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Currently, a wide range of digital sensors for capturing our architectural heritage are available. They offer the opportunity to acquire large sets of information in a relatively short time. These sensors include digital photography (photogrammetry—scaled rectified photography), total stations, laser scanners, high-resolution panoramic devices, etc. A lot of effort has been put in the application of these tools in the field of conservation, however a significant gap exists between the information needed by professionals working in the field of conservation and manufacturers claims of these new technologies. The realistic application of these tools for heritage documentation products needs to be addressed. Offering the architectural heritage community didactic material on how and when to use these tools appropriately can address this gap. This paper presents the teaching material being prepared under the CIPA/RecorDIM initiative to overcome these issues and begins to address the need for a common framework of standards in heritage documentation.
1. Introduction

For the past four years the CIPA/RecorDIM [7] initiative has provided an opportunity for documentation and conservation professionals to improve the practice of collecting, processing and managing information for conservation of architectural heritage. In particular, the results presented in this paper are the development of teaching handbooks that offer a structured approach to the use of technologies for capturing our cultural heritage, effectively providing a reference source for applying metric survey tools for conservation of architectural heritage.

1.1. Phases of the conservation cycle and the role of documentation

In order to understand the role of digital capture technologies in heritage documentation it is necessary to be clear about how the information provided by using them is useful; this is a crucial first step without which we are faced with ‘documentation for documentation’s sake’. The model of information required to inform conservation action is established in the Venice Charter (Article 16) and expanded in the ICOMOS Sophia Principles 1996 [8].

The conservation of built heritage is developed following a series of work phases, involving ‘analysis, diagnosis, therapy and controls’ [8] (See Figure 1).
Analysis (evaluation): corresponds with the phase of the investigation and research to establish value and significance in order to understand the priority of action and allocation of resource for a given site or aspect of it. Acquisition of key thematic, social and academic data for inventory and preliminary asset management planning. It is essentially multi-disciplinary with very selective mapping needs.

Diagnosis corresponds with the phase of the identification of the causes of damage and decay. It is the synthesis of the gathered information in order to achieve an understanding of condition and the forces or actions involved in maintaining an agreed state. Diagnosis should lead to definition of objectives and aims, based on deliberate and clear choices that on their turn are based on generally accepted restoration principles. Metric data, particularly records of coalition and ‘base map’ data are required as a framework for both monitoring and as a pre-intervention record.

Therapy (or intervention) corresponds with the phase of the choice of the remedial measures and their execution.

Monitoring (or Control) refers to the phase of reviewing and assessing the efficiency of the intervention or conservation regime. Because any change to historic material impacts on its authenticity the post-intervention status must be evaluated, not only in terms of material change but also in terms of its value and significance. In order to adapt conservation technique to respond to change it is essential to be able to describe such change; in order to achieve minimal impact on architectural heritage and use recourses in a rational way, it is necessary to repeat these steps in an iterative process. The different phases follow each other but frequent sub cycles to previous phases guarantee that each step is only made when enough validated information is available [8].

These 4 stages in the cycle have metric information needs that must be adequately met by establishing the principle of matching an intensity of capture to a given process. The validity of a variety of metric activities is established; for example, at the earliest stage of the cycle when hand drawn building plans and details can convey highly valuable information to the project team. Such drawings may not exhibit rigorous metric performance but require high orders of information selection in a short time span such as is needed for rapid assessment of damage or in the inventory of cultural heritage; an awareness of the enhanced value of such records when they have a metric base is, of course, important when planning information capture by anticipating future data utility.

In developing training in response to the conservation cycle information needs, we will focus on the ‘analysis and diagnosis’ phases, where information capture is required to meet both the needs of specific conservation issues and the wider baseline condition record requirement: the phases in the cycle where metric survey is the primary tool for preparing site information.
1.2. Classification of digital tools

Digital tools can be classified using different criteria, in this paper we have adopted ‘direct’ and ‘indirect’ as the primary classification. ‘Direct’ techniques are those which require the user to select information to be recorded at the point of capture (for example site drawing, EDM or GPS) and ‘indirect’ are those which capture a scene and allow post capture selection of information (for example photogrammetry or laser scanning). Direct techniques refer to sensors that require direct selection of discrete points but need a clear understanding of the information needs of both the conservation process and the architectural form involved. For example a laser distance meter (e.g. Disto) can be used for measurements to support a measured drawing but it can only record a highly selective version of a given subject. Indirect tools are those, where an operator can capture a large quantity of undifferentiated data (often, in a shorter time on site than a direct technique) and make a data set available for the selection of project specific information off site. Good examples of indirect techniques are the image-based methods of rectified photography and photogrammetry.

Application of tools:

Choosing a tool depends on the study of the different variables affecting the site that might have an impact on the operability of the sensors as well as a clear understanding of the expected information needs that are to be met by using it. The dynamic between skilled observation and the precise transmission of information must be based on making transparent choices in the documentation project brief. In this way all parties are aware of the risks and benefits of the chosen approach to document subjects which will, by their very nature as culturally significant, always need the support of not only the heritage conservation community but all cultural stakeholders, both local and global.

A considerable number of surveying strategies fail and are not suitable because the lack of a critical feasibility study based on balancing data capture tool performance against site constraints and expected outcome. The following table offers a list of variables to evaluate when preparing a strategy for metric documentation of cultural heritage.

<table>
<thead>
<tr>
<th>Site Constraints</th>
<th>Tool Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access (legal, environmental &amp; physically)</td>
<td>Speed: time to measure a point, feature and/or surface.</td>
</tr>
<tr>
<td>Permission for site occupation and information copyright.</td>
<td>Precision: accuracy factor of the survey equipment.</td>
</tr>
<tr>
<td>Risk: Personal and equipment safety</td>
<td>Measuring Range: reach of the tool, depends on distance and other environmental constraints.</td>
</tr>
<tr>
<td>Budget: available funds for the survey</td>
<td>Field operability: constraints in relation to the field work.</td>
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Table 1: Site and tool variables.
For training purposes, the handbook being prepared deals with presenting potential participants with real situations, where the constraints needs to be assessed before recording cultural heritage sites.

2. Selecting tools

Formulating a structured and procedural mapping strategy is important in the work of conservation because there is a wide variety of options in documentation available and an equally wide spectrum of user expectations. Agreement on what is to be delivered with an end user is vital in protecting the professional status of both the data provider and the data user before resources are committed to site. Understanding the balance between a data provider and a data user can only be achieved by the use of a correctly prepared brief and such a brief can only be achieved by understanding both the client information needs and the performance of the technologies available. The survey brief is the product of both the data supplier’s knowledge of the different variables that will affect the survey and the desired deliverable to be prepared. The most crucial variables (see Table 1) encountered are the expected quality and the level of detail delivered: it is vital the intensity of effort applied to the preparation of documentation is commensurate with both the immediate project needs and the value and significance of the subject are respected.

<table>
<thead>
<tr>
<th>Site Constraints</th>
<th>Tool Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected quality</td>
<td>Robustness: strength to extend adverse weather conditions and impact.</td>
</tr>
<tr>
<td>Level of detail</td>
<td>Portability: capability of being transport to remote sites, requirements of transport, power and other factors.</td>
</tr>
<tr>
<td>Expected outputs</td>
<td>Adjustment and corrections: processes required to obtain accurate results.</td>
</tr>
<tr>
<td>Timing</td>
<td>Supporting techniques: No one technique will capture a complete information set; some tools (EDM, CAD and drawing) integrate well, others less so (e.g. laser scans and drawing).</td>
</tr>
<tr>
<td>Expertise</td>
<td>Occlusion: respond to shadows, obstacles, and material related constraints (reflectivity).</td>
</tr>
<tr>
<td>Quantification</td>
<td>Cost: rental and/or purchase of the sensor/skill acquisition.</td>
</tr>
<tr>
<td>Other variables</td>
<td></td>
</tr>
<tr>
<td>Project information needs:</td>
<td>Condition mapping, inventory, management and conservation plans.</td>
</tr>
<tr>
<td>Cyclic monitoring requirements</td>
<td></td>
</tr>
</tbody>
</table>
The expected quality is dependent on the completeness and reliability of the maps resulting from survey. Scale is specifically linked to the measured dataset output requirements. Prior to starting the mapping of the site is important to define an effective scale of the map(s) so that sufficient information for the rapid-assessment studies is provided.

The level of detail determines how the elements are represented on the map and is related directly to the required scale of the map, including boundaries, roads, buildings, etc. In addition to this, the formulation of the mapping strategy should also take into account the type of control to be established to carry out the survey and the method chosen.

The interaction between the recorder and that which is recorded is a cause of both conflict and control in the documentation process. A teaching concept of balancing three key functions to determine the bias in information collection has proved to be a valuable way of understanding the constraints of method selection and information requirements. The three concepts are:

- Measurement method.
- Information selection.
- Presentation or communication criteria.

These form the three elements of the recording process and can be emphasized differently according to conservation needs, the resources available and the expected product of the action. For example, a direct technique such as EDM is a common tool for preparing metric survey drawings; it requires the selection of measured points and an agreed convention as to how they should be used to describe an object. An operator will need to be able choose which points are needed and know how they should be presented for, say, the preparation of a plan as an architectural drawing.

### 3. Planning outcome and required skills

Having identified a common professional knowledge gap and addressing it in the UK, the English Heritage Metric Survey team has run a series of short (3 day) summer courses in the UK at Stowe, Buckinghamshire (National Trust) and later Wrest Park, Bedfordshire (English Heritage) since 1989. The course has centered on the lack of experience conservation professionals have in handling metric survey techniques and latterly concentrated on the judgement required to prepare a brief for survey in the light of understanding the key aspects of the application of survey techniques to a variety of project needs. This experience has revealed a required skill set for those charged with carrying out or commissioning heritage documentation.

- Preparing a brief based on the constraints of a given project.
- Understanding the information needs of the conservation project team.
- Value measured drawing as an aid to observation and as a necessary component of metric survey.
Awareness of the capacity of a skilled observer in supplying key selective site information.

Understanding the differences between conservation information needs and those of archaeological inquiry.

Using a specification to procure appropriate metric survey.

The development of the short course has produced a standardized training package that delivers both hands on experience of using metric tools (EDM, rectified photography, photogrammetry and drawing) as well as practice in preparing a brief for a conservation information need. In 2000 the Raymond Lemaire International Centre for Conservation (RLICC-KU Leuven) invited the Metric Survey Team to deliver the short course to post graduate conservation students and this has become an annual event by agreement between the RLICC-KU Leuven and English Heritage. The material (figure 7) used for lesson planning and lectures has been compiled into the RecorDIM teaching manual in seven parts:

1. Introduction - the role of metric survey in conservation
2. Drawing
3. EDM
4. Rectified photography
5. Photogrammetry
6. GPS
7. Laser scanning

An emphasis on making metric techniques accessible is important in teaching their application, the emergence of robust, commercially viable
entry level tools (e.g. TheoLt for real-time CAD capture [figure 3] for REDM and PhotoPlan for rectified photography [figure 4]) make good opportunities to broaden the experience of non-survey professionals, increasing awareness of the difference between using a minimum skill set, developing metric and selection skills and understanding what requires commissioning expert help from a geomatics supplier.

4. The need for standards

The appropriate match between conservation project information needs and the products of digital data capture relies more on the relationship between the data provider and the data user than almost any other factor. In teaching the need to balance measurement technique with the understanding necessary to select pertinent information it is hoped the high
The quality demanded of the documentation of our cultural heritage will engender a professionalism guided by practical experience and good instruments of contract. There are very few examples of specifications for the supply of metric digital data in the cultural heritage sector: it is common practice to leave the decisions on the technical performance of a survey to the surveyor. Whilst this is a good advertisement for the honesty of the survey profession it is a risky way of doing business if the buyer does not seek an independent view of what kind of survey will work best for the funding available. It is surprisingly common for a novel technique to impress heritage managers with exciting 3D potential without being tested against a data performance requirement. It is also common for cultural heritage icons to be used to advertise the capabilities of novel techniques without reference to a project brief simply because a supplier knows ‘heritage sells’. This coupled with strong market associations with technology providing ‘solutions’ to data needs, has lead to widespread misapplication of terrestrial laser scanning for architectural scale surveys. The hard truth that it takes diligence, effort and time to get results from these technologies is overlooked in the excitement of the belief that 3D is suddenly easy and cheap; by the time the true project costs are in, everyone is sadder and wiser. The experience of HABS/HAER/HALS in using, what suppliers fondly imagine to be ‘documentation solution’, is far less widely known than perhaps it should be is reported in Preservation Architect, The Newsletter of The Historic Resources Committee December 29, 2006:

“But, with the laser scanner as with most things that initially may be thought to be a panacea, the rigors of creating documentation drawings, even with the ‘magic’ of lasers is still not the complete
answer nor is the usage of laser measurement tools appropriate in all situations. To match the quality of hand measurement and drawing translation, it takes a great deal of time, understanding and proper technique to yield good results. From the last dozen or so projects, we have begun to understand what the appropriate situations are to use the scanner and when we must use the tried and true Historic American Building Survey, Historic American Engineering and Historic American Landscape Survey (HABS/HAER/HALS) techniques that have evolved over the past 70 years. Not only are we struggling to define our procedures in terms of the most effective and efficient use of this electronic measuring tool, but also we are seeking how and when to incorporate AutoCAD or hand-rendering techniques to supplement the drawings. These decisions early in the project mean the difference in months or even years for project completion.” [4]

The only protection against wild variation between data needs and data provision is to adopt a specification based on the experience of using techniques proven to meet data needs and prepare clear project briefs for data acquisition. The careful description of the deliverable and its expected performance is the duty of the documentation team either by establishing the right work practice or ensuring services are correctly procured: the ICOMOS Sophia Principles of 1996 state that.

“The recording of the cultural heritage is essential:
- to acquire knowledge in order to advance the understanding of cultural heritage, its values and its evolution;
to promote the interest and involvement of the people in the preservation of the heritage through the dissemination of recorded information;

to permit informed management and control of construction works and of all change to the cultural heritage;

to ensure that the maintenance and conservation of the heritage is sensitive to its physical form, its materials, construction, and its historical and cultural significance."
and

“Recording should be undertaken to an appropriate level of detail in order to provide a permanent record of all monuments, groups of buildings and sites that are to be destroyed or altered in any way, or where at risk from natural events or human activities.” [6]

This statement forms the starting point for a standard for heritage documentation by development of agreed norms for work practice, technical performance and data management which in turn can be used as a teaching norm: at present there are many disparate standards in use ranging from excavation practice to GIS data formats; in looking at the capture technologies it has become apparent there is a need to integrate our understanding of best practice and the ad hoc standards in use world wide to refine a set of core principles in heritage documentation. Local standards include, at a technical level, for example, the Metric Survey Specification for English Heritage [2] which is an empirical standard for the specific heritage management information needs of English Heritage. The publication of conservation plans has prompted a number of standard briefs for the acquisition of survey and the emergence of briefs for ante-disaster records [10] are steps towards a standard for heritage documentation. The concept of documentation as a discipline in its own right will require the acquisition of consistent metric information to be considered at all steps in the conservation cycle rather than at points of intervention as is the more common case today. By underpinning the whole spectrum of conservation activities with a metric base it is possible that the rewards of exploiting digital documentation will be great and enhance the performance of conservation as a whole.

5. Conclusions

The need for conservation professionals to experience the conflicts and compromises of getting digital techniques to deliver heritage documentation is clear; the evident misapplication of techniques is often caused by a lack of accessible knowledge on these matters. By preparing a comprehensive teaching guide derived from practitioner knowledge of survey, procurement and teaching it is hoped that the appropriate use of metric technologies in heritage documentation will become more widespread and that the relationship between the survey professionals and conservation professionals will improve. In developing consistent teaching of the diverse technologies of metric data capture the need for a framework of standards for heritage documentation has emerged.

6. Future work

The preparation of the teaching material is currently under revision by a number of different institutions and it is being implemented in training courses organized by additional organizations, such as the University of Pennsylvania’s Preservation course, ICCROM’s built Heritage 2007 and
Bath University Architectural Conservation post graduate courses among others. This material will be available to institutions willing to improve capacity of their students and/or professionals. Additional work is proposed to cover issues like the use of laser scanning for anti-disaster recording under an EU project financed by the Leonardo Da Vinci Agency.

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References


Mario Santana Quintero, Bill Blake and Rand Eppich
Conservation of Architectural Heritage: The Role of Digital Documentation Tools
The Need for Appropriate Teaching Material

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Simulating the Use of Ancient Technology Works Using Advanced Virtual Reality Technologies

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