Theme 5
Emerging tools for conservation practice

Thème 5
Nouveaux outils pour la pratique de la conservation

Semantic and cognitive palimpsest Outfitting and communication project

Conservation
It's abacus of different shapes, and it let us interpretate conservation, starting from thing structure
Theme 5
Emerging tools for conservation practice

Thème 5
Nouveaux outils pour la pratique de la conservation

Cultural mapping, Capacity building, Micro-financing, Social values analysis and Multi-purpose GIS are revolutionising heritage practices.
How can they enhance conservation practice?

La cartographie culturelle, le renforcement des capacités, les Micro-financements, l’analyse des valeurs sociales et les SIG révolutionnent les pratiques patrimoniales.
Comment peuvent-elles améliorer la pratique de la conservation?

Sub-themes

5-1 Technological innovation
5-2 Community engagement
5-3 Theoretical tools
5-4 Communication and Interpretation
CONFERENCE PROCEEDINGS

THEME 5 - EXTRACT

Edited by
Maurizio Di Stefano

Salvatore Settis
President of the Scientific Symposium
Theme 5
Emerging tools for conservation practice

Introduction - Co-chairs of Theme 5
Paolo Salonia
Sheridan Burke

5-1 Technological innovation: Emerging enabling technologies for assessing and managing heritage

Complex Assets Management Tools: The Strategy of Preventive and Planned Conservation for the Built Cultural Heritage in the Historic Park of Monza
Anthoula Konsta

Strategies for Data Storing in CH Conservation Plans:
Façades Analyses in GIS Environment
Antonia Spano, Elisabetta Donadio, Elena Cerutti, Francesca Noardo

Landscapes beneath the Sea and Emerging Tools for Assessing and Managing Their (Heritage) Values
Chloë Claerhout, Maikel De Clercq, Ine Demerre, Tine Missiaen, Marnix Pieters, Sven Van Haelst, Oscar Zurita Hurtado

Martine Assenat, Jean-Claude Bessac, Philippe Bromblet, Olivier Henry, Livio De Luca, Eloise Noc, Antoine Perez, Gamze Saygi, Nevin Soyukaya

The Completion of Sagrada Familia: Questions of Heritage Authenticity, Authority and Authorship
Nancy Pollock-Ellwand

Towards monitoring and measuring change: the Silk Roads cultural heritage resource information system
Ona Vileikis, Koen Van Balen, Mario Santana Quintero

Photographing Masada by a Drone: Quantifying the Accuracy of Photogrammetry
Rebeka Vital, Michael Walczak

Turkish D-Light: Accentuating Heritage Values with Daylight
Sura Almaiyah, Hisham Elkadi, Zeynep Aygen, Mimar Sinan

A User Perspective on the ROVINA Project

Development of 3D Measurement Method for Historical Structure by Using Smartphone
Yoichi Kunii

5-2 Community engagement

Antarctica and Apollo: Heritage Horizons
Bryan Lintott

Cultural Mapping for Conservation Practice: Lessons from a Training Course in Penang, Malaysia
Jeffrey Cody

Krystal Buckley, Tim Badman, Peter Bille Larsen

5-3 Theoretical tools

Proposed Arabic-Islamic Contributions to the Theory of Conservation for Cultural Heritage
Hossam Mahdy

Implementing New Paradigms for Managing Change: the Sydney Opera House Experience
Sheridan Burke

Digital Media Technologies for the Management of Data on Construction Techniques and Damage
Xavier Romão, Esmeralda Paupério, Aníbal Costa
5-4 Communication and interpretation
Can architectural conservation become mainstream? 626
Cristina Gonzalez-Longo
Communicating the Value of Knowledge: “Venus and MARS” Whispering to Our Senses 631
Paola Calicchia, Lucilla Di Marcoberardino, Sara De Simone, Claudia Ceccarelli
Introduction

Theme 5 - Emerging tools for conservation practice

Which is the right direction?

Paolo Salonia, Co-chair of Theme 5

Theme 5 “Emerging Tools for Conservation Practice” completes the approach with which the ICOMOS Symposium 2014 has aimed to exhaustively characterize a profound reflection on the issue of conservation entirely based on the concept of Cultural Heritage as right and value of humanity. A close adherence really exists between this Theme and the other four Themes of the Symposium. In fact we can’t deal with the topics of tourism (better cultural tourism), landscape, sustainability based on the recognition of the indispensable role of tradition, local communities involvement in conservation processes, without developing at the same time an in-depth analysis of the role that new technologies can and must play within the entire scenario of Cultural Heritage conservation and safeguard.

Cultural Heritage requires an interdisciplinary and holistic approach to the problems of conservation. According to these assumptions, Theme 5 rightly interprets the Cultural Heritage as an ecosystem - Cultural Heritage Ecosystem - that is a complex system of interactions between different types of processes (knowledge, monitoring, conservation and enhancement, application) acting on a network of different types of Cultural Heritage and associated contexts, the work of diverse actors and stakeholders as equally diverse subjects.

In this conceptual system, it is crucial to design and enable innovative solutions for the management of these interactions through strong coordinated actions of research, training, results experimentation and dissemination, based on a complex and integrated network (network of networks) of enabling technologies.

The so-called enabling technologies, in fact, can act as a support and provide facilities for the governance of the conservation process, from the phase of knowledge to those of the intervention and of the monitoring of the kinetics arising, for the enhancement and enjoyment, to support knowledge sharing.

An implementation of the actions and strategies of risk reduction is required for the protection and safeguard of Cultural Heritage, as well as natural and man-made landscape of the historical territory, and for the control of dangers that affect urban systems. These risks have to be faced through an approach that integrates knowledge, analysis and multidisciplinary techniques.

For example, new materials (composites, shape memory, nanomaterials), as well as new techniques for seismic isolation, are now available for technical interventions aimed at the seismic protection of monuments. A multi-purpose GIS integration, between technologies for risks management and tools for cultural mapping, could be an interesting and sophisticated technological system for the integration and management of Cultural Heritage specific risks, as well as an effective tool for strengthening the sense of responsibility of the community in the preservation and protection of the heritage that history has entrusted.

Furthermore, Cultural Heritage has become not only a resource to be preserved, but also a source of innovation that combines art and science, creativity and technology, problem solving and problem finding, and generates innovations. It is responsibility of present generations to make this integration process as fast as possible at every level, in order to support transversality and transfer knowledge between societies, industry, research and professions.

This is, certainly, one of the main tools for the emerging practices of conservation for the future. The aim was to encourage contributions that could develop the Theme along specific lines: new and emerging technologies for dealing with risks of conservation (i.e. from climate change to globalization, from security to material sciences); new opportunities for information digitization and systematization; social media aimed at supporting, planning, organizing, managing, interpreting and monitoring conservation actions and values analysis.

Therefore, the call for paper intended to explore the variety of new tools that are emerging in conservation practices - from hard science and theoretical debates to the practical operational methods developed, tested and implemented worldwide - and it was divided into four sub-themes:

5.1. Technological Innovation - Emerging enabling technologies for heritage assessment and management: What is next in Information Technologies, storage and accessibility, for example webGIS, 3D modelling, and 3D printing? Which tools are developing for energy management and heritage sustainability, risk mitigation and disaster management planning, climate change and global warming?

5.2. Community Engagement - How can conservation instruments better deal with the
complexity of cultural values, the inclusion of other voices (anthropology, social geography or social archaeology) and improve different stakeholder engagement?

5.3. Theoretical Tools - Implementing new paradigms for managing changes such as the concept of tolerance for change. Do we need an update of the Venice Charter or of the Nara Document? Do some types of heritage typologies require different approaches to conservation such as, for example, Twentieth Century heritage or space heritage?

5.4. Communication and Interpretation - Which are the best practical tools for mobilizing conservation actions and heritage advocacy, generating public awareness, building capacities and training? How does the integration between specialist knowledge and traditional knowledge progress?

Many works (n.170) were submitted and a rigorous peer review activity took place, to which some of the other members of the Theme subcommittee have expertly contributed (Mario Santana, Trinidad Rico, Ayako Fukushima, Mina Elmgari, Cristina Iamandi, Claudia Ventura), as well as the co-chair Sheridan Burke.

In the two oral presentation Sessions of the Symposium, n.34 works were presented, the most of which related to the 5.1 sub-theme. The notes prepared by the rapporteurs who assisted in those two days, Grazia Tucci 1, Salvatore Siano 2 and the junior rapporteur Andrea Marcolongo 3, are helpful in order to give a summary assessment of the works presented.

« The authors presented a wide range of contributions that offered an updated vision of the state-of-arts in this discipline. Most papers focused on sub-theme 5.1: “Technological Innovation”. Contributions illustrated the challenges between the needs of caring for Cultural Heritage and the appropriate use of Information Communication Technologies.

In terms of methodological and applied approaches, most presenters used well-established international practices, although some contributions provided original and interesting emerging perspectives, which evidenced that new frontiers of research can certainly assist efforts toward the Cultural Heritage preservation. Anyway, regardless of the use of new technologies, most authors reflected on the need of continuing to use of well-established methodologies that ensure a holistic understanding of the past while looking at the future. Furthermore, the characterization of acquired data in appropriate Cultural Heritage ontologies, as well as the management and accessibility of Cultural Heritage information, are another critical emerging issues. For example, the use of conventional GIS versus web based information systems or commercial software versus open source tools. In any case, during the debates, contributors expressed the need of using international standards to be able to compare or share datasets across discipline boundaries. In addition, the need for training was identified in overcoming the lack of comprehensive and common vocabularies, as well as the use of standards and procedures. Further to the dissemination and public access to digital data, a lack of consistent objectives for safeguarding Cultural Heritage was stated, such as how the use of new technologies can raise awareness or foster community participation in efforts towards heritage preservation.

Also the use of interdisciplinary approaches was repeatedly identified. Finally, acquired data and digital information will become itself part of these important Cultural Heritage assets.» (Grazia Tucci and Andrea Marcolongo)

« All the contributions emphasized the crucial importance of safeguarding the authenticity, although its definition in terms of material stratification appears quite difficult and very variable among the different restoration philosophies. These highlighted the challenge of the long-term preservation of sites, buildings, and monuments of high cultural interest and showed the fundamental contribution that the novel technologies can provide in order to address such a difficult goal. Besides some contributions, focusing on documentation and deterioration, the sessions also approached aspects related with the restoration potential, disclosed by the advanced technologies, the transformation of monuments, and the dialog among different cultures.» (Salvatore Siano)

On the basis of the outcomes of the works and of the extensive debate that is followed, both within Sessions at the General Assembly, a number of considerations came out that deserve to be briefly exposed in this Introduction.

Although oral presentations did not reveal substantial innovations, we can anyway say that new opportunities are emerging for the systematization of vast amounts of information, for the digitization of heritage, for the use of social media in order to support the control, the planning, the organization, the management, the interpretation and the monitoring of conservation actions, but also for the identification of new forms of exploitation and enjoyment. However, the specificity of the current situation shows the consolidation of a more open gap between the technological development, which follows its own exponential growth according to other external rules and factors, and the delay of a disciplinary debate for affirming different ways of using these technologies, based on a critical awareness that knows how to question the real and necessary validity of those same technologies.

Basically, how much we are conditioned by technology in our approach to the conservation process? Therefore how much, even today, our critical-conceptual apparatus is properly developed in order
to control the smart use of technologies that speed up, refine, display hyper-realistically a reality of artifacts to be preserved, towards their inevitable virtualization, and perhaps not make us unaware of their progressive material loss? To what extent are heritage and digital currently oriented towards establishing a new cultural approach, both to heritage and to digital, which can be able to develop a real integration between the two terms of the problem? Where are problematic positions, at the level of research community and management, which are able to focus the debate on the critical rethinking of what should be the role of emerging technologies and how can these really help to ensure the respect for diversity and the spreading awareness on the significance of the heritage?

It is necessary, and it can't be longer postponed, that the theme of the relationship Heritage / Technology acquires a new focus in our reflection. Our first commitment, that could be said ethical, must constantly combine values that come from the principles of conservation with technological innovation.

Basically, we should always look for the compatibility of the technological and digital world, and of the potentialities introduced by it, with the disciplinary needs expressed by the world of conservation. It must be our complete framework of needs to impose choices of design and realization in the world of research and technology production. We must therefore ask ourselves how and how much the enabling technologies should not be confined only to areas of routine application, or rather how these should offer added value in order to contribute to full equality, inclusiveness, sustainability of a growth that puts strongly the centrality of Cultural Heritage.

Reflecting on these and other emerging topics, we have identified and formulated the three keys with which the Theme 5 has contributed to the recommendations of the Final Declaration of Florence 2014. These, properly articulated, are:

5.1 Cultural Heritage objectives need to drive the development of emerging tools, not vice versa, so they can consolidate the centrality of Cultural Heritage
a - New tools and technologies should support the various steps of the conservation process, as a means and not an end, promoting the centrality of Cultural Heritage as a human right.
b - Guidelines and networks should be drawn up and shared for theoretical and methodological objectives and applications to ensure authenticity in conservation practice.
c - Guidelines should be developed for interdisciplinary research (including those related to funding policies) in a collaborative way in order to fill gaps - technological, but primarily cultural - between technology specialists and heritage practitioners, between managers and users of information.

5.2 Promote new technologies that are accessible and inclusive for shared cultural growth
a - Local and traditional knowledge should be respected in order to ensure a fair and profitable balance between cultures, knowledge, materials, traditional and innovative technologies.
b - The key role of non-governmental organizations in strategic partnerships should be recognized in order to improve conservation outcomes.
c - Platforms and tools for the dissemination of knowledge should be consolidated and shared in order to overcome cultural and social inequalities.
d - There should be an active contribution to the exchange of best practice in conservation processes through debate and discussion in professional communities, while seeking to avoid the duplication of efforts.

5.3 Facilitate collaborative standardization and simplification of procedures and tools
a - Internationally recognized and applicable tools should be developed in order to ensure accuracy, reliability, and verifiability of results and to ensure the possibility of comparative analysis both geographically and over time.
b - Priority should be given to user-friendly and low-cost technologies to ensure the adoption of tools that can be used for Cultural Heritage documentation, conservation and monitoring, as part of a virtuous circle.
c - On-line toolkits and open source platforms should be developed as a priority, to provide access to standards and procedures in Cultural Heritage conservation practice in a democratic way.
d - It should be ensured that the application of technologies to Cultural Heritage responds to well-defined key objectives, avoiding the risk of only making progress in the technological sector without improving conservation practice.

These keys are deemed priority actions, necessary to start giving concrete and shared answers to the problems addressed by the Theme.

1. Architect, Associate Professor of Topography - Dipartimento di Ingegneria Civile e Ambientale, Università Firenze.
3. Architect, Research grant - Istituto per le Tecnologie Applicate ai Beni Culturali, Consiglio Nazionale delle Ricerche, Roma.
Introduction
Theme 5 - Emerging tools for conservation practice

Sheridan Burke, Co-chair of Theme 5

Theme 5 papers included insights into new and innovative ways that heritage practice is using technology, from the smart phones that we all carry that are now being used for heritage conservation action - not just as a phone or camera, but for data recording and materials analysis, historic interpretation delivery and providing safely remote access to knowledge in ways that were frankly impossible, even at the time of the last General Assembly in Paris.

Theme five sessions looked at the use of drones in site recording, underwater robots at work, and extraordinary projects that deliver 3D modelling of heritage sites in minutes and hours, where a traditional survey team would have been working at their drawing boards for months.

There is no doubt that electronic communications and technological advances have fundamentally changed all our daily lives (with huge regional and cultural variation in uptake and access) and theme 5 presenters introduced a variety of case studies that demonstrated the diversity of applications of these emerging communication tools - from site management planning to interpretation delivery.

The use of social media in heritage advocacy activity for example is facilitating ICOMOS work in terms of defending heritage places under threat - the use of instant International communication and activation is exemplified in the ICOMOS Heritage Alerts system. Focussing international attention on threats to heritage places is clearly influencing decision makers - ICOMOS ISC20C Heritage Alerts cases in Stockholm, Hong Kong and Mexico and Spain have all proved the success of swift international assessment and communication efforts. The exposure of these cases has meant that decision makers no longer feel answerable solely at a local level, when an international spotlight shining brightly upon them in the social media.

And with this speed of communication comes an urgent responsibility for us all as heritage practitioners to understand and if we can, take up the opportunities of these emerging technologies.

We were indeed privileged to be able to hear these presentations in person, and debate with the presenters their thoughts, but for our colleagues unable to join us in the glorious city of Florence, alternative access means are today mostly via the internet and social media.

The ICOMOS networks can now widely share expertise and experience through on-line platforms. The ISC on Twentieth Century Heritage and ICOMOS Australia have already successfully initiated such platforms for heritage toolkits, uploading best practice guidelines and examples for open access.

A resolution was passed at the General Assembly for ICOMOS international to establish an on-line Heritage Toolkit unanimously supported by members, because the ICOMOS brand, as the authoritative standard best practice and benchmark reference point must be upheld and communicated.

The challenge is to each of us to contribute, not only our hard-worked office bearers and Secretariat.

The 34 papers selected to be delivered (by 56 collaborators) in Theme 5 provided ideas and concepts that could well change members daily working lives in terms of practice and teaching. But it’s not only about wiz bang technology (although 50% of the papers featured such innovations), it’s just as much about implementing or mashing concepts, theoretical tools and ideas, and finding new applications for use in engaging community.

The significant majority of the papers were offered by universities and research institutes, naturally at the forefront of technological innovation and educational development. Whilst the speakers may hale from one region, their research focus is commonly elsewhere, truly multi-cultural teams are collaborating on projects all over the world that will be showcased in following days.

Fewer papers were offered by practitioners and community groups - a personal disappointment to me, as it’s the practical implementation that I am always excited to see.

Geographically the papers in theme 5 were disappointingly very few from Africa, the Arab World and Latin America, and only one paper represents each of those regions in theme 5; offers were numerous from the Asia Pacific region, especially from China, but only 4 were finally selected from that region. Fewer offers came from North America, where 4 were selected.

Not surprisingly, the majority of papers that were offered came from Europe, and 23 speakers will represent this region including 6 from Italy and 5 from the UK. 1.

The geographical distribution of papers suggested as much about where ICOMOS is well-known as about where we might expect to find innovation and speakers adept at sharing their knowledge, and the reach of speedy communication technology.

Amongst the very diverse range papers (which will be accessible on line), several stood out to me as being of particular relevance.

Around the world, funding for heritage conservation is in decline, statutory management is less
than enthusiastic, politicians have moved on to more pressing environmental matters. Even the word “heritage” has left government stationery, as Department names change to reflect other priorities. Specialist resources have diminished as the buffeting storms of failing economic models have hit us all very hard in the new century.

This forces us all as ICOMOS members to be very alert and attuned to doing "more with less", and to collaborate and engage for heritage outcomes in a diversity of ways not previously thought of as being “heritage main stream”. Long gone are the days of extensive government financial support for heritage research, diminished are the public resources for conservation at local, provincial, national and indeed at international level. Today it’s all about public private partnerships and outsourcing expertise, and the importance of sharing international standards and benchmarks has never been more important.

Susan Macdonald of the Getty Conservation Institute, described a noticeable diminution of funding for government led research, analysis and policy development, which meant that philanthropic funding often needed to be directed toward basic investigation, rather than exploring new/emerging areas of research in the heritage sector, a fundamental shift of emphasis.

Several speakers examined themes around the potential democratisation and improved accessibility of heritage information and places through using technological innovation.

Hossam Mahdy spoke of his ICCROM work developing a glossary of conservation terms including selected philosophical and theoretical concepts of Arabic-Islamic heritage which should enrich the universal debate and approaches to the conservation of cultural heritage internationally.

Theme five sessions included for case studies from across the globe- from Tunisia to Antarctica, Sydney to Canada, China to Morocco, as well as opportunities for publication and posters, several of whom were invited to speak when we have absent speakers.

I thank each member of our eventually 9 member committee for theme 5, who devoted days of time to the reading and selection tasks, and I thank my co-chair Paolo Salonia and committee members:

- Mina Elmgari Morocco,
- Ayako Fukushima Japan,
- Cristina Lamandi France,
- Trinidad Rico Argentina,
- Mario Santana Canada,
- Claudia Ventura Italy.

I offer special thanks to a co-opted committee member, Smriti Pant India for her wizard Excel spreadsheet skills and patience with endless changes and delays.

1. **EUROPE 23**: Germany 6 Belgium 2 UK 5 France 2 Greece 2 Switzerland, Israel 2 Portugal Netherlands; **ASIA PACIFIC 5**: Australia 3 Japan Singapore; **AMERICA N 4**: USA3 Canada; **SAM 1**: Colombia; **ME 1**: UAE.
Theme 5: Emerging tools for conservation practice
Theme 5-1: Technological innovation

Complex Assets Management Tools: The Strategy of Preventive and Planned Conservation for the Built Cultural Heritage in the Historic Park of Monza

Anthousa Konsta
Polytechnic University of Milan, Italy

Abstract

This paper concerns methodologies and tools for the implementation of the policies of cultural development, pointing to a systemic vision of the cultural heritage and its more efficient process management. Preventive and planned conservation is a strategy based on a long run vision, giving priority to the risk assessment and to the mitigation of decay causes.

The Park of Monza and its monumental complex constitute a cultural heritage of national interest and this study aims at the identification of an operational model for the complex assets management.

Keywords: Prevention, Planning, Management, Large Scale Strategy, Long Run Process

Scientific and cultural reference: the preventive and planned conservation.

The preventive and planned conservation is based on the strategies of prevention and care and it is opposed to the traditional practice of restoration as a solution to all problems and promotes instead a dynamic view of a long-term process. «The preventive and planned conservation is the methodology and practice of the physical preservation of the architectural heritage, founded on an accurate risk assessment, as well as on the promotion of systematic maintenance practices, minimally invasive and highly selected, so as to delay the restoration, extending in time the efficient cycles of the operations, with obvious advantages both of an economic and cultural order.»

Giovanni Urbani, director of the Central Institute of Restoration (ICR) from 1974-1983 is the first to develop the concept of planned conservation and to support the necessity of wide-ranging preventive action, based on a thorough knowledge of the building and its relations with the context. The pilot plan for the planned conservation of cultural heritage in Umbria is the application of his theoretical elaborations.

In the period between 1992 and 1996, the ICR carries out the Pilot Plan, initiating the Risk Map, a tool that crosses the knowledge of the consistency and distribution of the cultural heritage and its vulnerability to the hazard present in the specific area.

From 1998 onwards, regional studies have been developed on a scale of greater detail with the aim of overcoming the limits of the Risk Map. In particular, the Region of Lombardy from 1999 promotes various researches and tools, to arrive in 2003 to issue guidelines for the conservation plans of the historic buildings.

Since 2004, the concept of conservation is formalized by the article 29 of the Cultural Heritage and Landscape Code, which provides that: conservation of cultural heritage is ensured through a consistent, coordinated and planned activity of study, prevention, maintenance and restoration.

This study aims at the identification of an operational model for the complex assets management through the integration of both conservation and enhancement of cultural heritage.

The focus of the methodology is twofold: first, the analysis of the state of conservation of the built heritage that determines the intervention priorities and the scheduling of controls and monitoring; second, the design and the creation of a database for inputting, storing and managing the continuous acquisition of information.

The results of this research are illustrated by the layout of guidelines, able to control and manage the future transformations of the buildings, in a dynamic perspective of long-term process.

A brief history of the Park

In 1777 begins the story of the architectural and landscape project of the Park of Monza, where are intertwined the names of famous architects such as Giuseppe Piermarini, Ludwig Engel, Friedrich Schiller, Luigi Canonica and Giacomo Tazzini.

Piermarini prepared the draft of the Villa Reale as a country residence for the archduke Ferdinand of Austria, according to the most important European examples of eighteenth-century royal residences. The villa opens onto the gardens, designed according to the principles of the formal French manner which are then enlarged and embellished in accordance with the principles of the English garden.
The Park was created by the will of Eugene de Beauharnais, Napoleon’s stepson and viceroy of the Kingdom of Italy, as a complement to the Villa Reale, built several decades earlier by the Austrian Government. The Park was officially established by Napoleonic decree on 14 September 1805, as a place of delight, farm and hunting for the members of the government.

The architect Luigi Canonica designed the park and a number of buildings of high architectural quality, able to form a system of agricultural infrastructure and techniques used for the cultivation of the funds and their maintenance. Canonica maintains the position until 1824, and from 1808 was flanked by the architect Giacomo Tazzini. During the nineteenth century the park was managed first by the Austrian government and then by the Savoys, who ceded it to the community in 1919. The advent of World War II led to the transformation of numerous architectural structures in the park.

In 2009 was established the Consortium of Villa Reale of Monza Park, the present Consortium of Reggia di Monza. The new entity has as its primary objective the restoration and enhancement of the monumental complex of the Villa and the Park, by adopting a model of sustainable development and also promoting cultural activities of high institutional representation, starting with Expo 2015 that will be hosted in Milan.

The rural architecture in the Park

Today, the Park of Monza is one of the largest historical parks in Europe and the largest enclosed park, with a wall long 14 Km. It includes agricultural areas and farms, residences, sites devoted to culture and environmental education, accommodation and restaurants, leisure and sporting activities, the autodromo of Monza, forming an important landscape, of historical and architectural value.

The Park and its architecture are the result of Luigi Canonica’s laudable research to design a large rural territory in the service of an aristocratic dwelling with the renovation and rehabilitation of the existing buildings to the functional requirements and the new aesthetic, with the insertion of tree-lined avenues, creating visual relationships, perspectives and beautiful views, the valorisation of the natural elements, and the rehabilitation of the water supply. The new plans, the rich facades, the construction materials and care in the execution of the particulars demonstrate the high architectural quality.

In addition to the buildings in the Park, there are other smaller buildings, spontaneous and scattered in the green, part of a larger system of paths of visual axes and driveways and some small infrastructure, for example the bridges and the gates of the entrances, all of a high architectural interest.

The renovation, expansion, integration and the demolition of these structures had different reasons, depending on the cultural and historical context in which decisions were taken each time. Currently many of these buildings show signs of use transformations that occurred in the first half of the twentieth century, they have different problems and their conservation status varies.

The operating model

The objectives of this research are not only the preservation of the historic heritage according to the strategy of preventive and planned conservation, arresting the degradation with planned actions of monitoring and regular assessment of the condition of the buildings, but also the dissemination of good practices, creating a gradual change of the user’s attitude over the time through the dissemination of information and awareness.

The operating model is divided into seven phases:
1. gathering and verification of existent information,
2. condition assessment,
3. elaboration of a detailed record card,
4. planning of conservation activities,
5. cost evaluation,
6. data management,
7. raise awareness and affect mentality change.

The first step regards a preparatory work of gathering and verification of existent information and documentation relating to the built heritage and the examination of similar activities previously carried out on the territory, with the aim to re-order the results. The gathered material, in the second phase is enriched with an accurate collection in the field, with photographic surveys and interviews, of data relating to: the constructive materials and technologies, the condition assessment and the interactions between the different technological elements.

The third phase regards the processing of the information and the elaboration of a detailed record card of the condition assessment of the constructive elements. This record aims at the drawing up of a plan of priority actions. Before filling in the record card we proceed to an analysis of the artefact in technological classes, so as to outline the architectural structure and the relationships between the different parts. The record card contains information about the constructive materials, technologies, the description of both qualitative and quantitative degradation and
provides recommendations for the interventions divided in: preventive actions, regular monitoring, maintenance activities and repair or restoration activities.

The fourth next step comprises the planning of conservation activities and it includes:

1. A list of priority actions.
2. Methodological guidelines for the typical interventions, identified as a priority and are necessary to address the various problems that have emerged from the analysis, which are related to the defects, the degradation of the materials, the mechanisms of structural instability and deficiency of the requirements of comfort.
3. The Programme 5 of long term activities concerning the planning of monitoring, preventive actions and maintenance operations. Within the document are shown the manner and the timing of the planned activities.
4. The User’s Manual 6 is a set of instructions on the procedures for a better participation in the building control, preventive actions and cleaning that may be entrusted to the user directly and it is analyzed also according to the technological elements.

The fifth step involves the assessing the costs of conservation. The costs are calculated for a medium to long period of time from ten to twenty years and are attributable to the costs arising from: preventive actions, inspections and diagnostics activities, maintenance activities, any additional charges for the conservation of the building taken by the user.

The sixth step regards the data management. All the information acquired constitute a fundamental tool, which combined with those available on the buildings, produce a wealth of data, that once made available, queried and updated, represent one of the major outcomes of conservation activities. Subsequently to the creation of a database, it is proposed the integration of the system with a GIS platform for a more efficient management of relational database.

The final step consists in raising awareness and affecting mentality change. The meetings with the users of the buildings during the inspection activities could be an occasion of diffusing practices for the proper maintenance of the asset, emphasizing in this way their important role and contribution to the process of conservation.

To raise awareness of the user is also useful to spread information material with illustrations and sample Figures, organize meetings and educative courses, organize exhibitions, as well as drafting a user manual.

Conclusions

The study carried out in the context of the Park of Monza represents an attempt to apply the methodology of preventive and programmed conservation on a complex asset and is thus presented as a first methodological approach of analysis. The set of guidelines for the management of the heritage within the Park, the result of this work, can be applied to the buildings in the Park with different uses and in this way it becomes an operational model of management that promotes the vision of procedural and systemic problems. This will limit the use of isolated and episodic actions and pursues the search for an efficient strategy and organization on long term.

1. The present paper is based upon the author’s graduation thesis in the master “Preventive and Planned Conservation for the valorization of Cultural Heritage” and the stage in the Monza and Brianza Cultural District, in collaboration with the Consortium “Reggia di Monza”.
2. (Della Torre, 2004).
3. In the Legislative Decree 42/2004, Code of Cultural Heritage and landscape, in accordance with Article 10 of the Law of 6 July 2002, n. 137, art. 29 shows the following definitions: prevention is the complex of the proper activities so as to limit the risk situations related to the cultural heritage in its context; Maintenance refers to the set of activities and interventions designed to control the conditions, maintain the integrity, efficiency and functional identity of the built cultural heritage and its parts; for restoration refers to the direct intervention on the building through a series of operations aimed at the material integrity and the recovery of the same built heritage, to the protection and the transmission of its cultural values.
4. This type of approach is based upon the successful example of the non-profit organization Monumentenwacht, operating in several European countries (The Netherlands, the Flemish region of Belgium, Germany, Austria and Hungary) by performing periodic inspections, offering a regular condition assessment of the building and providing recommendations for maintenance and repair.
5. The program is one of the four documents (Technical Manual, Conservation Program, User Manual, Cost Assessment) that constitutes the conservation plan as it is derives from the Guidelines for the Conservation Plan, published in 2003 that contain not only a methodological introduction to the preventive and planned conservation, but also a part of rules for the compilation. See 1) Valeria Pracchi, The conservation program: methodological guidelines for preventive activities, 2) Chiara Sotgia, The conservation program: methodological guidelines for the monitoring activities, in (Della Torre, 2003).
Bibliography


Consorzio Reggia di Monza (2014): http://www.reggiadimonza.it/

Figure 2 - Mulini asciutti (mills).

Figure 3 - Cascina del Forno (farmhouse).
Abstract

The presented proposals concern the use of GIS technologies (Geographical Information Systems) for CH conservation data storage and management in order to arrange permanent and useful archives, even at the architectural scale, making controllable, correctable and improvable all the archived data. Such applications intend to satisfy some relevant and basic requirements: the need of easily query and detect systems, the interoperability and the easy access to the data. One first starting point consists in the use of terrestrial laser scanning and dense matching techniques for high detailed 3D point clouds generation. This approach is able to promise sustainable characterizations of many phases of conservation plan. Three cases study have been considered, all of them share the deepening study on façades of historical buildings, some of them use open source platform GIS, and geometric and topological relations among spatial data to base thematic comparisons.

Keywords: GIS, Façade Stratigraphy, Open Source Tools, 3D Models, Reality Based Models

Introduction

In recent years more and more technologies for managing data have been developed, which could play a key role in storing and sharing data about Cultural Heritage (CH), for documentation, preservation and maintenance aims. Usually GIS has been used for territorial studies and governance but recently some applications at architectural scale for the management of Cultural heritage has been developed. These platforms are structured using theories and tools deriving from different disciplines and they manage graphical data produced by metric survey and modelling. In the present paper we report the use of GIS tools to originally manage the data about façade stratigraphy, pathology and hypothesis of interventions.

Background

Standards for Cultural Heritage

The necessity of standards to create high quality inventories for immovable heritage is well recognized: standards are indispensable to preserve data, ensure their migration among systems and increase access, indeed the implementation of accessible systems and supported standard has become necessary in the CH area. The wide spread of standards has reached many sectors, such as spatial data, museum archives and photo inventories. But while the spatial data sector can refer to standards codified and adopted at international level (GML, CityGML), in the CH area the framework is more uncertain.

The CH international institutions, like UNESCO, ICOMOS, ICOM-CIDOC, CIPA and Getty Research Institute, have made significant efforts by developing guidelines, recommendations, ontologies and structured vocabularies: in this complex framework it is possible identify some effective standards applied to CH, tested with good results. CIDOC-Conceptual Reference Model (ISO 21127), defined by International Committee for Documentation with International Council of Monuments, is a formal ontology for exchange cultural heritage information and semantic interoperability; MIDAS Heritage, developed by the Historic Buildings and Monuments Commission for England, is a data standard free available for recording information about CH and adopts the INSCRIPTION, a collection of wordlist for monuments’ classification; Category for the description of Works of Arts (CDWA), defined by the Getty Research Institute, describes the content and format for records of art database, including architecture. In Italian framework, some efforts has been made by the “Commissione NorMaL” (NORmalizzazione Materiali Lapidei) in the field of monuments’ restoration to define unified methodologies and specifications for the materials’ conservation. These guidelines are to become standard UNI (Italian) and aim to be recognized in Europe.
**GIS use in CH conservation plan**

GIS are specific Information System for the storage, management and processing of data, in close connection to their geographical location. GIS allow to combine diverse needs of different users and also to study an object with a multiscale approach, this is the reason why they have become an important support for any kind of knowledge and planning phase in many sectors of human life and interaction with the land.

Nowadays GIS tools are more and more used for the protection and conservation of Cultural Heritage. Central and local authorities responsible for cultural heritage experienced on creating complex and integrated GIS recognized as a useful aid in the decision-making phase at different scales. This success is explained by the intrinsic spatial connotation that characterize archaeological sites and Architectural Cultural Heritage, where elements are closely linked to the landscape in which they are located and a multiplicity of heterogeneous information regards specific parts of artifacts. Furthermore, the Historical-Architectural Heritage is subject to continuous use, and also, over time, to maintenance, repair and restoration. For this reason it is essential to be able to document and record the transformations, in order to allow a continuous updating and monitoring. In restoration and monitoring phase, GIS tools represent an important support to understand the phenomena, the causes, and to head to the planning phase.

Since nowadays the open source tools are increasingly under interest in CH environment, it is remarkable that the most popular Open Source GIS projects are collected by Open Source Geospatial Foundation and they refer to standards of the Open Geospatial Consortium (OGC). Examples of GIS tools are: GRASS GIS (Geographic Resources Analysis Support System), QuantumGIS, GIS with user friendly graphical interface, SAGA GIS, System for Automated Geoscientific Analyses, MapWindow, for modelling and analysis, ILWIS (Integrated Land and Water Information System) GIS with Figures analysis and photogrammetric functions.

**The façade stratigraphy as a palimpsest of the building history**

Archaeology and later Architecture specialists borrowed the stratigraphy science from Geology, adapting it to their needs and applying it to archaeological sites and cultural heritage. The application of the stratigraphic method in archaeology arises from experiences conducted by Edward C. Harris starting from 70s (Harris, 1979). This transposition was made possible since the human activities of construction, destruction and transformation are considered similar to the natural forces of erosion and deposit. The same reasoning has allowed subsequently to extend the principles of stratigraphy to architecture too as a support for the restoration phase (Parenti, 1988). Contrary to the destructive nature of archaeological excavation, the stratigraphic analysis applied to architectural built heritage is a non-destructive knowledge method and an invaluable resource for the comprehension of the building’s transformations. (Doglioni, 1988)

The use of the term “palimpsest” for alluding to an architectonical façade is now widespread: from a façade we can derive and map lots of data about the building, and we can use this information in order to optimize the restoration and the conservation of each artifact. Practically, this analysis consists in the definition of the different historical phases that are readable on the walls themselves, and in their collocation at first in a relative chronology, named stratigraphic sequence, and then in an absolute chronology, using historical sources.

The process starts with in the identification of the stratigraphic units (SU) which represent a building action (construction/positive SU or demolition/negative SU) with temporal and material autonomy (De Guio, 1988). Surely this operation took advantage of digital Figures and their geometric correction, that allow to generate several representations (3D models, ortophotos) on which it is possible to study the object more in detail. The following step consists in the evaluation of the temporal relations between units and in the developing of the Harris matrix: a scheme where all the SUs are organized, according to the relative chronological sequence, allowing a diachronic and synchonous reading of the palimpsest. A final step consists in the historical and documentary research to assign specific data or period to the SUs identified.

The stratigraphic survey can be applied at widely different scales: at the territorial scale, considering the building and its context, or at a larger scale on architectonical fronts. With this method it is possible to map different materials, degradation, pathology, architectural elements, historical phases and so on. Some works have been made reading façades as a palimpsest for analysing the chemical changes of the façade materials (Sgobbi, 2010). Other works, more similar to the archaeologists’ ones, was aimed at identify the chronological sequence of the events, archiving subsequently all the information in a GIS where query and study all data processed (Trizio, 2007). Another similar work, but with a finer level, analysed micro-layers on the buildings (Casarino, 2001). The examples could be a lot, considering that the practice to interpret a historic building requires the individuation of a multitude of its characteristics, readable on the façades.

**Geomatic multisensor methods to generate 3D models suitable for deep readings**

Geomatic multisensor tools are affirmed methods for the knowledge and documentation of Cultural Heritage, as a number of experiences prove. Two of the most widespread techniques to acquire 3D information are LiDAR (active sensor) and digital photogrammetry (passive sensor). These techniques allow to acquire high precision data, suitable for several applications, and to generate well shaped 3D products (point clouds or meshes, both textured or not) on which it is possible to study the geometry, the material, the degradation and pathologies, the structure, the projected volumes and also the construction techniques by the individuation of the generating profiles.
LIDAR techniques allow to acquire a big amount of data; such collections are useful for the CH documentation, also thanks to the precision of measurement, high productivity, operational flexibility. Digital Photogrammetry has a wide application in CH documentation thanks to the developing of semi-automatic and automatic systems, based on Figure matching. These systems take advantage of the searching for corresponding points among Figures shoot by different positions.

By now the feasible 3D models are a consolidated representation in the field of CH in fact from this kind of data it is even possible to extract powerful 2D information (profiles, orthophotos, plotting, etc.)

**Three case studies**

The geomatic methods have been used to acquire data about the geometry and the thematic characterization of the buildings in the three presented examples. The first project illustrates an area-based matching test experimented for the Villanova Sepulchre, forming a part of the Sacro Monte di Belmonte (UNESCO Heritage, 2003). This technique requires a similar shooting geometry to allow a best correlation matching; then the surface material of the object is a key factor, since the search of correspondences is based on the radiometric intensity. 3D metric model was built in order to examine morphologic and thematic characters of the building and to extract all the necessary information, such as profiles section or orthophotos.

The advantage of this approach derives from the low costs of acquiring systems and make it particularly suitable in the CH field with low financial resources.

The second case study presented consisted in a 3D survey of a portion of the Staffarda Abbey Church of Santa Maria, made by terrestrial laser scanner techniques, and in the stratigraphic analysis of the north façade, followed by the data implementation in a GIS platform at the architectural scale. From laser point clouds several Figures have been extracted for 2D traditional plotting, then a 3D textured model of the church was developed in order to study the geometry, the material, the degradation of the Church and its structure at diverse height.

The third test, the 3D survey of the ex Convent of the Carmelite at the “Colletto”, was performed using integrated technologies aimed to collect data about some possible pathology’s cause and to verify existing plans. The terrestrial laser scanning technique had to define the asset of the two building wings, the position of the bell-tower and the relief of the court terrain, which was altered by the past stocking of demolition material of other two building wings. This could be the cause of the converging of meteorological waters on the northern-east part of the building and its consequent degradation due to humidity and capillary rise. A DEM (digital elevation model) of the court was produced, verifying the direction of meteorological water toward the building. Moreover, the survey is integrated by a photographic redressing of the back front of the NE building wing, which was the base for the pathologies analysis in a GIS.

**GIS testing for façades analyses**

The three applications in GIS environment represent three different phases of data collection and analysis in conservation plans: after survey data storing, the arrangement of a metric and non metric Figures archive by open source tools, a stratigraphic analysis for recognizing the different historical interventions and the phases of the building construction, the third detection of damages in order to point out next maintenance. Each phase is related to a different architectural asset, in the same order as described in the previous paragraph.

**Metric/non metric Figures archive managed in open source GIS (Sacro Monte of Belmonte)**

This application regards a GIS test to manage an archive of metric and non metric Figures useful to support conservation actions. The study was conducted on a specific sample of the Sacri Monti, devotional hilly routes including many chapels, where other assets, such as paintings and sculptures, are conserved. This work started from a data storage on the preservation state of the chapels using the simple photographic technique and the Figure matching technique for survey: the results have been stored by successive deepening levels (photographs, ortophotos and 3D models).

The products so obtained, carrying different information levels, were stored in a GIS tool, structured according to a multi-scale approach, from territorial scale to architectural scale with analysis of materials’ degradation starting from Figures.

The system has been carried out by open source tools: QuantumGIS for managing geographical database and maps creation and PostgreSQL for store Figures and alphanumeric data. The cartographic base implemented was structured through the re-elaboration of: CTR Piedmont Region, CTP and Orthophoto of Turin province, Forest Map and Aree Protette map (fig. 1). In addition to mapping, the attribute tables related to chapels’ features were associated to geometric entities, while attributes about technical information and decay’s analysis were joined to sensible areas directly on photos and orthophotos of the fronts.

Quantum GIS provides many functionalities and supports the connection to PostgreSQL, an advanced open-source Object Relational Database Management System (ORDBMS) based on Structured Query Language. It presents many advantages to operate on CH data storage: provides excellent spatial support, the ability to handle
large volumes of data, the instant recording of changes and above all the shared use among multiple users, since it is based on a client-server system. The standard interface of PostgreSQL, PgAdmin, allows to create and manage databases, tables, and store many type of data, which the Figures, simply providing their paths. The XAMPP platform that includes Apache, PHP and the extension for PostgreSQL (php_pgsqldll), allow make possible the Figures visualization by starting from a php script connection and so the loading data on a web page. With this method it is possible to carry out many analysis and queries on data, for example to find out the buildings in the worst conditions or to select the materials affected by certain types of degradations and it offers the possibility to assessment the priority of intervention (fig. 2).

A stratigraphic analysis managed in GIS environment (Santa Maria Church - Staffarda Abbey)

The work was dedicated to the survey and stratigraphic analysis of the north façade of the Santa Maria Church of the Staffarda Abbey and to the data implementation in a GIS for the architectural scale. This test aimed at proving the potentialities offered by these methods as a support for interdisciplinary knowledge and planning phase. The first step of the analysis was the Stratigraphic Units identification and their plotting, using point clouds and projected Figures of them, followed by the research of temporal relations between each SU and its adjacent ones, (fig. 3). The further step was the data implementation in a GIS so that it was possible to easily retrieve information from the stratigraphic analysis managed in automatic computation. In particular the goal was to create a model able to perform automatically the retrieval of spatial and temporal relation among SUs and to highlight the type of relation they have. To achieve this, new geometric entities were created in a structure based on topology in order to comply with the model structure: the architectonic elements were divided into singular entities as well as stratigraphic analysis data. In addition, a classification of stratigraphic information reached from the analysis was created and associated to spatial data.

The results of this work satisfied the predetermined goal since the system is able to highlight in the façade through a Query any SU, its adjacent ones and their several and different relations (fig. 4).

As a consequence, it was also possible to develop the stratigraphic sequence (matrix Harris) adding a new attribute linked to each SU, concerning its being contemporary-anterior-posterior to the adjacent ones.

The last elaboration consisted in several thematic data mapping. This feature offered by GIS is surely a remarkable potentiality because it allows the representation of only some selected information in favour of a better data interpretation. In order to show this, the different kind of architectonic elements, the SUs typologies, the temporal relations and the stratigraphic sequence have been represented with different colours in the final graphical products (fig. 5).

Graphical support to the preservation plan using new technologies tools (ex Convent of the Carmelite)

The experience was aimed to formulate a graphical support to the preservation project, so the mapping of the selected façade has been managed using a GIS. These systems permit to store related and georeferenced information about the façade, and the building, through the time (the 4th dimension they can manage).

For arranging the system a conceptual model was constructed using the entities “Surface”, portions of the façade characterized by an only material and an only pathology; “Material”; “Pathology”; “Intervention” (fig. 6). For the classification of these last entities a widespread method has been used, since standardized schemas and terminologies are not yet available. The rules established in this model and in the specification tables were followed to construct a coherent and unambiguous database using commercial software ESRI ArcGIS and MsAccess. This could be equivalently done using open source softwares, for maximizing compatibility and interchange of information through the time.

The “surfaces” were directly mapped in ArcMap on the reference of the redressed NE front of the building, and the values of the data tables “Material”, “Pathology”, “Intervention”, filled in in MsAccess, were automatically joined to each surface using ArcGIS Tools. In this way, for each surface we know simultaneously all the information about it, and we can simply read it, or automatically produce thematic maps, even by combining different values, execute queries (fig. 7), export tables with selected values.

All these possible operations permit to eventually infer other information from the whole system. Moreover, by reading attribute values such as “Pathology - Possible Causes” or similar the Restorer can be helped in his choices or can reach knowledge about the artefact in a faster way. Condition of this is the updating of the tables following innovations, discoveries, technologies.

Perspectives

In Cultural Heritage Conservation it is strictly necessary to have available the more information and knowledge as possible about each cultural asset, in order to effectively plan interventions and valorisation activities, in compliance with the needs of planned maintenance and according to the best-established practises and rules. Recent systems as the one we presented are able to save resources, in particular considering the different specialized investigations...
that are needed in any knowledge phase. Moreover, the representation of building façades performed by means of presented strategies could become part of the stratus in their history. Some extensive project have been fulfilled or they are still in progress; 3 furthermore recently several applications for data documentation and storage at architectural scale have employed BIM (Building Information Modeling) systems in place of GIS ones. BIM are parametric systems that allow to develop, in a 3D environment, computer generated model in which each element has related information. A building information model, in fact, collect different kind of data about building elements (dimensional, geometrical, constructive, thematic and historical information). HBIM (Historic Building Information Modeling) are recently tested for architectural heritage in order to collect different kind of 3D data to support the conservation and management phase.

Finally it is relevant to underline that there is a lack of common international standards for analyse cultural assets in their specific characteristics (we used the only available standard, which is for Figures 4); testing guide-lines and achieve experiences is the best way to approach them.

2. The development of diverse algorithms for Figure matching techniques, or comparison between active or passive methods are reported in many works, even from our group. (Chiabrando, F., Spanò, 2013 A., Points clouds generation using TLS and dense-matching techniques. A test on approachable accuracies of different tools. ISPRS ANNALS, II-5/W1. Chiabrando F., Lingua A., Noardo F., A. Spanò. 2014. 3D modelling of trompe l’oeil decorated vaults using dense matching techniques, ISPRS ANNALS, II-5/W1.)
3. Knowledge Plan for Pompei’s integrated conservation, is a GIS for archiving and cataloguing descriptive and geographic data of the archaeological site. Many GIS and software applications are also related to architectural heritage: ARKIS software (Architecture Recovery Knowledge Information System), fulfilled by CNR, is a system for the storage of data at architectural scale with both GIS and CAD functionalities; SICaR is an Information System dedicated to the documentation of restoration site and SIArch - Uniaq, fulfilled by University of L’Aquila, is a GIS finalized to the conservation of the historical architectural cultural heritage.
4. Data-Dictionary SKOPEO-BMS. Information about the Figure. RLG Working Group on Preservation Issues of Metadata.

**Bibliography**


Figure 1 - Visualization of chapels Figures on Sacro Monte map.

Figure 2 - (left) Visualization of decays in QGIS from photos and orthophotos of chapel fronts; (right) the web page connected to PostgreSQL to visualize the photos inventory.

Figure 3 - Stratigraphic analysis of the north facade conducted from the laser scanning point cloud.

Figure 4 - Result of a query about a SU: the system allow to identify the SU and its adjacent ones (left) and also to process a thematic representations according to the different type of relations they have (right).
Figure 5 - Thematization of the stratigraphic analysis: (left) the different type of relations between a SU and its adjacent ones are reported with different colours, (right) the Harris matrix relative to one SU is reported with different colors on the facade.

Figure 6 - ER model for the formulation of the preservation project in a GIS.

Figure 7 - Mapping of a Query retrieving the damaged plaster executed on spatial and textual data.
Theme 5: Emerging tools for conservation practice
Theme 5-1: Technological innovation

Landscapes beneath the Sea and Emerging Tools for Assessing and Managing Their (Heritage) Values

Chloë Clearhout
Ghent University, Krijgslaan, Belgium

Maikel De Clercq
Ghent University, Krijgslaan, Belgium

Ine Demerre
Flanders Heritage Agency, Brussel, Belgium

Tine Missiaen
Ghent University, Krijgslaan, Belgium

Marnix Pieters
Flanders Heritage Agency, Brussel, Belgium

Sven Van Haelst
Flanders Heritage Agency, Brussel, Belgium

Oscar Zurita Hurtado
Ghent University, Krijgslaan, Belgium

Abstract

Underwater landscapes including buried prehistoric landscapes are in focus of the international archaeological community as they are endangered by increasing commercial activities at sea and by unawareness. Especially for buried landscapes improved techniques or improved combinations of techniques for detection and evaluation are needed. A strategic research project in Flanders ‘SeArch - Archaeological Heritage in the North Sea’ (2013-2016) has the ambition to contribute to the solution of this challenge by developing an efficient methodology for imaging the sub-seafloor via the smart use of test-sites both in the offshore area and in the intertidal zone.

Keywords: Underwater Landscapes, Technological Innovation, Sub-Bottom Detection, Conservation Practice

Introduction and research context

The southern North Sea has been attractive for human settlement throughout the late Quaternary. During periods of low sea level (up to 120 metres lower than today) large parts were dry lands crossed by large rivers such as the Thames, Meuse and Rhine. These areas were attractive for animal and human communities and often crucial in the development of (prehistoric) societies and civilisations. The heritage values of these (prehistoric) underwater landscapes, nowadays buried below the seafloor, are today in focus of the international (geo)-archaeological community as they are very much endangered by the increasing commercial activities at sea and by general unawareness. International initiatives such as Splashcos (www.splashcos.org) and the recent position paper by the SUBLAND working group of the European Marine Board are instrumental for raising the awareness in this respect. As more and more examples of well-preserved underwater landscapes with associated archaeological features have come to light in recent years, the need for developing new technologies or at least for improving the existing technologies for detection, assessment and management of these landscapes is widely recognized.

Many technologies and techniques are currently available for underwater exploration but none of these is primarily developed from an archaeological perspective, and access to these technologies is also often restrained by their cost and fast evolution. Furthermore, an optimum method to apply technology more effectively is lacking. A current management practice in archaeology is to use the technologies within easy reach. In practice, this means mostly technologies that map the actual seafloor and don’t require much work for data treatment or processing (such as the multibeam echosounder or the side scan sonar echosounder). These techniques provide a lot of valuable information mainly on anomalies in the topography of the seafloor, and with increasing resolution, but they have
much difficulty in distinguishing anthropogenic features from natural phenomena. Furthermore, they stay mute on what happens beneath the seafloor. From the heritage perspective techniques are needed that can look into the seafloor with sufficient detail, i.e. with a resolution adapted to archaeological needs, and that also allow improved interpretations of the acquired data in archaeological and landscape terms.

A new research project financed by the government of Flanders 'SeArch - Archaeological heritage in the North Sea' (2013-2016) (http://www.sea-arch.be/) has the ambition to contribute to reaching this goal. The project aims to improve and tune the existing techniques to the specific archaeological targets. This is done through a thorough analysis of the available (conventional and non-conventional) technologies for the detection and assessment of landscapes and archaeological sites below the seafloor, beneath present-day sandbanks offshore as well as in the intertidal zone. This involves the smart use of test-sites representing different physical/geological environments and containing known heritage or important palaeolandscape features in the subsoil, which allow to test the ground-truth for the obtained geophysical (remote sensing) data. This test-site approach will allow, via trial and error procedures, to determine which technique (or rather which combination of techniques) produces the best result from a heritage perspective. The first results of this project will be briefly commented on through the presentation of the work done at two of the selected test-sites: an intertidal/subtidal test-site (the beach of Raversijde and adjacent nearshore area) as well as an offshore test-site (the Ostend Valley).

The ultimate goal is to provide practical guidelines for an optimal research methodology that allows smart and efficient evaluation (and management) of submarine buried landscapes and their heritage values, in environments similar to the Belgian continental shelf with mainly 'soft' geological materials such as sand, silt, clay and peat.

A final major challenge of this project is to integrate this improved technology and optimal research methodology for detection and assessment into the legal framework and management practice in Belgium. At present and generally speaking archaeological management of underwater cultural heritage, if it exists already, is worldwide strongly focused on individual shipwreck sites. The major challenge is however to deal efficiently besides these shipwrecks or other point like heritage sites also with landscapes and in particular with buried prehistoric landscapes. These cultural landscape values are at present mostly unknown and that makes it particularly difficult to integrate them coherently in a management approach. The management of the unknown is indeed a true challenge. The first important step is to raise awareness for these landscape values and this as widely as possible. Awareness raising efforts should target politicians and managers responsible for the sea and all the stakeholders active at sea but the public at large as well. In the context of the SeArch-project specifically targeted protocols for reporting finds at sea are being developed. Development of these protocols is one step but to be sure that these protocols become an efficient management tool their use has to be stimulated through life interaction on the floor with all the stakeholders in scope. This is a time and effort consuming exercise, but without the interaction, the protocols risk to become useless paperwork. The protocols that will be delivered at the end of this project will all have gone through an intensive testing period on the floor by the stakeholders themselves in a constant dialogue. This testing phase will allow to tailor these protocols maximally to the individual needs and we are convinced and hope that this will contribute to their effectiveness. Heritage management and conservation practice should move away from imposing protective measures to developing measures in dialogue with the stakeholders. It is the hard way but in our opinion it is the only rewarding and sustainable way.

The two case studies briefly presented: the ‘Ostend Valley’ (offshore) and the beach of Raversijde (intertidal)

The beach of Raversijde (Ostend, Belgium), entirely situated in the intertidal zone (fig. 1), is known as a valuable archaeological site since the late 19th century. Due to coastline retreat close to 1400 AD, a late medieval (13th-14th centuries) fishing settlement ‘Walraversijde’ was lost to the sea and the settlement remains are today partly situated on the actual beach (intertidal) and even partly beyond the baseline into the territorial sea of Belgium (subtidal). This settlement was associated to a former tidal inlet, a so-called ‘hythe’ that even appears in the name of the settlement: Walraversijde meaning the hythe (+/- the harbor or landing place) of a man called Walraf. Apart from medieval and Roman artefacts also prehistoric flint artefacts have been collected from this beach since the late 19th century. Besides artefacts also archaeological features related to peat extractions in medieval and possibly also in Roman times have been identified together with evidence for Roman dike building activities. All in all thus a very attractive archaeological site to test remote sensing techniques on their capacity to detect and allow analysis of the buried archaeological and landscape features.

The ‘Ostend Valley’ is a former river valley, incised during the Saale glaciation, that reaches up to a depth of roughly 40 m below the actual sea floor. This Saale river valley developed into a tide-dominated estuary during the Eemian interglacial, when the valley evolved to a 10 km wide estuary which got completely filled with estuarine sediments. During the following Weichselian glacial the valley again saw fluvial incision, though less severe that in the Saale period. Wind activity resulted in the formation of sand ridges which gradually dammed the valley thereby redirecting the river to the north. During the subsequent Holocene sea-level rise the valley got buried beneath tidal and marine sediments, including several large sandbanks. The Ostend Valley dominates the geological stratigraphy of the central part of the Belgian coast and continental shelf, and this buried estuarine and riverine landscape has
likely provided throughout the late Quaternary an attractive environment for human activities. A better knowledge of the geology of this former valley system would therefore contribute to a better understanding of this palaeolandcape and its archaeological potential. This, together with the technological challenge posed by sand banks, makes this second test site very well suited to analyse and optimise the detection methodology offshore.

**Methods and Techniques**

Many different geophysical surveying techniques to study the seafloor and underlying substrate have been worldwide developed so far. Acoustic methods are by far the best to provide the detailed information archaeologists or landscape specialists are looking for. In the context of this research project the available acoustic techniques have been compared and the ones best suited for the test sites have been selected, applied and further improved. As in both case studies the challenges were linked to detecting archaeological and/or landscape features below the seafloor, the focus was strongly put on sub-bottom profiling techniques. Whereas these techniques have been well developed for the offshore zone, their use in the intertidal and nearshore zone is rarely applied since it poses major technological challenges due to the shallow water depth, fierce wave action (surf zone), strong currents, large tidal range and the presence of shallow gas. For the seismic surveys at the intertidal site of Raversijde and the immediately adjoining nearshore area a parametric echosounder (SES-2000) was used. The surveys were carried out with a small catamaran with a very shallow draft allowing surveying in shallow waters. In the case of the Ostend Valley a range of high resolution sources were compared, including Sparkers, Boomers, Chirp, Geopulse, and Parametric Echosounder, and combined with different receiver configurations (single channel as well as multichannel streamers). Where possible different sources were used simultaneously.

**First research results**

The seismic investigations in the intertidal area of Raversijde produced several very interesting results. Analysis of the geophysical data allowed first of all the detection of an important tidal gully ("Yde or Hythe") running perpendicular to the shore. It is the first geophysical proof of the exact location of the old tidal gully that gave the name to the settlement (Raversyde). Until now only scarce archaeological information and information from written sources was available. The identification of this gully on geophysical data is a major breakthrough for the study of this settlement. It is very well conceivable that remains of medieval or earlier harbor infrastructure and/or remains of shipwrecks could be found in the gully infill.

Another important tidal gully, running parallel to the actual coastline, very possibly marks the seaward boundary of a former coastal barrier ("Testerep") that had been slightly prograding since the late Holocene. The precise age of this former ‘island’ is not known but it predates in any case the late medieval period when the fishing settlement Walraversijde was lost to the sea. Seismic imaging produced thus very valuable information for the interpretation of former coastal landscapes that is not available through other information sources.

Last but not least, the seismic surveys at Raversijde also allowed the mapping of areas on the intertidal beach where peat excavation had taken place in the past; due to the construction of breakwaters in the 1970’s these partially excavated peat layers are now all buried below a few meters of sand. This geophysical information was ground-truthed through detailed analysis of historic aerial photographs and through specially adapted augering techniques on the beach. First results already showed a good correlation between the geophysical, photographic and coring data. Over the next year(s) further methodological progress will be made by applying additional (non-conventional) acoustic methods in the intertidal zone, based on surface waves and shear waves.

The seismic imaging done offshore in the Ostend Valley allowed first of all to select the best suitable configuration of the tested seismic sources and receivers. The particular setting of the Ostend valley, i.e. largely covered by a major sand bank, represented a big challenge as the sound waves are quickly absorbed in the heterogeneous coarse sandy sediments, thus producing a decrease in signal penetration depth. The results of extensive data processing showed that even for relatively shallow depths multichannel data provide a better subsurface Figure with increased resolution in the deeper parts and along the flanks of the valley. A total of 18 channels in the streamer proved sufficient. Simultaneous use of the Parametric Echosounder and Centipede Sparker allowed the best possible detail in both the shallow and deeper part of the valley. The survey work in the Ostend Valley also produced hitherto unknown information related to the nature and infilling of the Ostend Valley. The next steps will consist of carefully gathering ground-truth information via the sampling of undisturbed cores using a vibrocorer deployed from a research vessel.

**Conclusion**

The results presented in this paper only provide a first step in our research. More work will be done in the near future, focusing on additional acoustic sources and different physical/geological environment, and also exploring the potential of unconventional, non-acoustic techniques for intertidal studies. Nevertheless these first results, although very preliminary in nature (the project continues until the end of 2016), are already very promising not only regarding the techniques and methods to be applied but also the interpretation of the obtained data.
from an heritage perspective. The geophysical data from the beach and the nearshore area at Raversijde, produced very valuable new insights about the former landscape and subsequent evolution of the study area. This will have its consequences for the management approach. The Ostend Valley case study offered not only a better understanding of the evolution of this former valley but also better insights for an efficient methodology in detecting and assessing offshore buried landscape features. Still further work is needed to provide the cost-effective, non-destructive and high-resolution methodology as mentioned in the introduction of this paper. In the meantime a lot of effort will be spent to raise awareness for underwater cultural heritage and for buried (prehistoric) landscapes in particular and to stimulate the reporting of finds by the stakeholders active at sea through the use of specifically tailored protocols.

Finally based on the new methodology and on the raised awareness proposals will be made to improve the legal framework and the related management practice.

Bibliography


Figure 1 - Aerial photograph of the beach of Raversijde in the late seventies of the 20th century.
Amida Diyarbakir between Past and Present:
New Technologies, New Archives of Heritage / Urban Landscape

Abstract

Diyarbakir, ancient Amida, in Mesopotamia must be enhanced, preserved and transmitted to future generations with its exceptional historical values; nevertheless, it is undergoing a strong demographic pressure. Today, new technologies allow us to take the scale of a metropolitan city into consideration; i.e., a fingerprint constituting a lively and interactive new archive. They promote mainstream operating 2D or 3D Figures, use of GIS, development of research, and raising awareness of public and institutions to the importance of tangible and intangible heritage environment.

Keywords: New Technologies, Urban Landscape, Conservation, Digital Archives

Diyarbakir, an innovative project for a city crossroads of civilizations and human values

We have chosen to present this article in category 5, new technologies, as so far the Amida project is outlined here, supported by their implementation. In addition, the scope of the project should lead to the development of the application of these technologies. The AMIDA I project started from the simple fact that at the scale of a city, the emergence of innovative technologies now let aspire us to gather representations and results which the means of conventional investigations do not allow to obtain.
A Mosaic City of Values and People

It should be underlined that the city of Diyarbakir carries unique and exceptional features as the result of the combined action of a mosaic of people in the diversity of their knowledge, culture and expertise. Each culture and generation contributed to the new reading of contemporary urban planning, civil and religious architecture, and intangible heritage, taking into account the movements, the transmission, the sharing of cultures, that of sedentary men or long-term travelers, that have occurred and are still at work in the city. It has been a major city in the Middle East at least since the Roman-Byzantine period; and it became Metropolis of the Roman province of Mesopotamia. This promotion based itself from the past of several thousand years of an agglomeration installed in an exceptional natural site. Since the second millennium, Diyarbakir was the meeting place for most of the major civilizations of the Near East: Mitannian, Aramaic, Assyrian, Iranian (Medes, Parthians and Sassanids), proto-Kurdish, Hellenic, Armenian, Roman. At last Syriac, Roman-Byzantine, Arab, Kurdish, Ottoman, etc. The importance of the city has obviously made it an object of desire and an architectural showcase of powers that occurred in these places. Natural and human architectural wealth of the site has never ceased to be as Diyarbakir (fig. 1) remains today with its 2 million inhabitants, the cultural and economic capital of East Turkey. This wealth has also motivated the city's application as UNESCO World Heritage Site for Diyarbakır Içkale, City Walls and the Gardens of Hevsel cultural landscape.

The implementation of appropriate scientific techniques, which can contribute to conservation, carries importance. In this research, new technologies are not only used as efficient systems of registrations, but also as research tools in the service of knowledge, protection, development of conservation strategies for heritage, and as assessment tools of measures implemented and to lead. They allow to combine and bring coherence to different layers and type of segments that the city has collected from civilizations and urban societies. Their traces can be read in the overall organization of the town from both past and present societies. Our aim is to combine them all into a knowledge organization system, thanks to the Geographical Information Systems (GIS), all that the urban landscape and the Gardens of Hevsel, which are the historical gardens of the city, reminiscent of gesture of city builders from its origins to today.

An Innovative Methodology

The methodology that we implement for Diyarbakir presents more than a title, it has an innovative nature: the scale at which new technologies are implemented, the comprehensive and multidisciplinary approach and the development of means in order to involve public and raise their awareness for this project. This methodological approach for heritage, takes its diversity as it is the manner of living together and the question of the transmission of knowledge and know-how is certainly central to our project, but is intended to be applied elsewhere.

Methodology and Objectives

To carry out our project, we are involving recent developments in techniques photogrammetry, three-dimensional model production showing both as-found state and temporal phases, implementation of Geographical Information System for urban heritage, and web-sharing of the produced knowledge thanks to the Internet.

1. Organizing the Knowledge

All aspects of the history of the city are concerned, including the study of a historically significant and exceptionally imposing monument; i.e., the city wall, a veritable conservatory of *ars militia* in the Middle East.

Indeed, this wall has been constantly enriched by defensive elements and inscriptions at least until the thirteenth century (the Umayyads, Abbasids, Mervanides, Ínalides and Nisanides, Ortokides, Seljuks). The development of this wall is more important than being a military work, as it became the symbol of the harmony of civilizations that succeeded on the site, and also a narrative element essential in the discourses of tolerance and peace between people developed by the government.

Although the methodology is applied to the entire site, the wall of the Roman-Byzantine city, a symbol of the meeting of cultures, is paradigmatic. The previous studies 5, 6 have been devoted always found an obstacle in the gigantism of the monument. Descriptions, although often satisfactory, have never managed to reach the full measure. These descriptions have never brought into the understanding of the history of this major city as a whole more than just association to the monument, in the Middle East and Mesopotamian gardens.

Considering its physical characteristics, it is longer than 5 km, all were built of black basalt. It has 82 towers and develops impressive dimensions with certain parts of the curtain walls of 4.5 m thickness and 12 meters of height.

A quick and superficially done calculation allows to estimate 40 m³ for 1 linear meter of required material amount for such a construction, a total of 200.000 tons for the whole monument if we reduce simply its route 5 km, with the exclusion of towers.

The orthophotography, thanks to the photogrammetric methods (fig. 2), establishes a digital cartography of the...
wall (fig. 3). Compared to a manual documentation work, i.e., drawing done stone to stone, the speed of data acquisition guarantees practical characteristics of the work. Nevertheless, up to date, the feasibility of the task has never been undertaken in the past due to the size of the monument. Besides, the orthophotos include both color and texture information (fig. 4) in the resulting representations, which allow different analytic readings; e.g., deteriorations and loss in material.

The results of the digital acquisition is also the basis aiming for further information analysis and applications in GIS. The records allow to put all elements in series that can help understanding the construction of the wall, architectural changes through history or decorative enhancements that sustained over time in different occupations, emphasizing that it is the work of several civilizations. This particularity relates to the architectural characteristics, building materials, decoration, carvings, moldings, opening forms, inscriptions, and other historical traces and clues.

At the same time, the records of GIS (fig. 5) includes all the city monuments by providing entries designed to take account of both the acquired knowledge and also the produced knowledge as the result analytic works of historians, architects, archaeologists, planners, stonemasons, ethnologists, geologists, specialists in heritage conservation or museum professionals. In this context, the recruited architectural elements that were a part of another monument, but afterwards have been moved and reused in another heritage building in the city are also taken into account; they are systematically described, photographed, measured, recorded (fig. 6).

This information is coupled with the documentation extracted from the ancient texts by historians (classical texts, narratives by travelers of the past and today). Similarly, all other available elements of documentation are mentioned (photographs, diagrams, planning reports, legal recovery, etc.).

2. Acquisition by Scientific Instruments

Data acquisition includes inventory tools, efficient analysis and flexible adaptations for different scales required for the complexity and depth of history and heritage field. It is to clear the permanencies in the transmission of tangible and intangible heritage, as well as breaks, identifying innovations. In this regard, special attention is given to materials and construction techniques.

Thanks to the new technologies, it is possible to assess the impact of the monument wall in its city. By engaging in a detailed analysis of the structure, which was made possible by the use of digital orthophoto as a base set of digital representation, it becomes possible to reconstruct and deconstruct the wall digitally, to go back when the quarry sites open, and understand the changes that were then assigned the city and its natural environment.

In this perspective, the basalt quarries are considered, for the first time in Diyarbakir as part of the monument. The wall elements are placed as far as possible in relation to the place of extraction.

This approach works well where it has been tested, that is to say, in the southern part of the city, where the basalt cliffs are directly accessible in direct contact with the Gardens of Hevesl and Tigris.

Return to the old site, try to rebuild the gesture of teams carriers, give attention to the origin of the materials used to examine the interactions between ecology and economy during the construction of the wall suggests the monument as a major component of the system in which the ancient city and the Gardens of Hevesl have evolved.

The construction of the wall has been transformed not only the physical relationship between the city and the gardens, but also economic relations seeing that the Tigris valley were used materials such as sand or wooden scaffolding. Deconstructing the wall allows us to understand these relationships, new technologies which case the only methodological tool that can provide the registration framework for effective analysis of information collected. This work on materials leads to the creation of a lexicon of stone which includes not only the wall but is also extended to all the architectural elements of the city, all periods 7. This approach is a tool for research and preservation of the heritage of first value for the first time because it addresses the issue of the construction of the city as a whole.

The digital 3D models experience the assumptions of theoretical refunds of parts of the wall and the historic urban planning. The data in GIS allow to serialize information including those relating to the ancient urbanism.

3. Integrating Human Values of the Past and Present Time

The question of the transmission of knowledge and the manner of living together is valued and made possible by the synchronized and diachronic approaches that GIS allow to perform in a large scale. For example, a simple query allows that at a given date, the urban landscape gives to see and share to a given population, or permits in any case making some other queries and getting the related information.

The participation of current residents is sought systematically. This is to involve many individuals, but also associations, foundations, civil institutions to the narration of their own city, and the development of more ecology-oriented and respect of the historic environment projects and natural. By its high sensitivity to the natural environment and the importance of the development of natural resources in the construction of the site, the project mobilizes stakeholders on environmental issues. It serves as a basis for the design of projects to bring the population patterns of consumption and production of environmentally friendly ones. As an exemplification, the Gardens of Hevesl are now perceived as an area of highly historical or archaeological sensitive that is to be preserved. This awareness opens the discourse to the rewarding nature of agriculture that would become cleaner, and would be consistent with
the preservation of the site. In the same direction, career enhancement as part of a historic monument promotes
the value of craftsmanship of the stone and its workers and grant it an important place in the development of city
projects. The historical inquiry encourages discussions with the population and underlines the value that may
represent a heritage known, but not enough valued when it is unspectacular, and yet it is essential for the overall
understanding of the site. Eventually this awareness leads to the creation of new jobs in cultural tourism industry.

4. Facilitate Public Access to the Work

Access to this work by the great majority would be possible by creating a website and a documentation center
located in a restored building to cultural vocation and museography studies. As a part of the future works, we also
plan to save a fingerprint of the main monuments of the city.
The results of the survey are to be presented in the museum of the city. Three dimensional models showing different
restitution phases are important in the means of awareness whose playful character captures the interest of the great
majority, and young audiences. This technology can also be used as complementary virtual visit and tour of the
parts of the city where pedestrian access could be dangerous or very limited for visitors on the site itself. The
provision of certain quantitative data extraction, GIS encourages curiosity and access to knowledge. In this
mediation, an educational version suitable for young audiences and eventually adapted versions for the disabled
are provided. Moreover, the provision of these tools that support multilingual access for a better communication
between all stakeholders (public, designers, etc.).

5. Evaluation and Preservation

The database is also a tool for the assessment and prevention and for heritage conservation.
GIS have also governmental benefits, including planning service and culture, a heritage review board in design, as
we consider the possibilities of new technologies; e.g., browsing between extreme proportions which passes from
scale of the entire city to a simple block of stone.
Both photographic and photogrammetric acquisitions lead to new types of digital archive, exportable and usable
elsewhere than on the site itself which in some parts of the world may become a backup value.
In Diyarbakir, GIS must be able to keep systematic records of observations by Interdisciplinary Center for the
Conservation and the Restoration of Stone (CICRP) and establish a map of the state of conservation of stone and
recommendations and treatment.
More than all already mentioned representations, it might offer, a map of administration interventions on heritage
presentation (projects, restorations, choice of techniques and materials, etc.). Therefore, new technologies are also
important tools of evaluation.

1. Archeology Measures Innovation Development Anatolia designed in partnership with the Metropolitan Mayor of Diyarbakir,
the French Institute of Anatolian Studies, University Paul-Valery-Montpellier and CRISES laboratory, MAP-GAMSAU-CNRS, CIRCP, Paris 8 and Sapienza Amida is the lauréate of ENVIMED / MISTRALS program of MAE / CNRS.
2. (Letellier, 2007).
4. (Venice Charter, 1964)
5. (Gabriel, 1940).
7. (Verges-Belmin, 2008).
8. (Denard, Salvatori , Simi, 2010).
Bibliography


Theme 5 - Emerging tools for conservation practice

Heritage and Landscape as Human Values - Conference Proceedings

Figure 1 - Aerial view of the historic city of Diyarbakır, and the Gardens of Hevsel on its South Eastern part (above). Partial views of the city walls (below).

Figure 2 - Data processing and creation of 3D mesh.

Figure 3 - A partial elevation of the city wall gathered by photogrammetric techniques.
Figure 4 - A partial elevation of the city wall between Tower 7 and 8.

Figure 5 - GIS elements of ancient porticos of Amida streets.

Figure 6 - Re-use of recruited building elements in the Great Mosque.
Theme 5: Emerging tools for conservation practice
Theme 5-1: Technological innovation

The Completion of Sagrada Familia: Questions of Heritage Authenticity, Authority and Authorship

Nancy Pollock-Ellwand
Dean- Faculty of Environmental Design, University of Calgary, Alberta, Canada

Abstract

Sagrada Familia’s fantastical design is the supreme expression of the Catalan architect, Antonio Gaudí’s, brand of Modernism. Begun in 1883, 143 years later in 2026 the Basilica will be completed aided by the innovative use of parametric modelling and 3D fabrication technologies. But on what authority does this work proceed on a masterwork named part of a World Heritage inscription (UNESCO, http://whc.unesco.org/en/list/320) 30 years ago? And can these computer-generated hyperboloids and paraboloids embody an authentic vision of the original author, Antonio Gaudí? An anathema to some heritage conservators, this use of advanced technologies challenges the basic assumptions and approaches to world heritage.

Keywords: Digital Modelling; Heritage Authenticity, Authorship, Authority

Introduction

The computer-assisted completion of Antoni Gaudí’s Sagrada Familia Basilica in Barcelona confronts both designers and heritage conservationists with some troubling questions. Who has the authority to finish the masterwork of a genius; and can the final product establish any authentic connection to the original author, the great Catalan architect, Antoni Gaudí? This paper contends that although not a conventional way to view World Heritage, the current work on the Basilica is in keeping with the World Heritage listing’s three inscription criteria. It is a case of the extension of these criteria into ongoing work - informing, and inspiring. Continuing work on a heritage property that does not fall into accepted standards of restoration, rehabilitation or reconstruction practice is challenging to assess and thus raises the spectre of a diminishment of the heritage resource’s significance. However, with a project such as Sagrada Familia with its immensity and complexity, extending beyond the lifespan of the designer Gaudí’s lifetime - other guiding principles must be employed. The World Heritage Listing of “Works of Antoni Gaudí” provides that direction. There are three criterion to justify the inscription of Gaudi’s Barcelona works. These same criterion serve to inform the ongoing work on Sagrada Familia Basilica - continuing contributions of this iconic structure to the field of architecture. Criterion (i) notes Gaudí’s outstanding architectural and building technology contributions. Similarly significant, the continued building of the Basilica is facilitated by the power of digital modelling, and state-of-the-art construction methods, approaches which also prove to be highly innovative today. Criterion (ii) talks of the influence of the Barcelona work for its time. The current work on the Basilica, as it was for Gaudi’s designs in the 20th century, serves as an exemplar for contemporary architects now searching for the full potential of parametric modelling and three-dimensional fabrications. Since the 1980’s the Basilica’s team of designers have been pioneering the use of this technology grounded on ‘rules’ that are fashioned after Gaudi’s own structural inventions-- making contemporary architectural moves based on geometry and structural forms that the original architect used. Finally, the extension of these Gaudiesque architectural inventions serves to reinforce the third criterion; that Sagrada Familia continues to represent a distinctive building typology.

History

The immense structure’s organically inspired design is the supreme expression of Gaudi’s brand of Modernism - blending Spanish traditions of mosaic-embellished surfaces with unique forms derived from nature. The Basilica’s extraordinary structure and finishes are a reflection of Gaudí’s intense Catholicism and his equally strong Catalan nationalism. Antoni Gaudí’s unique creations have garnered international recognition with elements of this Basilica (the Nativity Façade and Crypt of La Sagrada Familia) along with other works in the Barcelona area now listed as globally significant by United Nations Educational, Scientific and Cultural Organization (http://whc.unesco.org/en/list/320). Construction on the Sagrada Familia started in 1883, and Gaudí died in 1926 with the building still unfinished. In subsequent years efforts to complete the building were bedevilled by financial difficulties, political and social upheaval, and a fire in which many of Gaudi’s original drawings and models were lost. (Basilica de la Sagrada
Theme 5 - Emerging tools for conservation practice

Familia, http://www.sagradafamilia.cat/sf-eng/docs_servis/informacio.php) The project has continued under the direction of multiple designers and builders, and now it is anticipated the work will finally be completed in 2026, 143 years after its inception (fig.1). A protracted project such as this Basilica, continuing over generations, creates an architectural conundrum - who ultimately claims authorship for the building, and on what authority should successive architectural decisions rely?

On a recent visit to Barcelona to review the University of Calgary’s Faculty of Environmental Design’s Semester Abroad, I had the extraordinary opportunity to take a behind-the-scenes tour of the Sagrada Familia construction site. My guide along some narrow and very high scaffolding was Dr. Mark Burry, the architectural scholar and innovator from Australia’s Royal Melbourne Institute of Technology University (RMIT) who directs the computer simulations of future construction. His parametric modelling uses ‘rules’ to extrapolate forms, which could have been created by Gaudí. These ‘rules’ are based on an analysis of artifacts such as built examples of Gaudí projects, remnant blueprints, some rare photographs and models of the Basilica, and the architect’s writings.

The Questions

Burry acknowledges two central preoccupations: the first is on what authority does his work proceed? The second is, can these computer-generated hyperboloids and paraboloids embody an authentic vision of Gaudí’s design that can be built by the workers?

Gaudi himself knew he would not live to see the Basilica’s completion. In fact, at 73 he was severely injured and died soon after being hit by a tram in front of the Sagrada Familia (Castellar-Gassol 1999). He dedicated nearly 50 years of his life to this ambitious project knowing that he would inevitably relinquish authority to others to interpret the original intent of the design. He stated the work, “… should be the offspring of a long era, the longer the better.” (Burry, Grifoll and Serrano Burry, p. G8). Like all religious edifices of this magnitude he was part of a tradition of master builders that spanned generations and centuries.

Mark Burry is part of an exclusive group of Gaudí scholars and designers who have assumed that authority to continue the work (fig.2). A person is struck when talking to Burry how he measures this work in terms of lifetimes - he has committed his own career to the project as have other designers and builders at the Basilica. Burry began as a graduate student volunteer at Sagrada Familia’s workshop back in the 1980’s neither expecting this would become his life’s work nor that he might someday see the structure’s completion. But the digital innovations which he helped bring on over the years have dramatically accelerated the project.

Nature was the model for Gaudí’s structural inventions - and mathematics the engine. (Dos de Arte Ediciones) Today those same organic structures and mathematical calculations drive the work forward. This work however has proven to be anathema to some heritage conservators who believe the building should have remained a ruin - a static monument to Gaudí.

An influential group of Barcelona’s artistic and architectural establishment signed a petition in 2008 protesting the completion of the Sagrada Familia, “as a betrayal of Gaudi’s spirit... What stands out is the mediocrity of a group of technicians and developers who are well-meaning but full of an anachronistic paternalism in the best of cases and are once more using Gaudi to leave their personal mark on the building to the detriment of the original work” (Keeley, http://www.theguardian.com/artanddesign/2008/aug/14/Gaudi.sagrada.familia). Indeed a glance upward in the nave today may cause alarm amongst architectural purists with the decidedly contemporary feeling of the building - the chrome mesh lighting medallions mounted high atop the central sanctuary’s columns, the high speed elevator in the corners and the chrome railings on the balconies.

When it comes to the Sagrada Familia, I am not persuaded by these criticisms. Over the years I have been involved in many heritage conservation projects in Canada and overseas and the issues of authorship, authority and authenticity are often intensely debated. The arguments usually revolve around the well-entrenched notions of how historically significant buildings are to be treated. It is held that a significant architectural resource should be stabilized, restored, and rehabilitated but not radically extended, elaborated or enhanced (e.g., see the International Council on Monuments and Sites’ Venice Charter http://www.icomos.org/venicecharter2004/). Some of the most passionate exchanges I have ever seen have been over conservation approaches to heritage resources. I contend, however, that each project has unique circumstances which must be reflected in developing appropriate treatments; and, Sagrada Familia is one of those instances.

In the case of the present work on the Sagrada Familia there are three compelling aspects to consider: first, Gaudí was a realist, acknowledging he would pass along design authority for the structure’s completion to those who would come after him. He believed it was not only inevitable but desirable. Secondly, he was an innovator and would undoubtedly embraced contemporary advancements in architecture. One may even speculate that the computerized structural computations of today would have intrigued him and he would have known better than anyone how important they are to the accelerated work. Finally, the building continues to have the power to create an intense spiritual experience which was Gaudí’s original intent. His architectural ambitions are being realized. This is an intriguing case for heritage conservationists to ponder and debate. The principles that have guided the field have shifted over time as witnessed by the regularly updated UNESCO Operational Guideline for the Implementation of the World Heritage Convention- the latest one being July 2013 (http://whc.unesco.org/
It like other heritage policies, declarations and charters evolve through many forces that include technical advances, philosophical exchange, and cultural diversity. For instance, consider the shift in thinking around significant cultural landscapes that were primarily represented as settings for buildings in the Florence Charter (ICOMOS 1982) and two decades later conservationists are tackling landscape resources that are transitory and intangible with such Declarations as the Hoi An and Xi’an (ICOMOS 2003 and 2005). This is the case in many other areas of World Heritage. With Sagrada Familia we see a further challenge for the conservation field - a heritage resource significant in its own right but also gaining significance for what it inspires. In this new context, heritage is seen as something to protect but also to generate new advances in built form. This presents new exciting frontiers for the field.

Therefore this intriguing building not only stands as a challenge to how we view authorship in architecture and how we gain legitimate authority to proceed with future work but it also sits as a conundrum to conservationists. It is inevitable that the debates will continue about this famous Gaudí creation long after its completion. The central tower of the Sagrada Familia will rise in coming years to its full height (fig. 3) and the innovative interpretation of the Glory Façade will complete the final south façade (fig. 4, 5). Many generations of architectural authors will have to accept anonymity as they strive for the authentic Gaudí experience. However, the full power of the structure will be realized - it will have found its full authority.

1. **Criterion (i):** The work of Antoni Gaudí represents an exceptional and outstanding creative contribution to the development of architecture and building technology in the late 19th and early 20th centuries. Criterion (ii): Gaudí’s work exhibits an important interchange of values closely associated with the cultural and artistic currents of his time, as represented in el Modernisme of Catalonia. It anticipated and influenced many of the forms and techniques that were relevant to the development of modern construction in the 20th century. Criterion (iii): Gaudí’s work represents a series of outstanding examples of the building typology in the architecture of the early 20th century, residential as well as public, to the development of which he made a significant and creative contribution. (UNESCO, http://whc.unesco.org/en/list/320)


4. “Seven properties built by the architect Antoni Gaudí (1852-1926) in or near Barcelona testify to Gaudí’s exceptional creative contribution to the development of architecture and building technology in the late 19th and early 20th centuries. These monuments represent an eclectic, as well as a very personal, style which was given free reign in the design of gardens, sculpture and all decorative arts, as well as architecture. The seven buildings are: Parque Güell; Palacio Güell; Casa Milá; Casa Vicens; Gaudi’s work on the Nativity façade and Crypt of La Sagrada Familia; Casa Batlló; Crypt in Colonia Güell” (UNESCO, http://whc.unesco.org/en/list/320).

**Bibliography**


Figure 1- Basilica interior closed in 2008 nearly 125 years after placing the first stone in the early 1880s.

Figure 2- Mark Burry stands in front of Sagrada Familia model.

Figure 3- Construction of central tower of Basilica, Fall 2013, at 85 metre mark (half way to its ultimate height)
Figures 4 and 5 - The Glory Facade is the last of the facades to be built: period photo of the Gaudi model to left; and present day model of facade shown by Mark Burry.
Towards Monitoring and Measuring Change:
the Silk Roads Cultural Heritage Resource Information System

Ona Vileikis
Raymond Lemaire International Centre for Conservation (RLICC), University of Leuven, Heverlee, Belgium

Koen Van Balen
Raymond Lemaire International Centre for Conservation (RLICC), University of Leuven, Heverlee, Belgium

Mario Santana Quintero
Carleton University, Civil and Environmental Engineering, Ottawa, Canada

Abstract

The purpose of this paper is to present the application of Geospatial Content Management Systems for monitoring processes in cultural heritage. By showing results of the Silk Roads Cultural Heritage Resource Information System (CHRIS) the successful implementation for monitoring cultural heritage is illustrated. The developed system Silk Roads CHRIS aimed to assist the serial transnational World Heritage nomination and future monitoring of the Central Asian Silk Roads. It shows a great capacity as a management tool for the States Parties, practitioners and decision makers.

Keywords: World Heritage, Information Systems, Silk Roads, Risk Management, Monitoring

Introduction

Indiscriminate rapid development, lack of efficient site management, increasing tourism and natural disasters, are some of the threats identified by the Second Cycle of Periodic Reporting that nowadays affect World Heritage (WH) properties. As the number of listed properties increases every year together with the number of serial sites that need to be managed at a transnational level these threats are ever harder to control. In a context with different legislations and agendas, serial transnational World Heritage properties are initiatives that require effective collaboration, interaction and contribution among various stakeholders. This leads to the need of appropriate procedures for data collection and analysis, as well as to set up adequate monitoring and reporting methods. Thus, there is a need for reliable, complete and updated information supported by user-friendly systems allowing the relevant authorities to perform more accurate assessments to measure the changes of the Outstanding Universal Value (OUV), and organize and share the information related to the protection of the sites. Geospatial Content Management Systems (GeoCMS) are web-based tools that are changing the way of managing and sharing heritage information, aiding in conservation and risk assessments, and supporting the role of authorities and community in the preservation of cultural heritage. However, until today there was no application of this new digital technology in serial transnational WH nominations and monitoring.

In response, the Silk Roads Cultural Heritage Resource Information System (CHRIS) has been successfully developed to assist the nomination and further monitoring of the serial transnational WH nomination of the Central Asian Silk Roads. Its initiative has been set up in consultation with the Belgian Federal Science Policy Office (BELSPO) and the UNESCO World Heritage Centre (WHC); and was carried out by a Belgian consortium headed by the RLICC, KU Leuven. The web application allows the exchange of information, visualization, and dissemination of information, linked to a GIS and uses international standards in documentation. As a result, three States Parties, Kazakhstan, Tajikistan and Uzbekistan used the Silk Roads CHRIS to prepare their nominations, together with capacity building and technology transfer activities. Additionally, a monitoring tool has been developed and tested in Uzbekistan.

This paper illustrates with the case study of the Silk Roads CHRIS the use of GeoCMS towards the monitoring of serial transnational WH properties.
Monitoring serial transnational WH and Geospatial Content Management Systems

Serial transnational WH nominations are submitted by two or more States Parties as one property with one OUV, and their nomination, monitoring and management must be treated as such 1. In 2014, eleven WH properties are listed as serial transnational properties including the first nomination of the Silk Roads: the Routes Network of Chang'an-Tianshan Corridor along China, Kazakhstan and Kyrgyzstan 2. Within this category and towards a more representative, balanced and credible WH List, serial transnational nominations are an opportunity to encourage collaboration and exchange between States Parties. However, these nominations come together with more complex challenges, specifically in the systematization and management of the information.

With the development of the concept of serial heritage, WH properties are no longer conceived just as single monuments but as places related to their environment, such as cultural landscapes or heritage routes. This novel concept brings cultural heritage closer to human interaction with economic and social benefits towards a more sustainable well being. However, as the number of sites increases, the socio-economic and environmental pressures also greatly rise. Thus, since the beginning of the Convention, the concept of monitoring cultural WH, an objective of the reporting exercise, has evolved during time.

In the 80’s, monitoring was defined by IUCN as “measurements taken according to a standard methodology over a period of time, so that status and trends may be detected” 3. Almost a decade later, the concept recognized the protection of values, specifically the OUV and is defined as: “measures taken by the World Heritage Committee and its Bureau, to collate and collect information on World Heritage properties in order to be able to identify the threats to the values for which properties were granted World Heritage status, and take timely action to remove or minimize those threats” 4. At that time the Committee acknowledged that the system of field technical missions, i.e. site visits of members of the Advisory Bodies, supported by international campaigns was an effective one. One example was the UNDP/UNESCO Regional project for Cultural, Urban and Environmental Heritage in Latin America, the Caribbean and Mozambique 5. However, today, with more than 1000 properties listed and serial properties with often a large number of sites, the system of technical missions might still be effective but definitely not efficient.

Later on, the concept of monitoring was developed further and seen as a “continuous process, undertaken in the field, involving local partners, and on regional basis” 6. In 1993, following the previous idea, the State of Conservation (SoC) of the Jesuit Missions of the Guaranis, one of the listed cultural serial transnational properties, was monitored under a UNDP/UNESCO project. Results revealed the poor SoC of the missions. However, the monitoring activity offered a unique opportunity to revive the Guaraní cultural heritage at a territorial level.

Monitoring was here conceived as a participatory and integrative process including local communities, their environment and the different stakeholders.

Nowadays, obligations and roles of the States Parties, the Committee, Secretariat and Advisory Bodies related to monitoring and reporting are embedded in the 1972 Convention and its Operational Guidelines (OG) 7. In accordance with Article 29 of the Convention, periodic reports and the SoC of WH properties should be provided by the States Parties. In 2011, following the WH Committee decision to be more systematic in monitoring of threats, a SoC Information System was developed. It is an online database, open to relevant stakeholders where statutory information is available, statistical data about the threats of the properties can be exported and trends can be analyzed 8. This step marked a leap for the monitoring of WH and its use of information systems.

From simple user-friendly web-based databases to GeoCMS, i.e. geographical information systems (GIS) linked to databases; online information systems are becoming a convenient solution for storing and managing data. Common features of these systems are: They (1) are adaptable to specific user requirements; (2) are easy to use: it has basic spatial analysis capabilities, the possibility to edit attributes or shape file change of geometry using a thin client online GIS; (3) allow exchange of information: Stored data can be shared among a large number of people; web-based but protected: control access to data, based on user roles, easy storage and retrieval of data and improve communication between users; (4) interoperable by both standardizing data types and importing and exporting data; and (5) able to track and validate the information during the process.

Two recent examples of heritage inventory and management systems have been developed by the Getty Conservation Institute and World Monuments Fund. However, just the first one was foreseen for monitoring. First, the Middle Eastern Geodatabase for Antiquities (MEGA) is the national heritage inventory system in Jordan. An advantage of the MEGA aside from its monitoring tool is its bilingual user interface (Arabic-English). However, results of its implementation with data of Petra Archaeological Park showed that the system was limited to simple archaeological sites and could not record large datasets of a site like Petra 9. The second example is the Arches, a generic heritage inventory and management system launched in 2013. However, the model does not include a monitoring feature. A great advantage of this system is its functionality as open source, and no license fee is required. First case studies were presented at the last Arches Community Workshop 2.0 by the Public Works and Government Services Canada and the i3mainz as a contribution to the Arches community and its promotion 10.

Another example is the cultural resource management tool, Qatar National Historic Environment Record (QNHER). Although site monitoring was not the main aim in the development of the system, its interlinked data could be used for interpretation and analysis, for example, users could identify possible threats mainly caused by infrastructure development 11.
The use of information systems like the ones mentioned above is greatly increasing in the field of cultural heritage. A detailed overview and comparison of existing systems is beyond the scope of this article. However, to our knowledge none of them make use of a common management or monitoring tool specifically created for serial transnational WH properties.

**The Silk Roads Cultural Heritage Resource Information System (CHRIS)**

**Background and rationale**

Given its historical significance, the WHC and ICOMOS have been supporting the States Parties to propose the Silk Roads serial transnational nomination for inscription on the WH List. The Silk Roads is a network of historic routes linking Asia with the Mediterranean and the European world. In 1877, the term Silk Roads, ‘Die Seidenstrassen’, was given by the German geographer F. von Richthofen. From its beginning, the idea of the Silk Roads as being rather straight and well traveled has been rather romanticized. On the contrary, the Silk Roads consists of a network of alternating, unmarked paths between oasis cities or caravanserais under changing environmental and political conditions (fig. 1). Unlike the term suggests, silk was just one of the various goods among spices, perfume, gems, metals, ceramics and ivory that were traded along this network from the Han dynasty (206 BC - 220 AD) onward. In addition to the trade of tangible goods, the Silk Roads also enabled the diffusion of culture, technology and knowledge between East and West.

In 2014, the first Silk Roads WH corridor was listed as a start of a series of Silk Roads nominations. To achieve this goal, the State Parties involved have worked for the last seven years on gathering data, carrying out field works, organizing meetings at a national and transnational level, and setting up the nomination dossier. During those years a number of issues were identified, mainly, difficulties of integration of the large volumes and types of data at a transnational level; a need for standardization of information; and a need for capacity building on preparation of serial transnational WH nominations, heritage documentation, and monitoring. To overcome these issues, international support has been put forward. One initiative was the Silk Roads CHRIS. Its main objective was to design and implement an online GeoCMS capable of providing support for the preparation of the serial transnational WH nomination and further monitoring of the proposed WH sites in Central Asia. Recognizing the high significance of the OUV and the values attributed by all stakeholders to the WH properties and their long term protection and conservation, the Silk Roads CHRIS was designed with a values based approach and following the concept of preventive conservation. Preventive conservation aims to avoid or mitigate the damages and understand the risks. It also promotes maintenance as a preservation strategy based on proper monitoring. The development of the system came together with methodologies linking data collection, assessing significance and conditions towards planning for effective management and conservation of the sites (fig 1).

**System Architecture**

The Silk Roads CHRIS contains three major components: a GeoCMS with a configurator, a geospatial database and a geographic data server. The GeoCMS has been built using recent J2EE technologies and Java standards. It is fully configured towards the elaboration of the Silk Roads nomination dossiers with specific data models for the corridors and component parts. Every corridor has its own settings handled in the GeoCMS configurator. All configured information is stored by the GeoCMS in the geospatial database and serviced via a geographic data server.

**System Design and functionality**

The Silk Roads CHRIS was designed based on the requirements of the WH nominations and the periodic reporting; and the needs of Central Asian partners as follows:

- Accessible, secure and easy sharing: The online system allows exchange of information at a transnational level; different levels of stakeholders and partners involved in the nomination and the management of the sites. It counts with various levels of user access based on user roles: editor, creator or viewer. Moreover, it has a friendly user interface. For example, the content management system is multilingual, for now, English- Russian and there is no need of extensive trainings for the general users. Additionally, the system is able to track and validate information: during the data collection, the preparation of the nomination and monitoring process;

- Data standards, cross-reference and integration: A repository is completely integrated in the system. It includes bibliography populated by the States Parties and open to the general public, documents and Figures with their related metadata. 323 Figures were added to the system in 2012-2013. This information is linked to the nomination dossier and could be also linked to the risk assessments.

- Interoperable: by both standardizing data types and importing and exporting data. For example, with the export to PDF feature the full nomination dossier and monitoring reports roll out of the Silk Roads CHRIS, including Figures, maps and bibliography. The system was effectively used to prepare and create nomination dossiers, one was the Silk Roads: Penjikent-Samarkand-Poykent Corridor submitted to the WHC by the States...
Parties of Uzbekistan and Tajikistan for evaluation. Integration with existing catalogue systems is possible, e.g. with the SoC reports. Bibliography can be imported and other geographical data can be integrated. The datasets compiled by the Silk Roads ICOMOS Thematic Study were added:

- Sustainable: The software tools used to build the system were open source; there is no need for plug-ins or licenses for the end users.

**Monitoring Tool**

The model is built on the nomination dossier and the periodic reporting formats. Based on the system of corridors, concept proposed by the Silk Roads ICOMOS Thematic Study, users have access to information at three scales: the Silk Roads, the corridors and each component part. Maps are an inherent part of the nomination dossier. The background map is the Google Maps Application Programming Interface (API). Additionally, seven satellite figures were acquired with 50 cm accuracy from 2012 improving the quality of the background provided by Google Maps (Fig 2). Updated figures could be added in the future.

Built on top of the nomination dossier, a monitoring tool was designed. It is directly linked to the corridors and component parts. As explained in detail by Vileikis et al, the monitoring tool supports the States Parties in identifying the changes over time of the property and its component parts by carrying out a risk assessment.

The methodology for risk management is an improved version of a methodology already proposed by the RLICC in UNESCO WH properties. As shown in Figure 3, it is comprised of five parts that are constantly monitored and reviewed. The first part aims to assess the context where the component part is located and its characteristics: the national legal and management framework (level of heritage protection), heritage values, and the SoC. In part two, the agents of deterioration and indicators related to the threat are identified. Part three is the risk analysis: qualitative and quantitative risk impact and level analysis. Part four evaluates the risk. Finally, part five is the implementation of risk management strategies. The Silk Roads CHRIS allows for recording multiple monitoring activities at corridor or site level. Each activity recorded provides a risk assessment form linking threats to attributes and the main OUV. The form also includes specific fields to add documents such as updated laws or decrees of the legal framework or Figures illustrating the SoC. For example, 3D figures of the buildings were created with Autodesk 123D Catch, exported in PDF and later added to the system. These characteristics support a better analysis of the data available and decision making.

The monitoring tool methodology and system were first tested in Uzbekistan in 2013 by an interdisciplinary team with local and international participants (see figs. 1 and 2).

**Conclusion and Outlook**

Serial transnational properties are a great opportunity for States Parties to collaborate and share experiences under the umbrella of one OUV. Systematic monitoring is one pillar of the process towards the protection and management of cultural heritage. Monitoring serial transnational properties is a complex task. It requires a proper methodology for data gathering, values and condition assessments. GeoCMS have demonstrated its added value to fulfill this activity.

The Silk Roads CHRIS, tailor made for serial transnational WH nominations, has been a successful example of a cultural heritage system incorporated with leading edge technology in data structuring and geospatial software. An asset of the system is its design under a values based approach. The system has been successfully used for one nomination dossier; it is fully operational, hosted in Central Asia and with a local system administrator. Its interoperability, use of standards and open sources software aids to integrate it with other existing catalogue systems such as the WH SoC online system.

The case study of the Silk Roads CHRIS illustrates the capability of GeoCMS in cultural heritage as a management tool for the States Parties, practitioners and decision makers. Its methodological approach could serve as an example to similar WH properties. The monitoring tool could be further developed including a thesaurus and a gazetteer. Further research on how to integrate 3D and 4D features could be carried out in the future.

**Acknowledgements**

The authors wish to thank BELSPO and the WHC for their support. We would also like to thank Barbara Dumont and Vincent Tigny for their continuous advise in system development. We would also like to acknowledge the UNESCO Offices in Almaty and Tashkent, the Central Asian States Parties and experts participating in the Silk Roads CHRIS project.

---

9. (Paolini et al., 2012).
12. (Martin & Gendre, 2010).
16. (Vileikis, Cesaro, et al., 2012; Vileikis, Serruys, et al., 2012)
18. (Williams, 2012).
19. (Vileikis et al., 2014).
20. (Paolini et al., 2012).

Bibliography


Figure 1 - Silk Roads: Chor-Bakr, Uzbekistan. Condition and risk assessment field campaign - July 2013. Photo documentation: Comparison of each building with old photos (left) and site panorama photos (right) ©Ona Vileikis

Figure 2 - Silk Roads CHRIS. Example of Monitoring Tool: Risk Assessment. Babouddin Naqshband Architectural Complex, Uzbekistan. July 2013 ©Silk Roads CHRIS project. www.silkroad-infosystem.org
Figure 3 - Methodology for risk management. Based on Paolini, A. et al., 2012. ©Ona Vileikis
Photographing Masada by a Drone: Quantifying the Accuracy of Photogrammetry

Rebeka Vital  
Shenkar College of Design and Engineering, Israel  
Michael Walczak  
Bern University of Applied Sciences, Architecture, Wood and Civil Engineering, Switzerland

Abstract

Architectural and archaeological survey is an evolving field that has been affected during the past decade by the technological advancements in the field of data acquisition. In the digital documentation of the archaeological site of Masada in Israel several methods of data acquisition were used, namely laser scanning, photogrammetry by Figures from the ground and photogrammetry by Figures from the air. This paper aims to make a comparison between 3D meshes created by the aerial pictures taken by the drone and the meshes created from laser scanning, which are known to be highly accurate. In this way, we can have an initial evaluation of the accuracy of photogrammetry by series of pictures taken from the air.

Keywords: Photogrammetry, Laser Scanning, Archaeological Documentation

The site: Masada Fortress, Israel

Masada is a natural fortress in the Judean Desert overlooking the Dead Sea in Israel. The palace complex was built in the classic style of the early Roman Empire, by Herod the Great, King of Judaea, (reigned 37 - 4 B.C.). The camps, fortifications and attack ramp that encircle the monument constitute the most complete Roman siege works surviving to the present day. (Figure 1 - aerial photo of Masada) The Northern Palace is Masada’s most impressive structure, constructed against the northern cliff-face as if hanging over the abyss. It is built on three rock terraces, each containing grand rooms and supported by gigantic retaining walls to expand their size. The four bedrooms on the top level had a semicircular balcony that revealed magnificent views of the surroundings, especially En Gedi to the north and the Dead Sea and the Mountains of Moab to the east. A staircase led to the middle level - a large, round hall surrounded by a colonnade that extended almost to the cliff-edge. On the lowest terrace was another large, colonnaded hall adorned with spectacular wall paintings, and a private bathhouse for the palace’s residents. Herod also built a large bathhouse atop the plateau for the other inhabitants of Masada. On the top of the mountain Herod built 29 storerooms, each one 27 meters long. Excavations there turned up hundreds of clay pots that could hold huge amounts of food. Herod also hewed 12 gigantic cisterns into the mountainside to collect flood water; they had a capacity of some 40,000 cubic meters, enough to supply water for all the needs of the inhabitants, from drinking water to a swimming pool, bathhouses and agriculture. Thus in a rare combination of natural conditions and human initiative, Masada became an almost impregnable fortress I.

The digital documentation project

The Masada digital documentation project was developed as an on-going research collaboration between the department of Interior Building and Environment Design of Shenkar College of Design and Engineering, the department of Architecture of the University of Florence and the department of Architecture and Civil Engineering of the University of Pavia with the support of the Israel Park and Nature Authorities. The general aim of the project is to create a comprehensive digital documentation of the archaeological site of Masada. The data acquisition is done through digital tools that are able to give us a data base of accurate three-dimensional geometrical information in the form of a Point cloud and extensive photographic Figurery, which can be used to create textured three-dimensional geometry. Once all raw data is collected, 2D architectural drawings and 3D models of the site can be produced. The 3D models can represent the site “as-is” and can further serve as a basis for digital reconstruction that can illustrate our state of knowledge about the site, for different time periods.
The digital documentation methods

Digital methods in documenting cultural heritage sites are the latest endeavor both in the field of architecture and archaeology. Two main methodologies for digitally documenting the building were used in this project: laser scanning and photogrammetry. Each methodology has its limitations and advantages. This digital survey is comprised of both methodologies, so that the survey outcome can gain from the advantages of both ways of work. The general geometrical survey was implemented with a long-range laser scanner. The equipment used on-site was a C-10 Leica Scanstation that has the capacity to scan up to 300m radius. As of today, two thirds of the plateau was scanned by 110 scanstation locations. (fig. 2 - laser scanning Masada)

In addition, photographic figurery was acquired by digital cameras. Photographs were taken so that they have at least a 30% overlap, and subsequently can be combined through cloud computing to create three-dimensional textured meshes of areas of the site. Two ways of photogrammetry were applied in this project: A series of photos taken on the ground and photographs shot from the air. The pictures from above were acquired by a GoPro digital camera that was carried by a Phantom II drone. The view of the camera was transmitted to a screen on the ground, where the drone operator can control and plan the series of photographs that will be used for the photogrammetry. (fig. 3 - Photographing the site from a drone)

Each tool has its own strengths and weakness and can contribute to a specific aspect of the documentation. The outcome of the laser scan is a point cloud that gives a raw database of three-dimensional geometrical points, which is highly accurate. In addition, it gives some photographic information of the site that can be used to color the point cloud and give us a realistic preview of the existing geometry (fig. 4 - view into the point cloud). Laser scanning has advanced the quality of architectural documentation and allows for creating comprehensive three-dimensional databases of information. It also makes the data acquisition process very fast and efficient, compared with conventional survey methods. Still, the equipment is costly and bulky and the photographic figurery is not adequate in quality to produce textures for a virtual model.

High quality figurery for texture mapping purposes is best collected through high resolution digital cameras. There are various software and applications that allow for capturing geometry with a series of photographic figurery and through cloud computing or algorithms within the software, the photographic material can produce three-dimensional textured meshes. While the geometrical information of such meshes is not as accurate as the geometry of a point cloud that was created by laser scanning, the textures of the meshes are photorealistic and high resolution.

Comparison of meshes produced by laser scanning and by photogrammetry

In several cases, it seems that the photogrammetry gives a good three-dimensional mesh of the site or building in question. This paper is trying to establish a method for quantifying how accurate such a mesh can be, by testing a case-study. Two three-dimensional meshes were extracted for the Byzantine church on Masada, one from the point cloud and one from the photogrammetry. The two meshes we super imposed to set up a framework for comparison.

In order to compare two quantify how similar or different the two meshes are parametric software was used: Grasshopper. A process of parametrical logic was set up with the application of evolutionary algorithms. Evolutionary means in this case, moving several times one of the two scans in 3 axes (X,Y and Z) and analyzing in each alteration the specific distance to each other. With this approach, the algorithm can find the closest superposition of both different 3D scans, in relation to the target tolerance. The results are generating the percental divergence between both methods with the chosen tolerance. (fig. 5 - Superposition of meshes in Rhino)

By setting different tolerances, we got results on what percentage of the meshes is superimposed and what percentage does not match. The mesh was divided into areas for easier a faster and lighter calculation of the algorithmic process. The tolerance was set at 2cm, 10cm and 50cm, which are relevant for architectural scale. At a tolerance of 2cm, the highest super-position was 22% of the photogrammetry mesh matched the mesh of the point cloud (fig. 6 - percentage of matching at 2cm tolerance), at 10cm 74% matched (fig. 7 - percentage of matching at 10cm tolerance) and at 50cm 98% of the mesh matched. (fig. 8 - percentage of matching at 50cm tolerance) One should take into consideration that holes in the meshes contribute to the percentage that does not match.

Conclusions and further investigations

This case-study is an example of a comparative methodology that can quantify how accurate different areas of the photogrammetric mesh. This initial test shows that the photogrammetry has the potential of creating accurate documentations for an architectural project; however it depends on the density and the angels of the pictures taken. To establish the parameters that influence the accuracy of the mesh, one needs to study several case-study and analyze the pictures that were stitched to create the meshes. On a separate study, it would be important to compare the accuracy of meshed created from photographs from a drone and from photographs taken from the ground.


3. Examples of such applications are 123D catch and Recap 360° from Autodesk, and examples of such software are Photoscan from Agisoft.

**Bibliography**


Figure 1 - Aerial photo of Masada

Figure 2 - Laser scanning Masada

Figure 3 - Photographing the site from a drone
Figure 7 - Percentage of matching at 10cm tolerance

Figure 8 - Percentage of matching at 50cm tolerance
Turkish D-Light: Accentuating Heritage Values with Daylight

Sura Almaiyah  
University of Portsmouth, UK

Hisham Elkadi  
University of Salford, UK

Zeynep Aygen,  
Mimar Sinan Fine Arts University, Bern University of Applied Sciences, Architecture, Wood and Civil Engineering, Switzerland

Abstract

Historic buildings have their own cultural identity, which is often related to their aesthetic qualities, such as period characteristics, materials and construction. Daylight is one of the primary elements that have contributed to the distinctiveness of the visual environment of many historic buildings. Yet when construction preservation schemes of historical buildings are planned, daylight is rarely considered as one of the components that shape the character of buildings. Many of these buildings were originally designed to accommodate different activities to their new use. Preserving the quality of daylight that originally contributed to their visual identity is a challenging task. Maintaining the “daylit appearance” of a building can be particularly problematic if the building is to be used as a museum or a gallery due to artefacts’ conservation requirements. This paper investigates the opportunities of maintaining the original ambient conditions of renovated historical buildings while meeting the required daylight levels of the proposed new use. The paper utilises an annual daylight simulation method and hourly weather data to preserve daylight conditions in renovated historic buildings. The model is piloted in a Turkish bathhouse situated in Bursa, Turkey, that is currently under renovation. The simulation model produces 4483 hourly values of daylight illuminance for a period of full year using Radiance. The results of Radiance simulation show the extent of daylight contribution to the bathhouse’s visual environment. With the increasing pressure for valuing historic buildings in many parts of the world, the work reported in this study can be beneficial to those concerned with the conservation practice and the adaptive reuse of historic buildings.

Keywords: Daylight, Simulation, Visual Identity, Renovation, Minimum Intervention

Introduction

Several rehabilitation projects of urban centres have been recently implemented in Bursa, the fourth largest city of Turkey. A number of the city’s indigenous buildings were converted to museums, art galleries, cultural and community centres. Keeping and reusing historic buildings, a well-supported practice by the Turkish government, is often seen as a way not only to preserve the physical building fabric “as a tangible link with the past”, but as an opportunity to preserve the intangible heritage such as traditional skills and craftsmanship. The intention is to provide new accommodations where these skills can thrive. Many of these buildings were originally designed to accommodate different activities to their new use. Preserving the quality of daylight that originally contributed to their visual identity can be a very challenging task. Furthermore, as most historical buildings were originally designed to maximise daylight, maintaining the “daylit appearance” of a building can be problematic in terms of artefact conservation requirements. On the other hand, a successful utilisation of daylight can create a better visitor experience and museum environment as well as improve the energy efficiency of a building. In top-lit galleries (in temperate climates) savings in the order of 50% to 60% in installed lighting loads are estimated if daylight is properly integrated with artificial lighting.

Museums and art galleries are well recognized for their challenging day/lighting criteria. Whereas retrofitting of ordinary non-historical old buildings can offer a number of possibilities for improving the ambient conditions and energy efficiency of buildings, in a heritage building, a radical change to the original quality of daylight though an extensive use of artificial light or displacement of daylight can have a critical impact on the visual character and sense of place. Although the conservation practice in general is clear about the importance of applying and adopting “minimal intervention” when developing a rehabilitation scheme, the practice of implementing “minimal intervention” is often understood by designers in terms of preserving the tangible aspects of a building. Indeed

Theme 5: Emerging tools for conservation practice
Theme 5-1: Technological innovation

Heritage and Landscape as Human Values - Conference Proceedings
preserving the original tangible components of buildings such as their materials, fabric and fenestration features, is the key for preserving the physicality of the buildings. There are however many other facets of historical buildings that contribute to their distinctive quality and significance.

Daylight is one of these in/tangible elements that have contributed to the distinctiveness of many historical buildings and settlements. Yet when initiating preservation schemes of historical buildings daylight is rarely introduced as one of the components that shape the character of buildings. A review of relevant documents suggests that at present there is no clear recognition of the role of daylight in shaping the visual character of historical buildings. For example Nelson, in a chapter published in the U.S. government’s official text on saving old buildings, identifies the visual aspects and physical features that comprise the appearance of historical buildings as follows: “Character-defining elements include the overall shape of the buildings, its materials, craftsmanship, decorative details, interior spaces and features, as well as the various aspects of its site and environment”. Although the environment, as evident in this quotation, has been identified among the various components that give the building its visual character, the actual description does not provide an explanation of what this term means in relation to the building context, whether it is the surrounding external context or internal ambient conditions. The work is mainly limited to identifying tangible aspects related to the physical characteristics of buildings. Without a clear valuation and an understanding of the value of daylight in shaping the visual character of a historical building, it would be rather challenging to first establish whether daylight should be taken into account when developing a renovation scheme, and then what might be considered as “minimal intervention” in terms of preserving its ambient conditions.

Daylighting regulations and practice in Turkey

The role daylight can play in improving the energy efficiency in buildings has recently received much attention in energy performance regulations in Turkey. The value of daylight and the importance for maximising its effectiveness for illuminating building interiors, which were clearly stated in building performance legislations introduced in 2008, has been further emphasised recently with the latest introduction of the new Turkish Lighting Standard. As a candidate country for the European Union membership, Turkey has adopted the European Standard Lighting of Work Places in January 2012 as the Turkish Lighting Standard. Item 4.10 of this standard emphasises the role of daylight provision in buildings and provides in clause 5.4 the lighting requirements for retail premises, such as restaurants and hotels, theatres and concert halls, as well as exhibition halls and museums. All of these functions can also guide the re-use of historical buildings. While recommended light levels for most of these public premises are given in the European guidelines, there are no values given for museums, where lighting requirements are mainly determined by the display classification. However, other reliable international guidelines such as those recommended by the Illuminating Engineering Society of North America (IESNA) or by the Charted Institution of Building Services Engineers (CIBSE) can be used to establish lighting requirements in a museum or gallery environment. With the new Lighting Standard now in place, there is an even better ground or base to measure how traditional buildings perform against these recent requirements.

Daylighting requirements in museum buildings

Whilst the presence of natural light with its vibrant qualities is an attractive design feature in many building types, in a daylit museum environment certain preventive measures should be taken to minimise its “deleterious” effects on the museum collection. Daylight has always had (the most) desirable colour-rendering qualities for aesthetic reasons that are important to the museum function. However, the high energy in the Ultraviolet region (UV) of the spectrum can cause chemical and physical damage to the fragile objects in the collection, such as discoloration, fading, yellowing and surface cracking. Unnecessary visual light can also pose a threat to certain types of museum objects. The “reciprocity law” states that the cumulative photochemical effect “is directly proportional to the illumination levels multiplied by the time of exposure”. Thus 200 lux exposure for six months can cause as much damage as 100 lux exposure for one year. Reducing the exposure time is therefore another important measure to limit damage from light. On the other hand, the rate and extent of deterioration brought about by the amount of light and exposure time varies between the different types of objects depending on their material properties and chemical composition. Museum artefacts in general can be grouped into three categories based on sensitivity to light: highly sensitive objects derived from organic origins, partially sensitive objects contain organic and inorganic substances and insensitive objects have geological origin. The illuminating Engineering Society of North America (IESNA) established illuminance recommendations and annual exposure times for the various material - type categories found in a museum collection.

As illustrated in Table (1), a maximum of 50 lux is recommend for highly sensitive objects and a range of 200 lux and 300 lux for partially sensitive and insensitive objects, respectively. Similar illuminance values are also given in the Charted Institution of Building Services Engineers (CIBSE) Lighting Guide LG8 (1994). While reducing the length of exposure to light is important in terms of conservation considerations, determining the correct level of illumination in display spaces is equally important in terms of comfort and visibility. The limits recommend in Table 1 are widely accepted as practical for reducing damage while maintaining adequate view conditions, and thus adopted in the present study for assessing the annual illuminance values and the total annual exposure to daylight in the selected case study.
Table 1 Maximum illuminance levels and cumulative exposure values given in the IESNA lighting handbook and the CIBSE lighting guide for various types of exhibits

<table>
<thead>
<tr>
<th>Types of materials</th>
<th>Maximum illuminance</th>
<th>Maximum annual exposure</th>
<th>Types of materials</th>
<th>Maximum illuminance</th>
<th>Maximum annual cumulative exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objects insensitive to light, e.g. metal, stone, glass, and ceramics</td>
<td>CIBSE Guide Lighting</td>
<td>IESNA Lighting Handbook</td>
<td>Objects insensitive to light, e.g. metal, stone, glass, and ceramics</td>
<td>CIBSE Guide Lighting</td>
<td>IESNA Lighting Handbook</td>
</tr>
<tr>
<td></td>
<td>Subject to heating and adaptation effects</td>
<td>Depends on exhibition situation</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Objects moderately sensitive to light, e.g. textile with stable dyes and wood</td>
<td>200 lux</td>
<td>200 lux</td>
<td>Objects moderately sensitive to light, e.g. textile with stable dyes and wood</td>
<td>600,000 lux-hours</td>
<td>480,000 lux-hours</td>
</tr>
<tr>
<td></td>
<td>50 lux</td>
<td>50 lux</td>
<td>Objects highly sensitive to light, e.g. textile, costumes, and tapestries</td>
<td>150,000 lux-hours</td>
<td>50,000 lux-hours</td>
</tr>
<tr>
<td></td>
<td>50 lux</td>
<td>50 lux</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Methodology

Several site visits to selected heritage buildings (buildings that are recently converted to museums or to be converted to museums) in Bursa took place in May and August 2012 and September 2013. The selected buildings include the Demirçi bathhouse (a small bathhouse currently under renovation), the Uluumay museum (an old religious school that became a museum in 2000), the Ordekli bathhouse (converted to an art and cultural centre in 2008). The Muradiye Madrasa is soon to be also converted to a museum. The new use of the Demirçi bathhouse (fig. 1) is a cultural centre where art exhibitions can be organised regularly to benefit the village's community. The building offers therefore an opportunity to test the possible use of its original ambient daylight conditions for a better adaptive reuse strategy.

Until recently daylight studies of buildings have mainly focussed on assessing the illuminance values received into a building or part of a building on selected seasonal dates and times of day. Key seasonal dates that are often used for performing such analysis are the winter and summer solstices and the fall and spring equinoxes. Since the early 2000s, an increasing number of literature have argued the limitation of such approach and advocated for a more realistic systematic approach of evaluation; preferably hourly annual evaluation.

The revised methodology using annual evaluation of daylight illuminance levels is particularly essential in daylight studies of museums and exhibition buildings given the sensitivity of artwork objects to excessive exposure to illuminance levels. Since natural illuminance values are mainly affected by the sky conditions and the thickness of the sky cover, it is important to separate between the various sky conditions and choose the right sky type for each step/hour of the evaluation. Thus, Bursa sky conditions are classified into three types using hourly cloud cover data obtained from a typical weather file (ASHRAE IWEC weather file for Bursa). These are clear sky (has less than 30% cloud cover), partly cloudy sky (cloud cover ranges between 30% and 70%) and overcast sky (more than 70% cloud cover). The classification of the sky types presented here is in line with the CIE definitions of standard general sky models and the use of this hourly statistical based approach is similar to a previous work by Tzempelikos and Athienitis (2005). Then, hourly daylight simulations for a period of one year was performed to calculate annual illuminance values received into the selected bathhouse using existing CIE models for clear, overcast and intermediate sky conditions in the IES Virtual Environment Radiance.

Radiance is well known as a powerful and highly accurate modelling tool. Several previous studies with similar content to this work have used Radiance to assess daylight levels and visual comfort criteria in reused historical buildings. Al-Sallal and Dalmouk (2011), for example, used Radiance in their evaluation of the daylighting performance of one of the traditional residential buildings in UAE that was converted to a museum. Daylight levels and ambient conditions in the present town hall in Florence (Palazzo Vecchio), where some of the most precious and ancient tapestries are exhibited, were also examined using a Radiance modelling tool. A three dimensional digital model of the bathhouse was therefore developed using the geometry model creator (Model IT) in the Virtual Environment and the daylight simulation package Radiance was used to perform the annual illuminance evaluation (fig. 3).

In many building types such as in office buildings and schools daylight studies are usually performed by calculating the horizontal illuminance values on the work plane where most of the visual tasks take place. In exhibition halls, by contrast, where some artwork can only be mounted to the walls either vertically or horizontally, evaluating the distribution of daylight on the vertical surfaces of a room is as important as evaluating the values of work plane illuminance. For this reason, an internal view with a fixed camera position that shows the various zones illuminated with daylight within a selected room in the bathhouse was chosen for the evaluation (fig. 2). A series of reference points that were assembled on five main axes on the south, north and west - facing walls of the room was then used to predict the hourly values and the total exposure to illuminance during daylight hours (5 a.m. - 7 p.m. in summer and 8 a.m. - 4 p.m. in winter). The simulation model produces 4483 illuminance values for every calculation point.
The Case Study Building: The Demirçi Bathhouse

The plan of the Demirçi bathhouse or hammam follows the traditional layout of the Roman baths with a cold room, a semi-hot room and a hot area. The cold room is usually used as a transitional space between the changing rooms and the heated area. The semi-hot room is the room where beauty treatments such as oiling and massaging of the body take place, while the actual bathing takes place in the hot room “caldarium” that is often considered the most important place in a bath building. Traditionally, a bathhouse was both a “complex structure and an expensive enterprise” that was carefully designed and perforated to maintain certain ambient conditions necessary for the bathing requirements taking place.

Hence, and like any other hammams, there are no windows in the Demirçi hammam to avoid drafts, save and control steam and heat and daylight is provided by small glass openings stunning the domes while allowing a minimum amount to filter through (fig. 1). Today, only the hot area of the Demirçi hammam has survived, as the other two areas (the cold and semi-warm) were destroyed and rebuilt later. These additions which were demolished and rebuilt will be re-functioned along with the original hot complex as a cultural centre as stated before. The dimensions of the caldarium are 7.21m x 8.77m, including two hot rooms, a small cell for private bathing and the furnace room (fig. 3).

Discussion and Analysis

The transformation of heritage buildings to adopt new uses has challenged the possible maintenance of their original characteristics. Daylight is clearly a key ingredient of such transformation, particularly when the new use includes exhibitions of artefacts. The Demirçi hammam is an excellent case study to carefully study the possible use of daylight not only to sensitively illuminate the artefacts but also maintain the identity and ambience of such wonderful heritage building.

The year round hourly measurements have provided more accurate representation of daylight performance in the building. The dome of the hammam provides interesting temporal daylight distribution throughout the year. The interesting setting allows for testing the diverse daylight pattern on the north, south and west-facing walls. The distribution of dome lit daylight greatly differs through the year (figg. 4, 5) but provides steady levels of daylight on the surrounding walls.

Analysis of daylight levels on the three walls shows the possibility of maintaining acceptable levels of daylight within the safety levels (480,000 lux hrs) for moderately sensitive exhibits such as oil painting, fresco, ivory, and wood. A further in depth investigation revealed particular times at particular points on the walls when precautions need to be taken. While the overall cumulative of illuminance falls within the accepted range, contact with illuminance that exceeds maximum exposure levels (200 lux) at any particular time could cause serious damage to the exhibits. All points at the south wall appear to receive acceptable levels of illuminance exposure all year around. The average monthly illuminance remains under 140 lux. The accumulative levels similarly fall well within the 480,000 lux hrs limit all year around (fig. 4).

The north-facing wall receives a maximum monthly average illuminance of 220 lux in its upper part during April (fig. 7). The upper part of the wall seems to be the only section that would require attention during April and August if sensitive objects are to be exhibited. Similar results were also obtained for the accumulative illuminance. Precautions are therefore to be taken to avoid exhibits placed on the upper part of the wall and the middle section during August. The west-facing wall is a long running wall and provides excellent surface for exhibition of artefacts. For testing purpose, the wall was therefore divided into three parts; left, centre, and right sections. The analysis of the left side of the west facing wall shows no reason for concern. The maximum monthly average was again mostly under 120 lux except of a slight increase during April in the upper part of the wall. The annual accumulative exposures were also under the 480,000 lux hrs limits allowing for unconstrained usage of the wall for exhibition of moderately sensitive materials (fig. 5). Similarly, the centre part of the west facing wall shows higher illuminance level during summer period, particularly 25 May to 25 June, on the upper part of this section (fig. 6). The right side of the west facing wall has however much higher level of illuminance for the middle part of the wall for longer period of the year (April-September).

Conclusion

Daylight is a key ingredient for maintaining the identity of a cultural built heritage. In Bursa, intervention to adapt cultural built heritage to more contemporary use is essentials for their sustainability. Such intervention cannot just rely on the new Turkish lighting standards, particularly where museums are suggested as new functions for these buildings. The paper shows that a thorough evaluation of the seasonal variation of daylight and careful distribution of artefacts, in a heritage building, not only maintain its ambience and character but also assist in protecting the exhibited objects by limiting the damage caused by excessive exposure to daylight.

The outcomes of the simulation of Demirçi hammam highlight the importance of yearly daylight measurements rather than analysis on the base of sample dates data. The particular structure of this building together with daylight...
through the dome structure necessitates accurate investigation of the dynamic profile of daylight across various wall surfaces. The results also clearly show the possibility of using daylight across many walls of the building to exhibit sensitive objects and artifacts. The results would maintain the ambience and the original experience of the building despite the strict light requirements of the new use.

1. (Cengiz, 2012)
2. (Carver, 1994)
7. (NPS museum handbook, 1999).
8. (IESNA, 2000).
9. (CIBSE, 1994).
10. (Mardaljevic et al., 2011).
11. (Balocco and Frangiioni, 2010).

Bibliography

Figure 1 - The Demirci Bathhouse, Bursa, Turkey, (right) the toplit dome of the northern hot room

Figure 2 - Location of the digital sensors used in the analysis (the location of the selected 3D view is shown in the figure below)

Figure 3 - Plan of the Demirci hammam showing the various parts of the building - the heated area in the middle, the cold and warm areas on the west side on the building (right) digital model of the historic section of the hammam
Figure 4 - Daily total illuminance received by the southern wall between January 1st and December 31st.

Figure 5 - Daily total illuminance received by the left side of the western wall between January 1st and December 31st (reference points west 1a, west 1b and west 1c).

Figure 6 - Average Monthly Illuminance Received By The Central Section Of The Western Wall.

Figure 7 - Average monthly illuminance received by the three sections of the northern wall.
A User Perspective on the ROVINA Project

Vittorio Ziparo, Algorithmica, Italy. Daniele Calisi, Algorithmica, Italy.
Giorgio Grisetti, Uni Roma, Italy. Jacopoa Sarafin, Uni Roma, Italy.
Maurizio Di Stefano, ICOMOS, Italy. Luigi Petti, ICOMOS, Italy.
Wolfram Burgard, Uni Freiburg, Germany. Fabrizio Nenci, Uni Bonn, Germany.
Igor Bogoslavskyi, Uni Bonn, Germany. Olga Vysotska, Uni Bonn, Germany.
Maren Bennewitz, Uni Bonn, Germany. Cyrill Stachniss, Uni Bonn, Germany.

Abstract

ROVINA is a research project funded by the EC within FP7. ROVINA will provide tools for mapping and digitizing archeological sites - especially for difficult to access sites - to improve the preservation and dissemination of cultural heritage. Current systems often rely on static 3D lidar, traditional photogrammetry techniques, and are manually operated. This is expensive, time consuming, and can be even dangerous for the operators. ROVINA exploits the strong progress in robotics to efficiently survey hazardous areas and aims at making further progress in the reliability, accuracy, and autonomy of such systems.

Keywords: Robotics, Artificial Intelligence, Digitalization, Archaeological Site

Introduction

Europe has a wealth of cultural heritage sites and Italy is the country that has the largest number of them in Europe 1. The conservation of such sites is a challenging task, as it requires periodical surveys for which teams of experts have to carry heavy equipment in the field. Surveys require a substantial amount of time and manual labor by experts, thus rendering this task expensive. Furthermore, the process is slow and sometimes prone to error. In addition to that, many sites are dangerous to access for humans and pose serious risks to the surveyors in the field. In this paper, we present the ROVINA project (http://rovina-project.eu). ROVINA is a three and a half-year research project that is co-funded by the European Commission in the frame of the 7th Framework Programmed (FP7 ICT-600890). The ROVINA consortium is composed of the University of Bonn (DE), RWTH Aachen University (DE), the University of Freiburg (DE), the University of Leuven (BE), Sapienza University of Rome (IT), Algorithmica Srl (IT), and the Italian Committee of the International Council of Monuments and Sites (IT). ROVINA aims at making surveying of cultural heritage sites faster, cheaper, and safer through the use of autonomous robots, which will enable 3D reconstructions of hazardous sites at a new scale and quality. The ROVINA robots are meant to autonomously explore archeological sites. The data collected during the exploration is processed and stored in the cloud and will deliver advanced analysis services for structural engineers, historians, and preservation experts. As the models will be accurate and visually appealing, ROVINA will also feature a browser-based online museum for the general public.

The project will be evaluated through two case studies in the catacombs of Rome and Naples. Indeed catacombs are a very interesting case study and are found in several cities. There are approximately 100 catacombs in Italy, scattered through 29 cities. As one may expect, most of the catacombs are in Rome 2, that counts 48 of them, but there are another 11 concentrated in Naples 3. Catacombs are not limited to Italy, and there are others in Europe and around the world 4, for example in Paris and others in England, Ukraine, Malta, Egypt, and the Czech Republic. Catacombs often extend for several kilometers and at multiple depth levels. For example, the Roman catacomb of S. Priscilla extends for 13 km over multiple floors and this catacomb has been selected as ROVINA’s primary test site. Most catacombs are partially unexplored due to the high risk of entering them. On the one hand, catacombs are unstable and there is a high risk of collapse. On the other hand, several of the (non-ventilated) catacombs, for example those located in Rome, yield a high concentration of radioactive radon gas limiting human intervention to time periods of at most 15-30 min.
State of the art

The ROVINA project aims at automating existing practices, thus it is conceived to seamlessly integrate with current activities in the realm of cultural heritage. In the following of this section, we provide a brief overview of the core activities related to the preservation and documentation of archaeological sites.

**Measuring** is the key building block of any surveying activity. There are two types of measurements: “direct” and “indirect”. Direct measurements are those that the operator performs directly (and manually) on the artifact with classic tools such as Charles metric, the plumb line, water systems, etc. In these cases, operators either build polygons, possibly with the help of topography, to give “robustness” to measurements or, alternatively, they triangulate manually. Instead, indirect measurements are usually based on laser scanning and/or Figure analysis (using traditional photogrammetry techniques). Both, laser and Figure-based reconstructions allow morphometric surveys. Laser-based systems, and in general instruments based on “time-of-flight”, are typically used for large sites or large artifacts. These sensors can be rather expensive but offer a high precision. The Leica CyraX scanner, for example, has a scanning range of 2 m - 150 m with a resolution that is higher than 1 cm and a full 3D scan takes a few minutes. Depending on the application at hand, the requirements on the precision of the measurements may vary. For documentation activities, a range precision may increase. Figure-based systems have been shown to provide precisions similar to those of Lidar scanners, especially when sufficient Figures close to the surfaces can be taken.

They have the advantage that Figure/color data are available, that are perfectly aligned with the 3D data. The captured data - as for lidars - produce point clouds that need further post-processing. Figure-based systems usually employ high-resolution commercial cameras such as the 10MPixel Nikon D200 and commercial photogrammetry software or, more recently, self-calibrating structure-from-motion systems as ROVINA uses (Vergauwen and Van Gool, 2006; Moons et al., 2009) or multi-view stereo approaches.

**Documentation** is the core activity in surveys and aims at producing digital archives of the site under observation. In the realm of cultural heritage, documentation activities are performed by public bodies, which for the specific case of Italy usually are superintendences and ministries. The digital archives can take the form of 3D models that can be either purely geometric or can also include textures from Figures. When the surveys have a purely documentary purpose, i.e., they are not for the purpose of pure measurement or diagnosis, 3D models can have a lower resolution and do not need to be extremely precise but they should rather be visually appealing. Their main goal is to disseminate cultural heritage to broad audiences. To this end, tools such as virtual museums are of paramount importance.

**Classification** activities are usually tied to documentation tasks and pertain to the categorization of elements of a site into taxonomies or ontologies with different degrees of complexity. For example, in an industrial setting you may want to categorize rooms of a plant - and equipment therein - based on their functional properties. In a cultural heritage site, you may want to classify architectural components and items based on a number of parameters such as period of construction, materials used, state of conservation (“stato di conservazione”) and so on. Human users usually perform classification by manually tagging items and portions of the environment. Especially when data is collected on a geographical scale, the models are archived into Geographical Information Systems (GIS).

Data can then be queried on both a geographical and qualitative level. For example, one may look for all the sites built before 1000 B.C. in Italy or all the pots made of ceramic from Germany.

**Diagnostics** is typically associated with the goal to collect data on the state of the surveyed areas in order to prevent damage or perform restoration. From a practical perspective, the diagnostic activities have the purpose of generating specific deliverables that in the context of cultural heritage are the Table of Deterioration (“Tavola del Degrado”) and the Table of Materials (“Tavola dei Materiali”).

The Table of Deterioration is a map showing possible deteriorations such as cracks and molds. The Nazionale Italiano di Unificazione1 (UNI) and the Commissione NORmalizzazione MAteriali Lapidei (NorMaL). At a European level, the standards are dictated by CEN (i.e., WS Construction, WS Measurement, WS Material). The Table of Materials instead maps the areas of the site under survey to the different materials of which they are composed.

The ROVINA Robot

The core idea behind the ROVINA project is that one can improve measurement activities by replacing standard tools, which must be carried by operators into the site, with autonomous or semiautonomous robots that can be remotely supervised. Thus, one of the goals of ROVINA is to assess the technological and commercial feasibility of building robots capable of surveying cultural heritage sites. For this reason, the ROVINA robot, rather than being a production-ready system, is a prototype that has been designed having in mind flexibility and reduced cost. For example, the robot mounts the Ocular RE05 laser that has a maximum range of 30m and offers a lower resolution compared to the above mentioned laser scanners. Compared to the Faro Focus3D X330, for example, that has a range of 330 m and a resolution of 2 mm, the RE05 is inferior. Nevertheless, the RE05 costs much less and is very flexible as one can dynamically control the scanning field (full, bounded elevation, and region).

If the ROVINA system succeeds and operates with the RE05, it will be easy to upgrade the robotic system using...
a Faro laser scanner, as the algorithms are independent of the specific laser. Better performance of the laser will simply mean better performance of the entire system. Similar considerations apply also to other components. For example, we have opted for laptops rather than for embedded computers. This makes the life easier for developers and allows us to easily upgrade the hardware if needed. The price we pay is an increased volume of the robot and thus reduced mobility. At the same time, there is very little dependency on one producer or retailer when upgrading or replacing parts of the system.

Currently, we have built three robot prototypes. Figure 1 depicts one of these prototypes and Figure 2 shows a subset of the sensors of the ROVINA robot. The robot was designed based on a number of environmental and software requirements that have been gathered in a number of inspections of Catacombs (ROVINA Consortium, 2013).

The first requirement was the mobility. The robot must be able to navigate rough terrain and tackle small obstacles such as stairs or pallets, while still being able to go through the small passages of a catacomb that are roughly 80 cm wide. Figure 3 depicts typical environments and it illustrates some of the mobility challenges that we encountered during our preliminary inspections of the catacombs. These include debris, stairs, and holes in the ground. Given the peculiar structure of the environment the best option would have been to build a custom tracked robot with flippers. Nevertheless, for the sake of budget reduction and for providing a working prototype as soon as possible we decided to customize an existing, off-the-shelf, tele-operated robot. We surveyed a number of existing solutions and we finally identified the Mesa Robotics Element (rightmost element of Figure 2) as the platform with the best performance/cost ratio. This robotic platform is agile enough to traverse most of the obstacles encountered in the catacombs and is small enough to navigate through narrow corridors.

The Mesa Element is a remote controlled platform that we had to extend for the purposes of the project. We had to equip the platform with two laptops and a sensor suite (Figure 2 and Figure 5) composed of a Lidar, two RGB-D cameras, an array of RGB cameras, an inertial measurement unit (IMU), battery status monitors and thermal/humidity sensors. Regarding the array of RGB cameras, we were not able to identify an off the shelf solution to allow sufficient amount of control in the given environmental circumstances. Several iterations have been executed testing different camera configurations, including firewire and Ethernet based communication. We finally converged to custom arc setup of 7 Ethernet based cameras with a 2MPix resolution each, and having lenses of 60 degree opening angle. Allowing an omnidirectional view on the catacomb’s walls, outside the view range of the scanner or the other devices. The camera acquisition is designed to run on a separate second computer platform, which is independent from the platform needed for navigation and scanning. In order to avoid jeopardizing the autonomy of the Mesa Element by using its batteries to power the extra sensors and computational units, we designed an additional power system. Experimental evidence shows that the additional power system allows our robot to run at full power for ~6 hours.

Considering a target speed of 30 cm/sec we estimate that the robot can survey approximately an area corresponding to a path 6.5 km long. To house these components, we have built a case of aluminum and polycarbonate on top of the Element. The housing has been made shockproof where necessary and has been designed for maximizing ease of use. Figure 4 shows three iterations of the robot case, while Figure 1 shows the final version mounted on the Mesa Element. The robot must be able to operate in the target environments without damaging on-board devices. This means that the housing must be robust to water dripping from the ceiling, some dust, and high levels of humidity (~95%). To deal with these challenges, we provided the robot with an ingress protection to dust and water equivalent to IP52. The robot also has a cooling system capable of controlling both temperature and humidity inside the case.

**Mission Control**

The surveyor deploys the robot at the entrance of an archeological site and remotely operates it through the mission control interface. The interface is very similar to the one of a 3D videogame. The surveyor has a bird’s eye view of the robot and looks at a local 3D reconstruction while tele-operating it with a joystick. Automatic navigation systems avoid the robot causing damage due to human error, for example stopping the robot when it gets too close to an obstacle. Additionally, video streams can be projected on the 3D reconstruction and a 2D map is shown in order to provide a global view. This interface configuration of the mission control interface is called multi-modal. During the exploration the operator can select regions of the environment and annotate them for further analysis and classification after the completion of the mission. The robot itself can also highlight interesting areas (such as ones containing pots, frescos or bones) for further inspection.

The multi-modal configuration requires a lot of bandwidth that is provided by a dedicated point-topoint Wi-Fi connection. While this type of connection is suitable for many indoor environments, it has a limited range in a catacomb and its performance will quickly degrade until the connection is lost. To this end, as soon as the connection quality reaches a given threshold the robot starts releasing Zigbee devices (see Figure 5 right). These devices act as repeaters and allow for maintaining connectivity at the price of a lower bandwidth. These devices can create a low-cost wireless mesh network that can last years thanks to its low-power characteristics and that can act as a sensor network and continuously stream a wide set of data such as temperature, humidity and pressure. When the robot starts deploying zigbee nodes, the interfaces switches to a so-called Supervisory Mode in order to adapt to
the new bandwidth limitations. An example interface is shown in Figure 6 and 7. The map provides a more abstract 2D representation of the environment called traversability map (Bogoslavskyi et al., 2013).
Colors in the map provide qualitative information on the terrain: black denotes unexplored areas, green safe to traverse areas, yellow denotes the areas of uncertainty, where there is not enough information to make a safe decision and red denotes dangerous areas that the robot cannot traverse. The user can select a target location by clicking an area in the map. The robot will automatically compute the safest path and follow it to the target location without the need for direct tele-operation.
While traversing unexplored areas, the robot will update the 2D map accordingly to the new information it has perceived through its sensors. This is achieved through exploration techniques that consider the expected gain of novel information (Stachniss and Burgard, 2012; Stachniss and Burgard, 2003). In addition to that, the robot can recognize and signal interesting features and objects in the environment. For example, the robot can communicate to the surveyor that it has identified a manufact made of ceramic in a given location. The surveyor can then request a picture (as shown on the top left mockup of the mission control interface in supervisory mode) to further assess the discovery that then can be annotated in the map.
Although the zigbees can greatly increase the time that the robot is connected, the robot will eventually run out of devices to deploy. When this happens, the mission control interface will enter a so-called autonomy mode. In this mode the user pre-plans short missions during which it will lose contact with the robot. For example, the user may ask the robot to explore a given region for 30 min and to report on the traversability of the terrain and on interesting items it may encounter.
During the mission the robot will not be in contact with the operator. When time is over, or when the entire area is explored, the robot will return where the mission had started and report through the supervisory interface the traversability map of the explored area annotated with the interesting objects it has found.
On request, the robot may transmit additional data such as pictures. Based on this information, the operator can plan successive mission as, for example, to further explore the area or to go elsewhere.

Cloud Services

Once the measurement activities (i.e. the surveying mission) are over, the robot will have gathered an enormous amount of data from its sensors that include laser scans and pictures. These data are uploaded to a cloud computing facility in order to provide services for documentation, classification and diagnosis. At the core of all the services there is a high-resolution textured 3D model of the archeological site. Note that, although the robot builds a 3D model during the mission (Kümmerle et al., 2011), due to real-time requirements, the model is approximate (Grisetti et al., 2012). However, this model is just accurate enough to enable autonomous navigation and operator awareness. Our focus is set on making sure that the robot does not get lost rather than on the accuracy of the resulting models. To this end, we have devoted a considerable effort in making the approach more robust to outliers (Agarwal et al., 2014), to assessing the degree of consistency of maps (Mazuran et al., 2014) and to automatically calibrating the sensors (Basso et al., 2014; Tedaldi et al., 2014).
Despite being approximate, the 3D model that has been reconstructed online can be fed as an initial guess to more accurate, yet timeconsuming techniques (Vergauwen and Van Gool, 2006; Moons et al., 2009) which are then compute - off-line in the cloud - a highly accurate model based on the large amount of pictures that have been collected by the camera array. Figures 8, 9, and 10 show some examples of portions of the reconstructions.
The cloud-based services provide tools for classification activities. In particular, there is a web tool (see Figure1) that allows annotating areas of some of the pictures taken by the robot based on the composing materials and archeological taxonomies. These manual annotations are then fed to machine learning algorithms that generalizethe examples, and use them both for identifying interesting objects/areas during the mission and for annotating the accurate 3D model. Our approach to semantic mapping (Hermans et al., 2014) won the IEEE ICRA’14 Best Vision Paper Award. Once the 3D models are semantically annotated, users can pose complex queries. For example, one can look for all the niches made out of tuff in catacombs in the region of Lazio.
ROVINA also offers a number of services related to Diagnostics. Indeed, classified areas can also be used for automatically generating reports such as tables of materials and tables of decay. This can be simply achieved by Another use of the models in the realm of diagnostic activities is the possibility to compare 3D models of the same site at different points in time. Indeed, such a tool can greatly help engineers performing structural analysis, for Finally, as the 3D models generated by ROVINA are both accurate and visually appealing they are also used for Documentation purposes. The ROVINA services include a browser-based 3D virtual site viewer that allows virtual tourists to visit high quality 3D textured reconstructions of the sites, which are made interactive thanks to the semantic annotations and to additional information (e.g. videos, text etc.).
Conclusions

The ROVINA project, despite being at an early stage, has already achieved a number of important goals. Three prototypes of the robot are now available and are recording data. The obtained datasets show that our 3D reconstruction and semantic segmentation algorithms are capable of generating small-scale models that have many of the features of the final system. We are currently improving and integrating our developed techniques, while exploring new challenges related to autonomous navigation and user interfaces.

Bibliography


Figure 1 - The designed and constructed ROVINA robot (here depicted without the camera array).

Figure 2 - A subset of the sensors and the base of the ROVINA robot platform.

Figure 3 - Typical environments encountered by the ROVINA robot.

Figure 4 - Three iterations of the robot chassis design process.
Figure 5 - Considered setups for Figure acquisition. Left: test setup, middle: final camera configuration, right: Zigbee node.

Figure 6 - Guardian angel view of the user interface.

Figure 7 - Control interface showing the traversability analysis (green = traversable, red = non traversable, yellow = areas of high classification uncertainty).
Figure 8 - High-resolution reconstruction obtained through SfM.

Figure 9 - High-resolution reconstruction of a portion of the catacomb obtained through SfM.

Figure 10 - Detail from the reconstruction in Figure 9.

Figure 11 - Browser based semantic annotation tool. Environment structures can be colored and labeled through an intuitive user interface.
Development of 3D Measurement Method for Historical Structure by Using Smartphone

Yoichi Kunii
University of Agriculture, Tokyo

Abstract

Software has been developed in this investigation that can conduct 3D measurements of historical structures. Its algorithm is constituted by photogrammetric theory, and measurements are done by using a smartphone. Therefore, a field survey of a historical structure was performed by using only a smartphone. The conventional techniques of photogrammetry require some ground control points or indication of scale. Nevertheless, the developed software can be operated by using only taken Figures and GPS positioning data.

Keywords: 3D Measurement, Structure, Smartphone, Photogrammetry, Positioning

Introduction

Japanese cultural heritage includes many kinds of historical structures such as temples, shrines, and private houses. Such heritage must be observed by landscape architects or researchers to conserve landscape assets. Moreover, an efficient 3D measurement method needs to be developed for maintenance and conservation. Recent measurement devices are imaging total stations, 3D laser scanners, and so on. Additionally, digital photogrammetric technology is also applied for 3D measurement by using digital still cameras. The digital photogrammetry by a digital camera has received attention due to its convenient acquisition of measurement data and low cost system. However, 3D measurement by conventional digital photogrammetry requires that some ground control points be prepared at the measurement site. To prepare the ground control points, physical effort and operation skills are required for accurate surveying. Therefore, digital photogrammetry is difficult to apply to the measurement of the cultural heritage. To overcome this problem, software has been developed in this investigation that can be operated as a 3D measurement tool. The algorithm of the software is constituted by photogrammetric theory, and the 3D measurement of the historical structures is done by using a smartphone. The smartphone can simultaneously take photos and obtain positioning data by using GPS. The conventional method of photogrammetry requires some ground control points. Otherwise, indication of scale needs to be prepared from the measurement viewing angle. Nevertheless, the developed 3D measurement software can be operated by using only taken Figures and GPS positioning data. With such software, 3D measurement was observed for the Koma family house (Figure 1) located in Saitama prefecture, Japan. Koma House was built in the 17th century and designated a nationally important cultural asset in 1971. The results of the measurement are shown in this paper.

Data acquisition by using smartphone

The Figures and positioning data of Koma House were acquired by an iPhone 4 (Apple Inc.). The GPS positioning method of the iPhone adopts single point positioning, which is the commonest method for mobile phones. In addition, the number of pixels and other specifications of the Figure sensor are mostly general values. Therefore, the results of this observation will be applicable to other smartphones. The six Figures of the front of Koma House were taken by the iPhone 4, and GPS positioning was performed simultaneously (fig. 1). The GPS positioning data (latitude and longitude) was recorded as Exif data in each taken Figure (table 1).

Fundamental and processing procedure of the measurement

To acquire 3D data for structures such as Koma House, camera calibration for taken Figures must be performed, usually by using ground control points (GCP). However, to perform camera calibration more efficiently without GCP, combined adjustment, which combined relative orientation and a resection method, was adopted for these Figures. The combined adjustment can acquire exterior orientation parameters and only set locations of the original point and axis. Thus, efficient camera calibration became possible, and 3D data was calculated for the measurement points of the Koma House. Details of the orientation procedure are as follows.
(1) Acquisition of conjugated points
To perform 3D measurement by using digital photogrammetric techniques, some conjugated points need to be detected from each Figure. The conjugated points (corners and edges) were detected by manual operation with mouse clicks (fig. 2). Therefore, 50 points in each Figure were detected as conjugated points and used as measuring points in the following steps.

(2) Relative orientation
Generally, some ground control points (GCP) that have known 3D coordinates are required for photogrammetry to acquire 3D coordinates of camera positions and attitude angles. However, such GCPs are difficult to prepare at historical sites, so a measurement method must be developed that does not use GCPs. Therefore, relative parameters (camera positions and angles of the six Figures) were calculated by relative orientation. The relative orientation is performed on the basis of any two Figures as a stereo pair, and the leftmost Figure was set as the base Figure in this investigation. In addition, the relative orientation in this investigation calculated not only relative parameters but also interior parameters, which include focal length and lens distortion coefficients. Consequently, 15 relative and interior parameters were calculated for each stereo pair (table 2).

(3) Exterior orientation
Such relative parameters express each camera position and angle relatively, so a scale of measurement needs to be acquired. Therefore, GPS positioning data simultaneously obtained when Figures are taken was applied to measure distances between each camera position, and the relative parameters were converted into absolute parameters (table 3). Thus, interior and exterior parameters of six Figures were calculated in the above steps. In addition, temporal 3D coordinates of the 50 measurement points could also be calculated by using a collinear condition.

(4) Final orientation
In these steps, orientation parameters and 3D coordinates for all Figures were calculated. However, these parameters and coordinates were acquired as only temporal values with uncertain accuracy. Therefore, all the above values were set as unknown parameters again, and final orientation for these unknown parameters was performed. Consequently, 3D measurement was realized for Koma House.

Evaluation of measurement results
To confirm the effectively proposed measurement method, measurement accuracy was evaluated. The evaluation compared the measurement values of the proposed method with direct measurement by using a laser range finder. Specifically, lengths of seven lines on the front surface of Koma House were measured by direct measurement (fig. 3). Moreover, 3D coordinates of these line ends obtained by the proposed method were obtained, and lengths of all ends were calculated. Therefore, the lengths calculated by both methods were compared. As a result, standard deviation of residual errors between both methods was calculated as ±0.4m (table 4). Some factors for this error are as follows.

(1) Error in GPS positioning
Point positioning of smartphones was used, which has positioning accuracy of about ±10m. To make the positioning more accurate, the point positioning data was used as an approximate value of length for each camera position, and the final orientation was performed. Therefore, it seems that final errors were not compensated for in this procedure. However, accuracy of the Global Navigation Satellite System (GNSS) that includes GPS continues to be improved, so this problem should be able to be overcome in the future.

(2) Flexibility of focal length
Generally, the focal length of a camera should be fixed for photogrammetry to decrease the number of unknown parameters. To fix focal length, some functions (e.g. auto focus, zoom, or wide conversion) need to be disabled. Therefore, the proposed method enables focal length to be fixed flexibly. However, measurement accuracy of the proposed method became unstable due to an increase in the number of unknown parameters. Thus, the method must be improved to realize both flexibility and stability.

(3) Conjugation of points by manual operation
The 50 measurement points in each of the six Figures were conjugated by manual operation. Therefore, Figure coordinates of 300 points in total were decided by visual observation. The accuracy of such manual operation is estimated to be about ±1pixel. To measure more accurately by photogrammetry, sub pixel (<1pixel) pointing is required. Thus, automatic Figure matching by Figure processing should be adopted during this procedure.

Conclusions
This paper described the development of a method for 3D measurements of historical structures by using only a smartphone. The proposed method can measure 3D structures by using acquired Figures and GPS positioning data. The method has measurement accuracy problems that need to be resolved to make it operational. Nevertheless, it uses a consistent procedure to output 3D data from input Figures. In addition, there are other high-performance surveying devices: non-prism total stations, imaging total stations, terrestrial laser scanners, and so on. Such devices can accurately measure structures, but have little mobility of
operation since they are heavy and need tripods. Also, they require physical effort and operation skills. Moreover, another issue is that almost all such devices are expensive. Thus, the proposed method using only a smartphone requires little physical effort and costs much less.

For further work, the proposed method needs be improved by not only stabilizing accuracy but also improving its user interface to make the method easier to apply. Furthermore, a 3D measurement system will be redeveloped as a smartphone application, and it is expected that the whole 3D measurement procedure can be performed using only a smartphone. If this can be achieved, the proposed method will become a useful and convenient tool for 3D measurements of historical structures.

Acknowledgments

This investigation was supported by JSPS KAKENHI Grant Number 25870765. And I would like to offer my special thanks to Koma shrine.

1. (Agency for Cultural Affairs).
2. (Cosso, Ferrando, Orlando, 2014).
3. (Ohdake, Chikatsu, 2004).
4. (Chikatsu, Kunii, 2002).
5. (Schenk, 2001).
6. (Schenk, 2001).

Bibliography

Ohdake T., Chikatsu H. (2004). Development of Figure based integrated measurement system and performance evaluation for close-range application. In The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2004, XXXV(B5), pp. 684-689.
Table 1 - Figures and positioning data for Koma House.

<table>
<thead>
<tr>
<th>File name</th>
<th>Image 1 - Figure acquisition method.</th>
<th>Image 2 - Conjugated points for multiple Figures.</th>
<th>Table 2 - Relative orientation parameters.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MG 0938.JPG</td>
<td>MG 0939.JPG</td>
<td>MG 0940.JPG</td>
<td>MG 0941.JPG</td>
</tr>
<tr>
<td>Latitude</td>
<td>35° 53' 56.37&quot;</td>
<td>35° 53' 56.65&quot;</td>
<td>35° 53' 56.57&quot;</td>
</tr>
</tbody>
</table>
Table 3 - Exterior parameters for each Figure.

Figure 3 - Direct measurement for evaluation accuracy.

Table 4 - Results of accuracy evaluation.

<table>
<thead>
<tr>
<th>No.</th>
<th>Development method (m)</th>
<th>Direct measurement (m)</th>
<th>Residual error (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>4.287</td>
<td>3.873</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>4.580</td>
<td>3.793</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>4.287</td>
<td>3.692</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>5.555</td>
<td>3.088</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>3.763</td>
<td>2.230</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>5.545</td>
<td>5.766</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>5.702</td>
<td>5.563</td>
</tr>
</tbody>
</table>

Standard deviation: +0.335
Antarctica and Apollo: Heritage Horizons

Bryan Lintott
Scott Polar Research Institute, Cambridge University

Abstract

Antarctica and outer space are physically hostile environments where nations, groups, companies and individuals have undertaken human and robotic exploration, science and commercial activity; producing a legacy of physical and intangible heritage beyond the borders of the nation-states. Whilst a system has developed to protect Antarctic Historic Sites and Monuments (HSMs), no protocol exists for protecting non-terrestrial Historic Spacecraft, Sites and Monuments (HSSMs). This paper argues that the Antarctic system is relevant when considering heritage beyond the Earth.

Keywords: Antarctica, Moon, Apollo, Lunar Heritage

Introduction

The paper analyses how the Antarctic Treaty System (ATS) produced a system for designating and managing Antarctic HSMs. Developments in academic research and professional heritage endeavours related to protecting space heritage are then reviewed and discussed. The lessons learnt in Antarctica - including the limitations of the Antarctic HSM system - are considered for the safeguarding and management of potential HSSMs.

Antarctica

Prior to World War II, several nations and individuals undertook major Antarctic expeditions to conduct scientific research and accomplish a number of exploration challenges, e.g. attaining the South Pole and flying across the continent. In 1944, the United Kingdom’s ‘Operation Tabarin’ established the first permanent human presence on the Antarctic continent with the purpose of consolidating its territorial claim of 1908. In 1945, the Falklands Islands Dependencies Survey (FIDS) was established to operate British Antarctic bases on an ongoing basis as scientific research facilities. Competing territorial claims were made by Chile in 1942 and Argentina in 1943. During the 1940s and 50s, these three nations undertook robust measures and countermeasures to physically assert their Antarctic territorial claims. A former British Antarctic base, established by the British Graham Land Expedition (BGLE, 1934-37), was visited in 1946 by FIDS personnel and, ‘… found in good condition - but the Argentine Flag flew over it! On the door was written ‘1º/De Mayo, Marina de Guerra, Republico Argentina, Febro 1942’. Removing these signs of encroachment, a depot was left in the building under an official British notice nailed to the wall.’

In February 1953, territorial tensions in Antarctica between the United Kingdom, and Chile and Argentina were brought into sharp focus when huts were erected by Chile and Argentina on Deception Island, near a British base. The empty Chilean hut had a nearby flagpole and ‘Chile’ was painted on the British landing strip. The Argentine hut was occupied by two military personnel, who were apprehended by two British police officers (supported by two military officers and thirty-two Royal Marines), deported - under civilian law - and repatriated. The huts were dismantled and the Royal Marines used high explosives to destroy any remains. The Argentine and Chilean plaques from the opening of the huts were retained by the British. The actions by Chilean and Argentine military personnel entering an area claimed as sovereign territory by the United Kingdom, the physical structures and symbols that they left and the formal ceremonies of attaching commemorative plaques, could have been acted upon by the United Kingdom as a casus belli (justification for war). The Governor of the Falkland Islands, Sir Miles Clifford, stated that Argentina’s and Chile’s actions, ‘… presumably constitutes an act of war.’ Equally, Argentina and Chile could have argued that the destruction of their huts, state property in territory that they claimed, could also be a casus belli. Whilst the matter was resolved diplomatically there were deep concerns that the incident had verged on a military confrontation. It was one of many instances of flagpoles, etc. being damaged, removed or destroyed as statements of territoriality. During this period the United States and Soviet Union maintained a wary separation in Antarctica.
During the International Geophysical Year (IGY, 1957 - 58), it was decided that territorial claims would not be actively pursued due to the greater interests of science. This became codified in the Antarctic Treaty (1959) and resultant ATS through which the treaty signatories govern Antarctica by consensus, meeting at Antarctic Treaty Consultative Meetings (ATCMs) and implementing their decisions through domestic laws. In 1961, ATCM I approved a recommendation concerning the protection of ‘tombs, building or objects of historic interest.’ This implicitly assigned the ascription of heritage status to the interested nation but did not establish any mechanism for review and ratification by the ATS. In 1968, the need for a formal list HSMs was raised and the United Kingdom produced a ‘Draft Recommendation’ that urged the protection of a selection of HSMs and commenced with an early attempt to codify the criteria for HSMs, ‘Recognising that monuments which, by their survival, commemorate persons, actions, periods or events of significance in Antarctic history are objects of great interest to all visitors to the Treaty Area.’ In 1972, ATCM VII recommended 43 historic monuments for formal approval. In 1991, the Protocol on Environmental Protection to the Antarctic Treaty was approved and the issue of HSMs incorporated within Article 8, Annex V of the protocol. The primary heritage clause is that HSMs ‘… shall not be damaged, removed or destroyed, a clear rebuttal of certain actions prior to the treaty. In 1995, New Zealand presented a working paper to ATCM XIX on ‘New Historic Sites and Monuments: Suggested Guidelines for the designation of Historic Sites’, in which it proposed that ‘Parties would have access to a list based on international criteria which could be of assistance in the designation of historic sites and/or monuments.’

Whilst the resultant agreed criteria for Antarctic HSMs have some linkages to those of the World Heritage Convention (1972), they fundamentally reflect the human experience in Antarctica: exploration, science, endurance, innovation and the symbolic value of Antarctica as a zone of peace and science, and the heritage strategies utilised by several Antarctic nations.

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A particular event of importance in the history of science or exploration of Antarctica occurred at the place;</td>
<td>To represent a masterpiece of human creative genius; [1,2]</td>
</tr>
<tr>
<td>2 A particular association with a person who played an important role in the history of science or exploration of Antarctica;</td>
<td>To exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design; [4,5,7]</td>
</tr>
<tr>
<td>3 A particular association with a notable feat of endurance or achievement;</td>
<td>To bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared; [1,3,4]</td>
</tr>
<tr>
<td>4 Representative of, or forms part of, some wide-ranging activity that has been important in the development of knowledge of Antarctica;</td>
<td>To be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history; [5]</td>
</tr>
<tr>
<td>5 Particular technical or architectural value in its materials, design or method of construction;</td>
<td>To be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;</td>
</tr>
<tr>
<td>6 The potential, through study, to reveal information or has the potential to educate people about significant human activities in Antarctica;</td>
<td>To be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. [6,7]</td>
</tr>
<tr>
<td>7 Symbolic or commemorative value for people of many nations.</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Broad commonalities, within the ‘[]’ brackets, of ATS and WHC criteria

One limitation in the Antarctic system for HSMs is that only one level of classification is available for redundant structures, etc. so a nation must choose HSM status or (if the structure or equipment can be removed without major environmental impact) remove it. A more nuanced and robust framework would be a graduated structure: (a) World Heritage equivalent, (b) Antarctic history and (c) a nation’s history in Antarctica, with the International Committee on Monuments and Sites’ International Polar Heritage Committee (ICOMOS - IPHC) undertaking an independent review of proposals for HSM designation. In the late 1950s, restoration and conservation work began on the huts left by Captain R.F. Scott RN and Sir Ernest Shackleton, and a New Zealand hut from the 1950s is now being conserved, (Figures 1 & 2). The ICOMOS New Zealand Charter for the Conservation of Places of Cultural Heritage Value has informed much of this work.
The Moon

Speaking at the United Nations in 1960, President Eisenhower stated that the Antarctic Treaty offered the possibility that lessons learnt in resolving or ameliorating international disputes in Antarctica could assist in developing further international cooperation on Earth and in space 19. Whilst space was not transformed into a zone of direct military confrontation it became a region of competition during the Cold War. When the United States of America achieved the goal of being the first nation to land humans on the Moon it did so at great cost. In 1967, astronauts Virgil Grissom, Edward White and Roger Chaffee lost their lives in a fire while conducting ground tests in the command module (CM) of Apollo 1. The financial cost for placing two humans on the Moon is estimated at US$ 21.25 billion in 1969; the equivalent of US$100 billion in 2014 20. However, the rewards were significant: demonstrating technological superiority over the Soviet Union, major advances in science, and achieving the greatest feat of human exploration in the 20th century.

It became clear in the 1980s that space travel remained exceedingly expensive (early estimates of the frequency of Space Shuttle flights being optimistic) 21, dangerous, and the lunar bases envisaged in the 1960’s movie 2001: A Space Odyssey 22 were relegated to the realm of the imagination. However, by the late 1990s/early 2000s advances in robotics, comparatively more affordable launch costs and the need for historians to record in detail the first-hand accounts of the aging cohort of Apollo engineers and astronauts resulted in research projects, e.g. O’Leary and the archaeological mapping project of the Apollo 11 site, ‘Tranquillity Base’ 23. Discussions among heritage practitioners and museum curators were also occurring 24. In April 2007, the topic of the Apollo sites and the use of Antarctica as an analogue in heritage management and conservation were presented at the Mutual Concerns of Air and Space Museums Seminar by the author 25. Later that year, 13th September, Google announced a ‘Lunar XPRIZE’ to encourage a private robot expedition to the Moon with a bonus if an historic site was reached. In addition to built heritage and museum practitioners pondering the Apollo sites, academic scholars, e.g. P. Capelotti, A.C. Gorman and B.L. O’Leary, have considered space heritage: theoretically, conceptually and legally 26. In response to concerns being raised about the potential for damage to the Apollo sites Google announced that any visits to historic sites had to be approved in advance. In 2011, NASA produced, ‘…with advice from external experts…’ NASA’s Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts 27. Google subsequently agreed to these guidelines 28. NASA’s recommendations include:

1. The avoidance of biological, chemical or radiological contamination;
2. Strict limits on descent and landing profiles to minimise disruption and/or damage to the sites by rocket blast driven regolith (lunar rocks and dust) and to ensure that a crash would impact outside the historic sites;
3. The Apollo 11 and Apollo 17 sites (Figures 3 & 4) being exclusion zones;
4. Protection of operational scientific equipment, e.g. Lunar Laser Ranging Retroreflectors;
5. The option of NASA approving scientific and/or engineering investigation, e.g. what effects, if any, have the radioisotope thermoelectric generator (RTG) had on the surrounding area; do switches still operate 29?

However, the recommendations do not have the force of law. A similar situation could arise with the Apollo sites that occurred with the tent left by Roald Amundsen at the South Pole in 1911. In response to information that a private party hoped to journey to the South Pole and excavate the tent, a precautionary mechanism, ‘Guidelines for handling of pre-1958 historic remains whose existence or present location is not known’, was adopted by the ATS in 2001 as a proactive means of hindering unauthorised Antarctic “adventure archaeology”, and to deal with the discovery of historic material 30. In 2005, Norway proposed that Amundsen’s tent be formally listed as an HSM, stating that the 2001 Guidelines would not legally stop excavation of a site (specifically the snow and ice above Amundsen’s tent, assuming it could be located) provided any discovered items were left in situ 31. In a similar manner, whilst the ownership of the Apollo artefacts is clearly with the United States’ government under Article VIII of the Outer Space Treaty, disruption to the site, with the resultant damage to the historical and scientific record, is not illegal.

In 2013, a bill, ‘H.R. 2617. To establish the Apollo Lunar Landing Sites National Historical Park on the Moon and for other purposes’, was introduced in the United States House of Representatives that proposed: ‘5 (a) … there shall be established as a unit of the National Park System the Apollo Lunar Landing Sites National Historical Park… 8 [The U.S.]… shall submit the Apollo 11 lunar landing site to the United Nations Educational, Scientific, and Cultural Organization (UNESCO) for designation as a World Heritage Site.’ 32

O’Leary diplomatically stated, ‘I applaud the idea that two Congresswomen have decided to spark public dialogue about protecting the artefacts on the moon as an important part of American and ultimately, humanity’s lunar legacy.’ 33 Others, e.g. space law practitioners M.J. Listner and G. Robinson, focused on the Bill’s inherent flaw: the Moon is not American territory therefore the Apollo sites cannot be managed by the US National Park Service or nominated for World Heritage status 34.
Conclusion

Confronted with the challenge of protecting HSMs in non-territorial areas, the Antarctic nations have developed a workable system of historic site and monument designation and management. Criteria have been agreed and decisions are reached and implemented. It has proved to be a robust system and adaptable to change albeit slowly. However, the Antarctic HSM system has its limitations and there are important roles for ICOMOS, and heritage academics and practitioners, to further develop and enhance Antarctic heritage conservation. In regards to outer space, with one current exception, all the space faring nations have endorsed the Antarctic system, providing the possibility of the smooth adoption of an ‘Outer Space, Moon and Celestial Bodies Protocol on Historic Spacecraft, Sites and Monuments’. In conclusion, there is a growing need to implement an agreement to protect non-terrestrial heritage and to further develop heritage conservation practice beyond the Earth.

13. Ibid. 4.
29. Ibid.
34. Ibid.
35. At the time of publication, the Islamic Republic of Iran, had joined the Scientific Committee on Antarctic Research (SCAR), but had yet to ratify the Antarctic Treaty.

Bibliography

Figure 1 - Discovery Hut, British National Antarctic Expedition (1901 - 04), HSM 18. Lintott, B. 2007.

Figure 2 - 'A' Hut, Commonwealth Trans - Antarctic Expedition (1955 - 58), HSM 75. Lintott, B. 2007.
Figure 3 - ‘Buzz’ Aldrin and the Apollo 11 Lunar Lander

Figure 4 - Gene Cernan driving the Lunar Rover,
Apollo 17
Cultural Mapping for Conservation Practice:
Lessons from a Training Course in Penang, Malaysia

Jeffrey Cody
Getty Conservation Institute, Los Angeles

Abstract

Cultural mapping can provide conservation practitioners with potent means of documenting historic landscapes more comprehensively, and of engaging with local communities more effectively. However, significant challenges can sometimes prevent ideal effectiveness. The paper highlights three key lessons: (1) the importance of determining where and what to map; (2) the need to link intangible values to physical heritage attributes; and (3) the significance of synthesizing mapping results as a step towards proposing conservation recommendations in complex ecological places, such as urban areas.

Keywords: Cultural Mapping, Documentation, Inventories

Broad Context Related to the Penang Training Course

The lessons framing this paper stem from two courses that the Getty Conservation Institute (GCI) helped organize, in collaboration with two Malaysian institutional partners, in George Town, Penang, which (jointly with Malacca) was inscribed on the World Heritage List in 2008 (fig. 1). Both courses were two weeks in duration and were geared primarily to mid-career Malaysian urban planners and architects, none of whom had had formal postgraduate training in either architectural or urban conservation.

The first course was delivered in spring 2012 and the second in fall 2013. The GCI’s partners in this venture were the Heritage of Malaysia Trust (Badan Warisan Malaysia, www.badanwarisan.org.my) and Think City (www.thinkcity.com.my), a division of Khazanah National, a public-private partnership with links to Malaysia’s Ministry of Finance. As chief coordinator of the course, I worked with a dedicated and highly competent team of conservation and planning professionals, initially in 2012 from four countries (Australia, USA, Italy and Malaysia) and in 2013 from five countries (Australia, USA, Thailand, Malaysia and Myanmar), in delivering two, slightly different versions of the course. The main objectives of these courses were to provide participants - sixteen in the 2012 course and eighteen in 2013 course - with targeted training in urban conservation planning methodologies and practical tools for conservation; to inspire the participants to incorporate these methodologies and tools into their professional work, and in so doing, to respond to critical needs in Malaysia arising from rapid urbanization, especially along the so-called “Malacca Straits Diagonal,” stretching from Johor (bordering Singapore) to Kedah (bordering Thailand), where 16 million Malaysians live. One other crucial objective, from the GCI’s standpoint, was to assist in providing Malaysian planning and architectural practitioners with greater capacities in confronting significant conservation challenges and, thus, to advance conservation practice within Southeast Asia, one of several conservation education and training projects the GCI has coordinated since its creation in 1983.

In Penang, given the importance of inventorying and documentation to conservation practice in general, and given the need (in Penang and elsewhere) to take into account both tangible and intangible heritage in the context of documentation, our team concluded that cultural mapping should be both used and taught to the Penang course participants as one of the most fundamental methods for effective conservation results in Malaysia. We employed the Burra Charter (1979, with revisions) as a conceptual and practical road map for participants to better understand commonly employed conservation methodologies. We enlarged a one-page version of the Burra Charter and mounted it on a large board, which we referred to throughout the course. Juxtaposed with this highly visible version of the Burra Charter, we created a similar chart that depicted the sequence of planning actions Malaysian planners use when they create Structural Plans and, more particularly to the needs of conservation, what are termed “Special Area Plans.” These charts reflected several common denominators associated with conservation and planning, but for the purposes of this paper, one of the most striking similarities related to the fundamental need for documentation of the place in question. Therefore, after an introductory series of short lectures and discussions about the history and fundamentals of conservation - for an audience largely untrained in our field - the first module of the course related to inventorying and documentation. It was in this logical context that we introduced the concept of, and practicalities associated with cultural mapping.
Cultural Mapping, an Increasingly Prevalent Tool for Cultural Planning

Although “cultural mapping is not a new notion for planners”, as evidenced by the ‘map before you plan’ credo of Patrick Geddes (1854-1932), “the past decade has seen renewed interest in cultural mapping, most often in the context of it being a foundation for [what is sometimes called] cultural planning”. Greg Baeker, a planner who has actively practiced cultural mapping throughout his native Canada, has asserted that “in the North American context, cultural mapping is increasingly embraced by professional planners as an essential tool in carrying out their work”. In Australia, the UK, and throughout much of East Asia, conservation professionals are increasingly employing a variety of cultural mapping approaches in a wide array of cultural contexts to better understand cultural significance and to deal more effectively with what is commonly called the tangible and intangible values and/or attributes of heritage places. As summarized by Janet Pillai, one of the course’s instructors, in her recently published book about the rationale, procedures and implications of this methodology, “cultural mapping is a systematic approach to recording and presenting information that provides an integrated picture of the cultural character, significance, and workings of a place”. For mapping cultural assets and evaluating significance, the spectrum of methodologies being utilized – particularly throughout Asia, but not limited to this vast region – suggests that cultural mapping provides a practical framework not only for categorizing information about a place, but also preparing a useful foundation for deeper analysis about the cultural, as well as physical nature of the place.

The Approach to Cultural Mapping Employed in Penang, 2012-2013

In 2011, as the GCI, the Heritage of Malaysia Trust and Think City conferred about the operational dynamics of what we called “Urban Conservation Planning in Malaysia”, our team of instructors began to confront sharp challenges associated with responding to the needs of Malaysia, in part reflected in the “Second National Physical Plan” (2010), which called for “the authentic multi-cultural and historical heritage of the country” to be “conserved”, stated that “towns with special features shall be identified”, and urged that “better land use planning and management at all levels” should be employed “implemen[ted] to ensure conservation and wise use of natural resources, biodiversity and ecosystem services in Peninsular Malaysia”. We contextualized our course in part within these broad national mandates, but we also localized the course in the context of the World Heritage site, its buffer zone, and the wider geographical spaces related to both George Town and, further inland on Penang Island, the agrarian town of Balik Pulau. The multicultural history of Penang, situated at the northern end of the Straits of Malacca with strong historical links to both India and China, helped make it “a trading hub, emerging as one of the first free trade ports in East Asia in the late 18th century. It was centrally located with access to major markets in Burma (now Myanmar), Thailand, Sumatra and northern Malaya. It thrived on trade in rubber, tin, rice and other commodities”. Penang’s built environment palpably reflects these linkages and its contemporary multi-ethnic society still reflects deep connections to these rich Asian cultures. Since the mid-19th century, one of the city’s most prevalent building types has been the so-called “shophouse” (fig. 2). One of our key challenges related to the documentation of this built heritage, therefore, was how to train planners to validate both the physical architectural fabric of Penang’s diverse urban neighborhoods and the social dimensions of the place that infused that physical fabric. In the articulate words of Laurence Loh, one of our other key instructors, “The brave planners [who participated in the course] quickly recognized that they could not plan from on high and make decisions that would affect thousands of lives and properties without going down to the ground to try to understand how people use their space, what their heritage and social values are and how it all connects up, that planners draw spaces, but people make places”.

Lesson One: where and what to map; and Lesson Two: physical merged with social

As we proceeded with helping participants understand the dynamics of cultural mapping, we began learning ourselves – as conservation educators or trainers – about the crucial need to find a proper scope and a manageable set of deliverables related to the cultural mapping exercise. Three of our Malaysian instructors had already been working “on the ground” in four different locations in Penang related to cultural mapping: Chowrasta Market, Campbell Street Market, Kedah Road and the inland town of Balik Pulau. This preparatory foundation was crucial; without prior research about the historical evolution of the places and how those places had been changed (and were still being changed) by different residents over time, we would have been lost. For the first exercise, we chose Kedah Road, just outside the buffer zone of the World Heritage site (figgs. 2-3). During the second week, when participants were required to integrate the documentation exercise into a more comprehensive set of recommendations (in the context of a Special Area Plan), we chose Balik Pulau (figgs. 5, 6 and 8). Although we thought we had provided them with an appropriate set of instructions about the rationale for, and the mechanics of doing a cultural mapping exercise, some of the participants were initially confused about how to engage in what amounted to an anthropological field exercise (fig. 7). We divided them into four groups of three or four, each with a set of tasks that required them to engage with local residents: documenting the “building profile” of Kedah Road, understanding its “environmental profile”, clarifying...
the “social profile of local residents”, and “social profile of foreign residents.” All four groups were also tasked with documenting the “economic profile” of the neighborhood. On the extremely positive side, all of the participants became actively engaged with local residents. Few of them, as Laurence Loh noted, appeared to have spoken directly to people about their social or physical heritage, and they were thrilled to be “in the trenches.” However, they became so thrilled with the stories they were hearing and the sociological dimensions of the assignment that, ultimately in the results, they paid much less attention to the physical aspects of the place. The net result was that they learned a large lesson in what is now often termed “intangible heritage”, but they learned much less about the importance of linking this heritage to the physical attributes of the neighborhood.

At first, this did not seem to matter a great deal. However, in the second week, when they embarked on the larger Special Area Plan exercise in Balik Pulau, they again were called upon to engage in cultural mapping there, and once again the results were both exciting (because of their eyes being so opened to the community they were supposedly serving as planners), and less than perfect (because of a lack of attention to the careful documentation of the physical components of the place. The lesson I wish to stress here is the need, as teachers of conservation practice, for a proper balancing of the physical with the social, a holistic melding of the two.

Lesson Three: Synthesis

In both versions of the course we encountered similar challenges to the ones just outlined, suggesting to us the need to find a proper scale for the cultural mapping as well as more focus on the integration of the physical with the social. However, this was only one way in which synthesis needed to occur. The second way stemmed from a need to take the results of the cultural mapping exercise and explore more fully the implications of the analysis that participants had done. In other words, if the cultural mapping made the participants question some of their assumptions about what planners should be doing, then the recommendations arising from the more complicated and longer Special Area Plan exercise ideally should have been more directly linked to the documentation. This holistic approach, which is one of the great hallmarks of the Burra Charter (as well as similar values-based conservation approaches) dovetails documentation with an understanding of cultural significance, which then leads to solidly grounded action recommendations, and finally a monitoring of the actions to ensure that the significance and values of the place are safeguarded. Based on several types of evaluation, our course participants in both 2012 and 2013 were pleased with what they had learned, but as instructors we concluded that most participants had not truly grasped the kind of synthesis about conservation that we had hoped for.

We are now planning a third version of “Urban Conservation Planning in Malaysia”, which will occur in Kuala Lumpur in April 2015. We hope to improve the course yet again, taking into careful account the lessons I have briefly outlined here. In essence, the people-based dimension of cultural mapping was thrilling for our previous participants. Finding an optimal balance, however, between the social and the physical proved to be elusive. Crafting an even more integrative course with even better results will, we hope, be our experience in our third iteration of this fascinating training course.

1. (Majeed, 2014) and (Kharas, Zeufack, Majeed, 2010).
2. See www.getty.edu/conservation/.
4. Ibid. Also see (Baeker, 2010).
5. (Teaiwa and Mercer, 2011), (Evans and Foord, 2008), (Mercer, 2006), and (Asian Coalition for Housing Rights, 2011).
8. (Federal Department of Town and Country Planning, 2010.), NPP 11 on p. 5-28; NPP 17 on pp. 5-43 and 5-44.
9. (Kharas, Zeufack, Majeed, 2010), 51.
10. (Khoo, 1993), 17.
11. (Loh, 2012).

Bibliography

Figure 1 - George Town, Penang. Near, but not in buffer zone of World Heritage site.

Figure 2 - Kedah Road. Site for first cultural mapping exercise.

Figure 3 - One of several bakeries within site for cultural mapping exercise.

Figure 4 - Course participants interviewing local residents.

Figure 5 - Balik Pulau, Penang Island. Site for Special Area Plan exercise.
Figure 6 - Balik Pulau, an urbanizing rural landscape.

Figure 7 - Janet Pillai, course instructor, guiding participants in a field exercise.

Figure 8 - Christian-Chinese-Malay hybrid identities in Balik Pulau.
Abstract

This paper discusses current joint work by IUCN and ICOMOS to address issues that can arise when natural and cultural values and issues are considered separately within World Heritage processes. The Connecting Practice programme has conceptual and practical dimensions, and intersects with related work on rights-based approaches. Focusing on the importance of improving conservation outcomes, we propose a way forward situated in a ‘middle ground’ that links both theory and practice, and emphasises the critical importance of a joint approach - ‘connecting’ natural and cultural heritage practice. Some early findings of project field visits will be shared with the Scientific Symposium as a means of furthering the dialogue between practitioners.

Keywords: Nature/Culture, Biocultural Diversity, World Heritage, Heritage Concepts

Identifying the Problem

This paper shares some early outcomes of work initiated by IUCN and ICOMOS to explore the inter-relatedness of nature and culture, using the World Heritage system as its focus. Ideas about the separation of culture and nature are easily understood as arising from western constructions of knowledge and Cartesian divides that are not universal. However, it is also the case that the 20th century successes of universalising mechanisms such as the World Heritage Convention have encouraged the establishment of heritage institutions that replicate the divide. Recognition of the limitations of the nature/culture duality has many implications for the work of ICOMOS and IUCN, especially in their efforts to provide policies and guidance for practice in their respective fields.

Critiques of the ontological bases of heritage systems have included these issues of nature and culture, and the power relationships that establish and support their separateness or duality. While the underlying philosophies and historiography of these ideas is an important area of inter-disciplinary research, this is a matter that goes beyond academic concerns. This paper argues that much of the critique of the nature-culture dichotomy and its implications for heritage conservation has situated the problem conceptually and historically, neglecting the institutional practices that constitute and constrain everyday activities. While natural and cultural heritage practitioners and institutions might be positioned at the ‘heart’ of the problem, they are also those most easily able to affect change.

In our work, we are developing several strands of research based on a ‘middle ground’ that situates the possible ways forward within a dynamic interplay between theory and practice. As researchers and practitioners working closely inside the World Heritage system, we have particular perspectives that recognise its problems, but also the significant opportunities it offers to promote connected practice.

From its adoption in 1972, the World Heritage Convention has provided an inspiring multi-lateral mechanism for consideration of natural and cultural heritage within a single framework. However, for the most part the implementation of the Convention continues to treat natural and cultural heritage separately, with separate institutions, fields of specialisation, concepts, constituencies and decision-making regimes. Non-western perspectives on heritage that conceptualise culture and nature differently have begun to challenge the ways in which nature and culture are understood in the World Heritage system, but there are many obstacles. World Heritage is the focus of various criticisms relevant to these issues. Its present-day operations are often...
characterised as politically charged, promoting nationalist agendas at the expense of the local interests and rights, and promoting commodified notions of what can be counted as ‘heritage’. Moreover, through its expert-driven processes, it has been identified as one of the ways in which an ‘authorised heritage discourse’ has been promulgated, at the expense of the rights and self-determining needs of many people 4.

In particular, experience demonstrates how the perpetuation of the separateness of nature and culture can have impacts on the ways that heritage is thought about, labelled, protected, managed and presented to global and local audiences.

The appeal and near-universal participation in the World Heritage Convention has influenced the establishment and operations of institutions and professions, with many implications for local and national heritage discourses and outcomes. Sometimes these can be detrimental to the visibility of the full suite of values of heritage properties, and to the rights, interests and choices of associated communities, including Indigenous peoples 5. However, the emphasis on international cooperation for conservation, the ability to adapt to conceptual shifts, and the development of new management approaches are enduring strengths of the World Heritage system that underpin the positive potential of our work.

In exploring the capacity to develop new practices in the World Heritage system that address the conceptual and institutional divides between nature and culture, IUCN and ICOMOS are steering a joint project titled ‘Connecting Practice’, complemented by an ICCROM-led development of a training module for heritage practitioners on nature-culture inter-linkages as part of the World Heritage Capacity Building programme. There are several cornerstones to our work, and these are briefly outlined in this paper.

- Recognising the entanglement of nature and culture
- Identifying institutional constraints and opportunities
- Crossing boundaries in our thinking and language
- Connecting our practices by adopting a ‘learning by doing’ approach

**Crossing Boundaries**

A number of early findings have guided our work, but the most important is that the need to find more integrated concepts and approaches to nature and culture will mean different things to different people 6.

Although there is an emerging consensus about the ‘entanglement’ of nature and culture in many World Heritage settings, there is a very broad spectrum of issues and divergent perceptions about their practical implications. No one ‘frame’ will work - and indeed, the acts of ‘framing’, codifying and classifying, which characterise much of the practice of World Heritage is possibly part of the problem. Moving to re-think our concepts and looking more closely at the underlying theoretical bases of the divide are therefore necessary.

Issues of language pose some immediate challenges. The most obvious of these concerns the pre-dominance of the ‘working languages’ of the Convention that mean that the complexities of world views (including understanding of the relationships between human life and nature) must be explained in English or French. For IUCN and ICOMOS, one of the communication barriers we experience is the translation of World Heritage terminology into local languages (and vice versa). This can result in the loss of the meanings applied to nature and culture - but also in the ways that technical terms are applied, leading to misunderstanding, confusion and alienation for the very people whose heritage is being recognised 7.

In other cases, our uses of terms emphasise and deepen the divide, even when we are trying so diligently to overcome it. This can be a matter of using the same terms, but with different understandings and applications; or where different criteria have been elaborated and refined for the natural and cultural heritage fields. Concepts such as integrity and authenticity are tied to specific domains of expertise and action 8. The Connecting Practice roundtable, comprised of natural and cultural heritage specialists from different regions highlighted that we do not yet have a ready-made set of words that move us beyond the divide.

Because words - and the theoretical and practical implications they carry - are so important, we looked for a new context for this dialogue. We have selected biocultural diversity as one of the concepts to further explore and apply. Biocultural diversity stresses the co-evolution and entanglement of culture and nature rather than their separation. It addresses the earth’s biological and cultural diversity and seeks to document the inter-relations and mutually supporting factors between them. A number of organisations have begun to use this term, recognising the importance of language diversity and traditional ecological knowledge.

Biocultural diversity is the interweave of humankind and nature, cultural pluralism and ecological integrity. It arises from the continuing co-evolution and adaptation between natural landscapes and ways of life, and between biological processes and cultural endeavors. Biocultural diversity tends to be richest in locations where cultures have had long intimate connections with their landscapes, is reflected within languages and traditional ecological knowledge systems, and manifests in beautiful ways through cultural and artistic expression 9.

Biocultural diversity has been used by heritage practitioners looking for improved ways to explain how nature and culture are mutually related in the production and continuation of distinctive cultural traditions and landscapes. Researchers writing about Australia’s Wet Tropics have pointed to the potential usefulness of this framing in augmenting the recognition of cultural landscapes within the World Heritage system.
Biocultural diversity, defined as the total variety exhibited by the world’s natural and cultural systems, denotes three concepts: (1) diversity of life includes human cultures and languages; (2) links exist between biodiversity and cultural diversity; (3) these links have developed over time through mutual adaptation and possibly co-evolution. The notion of World Heritage Cultural Landscape closely aligns with concepts of biocultural diversity, explicitly recognising the relationship between biological and cultural diversity, and between tangible and intangible cultural heritage. World Heritage Cultural Landscape designation acknowledges the role of people in creating biodiverse landscapes and provides a mechanism for explicit recognition of that role.

There are some contexts in which these ideas find an easier application and relevance, particularly those landscapes and seascapes where the traditional custodianship, customary practices and cultural knowledge of Indigenous peoples is a critical part of the maintenance of biodiversity. The dialogue of Connecting Practice also brings us into the realm of joint work by the World Heritage Advisory Bodies on the development of rights-based approaches titled ‘Our Common Dignity’ since effective rights-based approaches are an essential starting point for addressing the challenges resulting from the nature-culture divide.

In selecting biocultural diversity for our work, we acknowledge that it is relatively under-operationalised and does not necessarily provide a perfect fit for every nature/culture context. However, what this concept has done for our work is to provide some new terrain to collectively discover.

Connecting Practice

We have identified a number of boundaries that need to be crossed in order to better connect our practices. The boundaries between natural and cultural heritage practice have already been breached in places where natural and cultural specialists work together toward integrated solutions. This is evident in the growing number of cases involving natural resource management and/or Protected Area management through Indigenous or other community partnerships. These are extremely valuable achievements to build on as we look ahead to larger transformations.

While it can be generally asserted that all World Heritage properties have both cultural and natural values, there is less consensus about what that means for our institutional mechanisms and practices (especially management tools and approaches). We are especially interested in the factors that enable new thinking, and allow for more complex understandings to emerge, and recognise that each major ‘actor’ has interests and practices that will need to be addressed.

As an arena of national and international activity, States Parties are creative and strategic in their engagement with World Heritage processes, seeking to maximise their prestige and strengthen important trans-national interests. In practice, this orientation may prevent adequate attention being paid to the complex aspects of World Heritage properties (including their potentially ‘mixed’ values). This can lead to unrecognised issues appearing later, usually in the form of threats or pressures on conservation.

‘Experts’ and the institutions that represent their interests are our primary focus. There are many issues that need to be better understood to enable the needed shifts. For example, there can be a lack of desire to collaborate, or just too little time to move beyond ‘standard’ practices. The Advisory Bodies are tied to an unrelenting calendar and set of rules established by the Operational Guidelines. The spaces to reflect and innovate are rare, even though scene-setting documents such as the World Heritage Capacity Building Strategy identifies “the lack of collaboration between the nature and culture sectors within the context of the World Heritage Convention” as a significant obstacle to improved practice.

Working from the premise that all places and landscapes have natural and cultural attributes, processes and values has the potential to illuminate and support better approaches. If the ways in which professional institutions work with heritage is part of the super-structure that perpetuates a divided nature-culture understanding, future adaptations could be rather revolutionary. Changes to the standard World Heritage lexicon and tool kit are extremely challenging to contemplate in practice, but possibilities for new understandings of criteria, conditions of integrity and authenticity, boundaries and buffer zones, management effectiveness, sustainable use and monitoring - will all need to be ‘on the table’ as we move ahead.

Four models of engagement that are useful when further considering better integration of cultural and natural heritage practices:

- The ‘rethinking’ approach - which recognises the western origins of the separation of nature and culture, and seeks to rethink the ‘categories’ altogether, emphasising that they are both products or constructions of cultural knowledge;
- The ‘integration’ approach - which also recognises the problem of the ‘divide’ but looks for practical ways to bridge it, or at least better communicate and coordinate how the different halves approach their subject matter;
- The ‘synergy’ approach - where natural and cultural heritage remain separate domains, but pragmatic concerns for effectiveness drive cooperative work; and,
- The ‘critical approach’ - which has elements of each of the previous models, but focuses its attention on the ways that heritage (and in this case, World Heritage) is framed and institutionalised, and looks to its social effects.

These different perspectives have been fruitful since each implies different activities, skills and scales of required...
change. For example, when undertaking management planning for an existing or proposed World Heritage property: the ‘synergy’ approach might support the development of a single integrated management plan rather than separate ones for natural and cultural heritage; the ‘integration’ approach might direct attention to how natural values are embedded in a cultural context or vice-versa; and the ‘rethinking’ approach could involve attempts to craft values that mirror the local world view. The critical perspective requires understanding of how World Heritage recognition triggers social and cultural transformations of values, power dynamics and social practices. Reconciling community perspectives and rights are parts of these transformations. While it is almost impossible to manage properties without taking such inter-linkages into account, the different perspectives emphasise different avenues for addressing them and begin to suggest the development of new tools that will assist 16.

It is clear that there is also an urgent need to articulate what ‘better’ outcomes might involve, since this will guide the direction of change. For that reason, we have organised field visits to selected World Heritage properties in this stage of the Connecting Practice programme. By sending natural and cultural heritage practitioners to work together in the field, we hope to more precisely identify the practices that need adjustment or innovation in order to connect nature and culture.

Moving gently away from a fixed or ‘intrinsic’ view of value to one that is more fluid and dynamic; acknowledging the multiple meanings for people in the uses and sustaining of environmental services; and providing mechanisms to view spaces and places within their cultural, biophysical and spatial (or ‘landscape’) contexts will enable new approaches to move from the fringes to the common ground of heritage practices. Our task is to map this trajectory and disseminate its useful practices.

**Concluding Remarks**

This paper stresses that the wider institutional context is a necessary starting point for understanding how the nature-culture divide is perpetuated and potentially transformed. By considering multiple perspectives from the ‘middle ground’ that includes the social contexts and practices of natural and cultural heritage conservation, we are beginning to develop alternative routes for rethinking how nature and culture are inter-related. Addressing this middle ground allows us to escape from the impasse of merely acknowledging the divide, and to develop better practices.

World Heritage is a dynamic, highly visible and politically important location where problems of recognising and operationalising the nature/culture entanglement can be addressed. Many communities, site managers and practitioners associated with World Heritage properties are seeking this additional dialogue as they work through the issues specific to their situations, so there is an opportunity to learn from local innovation and to feed the international flow of ideas. In fact, we are seeking to make the visibility of World Heritage work for us - its connections with national interest and prestige give us some room to consult, innovate and share the experiences.

The ‘Connecting Practice’ project is in its first stage, and some modest outcomes will be shared during 2014 and 2015. By November 2014, when the Scientific Symposium Heritage and Landscape as Human Values for the 18th ICOMOS General Assembly takes place in Florence, we will have some early results of the field visits to share. We will also take these to the World Parks Congress in Sydney, with its theme of Parks, People, Planet: Inspiring Solutions. For us, this issue is the primary challenge for the heritage ‘experts’ of our time. Generating a larger dialogue that could dramatically transform our practices is the goal, and the work that lies ahead 17.

---

1. (Brockwell et al., 2013).
3. (see Prosper, 2014).
4. (Smith, 2006).
5. (IWGIA, 2013).
7. (Buckley & Badman 2014).
8. (See Dudley, 2011).
9. (The Christensen Fund: http://www.christensenfund.org; see also Maffi and Woodley, 2010).
10. (Hill et al., 2011: 572).
12. (Larsen et al., 2014).
15. (Larsen, 2014).
17. The ideas and proposals expressed in this paper are the authors’ own and do not represent the positions of IUCN or ICOMOS. We are indebted to the intensive engagement we have experienced with many practitioners, site managers and communities associated with World Heritage properties and processes that has driven our interests in this work. The ‘Connecting Practice’ project is a joint initiative between IUCN and ICOMOS and has benefited from the insights provided by members of an Advisory Bodies roundtable, the cooperation with the State Parties of Ethiopia, Mexico and Mongolia, financial support from The Christensen Fund and partnerships with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the
German Bundesamt für Naturschutz (BfN), COMPACT and The Swiss Federal Office for the Environment (FOEN). The project has been coordinated by Leticia Leitao, and supported by Sophie Zielcke (IUCN) and Gwenaelle Bourdin (ICOMOS). The World Heritage Capacity Building programme development is led by ICCROM and involves many partnerships, but the generous support of the Swiss Government for this component needs special acknowledgement. The ‘Our Common Dignity’ programme has been led by ICOMOS Norway on behalf of ICOMOS, IUCN and ICCROM, and has received financial support from the Norwegian Ministry of the Environment.

Bibliography


Theme 5 - Emerging tools for conservation practice
Theme 5-3: Theoretical tools

Proposed Arabic-Islamic Contributions to the Theory of Conservation for Cultural Heritage

Hossam Mahdy
Abu Dhabi Tourism and Culture Authority, Abu Dhabi, UAE

Abstract

The paper presents and discusses nine selected concepts from the philosophical and theoretical Arabic-Islamic heritage. They are atlaal, haram, tabher, ‘ibra, ‘urf, ‘amara, fiqh al Hifaaz, and Naf. These concepts should be useful tools for conservation in the Arab region. Furthermore, some or all of them may be an interesting Arabic contribution to the theory and application for conservation of cultural heritage globally.

Keywords: Arabic, Islamic, Concepts, Terms, Conservation

Introduction

The relationship between Arabic and Islam is unequaled in human experience. On the one hand Arabic is the language of Qur’an and of most Islamic rituals. On the other hand Islamic religion, values and worldview influenced the Arabic language immensely. The concepts and terms identified in the present paper are therefore both Arabic and Islamic. Arabic is the official language in more than twenty-five countries and is highly influential in more than fifty Muslim countries. These concepts are deeply rooted in the Arab region and highly relevant in the Muslim world. However, they have been left out of the modern discourse in Arab and Muslim regions. This paper is an endeavour to reintroduce Arab-Islamic concepts to the academic and professional conservationists. Furthermore, the identified concepts, or some of them may be an enriching contribution to the international discourse on conservation of cultural heritage.

Atlaal

The term means both tangible and intangible aspects of ruins, including memories and feelings. Atlaal were held in a special place within pre-Islam Arab culture. In those days, Arab tribes led a nomadic life moving from one place to another in search for water sources and grazing their animals. They were continuously obliged to leave their settlements behind and move on. This pattern of life made them highly nostalgic for places that witnessed a person’s growing up, falling in love, enjoying the company of relatives and other fondly cherished feelings and memories. Therefore, it became a well-established tradition to visit ruins and reflect on the passing of time and remember the bustling life that one day filled a place before falling into ruins. Thus, atlaal had been the classical opening line(s) of Arab poem. For more than fifteen centuries and up to the present, atlaal has, and still is, an emotionally and historically charged concept in poetry, songs and other Arab cultural expressions. In modern Arab culture, archaeological ruins are conserved and managed as a scientific and professional practice following the Western model that was not known in pre-modern Arab culture and with no reference to the well-established Arabic concept atlaal. The proposal to endorse atlaal by conservation professionals in the Arab region should build on a long tradition of celebrating and cherishing the symbolic and emotional values of ruins as well as their material and visual values. The same term addresses both tangible and intangible values and aspects of historic ruins. It builds on a huge body of poetry and intellectual works since pre-Islamic periods and up to the present, which is firmly rooted in Arab culture. For the international body of conservation theory, atlaal may prove useful as a concept and term to valorize the significance of archaeological remains by a holistic approach, including tangible and intangible aspects of ruins, including memories and feelings.

Haram

The concept means a protected place that includes a significant site as well as its associations, intangible aspects and its buffer zone. According to tribal rules of pre-Islam Arabs, the concept haram was well established mainly to demarcate a well, a farm or a house including the zone that is needed to access, use, manage or protect it. The concept of haram was adopted and further developed by Islaim to include religious as well as non-religious subjects or sites. Today, the concept of haram remains used for religious subjects and sites. It is also applied sporadically to
non-religious subjects and sites by Arab professionals. However, outside the religious domain, it is a term given as a translation of the Western concept of “buffer zone”. For example, “haram al-tareeq”, is used by urban planners and municipalities’ officials to indicate the buffer zone of a road, where certain rules for activities, construction and development apply. Similarly, a buffer zone for a historic building or archaeological site is called haram in Arabic without reference to the old dictionary meaning of the word. Linguistically, however, haram retains its dictionary meaning as a protected place that includes a significant place, its associations, intangible aspects and its buffer zone. This discrepancy between religious/traditional meaning and secular/modern use of the concept is a good example of the embedded Western worldview within the modernization endeavors in the Arab region 4. Hence such a distortion of meaning remains limited to non-religious subjects, while haram retains its original Arabic meaning for religious buildings and subjects, as they were not affected by modernization as they are specific to Arab-Islamic culture. Until today, each of the holy mosques in Jerusalem, Mecca and Medina together with its buffer zone and associations is called “Haram Sharif”. Should Arab conservation professionals revert to the original meaning of haram and use it to mean both a heritage site and its buffer zone and associations, a holistic approach will be adopted and the integrity of the site will be better preserved. Perhaps using the term haram for sites on the World Heritage List may secure a kinder treatment to buffer zones of designated WH sites.

**Taher**

It is the Islamic concept of purity and cleanliness. Taher is a pre-Islam Arabic word for purity and cleanliness. However, Islamic rules for purity and cleanliness carved particular meanings of taher for different situations and substances. The concept is based on rituals and meanings as well as physical characteristics and contexts. For example, clean water is considered a taher substance. It also is means to become taher through ablution rituals. However, a wet ground, even if the water that is causing its dampness is clean, is not fit for prayer and is not considered a taher place. Furthermore, while ablution should be performed by water, if water is not available, ablution may be performed with dust, which is normally considered impure within other contexts. Another example is alcohol, while it may cause a place to be considered not taher if it is meant for drinking. On the other hand, the same substance is taher if it is used for medical purposes or for cleaning. Like other religious concepts, the meaning of taher remained without changes and was not impacted by modernization. The rules for a place, object or person to be taher are very particular and must be observed for Muslim religious activities and many non-religious activities too 5. The understanding of the Islamic concept taher will enhance the understanding of conservation specialists for religious built heritage, such as mosques and other religious buildings. Taher also is important for some aspects of Islamic civic buildings such as houses, schools and caravanserais as often a religious function is included in one or more of the spaces of such buildings. The correct understanding of how a building or part of it is meant to be taher should lead to an appropriate conservation decision from the point of view of understanding the values and significance of the heritage property as well as being more relevant and thus appreciated by users and local communities.

**‘Ibra**

The concept encompasses the thoughts, feelings and lessons learnt from heritage, history and archaeology. Islam brought a completely new importance to this concept. While in pre-Islam Arabic culture it didn’t carry more weight than its linguistic meaning, ‘ibra became the ultimate purpose of studying history and visiting heritage places. ‘Ibra was mentioned directly and indirectly in the Qur’an as the objective of prophets’ stories, history telling and the survival of physical remains of older communities and civilizations. Muslims are encouraged to travel and reflect on different peoples and places both natural and manmade. Accordingly, many books of history, geography and travels which were written by Muslims have been either given titles that included ‘ibra or made it clear in their introductions that ‘ibra is their main objective. Ibn Khaldun’s “Muqaddimah” was inspired by the Qur’anic instructions regarding ‘ibra. The Muqaddimah, which is the Arabic word for “introduction” was the introductory tome to a multi-volume historical accounts. It included reflections and discussions on lessons drawn from history, and concluded by patterns of the causes, symptoms and signs of the rise and fall of nations and civilizations 6. Because of his Muqaddimah, Ibn Khaldun is considered by some modern day sociologist as the founding father of sociology as we know it today. Endorsing the meaning and place of ‘ibra in dealing with history and material historical remains should furnish a common ground among conservation professionals and local communities for the appraisal and celebration of the built heritage. The concept of ‘ibra may also prove relevant to non-Arab and non-Muslim societies in appreciating their built heritage and identifying the purpose of its conservation.

**‘Urf**

It includes the conventions, norms, traditions and rules inherited and applied by a community. Pre-Islam Arabs led a nomadic tribal life. They were mostly illiterate. For these communities, ‘urf was their reference system and what they based their conduct on. They didn’t have written laws or established courts of justice. ‘Urf was all what they had, governing different aspects of life. Although many of the rules and norms set by ‘urf were made obsolete by
Islamic law “shari’ah”, Islam endorsed the different aspects of ‘urf that didn’t conflict with its doctrine. In modern Arab states, ‘urf almost disappeared from formal legal, administrative and social systems. However, it remains the main reference system to the masses in informal urban communities as well as in rural communities and more so for desert tribes. Acknowledging ‘urf by conservation specialists should avoid conflicts with local communities’ powerful value systems. Furthermore, ‘urf can be a highly efficient vehicle for enforcing conservation measures should they be endorsed by and integrated into local communities’ ‘urf. International charters, and other doctrinal documents on conservation should acquire high influence as well as become more culture-sensitive, should they respect ‘urf and make sure to incorporate their values before interventions in traditional local communities. The concept of ‘urf may also prove highly relevant for the conservation of the built heritage of non-Arab non-Muslim traditional communities.

‘Amara

The concept encompasses both tangible and intangible aspects of building a place as well as revitalizing it. ‘Amara may be used in the literal sense of constructing a building or in a more conceptual way meaning living in a building. For pre-Islam nomadic Arabs, the division was not always clear between the tangible and intangible aspects of establishing a place for living. Their living places were often mobile structures such as tents and huts made of palm frond. The concept ‘amara therefore referred to all or some aspects of living and flourishing places. The holistic nature of ‘amara was emphasized by Islam. The Qur’anic verse that applies the concept to mosques is interpreted as building, maintaining, repairing, furnishing a mosque as well as endowing money for its upkeep and praying in the mosque. Today ‘amara is used with the same holistic meaning. ‘Amara a house may mean constructing, repairing, enlarging or restoring the house. It may also mean living in it or the flourishing and the wellbeing of those who live in it. Adopting the concept of ‘amara in the field of conservation should provide a holistic concept, which includes tangible and intangible attributes to cultural heritage. ‘Amara also brings architectural and urban conservation closer to communities’ present and future mainstream activities. ‘Amara can also be a term indicating the addressing of both tangible and intangible aspects of the significance of the built heritage.

Fiqh al hifaz

The term fiqh means the applied knowledge of Islamic views in a particular field or aspect of life. Fiqh al hifaz means applied Islamic knowledge in the field of conservation of cultural heritage. Islam introduced differentiation between theoretical knowledge (‘elm) and applied knowledge (fiqh). A scholar who has a wealth of theoretical knowledge may not have fiqh, which means that his knowledge remains theoretical and that he would not know how to apply that knowledge in a particular circumstance or case. The concept of fiqh as opposed to ‘elm was initially pertaining to Islamic instructions. With time, this concept was extended to include specialized fields such as economy, law and medicine. Fiqh for a particular field identifies Islamic views and instructions concerning that particular field. The present paper proposes establishing fiqh al hifaz, which should identify Islamic views on different aspects of conservation. This will secure the conviction of devoted Muslim communities to endorse conservation of the built heritage.

Naf’

It is the utility, use and function of an object, place, person or concept. In pre-Islam Arab cultures, as in other traditional cultures, the function and use of an object, place or concept was and still is its raison d’etre. The exception from this for non-Islamic cultures had been “sacred objects”. The importance of function and utility is strongly emphasized by Islam and expressed by naf’. Furthermore, one of the main objectives of Islam is to dissociate sacred intangible principles from tangible objects, which is the essence of the outcry “to destroy the idles” and not to associate anything or person with Allah, the only God. At present, Arab Muslim societies followed the Western model of modernization, in which cultural heritage objects have been stripped off their function and put in glass boxes for the benefit of the scholar and the tourist. In addition, most historic buildings were divorced from their intended functions and transformed into museums, which alienated them from local communities. Endorsing naf’ should emphasize values-based conservation approach, which was recently adopted by the international conservation movement. Integrating naf’ within the conservation of the built heritage discourse in the Arab region will recognize highly appreciated values by local communities and should secure better integrity for Arab built heritage which was built with naf’ as a major objective and value. Beyond Arab-Muslim communities integrating naf’ within the theoretical body of conservation for cultural heritage will recognize values, which are cherished by traditional communities and are at present excluded from modern conservation discourse.

Waqf

It is a system of endowment that was developed in Muslim communities to secure the sustainable management and conservation of public, charitable and religious institutions and functions. Endowment was known in pre-Islam communities and are at present excluded from modern conservation discourse.
cultures and is adopted in many non-Muslim communities today. However, the Islamic worldview and concept of man’s place and role in life gave it an exceptional place and role in Muslim built environments. The waqf system secured the sustainable management and conservation of both tangible and intangible aspects of all non-profit, charitable and community service institutions and buildings. Modern conservation for Arab-Islamic built heritage dismissed waqf as a management and conservation mechanism and, thus, separated a building from its waqf arrangement which was the mechanism that sustained it for centuries. Today as the concept of conservation management planning is applied to the field of cultural heritage, the waqf system makes more sense than before. The endorsement of waqf by Arab conservation professionals will build on a well-tested system that is known and respected by local communities. Beyond Arab-Muslim communities, the concept of waqf is already known and implemented in the field of heritage conservation through trust and endowment arrangements.

**Conclusion: Tools for Conservation Practice**

The identified concepts should contribute to the theory of conservation on two levels. The first and obvious level is pertaining to the conservation of cultural heritage in the Arab region and of Islamic cultural heritage everywhere. On another level, these concepts should contribute with varying degrees to the theory and practice of conservation on a global level.

1. Conservation in the Arab region and for Islamic cultural heritage: The tragic destruction of highly significant Islamic and non-Islamic cultural heritage in Mali, Libya, Syria, Iraq and Afghanistan in the name of Islam, is condemned by Muslim scholars and devoted public alike. Such destructions with false justifications highlights the critical need for respecting Islamic values and integrating Islamic-Arabic terms and concepts into conservation of the built heritage in the Arab region and wherever Muslim communities and their heritage are concerned. Destruction to the built heritage in Arab and Muslim countries is caused, not only by extremist outlawed groups, but also by formal development initiatives. This occurs when archaeological, scientific and aesthetic values conflict with religious, cultural and socio-economic values in the eyes of local communities and governments. An example of such situations is the development of the haram in both Mekkah and Medina to serve the requirements of the ever-increasing numbers of pilgrims performing the Islamic hajj rituals. The Arab region is full of many other examples on different scales. It is, therefore, crucial for the conservation practice in the Arab region and in Muslim contexts to develop fiqh al hifaz and to endorse the concepts identified in the present paper to establish the appropriate theoretical background and the relevant tools to conserve the built heritage. This will also encourage the participation of local communities by speaking their language and referring to their value systems.

2. Beyond the Arab-Islamic context: The identified Arab-Islamic concepts should prove useful beyond the Islamic context as they belong to a holistic approach to conservation. Furthermore, they should enrich the existing tools for conservation practice in the following fields:
   - Management of the built heritage;
   - Values-based conservation;
   - Living heritage conservation;
   - Religious heritage conservation; and
   - Participatory and community based conservation.

3. The way forward: The identified concepts should be put to the test by thier inclusion in the conservation theoretical discourse and by integrating them in approaches to conservation interventions on the ground. Further discussions and experimental applications may result in refining, shifting focus or identifying further concepts and terms to enrich the conservation of the built heritage in Arab-Muslim contexts. Moreover, they may prove useful if applied fully or partially to other geographic and cultural regions and domains, which may prove effective in breaking away from Euro-centric conservation theory and practice and rendering it more relevant outside Western cultures. An interesting example of another non-Western contribution to the conservation discourse is the Japanese approach to the concept of authenticity, which became more internationally visible and influential since the Nara Conference on Authenticity held in 1994.

---

1. Identified in Mahdy, 2008.
9. Hakim, 1986
10. Amin, 1980.

Bibliography

Theme 5: Emerging tools for conservation practice
Theme 5-3: Theoretical tools

Implementing New Paradigms for Managing Change: the Sydney Opera House Experience

Sheridan Burke
Director GML Heritage, Sydney, President ICOMOS International Scientific Committee on Twentieth Century Heritage, Adjunct Professor University of Canberra, Australia

Abstract

This paper will review the development of benchmark conservation management tools in daily use at the World Heritage listed Sydney Opera House (SOH) the Utzon Design Principles, 2002 (UDP) and the Conservation Management Plan, 2014 (CMP). The new CMP comprehensively engages with the UDP and it includes a new conservation management tool, the concept of assessing 'Sensitivity to Change' (StC). How the original creator may contribute to the conservation process will be explored in examining the re-engagement of the original architect Jorn Utzon in new SOH projects.

Keywords: Conservation Management Plan, Sydney Opera House, Utzon

Preamble

The development of the concept of Sensitivity to Change has been trialed and tested by GML Heritage over some years, and this paper draws upon a number of projects and presentations that I have delivered during that time on this subject. I wish to acknowledge and thank my friend and colleague, Alan Croker, Director and Principal of Design 5 who is the author of the forthcoming 4th edition of the Conservation Plan 2014 and the management of the Sydney Opera House, in particular Greg McTaggart, Director Building Development and Maintenance. Mastering the art of heritage conservation requires understanding a complex system of interactions between scientific knowledge, technical expertise, consistent management, innovative development, regular monitoring and sensitive interpretation. It involves the responsibilities and work of diverse stakeholders on equally diverse subjects, all in pursuit of the goal of “authenticity” - safe-keeping the reasons why the place is significant, why it is valued by communities and experts alike. Conservation requires a deep understanding the heritage values of the place to direct the carefully considered management of changes that must be accommodated, whilst ensuring the authenticity of its heritage values are retained.

For the heritage places of the Twentieth Century, a unique opportunity for intergenerational interaction arises for transfer of knowledge between the original designers and today’s conservators, and at the Sydney Opera House (SOH), the re-engagement of Danish architect Jorn Utzon after a gap of 40 years exemplifies the benefits of seizing such chances.

A Very Long Engagement

Utzon’s re-engagement in 1998 for the development of the Utzon Design Principles (UDP) formalised a dialogue with the original designer, which is now integrated in the 2014 Conservation Management Plan (CMP) to simultaneously conserve and facilitate functional change to Australia’s busiest performing arts venue and premier tourist attraction. Added to these two key documents is the new concept of “sensitivity to change” which has improved the definition of responsibility for decisions and policies by expanding the sources and types of information available to a wider range of SOH stakeholders in different formats and media. In my practice at GML Heritage, we have demonstrated that such emerging tools for conservation practice can be adapted and applied to the full range of heritage places.

The Sydney Opera House story

Much of what we see today at the SOH is the design of Danish architect Jorn Utzon, winner of the 1956 international design competition. The building was designed and constructed under his supervision from 1957 until 1966, when Utzon left Australia after disagreements with the state government, never to return. The interiors and a range of finalising works were designed by Australian architects Hall, Todd and Littlemore, who completed the project by 1973.
Dynamic Management

The SOH site is 5.8 hectares, has 2000+ rooms and 7 major performance venues, together with extensive retail and dining venues. 480+ staff welcome more than 8.2 million visitors every year; 1.2 m patrons attend more than 2,500 events and performances annually. It is a 24 hour- a-day, 363 days per year very active venue. An exciting but challenging mix of creative performance demands and commercially focused requirements must be reconciled with conservation regulations and community expectations of a World Heritage site, in even the smallest of management and maintenance decisions.

However, this marvelous building has some acknowledged functional problems, and resolving such weaknesses are long-term projects, and costly. In recent years major changes have been initiated to improve acoustics in the Concert Hall, lifts and escalators have been installed, and disabled access has been improved, though not resolved. The Vehicle Access and Pedestrian Safety Project presently concluding will enhance tourist and visitor safety by removing heavy vehicles that daily provision and bump in sets and orchestral equipment from the Forecourt to a new underground loading dock.

This is a building that is much loved and much touched- it’s an incredibly tactile place, visitors love to engage with it personally. Whilst most of its fabric is robust, maintenance and visitor management are insistent daily demands. Concerns as diverse as public safety and concrete repair compete for management attention, and funding. The public expenditure purse is tight, but the expectations of 8.2 m visitors each year, are consistently high.

Opera House Enterprise Strategy 2013 notes:

“When the Opera House was designed and constructed, building codes, safety standards, accessibility requirements and work practices were significantly less stringent than today….We need to be able to accommodate the multi-dimensional and technologically advanced productions that artists and audiences expect in the 21st century. Our World Heritage Listing adds greatly to the complexity of the task. We need to find innovative and respectful solutions that address these issues, so that we continue to be recognised as a great performing arts venue, strengthening our appeal to artists and audiences worldwide” 1.

Use is a key attribute of significance

What is different at SOH from most other World Heritage sites is that part of the significance of the place is its very active performance role-its functional use is an attribute of its heritage significance, just as much as its built form, exquisite fabric and superb location and harbourside setting. The integral importance of ongoing use and change was fully acknowledged when the SOH was nominated in 2006:

“Changes introduced over the construction process and after inauguration must be considered as the natural result of the development of a living monument; they do not jeopardize the intrinsic values of the original architectural ideas and design but illustrate the process of constructing and managing one of the landmarks of 20th century architecture” 2.

And when the World Heritage listing was approved in 2007 and the World Heritage Committee resolution noted:

“The Sydney Opera House continues to perform its function as a world-class performing arts centre. The Conservation Plan specifies the need to balance the roles of the building as an architectural monument and as a state of the art performing centre, thus retaining its authenticity of use and function. Attention given to retaining the building’s authenticity culminated with the Conservation Plan and the Utzon Design Principles” 3.

The SOH Conservation Plan

The first Conservation Plan for the SOH was developed in 1993 by the late Dr JS Kerr to assist the SOH Trust to manage the heritage values of the site, which had been proposed for World Heritage listing as early as 1980. In Australian practice, CMPs are reviewed every five years, or as changes to the property demand, and the SOH CMP was subsequently revised in 1999, 2003 and most recently 2012-4.

Australian conservation plans follow a standard methodology and structure 4 to assess the significance of the place, describe its attributes and provide policy guidance for its management. This methodology reflects the principles and process of The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance, 2013. This remarkably influential document, now in its fifth iteration, was developed in the late 1970s by Australian heritage experts. Reflecting upon the Venice Charter 5, the Burra Charter sets an Australian standard of practice for those who provide advice, make decisions about or undertake works to places of cultural significance including owners, managers and custodians.

It is the nationally endorsed benchmark guideline for heritage management, used when heritage places are undergoing conservation and development. In summary, the Burra Charter simply says: Understand the values of the place, develop policy to safeguard those values and manage the place in accordance with the policy framework. The policy framework of the SOH CMP is similar to any other Australian heritage building except for the uniqueness of its incorporation of Utzon’s own words, extracted from the UDP to inform its overarching policies and specific policies for each major building element: the setting, the exteriors (podium, forecourt, shells etc.) and
the interiors; and detailed operational policy sections that cover general issues such as interpretation, accessibility, care of building fabric and housekeeping, managing records and information as well as detailed component level policies with include guidance on managing the process of change for smaller components such as doors, furniture, fittings artwork, machinery, lighting and signage.

**The Utzon Design Principles**

Since 1998 Australia has been fortunate to have enjoyed a most unusual re-engagement with Jørn Utzon working in collaboration with his son Jan and the distinguished Australian architect Richard Johnson and his firm Johnson Pilton Walker to contribute to the ongoing evolution of the building. This has meant extraordinary access to first-hand knowledge about how and why the SOH was built the way it is, and the creator’s insight into the way the building might evolve.

Utzon’s re-engagement was ‘To document his original design intentions for posterity and to advise on future work’ which would both safeguard the house and address its ongoing function as a performing arts centre. Utzon saw the UDP as: ‘a permanent reference for the conservation of the building and its setting’ intended ‘to clarify original design intent, to manage proposals for change and influence planning controls for the precinct’.

By 1998, the SOH Trust had thirty years of experience of the practical performance of the building- changes were needed. Utzon’s’ own ideas had evolved and matured. At the time of his re-engagement, Utzon was 84 years of age, and his son Jan was the key collaborator in his practice and he continues to advise the SOH following Jorn’s death in 2009.

The Utzon Design Principles were developed over a four year period (1998-2002). They were compiled by Richard Johnson after many long meetings, conversations and correspondence between Denmark and Australia, and the text was approved by Jorn Utzon. The UDP set out in Utzon’s own words the sources of inspiration for his vision, providing an insight into his design methodology and the ideas that he used to determine the overall concept, as well as the detail of the place.

The Utzon Design Principles have been integrated into the 2003 and 2014 editions of the SOH Conservation Plan, setting out ‘how to retain’ significance in relation to Utzon’s principles and how to implement and manage change. Together these two key documents explain the creator’s intentions and meet the conserver’s needs by providing the context within which proposals for change would be reviewed.

**Specialist Advice**

The SOH Trust has also established two committees to provide expert heritage and design advice. The Conservation Council was appointed in 1996 to provide specialist advice on the care, conservation and maintenance of the authenticity of the Opera House. Meeting three times per year, the Conservation Council (of which I am a member) provides expert advice and recommendations on projects and issues as they arise, supporting in-house specialist staff.

An Eminent Architects Panel was established in 2010 as an advisory body to the SOH Trust to provide high-level independent expert advice (via the Trust Building Committee) on issues of architecture or design as it adapts to changing circumstances.

The Council and the Panel provide a range of expertise and experience to advise the Trust in strategic decision making that impacts heritage values. Specialist consultants are engaged by the Trust also provide advice and reports on specific management issues.

**Scottish Ten 3D Digital Recording**

In 2012, The SOH was fortunate to become the fourth of five international World Heritage sites to be digitally recorded as part of the Scottish Ten project, delivering extraordinarily accurate digital modelling data to inform site management, interpretation and conservation projects. Working closely with the Opera House building management team, the Scottish Ten team generated 3D Figures of the shells/sails, auditoria and foyers.

**Day to day decisions**

How are the differing use interests practically managed on a day by day basis? The evaluation of the sometimes competing needs of site activation, performance and heritage conservation need careful assessment and early guidance to minimize, avoid or mitigate and impacts.

Everyday site management already sits within a complex web of local statutory planning and building controls and codes; state heritage regulations and the federal government responsibilities in relation to the World Heritage Convention. Major works projects are of course assessed using the standard Australian practice of Heritage Impact Assessment.

At the macro scale, to retain and respect the authenticity and integrity of Utzon’s work and the contributions made by Peter Hall and others in its completion, the 2104 CMP requires that all future designers should accept and utilize the Utzon Design Principles established as the basis for all new work. No new design work should contrast or compete with
the Utzon or Hall work. New work should be read as subtle and sympathetic addition to the existing work. But monitoring minor works and site activation proposals for festivals and outdoor events at the micro level can be equally important. As more and more SOH activities are delivered outside the shell of the building, the impact on the appearance of the exterior and the intangible experiential values of the house on its 8.2 million visitors is markedly increased. Impacts on the tangible fabric-based heritage values also pose similar risks— a simple operational change such as replacing floor coverings or stair handrails to ensure functional capacity, or to meet building code and safety standards could adversely impact the heritage values as well as its physical building fabric, and thus diminish its authenticity incrementally. SOH management is well aware of the heritage risks of making cumulative small decisions under the pressure of immediate operational needs, because the small decisions that may erode the overall heritage significance of the place often need to be made swiftly. A simple methodology for assessing and avoiding adverse heritage impacts whilst responding quickly to the urgent needs of public performance venues was needed. It is called the sensitivity to change (StC) concept.

The Concept of Sensitivity to Change

Each policy section in the 4th edition CMP is preceded by an excerpt from the UDP, giving Utzon’s own “big picture” introduction first, and the detail of the policy follows, utilizing a micro-management tool called “Sensitivity to Change” (StC). The StC tables provide guidance in implementing the policies. The Policy is the ‘yes’ or ‘no’; the StC table gives the ‘here’s how’ or ‘how to manage or reduce impact’. Implementing StC requires a thorough understanding the relative significance of each element of a place to assess how the qualities such as authenticity and integrity are vulnerable to harm or loss, so the sensitivity or “tolerance for change” of the element can be established. The StC methodology embodies two simple interrelated but separate processes:

Firstly, the identification of the specific attributes of the building in which its heritage values are embodied—usually heritage values are associated with its form, fabric, function or location, and intangible values. Different values may have differing levels of sensitivity to change.

Secondly, an evaluation of the amount of change that each attribute can sustain, without adverse impact or loss of value is made. Some attributes of some heritage places can tolerate a ‘counter-intuitive’ amount of change—i.e. highly significant attributes of highly significant places may be able to accommodate a great amount of change, while conversely, attributes of low significance may not be able to be changed much at all without fundamental loss of heritage value. The innovative aspect and indeed the whole point of the StC methodology is that it allows for judgments of this kind to be uncoupled from the linear logic that usually simply links significance and change. It is not, however, an endorsement of change without proper regard to heritage values and significance ranking. The 2014 CMP StC policy reads:

“All elements of the Sydney Opera House are to be maintained, used and managed in accordance with their relative level of significance and the identified sensitivity to change for their component parts. The higher the significance or sensitivity to change, the greater the level of care and consideration required in determining any decision or action which may affect it, the objective being to ensure that the work or proposal whether it be temporary or permanent, will reinforce and not reduce, the identified significance” 12.

Each of the building elements has its own StC table, which adds detailed guidance for the implementation of the main CMP policies. As an example:

“The Forecourt has a relative significance ranking of A — exceptional because of the role it plays in the setting of the whole place and in the sequence of approach to the building. The granite sett paving (installed in 1988 to replace the temporary bitumen) is listed as one of its component parts. The function and location of the paving are identified as 1, having a high sensitivity to change due to their fundamental sensitivity to change due to their fundamental role in supporting the exceptional significance of the Forecourt, whereas its form is ranked 3, as the small scale of its components is contrary to the large-scale units envisaged by Utzon. Thus its fabric is ranked 2 — moderate sensitivity to change. Under ‘Further Considerations’ it is noted: "Pink granite is the preferred material for this area, but the form and scale (sets versus slabs) and configuration of the paving can be changed to provide a more appropriate relationship to the broadwalks and podium." This provides direction for change while allowing for a range of possible design solutions 13.

The rationale for breaking down cultural significance in this way—attribute by attribute—is that these different attributes and values may have differing tolerance/sensitivity to change, and need different policy approaches. The StC process can be a useful adjunct at a micro level to step building managers/owners through the significance of each element to carefully assess how much change may be tolerated. In order to better understand how and where changes to elements may acceptably occur, a StC assessment table which indicates sensitivity/tolerance for change has been developed for all the major elements of the Opera House.

Re-engaging with the Original Designer

I would like to close by exploring some of the ambiguities about whether the original creator has privileges and priority over the conservator, and the practical potential for ongoing involvement or re-engagement of the original designer in the evolving life of the building. This was an issue that was explored in the 2009 Australia ICOMOS...
conference,’(Un)loved Modern’, which was partly held at SOH, in a series of national and international papers which are available on the Australia ICOMOS website. I’ve observed and personally been involved in several such re-engagements of original designers when a building is to be conserved or developed, and it can be a tense relationship, not always favorable to authentic outcomes. In the case of Utzon, the self-effacing nature of the man dictated his approach. The temptation to reconstruct what Utzon had planned in the 1960s but which was not realised in the work which followed his departure from Sydney, had been a matter of ongoing debate amongst architects and critics. Once, and for all time, Utzon himself rejected this idea in 2002, stating in the UDP that: “It would not be correct to go back to the thoughts and ideas that were new in the 1960s which were based on a different program for the building. As the architect of the Sydney Opera House, as the creative force behind its character, I sincerely believe that a large multipurpose structure such as this building in time will undergo many natural changes. The ideas as they were developed in the sixties, evolved as a result of needs and technique at the time. As time passes and needs change, it is natural to modify the building to suit the needs and technique of the day. The changes, however, should be such that the original character of the building is maintained. That is to say I certainly condone the changes to the Sydney Opera House. Both changes are due to general maintenance and changes done due to functional changes. Had I completed the SOH as the architect in charge, the building would have developed and changed with time ever since. The Utzon Room and the Western Foyers projects demonstrate the outcomes of that happy re-engagement. Together, the integrated management tools of the UDP and the 2014 CMP can cherish this extraordinary building going forward, with expert staff and advisers monitoring the daily need to manage incremental changes by using the Sensitivity to Change process. The Sydney Opera House has equipped itself with a range of conservation management tools which can secure its authenticity, befitting such a place of outstanding universal value, achieving one of five key elements of the Sydney Opera House Enterprise Strategy 2013. “As custodians we will do the building justice, honouring the Utzon design principles, its standing as one of the world’s pre-eminent works of architecture and performing arts venues. To do this, we will work to conserve and renew the building, preparing it for future generations of artists, audiences and visitors”.

Bibliography

1. Sydney Opera House Enterprise Strategy 2013
2. WHC 07-31com-inf8b1e p 92.
3. WHC 07-31 COM 88.31.
7. Extract from Media Release 1 September 1998 by the Chairman of the Sydney Opera House Trust Mr. Joseph Skrzynski.
9. SOH Conservation Management Plan 2014 (in publication)
10. The Sydney Opera House was included in the National Heritage List in 2005 under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) and on the State Heritage Register of New South Wales in 2003 under the Heritage Act 1977 (NSW). Listing in the National Heritage List implies that any proposed action to be taken inside or outside the boundaries of a National Heritage place or a World Heritage property that may have a significant impact on the place’s heritage values is prohibited without the approval of the Minister for the Environment and Heritage. A buffer zone has been established.
11. The concept is also sometimes termed “Tolerance for Change”, was developed by the author.
15. ibid p 48, letter from Utzon to Sydney Opera House Trust, 19 August 2000.
Digital Media Technologies for the Management of Data on Construction Techniques and Damage

Xavier Romão
Faculty of Engineering of the University of Porto, Portugal

Esmeralda Paupério
Construction Institute of the Faculty of Engineering of the University of Porto, Portugal

Aníbal Costa
University of Aveiro, Campus Universitário de Santiago, Aveiro, Portugal

Abstract

Sustainable management and conservation strategies for constructions are known to be highly dependent on the availability of adequate documentation and recordings of relevant data, namely about the structural conditions and the materials of the construction. Available digital technologies have been changing the recording practice by offering new tools to collect, analyse and disseminate information about existing constructions. In this context, the role of GIS-based tools and multimedia technologies in managing and presenting information on existing constructions is addressed herein.

Keywords: Construction Survey, GIS, Digital Damage Maps, Damage Assessment, Digital Media

Introduction

The traditional constructions of a country, as an essential part of its historical and cultural identity, need to be preserved. The development of sustainable management and conservation strategies for such constructions are seen to be highly dependent on the availability of adequate documentation and recordings of relevant data, namely about their structural conditions and the construction materials. Hence, the technical survey of a construction must involve appropriate information identification and acquisition techniques capable of producing useful data that will enable the technicians to understand the construction and its context with the necessary precision. Available digital technologies have been changing the recording practice by offering new tools to collect, analyse and disseminate information about the constructions [1,2]. Therefore, one can expect the amount and the type of recorded information to have the tendency to increase. This fact leads to the need for adequate systems enabling an efficient management of such information. In this context, the development of recording tools based on geographical information systems (GIS) has been taking a leading role given their advantages, especially in areas where spatial and/or geographical data analysis is fundamental. In the field of construction-related data recording and management, the usefulness of GIS-based tools is related to their versatility to enable the manipulation, analysis, recording and mapping of large amounts of data. As an example of this type of approach, a GIS-based tool recently developed for the recording and management of construction data is presented herein.

The conservation of existing constructions asks for an integrated methodology that includes the steps of Analysis (which involves the technical survey), Diagnosis, Therapy and Control [3]. The Analysis and Diagnosis phases are essential for the definition of a correct intervention, both in terms of the technologies and materials that are better suited to the characteristics of the construction. Therefore, the sustainable rehabilitation of a construction, accounting for its architectural, historical and constructive values, must involve carefully developed Analysis and Diagnosis steps. The results obtained from these two steps are usually presented in a written technical report, which is the fundamental asset supporting the intervention (Therapy and Control) options. This report not only serves as the input and justification for the decisions that have to be made in terms of the rehabilitation process, but it is also an archive of information about the construction that might be needed in future studies. Since conservation/rehabilitation projects normally involve a multidisciplinary team of technicians, this report needs to highlight the different approaches and interests of each area of expertise. The main drawback of this approach, as an information presentation tool, is that multidisciplinary reports presenting information on a vast number of areas of expertise are becoming less practical due to the large amount of information they contain.
In such cases, each technician chooses to consult only the information directly addressing its area of expertise, thus missing out on the comprehensive multidisciplinary conservation/rehabilitation approach.

In order to address these issues, complementary means of information and knowledge presentation are also presented herein. The proposed examples involve data representations that are not easily introduced, or are simply unable to be included, in a classical written report format. Nonetheless, it should be emphasized that such new means of data presentation serve only as a complement to the written report and not as its replacement.

Regarding the presented examples, most of the survey procedures involved were visual assessments and geometric data was obtained by hand surveys. Drill holes and non-destructive tests were also used to determine material properties when needed. A detailed presentation of such procedures is not addressed herein since the focus of the proposed paper deals mainly with the advantages of using digital media to present the recorded data.

GIS-based recording of construction-related data

Description of the proposed GIS-based tool

To help in the recording and management of data obtained during the technical survey of an existing construction, a GIS-based tool was developed by the Construction Institute of the Faculty of Engineering of the University of Porto. This tool, called SIMDE (System of Inventory for Materials and Damages in Buildings) (fig. 1), is an application that runs over the ArcGIS software 4. SIMDE was developed to enable the recording of detailed information about materials and damages of existing constructions, having in mind both practice-oriented and strategic objectives for the preservation of such constructions. After performing an on-site survey of the data with SIMDE, using a tablet PC, SIMDE enables the automatic definition of customized damage and material maps that use specifically defined symbols for the mapping representations.

Besides the technical merits of such graphic representations, these maps also work as efficient visual aids for decision makers. Therefore, SIMDE was developed in order to enable the production of easy-to-read materials and damage maps in a more automatic way. By doing so, it is expected that the information processing time after the on-site recording and survey operations is considerably reduced. Moreover, SIMDE also features the possibility of managing recordings and surveys carried out over different instants in time for the same construction.

This feature enables the monitoring of the construction conditions by a direct overlapping of different layers representing the different surveys. Although it is possible to identify several advantages about the use of a tool such as SIMDE, attention is brought to three particular aspects. First, a near 100% reduction of the information processing time after the on-site survey can be expected since the production of output maps is carried out automatically by SIMDE. Second, the availability of such detailed information about the constructions in an attractive graphical format, including its evolution over time, allows decisions about the need to rehabilitate the construction to be more easily made by decision makers. Third, such information can also be seen to be of extreme value in emergency situations where information about the initial state of a given heritage construction is necessary for surveys and condition assessments after an accident (e.g. a fire or an earthquake). Furthermore, in such cases, SIMDE can be used to record the updated state of the construction to be used for posterior safety analyses.

Example application of SIMDE

The example application presented in the following involves the partial survey of a building. The initial survey of the building was carried out using traditional methods 5. Part of the survey was then repeated using SIMDE to highlight its advantages. Figure 2a) presents a view of the main façade while fig. 2b) presents a view of the interior of the selected building, which is a XIXth century palace located in Porto, Portugal.

The part of the survey that is addressed herein involves the recording of damages to the high-value interior finishes and decorative elements.

Figure 3a) shows the damage map obtained for one of the building rooms using a traditional survey. Each type of damage was recorded using a different terminology and symbol. The final damage map was prepared using CAD, based on the detailed manual survey carried out in-situ using technical drawings. The map colors were defined to enable a clear reading of the damages due to the significant number of damaged areas in each room. The intensity of the damages, however, was not represented. Still, two intensities of cracks were represented (light crack and intense crack), each one with a different symbol.

The survey of this room took two hours and involved two persons. The final damage map in CAD took four more hours to be produced by one person. Figure 3b) shows the damage map of the same room after it was surveyed using SIMDE. Although the in-situ survey time was the same, involving also two persons, no further post-processing was needed since SIMDE produces the damages maps automatically.

As previously referred, the symbols used in these maps were specifically developed for SIMDE. In these symbols, the different colors refer to the damage intensities, which allow a more clear assessment of the overall state of damage of the room. By comparing the two survey approaches, it becomes clear that SIMDE is more effective, particularly in terms of the time involved to produce the final map.
The need for the adequate documentation and presentation of survey data

Although damage and material maps that can be developed using a GIS-based tool such as SIMDE enhance the readability of the data gathered during the technical survey, there are other aspects of the data obtained from the survey that must be adequately documented and presented. Difficulties in the documentation and presentation of the such data, resulting from the use of inadequate dissemination formats, may be responsible for enhancing the gap between the information users (project managers, planners, politicians and general decision makers) and the information providers (surveyors and specialists of more technical areas of expertise).

For the information users, the presented data must remain clear and self-explanatory, and should increase the interest in having this knowledge, thus highlighting the value of the construction and justifying the need for the intervention. Therefore, data documentation and presentation can be seen to be accountable for the successful development of a conservation project at the technical, financial and social levels.

Information identification and acquisition techniques have to meet specific requirements depending on the problem at hand (e.g. a structural stability problem, the deterioration of a stone or adobe surface or the conservation of a wall painting), and will also depend on the size of the construction and on the level of accuracy needed. Nonetheless, one must keep in mind that survey protocols ideal for all circumstances do not exist. Therefore, detailed operative strategies for construction surveys are defined on a case by case approach. Construction survey operations include geometric recordings, damage levels recordings, photographing, in-situ chemical or structural tests on materials and data gathering on the history and present condition of the construction.

Data resulting from the survey must then be organized, harmonized and presented to enable a well-founded analysis of the construction that will ultimately produce a Diagnosis about the state of the construction. In most cases, the information is presented using a self-contained written report containing the full range of information related to the different areas of expertise. Since conservation projects normally involve a multidisciplinary team of technicians, the preparation of this report contributes to the conciliation of the different areas of intervention.

For example, engineers must be aware that a particular wall that needs to be retrofitted has a finishing that must be preserved (e.g. paintings), while conservators/restorers should know that the referred finishing is part of a wall that will be retrofitted. As previously referred, the main disadvantage of this approach as a data presentation tool is that multidisciplinary reports presenting information on a vast number of areas of expertise are not always practical due to the large amount of information they contain.

Common problems with classical written reports range from fluidity and transparency of information communication, misleading interpretation of technical data and poor interdisciplinary collaboration. Therefore, such reports are reckoned to fall short in presenting the information in a suitable way and, simultaneously, to be difficult to examine and handle when they include a broad range of information.

Multimedia for construction conservation and rehabilitation

In order to address the previously referred data management and presentation issues, the development of complementary means of data presentation are addressed herein. The proposed examples involve data representations that are not easily introduced, or are simply unable to be included, in a classical written report format. These complementary means consist of multimedia modules that can be integrated into multimedia presentations or CD-Roms.

Multimedia frameworks types

Multimedia data presentation frameworks allow data in the form of text, photos or technical drawings to be combined with components having different levels of interactivity. For example, it is possible to develop interactive damage maps allowing interactive switching between schematic representations of the observed damage and real photos of the damage (along with its possible evolution over time) at selected locations. Interactive 3D models of the construction can also be developed. Such models may address the architectural aspects of the construction, the structural aspects, or even both. This type of information presentation enables real-time interaction between the user and the model, allowing the user to move, rotate or zoom the model, to turn on or off the visibility of specific elements of the construction by accessing the model tree hierarchy, to define 3D cross-sections and 3D measurements. Dynamic and interactive linking between different sources of information in the Internet opens a wide range of possibilities and opportunities for information organization and presentation. Finally, movies are another important type of information that can be included in such multimedia platforms. One interesting and useful example of this type of information might be the inclusion of video recordings of tests performed during the structural assessment stage.

Examples of multimedia frameworks

Several examples of multimedia applications that were developed for the presentation of data about a house with interesting structural and architectural features are reported in the following.

The house is located in Vila do Conde, Portugal, and has a ground level, an elevated storey and an attic (fig. 4). The particular significance of this house comes from the fact that it represents a rather common XIXth century
rural construction of the northern part of Portugal that has undergone little alterations over the time. After carrying out a survey of the construction, it was found that a structural repair and strengthening intervention was required. The structural rehabilitation was carefully defined in order to minimize the intervention, as suggested by ICOMOS. In addition to the fact that the construction has undergone very few alterations with respect to its original form, whether it is in terms of the granite masonry walls, or in terms of the floor and roof timber structures, the finishing techniques of the interior walls also present interesting details. Moreover, some interior architectural elements were also found to add to this interest.

Some of the multimedia frameworks that were developed include global damage maps of the house, pictorial representations of the damages by façade that integrate interactive photos of the real damage (fig. 5a), an interactive map for the geographical location and the urban surroundings of the house that include photos (fig. 5b) and digital maps of the finishes of the façades (fig. 6a). A digital library of the techniques of the finishes of the interior walls and ceilings was also developed (fig. 6b). This library includes descriptions of each technique, obtained from the existing literature and photos of their application on the house. An interactive 3D model of the house was also developed (fig. 7a and b). This model was developed to characterize and define with sufficient precision the structure of the house. However, it also features architectural elements such as interior walls, door and windows. Using this model, it is possible to define dynamic cut cross sections to view parts of the house, to measure the depth of structural walls, the length of the timber beams of the floors or to visualize the connection points between the different structural elements. Final remarks

The inventory and management of information about existing constructions have an unquestionable importance in modern society where strategic aspects such as sustainability are critical in the management of the built environment. In this context, the usefulness of tools based on Geographic Information Systems (GIS) is demonstrated by their ability to analyze, handle, store and map large amounts of data. The proposed paper presented a GIS-based tool called SIMDE that was specifically devised to enable the inventory of materials and damages gathered during the survey of existing buildings. The particular advantages of having such tool were addressed, namely in terms of its higher efficiency when compared to that of traditional survey approaches. An application example was also presented to highlight the referred advantages.

The paper also addressed the use of multimedia techniques for presentation, organization and management of technical information about existing constructions. These multimedia applications are a complement to the technical survey report since they are able to present important information that is difficult to integrate and compile within a text report. Such tools are reckoned to be valuable aids for presenting of different types of information and providing a simple and enlightening way to classify and organize the available data. Moreover, multimedia frameworks enhance and ease the exchange of information between different members of multidisciplinary teams involved in the assessment and rehabilitation of constructions, thus increasing the overall efficiency of the project management.

Examples of such multimedia applications were presented for a case study involving a traditional house. Applications were developed to present information about construction techniques, structural and architectural features, and general/local geographical aspects of the construction. The development of these multimedia applications was found to be an interesting example on how simple multimedia tools and environments can assist in information management and presentation. In sum, information presentation with the aid of such tools is an affordable component of increasing importance within the current information society in which communication and visualization of data are fundamental issues.

1. (Eppich, 2011).
2. (Letellier, 2011).
3. (Searls et al., 1997).
5. (Costa et al., 2005).
6. (Costa et al., 2004).
8. (Dias, 1999).
9. (Segurado, n.d.).
Bibliography


Figure 1 - A view of the interface of SIMDE.

Figure 2 - Façade (a) and interior view of the building in Porto.

Figure 3 - Map of the damages recorded in a room of the building using a traditional survey (a) and using SIMDE (b).

Figure 4 - Main façade of the house in Vila do Conde.
Figure 5 - Mapping of the damages with interactive display of a structural damage (a); interactive map of the urban surroundings (b).

Figure 6 - Mapping of the exterior finishes (a); library of the techniques of the finishes of the interior walls and ceilings (b).

Figure 7 - Interactive 3D model of the house: view of the exterior (a) and view of the interior (b).
Can architectural conservation become mainstream?

Cristina González-Longo
Director, MSc in Architectural Design for the Conservation of Built Heritage, Department of Architecture, University of Strathclyde, Glasgow

Abstract

Heritage is recognised today as a sector of international strategic importance and the conservation of historic buildings becomes, internationally, an increasingly common and shared activity for architects and other professionals. There is however a lack of understanding between the general public of what conservation and restoration is, as well as a shortfall between theoretical and philosophical developments concerning the contemporary concept of built cultural heritage and the current professional practices, and even research methodologies. This paper reflects on this observation and proposes a model for the integration of traditional knowledge and contemporary technologies and for a more effective communication with the wider public.

Keywords: Architectural Conservation, Theory, Practice, Education

Introduction

The conservation of built heritage is becoming one of the biggest sectors within the construction industry. The combined value for the UK’s built heritage construction sector is equivalent to almost £12.5 billion in respect of GDP, supporting more than 530,000 FTE jobs. Additionally, one fifth of the housing stock is now more than 90 years old, mostly traditionally built and the sensitive continuous use of historic buildings is crucial to meet the UK government targets for reducing carbon emissions by 2050. All these compelling facts do not have however a current direct translation on the existing provisions for education and training at a professional and citizen levels. Although we understand now the close relationship between immovable-movable and tangible-intangible built cultural heritage, existing research and conservation practices do not support this theoretical framework. One of the main barriers is the difficulty to record, access and analyse the large amount of buildings and data, many times dispersed in a variety of locations and ownerships.

Heritage science on the one hand has developed enormously and there is a great amount of existing specialist knowledge concerning the pathology of materials. On the other however, there is a lack of undergraduate education and skills in other important aspects of architectural conservation - such as theory, design and history- and only minor integration between the relevant disciplines within the context of international principles, local regulations and practices.

Architectural conservation today

Theoretical and design concerns seem to lag behind scientific/ technical developments in architectural conservation, and there is a lack of awareness even on existing contemporary theories of conservation and only limited informed open and public debates on conservation. This is clearly exemplified by OMA’s travelling exhibition ‘Cronocao’, with the re-emergence of radical surrealist proposals such as the need to destroy urban buildings over 25 years old in order to avoid being “at the mercy of unsolvable problems forever”. ‘Cronocao’ reveals the lack of contemporary international popular debate on architectural conservation theory and practice, even its superficiality. Despite more than two hundred years of developments in the theory and practice of architectural preservation and conservation, the exhibition claims that this theory does not exist. This shallow statement has not prevented it from being displayed in some of the most prestigious venues of the world, from the International Architecture Biennale in Venice 2010 to the Royal Academy of Arts of London (2011). The exhibition was even presented as “theory of preservation” at the Festival of Ideas for the New City (2011). The inaccuracies continue also with the misunderstanding that heritage-listed buildings are ‘untouchable’ and with the poor historical background to the field displayed, limiting it to the dated dilemma Ruskin versus Viollet le Duc. OMA created this public exhibition as a manifesto and provocation, and it is remarkable that this global event, with substantial press coverage, has
not provoked much reaction within the profession, or even worst, in some instances the reactions seem to have been actively sidelined.

What appears evident is that the main historical and contemporary positions on architectural conservation are not well known, not only at public but also at professional levels, which is a cause of concern. There is also a clear language barrier which prevents, for example, the extensive Italian reflections to penetrate the Anglo-Saxon world.

From the other hand, there are misunderstandings and sometimes even serious discrepancies between international principles, local regulations and practices. Our global world which was supposed to facilitate exchanges is somehow fragmented when it comes to the understanding of architectural conservation.

Architectural conservation education

Most of the Architecture and Engineering schools do not teach architectural conservation, certainly at undergraduate level, and there is little room in the curriculum to teach much about traditional materials or even survey and diagnostics, two important areas in conservation. As in many other countries, the criteria for the prescription of architecture qualifications in UK are orientated to new buildings, and do not refer explicitly to the conservation of existing ones. It includes however criteria which is applicable to the conservation of historic buildings, for example criterion GC2 requires the “Adequate knowledge of the histories and theories of architecture and the related arts, technologies and human sciences”. As Loughlin Kealy has noted: ‘the difficulty in integrating conservation into mainstream architecture education derives directly from the fact that ‘legitimacy’ in design remains (and is celebrated by professional bodies everywhere) rooted in the idea of avant-garde and the aspiration to be part of it’.

We need to incorporate to the architecture and engineering curricula teaching about traditional construction materials and techniques, explaining how they relate to modern construction materials and methods, so that students can understand the nature of older buildings and suitable conservation techniques.

The education in architectural conservation is at the moment concentrated at postgraduate level, and there are a number of postgraduate conservation courses, with a focus ranging from heritage management to heritage science. There are also short courses on offer with a more technical and practical approach. Organisations such as the Institute of Historic Building Conservation (IHBC), the professional body for building conservation practitioners and historic environment experts working in UK, carry out a great role in supporting conservation professionals, training and dissemination information between institutions and individuals. The Conference on Training in Architectural Conservation (COTAC) has created the online educational resource to help to develop your conservation skills, based on the International Council on Monuments and Sites’ (ICOMOS) Education and Training Guidelines.

Architectural conservation as architectural design project

Somehow we have stopped seeing historic buildings as architecture and this is affecting their conservation. Fixations with the romantic views about historic buildings and the issues of authenticity have distorted and limited the discourse, in many cases conducting, ironically, to reconstructions, even today. Since the eighteenth century developments, the archaeological value of historic buildings prevailed and turned them into artefacts, carriers of idealistic Figures from the past, sometimes just documents or city’s scenography. Previous architectural practices of reusing, transforming and intervening in a contemporary way in historic architecture had somehow stopped and it would not be consciously undertaken again until the twentieth century. We need to reflect on the limiting current routine of reusing buildings in a “new versus old” fashion and look at the best tradition of architects in history who were able to create contemporary architecture masterpieces by intervening on existing buildings.

It is a fact that many of the buildings would not have survived if they were not transformed: history demonstrates that architectural design is an active agent for conservation and architectural conservation should be, first of all, an architectural project.

We need to start moving from the existing tendency of classifying practices, and start looking at projects on an individual basis, in detail and debating the processes and outcomes, including their architectural qualities. This will enhance knowledge and critical skills that can be also used in the new design, moving on from so many historic buildings becoming only museums of themselves, and stopped in time. Projects such as the St Kolumba Diocesan Museum, in Cologne or Neues Museum in Berlin have been extensively published in architectural journals but there could have been more discussion about the conservation aspects. The fact that in the Neus Museum the project was divided into two (new build and conservation) raises many questions about the integration of architectural design and conservation today. It presents also an interesting case study to analyse, clarifying what could appear as a discrepancy in the approach: at building level, the gaps in the existing structure were filled while in the individual elements the lacune were left untouched. The project should also be discussed in comparison with other relevant projects such as the conservation of the Sala delle Cariatidi at Milan’s Royal Palace, not only in terms of outcomes but also of different approaches to the treatment of the ruin, the different conservation methodologies and techniques.
Communicating architectural conservation to a wider audience

If we want to improve the conservation of built heritage, we need to solve a major problem: how we translate conservation research into effective policies and how we educate students and the general public about conservation. But even before that, we would need to educate about architecture in general. ICOMOS Charters and Conventions as well as the Council of Europe recommendations have played at important role as international references, but their quantity and different priorities make difficult for the public - and even to professionals- to effectively use them. There is still a lot of work to be done for a real integration of Conservation and Sustainability, as there are still many conflicts between policies and practices in both fields to be resolved. International guidelines should be at higher level and more concise, giving only a general framework in which local policies and practices should be developed.

The different interpretation of Standards and even Regulations produces as consequence discrepant practices which very much confuse the general public and even professionals. Unfortunately there is not enough public discussion on these matters, and each project ‘fights’ its own battles in isolation and there is never enough time after the projects finish to reflect and disseminate them. Many of the debates in conservation are related to controversies about demolition of historic buildings proposals, for example Covent Garden and St. Pancras in London and George Square in Edinburgh. In the case of Edinburgh, it went beyond, leading to the creation of the influential Architectural Heritage Society of Scotland (AHSS). In the majority of cases, the debate in conservation is limited to these events and it is not continued and developed later in the public domain. This lack of public debate and awareness about architectural conservation affects projects significantly, as many difficulties during the planning process and public consultations could be avoided if there was a baseline of skills and knowledge in conservation to start from.

The conservation professionals need to engage more with the local communities and general public, using a more accessible language and media, providing clear information about the history and theory of conservation and disseminating more effectively the outcomes from conservation projects. But citizens need also to be educated on architecture primarily and subsequently conservation, and this should start in the primary schools. The education in conservation is fundamental for the development of good citizens, and, in the same way that sustainability and environmental awareness is, conservation should be included in the curriculum. As the European Commission has recently concluded, we need to develop a more integrated approach to the preservation and valorisation of our cultural heritage, and it is possible to progress from an appreciation of the unique nature of one's heritage to a respect and interest for other people's heritage 8.

Capacity building through research and education in conservation

If we want to improve the conservation of built heritage, we need to solve a major problem: how we translate conservation research into effective policies and how we educate students and the general public about conservation. The Universities have a key role on this. Following ICOMOS-CIF recommendations, the University of Strathclyde has been working on capacity building in conservation within a wider approach. A starting point has been the creation of a postgraduate course, the MSc in Architectural Design for the Conservation of Built Heritage, and the Architectural Design & Conservation Research Unit (ADCRU). These initiatives constitute a research, teaching, training and dissemination hub, which tries also to make the theory and practice of conservation more open and comprehensible to the general public. Conservation is further placed in the professionally prescribed architectural curriculum by offering two new optional classes to fifth year Diploma architectural students: conservation theory and architectural and construction history.

This whole new postgraduate programme, fully recognised by IHBC has a new ethos as it is design-orientated and research-based, with a methodological, critical and interdisciplinary approach to architectural conservation, integrating the theoretical, technical and creative aspects of the architectural conservation project. The intention is to provide a robust theoretical and practical education in architectural conservation and the complexities of the built heritage, in a local and international context.

One of the strengths of the new course is the quality and extent of the teaching team: knowledgeable and experienced staff and professionals from government, local authorities, conservation bodies and industry. This ensures that the information disseminated is relevant to current and future practice, up to date and with a diversity of specialisms and points of view. The teaching team has a contagious passion for the conservation of our built heritage and a genuine interest in sharing their knowledge and experience with others. Students will be in this way exposed to a range of conservation professionals on all levels, so that they can understand the different professional backgrounds and cultures, developing also their communication skills.

The doctoral research at ADCRU has started by identifying and mapping a not very well known but important heritage, such as the seventeenth and eighteenth century Scottish architecture. Some of the buildings have been demolished or lay now in ruins, but many are still occupied by the descendants of the families who built them (fig.1), which constitutes a wide range to reflect on architectural conservation in a larger time frame. The database has at
the moment 1239 singular buildings (fig. 2). By researching about elements of these buildings such as the timber roof structures or masonry within the overall architectural context, we are raising awareness about their importance and disseminating best conservation practice. This research has allowed also to realise that, unfortunately, the fact that elements of buildings are not visible dictates their fortune, as it seem the same efforts are not put in their conservation. This is a lack of understanding of what architecture and architecture conservation are and we find the research will impact not just in the conservation of roofs themselves but also in the whole field of architectural conservation.

The intention is that the outcomes from the research are disseminated to a broad range of audience: clients, users, architects, craftsmen, engineers, conservators, historians, archaeologists, researchers, builders, students, technicians, planners, educators, policy makers and communities. This will require different methods and media. The scope is also to help to integrate better the input and collaboration of many stakeholders, benefiting also from the interaction between the different disciplines. We would like to encourage a creative approach to the planning and implementation of projects, rather than just follow standard systems. For smaller organisations, as is often the case in conservation, standard systems could impose an unsustainable level of bureaucracy which will distract them from the main scope: to safeguard and conserve the built heritage.

1. (Ecorys, 2012).
2. For an overview of the history and theory of conservation, see Carbonara (1997) and Torsello (2005).
3. (ARB, 2010).
4. (Kealy, 2005).
5. COTAC, Understanding Conservation.
7. (Carbonara, 2012).

Bibliography

Figure 1 - North Elevation Of Drumlanrig Castle, Scotland

Figure 2 - Distribution of key seventeenth and eighteenth century architecture in Scotland (adcru database)
Communicating the Value of Knowledge: “Venus and MARS” Whispering to Our Senses

Paola Calicchia, Lucilla Di Marcoberardino, Sara De Simone
Institute of Acoustics and Sensors “O. M. Corbino” IDASC-CNR
Claudia Ceccarelli
Institute of Structure of Matter ISM-CNR

Abstract
In the Strada Nuova Museums, one of the major oil paintings hosted in Palazzo Bianco Gallery, Venus and Mars by Rubens, was analysed on site for identifying its current state of conservation after a number of restoration interventions and the installation of controlled microclimate. The diagnostic method, based on a non invasive acoustic imaging technique, and the results of the study were exposed to the visitors during usual museum exhibition time: an opportunity to transmit an extended knowledge regarding both the cultural patrimony and the scientific advancement in the conservation process.

Keywords: Field Diagnostics, Acoustic Imaging, Panel Painting, Heritage Communication, Science Communication

Introduction
Nowadays the Cultural Heritage Value Chain needs to experiment new strategies for its empowerment, occurring when the different actors interact sharing their expertises in a process of mutual enrichment. The synergy between Cultural Patrimony and Science discloses an added value, representing a great potential for the human experience. The amount of knowledge carried by the innovative scientific methodologies adds dimensions to the traditional perception and interpretation of an artwork. The conservative and the diagnostic activities of many professionals as restorers, conservation scientists and researchers are part of those cultural assets that need to be disseminated and conveyed to the general public, also using exhibition environments such as museums or archaeological sites. More and more frequently, examples can be found where the conservation process becomes part of the exhibitions widening their purpose and scope. Citing only few recent cases, in the exhibition “RUBENS The Triumph of the Eucharist” (organized by the Museo Nacional del Prado and the J. Paul Getty Museum) the panel paintings conceived by Rubens as modelli for the realization of the tapestries are left “naked” and visible also from the rear side in order to give evidence to the relevant interventions on the surface and on the backing structure. Similarly, movies describing the phases of the restoration process complete the exhibition. The Acropolis Museum in Athens has chosen to realize the structural restoration and the laser cleaning of the Caryatids inside the Museum Galleries, avoiding the risks due to additional move, but also to provide visitors with the opportunity to observe procedures that are usually undertaken in the laboratory.

In this paper the tradition of the Palaces of Genoa will be recalled in a new interpretative frame, where its legacy seems renewed in an original form of hospitality during one of the greatest international events in Italy dedicated to science, the Genoa Science Festival. In this scenario an on-site investigation on one of the major oil paintings of the remarkable collection of the Strada Nuova Museums hosted in Palazzo Bianco Gallery, Venus and Mars by Pieter Paul Rubens, was realized with the participation of the visitors of the museum and of the science festival during usual exhibition time.

The Territory
The legacy of the Genoa Territory finds its major expression in the tradition of the Strade Nuove and the Palazzi dei Rolli, UNESCO World Heritage Site since 2006 as the first European modern system of unitary urban architecture. The site includes a great number of aristocratic residences representing the financial power of the Republic of Genoa, during the 16th and 17th century, with an urban plan defined by a public authority. This great number of renaissance and baroque palaces belonged to official lists (called Rolli) and were chosen to host state visits and exponents of the international culture. It represented a model of a finely distributed hospitality for the promotion.
of the culture, the economy and the patrimony of an entire territory. The relevance and the influence of this urban design model spread out over the entire Europe in the following period, attracting particular attention. Remarkable is the collection of drawings realized by Pieter Paul Rubens and published in 1622 as “Palazzi di Genova”. The Flemish painter is among the first men of culture who gave evidence to the relevant fine architecture, inspired to the classic culture, of the private residences in the urban design model that “[...] due to their quantities, constitutes the body of the whole town”.

Re-interpreting the territorial aptitude

The awareness of the territorial aptitude, its legacy and historical value, allows to reinterpret its peculiarity through modern contexts. This is the case of the Genoa Science Festival: being one of the greatest international events in Italy dedicated to science, it has the mission to spread a high scientific public awareness. The intensive participation of the whole city, covering both the organization and the participation aspects, represents its distinctive character. All the activities are distributed throughout the city hosted in historical buildings and museums, also increasing tourism and allowing the international participation. This type of events brings science outside research laboratories and closer to the public, thus reaching a larger number of people. Every year these events attract an increasing number of guests witnessing the success of this work and, at the same time, answering to the public’s curiosity towards “the science around us”. The traditional hospitality of the Palazzi dei Rolli revives nowadays in a new and more extensive hospitality for the promotion of the scientific culture. This context was the framework of our experience: the union of Art and Science in a field experimentation, which was participated by both the professionals of the CH domain and the visitors. The aim was the promotion of a new form of art fruition, not separated from the diagnostic activity or the conservation process, offering to anyone a deeper interaction with the artworks. As the value of such masterpieces resides in the ability to penetrate history, revealing different historical contexts, the employment of scientific tools is able to penetrate their tangible aspects, letting these objects unveil the hidden tracks that time has left on them, as fascinating story tellers.

Venus and Mars by Pieter Paul Rubens (1632 - 1635)

Painted in Antwerp during the last period of Rubens’ life, this oil on panel is conceived as a portrait probably of a member of the Van den Wijngaerd family, that Rubens reproduces also in another work. It is simply inventoried as “Lansquenet with his Sweetheart” (as reported also in the Corpus Rubenianum Ludwig Burchard) and only recently in terms of mythological subject. The man and the lady wear contemporary garments but the myth of Venus and Mars is clearly recalled (fig. 1a). With its distinctive vivacity, the ability of Rubens in capturing snapshots of the real world and interpret it through the myths of the classical culture clearly emerges, thus providing his reading of the power of life between opposite tensions. As a great number of his masterpieces, the initial nucleus of this painting is likely restricted to the central characters while other ones are introduced later through the insertion of an additional board on the right side. The oak substrate measures 142 × 133 cm2 and, at present, its mean thickness is 3.5 mm. The preparatory layer and the painted film are very thin as well. As a great number of panel paintings of that period, it is thinned and heavily cradled in order to prevent the bending of the wood. The support presents four horizontal boards and a vertical one having grain running normal to the first, (fig. 1b); the arrangement of the boards thus denotes a high sensitivity to possible change of the environmental parameters. A brief chronology: the artwork remains in Antwerp until the death of the painter (1640), and then begins a long travel across Europe, first in London then in Madrid, in the collections of the most important royal families of the time. It arrives in Genoa after 1691, property of Francesco De Mari and then passes to Giovanni Francesco II Brignole Sale, Doge of Genoa. The painting undergoes, for unknown reasons, a reduction of 60 cm in the lower part. As part of the private collection of the last descendant of the Brignole Sale family, the Duchess of Galliera, follows her to Paris in 1874 until her death in 1888. In 1889 the entire private collection of paintings of the Duchess and the Palaces are donated to the Municipality of Genoa; since 1892 the Rubens’ masterpiece is visible in Palazzo Bianco Gallery. Restoration interventions: the artefact undergoes important events that cause significant deterioration. Between 1909 and 1939 only partial restorations are carried out: the static conservation of the wood, insertions to repair the voids and to consolidate the joints, the consolidation of the pictorial film, while the need to intervene on the existing chestnut wood cradle is evidenced. The major interventions are later and here summarized:

1952-55 - the chestnut cradle is removed, visible in (fig. 2a), disclosing the actual arrangement of the support, as shown in (fig. 1b). Butterfly inserts and a new oak wood structure, visible in (fig. 2b), are placed. Surface conservation is accomplished.

1965 - constraints by the new cradle are present, substituted by a third one in pitch pine, (fig. 2c), guaranteeing independent movements of the vertical board with respect to the other ones.

1981 - relative humidity as low as 23% is revealed in some rooms of the Gallery. Glass doors between the rooms are installed to reduce the rate of thermo hygrometric variations.

1981-84 - restoration realized by the Istituto Centrale del Restauro. The substrate is only treated for infestation (gassing) while the cradle is left unchanged. Although it is not completely adequate, it is considered in equilibrium.
with the thinned panel, and the risks due to its displacement are avoided. Surface conservation is accomplished. An environment with stable thermo hygrometric conditions is recommended for a proper preservation of the panel.

The acoustic imaging technique

The present investigation aims at identifying the current state of conservation of the Venus and Mars after about thirty years from the last restoration intervention completed in 1984\textsuperscript{5}. The applied diagnostic method is based on the determination of the acoustic energy absorption coefficient, using a non-contact setup\textsuperscript{6}. The method provides acoustic Figures of multilayer structures (frescoes, ceramics, panel paintings) affected by detachments and flaws, localizing the defects where the absorption coefficient is considerably high. Acoustically speaking, a detachment is a sub-surface air cavity which behaves as a selective acoustic absorber, vibrating at specific frequencies when it is excited by an external pressure field. As a mass - air spring system, its fundamental resonance frequency depends on the density of air inside the cavity, on the surface layer's density and thickness, and on the air cavity depth. The device (ACoustic Energy Absorption Diagnostic Device) automatically scans an area, while an acoustic source S radiates towards the surface an acoustic wave with audible frequency content. A microphone M, aligned with the source S, records both the incident wave \( p_i(t) \) and the reflected wave \( p_r(t) \), with a delay time \( \tau \) due to the difference of the two acoustic paths. Both the reflection and the absorption coefficient are calculated from the acoustic impulse response \( h_S(t-\tau) \) of the analysed surface. For each \( i \)-th point, the result is expressed in terms of the total reflected energy \( \Sigma_i \) and in terms of the absorbed energy percentage \( \text{ABS}\%_i \) with respect to the most reflecting point over the entire analysed area

\[
\Sigma_i = \int_{-\infty}^{\infty} h_S(t-\tau)^2 dt, \quad \text{ABS}\%_i = \left( \Sigma^*_R - \Sigma^*_i \right) / \Sigma^*_R.
\] (1a, 1b)

The two indicators are also extracted as functions of frequency, providing an insight into many aspects regarding the conservation state of the artefact. The frequency analysis may evidence different elements, where smaller defects size is related to high frequency bands. The study of panel paintings must conjugate a suitable extension to cover wide analysed surfaces and a high spatial resolution for revealing small defect size. The acoustic imaging tic array\textsuperscript{8, 9}, shows a great potential in on site non destructive applications thanks to the small size and the high directivity of the acoustic source, and to the great flexibility of the instrumentation which can be easily used where the artefact is placed (fig. 3a).

The experimental results

In the case of panel paintings, the properties of the wood substrate must be taken into account, since it greatly influences the experimental methodology and the results interpretation. A preventive evaluation of the acoustic behaviour of the wood substrate is recommended, in order to discriminate its response from that of possible detachments of the pictorial film. This is accomplished restricting the incident acoustic field to a suitable frequency band, thus avoiding the excitation of normal modes of the entire support (approximately below 3kHz). The measurement on Venus and Mars was carried out in its standard location, characterized by a very stable environment (\( T = 22^\circ \text{C} \) and RH\% = 56\%), as conservation protocols recommend\textsuperscript{10}. A chirp signal with high frequency content (4 - 16 kHz) was selected, and the system examined a surface of (1.36 \times 1.1) m\(^2\) scanning a sequence of vertical profiles comprising 15207 points, 1 cm apart. The measurements were carried out during few days, according to the scheduled visits, and a fast scanning procedure was adopted to make its duration more compatible with the exhibition. For evaluating the accuracy of the experimental data, two selected profiles were repeatedly acquired, and the dispersion of values calculated. According to the result of this repeatability test, a proper post-processing\textsuperscript{11} has been applied in order to obtain a suitable accuracy (\( \Sigma_i \) distribution with mean standard deviation of 6\%).

The visitors had the opportunity to assist to the measurement, (fig. 3b), and to discuss about the outcomes of the examination: as expected, an overall good state of conservation was actually assessed. The distribution of values of the indicator ABS\% and the corresponding acoustic Figure superposed on the painting's Figure are shown in (fig. 4). The histogram evidences a good degree of homogeneity of the overall acoustic response, with a high fraction of analysed surface presenting low absorption percentage (hasing on previous knowledge, ABS\% < 30\% is frequently found also in homogeneous reflecting materials). Anyhow a slight asymmetry towards higher absorption percentage indicates that some defects has been revealed. The acoustic Figure displays the ABS\% data using a colour palette with a first threshold at 35\% (green) and a second one at 45\% (yellow), where the most critical points (fading to red) are mainly located in the upper part of the painting. A light weakness appears in the upper half panel, while the most damaged portion runs horizontally over the heads of the principal characters. Observing the reverse (fig. 1b) of the panel, this portion corresponds to a flaw inside the upper board between the two lines of butterfly inserts. This defect slightly appears in the photograph taken during the '50s but, on the basis
of the present investigation, it can be assumed that a periodic monitoring of the evolution of the deterioration process in this area can be useful to prevent further damage. On the contrary, the red vertical portion on the left boundary results a fake caused by a light rotation of the painting that, in this restricted region, irregularly cuts and scatters the incident acoustic beam along the vertical axis.

Frequency-resolved data may help the understanding of the causes of deterioration. The (fig. 5) shows the resulting acoustic Figures in the most relevant frequency intervals: expressed in 1/3 octave bands, the nominal central frequencies and the approximated bandwidths are here reported fa [6.3kHz, 1.5kHz]; fb [8kHz, 1.8kHz]; fc [10kHz, 2.3kHz]; fd [12.3kHz, 2.9kHz]. The Figures at the two lower bands, (figg. 5a-5b), confirms the weakness in the upper half of the panel disclosing an unexpected periodic structure. A deeper exam of this feature will indicate if this effect can be ascribed to the cradle structure, that might have lost adhesion to the oak substrate. Indeed the current approach prefers the removal of the heavy cradles for the thinned panels, replaced by light and flexible structures connected to the panel through springs 12. As frequency shifts towards higher values, see (figg. 5c-5d), the narrow horizontal flaw becomes more and more evident. Moreover also a vertical stripe on the right side clearly appears, running along the entire length of the vertical board.

Assuming for example the same order of magnitude for the thickness of the air cavity and for that of the superficial layer, assigning to this last an approximate density of 0.9g/cm3, the thickness of the detached area can be estimated about 1.6mm for the higher frequency band (12.3kHz) and about 3.2mm for the lower frequency band (6.3kHz). For this last, assuming the oak wood density of about 0.7 g/cm3, for the superficial layer, the defect size results about 3.6mm. For an accurate evaluation of these quantities, the knowledge of more realistic values of density and thickness both of the support and of the painted layer is required.

Conclusion

The acoustic imaging system, described in this work, conjugates a relatively low cost equipment and a great flexibility for diagnostic investigations feasible where the artefact is placed. The study of the Venus and Mars confirms a relatively good state of conservation of the artwork, although a structural weakness in the upper board may require periodic test in the future. Moreover the defects of the wood support can be discriminated by those of the pictorial film by studying the acoustic Figures in the frequency domain. The authors gratefully acknowledge Piero Boccardo, the Director of the Strada Nuova Museums, Luca Pitolli, CNR Artov, the organization of the Genoa Science Festival who gave us the opportunity to materialize this study, and Susanna Canepa, Federica Lucchesi, Davide Pagiaro, Angelo Semola and all the visitors who shared with us this exciting experience.

1. (Woollett et al., 2014).
2. (Caskey, 2011).
3. (Rubens, 1622).
4. (Cordaro et al., 1985).
5. (Cordaro et al., 1985).
6. (Calicchia et al., 2013).
7. $\Sigma_i$ is calculated by integrating the square modulus of the impulse response over a suitable time window $W$ as wide as the delay time $\tau$. For the Parseval’s theorem, the integral in equation (1a) equals the integral over frequency of the square modulus of the Fourier Transform of the impulse response, $H(f)$, related to the reflection coefficient $r(f)$. Physically, $\Sigma_i$ represents the total reflected energy, regardless of the frequency component.
8. (Calicchia et al., 2012).
9. (Calicchia et al., 2014).
11. The uniformity of the lower half of the painting, evidenced in the unprocessed data, allowed a normalization of $\Sigma_i$ in the vertical profiles, with respect to the mean value calculated over the lower 30 cm of each profile.
12. (Phenix et al., 2011).

Bibliography


Figure 1 - Venus and Mars, Rubens, oil on panel, 142 × 133 cm2: front (a) and reverse (b) showing the arrangement of the oak wood boards (b).

Figure 2 - Reverse with the cradle structures: chestnut wood cradle (a); oak wood cradle (b); pitch pine wood cradle (c).

Figure 3 - The acoustic diagnostics equipment (left), and visitors during the on-site experimentation in the Palazzo Bianco Gallery (right).
Figure 4 - Distribution of values of the ABS% indicator in the whole map, where relevant thresholds are marked with arrows (left); acoustic Figure superposed on the painting’s front surface (right).

Figure 5 - Frequency resolved acoustic Figures: 6.3kHz (a), 8kHz (b), 10kHz (c), 12.5kHz (d).