of Ballet (7). The pros of this method lie to the possibility of linking any type of file or contents bearing to further details as the results produced by different working group, both in case they operate contemporarily and subsequently. VT/IM is thus an easily accessible system for sharing and managing data. However, it could be implemented to be even more efficient as a tool for the design phase, e.g. by ensuring the possibility to obtain geometrical measurements directly from the pictures.

2.2 Advanced geomatics and CMP for the 20th century architectural heritage

The CMP has already been applied to the conservation of a number of buildings of the past, of various types and ages. In this part of the article, we intend to narrow the field of investigation and to examine how advanced geomatics has already contributed to the development of some CMPs that were designed precisely to preserve the architectural heritage of the 20th century. We then analyzed the results of the Keeping It Modern program. Thanks to this international program, the Getty Foundation has been supporting the writing of CMP for major architectural masterpieces of the 20th century since 2014. Keeping It Modern has supported 54 grant projects of outstanding architectural significance that contribute to advancing conservation practice. Current active grants focus on the creation of conservation management plans that guide long-term maintenance and conservation policies, the thorough investigation of building conditions, and the testing and analysis of modern materials. Technical reports from grant projects are freely accessible online through the website of the Foundation. This public library is updated periodically with new reports as they are completed. We thus studied the structure of different CMPs to highlight the contribution of advanced geomatics in each case. This lead us to some further conclusions that will be critically applied with respect to the case of the National Arte Schools.
Developing an information system is a crucial point for most CMPs developed within the K.I.M. initiative. Many refer to the use of the BIM system linked to a 3D model. This is consistent with the fact that most cases focus on a building, as it makes relatively easy to develop the model. A Revit-Based 3D model was done within the drafting of the CMP for Saint John's Abbey Church's (8). The church was built in Minnesota (U.S.A.) between 1958 and 1961. The irregular and unique shape of the reinforced concrete structures characterizing the church, made the 3D model particulary useful, as it allows you to better manage the overall structural analysis, including calculations and evaluations. Similarly, the CMP for the Einstein Tower (architect Mendelsohn, Potsdam 1920s) was based on a 3D model made with Autocad (9). The 3D model is currently limited to the main tower of the building, since the focus of the CMP is on the structural behaviour of this element. In fact, most of the temperature sensors and the cracks monitoring system are connected there. The information for designing the model was initially provided by the archive drawings of the building. Subsequently new drawings were produced during the damage analysis even by using photogrammetry methods, as well as measurements directly taken on site.
A database and data management system were designed within the CMP for the Collegi in Urbino (10). This huge complex was designed by architect Giancarlo De Carlo between the 1960s and 1980s and is comparable for age and size to the National Art School of Havana. The data collection of the Collegi has been conceived and organised not simply as a support to the conservation plan itself, but also in view to set a panel of monitoring to be kept in use on the long run for the everyday management of the building. The data were collected and organized through a code system into a unique information system based on a software named PlaNET Beni Architettonici, TeamSystem-STR. This sofware was especially conceived for the management of the historical buildings. The case of the Urbino thus also allowed to test it with respect to a relatively recent heritage building. Each element of the complex was identificed thanks to a specific code. Each code refers to a specific tab within the information system, where other specific information can be inserted and are therefore organised to be accessible by any professionals involved in the management. This database does not employ any advanced geomatic tool. It can be implemented and updated over time, simply by adding new data and documents. This follows the idea not to overfeed the CMP by using highly specialized sofware and tools, in order to let the data easily accessible in the future, even to a not specifically-trained staff. This was consistent with the general approach of this project: as simpler is the coding system as

(7) R. Napolitano, I. Douglas, M.E. Garlock, B.Glisic, 2017

(8) CSNA Architects, BKBM, Studio NYL, Beton Consulting Engineers LLC, Braun Intertec,2016
(9) Leibniz Institute for Astrophysics Potsdam (AIP),2018
(10) MTA Associati, Politecnico di Milano, ICVBC-CNR, Università degli studi di Urbino, ERSU, 2017

easier will be in the future to implement the system and to keep it in use.

Among the grantees of Keeping it Modern initative, two cases decided to base the CMP on a 3D model integrated with a data management software, that is a BIM system.

Max Berg's Centennial Hall in Wroclaw, Poland (11) is the first example. A BIM model was realized for the structural analysis of the large dome characterizing the building. The model was based on a laser scanner survey and on a linking point clouds. A combination of softwares was thus needed: Autodesk AutoCAD, ReCap, Revit and Meshlab for processing the laser scanner survey. 3D FARO Scane, Geomatic Design X and RhinoCeros for processing the linking point clouds. A BIM and FEM (Finite Element Method) model was then developed to describe, and illustrate the state of repair of the Centennial Hall. Basing on the same model, the subsequent phases of the CMP were then implemented. The model also the basis for implementing a Long-Term Monitoring System of the structure. It allows to store and manage a relevant amount of data collected from a number of structural sensors placed in different points of the building.

Among the CMPs developed for a 20th century heritage building, the case of Sydney Opera House (12) is probably one of the most advanced. The CMP for the Sydney Opera was based in 2003 (3rd edition) on a number of study cards for each architectural element making parts of the building. This systematic approach already meant to gathering the results of each investigation within a system just like a BIM, that had thus to organize the whole building by elements and to associate a complete and specific information for each of them. This effort required a long work and was set up and carried out along the subsequent editions of the CMP. The 4th edition was launched in 2017 and develops a geospatially model with the BIM system, to link all data, construction processes and management and to maintain and update them. The result makes the Sydney Opera House not only an architectural symbol but also a milestone as a Conservation Management Plan for 20th century heritage buildings.

This brief selection of cases taken from the Keeping it Modern program proves how advanced geomatics can contribute to the research on CMP for 20th century architecture. The structural issue leads to investing time in the construction of an advanced 3D model, since it proves useful for structural analysis and for the consolidation project. In the case of large architectural complexes, the GIS systems have proved useful for managing large amounts of data according to a topographical criterion. It must be said that GIS and BIM tools are not easy to use for staff who are not always adequately trained on these issues. This can slow down the spread of these tools but, at the same time, it also represents a further stimulus to increase the training activity for the personnel involved in the ordinary management of 20th c. heritage buildings.The cases analyzed above still have an experimental character, thus demonstrating as this field is open to new studies and research.

3. CONCLUSION

This overview helped identifying a number of geomatics methodology and tools than might be successfully applied within a CMP for the National Art Schools of Havana. The management activity is evidently more effective when it is coordinated by an advanced geomatic tool. A number of examples proved positive outcomes on a single scale level e.g. territorial area or single building. Nevertheless it is not so common to apply these tools at both scales simultaneously. Such double-scale approach is the key of the Schools' CMP. A combination of different tools and methodology is therefore needed: the first for managing the territorial scale, including the park and the pathway system connecting the five buildings. The second regards each single building and its surrounging. The dimension and complexity of the National Art Schools call for a conservation plan that ought to guarantee effectiveness both on a larger scale – as a urban system – and on a smaller scale, thus granting the conservation in use of the whole complex. This issue is crucial when facing the five key points of a CMP, from collecting and managing data, to the implementation of any specific conservation activitiy.

All the information gathered during the analytical phase should then be organized into a GIS map, following the exeperience that has been widely developed in the field of cultural heritage, at a urban scale. Among the mentioned examples, the case of Thann is significant as the whole area is managed through a GIS based tool. The GIS system collects the geo-referenced information concerning the entire area, setting an order for the different data and moreover organizing the various outcomes produced by different work group into a single repository. Just like an archaeological area, the Cuban case requires an attentive collection and organization of the information emerged throughout the knowledge phase, concerning each single sub-area and each expertise involved. The similarity with an archaeological area also regards the multiple aspects that need to be controlled, e.g. risk assessment, prioritization, intervention guidelines, use policy, visits, futher requirements, etc. The GIS plan could act as an interactive geographical map, collecting those information that do not need to be displayed on a 3D model e.g. location of cracks, deterioration processes, etc. Furthermore, the GIS file will collect all the data concerning the green area, the Quibù river and the issue of hydrogeological risk, the safety and accessibility to the area, and all the aspects characterizing the Schools as an integrated system of buildings.

A further scale will focus on the single buildings, since each has different features in terms of design, construction deterioration and use. A VT/IM has already been applied to the National Schools by Princeton University when focusing on the structural behaviour of the domes. This experience proves that VT/IM allows to link different kind of information and data, such as the outcomes of the studies conducted by each different work group involved. VT/IM can thus become an easily accessible support for sharing and collecting data. Following the Princeton University's early outocomes, a VT/IM technology is promising and consistent with the aims of a CMP. It will also be suitable for representing the sinuous forms of the National Art Schools in a rather convincing way and to outline the various issues related to the conservation of the domes.

A question might thus be if such method is effective for the purposes of a CMP, since through VT/IM it is not always easy to control the dimensional data that are actually crucial when designing a restoration or any kind of physical intervention. This leads us to a futher question regarding the possibility to make the VT/IM tool effective not only for the knowledge phase and data storage, but also as a support to the planning and conservation activities and to the construction site. Finally, we may wonder how and to which extent it would be possible to integrate the VT/IM technology with the GIS platform. Could a VT/IM also be applied to the urban/landscape scale? This would make this tool highly consistent with the main purpose of a CMP for the National Art Schools of Havana, that is to ensuring the long term conservation of a 20th century architectural masterpiece, together with a pragmatic management of such a wide and lively complex of art schools.

(11) J. Ilkosz, H. Červinková, G. Grajewski, J. Nawara, J. Urbanik , 2016
(12) A. Croker,2017

		Pros	Cons
Basilica San Marco's floor , Venice (Italy)	3D Digital Orthophoto + ArcGIS	- detailed and precise; - useful for project and construction site; - understandable and scalable	- works on a single architectural object; - demanding and costly for multiple large buildings
ReDi Centre, L'Havana (Cuba)	Laser Scanner + Truview software	- rapid survey; - good level of detail; - useful for project and construction site; - understandable and scalable	- works on a single architectural object; - demanding and costly for multiple large buildings
Streicker Bridge at Princeton University's (U.S.A.)	spherical photographic images + VT/IM	- faster than laser scanner for big buildings; - good quality of virtual model; - useful for manage data; - understandable	- not useful for project or construction site; - not scalable or measurable
Archaeological site of Thann (France)	3D model + VT/IM + GIS	- excellent virtual reproduction of the area; - good quality of virtual model; - useful for manage data and knowledge; - understandable; - GIS allow to manage the general area and linked the objects	- 3D models of every object makes the method expensive and heavy in case of big buildings

Table 1. Pros and Cons of advanced geomatics for architectural heritage

		Pros	Cons
Collegi di Urbino (Italy)	PlaNET System	- collect and manage project data and actions in big buildings	- no measurable area model
Centennial Hall, Wroclow (Poland)	BIM	- high integration between actions; - manage all data and actions on a measurable model	- works on a single object; - demanding and costly for multiple large buildings
Sydney Opera House, Sydney (Australia)	BIM	- high integration between actions; - manage all data and actions on a measurable model	- works on a single object; - demanding and costly for multiple large buildings

Table 2. Pros and Cons of advanced geomatics for 20th century architecture and for CMP

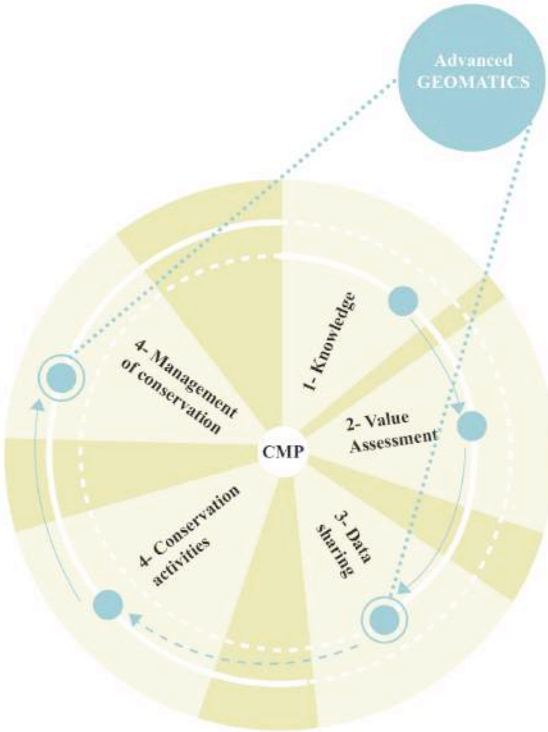

Table 3. Interaction between CMP and advanced geomatics

Table 4. Double-scale approach of the CMP for the National Art Schools of Havana

ACKNOWLEDGEMENTS

The authors would like to thank prof. maria Garlock, prof, Branko Glisic and PhD Rebecca Napolitano at Princeton University for her helpful during the writing of this paper.

REFERENCES

D. Del Curto (editor), The National Schools of Art. La Habana, Cuba. Application to the 5th edition of Keeping it Modern initiative, The Getty Foundation 2018

Leibniz Institute for Astrophysics Potsdam (AIP), The Einstein Tower in Potsdam, Final Report 2018, published with the assistance of the Getty Foundation as part of its Keeping It Modern initiative, 2018

R. Napolitano, G. Scherer, B. Glisic, Virtual tour and informational modelling for conservation of cultural heritage sites, Civil and Environmental Engineering Department, Princeton University, in Elsevier, 2017

R. Napolitano, I. Douglas, M.E. Garlock, B.Glisic, Virtual Tour Environment of Cuba's National School of Art. ISPRS 2017, XLII-2/W5

M. Lo Turco, M. Mattone, F. Rinuado, Dal rilievo metrico all'hBIM per l'analisi dello stato di conservazione della fabbrica in "Ananke", novembre 2017, pp. 141-146

D. Oreni, S. Della Torre, R. Brumana, Disegno e modellazione parametrica per la conservazione di un edificio monumentale danneggiato da un evento sismico. Dal rilievi al cantiere in "Ananke", novembre 2017, pp. 153-158

A. Raschieri, El levantamiento laser escaner en el sitio REDI, in CUBA04–QA Stories, Quaderni di Assorestauro, a.II, settembre 2017, pp. 18-19

A. T. Albourae, C. Armenakis, M. Kyan, Architectural heritage visualization using interactive technologies, University, Toronto, Canada, in The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W5, 26th CIPA Symposium 2017, Ottawa, Canada

P. Pauwels, R. Verstraeten, R. De Meyer, J. Van Campenhout, Architectural information modelling for virtual heritage application, Dept. of Architecture and Urban Planning, Faculty of Engineering, Ghent University, in The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W5, 26th CIPA Symposium 2017, Ottawa, Canada

A. Croker, Respect the vision - Sydney Opera House, a Conservation management plan, IV edition, Sydney July 2017

A. Raschieri, La mezquita de Enez, in CUBA03 – QA Stories, Quaderni di Assorestauro, a.II, aprile 2017, pp. 26-31

MTA Associati, Politecnico di Milano, ICVBC-CNR, Università degli studi di Urbino, ERSU, Giancarlo De Carlo "Collegi" in Urbino. Conservation Management Plan, published with the assistance of the Getty Foundation as part of its Keeping It Modern initiative, 2017

J. Ilkosz, H. Červinková, G. Grajewski, J. Nawara, J. Urbanik, Centennial Hall in Wraclow. Conservation Management Plan, published with the assistance of the Getty Foundation as part of its Keeping It Modern initiative, 2016

CSNA Architects, BKBM, Studio NYL, Beton Consulting Engineers LLC, Braun Intertec, Saint's John Abbey, Conservation-Restoration-Preservation, Final Report, 2016, published with the assistance of the Getty Foundation as part of its Keeping It Modern initiative, 2016

M. Koehl, N. Brigand, Combination of virtual tours, 3d model and digital data in a 3d archaeological knowledge and information system, INSA Strasbourg, France, in International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XXXIX-B4, 2012, Congress 2012, Melbourne, Australia

L. Fregonese, C. Monti, Il pavimento tessulare di S.Marco a Venezia, DIP. BEST - SITECH – 3DSURVEY GROUP, Politecnico di Milano, 2010

D. Worthing, S. Bond, Managing Built Heritage The role of cultural Significance, Blackwell Publishing, 2008

Heritage Lottery Fund, Broadening the horizons of heritage - The Heritage Lottery Fund Plan 2002-2007

R. Brumana, L. Fregonese, C. Monti, E. Vio, C.C. Monti, G. Monti, L. Taffurelli, Ortofoto 3D digitale alla scala 1:1 dell'intero pavimento musivo della Basilica di San Marco a Venezia. Uso dell'ortofoto per la manutenzione e i restauri, in Actas del V Congreso Internacional Restaurar la memoria – Patrimonio&Territorio AR&PA, 2006

J. Kerr, The conservation plan: a guide to the preparation of conservation plans for places of european cultural, Sydney: National trust of australia (NSW), 1996